Contents

Setting the scene

First overviews

By the end of 2016 a first overview of roadmaps, pilots and test sites was provided by The Netherlands as part of their knowledge agenda for automated driving.

http://knowledgeagenda.connekt.nl/engels/2017/03/09/overview-roadmaps-and-pilots/

The European Commission, supported by CARTRE organized two workshops in which additional information on national roadmaps and initiatives was shared:

- "Large Scale Automation Pilots on public roads in Europe" (16 December 2016, Brussels); https://connectedautomateddriving.eu/event/large-scale-automation-pilots-on-public-roads-in-europe/
- "workshop on automation pilots on public roads" (18 May 2017, Brussels); https://connectedautomateddriving.eu/event/workshop-automation-pilots-public-roads/

The information generated by these initiatives serves as a basis for this document. Numerous other road maps, initiatives, pilots and test sites that had not been included in the overviews or have started since, and are now included to provide an overview that is as complete and recent as possible. But given the nature of the dynamic and frequent developments in the field of Connected and Automated Driving, this can not be a complete overview.

Overview roadmaps

This chapter gives an overview of CAD roadmaps

Organization	Countries	date	roadmap	online
EU MS, EU Commission, Industry	EU	April 2016	Declaration of Amsterdam "Cooperation in the field of connected and automated driving"	link
The Netherlands	EU	February 2017	1st High Level Meeting on connected and automated driving	link
Germany	EU	September 2017	2nd High Level Structural Dialogue in Frankfurt/M	link
The Netherlands Institute for Transport Policy Analysis (KiM), Ministry of Infrastructure and the Environment	NL	March 2017	Paths to a self-driving future	link
Department for Transport, United Kingdom	UK	February 2015	The Pathway to Driverless Cars	link
Federal Ministry of Transport and Digital Infrastructure, Germany	DE	September 2015	Strategy for Automated and Connected Driving	link
Finnish Transport Agency, Finland	FI	2016	Road Map and Action Plan 2016–2020	link
Federal Ministry of Transport, Innovation and Technology, Austria	AT	June 2016	Automated - Connected - Mobile	link
La Nouvelle France Industrielle – Véhicule Autonome, France	FR	2015	Objectifs de recherche Nouvelle France Industrielle Véhicule Autonome	link
Federal Public Service- Mobility and Transport - Belgium transport authority	BE	2017	Belgian procedure for testing of automated vehicles and how the code of practice contributes to safe testing	link
Direccion General de Trafico, Spain	ES	December 2016	Spanish approach on Autonomous driving	link
European Commission	EU	May 2018	On the road to automated mobility: an EU strategy for mobility of the future	link
Juncker Commission	EU	May 2018	Europe on the move	link
EUEIP	NL	March 2017	Cooperative ITS towards Cooperative, connected and Automated Mobility – Phase II final report	link
European Commission	EU	December 2017	H2020 Transport	link
Minister van Nieuwenhuizen (IenW)	NL	March 2018	Speech Minister Van Nieuwenhuizen (IenW) at Intertraffic	link
ECSEL Europe	AT	February 2016	Research, Development & Innovation roadman for AV	link
European Commission	EU		GEAR 2030 Discussion Paper	link
The conference board of Canada	CA	January 2015	Automated vehicles	link
Ontario Good Roads Association, Canada	CA	July 2015	The Roadmap for Autonomous (Self-Driving) Vehicles in Ontario	link

Transport and Infrastructure Council, Australia	AUS	August 2016	National Policy Framework for Land Transport Technology	link
Main Roads Western Australia	AUS	January 2015	Automated Vehicles: Are we ready?	link
National Transport Commission (NTC), Australia	AUS	November 2016	Regulatory reforms for automated road vehicles	link
New Zealand Government, Ministry of Transport	NZ	November 2016	Testing autonomous vehicles in New Zealand	link
Department of Transportation, United States	US	December 2014	ITS Strategic Plan	link
Department of Transportation (DOT), United States - National Highway Traffic Safety Administration (NHTSA)	US	September 2016	Federal Automated Vehicles Policy	link
Department of Transportation (DOT), United States - National Highway Traffic Safety Administration (NHTSA)	US	September 2017	Automated Driving Systems 2.0	link
Cross-Ministerial Strategic Innovation Promotion Program (SIP), Japan	JP	October 2016	Automated Driving Systems Activities	link link link
The Korea Transport Institute	SOKO	October, 2015	Automated Driving Development in Korea	link
North Carolina department of transportation	US	November 2016	NC Readiness for connected and autonomous vehicles (CAV)	link
American Association of State Highway and Transportation Officials	US	2015?	Connected/Automated Vehicle Research Roadmap for AASHTO	link
ERTRAC Working Group “Connectivity and Automated Driving”	EU	May 2017	Automated Driving Roadmap	link
European Technology Platform on Smart Systems Integration (EPoSS)	EU	April 2015	European Roadmap Smart Systems for Driving	link
iMobility Forum, Working Group Automation in Road Transport	EU	May 2013	Automation in Road Transport	link
EATA- European Automotive and Telecom Alliance	EU	February 2017	EATA Roadmap	link
European ITS platform	EU	March 2017	Draft road map and action plan to facilitate automated driving on TEN road network	link
Polis	EU	January 2018	Road vehicle automation and cities and regions	link
European Commission	EC	2010	SMART study report	link
SCOUT	EU	May 2017	Context map and vision for AD in EU	link
Conference of European Directors of Roads	EU	2016	CEDR Position on Road Vehicle Automation	link
International Task Force on		2016	International Task Force on Vehicle-Highway	link

Vehicle-Highway Automation			Automation	
CLEPA, European Association of Automotive Suppliers	EU	October 2014	CLEPA Automated Driving Position Paper	link
Robert Bosch		2015	The road towards automated driving	link
Continental		2015	From Assisted to Automated Driving	link
Groupe Renault	FR	2015	France industry plan	link
Japan Automobile Manufacturers Association, Inc. (JAMA)	JP	February 2016	On the road to automated driving	link
European Automobile Manufacturers Association (ACEA)	EU	May 2017	EU Roadmap for Truck Platooning	link
Nissan		2017	Autonomous Drive Technology Roadmap	link
Gartner		2017	Gartner Hype Cycle	link
Euro NCAP	EU	September 2017	Euro NCAP 2025 Roadmap	
TNO, The Netherlands	NL	February 2015	Truck Platooning	link

Declaration of Amsterdam "Cooperation in the field of connected and automated driving"

On 14 April 2016 at the Informal Transport and Environment Council in Amsterdam, 28 EU Ministers of Transport endorsed the "Declaration of Amsterdam" to work towards a more coordinated approach enabling the introduction of connected and automated driving (see fig X). Close cooperation between Member States, the European Commission and industry partners is seen as an important prerequisite for the widespread introduction of innovative and interoperable connected and automated driving technologies in Europe. The Declaration of Amsterdam on Connected and Automated Driving, was an important first step towards a common European strategy in this field and includes a joint agenda for further action to support the shared objectives. Key action points for Member States mainly involve the need to address legal and practical barriers to the testing and deployment of connected and automated vehicles. The Declaration of Amsterdam also called for the establishment of a high level structural dialogue for Member States to exchange views and best practices regarding the development of connected and automated driving and to monitor progress.

https://www.government.nl/topics/mobility-public-transport-and-road-safety/question-and-answer/what-is-the-declaration-of-amsterdam-on-selfdriving-and-connected-vehicles

https://www.rijksoverheid.nl/documenten/rapporten/2016/04/29/declaration-of-amsterdam-cooperation-in-the-field-of-connected-and-automated-driving

https://www.government.nl/topics/european-union/the-netherlands-eu-presidency

Fig X group picture after the endorsement of the Declaration of Amsterdam

High Level Meetings

The Netherlands on 15 February 2017

The first High Level Meeting, organized by the Netherlands, was held in Amsterdam on 15 February 2017. It was attended by representatives from 24 EU Member States, Norway and Switzerland. Transport and Telecom ministers, the European Commission and parties from the automotive and telecom industries were also present. The open and informal discussion made it possible to identify concrete steps to enable further progress in the introduction of connected and automated driving on the Europe's roads.

The participating Member States, the European Commission and the automotive and telecom industry:

1. agreed to continue the High Level Meeting on connected and automated driving;
2. expressed support for a joint European approach;
3. considered willingness to share vehicle data contributing to traffic safety and congestion reduction and the set-up a public-private data task force;
4. the European industry is actively striving towards rapid development of V2V and V2I;
5. considered the need for cross border testing;
6. emphasized the need for close cooperation in UN-ECE;
7. agreed to work together on coherent national, international and European regulation;
8. agreed to elaborate this working agenda of connected and automated driving.

Link: https://www.government.nl/documents/leaflets/2017/05/18/on-our-way-towards-connected-and-automated-driving-in-europe

Fig X High level group meeting in the Netherlands on 15 February 2017

Germany on 15 September 2017

The second High Level Meeting, organized by Germany, was held in Frankfurt on 15 September 2017. At this meeting the EU and EFTA Member States, the European Commission and associations of the automotive and telecom industry, have clearly focused on automated and connected driving and have developed an action plan to further advance the technology at European level, including the following main activities:

1. Establish Task Force on European medium and long-term targets on cross-border testing
2. EC to set up an EU-wide campaign to spread CAD knowledge and realistic expectations
3. Establish Task Force chaired by Germany to highlight CAD ethical issues
4. Support and continue the work “Guideline on data protection and cybersecurity” started at UNECE WP.29 and C-ITS Platform activities; MS and EC to incorporate results in EU policy and regulation
5. Data Task Force to continue cooperation work and expand the initial scope from traffic safety data, to traffic and mobility management by 2019
6. EC and Data Task Force to explore collaborative pan European solution towards common architecture for providing and sharing data from all categories within each MS to allow cross border exchanges and pan European solutions
7. Create regulatory framework for CAD: amending Geneva and Vienna conventions, provision on licensing vehicles and road rules and infrastructure aspects.

Link: https://www.bmvi.de/SharedDocs/EN/Documents/DG/action-plan-automated-and-connected-driving.pdf?__blob=publicationFile

Fig X High Level meeting in Germany on 14-15 September 2017 (source: FIA https://www.fia.com/news/fia-takes-part-european-ministerial-meeting-automated-vehicles)

The third High Level Meeting was organized by Sweden on 18-19 June 2018. Link: https://www.government.se/articles/2018/06/third-high-level-meeting-on-connected-and-automated-vehicles-led-to-common-conclusions/

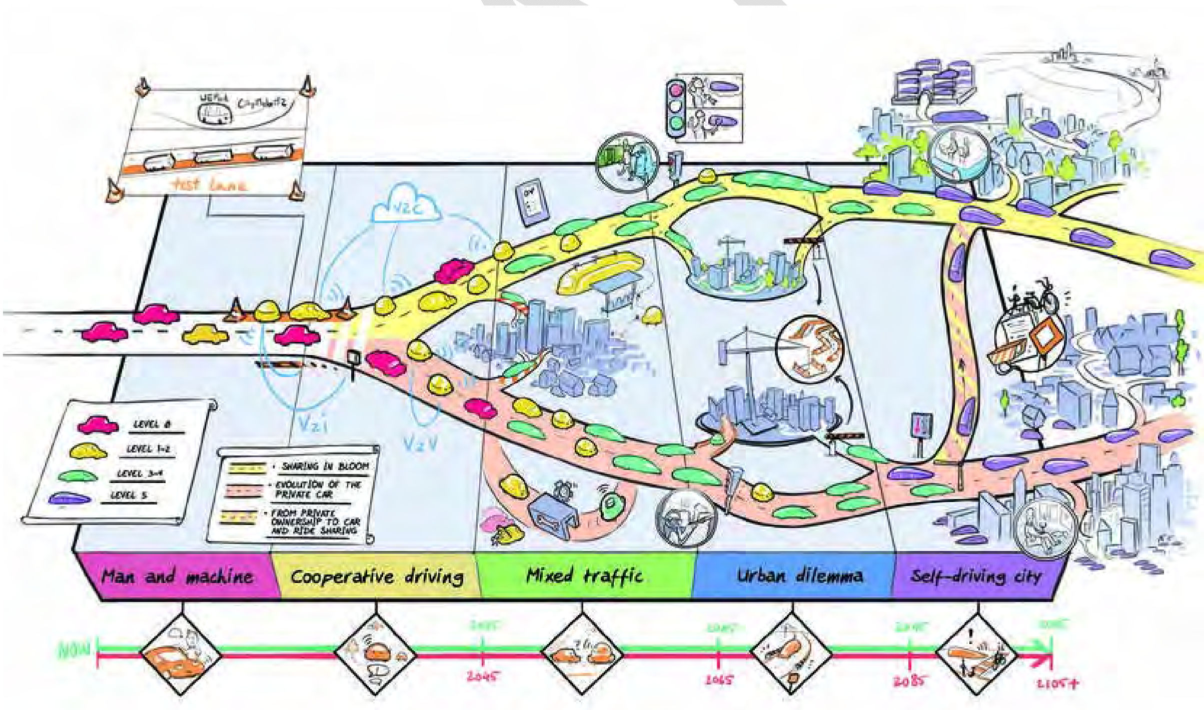
Paths to a self-driving future – KIM, The Netherlands, 2017

In the study ‘Paths to a self-driving future – Five transition steps identified’ the KiM Netherlands Institute for Transport Policy Analysis has devised two transition paths to a future traffic and transport system involving self-driving vehicles: ‘Evolution of the private car’ and ‘Sharing in bloom’. The first path, ‘Evolution of the private car’, describes a transition in which most people still prefer to own their own vehicles, and the technological possibilities for self-driving vehicles increase step-by-step and gradually come onto the market. In the ‘Sharing in bloom’ transition path, the sharing of vehicles is commonplace. For both of these paths, how fast the transitions occur is a major uncertainty, and this will not only depend on technological developments, but also on how fast self-driving vehicles actually come onto the market and if they appeal to the public.

There are five steps on both transition paths in which an interplay of developments can profoundly impact the transition:

1. the interaction between man and machine;
2. cooperative or autonomous driving;
3. mixed traffic on the highway;
4. yes/no separating traffic streams in cities;
5. the ‘self-driving city’.

Specific policy action points were mapped for each of these transition steps, and then divided into four categories: regulation and coordination; facilitation, execution and experimentation; conducting research; monitoring and evaluation.

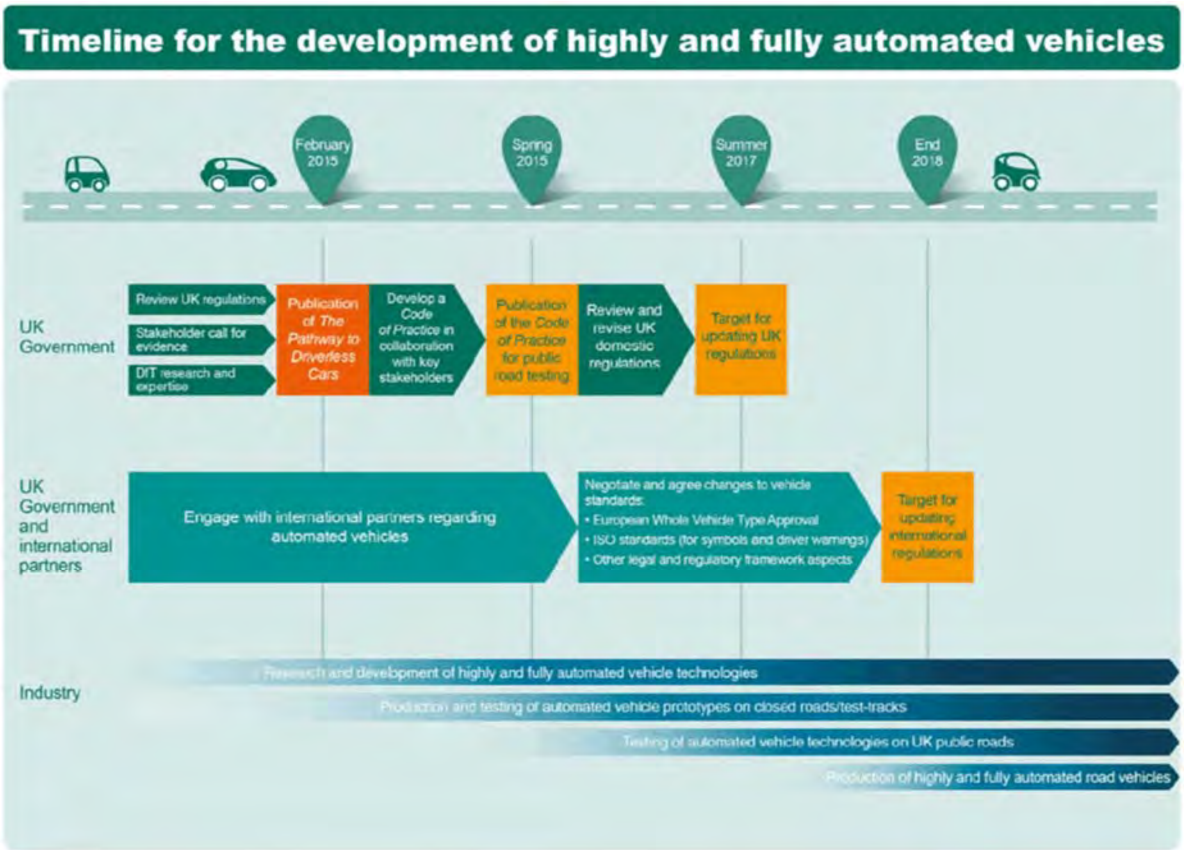


https://english.kimnet.nl/latest-news/news/2017/03/27/paths-to-a-self-driving-future

The Pathway to Driverless Cars – DoT, United Kingdom, February 2015

A detailed review of regulations for automated vehicle technologies

The focus of this review is to ensure the UK is at the forefront of the testing and development of the technologies that will ultimately realise the goal of driverless vehicles.



https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/401565/pathway-driverless-cars-main.pdf

A Code of Practice for testing

The publication of this Code of Practice is intended to help manufacturers and those organising testing of these technologies by providing clear guidelines and recommendations for measures that should be taken to maintain safety during this testing phase.

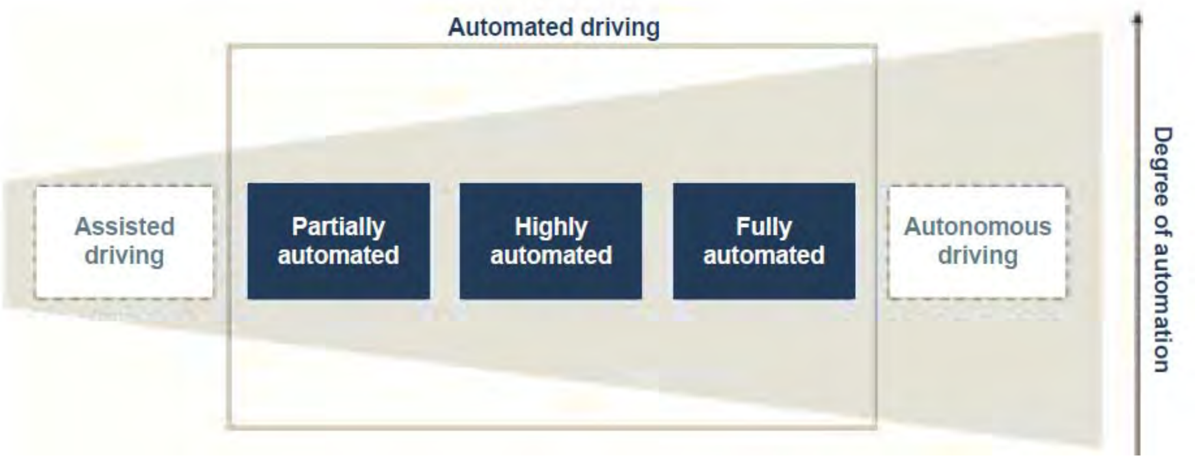
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/446316/pathway-driverless-cars.pdf

Strategy for Automated and Connected Driving, Germany, September 2015

In September 2015, on the basis of recommendations made by the "Automated Driving" Round Table, the Federal Government published the "Strategy for Automated and Connected Driving - Remain a lead provider, become a lead market, introduce regular operations", thereby adopting guidelines on how to exploit the opportunities for growth and prosperity inherent in automated and connected driving. These technologies harbour the potential to increase road safety and traffic efficiency, reduce traffic-related emissions and strengthen Germany as a competitive business site for economic activity and a more attractive location for innovative businesses. The implementation of the strategy, which was supported by members of the Automated Driving Round Table, triggered measures in five fields of action:

- Infrastructure
    - Digital Infrastructure
    - Standards for intelligent roads
- Legislation
    - International regulatory framework
    - National regulatory framework
    - Driver training
    - Type approval and technical inspection
- Innovation
    - Digital Motorway Test Bed
    - Research funding
- Interconnectivity
    - Mobility data and spatial data
    - Interlinking of traffic signs
    - High-precision map systems
- Cyber security plus data protection
    - Standardization of cyber security
    - Data protection

https://www.bmvi.de/SharedDocs/EN/Publikationen/strategy-for-automated-and-connected-driving.pdf?__blob=publicationFile



Road Map and Action Plan 2016–2020, Finland, 2016

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:

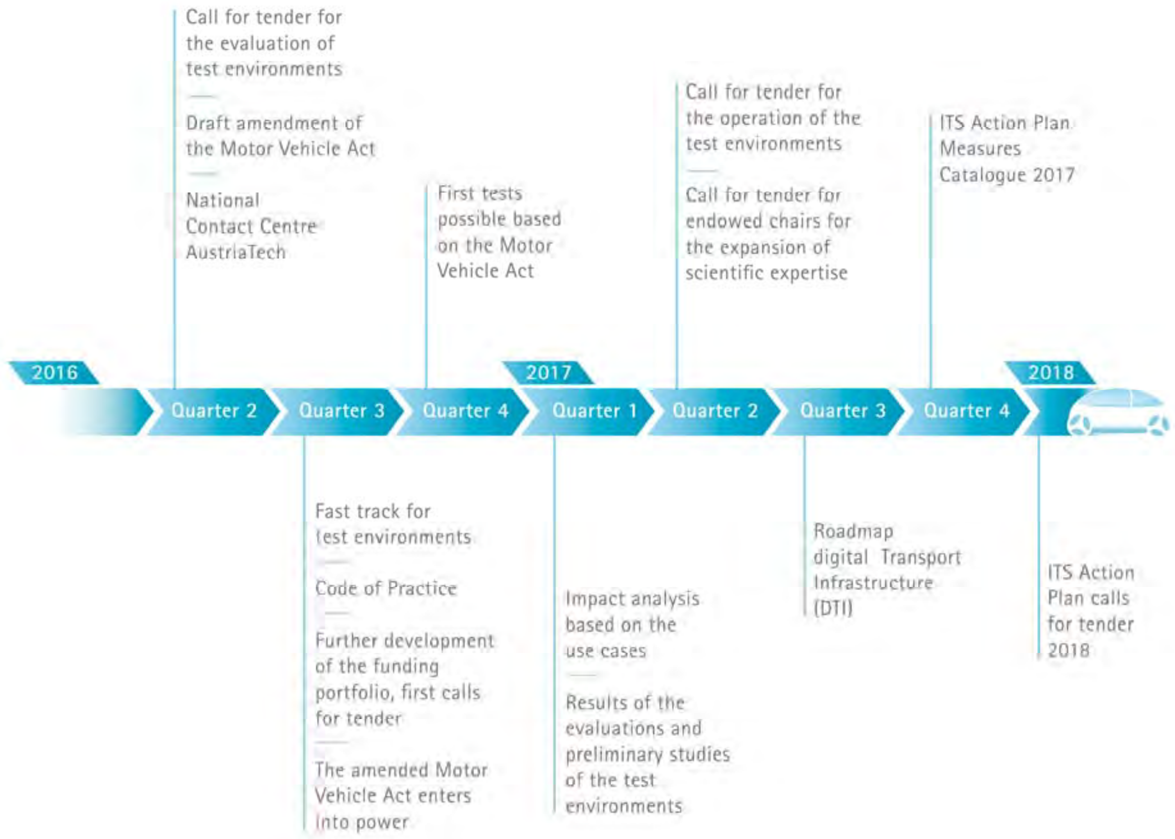
- Technological Development,
- Driver Behaviour,
- Acceptance of Road Transport Automatisation,
- Transport System-Level Impacts,
- Regulatory Issues.

Figure x - Evolutionary paths for road transport automation

http://www2.liikennevirasto.fi/julkaisut/pdf8/lts_2016-19eng_road_transport_web.pdf

Automated - Connected – Mobile, Austria , 2016

The goal of the action plan was to organise a process in Austria that involves all the perspectives and interests of all the stakeholders. The stakeholders include companies from the automotive and IT industry together with infrastructure operators as well as policy makers and management who are all working to network and automate transport, thus making mobility safer, cleaner and more efficient. The action plan will not only take short and medium term issues into consideration, but also long-term issues such as the impact on infrastructure and urban planning processes. In addition to road safety, which is the main focus of the action plan, issues concerning data security and cyber security must also be considered in an international context. For the anticipated potential for added value and opportunities for Austrian actors, the focus should go beyond pure product innovations in hardware and software and include organisational aspects and new service-based business models.



http://www.smart-mobility.at/fileadmin/media_data/services/Thematisches/Actionplan_automated_driving.pdf

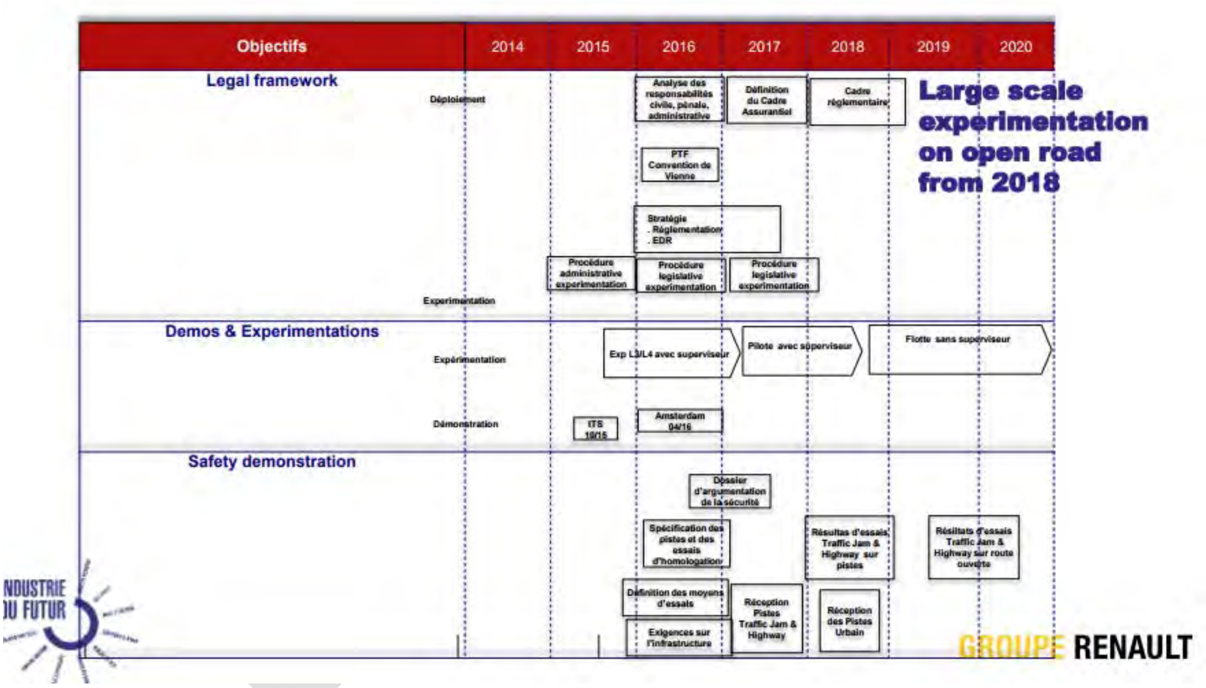
Objectifs de recherche Nouvelle France Industrielle Véhicule Autonome, 2015

Research subjects:

- In-vehicle intelligence
- Sensing and data fusion
- Decision making
- Positioning
- Connectivity
- Human factors and HMI
- Security

Deployment:

- New legal framework for AD experimentation
- 10 000 Kms available on open roads
- 15 experimentations
- 11 working groups on legal, technical regulation, homologation, technologies, safety & security
- > 30 projects (test bed, Advanced technologies, Safety)



http://www.pfa-auto.fr/wp-content/uploads/2016/03/Objectifs-de-recherche-Vehicule-Autonome.pdf

https://connectedautomateddriving.eu/wp-content/uploads/2017/02/FR-Presentation-Workshop-16.12.2016.pdf

Belgian procedure for testing of automated vehicles and how the code of practice contributes to safe testing, 2017

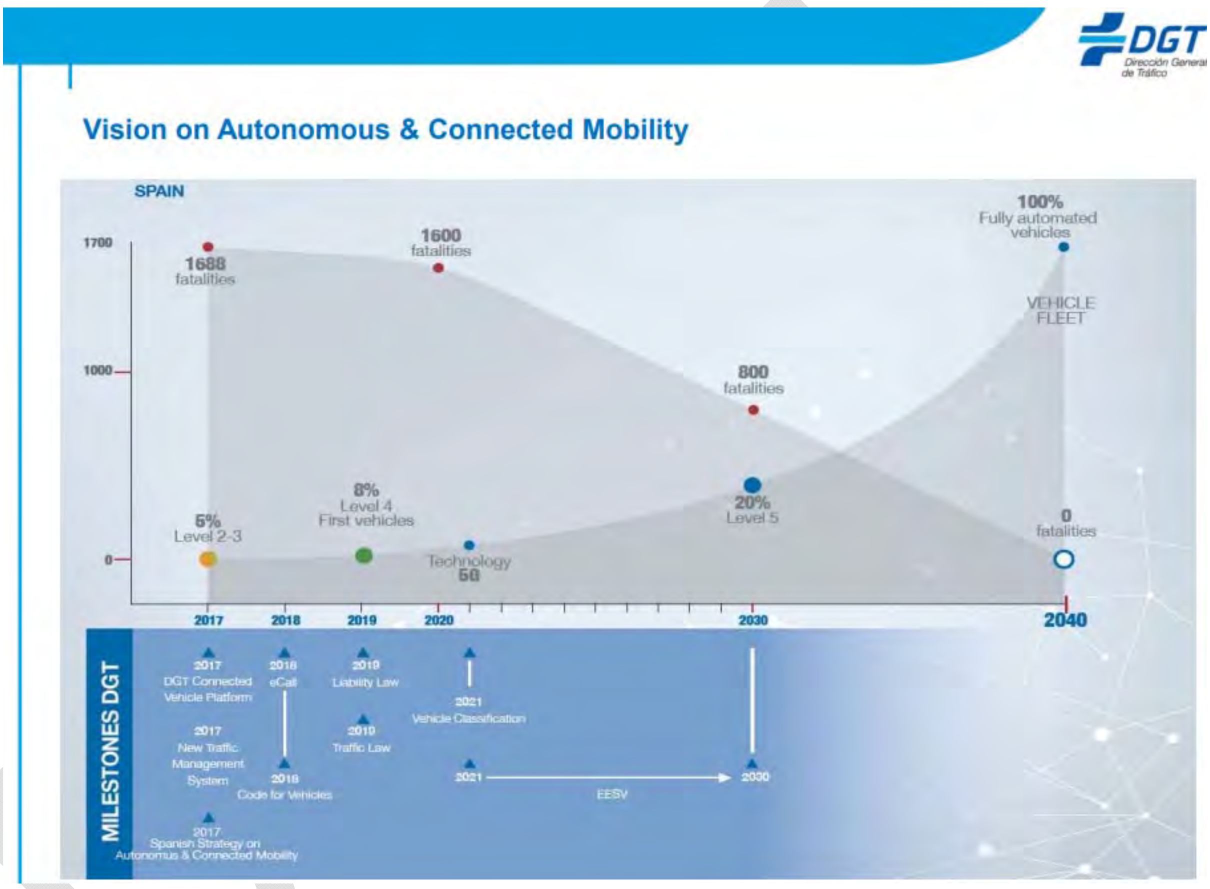
Highlights:

- Code of Practice approved by Council of Ministers on 15 September 2016
- All kinds of automated vehicles and all levels of automation
- Conditions and procedures for testing
- European Truck Platooning Challenge
- National Platoon test (2016)
- Autonomous Shuttle Brussels airport (on going)

https://www.unece.org/fileadmin/DAM/trans/doc/2017/wp1/ECE-TRANS-WP1-Automated-Vehicles-Presentation-12e.pdf

Spanish approach on autonomous driving, 2016

Highlights:

- Strategy on CAD - 2017
- Working Groups – legal frameworks:
    - Code for vehicles – 2018
    - Liability & Traffic law – 2019
    - Vehicle classification – 2021
- Promoting CAD real tests in Spain
- Cooperation with OEMs
- Support UNECE WP29
- 

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http://exeforum.biz/jornadas/smartmobility/dgt.pdf

https://connectedautomateddriving.eu/wp-content/uploads/2017/02/ES-Presentation-Workshop-16-12-16.pdf

On the road to automated mobility: an EU strategy for mobility of the future, 2018

Mobility is at a cross-roads. Mobility is at a new digital frontier with:

- increasing automation
- connectivity allowing vehicles to "talk" to each other, to the road infrastructure, and to other road users

The goal is to open up an entirely new level of cooperation between road users which could potentially bring enormous benefits for:

- road users
- the mobility system as a whole
- making transport safer, more accessible and sustainable.

Main goal: Making the EU stronger on technologies and infrastructure for automated mobility

- significant investments will be needed, up to 450 EUR available to suppport digitisation in transport in support to automation
- key technologies, services and infrastructure need to be developed and produces in Europe
- necessary regulatory framework needs to be in place
- EC will initiate work with Member States and stakeholders on a new approach for vehicle safety certification for automated vehicles

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0283&from=EN

Europe on the move, 2018

In his State of the Union address of September 2017, President **Juncker** set out a goal for the EU and its industries to become a world leader in innovation, digitisation and decarbonisation. Building on the previous *'Europe on the Move*' of May and November 2017, the Juncker Commission is today putting forward a third and final set of measures to make this a reality in the mobility sector. The objective is to allow all Europeans to benefit from safer traffic, less polluting vehicles and more advanced technological solutions, while supporting the competitiveness of the EU industry. To this end, today's initiatives include an integrated policy for the future of road safety with measures for vehicles and infrastructure safety; the first ever CO2 standards for heavy-duty vehicles; a strategic Action Plan for the development and manufacturing of batteries in Europe and a forward-looking strategy on connected and automated mobility. With this third 'Europe on the Move', the Commission is completing its ambitious agenda for the modernisation of mobility.

- Safe mobility
    - measures to increase road safety
    - long-term goal of moving close to zero fatalities and serious injuries by 2050 ("Vision Zero")
- Clean mobility
    - putting forward the first ever CO2 emissions standards for heavy-duty vehicles
    - design more aerodynamic trucks
    - labelling for tyres.
    - putting forward a comprehensive action plan for batteries that will help create a competitive and sustainable battery "ecosystem" in Europe.

https://ec.europa.eu/transport/modes/road/news/2018-05-17-europe-on-the-move-3_en

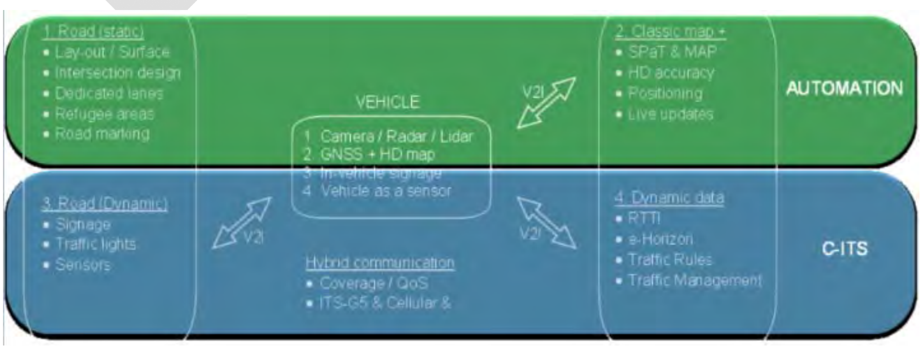
Cooperative ITS towards Cooperative, Connected and Automated Mobility – Phase II report, EC DG MOVE C-ITS platform, September 2017

WG Cooperative ITS and Automation in Urban Areas:

- Demonstrate how automation should be used to support integrated and sustainable urban mobility through optimal and sub-optimal use cases;
- Identify which tools and enablers can be used by urban stakeholders to influence the operation of automated vehicles and what they need to prepare for;
- Ensure the complementary of Urban C-ITS deployment and higher levels of automation

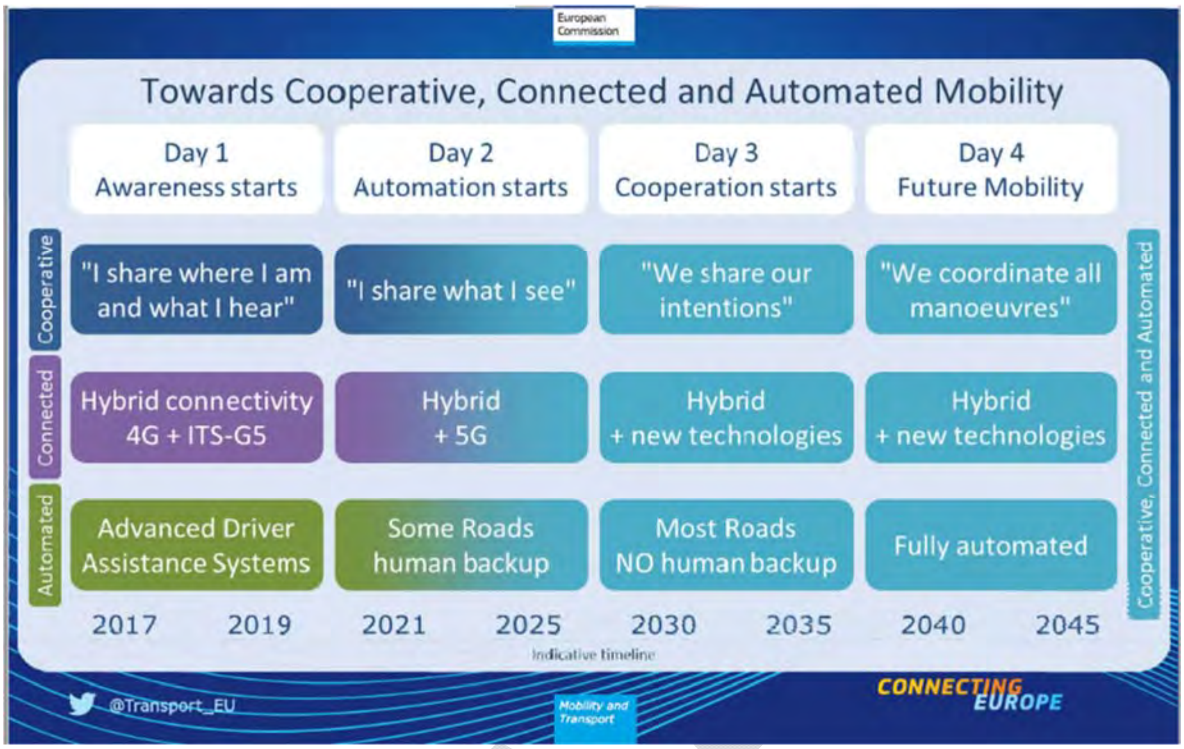
WG Physical and Digital Infrastructure:

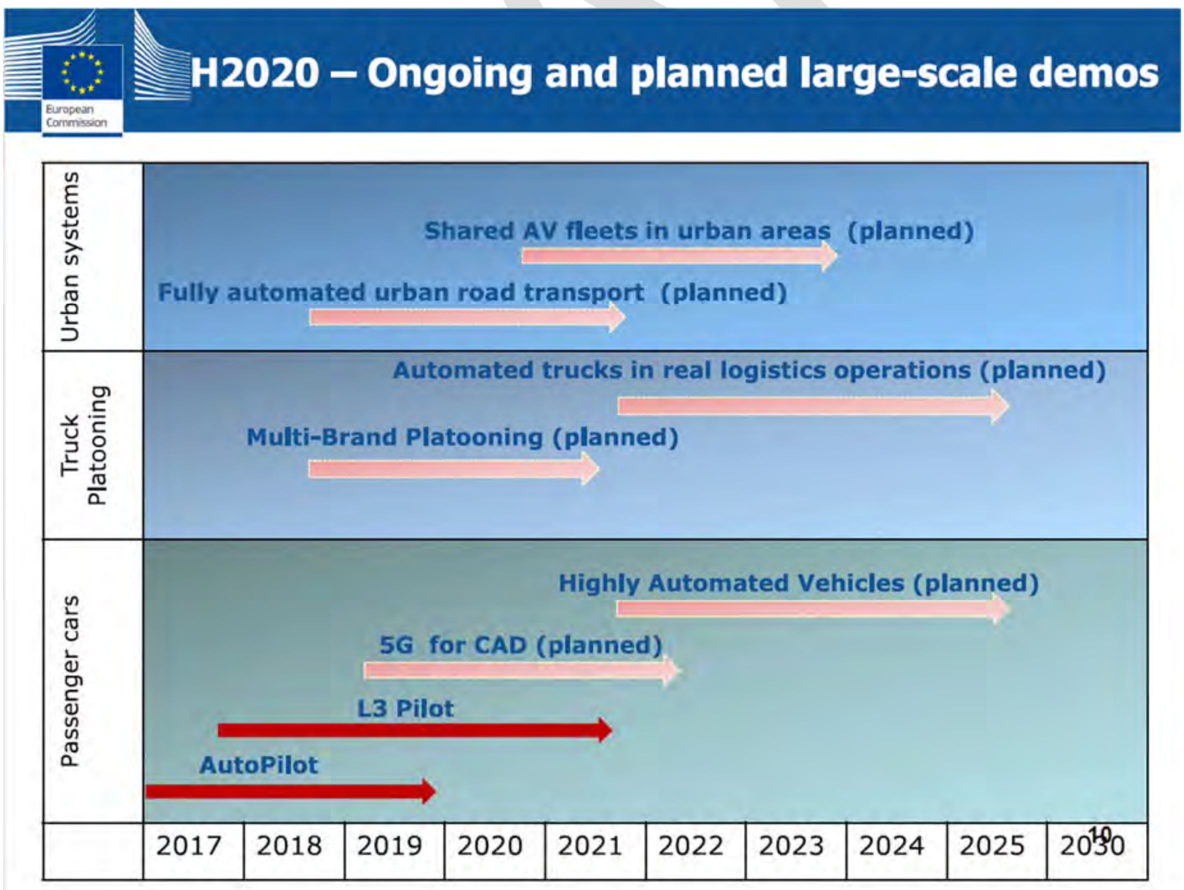
1) Physical and digital infrastructure support for automated mobility
    a. True level 5 may never happen, it also may not be needed
    b. Focus on level 4 islands where infrastructure investment makes sense to integrate automated vehicles in the mobility system
2) Roads for automation
    a. Identify key attributes of roads relevant for automated driving
    b. Standards in Management of Electronic Traffic Regulations
    c. Investigate the (regulatory) consequences of Quality of Service
3) Connectivity for automation
    a. Support from the infrastructure (particularly in the form of data) needs to be communicated
    b. Automated vehicles will (need to) be connected and cooperative hybrid approach from Phase I still fully valid
4) Connectivity for automation
    a. All automated road vehicles will need (lane) accurate positioning and improved GNSS alone will not be sufficient
    b. Cameras, radars and lidars will help the vehicle "see" and position itself but these systems need reference points for fast matching with sensory input
    c. Investigate how physical and digital infrastructure can contribute to redundancy and safety in accurate positioning
5) Handling complex situations
    a. Complexity from road lay-out and challenging intersections & cross-traffic (including VRU & other modes)
    b. C-ITS evolving from awareness (I share where I am) to perception data (I share what I see)
    c. We need standardised C-ITS messages for traffic regulations
    d. We need specific standards on the context and the interpretation boundaries
6) Consistency physical / Digital
    a. Physical infrastructure will increasingly be complemented by digital. To avoid confusing and potentially dangerous situations consistency is vital

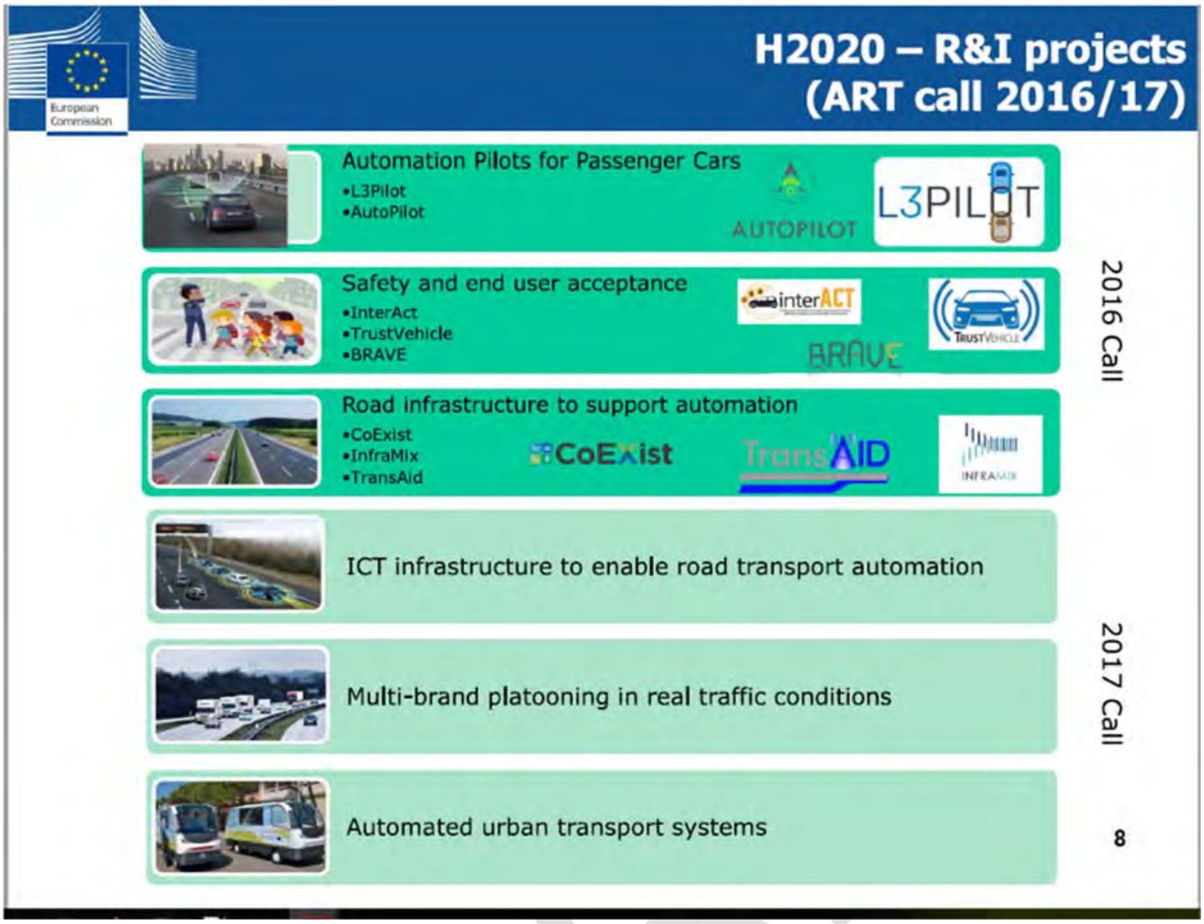


https://www.its-platform.eu/filedepot_download/1950/6112

H2020 – Ongoing and planned large-scale demos, 2017







https://www.dropbox.com/s/c95le6hj04q9hiu/ART%20Workshop_slide%209%20%26%2027%20%26%2029.pdf?dl=0

Speech Minister Van Nieuwenhuizen (IenW) at Intertraffic, 2018

Challenges:

- Mobility continues to grow.
- Our infrastructure is being stretched to the limit.
- The number of road traffic fatalities is on the rise again.
- And liveability and air quality are at stake.

Smart mobility gives us the chance to tackle these challenges effectively

Aspects relevant for road authorities

- ensure our infrastructure is ready for connected and automated driving
- enable the next generation of vehicles to actually take the road
- creating a legal framework for automated driving
- laying down requirements for reliability and safety that cars must meet before they can hit the road
- create room for new transport concepts and make sure people can use them easily

https://www.rijksoverheid.nl/documenten/toespraken/2018/03/26/speech-by-cora-van-nieuwenhuizen-minister-of-infrastructure-and-water-management-at-the-opening-of-intertraffic-amsterdam-20-march-2018

Research, Development & Innovation roadmap for AV, 2016

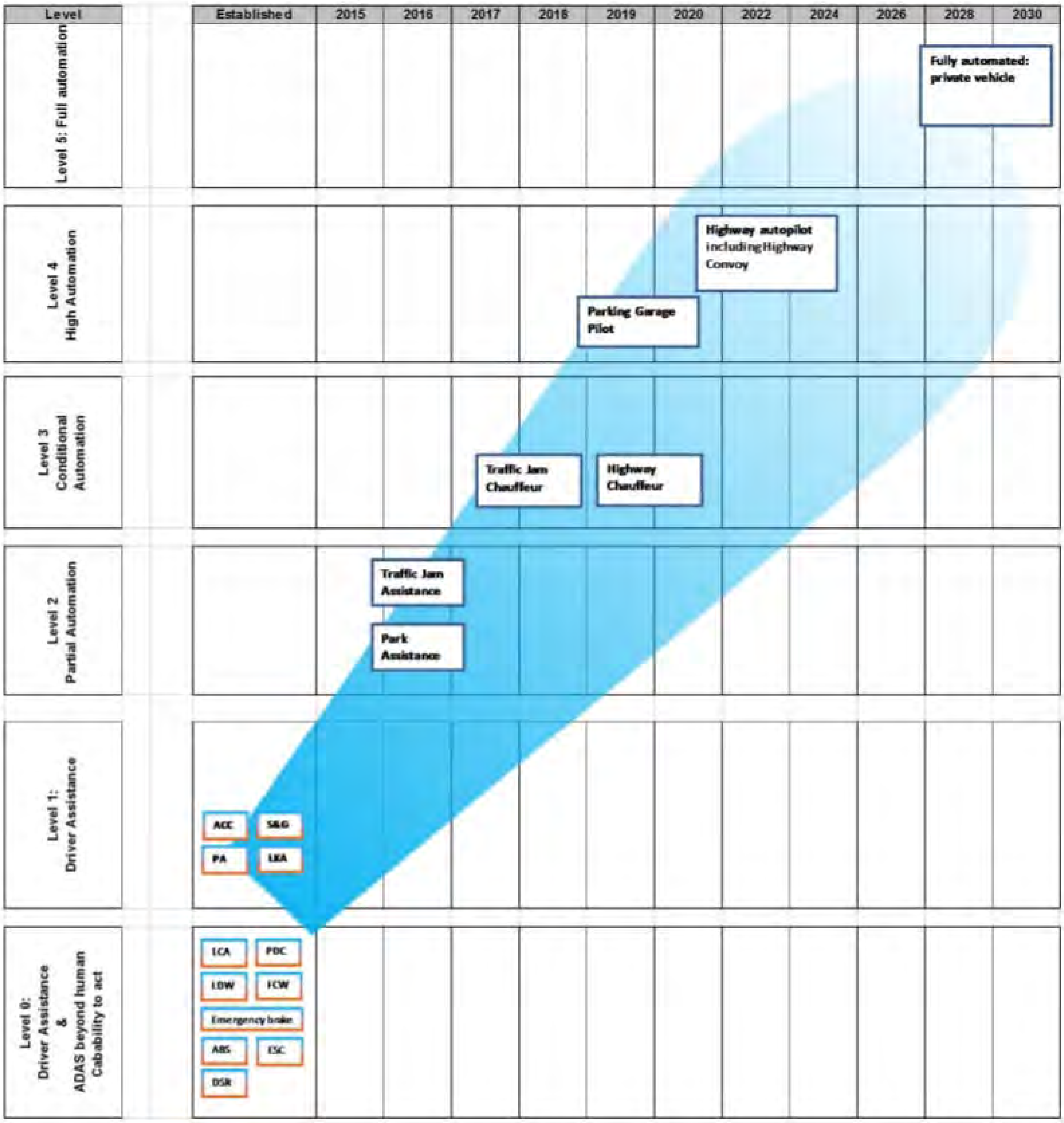
The present “Austrian RDI Roadmap for Automated Vehicles” is a technology roadmap driven by Austrian industry with support from the Austrian research community, and reflects the view of the main Austrian players in ICT and mobility. It covers Technology Readiness Levels (TRLs) from 1-8 and a time span of about 15 years and beyond. The aim of this roadmap is not to “re-invent” existing European and national roadmaps, but rather to align with them and to identify specific areas and focusses and related research, development and innovation (RDI) needs and topics for the Austrian automated vehicles community.

It is an initiative of ECSEL Europe, supported by bmvit, ITS Austria, ECSELAustria, A3PS, AustriaTech, ASFiNAG, ÖBB, FFG, Austrian industry, and Austrian research & academia

- Wide range of areas, including aerospace, railways and waterways
- Five main task fields of activities (TF) have been identified as highly relevant for Austrian industry and thus constitute the backbone of the Austrian RDI Roadmap “Automated Vehicles”:
    - TF_1 System architecture,
    - TF_2 Hardware, Sensors, Actuators, Connectivity,
    - TF_3 Embedded SW & Cyber-Physical Systems,
    - TF_4 Integration, V&V, and Field Tests, and
    - TF_5 ADAS Applications.

		National			European			
	Sub-task field (RDI topics)	ICT	Mobility	Austrian flagship programme AD	ICT (Information & Communication Technologies)	ART (Automated Road Transport)	IoT (Internet of Things)	ECSEL
TF_1: System architecture, Tools & Methods	Architectures	x	x		x			x
	Tools and methods	x	x	x	x			x
	Dependability, safety and security	x	x		x	x	x	x
TF 2: Hardware, Sensors, Actuators, Connectivity	Hardware platform for automated vehicles	x					x	x
	Sensors & perception	x	x					x
	V2x Connectivity	x	x	x		x	x	x
	Stimuli	x				x	x	x
	Traffic management HW platform	x	x			x		UC
	Environmental design	x	x			x		
TF 3: (Embedded) SW & Cyber-Physical Systems	Traffic management SW platform	x	x		x	x		x
	Embedded SW, Sensor data fusion	x			x	x	x	x
	Environmental awareness, Control	x	x		x	x		x
	HMI and user acceptenance	x	x			x	x	UC
	Virtual environment, perception, driving strategy, path planning	x	x		x	x		UC
TF 4: Integration, V&V	Test scenarios, Verification & Validation, Virtual testing	x	x			x	x	x
	Security and Cost-Benefit Analysis	x	x					UC
TF 5: Applications & Field tests	Automotive domain - prototype of connected vehicle(s)			UC		x	x	x
	Automotive domain - prototype of automated vehicle(s)			UC		UC	x	UC
	Off-road vehicle domain			UC			x	UC
	Aerospace domain			UC				UC
	Rail domain			UC				UC
	Waterway domain			UC				UC

UC = Use Case / Demonstrators



https://www.ffg.at/sites/default/files/downloads/call/austrian_roadmap_automated_vehicles.pdf

Gear 2030 Discussion Paper

Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs

Preliminary review of the EU legislation

- I -LARGE SCALE TESTING OF HIGHLY AUTOMATED VEHICLES
- II- UPCOMING INCREASINGLY AUTOMATED VEHICLES
  - Road safety, traffic rules, driver behaviour and other users, driving licence
  - Insurance, liability and defects
  - Vehicle approval legislation, vehicle roadworthiness and maintenance
  - Connected vehicles, data protection and security
  - Infrastructure requirements
    - This could include e.g. minimum standards for road signs and markings, digital mapping of speed limits, digital infrastructure for connectivity, common agreement for readability of temporary structures e.g. around road works, etc.

This is the purpose of the GEAR 2030 roadmap. This roadmap should cover:

- A shared vision of increasingly automated vehicles which should come step by step focusing first on very well defined and safe traffic conditions, e.g. automated driving on motorways with no crossroads, and including connectivity aspects as appropriate along the way (See Annex 1). The shared vision should also address issues of societal acceptance early on, in an inclusive process.
- A list of actions covering:1) the review of the existing legal and policy framework for highly automated and connected driving 2) Coordinated research, innovation, large scale tests and other financing tools 3) international co-operation action and competitiveness.

The different issues on automated and connected vehicles mean that we will need to work closely with other DGs (mainly DG CONECT, DG GROW, DG FISMA, DG JUST, DG MOVE, DG RTD or) in a coherent manner at EU level.

https://circabc.europa.eu/sd/a/a68ddba0-996e-4795-b207-8da58b4ca83e/Discussion%20Paper%C2%A0-%20Roadmap%20on%20Highly%20Automated%20Vehicles%2008-01-2016.pdf

High Level Group GEAR 2030 Final report 2017

The report offers recommendations on how the automotive industry can anticipate and adapt to current trends - thereby turning short to medium-term threats into long-term opportunities. The HLG consists of public and private sector representatives.

For connected and automated driving (CAD), the report encourages large-scale research and financing programmes at EU and national levels, while supporting further policy and regulatory actions to create a real EU internal market as well as a real EU governance to ensure a coordinated approach. It also recommends that CAD's potential impact – especially on jobs and ethical issues – be assessed, discussed and accounted for in broader EU policies.

The report presents 5 areas for the European automotive sector to address and makes a number of recommendations:

- new technologies and business models – requiring high investment
- climate and health concerns – such as the need to reduce greenhouse gas emissions
- societal changes – changes in consumer behaviour with regard to cars
- globalisation – remaining competitive and responding to international demand, as well as ensuring fair access to international markets
- structural change – the impact on the workforce as the industry moves towards automated driving and low and zero emission vehicles

More specifically on automated and connected vehicles

- Development of large scale open road testing and trials by EC and MS
- Only one EU-wide focal point for exchange lessons learnt.
- data storage requirements in the type-approval legislation to clarify liability
- Traffic rules system and reporting to support converging approaches across the EU.
- EU type-approval framework for the certification of automated vehicles, including alternative assessment methods and identification of work priorities at the UNECE, EU and Member State levels.
- EU legal instruments such as the driving licence directive, professional driving directive, the directive on roadworthiness testing
- agree on Regulatory approaches that foster the investments
- ITS Directive and its delegated Regulations.
- Inclusion of societal challenges and social acceptance considerations in broader European visions and strategies on automated and connected vehicles,
- Better co-ordination of national and multinational funding programmes require EU financing;

https://ec.europa.eu/docsroom/documents/26081

http://ec.europa.eu/growth/content/high-level-group-gear-2030-report-on-automotive-competitiveness-and-sustainability_en

Automated vehicles, Canada, 2015

"The coming of the next disruptive technology", The conference board of Canada

Highlights:

- Status of Automated Vehicles and Trends
- The Impact of AVs on Canada's Economy
- The Impact of AVs on Infrastructure
- The Automated Vehicle's Impact on Our Wallets
- Five potential priorities for Canada:
    - Augment political leadership at the federal level, comparable with what we see in other countries, especially for the impact on vehicle standards, the technology sector, the auto industry, and the economy.
    - Enhance political leadership at the provincial and territorial level for transportation systems and regulations.
    - Boost leadership at the municipal level to incorporate the impact of AVs into urban planning, transit, and the design of infrastructure projects.
    - Measure the potential impact of AVs on Canadian businesses.
    - Encourage the creation of a Canadian ecosystem to compete for a share of the global market for AV software, parts, and components
- The cumulative potential benefits from the factors described above are $65 billion per year
- In total, the estimated cost savings are nearly $3,000 per household

http://www.cavcoe.com/articles/AV_rpt_2015-01.pdf

The Roadmap for Autonomous (Self-Driving) Vehicles in Ontario, Canada, July 2015

Highlights

- An ecosystem (of “hubs”) for success
- Being careful with personal data
- Integrating with the education sector
- Laws and regulations

https://www.ogra.org/.../Roadmap%20for%20AVs%20in%20Onta

National Policy Framework for Land Transport Technology, Australia, 2016

Action Item	Timing
Establish a regulatory framework for testing automated vehicles	Late 2017
Develop national operational guidelines to support the on-road use of automated vehicles	Late 2017
Undertake priority trials and research of Intelligent Transport Systems	2016-2019
Develop a connected vehicle (Cooperative ITS) infrastructure road map	Mid 2017
Publish a connected vehicle (Cooperative ITS) statement of intent on standards and deployment models	Early 2017
Develop a nationally agreed deployment plan for the security management of connected and automated vehicles	Mid 2018
Investigate options to provide enhanced geo-positioning information to the land transport sector	Late 2017
Improve the availability of open data in the transport sector	2016-19
Explore options to increase the uptake of telematics and other technologies for regulatory and revenue collection purposes	Mid 2017
Evaluate low–cost technologies to improve safety at rail level crossings	Late 2017
Explore how data from telematics and other intelligent transport systems can be used to optimise operations and planning for port precincts and intermodal terminals	Mid 2017
Investigate options for interoperable public transport ticketing	Late 2017
Investigate the costs, benefits, and possible deployment models for Automatic Crash Notification	Mid 2017
Explore the merits of adopting new safety and traffic management technologies	2016-19

Table x National Transport Technology Action Plan

http://transportinfrastructurecouncil.gov.au/publications/files/National_Policy_Framework_for_Land_Transport_Technology.pdf

Automated Vehicles: Are we ready? – Australia, January 2015

Internal report on potential implications for Main Roads WA.

- Emerging issues with Automated Vehicles
    - Electronic control system safety
    - Human factors
    - Liability and insurance
    - Legislation
    - Privacy
    - Cybersecurity (vulnerability to hacking)
    - Public acceptance

Timescale	Potential Implementation
Now - 2025	• Increasing automation of driving functions, even on affordable cars • Vehicles park themselves • Vehicle to vehicle communication • Vehicles drive themselves in traffic jams or highways (adaptive cruise control) • Early adopter entrepreneurs start to hire out AVs • Taxi industry disruption • Standardisation of communication and technology protocols
2025 - 2035	• Car ownership declines - car sharing increases. Demand for parking starts to decline • Bus service disruption - segregated or guided busways become fully driverless, bringing costs down • Logistics industry disruption • Vehicle to vehicle and vehicle to infrastructure communication technology matures • Accidents/collisions significantly reduce
2035 - 2045	• Vehicle size/weight/emissions reduce. New vehicle platforms • Catalyst for alternative mass produced propulsion systems - electric • Catalyst for fiscal incentives (road charging, pay as you go) • Urban road-space optimisation - narrower lanes, tighter intersections etc • Reduced need for urban parking - re-inventing/relocating car parks, on-street parking space reclaimed for other road uses (walking, cycling, market stalls) • Vehicles on demand - no reduction in availability or quality of services
2045 onwards	• Maturing technology, convergence and standardisation. Artificial intelligence in vehicles 'learns to read' the road • Eradication of congestion on highways • Elimination of accidents/collisions • Significant reduction in urban congestion • Ubiquitous autonomous door-to-door travel • Increased urban sprawl

Figure 5.3 Potential 30-year implementation scenario for AVs (adapted from Jacobs, 2013a)

-
    - Vehicle positioning accuracy

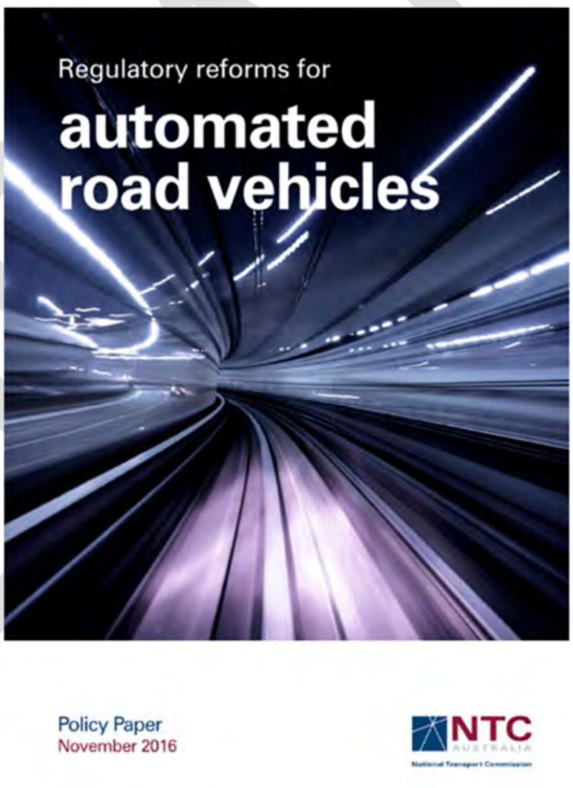
https://www.mainroads.wa.gov.au/.../Automated%20Vehicle%20R...

Regulatory reforms for automated road vehicles, Australia, November 2016

Recommendations approved by the Transport and Infrastructure Council. This policy paper sets out transport and infrastructure recommendations for policy and regulatory reforms to support automated road vehicles in Australia.

Roadmap: near-term reforms (2017-2018):

- Government support of on-road trials of automated vehicles for all levels of automated driving
- Certainty for industry and governments as to:
    - (1) who is in control of an automated vehicle
    - (2) how enforcement agencies will apply the ‘proper control’ requirement in the road rules to all levels of driving automation
- A complete regulatory framework to support the safe commercial operation of automated vehicles
- A complete regulatory framework to support the safe operation of automated vehicles
- Regulation of government access to automated vehicle data to achieve road safety and network efficiency outcomes, efficient enforcement of traffic laws and sufficient privacy protections for users

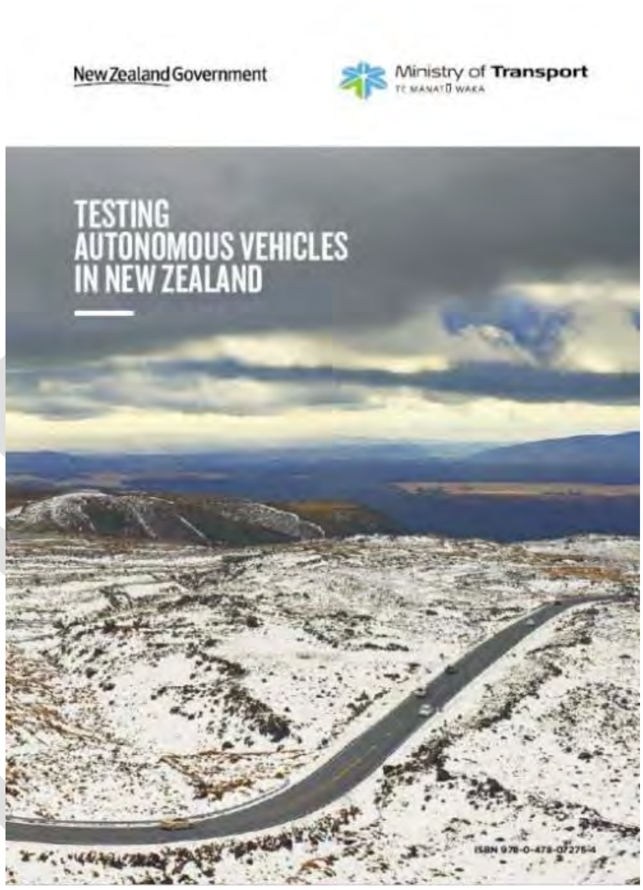


http://www.ntc.gov.au/Media/Reports/(32685218-7895-0E7C-ECF6-551177684E27).pdf

Testing autonomous vehicles in New Zealand, November 2016

Invitation for testing in New Zealand. Potentially, testing can take place on any part of the road network. Highlights:

- General obligations for anyone wanting to test autonomous vehicles
- Insurance
- Testing and safety management plans
- Engagement
- Test vehicles
- Test vehicle operators
- Control of software and data security



http://www.transport.govt.nz/ourwork/technology/specific-transport-technologies/road-vehicle/autonomous-vehicles/testing-autonomous-vehicles-in-nz/

ITS Strategic Plan, Department of Transportation, United States, December 2014

- Strategic Priorities and Themes
    - Enable Safer Vehicles and Roadways
    - Enhance Mobility
    - Limit Environmental Impacts
    - Promote Innovation
    - Support Transportation System Information Sharing
- Automation program goals
    - Define the core elements and the performance criteria for automation (*Research*)
    - Test automation components in the CV Pilots, as well as in other test situations as available (*Development*)
    - Define the Federal role in facilitating and encouraging deployment of automated systems (*Adoption*)

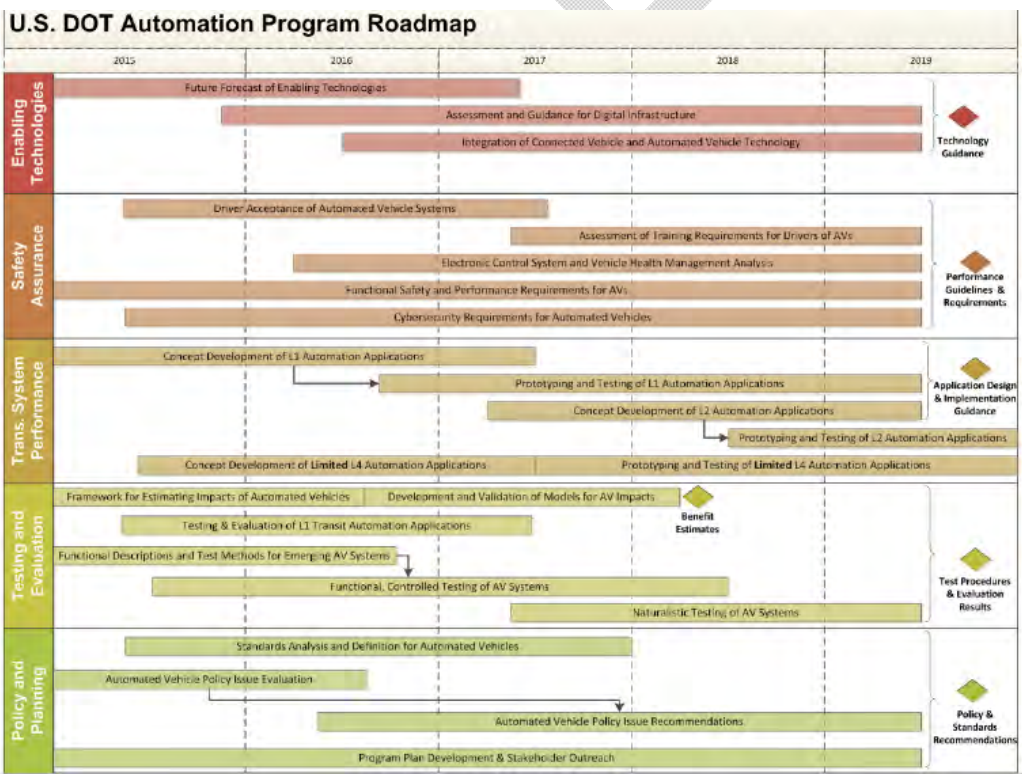


Fig x – U.S DOT Automation Program Roadmap

http://www.its.dot.gov/strategicplan.pdf

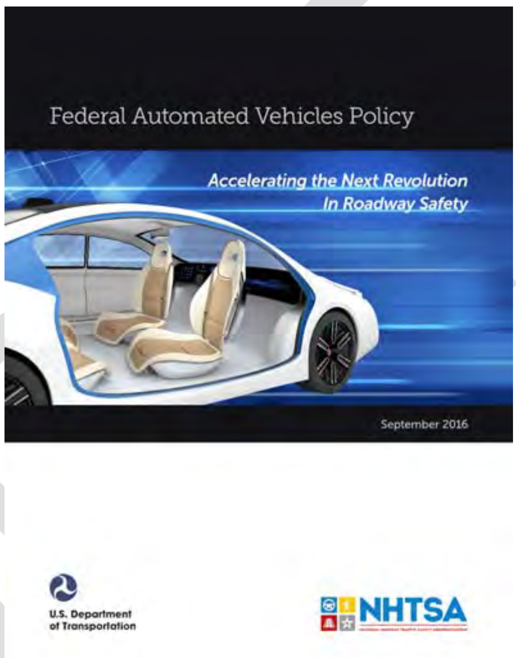
Federal Automated Vehicles Policy, Department of Transportation (DOT), United States - National Highway Traffic Safety Administration (NHTSA), September 2016

As the Department charged with protecting the traveling public, we recognize three realities that necessitate this guidance:

- First, the rise of new technology is inevitable.
- Second, we will achieve more significant safety improvements by establishing an approach that translates our knowledge and aspirations into early guidance.
- Third, as this area evolves, the “unknowns” of today will become “knowns” tomorrow. We do not intend to write the final word on highly automated vehicles here. Rather, we intend to establish a foundation and a framework upon which future Agency action will occur.

Tasks of facilitating the safe introduction and deployment of HAVs:

- Vehicle Performance Guidance for Automated Vehicles
- Model State Policy
- NHTSA’s Current Regulatory Tools
- New Tools and Authorities



http://www.nhtsa.gov/nhtsa/av/pdf/Federal_Automated_Vehicles_Policy.pdf

Automated Driving Systems 2.0, Department of Transportation (DOT), United States - National Highway Traffic Safety Administration (NHTSA), September 2017

Updated policy framework for the safe deployment of automated vehicles:

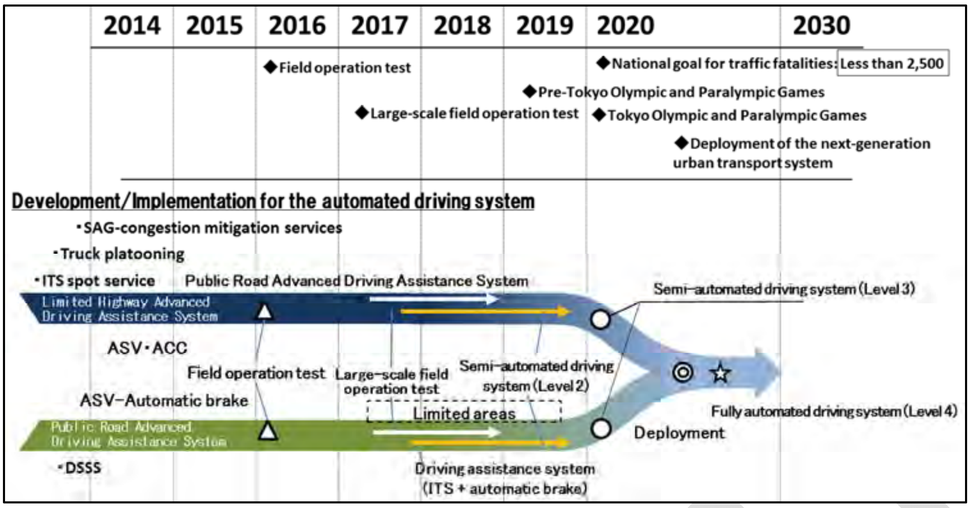
- Encouraging new entrants and ideas that deliver safer vehicles;
- Making Department regulatory processes more nimble to help match the pace of private sector innovation; and
- Supporting industry innovation and encouraging open communication with the public and with stakeholders.

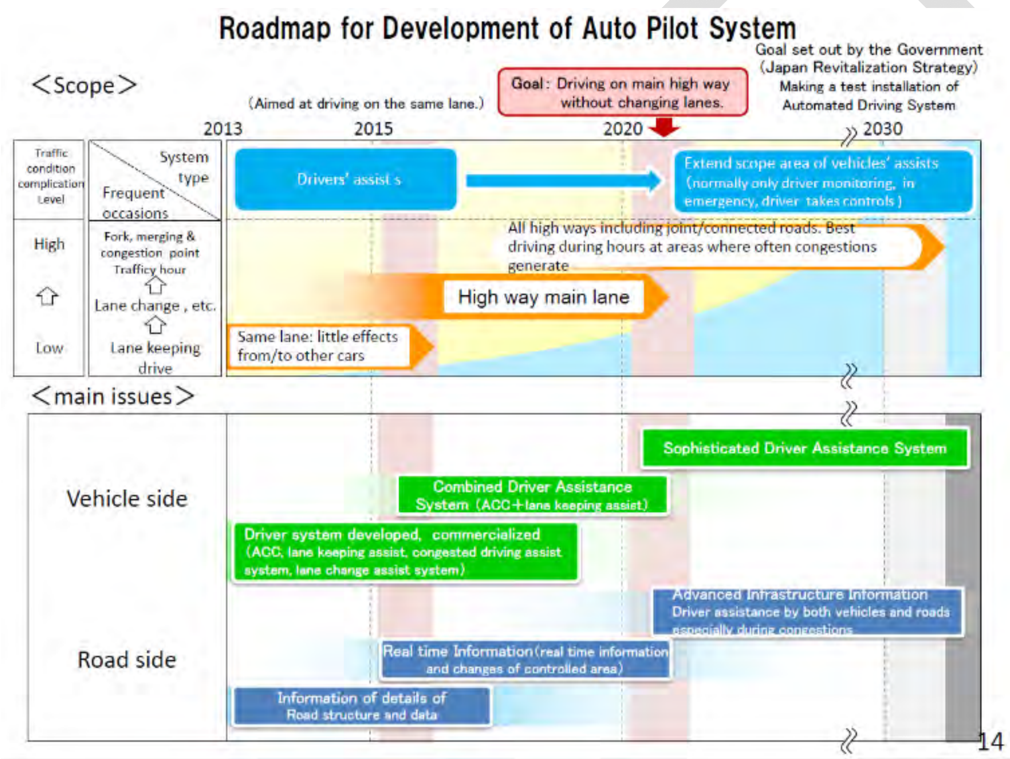
Nonregulatory approach /voluntary guidance to automated vehicle technology safety:

- Focuses on SAE International Levels of Automation 3-5 – Automated Driving Systems (ADSs) – Conditional, High, and Full Automation);
- Clarifies the guidance process and that entities do not need to wait to test or deploy their ADSs;
- Revises unnecessary design elements from the safety self-assessment;
- Aligns Federal Guidance with the latest developments and industry terminology;
- Clarifies Federal and State roles going forward.

https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf

Automated Driving Systems Activities, Cross-Ministerial Strategic Innovation Promotion Program (SIP), Japan , October 2016



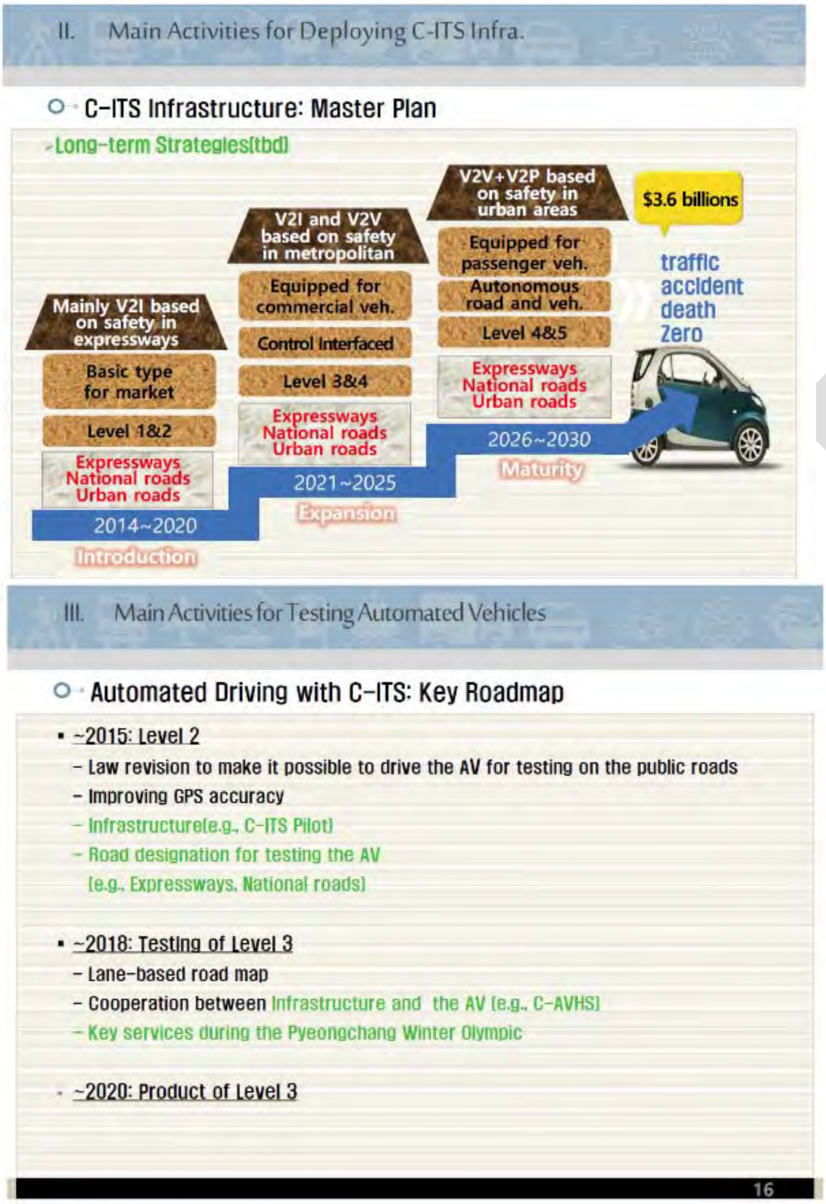


https://www2.unece.org/wiki/download/attachments/17760916/03_Japan%E2%80%99s%20views%20on%20Automated%20Driving%20rev.pdf?api=v2

http://en.sip-adus.jp/sip/file/sip_en_2016_achievement.pdf

https://drive.google.com/drive/folders/0BzVsv7r9vCuRRTRlQWhtalJxUms?usp=sharing

Automated Driving Development in Korea, The Korea Transport Institute, October 2015



https://drive.google.com/drive/folders/0BzVsv7r9vCuRRTRlQWhtalJxUms?usp=sharing

NC Readiness for connected and autonomous vehicles (CAV), 2016

Project goals:

- Identify the wide range of questions raised by CAV technology
- Define an approach, or Activities Roadmap, for how NC should prepare for CAV technology

Figure 1. Opportunities and Impacts of CAV Technologies

Kimley»Horn

Table 3. Activities Roadmap Summary

	Working Group	Activity Owner	Schedule	Budget
A. Group Structure and Organization				
A-1: Develop CAV Oversight Structure		NCDOT	<1 month	Internal
A-2: Identify CAV Program Manager		ELT	< 2 months	Internal
A-3: Develop Business Plan		ELT, CAV PM	< 4 months	Internal
B. Political Leadership Engagement				
B-1: Present Activities Roadmap to Leadership (including political groups)		CAV PM	3 months from Activities Roadmap Approval	Internal
B-2: Present Findings and Updates to Leadership (including political groups)		CAV PM	Biannual	Internal
B-3: Present Findings and Updates to Major Business and Industry Associations		CAV PM	Biannual	Internal
C. Changes to Laws and Motor Vehicle Code				
C-1: Modifications to Laws and MVC for AV Testing		NCDMV	1 year	Internal
C-2: Modifications to Laws and MVC for AV Operations		NCDMV	2 years	Internal
C-3: Engage AAMVA/NHTSA AV Model Policy Group		NCDMV	1 year	Internal
C-4: Conduct an Insurance Expo Workshop		NCDOI	< 6 months	$50K
C-5: Define Advanced Driver Education Programs		NCDMV	1 year	Internal
D. Long-Range Transportation Plans				
D-1: Monitor and Participate in LRTP Research		NCDOT TPB	1 year	$100K
D-2: Review and Revise NCDOT 2040 Plan		NCDOT TPB	< 6 months	$100K (review); $300K (revision)
D-3: Develop Guidance for MPOs' 2040 Plans		NCDOT TPB	< 6 months after NCDOT 2040 Plan	$200K

NC CAV Activities Roadmap Executive Summary 6
November 2016

Kimley»Horn

	Working Group	Activity Owner	Schedule	Budget
E. Mobility and Access Improvements				
E-1: Modify Laws and Regulations regarding Holistic Transportation Services		NCDOT with NCHHS	2 years after AV testing legislation	Internal effort
E-2: Conduct Workshop Focused on Opportunities for Disabled Traveler Services		Disadvantaged Sub-Committee Chair	< 1 year	$50K
E-3: Develop Partnerships with Department of VA, Hospitals, Advocacy Groups, and Transit/Paratransit Operators for Funding		Disadvantaged Sub-Committee Chair	< 6 months (sub-committee); < 1 year (grants apps)	$100K ($10K per grant app)
F. Pilot Projects and Research				
F-1: Conduct Workshop on Potential Opportunities		CAV PM	< 6 months	$25K
F-2: Join CV Pooled Fund Study		CAV PM	< 6 months	$50K per year
F-3: Develop Statewide Consortium for CAV Research		CAV PM, Business Working Group Chair	TBD (> 1 year)	TBD
F-4: Engage NASCAR		CAV PM	TBD (> 2 years)	$15M+
G. Outreach/In-Reach Strategy				
G-1: Develop an Outreach/In-Reach Strategy		CAV PM	< 6 months from start of regulatory actions	$100K
G-2: Conduct Webinars for Activities Roadmap Intro		CAV PM	< 6 months from initiation	$25K
G-3: NCAV.org for the Public		CAV PM	< 6 months from initiation	$25K
G-4: NCAV.org Content Expansion		CAV PM	< 6 months from initiation	$50K
G-5: Participation in National Organizations and Conferences		CAV PM	Ongoing	$15K
G-6: Highlight the Ability of Toll Roads to Leverage CV Technology		CAV PM	Within 1 year	Internal effort

NC CAV Activities Roadmap Executive Summary 7
November 2016

http://www.ncav.org/wp-content/uploads/2016/03/NC-Roadmap-for-AV-Final_ES_FINAL.pdf

Connected/Automated Vehicle Research Roadmap for AASHTO, 2015

- American Association of State Highway and Transportation Officials, United States
- National Cooperative Highway Research Program (NCHRP), United States
- NCHRP 20-102 [Active]

LISTING OF TASKS

20-102(01) Policy and Planning Actions to Internalize Societal Impacts of CV and AV Systems into Market Decisions

20-102(02) Impacts of Regulations and Policies on CV and AV Technology Introduction in Transit Operations

20-102(03) Challenges to CV and AV Application in Truck Freight Operations

20-102(05) Strategic Communications Plan for NCHRP Project 20-102

20-102(06) Road Markings for Machine Vision

20-102(07) Implications of Automation for Motor Vehicle Codes

20-102(08) Dedicating Lanes for Priority or Exclusive Use by CVs and AVs

20-102(09) Providing Support to the Introduction of CV/AV Impacts into Regional Transportation Planning and Modeling Tools

20-102(10) Cybersecurity Implications of CV/AV Technologies on State and Local Transportation Agencies

20-102(11) Summary of Existing Studies on the Effects of CV/AV on Travel Demand

20-102(12) Business Models to Facilitate Deployment of CV Infrastructure to Support AV Operations

20-102(13) Planning Data Needs and Collection Techniques for CV/AV Applications

20-102(14) Data Management Strategies for CV/AV Applications for Operations

To create a link to this page, use this URL: http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3824

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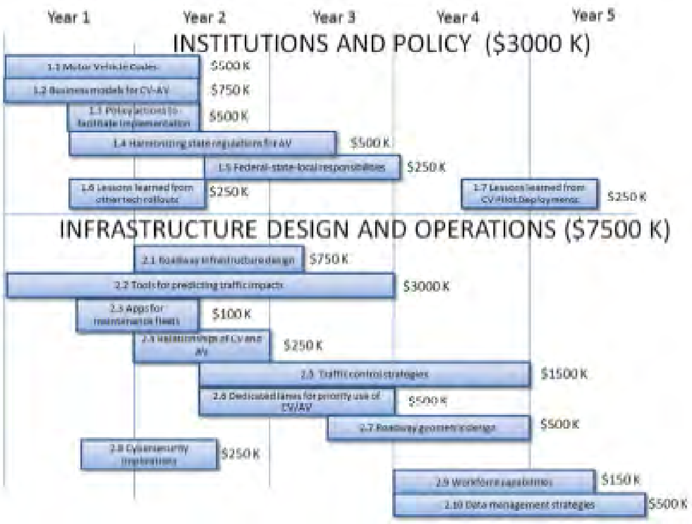
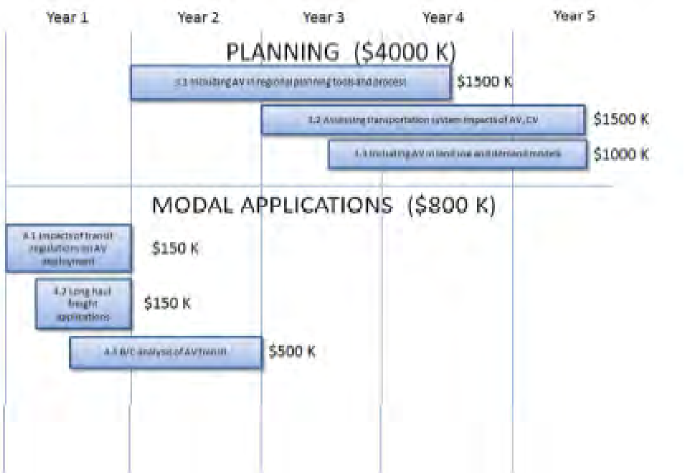
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(98)_RoadmapTopics_Final.pdf

Connected/Automated Vehicle Research Roadmap for AASHTO, NCHRP - US

This project is assessing those open issues and developing a roadmap of future research projects and efforts that AASHTO, U.S. DOT and related groups should pursue. There are four tasks in the project. First, the research team compiled a catalog of institutional, legal, policy, and operational issues related to CV/AV technologies that will affect agencies and the public. The catalog was narrowed to critical issues designated for near term research by consolidated rankings by the panel. These highest-ranked issues were consolidated into projects, with description of goals, scope, anticipated outcomes, budget, schedule, and linkages to associated research and efforts undertaken by others. A procedure for maintaining and updating the roadmap will be developed following consensus on the content of the projects. Finally, the project will be summarized in PowerPoint slides (executive summary and long-form) that can be used by AASHTO and member agencies in disseminating the information to decision-makers, partners and stakeholders.





http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP20-24(98)_RoadmapTopics_Final.pdf

Automated Driving Roadmap, ERTRAC, May 2017

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

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

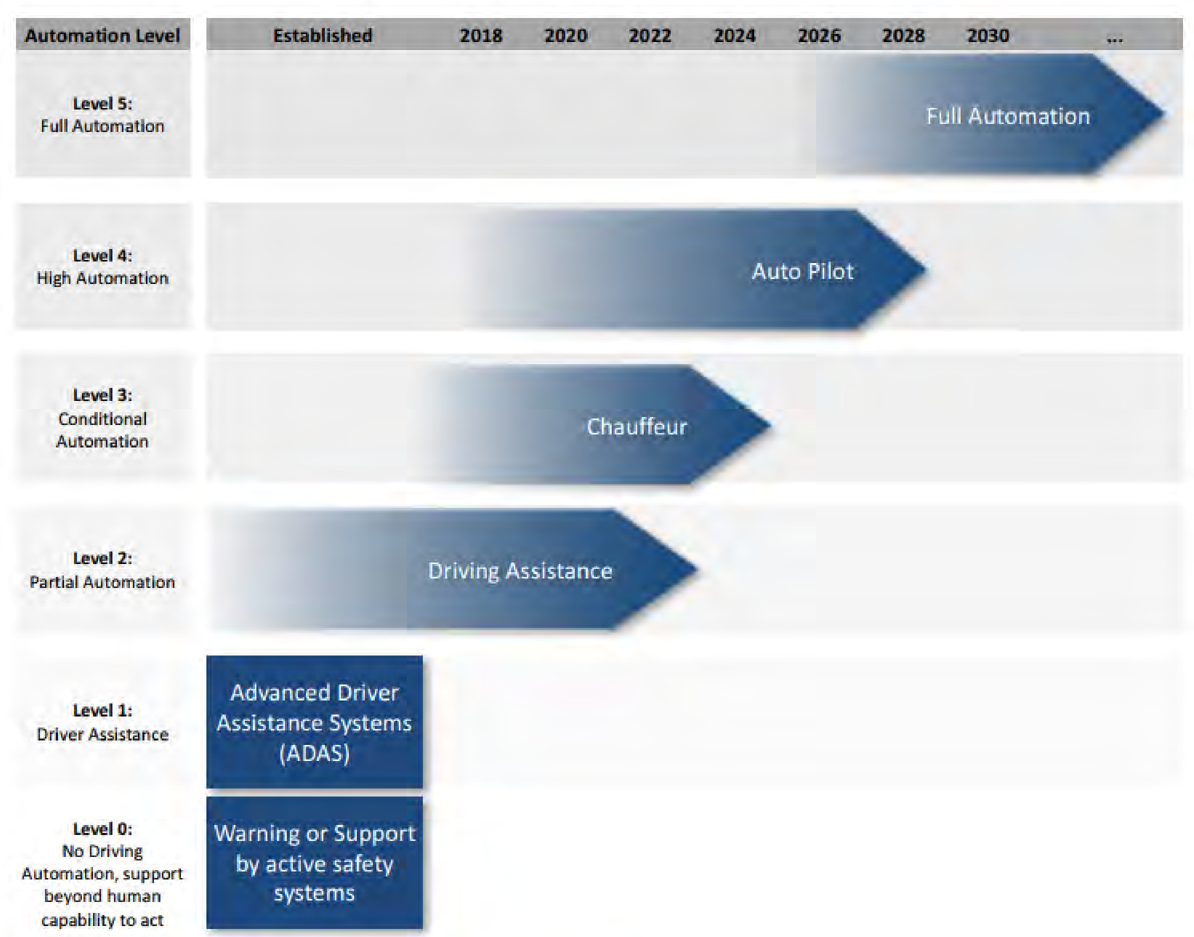


Figure 2: The vehicle automation development paths

http://www.ertrac.org/uploads/images/ERTRAC_Automated_Driving_2017.pdf

European Roadmap Smart Systems for Driving, EPoSS, April 2015

This roadmap is based on surveys and consultations among major European automotive manufacturers and suppliers. Starting from an analysis of goals and challenges towards the introduction of automated driving (AD) and a description of the state-of-the-art technologies, technology roadmaps that provide information about content and timescales of actions in Research and Innovation (R&I) on technology and in framework conditions, are presented. These roadmaps are organized along milestones for implementation of highly automated driving

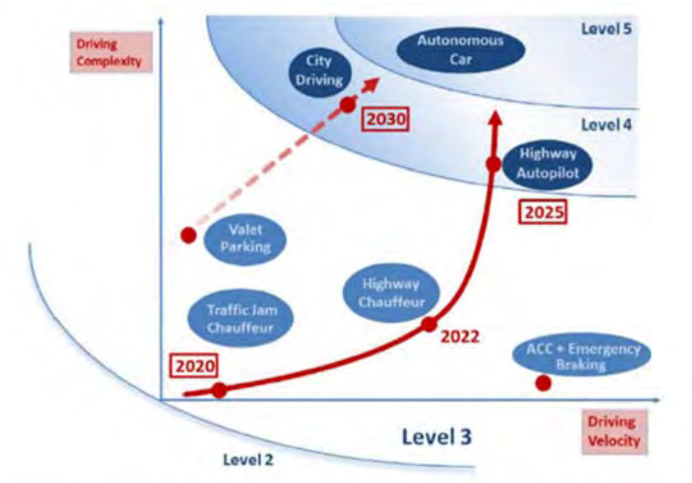
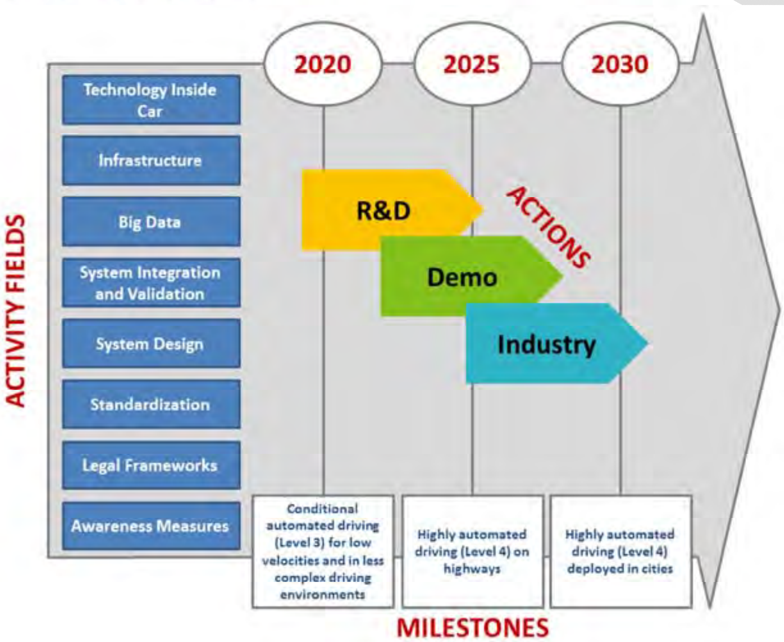
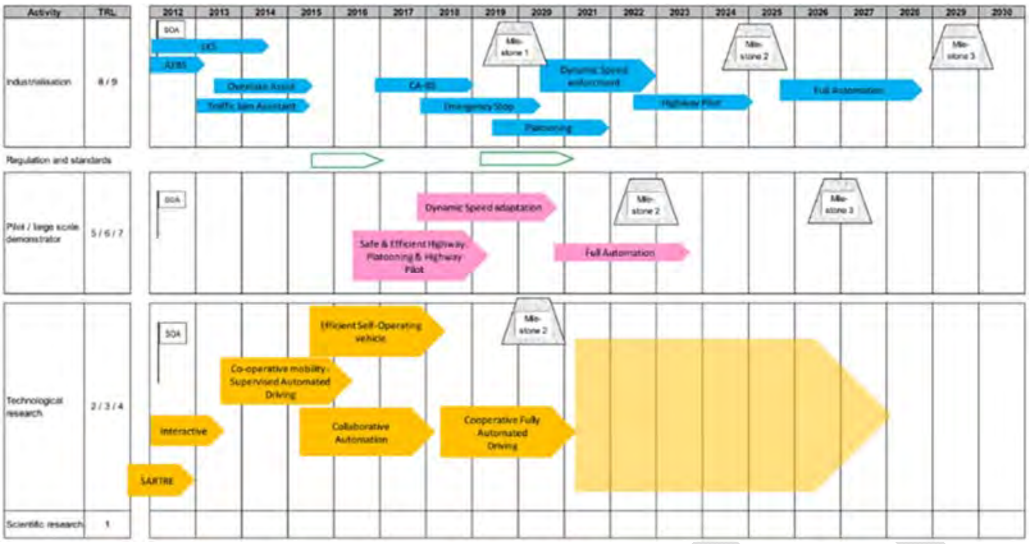


Figure 4: Development paths and milestones for Levels 3 and 4 of road vehicle automation until 2030 depending on velocity and complexity of the driving situation. The solid path represents the evolutionary scenario and the dashed line the revolutionary one. Both paths may eventually lead to the autonomous car which is indicated here as Level 5 of automation. The three milestones are indicated as years surrounded by frames. The full availability of the traffic jam chauffeur is to be expected for 2020 at the latest, while the availability of the highway chauffeur should follow right afterwards, around 2022. The highway autopilot as Level 4 is indicated as the second milestone which is to be reached in 2025. Undisturbed and safe driving in cities is considered to be the most complex task of the Level 4 automation for which full availability will be expected for 2030 in protected environments.

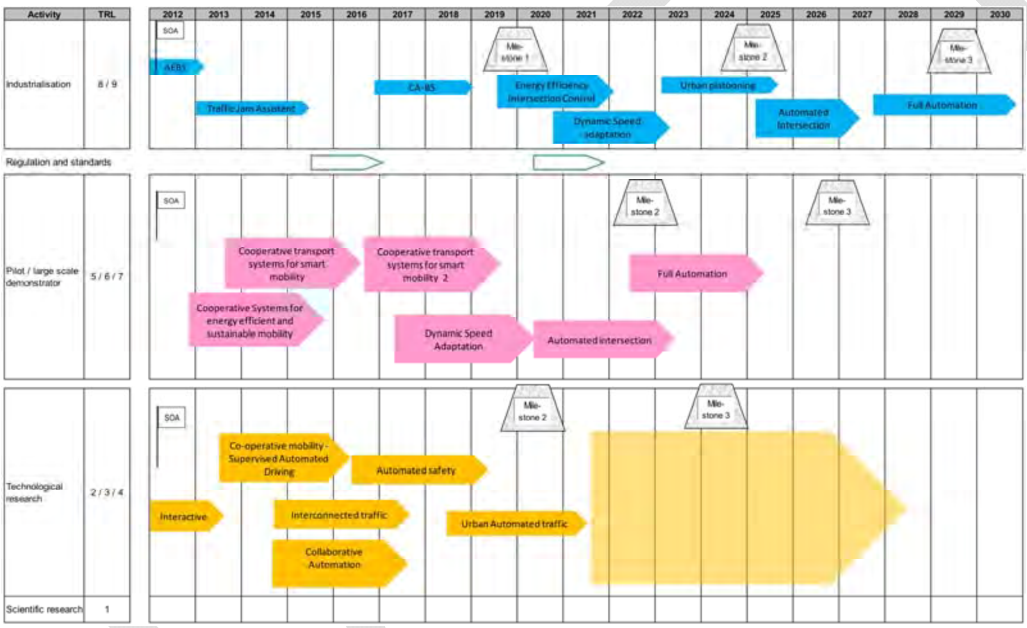


http://www.smart-systems-integration.org/public/documents/publications/EPoSS Roadmap_Smart Systems for Automated Driving_V2_April 2015.pdf

Automation in Road Transport, iMobility Forum, May 2013



Roadmap highway



Roadmap urban

http://www.imobilitysupport.eu/library/imobility-forum/working-groups/active/automation/reports-3/2185-auto-wg-automation-roadmap-final-report-june-2013/file

European Automotive and Telecom Alliance Roadmap, February 2017

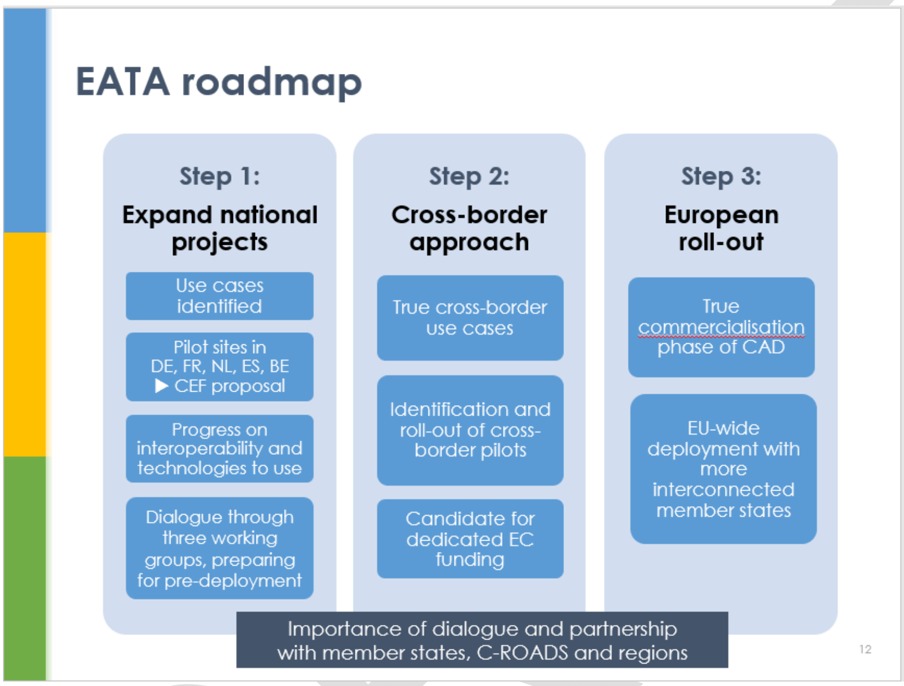
EATA objectives: Facilitate and accelerate the EU-wide deployment of connected and automated driving:

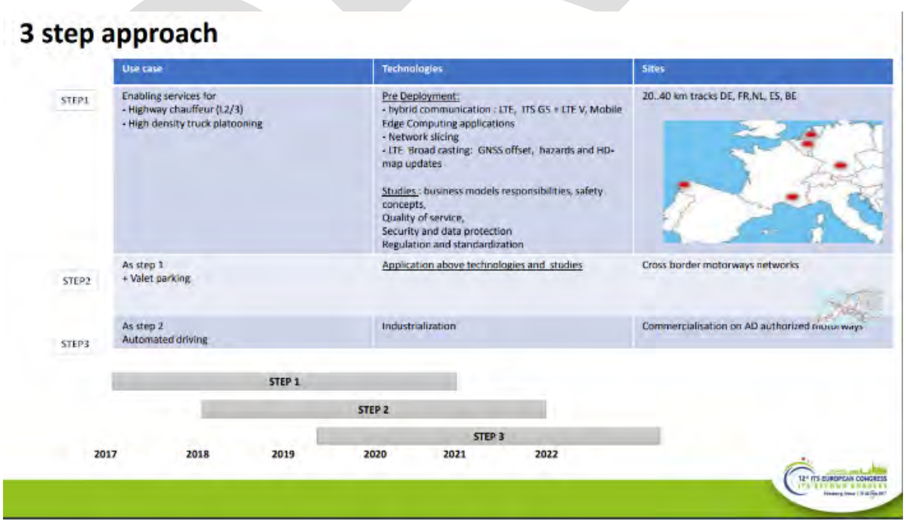
• Remove potential roadblocks and highlight needed technical and regulatory measures

• Identify the business models underlying connected and automated driving and encourage public investment for innovation and deployment of connected & automated driving

• Help make Europe a global leader in this field. Promote the European digital economy

• Provide a platform for knowledge-sharing between the automotive and telecommunications sectors to develop a ‘common language



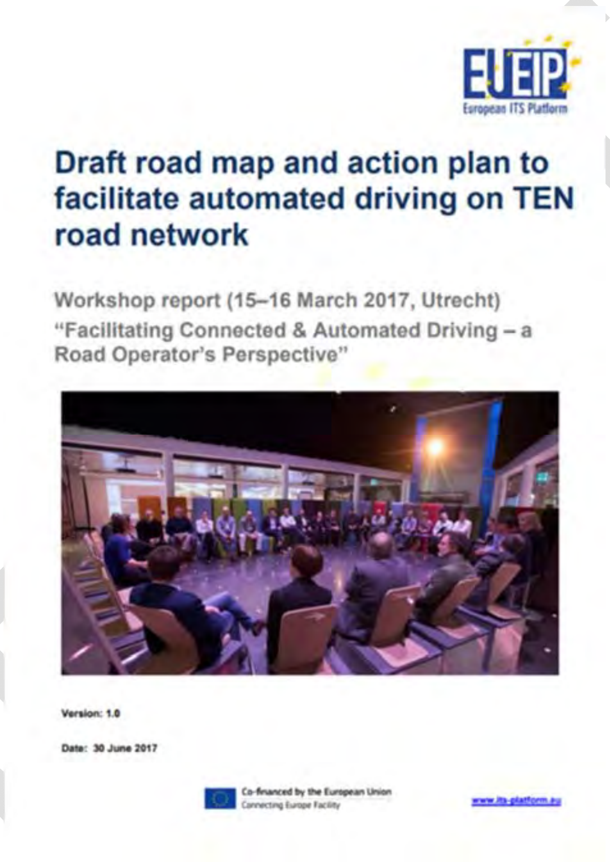


	Use case	Technologies	Sites
STEP1	Enabling services for - Highway chauffeur (L2/3) - High density truck platooning	Pre Deployment: - hybrid communication : LTE, ITS G5 + LTE V, Mobile Edge Computing applications - Network slicing - LTE Broad casting: GNSS offset, hazards and HD-map updates Studies : business models responsibilities, safety concepts, Quality of service, Security and data protection Regulation and standardization	20..40 km tracks DE, FR,NL, ES, BE
STEP2	As step 1 + Valet parking	Application above technologies and studies	Cross border motorways networks
STEP3	As step 2 Automated driving	Industrialization	Commercialisation on AD authorized motorways

https://connectedautomateddriving.eu/wp-content/uploads/2017/08/2017-06-21_EATA_SIS27-Automotive-and-Telecom-Alliance.pdf

Draft road map and action plan to facilitate automated driving on TEN road network, European ITS Platform, March 2017

The sub-activity 4.2 'Facilitating automated driving' of EU ITS Platform has a scope to prepare road authorities and operators to make decisions on facilitating automated driving and automating their own core business. This is a report of task 3 'Road map and action plan'. This task focuses on the requirements of higher levels of automated driving, and especially the requirements of automated driving towards the road authorities and operators concerning road markings, traffic signs, real-time and predictive traffic information, digital maps, cooperative ITS infrastructure and other aspects. The scope of the task was extended to encompass requirements of automated driving to ensure the safety and the efficiency of the transportation system.


EU EIP
European ITS Platform

Draft road map and action plan to facilitate automated driving on TEN road network

Workshop report (15–16 March 2017, Utrecht)
"Facilitating Connected & Automated Driving – a Road Operator's Perspective"

Version: 1.0

Date: 30 June 2017

Co-financed by the European Union
Connecting Europe Facility

www.its-platform.eu

https://www.its-platform.eu/filedepot_download/1950/6112

Road vehicle automation and cities and regions, 2018

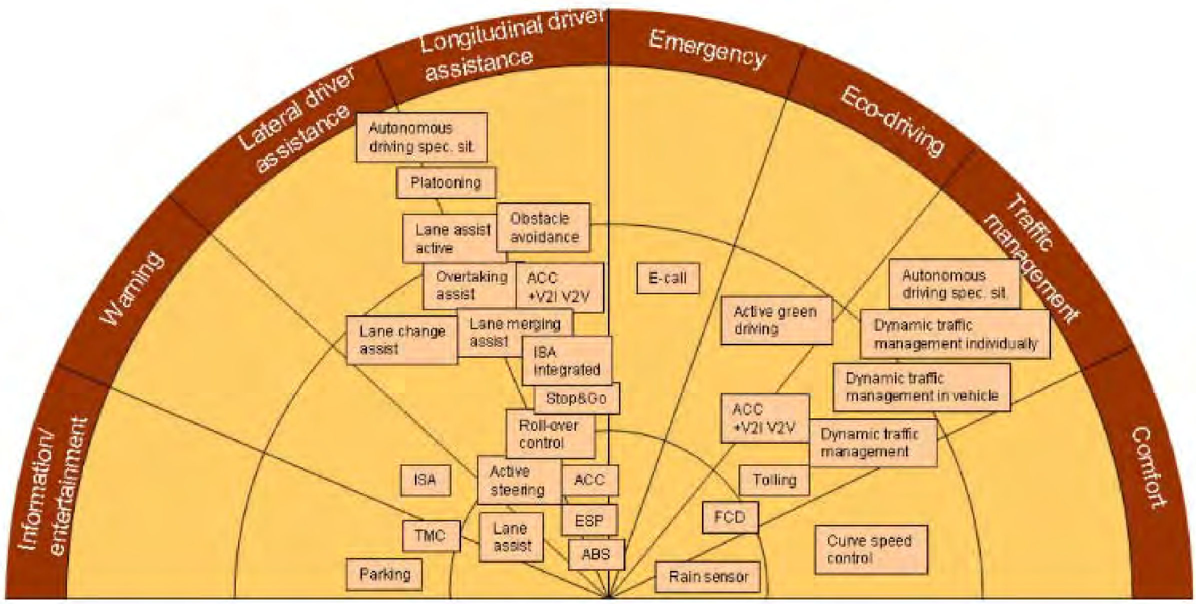
the perspective of Polis member cities and regions on road vehicle automation

Aspects for road authorities:

- Spatial aspects
  - Reduction of parking space
  - urban sprawl and longer commuting trips
  - socio-economic aspects
  - enhancing accessibility to persons with limited transport access
  - increasing social division and inequality
  - employment
  - value of time
  - public finances
- Road safety
  - using technology to tackle driver distraction and to enforce road safety rules
  - Interaction with non-AV road users
- Traffic efficiency
  - road space management
  - richer data for traffic and asset management
- Infrastructure
  - Infrastructure requirements
  - the role of C-ITS in the AV picture
- Legal, liability and regulatory aspects
  - There should always be someone legally responsible for the driving of a car
  - New AV-specific traffic rules may need to be created
  - Where AV fleets are rolled out in car-sharing clubs, the public authority may be expected to have regulatory oversight, as they currently do with taxis
  - Where road authorities interact with the automated vehicle, by means of communication technology (CAV/CCAV), (i) the issue of liability needs to be understood and (ii) EU rules may be needed to enable road/traffic authorities to access vehicle data to support the traffic and asset management and enforcement task.

https://www.polisnetwork.eu/uploads/Modules/PublicDocuments/polis_discussion_paper_automated_vehicles.pdf

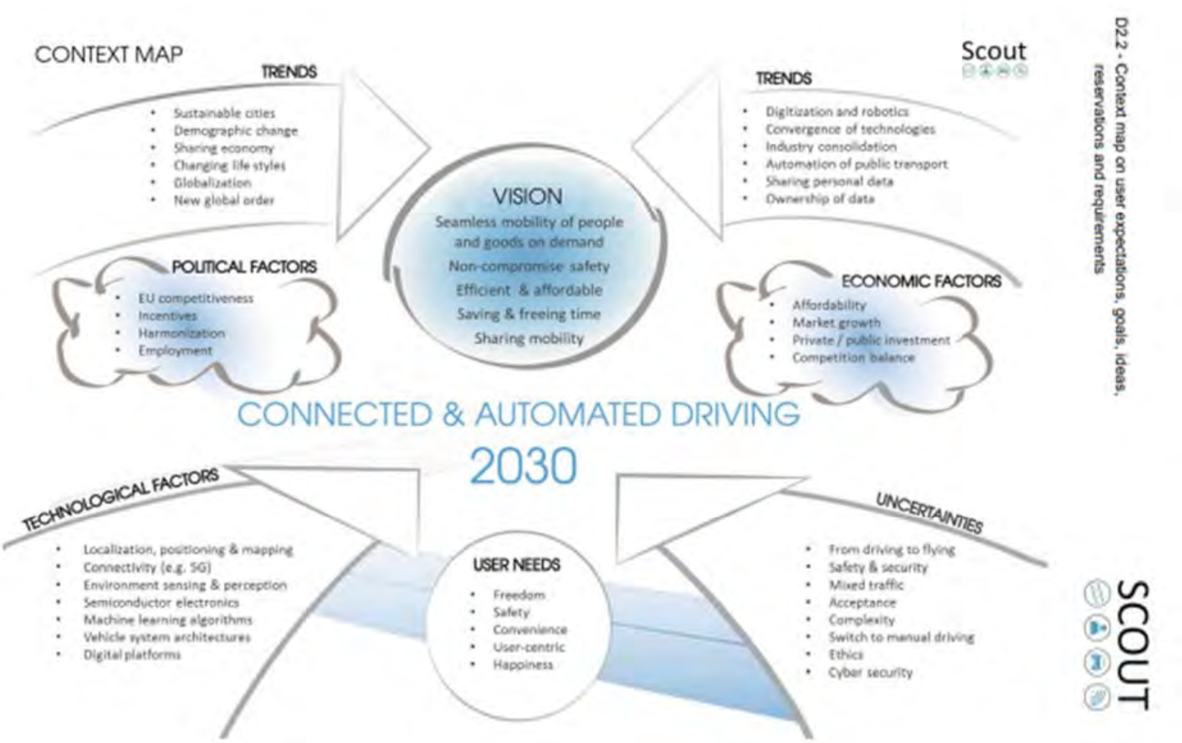
SMART study report, European Commission, 2010 This report addresses the challenges that come along with the transition from the slightly automated cars of today, through an ecosystem of highly automated vehicles assisting the driver in practically any difficult situation. The report builds upon the state of the art in ADAS technologies and formulates answers that could guide the automotive industry in this transition process and could help the legislators, the road authorities, the consumers, and the relevant industry define the healthy traffic environment of the future. Due to the imminent, large-scale penetration of ADAS and to a certain extent also of the V2V and V2I technologies, the main objective of the report is fairly limited to automated driving.



http://vra-net.eu/wp-content/uploads/2014/12/SMART_2010-0064-study-report-final_V1-2.pdf

Context map and vision for AD in EU, 2017

Germany, France, Italy, Netherlands, UK, Belgium, Spain



file:///C:/Users/VCMAP-operator/Downloads/Attachment_0.pdf

CEDR Position on Road Vehicle Automation, 2016

In April 2016, the European Transport Ministers gave out a declaration on connected and automated driving, indicating strong EU and Member State support to developing and deploying road vehicle automation. A week later, the CEDR Governing Board discussed road vehicle automation in a dedicated workshop facilitated by CEDR Task Group “Utilising ITS for NRAs”. This position paper reflects the GB view based on that workshop. In doing so, this position paper complements the CEDR ITS Position Paper (issued 2014).

CEDR view on road vehicle automation:

- Supports the European Transport Ministers’ Declaration of Amsterdam
- Recognizes the need to act right now since automation is disruptive
- Active National Road Authorities (NRAs) will benefit from “learning by experience” using a rapid learning circle via piloting and test areas
- Encourages strong liaison with European and national regulatory bodies in order to remove legal barriers
- Encourages public private cooperation with industry and service providers in the automotive, telecommunications, IT, mobility, and other relevant sectors in order to ensure required research and innovation, testing and piloting, evaluation, and deployment actions.
- Considers setting up a multi-stakeholder coordination group
- Highlights the importance of agreeing on the requirements of automated driving towards NRAs

http://www.cedr.fr/home/fileadmin/user_upload/Publications/2016/2016-CEDR_GB_Automated_driving-position-v04a.pdf

International Task Force on Vehicle-Highway Automation, 2016

A forum to discuss government-industry roles in development and deployment of advanced driver assistance systems.

An informal group for exchange of information and strengthening global linkages.

https://drive.google.com/drive/folders/0BzVsv7r9vCuRRTRlQWhtalJxUms?usp=sharing

CLEPA Automated Driving Position Paper, October 2014

Setting up an effective global regulatory framework is one of the vital pre-conditions for successful developments and market introduction. Another issue for a successful deployment of automated driving is user and societal acceptance.

CLEPA R&I roadmaps include necessary progress and implementation of advanced safety technologies, communication, data handling, highly precise dynamic positioning, environmental recognition, human factors and human machine interaction, etc.

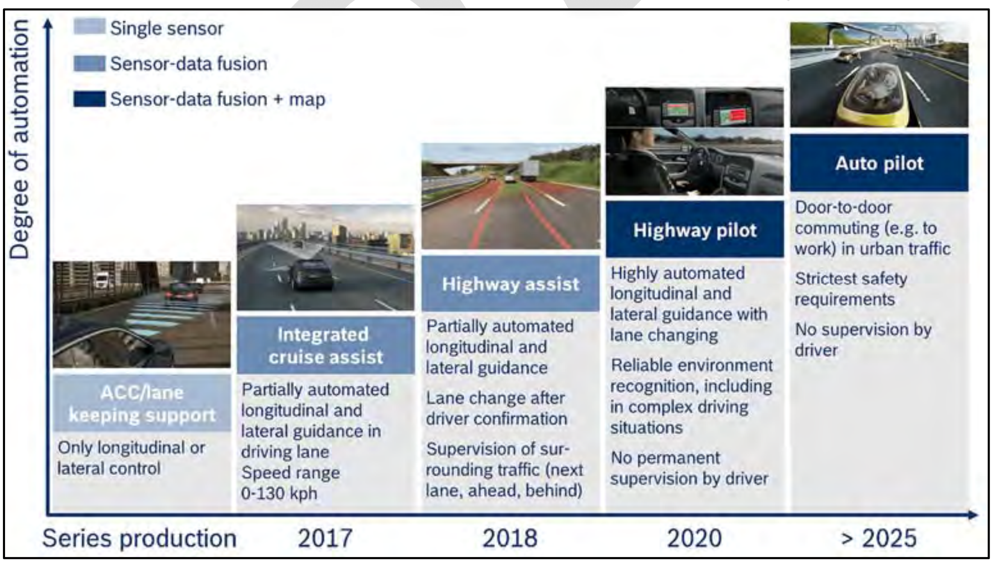
CLEPA supports activities accelerating deployment of vehicle to vehicle (V2V) and vehicle to 2 infrastructure (V2I) communication such as the development of an interoperable, open access, secured and standardised telematics platform.

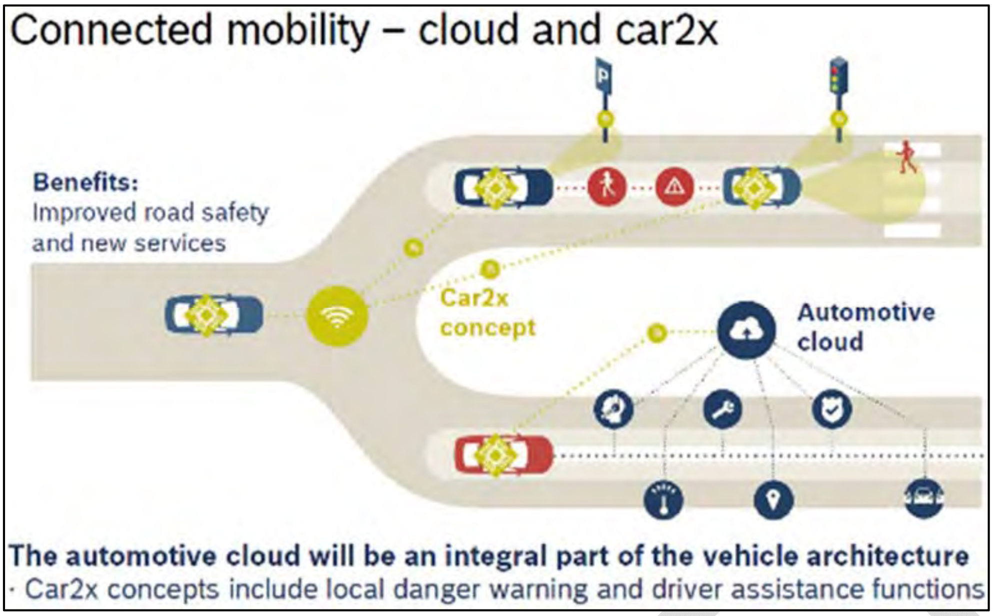
http://clepa.eu/wp-content/uploads/2015/08/20141001_CLEPA_PP_Automated_Driving.pdf

The road towards automated driving, 2015
Robert Bosch

Highlights:

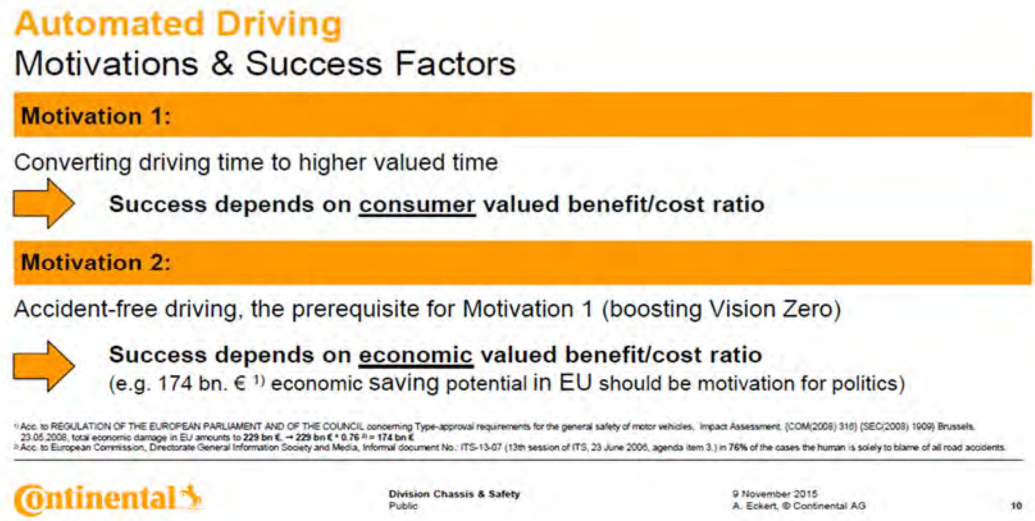
- The communication protocols for data exchange between vehicles must also be standardised.
- A critical mass of vehicles that can communicate with each other (around 10 percent) is required for standard operation.
- In addition to the technical challenges, the legal framework must also be adjusted or recreated from scratch in order to pave the way for automated driving.
- In many countries, the law states that:
    - Any moving vehicle must have a responsible driver
    - The driver must constantly be able to control the vehicle
    - The driver must refrain from all other activities while driving the vehicle
- A major regulatory milestone towards the deployment of automated vehicle technologies was attained on 23 March 2016 with the entry into force of amendments to the 1968 Vienna Convention on Road Traffic. As of that date, automated driving technologies transferring driving tasks to the vehicle will be explicitly allowed in traffic, provided that these technologies are in conformity with the United Nations vehicle regulations or can be overridden or switched off by the driver.

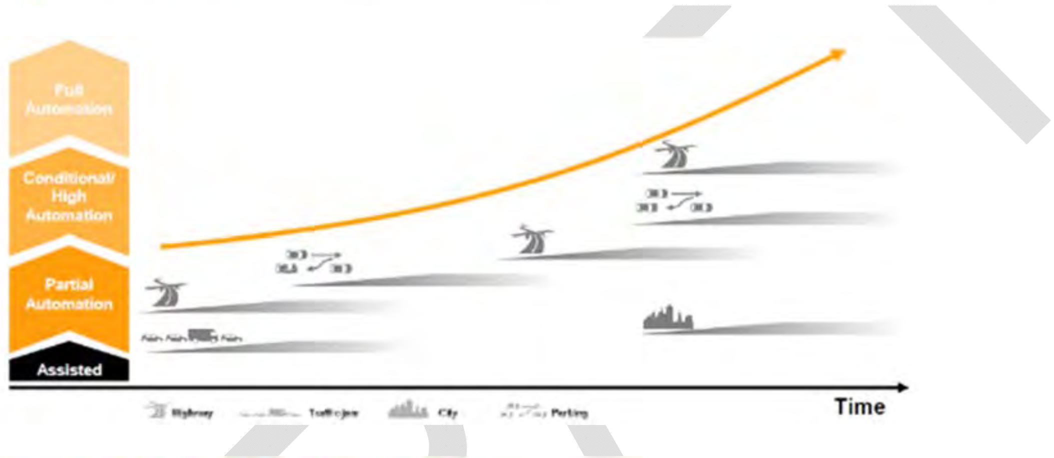


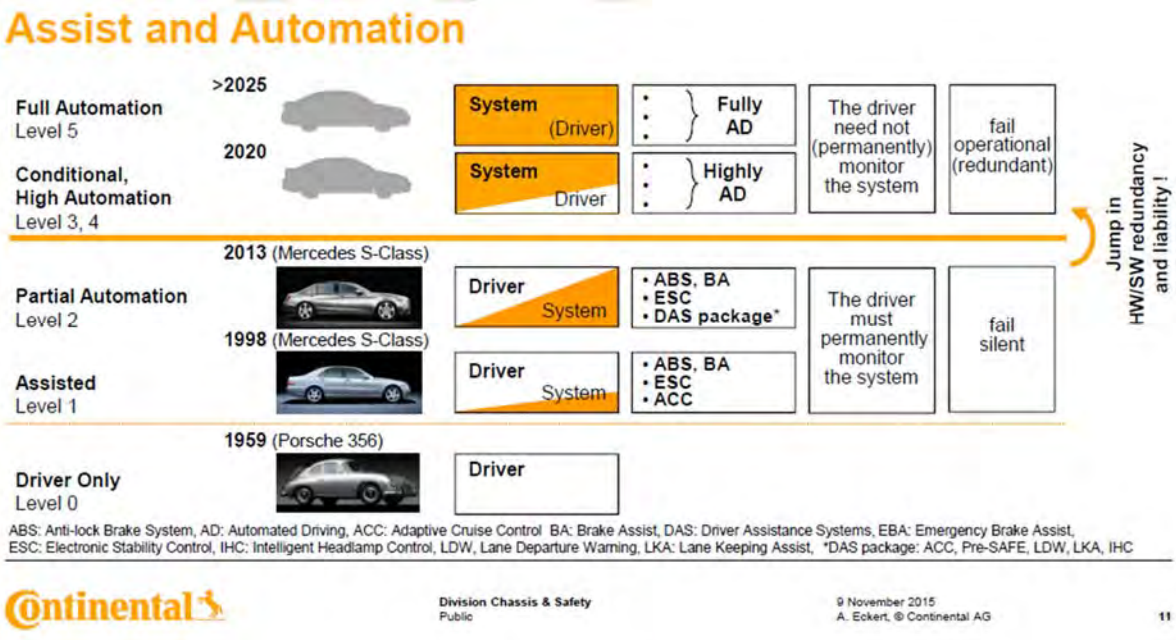


https://higherlogicdownload.s3.amazonaws.com/AUVSI/3a47c2f1-97a8-4fb7-8a39-56cba0733145/UploadedImages/documents/pdfs/7-15-14%20AVS%20presentations/Jan%20Becker.pdf

From assisted to automated driving, 2015





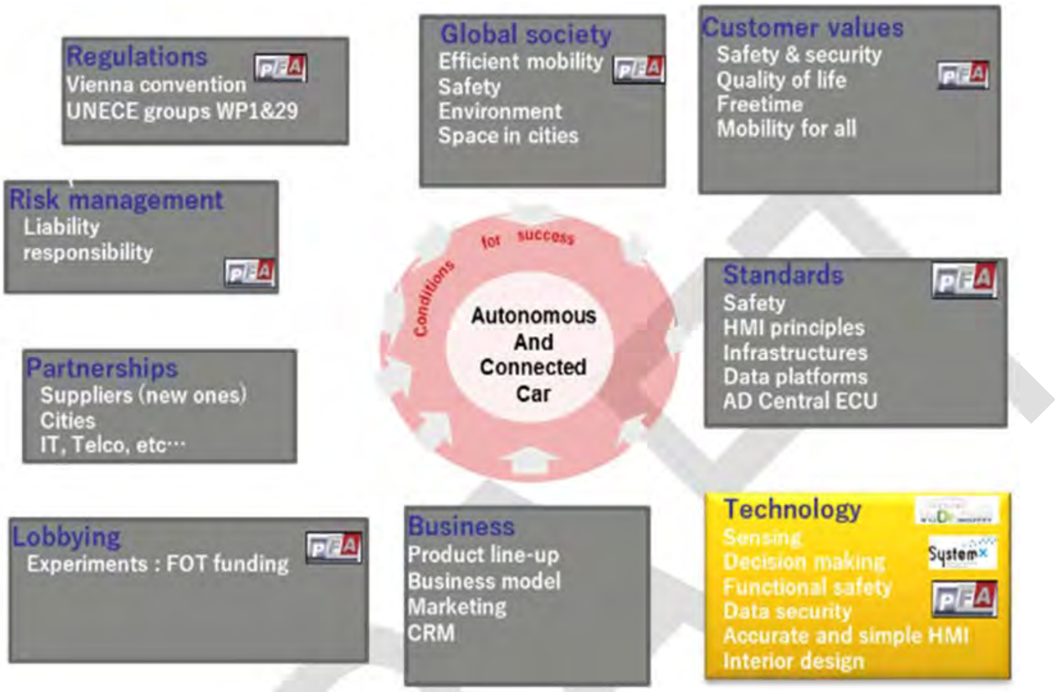


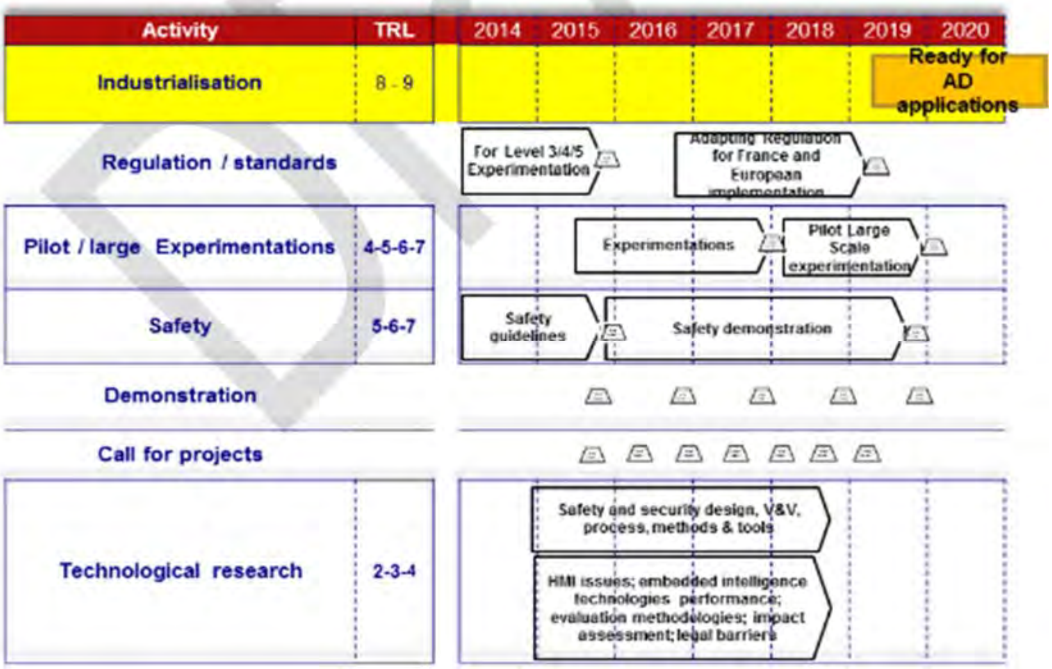
https://www.continental-corporation.com/en/products-and-innovation/innovation/automated-driving/automated-driving-10556

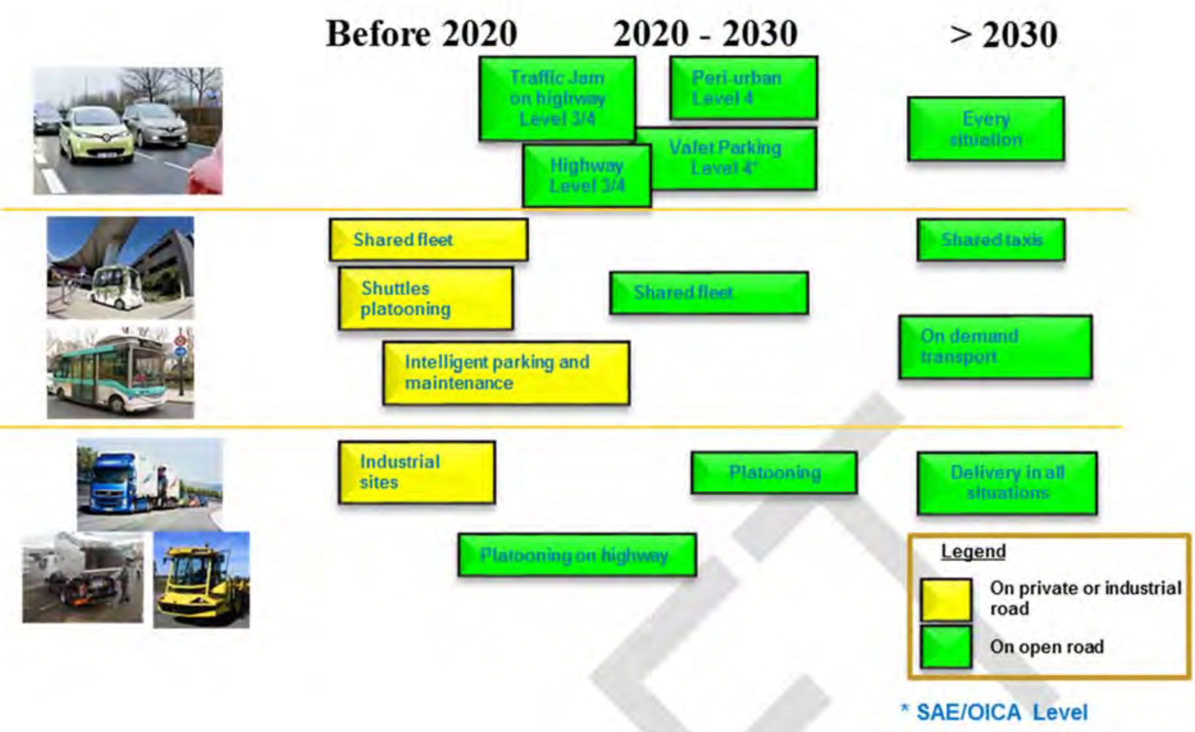
France industry plan Groupe Renault, 2015

3 ambitions for France:

- a place for autonomous vehicle experimentation
- a center of excellence for embedded intelligence technologies
- a key player within critical system safety domain



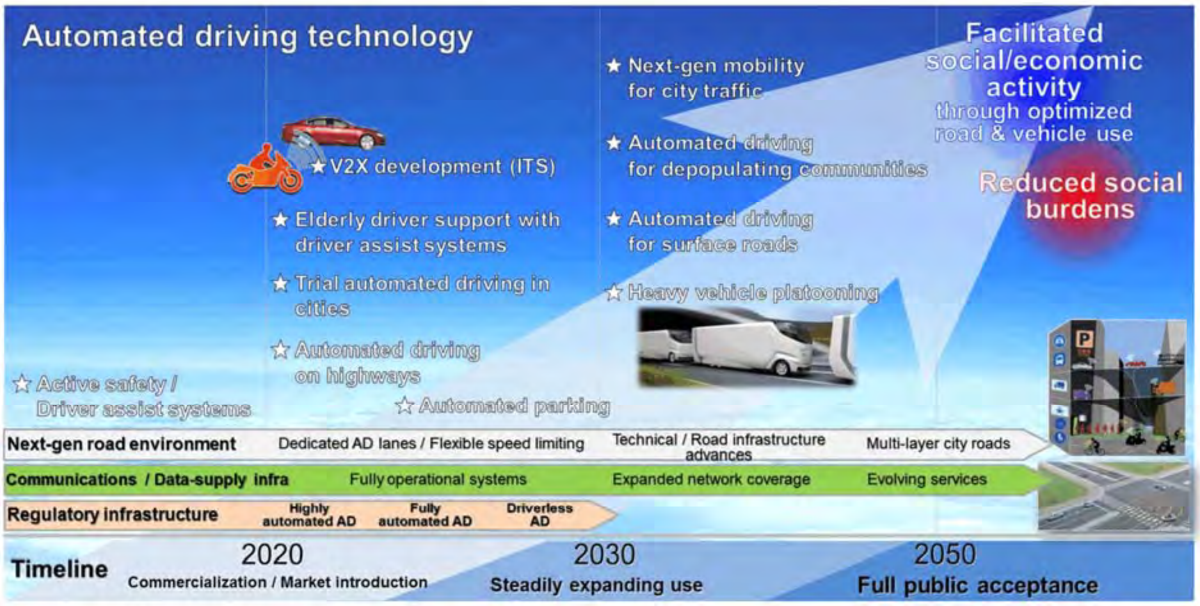




http://vra-net.eu/wp-content/uploads/2015/11/Jean-Fran%C3%A7ois-Sencerin.pdf

On the road to automated driving, Japan, February 2016

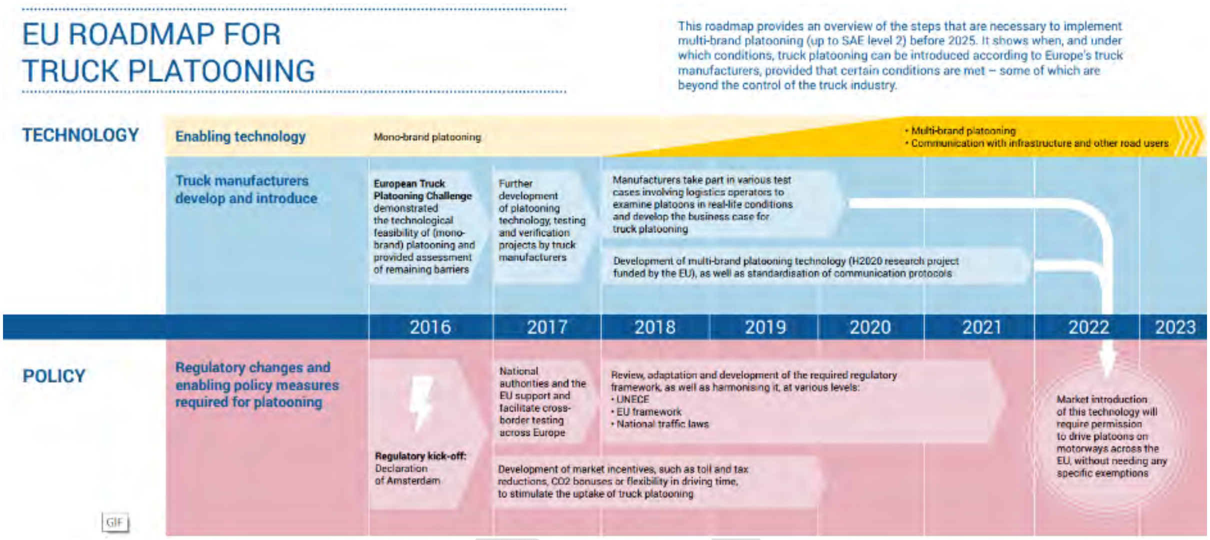
A "Strategic Innovation Program" is in fact underway in Japan, aimed at introducing next-generation road traffic systems and automated driving systems by the target year of 2020, when Tokyo is scheduled to host the Olympic and Paralympic Games.



http://www.jama-english.jp/publications/On_the_road_to_automated_driving.pdf

EU Roadmap for Truck Platooning, ACEA, May 2017

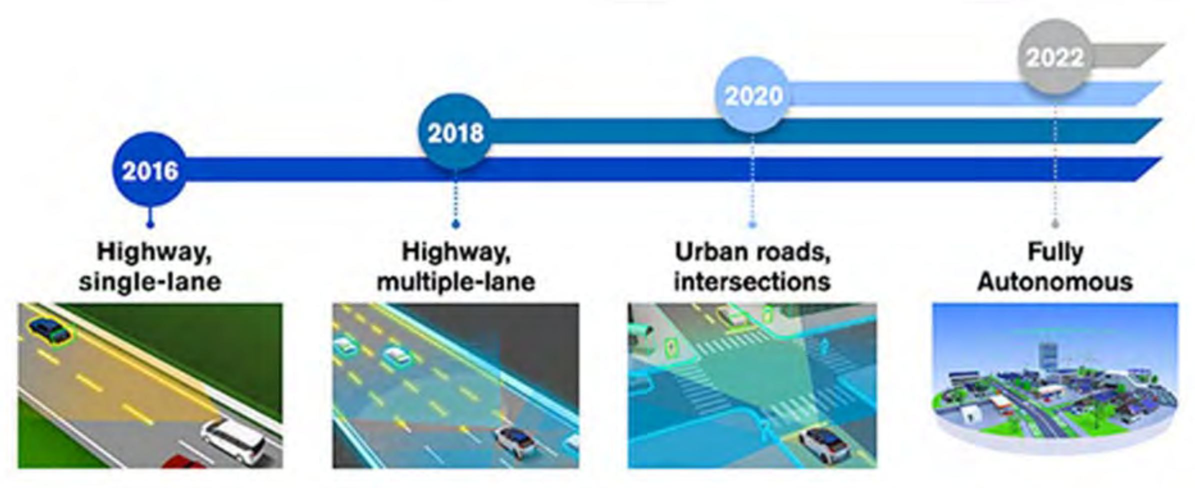
This roadmap provides an overview of the steps that are necessary to implement multi-brand platooning (up to SAE level 2) before 2025. It shows when, and under which conditions, truck platooning can be introduced according to Europe's truck manufacturers, provided that certain conditions are met – some of which are beyond the control of the truck industry.



http://www.acea.be/uploads/publications/Platooning_roadmap.pdf

Autonomous Drive Technology Roadmap, Nissan, 2017At Nissan, advances in AI are making our vehicles smarter, more responsive, and better at making their own decisions. We are developing a vehicle that will be capable of autonomous driving on a single lane highway in the near future. The next step will be multi-lane highway, then city driving, and ultimately fully autonomous driving in all situations.

- Highway single lane
    - SERENA, X-TRAIL, Nissan LEAF in Japan,
    - Rogue in US in 2017
    - Qashqai in Europe in 2018.
- Multi-lane autonomous driving technology will enable automatic lane changes on highways planned for 2018
- Autonomous driving urban roads and intersections planned for 2020

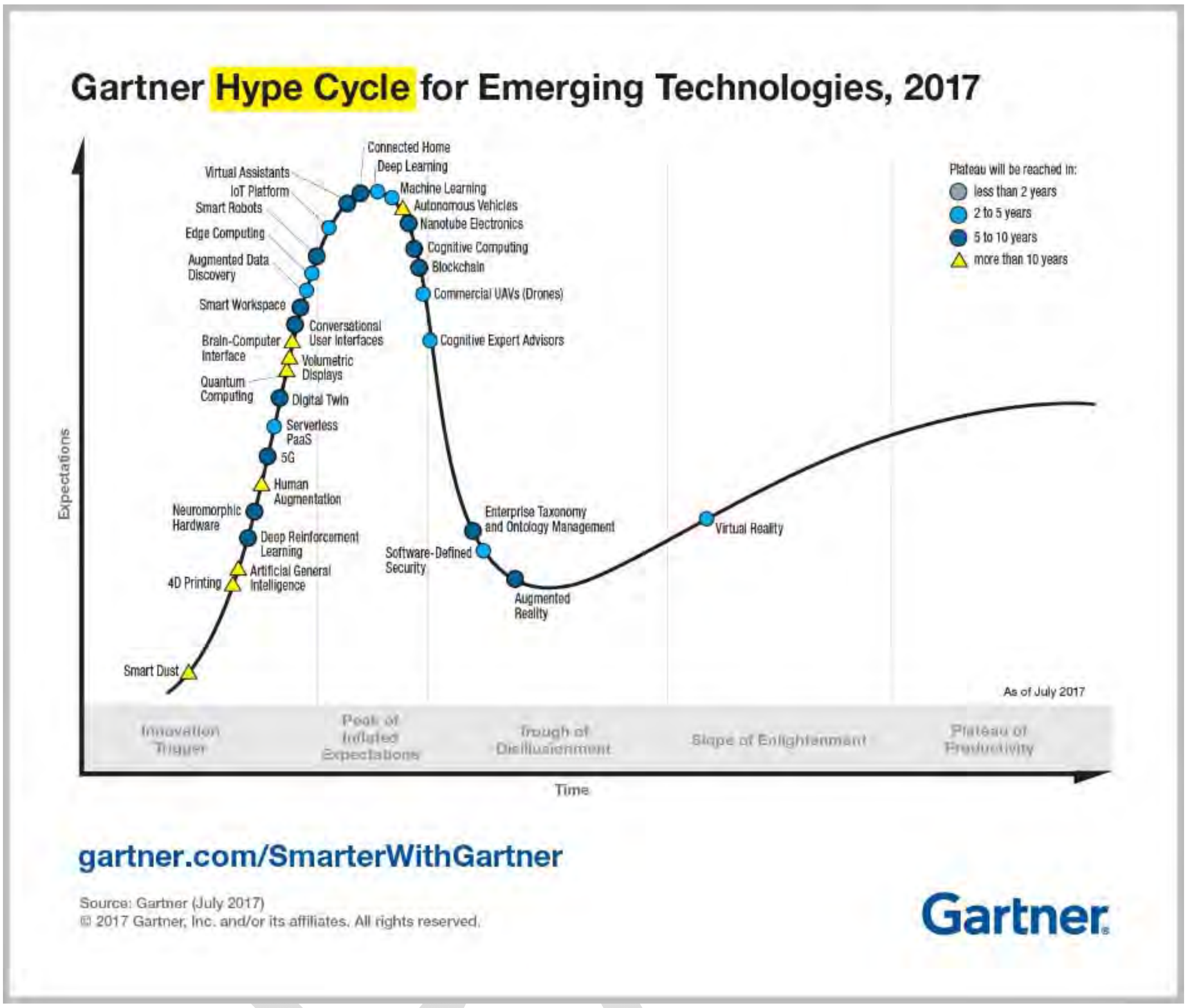


https://www.nissanusa.com/blog/autonomous-drive-car

http://www.nissan-global.com/EN/TECHNOLOGY/OVERVIEW/autonomous_drive.html

https://www.nissanusa.com/intelligent-mobility

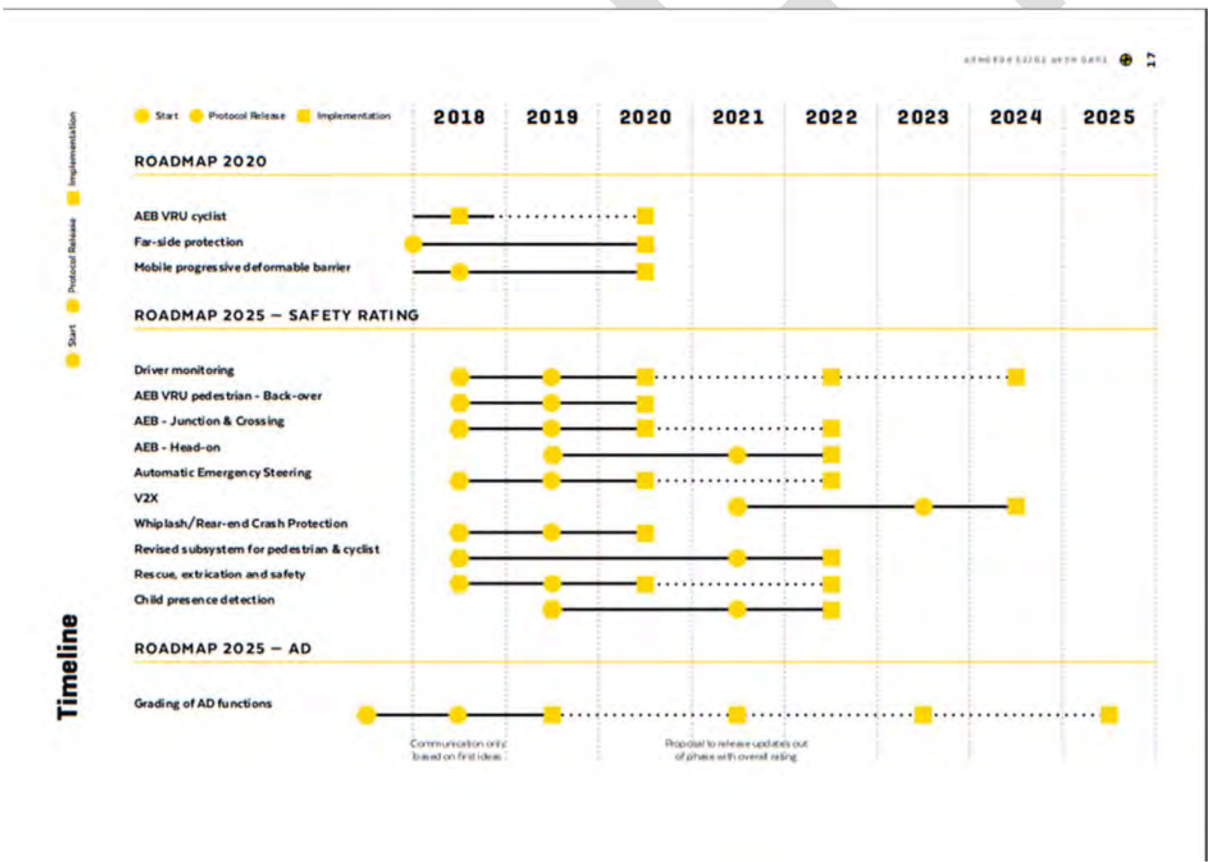
Gartner Hype Cycle, 2017



https://blogs.gartner.com/smarterwithgartner/files/2017/08/Emerging-Technology-Hype-Cycle-for-2017_Infographic_R6A.jpg

Euro NCAP 2025 Roadmap

- Primary safety
    - Driver monitoring (2020)
    - Automatic emergency steering (2020 - 2022)
    - Autonomous emergensy braking (2020 - 2022)
    - V2X (2024)
- Secondary safety
    - Whiplash/rear-end crash protection (2020)
    - pedestrian and cyclist safety (2022)
- Tertiary safety
    - rescue, extrication and safety (2020)
    - child presence detection(2022)



file:///C:/Users/VCMAP-operator/Downloads/euroncap-roadmap-2025-v4.pdf

Overview pilots

This chapter gives an overview of CAD pilots

Organization/country	Country	date	Title	Link
Volvo	SE	2017	Drive Me Sweden	link
TLR, Innovate UK	UK	2016	GATEway project	link
Mercedes	US	2016	DRIVE PILOT	link
Audi / VW (VW Group)	CN	2016	Shanghai, China	link
BMW	GE	2016	iNEXT Initiative	link
Companion	SE, GE, ES, NL	2016	COMPANION Project	link
IVECO, KAN, VOLVO, SCANIA, DAIMLER, DAF	NL, BE, DE, DK, SE	2016	European Truck Platooning Challenge	link
PostBus	CH	2016	PostBus	link
TUDelft, Spring, MAPscape, Connekt	NL	2015	WEpods	link
Uni Bristol, Bristol, AXA, First, ATKINS, FUSION	UK	2016	VENTURER	link
Mercedes-Benz	NL	2016	Future Bus	link
Appelscha	NL	2016	EasyMile - Appelscha	link
Flanders, RHDHV	BE	2016	National Platoon Test Belgium Flanders	link
CityMobil 2, Trikala	EL	2015-16	Driverless buses in the city of Trikala	link
6Aika -project, Helsinki	FI	2015-16	SOHJOA automated electric buses	link
L3Pilot	AT, BE, FI,FR, GE, IT, NL, SE, LU, UK	2017-20	Multiple locations in Europe	link
AUTOPILOT	NO, SE, FI, BE, FR, GE, NL, CH, UK, IE, IT, ES, EL, CZ, SOKO	2017-19	Multiple locations in Europe	link
TNO	NL	February 2015	Truck Platooning TNO	link
Uber	US	2016	Pittsburgh, US	link
Otto	US	2016	Denver, US	link
Waymo	US	2016	Multiple cities, US	link
Nissan	JP	2016		link
Tesla Autopilot		2016		link
General Motors	US	2016	San Francisco US	link
Delphi Drive	US	2015	US	link
RobotTaxi	JP	2016	Fujisawa, Japan	link
2getthere	UAE	2010	Abu Dhabi, United Arab Emirates	link
Ford		2016		link
Large Scale Video Analysis	EU	January 2018	Cloud LSVA	link
UnCoVer CPS	FR, DE, IT, ES, UK	January 2015	Unifying Control and Verification of Cyber-Physical Systems	link
InLane	AT, BE, FR, DE, ES, NL	January 2016	InLane – Lane navigation Technology	link

VI-DAS	ES	sep-16	VI-DAS – Video Inspired Driver Assistance Systems	link
ADAS & ME	SE	January 2026	ADAS & ME	link
MAVEN	GE, NL, UK	2016-19	Multiple locations in Europe	link
AutoMate	FR, DE, IT	September 2016	AutoMate Project	link
AdaptIVE	DE	January 2014		link
ENSEMBLE	NL	2018		link
Fabulos	EU		Future Automated Bus Urban Level Operation Systems	link
Ko-Haf	Germany	2016	Kooperatives Hochautomatisiertes Fahren!	link
BRAVE	ES, SE, FR, GE, ES, SI, US, AUS	2017-20	BRAVE	link
CoExist	GE, BE, FR, NL, SE, IT, UK	2017-20	CoExist	link
INFRAMIX	AT, EL, GE, ES,	2017-20	INFRAMIX	link
MERIDIAN	UK	September 2017	MERIDIAN	link
ERTICO	CEF	November 2017	CONCORDA	link
InterACT	DK, GE, AT, IT, EL, UK	2017-20	InterACT	link
TrustVehicle	AT, FR, UK, TUR, IT, FI, SE	2017-19	TrustVehicle	link
TransAid	ES, UK, NL, BE, GE, EL	2016-20	TransAid	link
AutoNet2030	SE	2013 – 2016	AutoNet2030	link
i-Game	EU	2013 – 2016	i-Game	link
Connekt, TNO, TUDelft, AutomotiveNL	NL	November 2013	DAVI	link
HAVE-it	EU	February 2008	HAVE-it	link

Drive Me - Gothenburg, Sweden, Europe

Volvo Cars, Autoliv, the Swedish Transport Administration, the Swedish Transport Agency, Chalmers University of Technology, Lindholmen Science Park and the City of Gothenburg.

Drive Me is partly financed by FFI - Strategic Vehicle Research and Innovation.

Highlights:

- 100 families in de coming 4 years will receive Volvo XC90s
- Volvo plans to have a fully autonomous car commercially available by 2021
- Approximately 80km road; average speeds of 70km/h; suburban environment; no pedestrians; plenty of separation between lanes
- Real customers
- Technology
    - Building confidence
    - average speeds of 70km/h
    - Infrastructure requirements for autonomous driving
    - Typical traffic situations suitable for autonomous vehicles
- Human behavior
    - We need to understand how human drivers react to and interact with self-driving cars to make autonomous technology work
    - Customers' confidence in autonomous vehicles
    - How surrounding drivers interact smoothly with a self-driving car.
- Impact
    - How autonomous vehicles bring societal and economic benefits by improving traffic efficiency, the traffic environment and road safety
- Deployment
    - 2017: London
        - 100 Volvo XC90s
        - M4 connecting Heathrow airport and central London
    - 2018 Sweden:
        - 100 Volvo XC90w
    - 20xx: China

http://www.volvocars.com/intl/about/our-innovation-brands/intellisafe/autonomous-driving/drive-me

https://www.media.volvocars.com/global/en-gb/media/pressreleases/217555/swedish-families-help-volvo-cars-develop-autonomous-drive-cars

GATEway project - Greenwich Automated Transport Environment, 2016

TLR, Innovate UK.

- **Automated passenger shuttles:** exploring the use of automated shuttle vehicles as a small scale transport service.
- **Automated urban deliveries:** using automated vehicles for last mile transportation; potentially from a local delivery depot to a residential neighbourhood.
- **Additional traveller needs:** exploring the benefits of automated vehicles for people with additional travel needs.
- **Remote teleoperation:** where a human operator must intervene to recover a fully automated vehicle to a safe mode of operation.
- **High-fidelity simulator tests:** to investigate how drivers of regular vehicles respond and adapt their behaviour to the presence of automated vehicles on the roads.
- **Technology**: The safe and efficient integration of sophisticated automated transport systems into complex real world smart city environments. A validated test bed in the heart of London for the evaluation of next generation automated transport systems, including the detailed testing protocols and benchmark data for independent verification of automated systems.
- **Human Behaviour**: Understand cultural and social challenges
- **Legal**: Understand legal challenges
- **Impact**: Inspire industry, public bodies and the wider public to engage with autonomous transport technology. UK PLC at the forefront of the global connected and autonomous vehicle marketplace, encouraging inward investment and job creation.
- **Deployment**: Valuable, exploitable knowledge of the systems required for the effective validation, deployment, management and integration of automated transport within a smart city environment

https://gateway-project.org.uk

Mercedes, Nevada US, Dubai 2016

- 2016, Nevada, US
- 2016, Dubai to Abu Dhabi

- DRIVE PILOT in the new E-Class

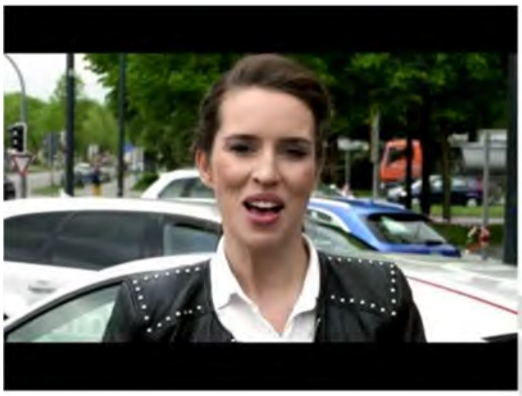
https://www.mercedes-benz.com/en/mercedes-benz/innovation/test-licence-for-autonomous-driving/

https://www.mercedes-benz.com/en/mercedes-benz/next/connectivity/the-new-human-machine-team

Audi / VW (VW Group), Shanghai China, 2016

Audi A7: “While piloted driving is planned to enter series production for the USA and Germany in 2017 with the new A8, Müller’s team is still at the very beginning of the process for the Asian region. When it comes to the development of driver assistance systems, the infrastructure and driving behaviors of the respective countries play a major role. “We have to adapt and approve the system for each region. And reliability is the key factor for Audi. At the end of the day, it’s all about safety”

VW I.D. Concept: “In the year 2025: the I.D. is the first Volkswagen concept car to be fully autonomous in the "I.D. Pilot" mode. The "I.D. Pilot" is activated by touching the VW logo on the steering wheel, which then disappears into the instrument panel and gives the driver an entirely new feeling of space.”



Audi

Volkswagen

http://www.audi.com/en/innovation/piloteddriving/piloted_driving.html

https://www.volkswagen-media-services.com/en/detailpage/-/detail/Volkswagen-at-2016-Paris-International-Motor-Show-World-premiere-of-the-visionary-ID-concept-car/view/4015603/7227fa995ef711551e7c4741077ed756?p_p_auth=dMErM46w

iNEXT Initiative, 2016

- 2016: demonstrate an autonomous test drive with a highly automated driving (HAD) prototype.
- 2017: the platform will extend to fleets with extended autonomous test drives.
- 2021: To bring solutions for highly and fully automated driving into series production.

https://www.press.bmwgroup.com/global/article/detail/T0261586EN/bmw-group-intel-and-mobileye-team-up-to-bring-fully-autonomous-driving-to-streets-by-2021

COMPANION Project, Sweden, 2016

COMPANION is a three-year European research project aiming at identifying means of applying the platooning concept in practice in daily transport operations.

http://www.companion-project.eu/

http://www.companion-project.eu/wp-content/uploads/20160915-COMPANION-Assessment-of-Truck-platoons.pdf

European Truck Platooning Challenge, 2016

- Sweden, Denmark, Germany, Belgium and the Netherlands
- Motorways in normal traffic conditions

https://www.eutruckplatooning.com/default.aspx

PostBus,Sion, 2016

https://www.postauto.ch/en/news/start-public-testing-autonomous-shuttles

WEpods, The Netherlands, 2015

- Two EZ-10 vehicles
- Operate on public roads in mixed traffic
- Steward on board
- Maximum speed of 25 kilometers an hour

http://wepods.nl/

VENTURER, UK, 2016

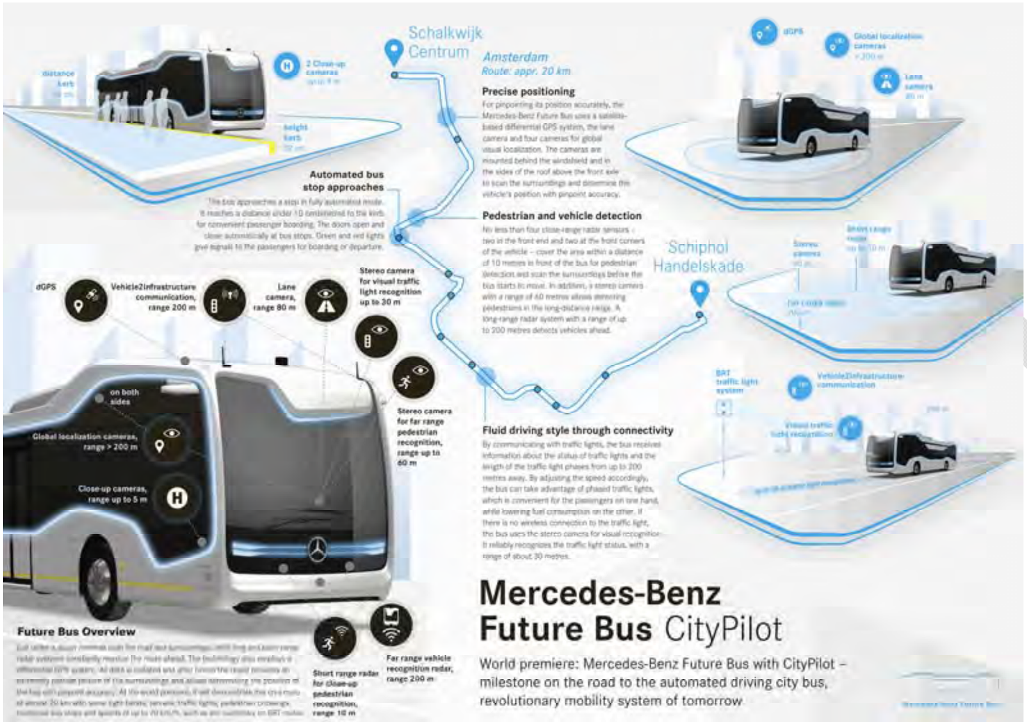
- real urban environment
- The VENTURER trials go hand in hand with developing an understanding of the insurance and legal implications of increased vehicle autonomy.
- VENTURER is also establishing a realistic simulation environment.

http://www.venturer-cars.com/

Future Bus, Amsterdam, 2016

Mercedes-Benz Future Bus CityPilot

- BRT routes
- A route of almost 20 kilometers
- Tight bends, tunnels, traffic lights, pedestrian crossings, numerous bus stops
- Speeds of up to 70 km/h



www.daimler.com/innovation/autonomous-driving/future-bus.html

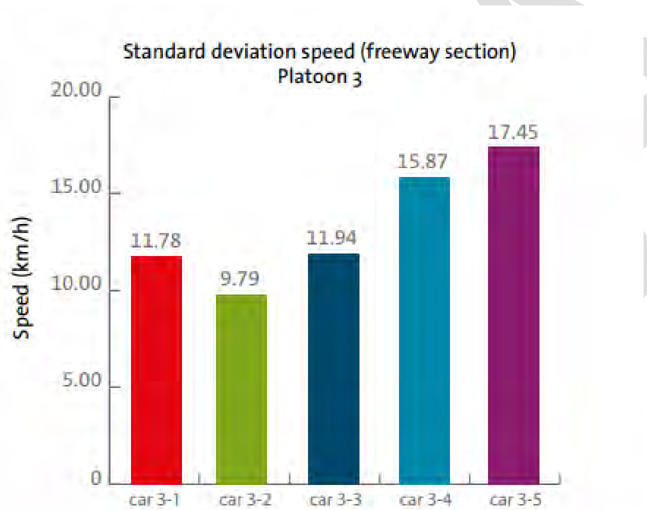
EasyMile - Appelscha, 2016

- an EZ10 driverless shuttle
- moving along a 1850 meters segregated lane that is shared with cyclists and pedestrians
- transporting people along the route with 3 stops
- 15 km/h

http://easymile.com/pilot-project-appelscha-netherlands/

National Platoon Test Belgium Flanders, 2016

- 30 cars driving in groups of 5 in a “platoon”
- Testing Adaptive Cruise Control (ACC) and Lane Keeping Assistance (LKAS)
- Cars used are commercially available
- Test performed on public roads



https://www.uhasselt.be/Documents/IMOB/Nieuws%20en%20Agenda/Brochure%20National%20Platoon%20Test_V3Los.pdf

https://connectedautomateddriving.eu/wp-content/uploads/2017/02/BE-FL-Presentation-Workshop-16.12.2016-1.pdf

Driverless buses in the city of Trikala, 2016

- Six automated buses (capacity 11 passengers) in an urban loop route of 2.4 km with nine stops
- Fully automated and driverless driving
- Emergency remote control from a traffic management center
- Daily operation from November 2015 until the end of February 2016

1,490 trips = 12,138 passengers

http://www.citymobil2.eu/en/City-activities/Large-Scale-Demonstration/Trikala/

https://connectedautomateddriving.eu/wp-content/uploads/2017/02/EL-Presentation-Workshop-16.12.2016.pdf

SOHJOA automated electric buses, Finland, 2016

- 2 EasyMile buses (SAE Level 4)
- Public streets
- Traffic lights, street markings
- Signs indicating AV testing

http://sohjoa.fi/sohjoa-in-english

L3Pilot- Multiple locations in Europe, 2017-21

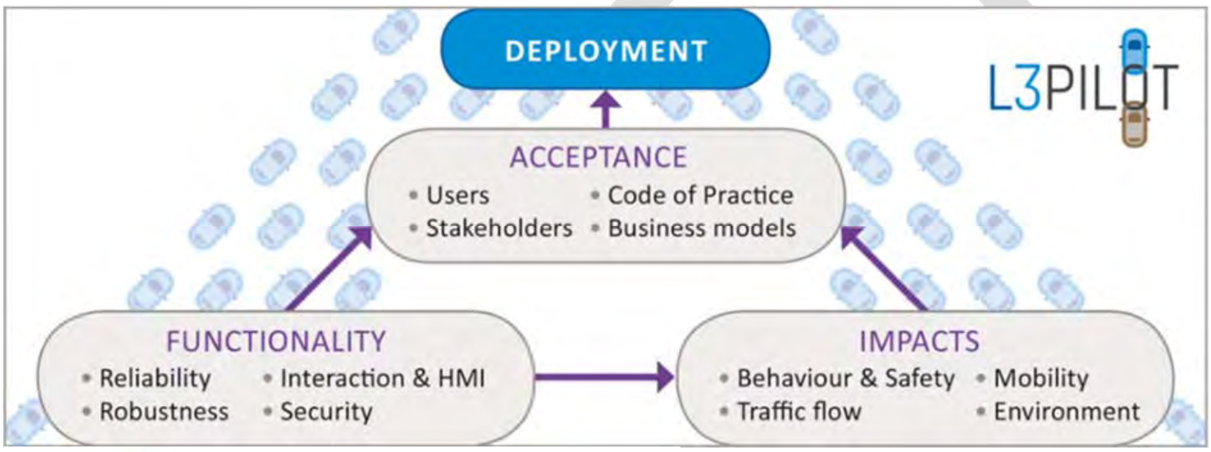
1,000 test drivers and 100 vehicles in 11 European countries tests the viability of automated driving as a safe and efficient means of transportation. L3Pilot focuses on large-scale piloting of SAE Level 3 functions, with additional assessment of some Level 4 functions. It is co-funded by the European Union under the Horizon 2020 programme, Grant Number 723051, and is supported by the European Council for Automotive R&D.

Coordinator Aria Etemad, Volkswagen Group Research

Participants 34 partners: OEMs, suppliers, research, SMEs, insurers, authorities and user groups

Countries Austria, Belgium, France, Finland, Germany, Greece, Italy, Netherlands, Norway, Sweden, Switzerland, UK

http://www.l3pilot.eu/



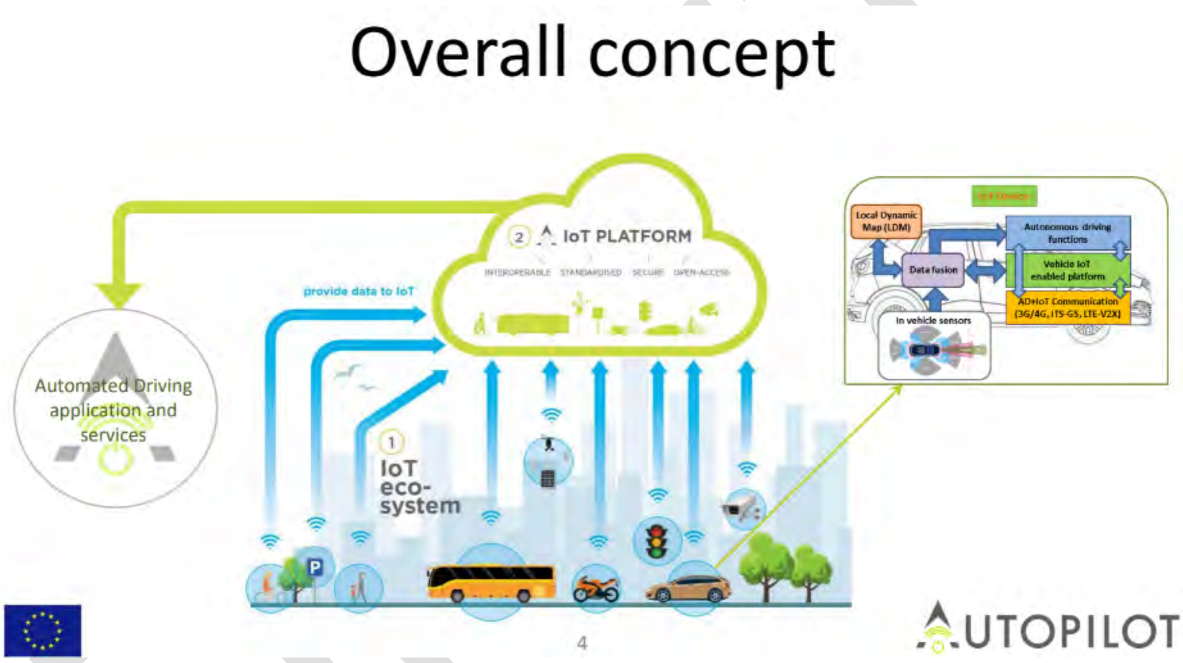
AUTOPILOT- Multiple locations in Europe, 2017-19

In order to stay competitive, the European automotive industry is investing in connected and automated driving with cars becoming moving “objects” in an IoT ecosystem eventually participating in BigData for Mobility. AUTOPILOT brings IoT into the automotive world to transform connected vehicles into highly and fully automated vehicle.

Co-funded EU project Funded under the call H2020-IOT-2016 Topic: IoT-01-2016 - Large Scale Pilots. Coordinator: ERTICO – ITS Europe.

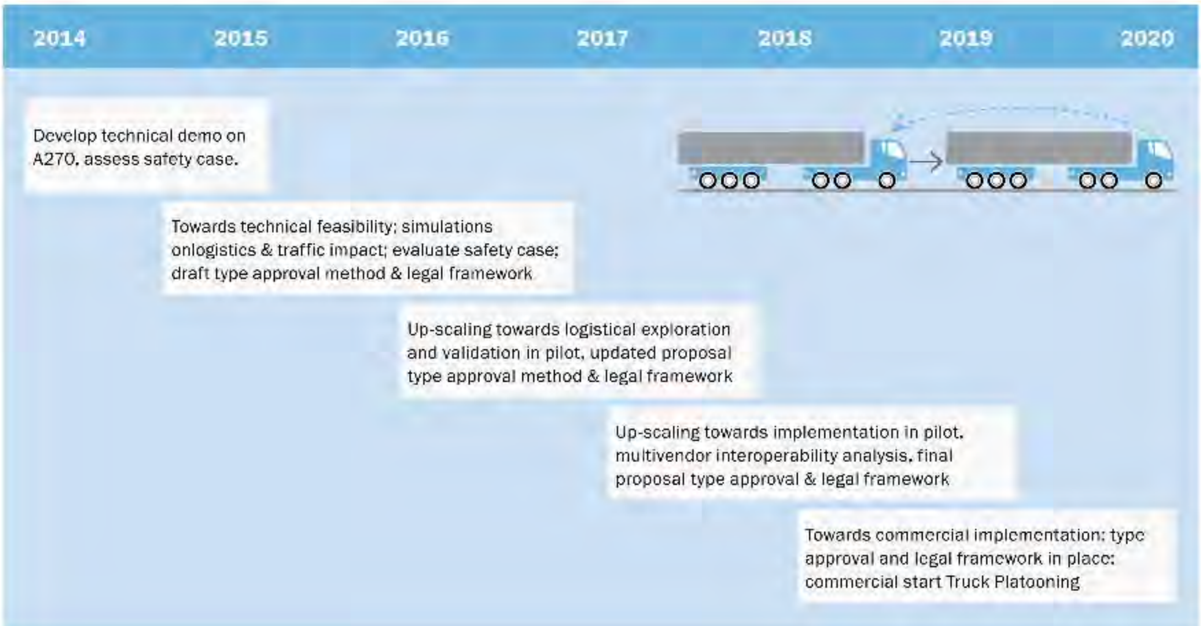
6 permanent large-scale pilot sites in Finland, France, Italy, the Netherland South Korea and Spain.

http://autopilot-project.eu/



Truck Platooning, TNO The Netherlands, February 2015

In this TNO whitepaper, we explain what platooning is, what kind of benefits it brings for which parties in the supply chain, and the roadmap towards deployment of platooning on Dutch and European roads. Developments in the underlying Cooperative Adaptive Cruise Control (CACC) technology have been ongoing for years, yet widescale deployment of truck platooning is a system-wide innovation challenge that requires a concerted approach of all stakeholders in society.



http://publications.tno.nl/publication/34616035/dLIjFM/janssen-2015-truck.pdf

Waymo, multiple cities US, 2016

- 2016:
    - The Google self-driving car project became Waymo
    - 1 billion simulated miles in 2016
- 2 million miles self-driven
- Largely on city streets
- 2017:
    - 100 new Chrysler Pacifica Hybrid minivans

https://waymo.com/

Nissan, 2016

- Nissan Serena
- ProPILOT
- 2016: Highway single-lane
    - No lane changes
- 2018: Highway multi-lane
    - With lane changes / overtaking
- 2020: City
    - Urban environments

http://nissannews.com/en-US/nissan/usa/releases/nissan-s-new-serena-propilot-technology-makes-autonomous-drive-first-for-japanese-automakers

Tesla Autopilot, 2016

- Develop a self-driving capability that is 10X safer than manual via massive fleet learning
- All Tesla vehicles to be produced will have the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver.
- 2015: Autopilot
- 2016: Full Self-Driving Hardware

https://www.tesla.com/blog/all-tesla-cars-being-produced-now-have-full-self-driving-hardware

https://www.tesla.com/blog/master-plan-part-deux

General Motors, San Francisco, US, 2016

https://www.getcruise.com/

http://www.theverge.com/2016/9/18/12944506/lyft-self-driving-car-prediction-2021-john-zimmer

http://www.azcentral.com/story/money/business/tech/2016/11/22/general-motors-bolts-driving-themselves-around-scottsdale-self-driving-autonomous-vehicles/94242102/

Delphi Drive, US, 2015

- From San Francisco to New York
- Public roads
- Distance: 3,400 mile
- CCTVs, DSRC beacons,

http://www.delphi.com/delphi-drive

RobotTaxi, Fujisawa, Japan

- Fujisawa residents
- 10 participant groups
- Autonomously on Chuo Keyaki Street
- Driver manually operates the vehicle on all other roads
- 2020: Tokyo Olympics

https://robottaxi.com/en/

https://robottaxi.com/en/news/2016/02/fujisawa/

2getthere, Abu Dhabi, United Arab, 2010

Masdar PRT system is approximately 1.4 kilometers long and features 2 stations: the North Car Park and the Masdar Institute for Science and Technology. The system opened to the general public on November 28, 2010, while the system availability and vehicle reliability consistently exceed 99.6% and 99.9% respectively. The PRT system is operational 18 hours a day, from 06.00hr until midnight, every day.

The 10 vehicles operate on-demand, featuring angled berth stations allowing for independent entry and exit of vehicles. The system is carrying 5 times the anticipated amount of passengers, averaging >85% average occupancy during the weekends. On May 22nd, 2014 the system carried its 1 millionth passenger, with the 2 millionth passenger expected in November 2016.

https://www.2getthere.eu/projects/masdar-prt/

Ford, 2016

This year, Ford will triple its autonomous vehicle test fleet to be the largest test fleet of any automaker – bringing the number to about 30 self-driving Fusion Hybrid sedans on the roads in California, Arizona and Michigan, with plans to triple it again next year.

Ford announced its intent to have a high-volume, fully autonomous SAE level 4-capable vehicle in commercial operation in 2021 in a ride-hailing or ride-sharing service.

https://media.ford.com/content/fordmedia/fna/us/en/news/2016/08/16/ford-targets-fully-autonomous-vehicle-for-ride-sharing-in-2021.html

http://www.bbc.com/news/technology-37103159

Cloud LSVA, 2016

Cloud-LSVA seeks to create Big Data Technologies to address the open problem of a lack of software tools, and hardware platforms, to annotate petabyte scale video datasets. The problem is of particular importance to the automotive industry. CMOS Image Sensors for Vehicles are the primary area of innovation for camera manufactures at present. They are the sensor that offers the most functionality for the price in a cost sensitive industry.
By 2020 the typical mid-range car will have 10 cameras, be connected, and generate 10TB per day, without considering other sensors. Customer demand is for Advanced Driver Assistance Systems (ADAS) which are a step on the path to Autonomous Vehicles. The European automotive industry is the world leader and dominant in the market for ADAS. The technologies depend upon the analysis of video and other vehicle sensor data. Annotations of road traffic objects, events and scenes are critical for training and testing computer vision techniques that are the heart of modern ADAS and Navigation systems. Thus, building ADAS algorithms using machine learning techniques require annotated data sets and since human annotation is an expensive and error-prone task that has only been tackled on small scale to date, currently no commercial tool exists that addresses the need for semi-automated annotation or that leverages the elasticity of Cloud computing in order to reduce the cost of the task.
Thus, providing this capability will establish a sustainable basis to drive forward automotive Big Data Technologies. Furthermore, the computer is set to become the central hub of a connected car and this provides the opportunity to investigate how these Big Data Technologies can be scaled to perform lightweight analysis on board, with results sent back to a Cloud Crowdsourcing platform, further reducing the complexity of the challenge faced by the Industry. Car manufacturers can then in turn cyclically update the ADAS and Mapping software on the vehicle benefiting the consumer.

CloudLSVA
Large Scale Video Analysis

http://cloud-lsva.eu/

UnCoVer CPS, 2015

UnCoVerCPS prepares the EU to be able to develop critical cyber-physical systems that can only be realised and certified when uncertainties in the environment are adequately considered. This is demonstrated by applying our ground-breaking methods to automated vehicles, human-robot collaborative manufacturing, and smart grids within a consortium that has a balanced participation of academic and industrial partners.

https://cps-vo.org/group/UnCoVerCPS

InLane, 2016

inLane's vision is to develop a low-cost, lane-level, precise turn-by-turn navigation application through the fusion of EGNSS and Computer Vision technology. It envisions a new generation of enhanced mapping information, made possible by real-time updates based on crowdsourcing techniques, which will result in lane-level vehicle positioning to take navigation to a new level of detail and effectiveness. 10 partners from 6 European countries form the inLane consortium.

https://inlane.eu/about/at-a-glance/

VI-DAS – Video Inspired Driver Assistance Systems, 2016

European project which aims to develop intelligent driver assistance systems for automated driving. VI-DAS will advance in computer vision and machine learning will introduce non-invasive, vision-based sensing capabilities to vehicles and enable contextual driver behavior modelling.

http://vi-das.eu/

ADAS & ME

The ADASANDME project develops adapted advanced driver assistance systems that take into account the driver's state and the situational and environmental context to automatically transfer control between the vehicle and the driver for safer and more efficient road usage. Seven provisionally identified use cases for cars, trucks, buses and motorcycles covering a large proportion of driving on European roads will be carried out along with experimental research on algorithms for driver state monitoring as well as HMI and automation transitions.

The project will develop robust detection and prediction algorithms that monitor different driver states, such as fatigue, sleepiness, stress, inattention and impairing emotions, employing existing and novel sensing technologies. It will also take into account traffic and weather conditions via V2X and personalise them to individual driver's physiology and driving behaviour. In addition, the core development includes multimodal and adaptive warning and intervention strategies based on current driver state and severity of scenarios.

The project targets successful fusion of the developed elements into an integrated driver state monitoring system that is supported by vehicle automation of levels 1 to 4. The system will be validated by a wide pool of drivers/riders in simulated and real road conditions and with different driver states. The pilot vehicles will be two cars (conventional and electric), a truck, two PTWs and a bus. This challenging task has been undertaken by a multidisciplinary consortium of 30 partners, including an OEM per vehicle type and seven Tier 1 suppliers.

ADAS & ME

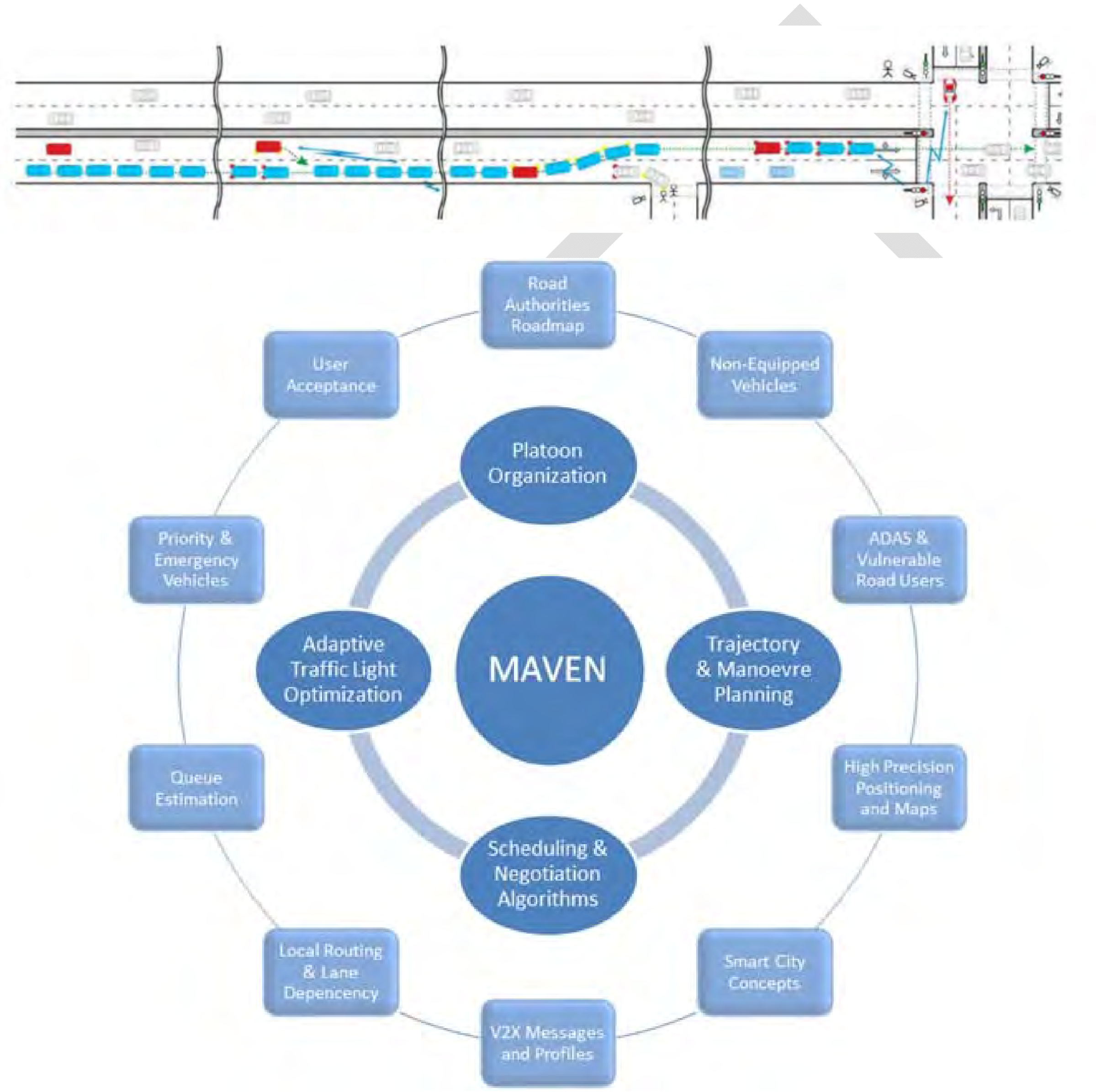
http://www.adasandme.com/

MAVEN- Multiple locations in Europe, 2016-2020

The project will develop infrastructure assisted algorithms for the management of automated vehicles, which connect and extend vehicle systems for trajectory and maneuver planning. Simultaneously these algorithms will yield substantial better utilization of infrastructure capacity, reduction of vehicle delay and emission, while ensuring traffic safety.

Funded under the call: H2020-MG-2014-2015 Topic: MG-3.6a-2015 - Safe and connected automation in road transport

http://www.maven-its.eu/



AutoMate, 2016

The design of the human-machine interaction in highly automated passenger cars is crucial to fully exploit the automation's potential, improve traffic safety and bring these cars to the market. The AutoMate project is working a novel driver-automation interaction and cooperation concept based on viewing and designing the automation as the driver's transparent and comprehensible cooperative companion or teammate. Driver and automation are seen as members of one team that understand and support each other in pursuing cooperatively the goal of driving safely, efficiently and comfortably from one point to another. Only such kind of systems can enhance safety by using the strength of both the automation and human driver in a dynamic way, and thus gain consumers' trust and acceptance.

The top-level objective of AutoMate is to develop, demonstrate and evaluate the TeamMate Car concept as a major enabler of highly automated vehicles. The project's team will develop seven technical enablers:

• Sensor and communication platform

• Probabilistic driver modelling and learning

• Probabilistic vehicle and situation modelling

• Adaptive driving manoeuvre planning, execution and learning

• Online risk assessment

• TeamMate HMI

• TeamMate System Architecture These innovations will be implemented on several car simulators and real vehicles to evaluate and demonstrate the project progress and results in real-life traffic conditions.

http://www.automate-project.eu/

AdaptIVE, 2014

AdaptIVe develops various automated driving functions for daily traffic by dynamically adapting the level of automation to situation and driver status. Targets for research and development are:

- Demonstrate automated driving in complex traffic environments. Test integrated applications in all possible scenarios taking into account the full range of automation levels.
- Enhance the perception performance in complex scenarios by using advanced sensors supported by cooperative and communication technologies.
- Provide guidelines for the implementation of cooperative controls involving both drivers and automation.
- Define and validate specific evaluation methodologies.
- Assess the impact of automated driving on European road transport.
- Evaluate the legal framework with regards to existing implementation barriers.

http://www.adaptive-ip.eu/

Ensemble, 2018

- implementation and demonstration of multi-brand truck platooning
- led by TNO
- Truck manufacturers involved:
  DAF, DAIMLER, IVECO, MAN, SCANIA and VOLVO GROUP

ENSEMBLE's mission: Platooning technology has made significant advances in the last decade, but to achieve the next step towards deployment of truck platooning, an integral multi-brand approach is required. Aiming for Europe-wide deployment of platooning, 'multi-brand' solutions are paramount. It is the ambition of ENSEMBLE to realise pre-standards for interoperability between trucks, platoons and logistics solution providers, to speed up actual market pick-up of (sub)system development and implementation and to enable harmonisation of legal frameworks in the member states.

Project website: https://platooningensemble.eu

https://www.tno.nl/en/about-tno/news/2018/2/multi-brand-truck-platooning-will-become-a-reality-in-europe-thanks-to-the-eu-co-funded-ensemble-project/

Fabulos - Future Automated Bus Urban Level Operation Systems

The FABULOS (Future Automated Bus Urban Level Operation Systems) project focuses on how cities can use automated buses in a systematic way. The goal is to procure the operations of an autonomous bus line. Self-driving minibuses have already been tested in technical demonstrations in various countries, but a proof-of-concept for the management of autonomous fleets as part of the public transportation provision is not yet available.

Furthermore, some parts of the driving automation need to reach a more mature stage in their development in order to be employable in normal urban settings, such as open roads. In other words, a demonstration of the economic, technical, societal and legal maturity of the solution needs is required. This should be carried out in a real-life setting, integrating automated minibuses into the public transportation ecosystem.

The six partner cities are embracing this challenge by collectively procuring R&D for the prototyping and testing of smart systems that are capable of operating a fleet of self-driving minibuses in urban environments. These solutions should be all-inclusive: software, hardware, fleet and services. The cities play an important role by combining their efforts in supporting the market to develop such systems. This kind of intelligent transportation system and integrated transportation approach is key to facilitating the sustainable development of public transportation and for cities to be able to become car-free in the foreseeable future.

https://fabulos.eu/

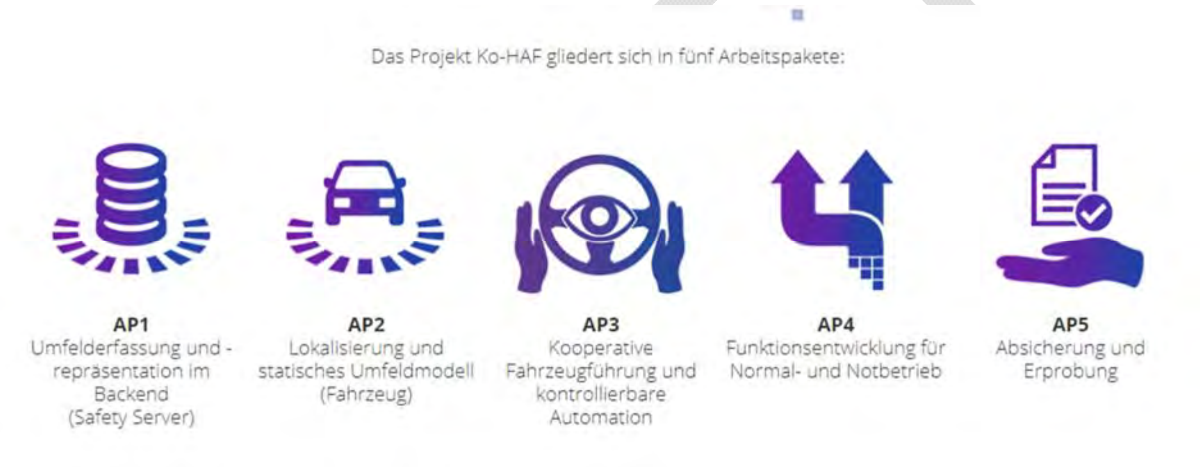
Ko-Haf

Main goal: make sure that human machine interaction goes smoothly

Driver needs time to switch from another task to driving, so the car needs to recognise the environment and traffic situation for this time at least

Other aims of the Ko-HAF project

- precise self-localization necessary for the fusion of the information provided by the Safety Server and the data determined by the vehicle's own sensor system
- the involvement of the driver in the highly automated system
- the functional enhancements for highly automated driving including emergency operations
- the protection and testing of the entire system.



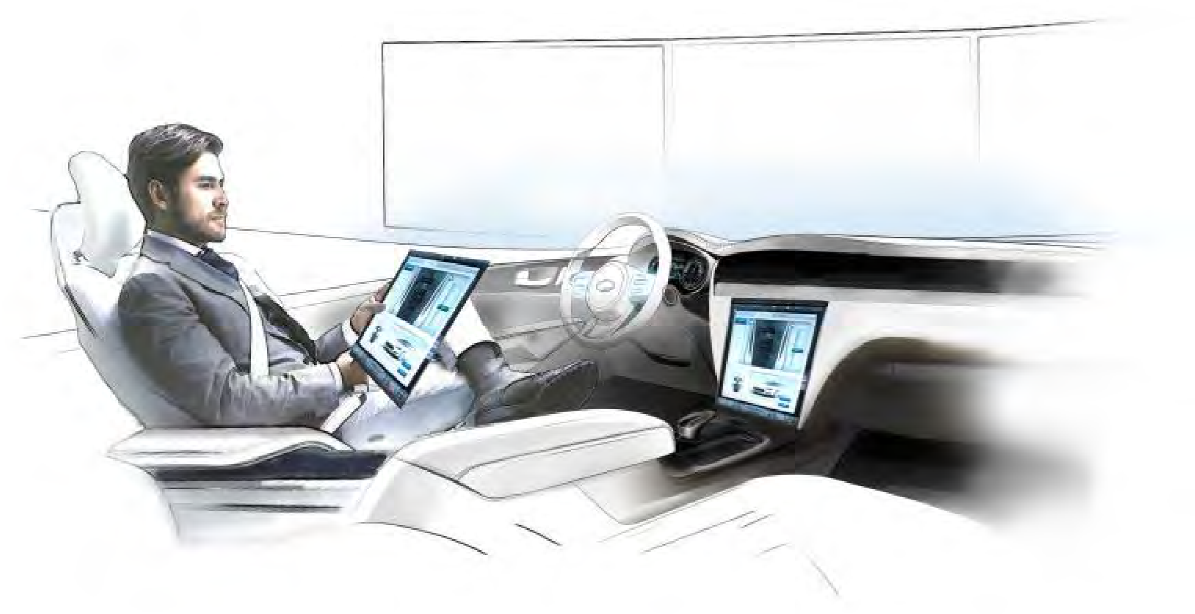
https://www.ko-haf.de/startseite/

Brave - Multiple locations in Europe, 2017-20

The main objective in BRAVE is to improve safety and market adoption of automated vehicles, by considering the needs and requirements of the users, other road users concerned (drivers and vulnerable road users) and relevant stakeholders (i.e. policy makers, standardisation bodies, certifiers, insurance companies, driving schools), assuring safe integration of key enabling technology advancements while being fully compliant with the Public deliverables. BRAVE will support a fast introduction of automated driving by assuring the acceptance of all relevant users, other road users affected and stakeholders.

European Union’s Horizon 2020, grant agreement No 723021

http://www.brave-project.eu



CoExist - Multiple locations in Europe, 2017-20

The mission of CoEXist is to systematically increase the capacity of road authorities of getting ready for the transition towards a shared road network with increasing levels of automated vehicles (AVs), both in terms of vehicle penetration rates and levels of automation using the same road network as conventional vehicles (CVs).

CoEXist will enable mobility stakeholders to get "AV-ready" – which CoEXist defines as conducting transport and infrastructure planning for automated vehicles in the same comprehensive manner as for existing modes such as conventional vehicles, public transport, pedestrians and cyclists, while ensuring continued support for conventional vehicles on the same network.

Belgium, France, Germany, Italy, Netherlands, Sweden, United Kingdom

http://www.rupprecht-consult.eu/nc/projects/projects-details/project/coexist.html

CoEXist

InfraMix - Multiple locations in Europe, 2017-20

INFRAMIX is preparing the road infrastructure to support the transition period and the coexistence of conventional and automated vehicles. Its main target is to design, upgrade, adapt and test both physical and digital elements of the road infrastructure, ensuring an uninterrupted, predictable, safe and efficient traffic.

To meet this high level objective INFRAMIX is working on different technologies. It starts with the use of mature simulation tools adapted to the peculiarities of automated vehicles and develops new methods for traffic flow modelling, to study the traffic-level influence of different levels of automated vehicles in different penetration rates. It also implements relevant traffic estimation and control algorithms dynamically adapted to the current situation. Then it proposes minimum, targeted and affordable adaptations on elements of the road infrastructure, either physical or digital or a combination of them. This work includes ways of informing all types of vehicles about the control commands issued by the road operator and the proposal of new kind of visual and electronic signals for the needs of mixed scenarios.

http://www.inframix.eu/

MERIDIAN

MERIDIAN, funded jointly by the government's flagship £100m CAV investment programme and by industry, will create a cluster of excellence in driverless car testing, along the M40 corridor between Coventry and London, to accelerate the development of this technology, grow intellectual capital and attract overseas investment in the UK.
A key part of the Industrial Strategy commitment to develop world-class CAV testing facilities and infrastructure, the launch of the MERIDIAN brand follows a call for evidence by the Centre of Connected and Autonomous Vehicles (CCAV) in May 2016 into how the UK can integrate and strengthen its CAV testing facilities and to consider the case for a test bed to provide a focus for the industry.

https://www.gov.uk/government/news/government-launches-meridian-to-accelerate-connected-autonomous-vehicle-technology-development-in-the-uk

CONCORDA

The CONCORDA (Connected Corridor for Driving Automation) project contributes to the preparation of European motorways for automated driving and high density truck platooning. The main objective of the project is to assess the performance of hybrid communication systems, combining 802.11p and LTE connectivity, under real traffic situations.
CONCORDA paves the way for solutions based on the combination of connectivity and infrastructure that will help build the vehicle's environmental perception model. Moreover, the project aims to aid in the improvement of accuracy and integrity of the localisation services.
The CONCORDA project will commence based on common application specifications that will be updated during the project in an iterative manner (during the pilot operation according to evaluations and lessons learned) and in cooperation with C-Roads. New standards, or evolutions of existing standards, will be proposed as a result of this process.
CONCORDA will have test sites in the Netherlands, Belgium, Germany, France, and Spain. Interoperability and continuity of services will be applied on all test sites, aiming at EU-wide interoperability of services. Vehicles will be equipped with COM boxes and C-V2X chipsets.

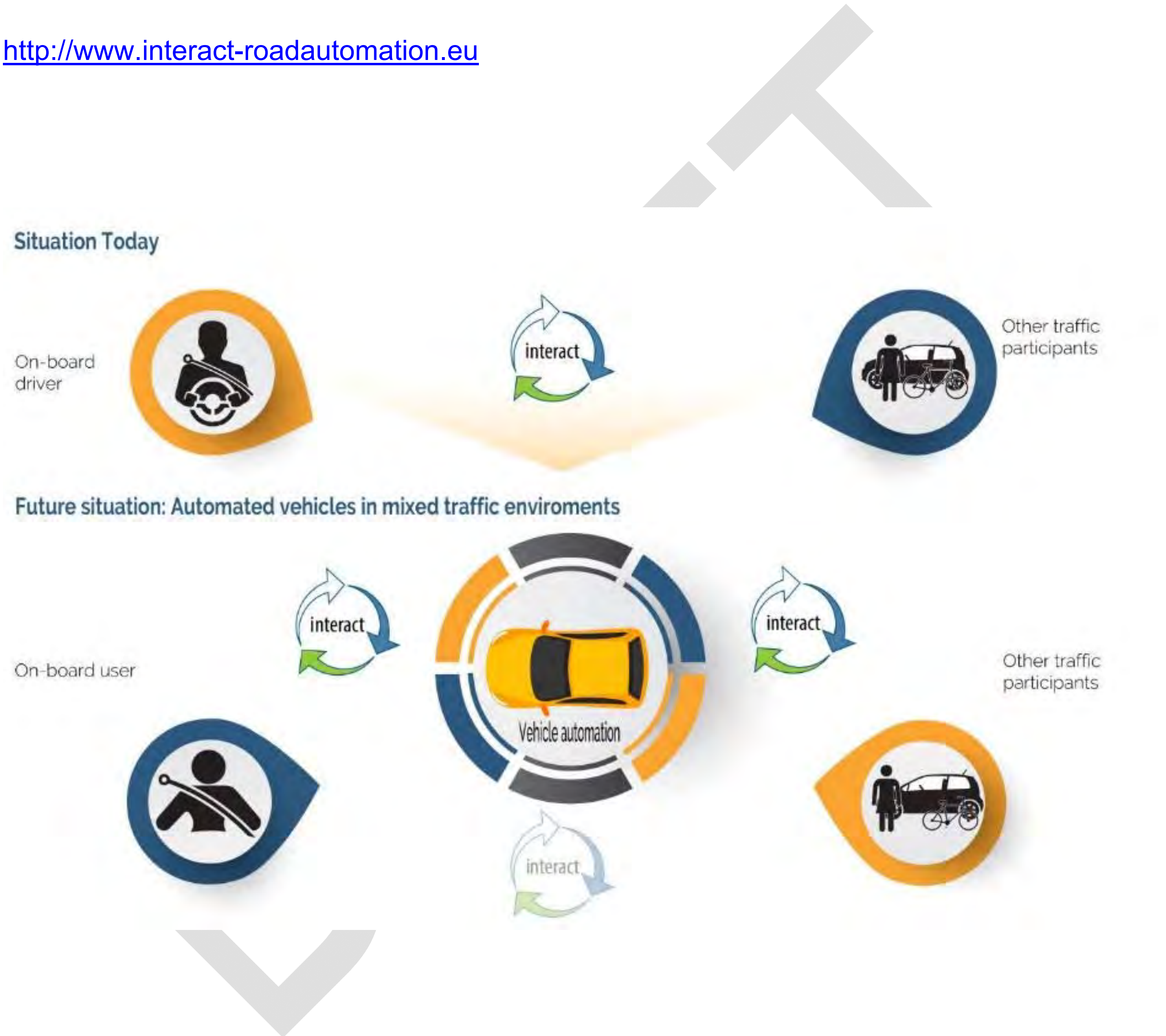
http://erticonetwork.com/new-project-driving-automation-kick-off-brussels/

interACT - Multiple locations in Europe, 2017-20

As Automated Vehicles (AVs) will be deployed in mixed traffic, they need to interact safely and efficiently with other traffic participants. The interACT project will be working towards the safe integration of AVs into mixed traffic environments. In order to do so, interACT will analyse todays' human-human interaction strategies, and implement and evaluate solutions for safe, cooperative, and intuitive interactions between AVs and both their on-board driver and other traffic participants.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723395.

http://www.interact-roadautomation.eu



TrustVehicle - Multiple locations in Europe, 2017-19

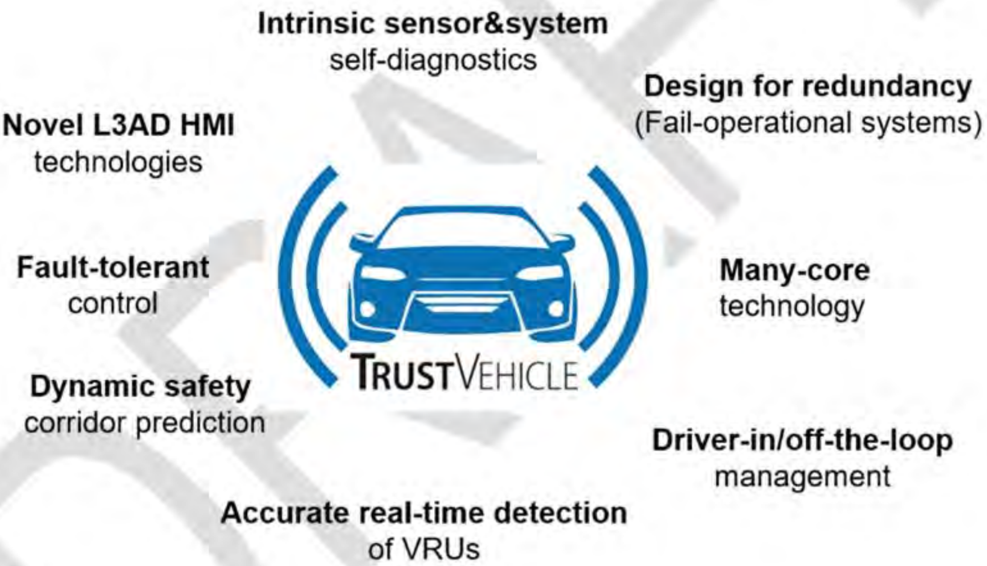
TrustVehicle aims at advancing L3AD functions in normal operation and in critical situations (active safety) in mixed traffic scenarios and even under harsh environmental conditions. TrustVehicle follows a user-centric approach and will provide solutions that will significantly increase reliability and trustworthiness of automated vehicles and hence, contribute to end-user acceptance.

Improved Trustworthiness and Weather-Independence of Conditionally Automated Vehicles in Mixed Traffic Scenarios

Call: ART-04-2016 – Safety and end-user acceptance aspects of road automation in the transition ; Project Coordinator: Dr. Daniel Watzenig

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723324.

http://www.trustvehicle.eu



TransAid- Multiple locations in Europe, 2017-20

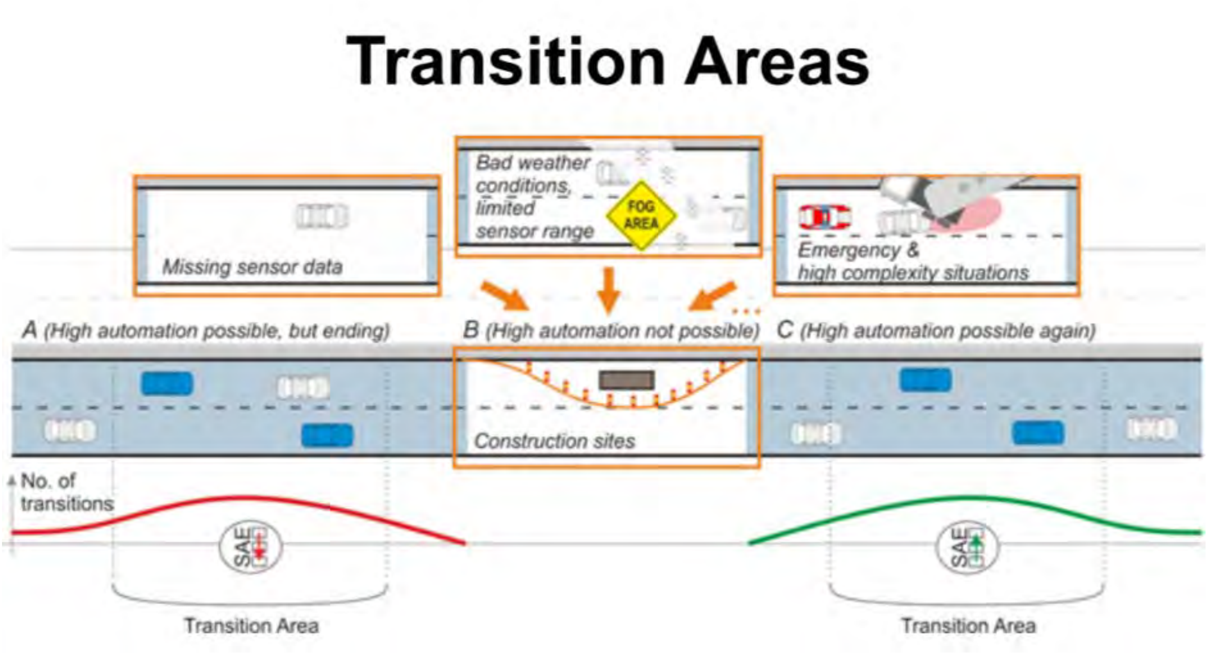
As the introduction of automated vehicles becomes feasible, even in urban areas, it is necessary to investigate their impacts on traffic safety and efficiency. This is particularly true during the early stages of market introduction, where automated vehicles of all SAE levels, connected vehicles (able to communicate via V2X), and conventional vehicles share the same roads with varying penetration rates.

There will be areas and situations on the roads where high automation can be granted, and others where it is not allowed or not possible due to missing sensor inputs, high complexity situations, ... At these areas many automated vehicles will change their level of automation. We refer to these areas as “Transition Areas”.

TransAID develops and demonstrates traffic management procedures and protocols to enable smooth coexistence of automated, connected, and conventional vehicles, especially at Transition Areas. A hierarchical approach is followed where control actions are implemented at different layers including centralised traffic management, infrastructure, and vehicles.

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 723390. Coordinator: DLR, Germany

https://www.transaid.eu/



AutoNet2030 – Sweden – 2013

Procedures of a cooperative automated driving technology which is based on a decentralized decision making strategy. This technology works with a sharing of mutual information between nearby vehicles. The project is set to 2020-2030 deployment time horizon, always taking into account the expected preceding introduction of the sensor based lane-keeping and cruise control technologies.

Objectives

- Specifications of V2X messages for automated driving, also feeding ETSI ITS standardization
- Development of maneuvering control algorithms for cooperative vehicle automation
- Development of cost-effective on-board architecture for integrated sensing and communications
- Development of a new HMI facilitating the interaction between manually driven and automated vehicles

http://www.autonet2030.eu/

i-Game – EU, 2013 – 2016

i-GAME is an international project in which the next step is being taken towards the cooperative automation of vehicles. The i-GAME project is an applied research approach that employs a combination of research and demonstration in the interoperable exchange of messages (vehicle-to-vehicle and vehicle-to-infrastructure communication) in a standardized way.

Partners:

1. TNO
2. Technische Universiteit Eindhoven (TU/e)
3. Spaanse IDIADA
4. Viktoria Swedish ICT

Reference Group:

1. Scania
2. Volvo Car Corporation,
3. Volvo AB
4. INRIA
5. NXP
6. ETSI
7. Broadbit
8. Ertico
9. CLEPA
10. DAF
11. EARPA
12. Hitachi

http://www.gcdc.net/en/

DAVI – Netherlands, 2013

Dutch initiative to investigate, improve and demonstrate automated driving on public roads. Includes both Dutch and international partners. public sector, private sector, and academic partners. For this purpose, DAVI will develop automated vehicles equipped with all necessary technologies that enable the vehicle drive in automated mode on public roads.

http://davi.connekt.nl/

HAVE-it – EU, 2008

HAVE-it – Highly Automated Vehicles for Intelligent Transport (HAVE-it) was a FP7 project which was aimed at realising highly automated driving for intelligent transport. The project began in February 2008 and ran until June 2011 and involved Continental, Haldex, Volkswagen and Volvo as well as SMEs, research institutes and universities. Driver awareness, optimised task repartition between the driver and the system and misuse are examples of focus areas of the study. The HMI concept developed in the project was considered as an enabler for integration of highly automated driving functions with then existing driver assistance systems. The final event included seven demonstration vehicles.


http://www.haveit-eu.org/displayITM1.asp?ITMID=6&LANG=EN

Overview test sites

This chapter gives an overview of CAD test sites

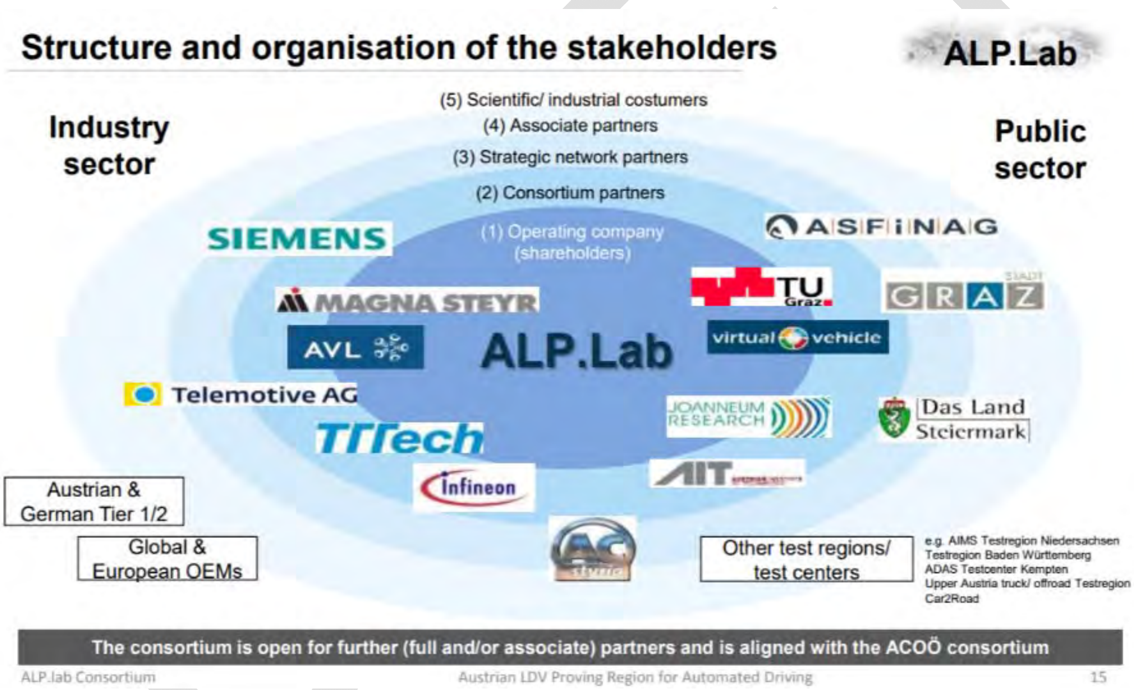
Organization/country	Country	open	title	online
Austria ALP.Lab	AT	2016	Austrian LDV Proving Region for Automated Driving	link
Austria DigiTrans - Logistics	AT			link link
A9 Digitale Autobahn	DE	2015	Ministry of Transport and Digital Infrastructure (BMVI),	link link link
CARNET	ES		Barcelona, Spain	link
Aurora Snowbox	FI		Fell Lapland, Finland	link link
AstaZero	SE		Sweden	link
UK CITE	UK	2016-18	Coventry-Milton Keynes UK	link
UK Autodrive	UK	2015-18	Coventry-Milton Keynes UK	link
Kista	SE	2016	Sweden	link
Singapore	SG	2016	One-North, Singapore	link
Korea	KR		K-City	link
Pennsylvania	US		PennSTART	link
Texas	US		Texas AV Proving Ground Partnership	link
ACM Willow Run	US		American Centre for Mobility at Willow Run	link
CCTA & GoMentum Station	US		CCTA & GoMentum Station	link
ICADG	US		Iowa City Area Development Group	link
University	US		University of Wisconsin – Madison	link
CFAVP	US		Central Florida Automated Vehicle Partners	link
Baden-Würtemberg	DE	May 2018	Testfeld autonomes Fahren Baden-Würtemberg	link
Niedersachsen	DE		Testfeld Niedersachsen	link
Helmond, The Netherlands	NL	2011	Helmond Smart Mobility Living Lab: A270 Testbed and Prescan virtual testing	link link
Austria	AT		Austrian Light Vehicle Proving Region for Automated Driving	link

Austria ALP.Lab, 2016

ALP.Lab facilities:

- Model in the loop; software in the loop
- Hardware in th eloop
- Driving Cube: powertrain TestBed
- Proving Ground Test
- Public Road Test (test field)
- Asfinag vehicle sensors& DTI

https://connectedautomateddriving.eu/wp-content/uploads/2017/02/AT-Presentation-Workshop-16.12.2016.pdf



Austria DigiTrans - Logistics

Test region for automated and connected driving that address the requirements from industry and manufacturing in a sustainable and effective user-centered fashion

- Specific support for logistics- & freight use cases and applications (incl. Logistic chain integration)
- Development platform(s) for automated logistic services
- Implementation of freight specific infrastructures
- Freight Specific test procedures (safety, liability, acceptance)

https://connectedautomateddriving.eu/wp-content/uploads/2017/02/AT-Presentation-Workshop-16.12.2016.pdf

http://www.testregion-digitrans.at/

A9 Digitale Autobahn, 2015

- Currently test vehicles from Audi, Mercedes and BMW
- The use of the digital test field motorway for automated and networked driving is open to all interested companies and research facilities
- The testing of automated driving systems in real operation: For this drive highly automated cars autonomously on the DTA . Even truck -Platoons, where several trucks from the first vehicle be remote controlled, are on the A9 in Bayern on the way
- The centimeter-accurate detection of the digital test field as a digital HD card, with which automated vehicles can be controlled very precisely over the road
- Ministry of Transport and Digital Infrastructure (BMVI), Infineon and Siemens Audi, Mercedes and BMW Continental, Deutsche Telekom AG, Fraunhofer ESK and Nokia

http://www.bmvi.de/DE/DigitalesUndRaumentwicklung/DigitalUndMobil/DigitalesTestfeldAutobahn/digitales-testfeld-autobahn_node.html

http://www.siemens.com/innovation/en/home/pictures-of-the-future/mobility-and-motors/urban-mobility-radar-technology-for-highways.html

https://www.telekom.com/en/media/media-information/archive/continental--deutsche-telekom--fraunhofer-esk--and-nokia-networks-showcase-first-safety-applications-at--digital-a9-motorway-test-bed--362078

CARNET, Barcelona Spain

CARNET aims to solve the challenges of urban mobility, and focuses on innovative technologies and new mobility concepts and needs, which arise from potential future urban lifestyles.

In order to create new product solutions, CARNET wants to transform traditional concepts of the automotive product and technical development methods into cooperative approaches that bring together vehicle manufacturers, communities and potential service operators.

CARNET's general approach to urban mobility contributes to the vision of becoming a "lighthouse" region for the development and demonstration of future mobility technologies.

Cooperative Automotive Research Network

SEAT, Volkswagen Group Research and the Universitat Politècnica de Catalunya (UPC)

http://www.carnet.barcelona/

Aurora Snowbox, Finland

- From autonomous driving to snowtonomous driving
- Situated above the Arctic circle
- Test on safe and secured tracks closed from traffic and suitable even for early phase prototype testing
- Tests can be carried out also among other traffic as current Finnish legislation already facilitates advanced automation on public roads
- The Aurora test ecosystem is designed for verifying and validating new ITS solutions and innovations in real extreme weather conditions.

http://www.liikennevirasto.fi/web/en/e8-aurora#.WDbolJbhBhE

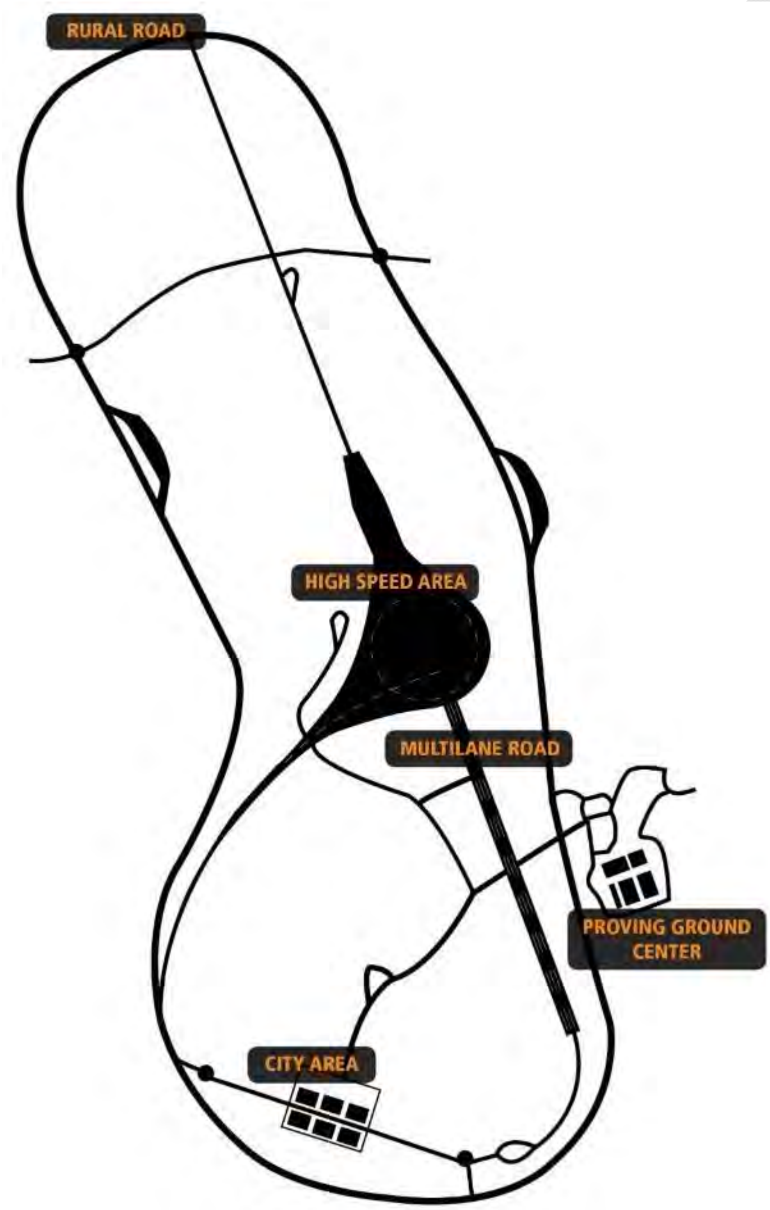
http://www.trafi.fi/en/road/automated_vehicle_trials

AstaZero, Sweden

SP, Technical Research Institute of Sweden and Chalmers University of Technology and partners and contributory financiers are, AB Volvo, Volvo Car Corporation, Autoliv, Scania, The Swedish Transport Administration, Region Västra Götaland, Vinnova, Tillväxtverket and Test Site Sweden

- Test environments:
    - rural road
    - high speed area
    - city area
    - multilane road

http://www.astazero.com/



UK Cite, 2016

40 miles of urban roads, dual-carriageways and motorways with five different types of roads and junctions

Visteon Engineering Services Limited, Jaguar Land Rover Ltd, Coventry City Council, Coventry University, Highways England Company Ltd, HORIBA MIRA, Huawei Technologies (UK) Co Ltd, Siemens PLC, Vodafone Group Services Ltd and WMG at University of Warwick

- A project to create the most advanced environment for testing connected and autonomous vehicles.
- It involves equipping over 40 miles of urban roads, dual-carriageways and motorways with combinations of three “talking car technologies” and testing for a fourth, known as LTE-V.
- The project will establish how this technology can improve journeys; reduce traffic congestion; and provide entertainment and safety services through better connectivity.

https://www.ukcite.co.uk/

UK AUtodrive, 2015

- Milton Keynes and Coventry will host the UK Autodrive programme. Among other parties, this involves Ford, Jaguar Land Rover and the engineering consultancy Arup and will test both selfdrive cars on the road as well as self-driving pods designed for pedestrian areas. Part of this group's work will be to develop the technologies that will need to be built into roads and the surrounding infrastructure to aid vehicle navigation.
- Aims:
    - Validate driverless technology
    - Develop interoperability of technologies and interaction with other road users
    - Demonstrate how solutions can be scaled to different city / town infrastructures
    - Increase public and awareness and acceptance of driverless vehicles
    - Promote zero-emission urban vehicle technology
    - Develop new business models for new mobility services
    - Position the UK as a world leader and global hub for technology development
- First tests just finished (October 2016)
- LUTZ Pathfinder programme is overseeing a trial of 3 autonomous pods in Milton Keynes. Goal is 40 pods.
  The pavement-based pods are designed to operate completely autonomously. By the end of the programme the pods will be used to demonstrate a small-scale public transport system in Milton Keynes.
- 7 “regular” passenger M1 class cars.
  The M1 vehicles will be trialling technologies that offer ever-increasing levels of automation and driver assistance with the aim of reaching fully autonomous operation in some controlled circumstances. Some of the cars in the road-based trials will be used to demonstrate car-to-car and car-to-infrastructure communications systems, rather than autonomous systems.

http://www.ukautodrive.com/

Kista – Sweden, 2016

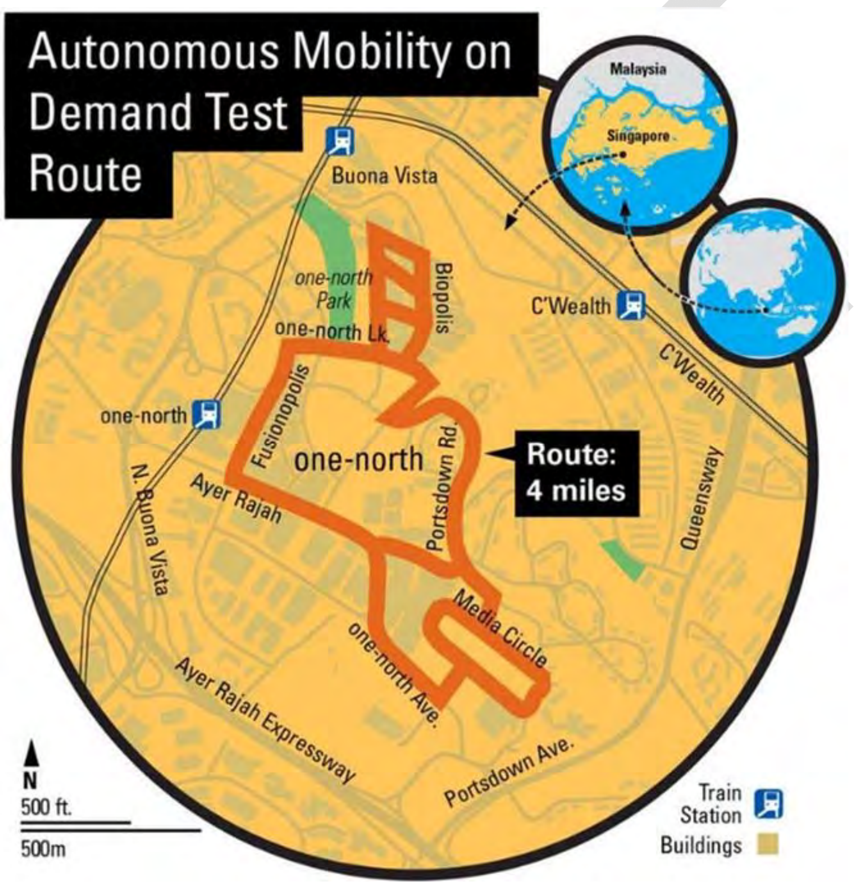
Kista Science City is the largest Information and Communication Technology (ICT) cluster in Europe and the third largest ICT cluster in the world.

http://www.urbanictarena.se/smart-self-driving-buses-start-operating-kista-today/

One-North

Land Transport Authority (LTA), JTC, Delphi Automotive Systems, nuTonomy

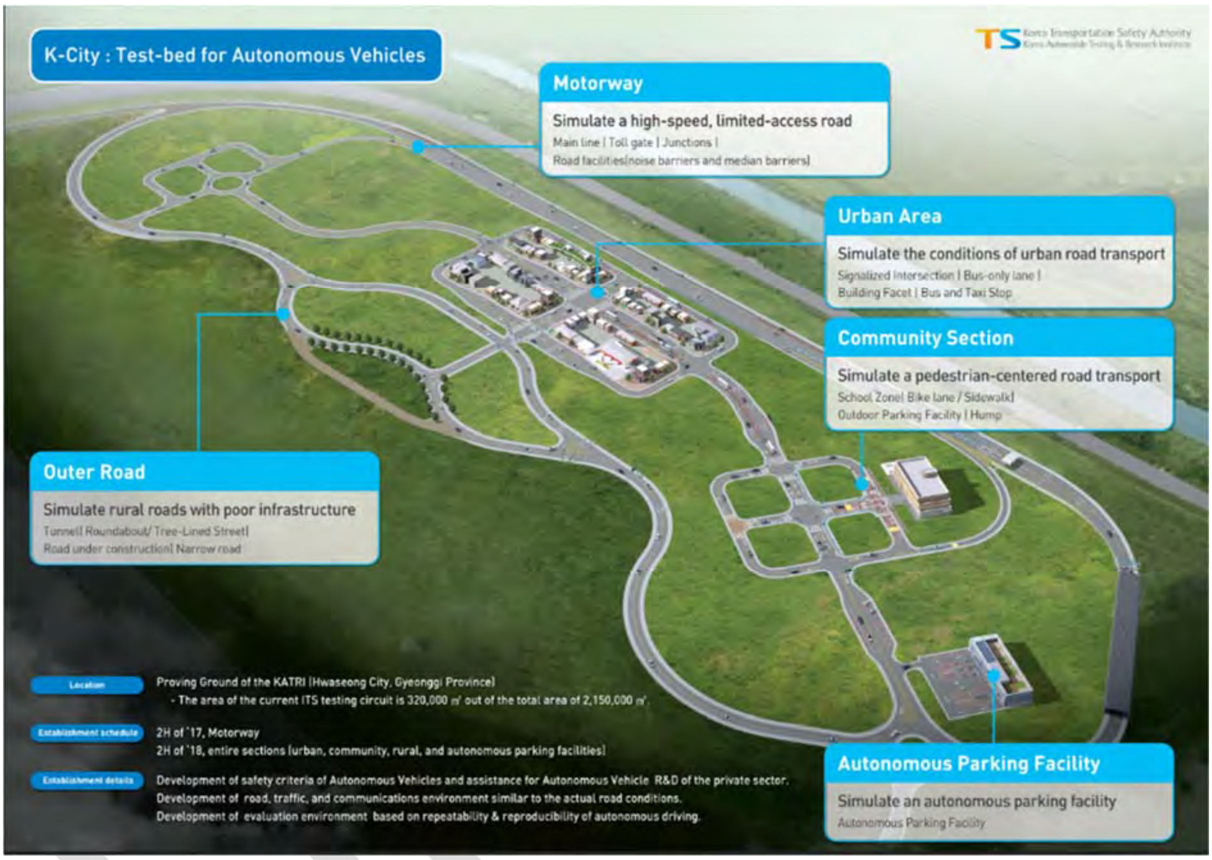
- Four distinct local and international parties carrying out regular autonomous vehicle on-road testing
- Public roads
- Distance: 12km
- CCTVs, DSRC beacons,
- Delphi: five shared SDVs for first-and-last-mile travel
- nuTonomy: fleet of vehicles in 2018



https://www.lta.gov.sg/apps/news/page.aspx?c=2&id=9fc4a578-094c-4e70-84f2-d598784a3058
https://www.lta.gov.sg/apps/news/page.aspx?c=2&id=73057d63-d07a-4229-87af-f957c7f89a27

K-City – South Korea

- Worlds largest test bed (360.000 m2)
- equipped with bus-only lanes, expressways, zones for autonomous parking and so on
- possibility to repeat same situation several times to test improvements (which is impossible in real traffic)



https://www.want.nl/k-city-testcircuit-zelfrijdende-autos/

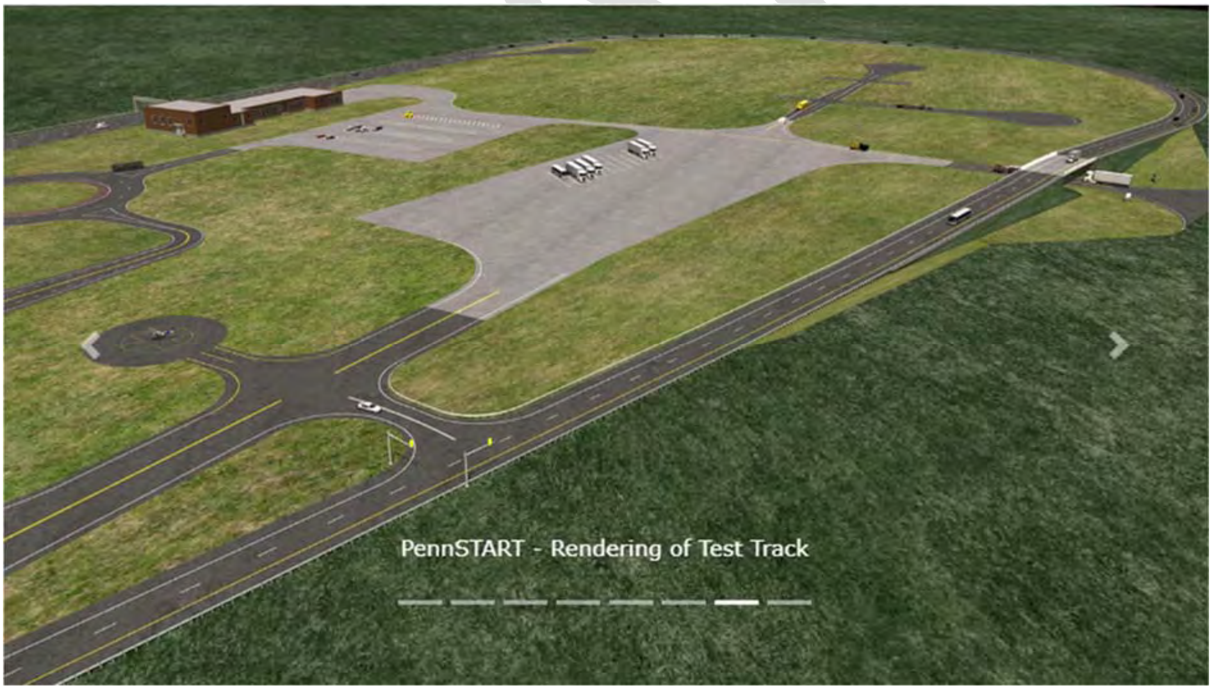
PennSTART – Pensylvania

Pennsylvania Safety Transportation and Research Track

state-of-the-art facility that will benefit emergency transponders, transportation organizations and research institutions

Examples of technologies for which safety and operational testing, as well as training, could be conducted:

- TIM training;
- Testing and hands-on training for new ITS, tolling, and signal equipment;
- Safe, simulated training for higher-speed and mobile work-zone operations;
- Safety certification training opportunities;
- Simulated environments for temporary traffic control device testing and evaluation;
- Smart truck-parking applications and other opportunities for commercial vehicle technology partnerships; and
- Controlled environments to test various connected and automated vehicle technologies for infrastructure equipment, fleets, and other applications.



https://pennstart.org/

Texas AV Proving Grounds Partnership

- network of proving grounds and test bed sites
- three premier research entities: The Texas A&M University System (TAMUS), The University of Texas at Austin (UT), and Southwest Research Institute (SwRI).
- urban and freight test sites supported by local stakeholders in each region

Main purposes:

1. be a resource to USDOT on AV technology
2. provide a network of testing sites for public and private entities interested in researching, developing, testing, and verifying AV technologies
3. be an AV information sharing network. The Partnership offers the USDOT multiple proving facilities with a diversity to test a range of applications and a collaborative alliance who are dedicated to openly sharing best practices.

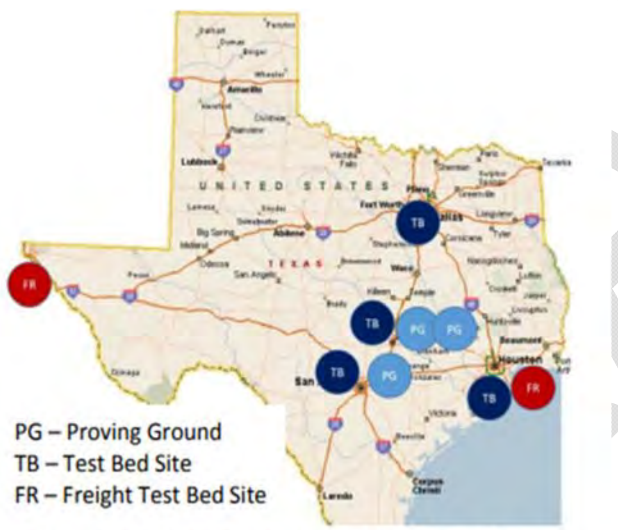
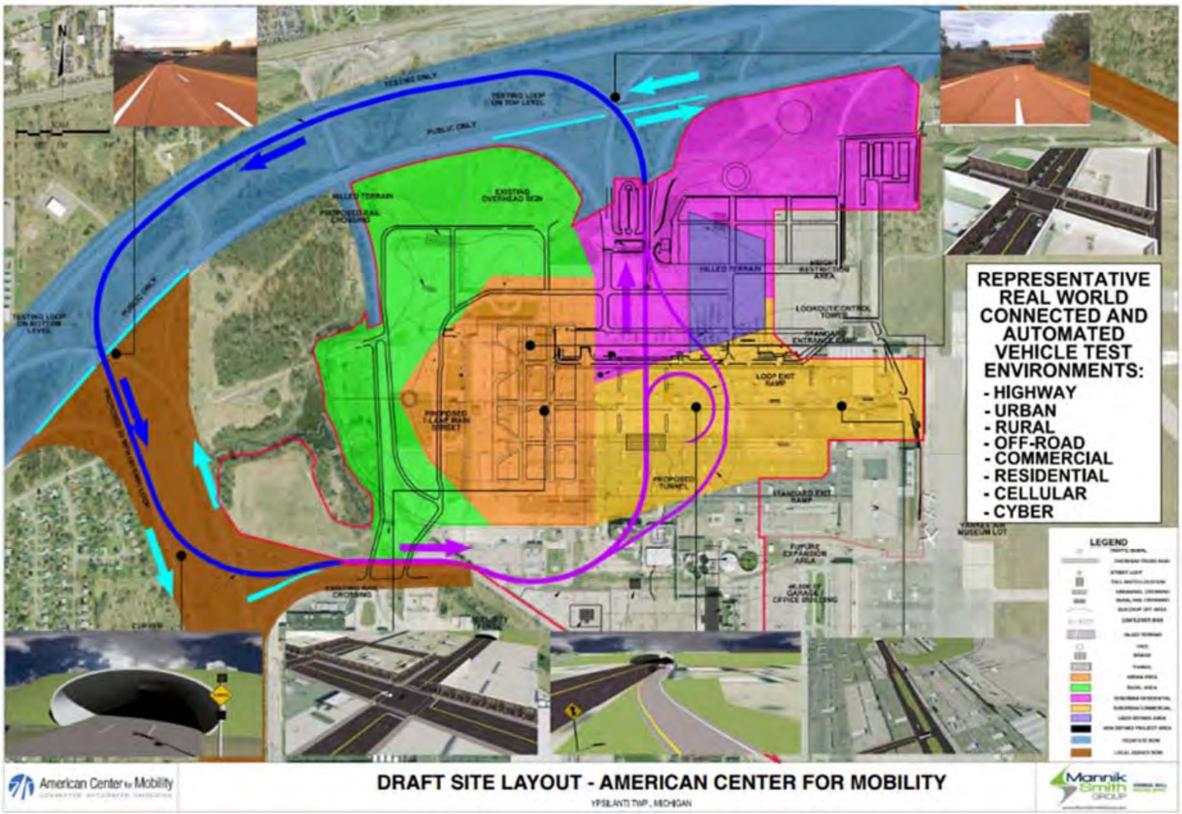


Figure 1. Texas AV Proving Grounds and Test Sites

https://groups.tti.tamu.edu/connected-vehicles/files/2014/02/Texas-AV-Proving-Ground-Partnership-Proposal-12192016-Final-updated.pdf

American Center for Mobility (ACM) at Willow Run

- non-profit testing and product development facility for future mobility
- designed to enable safe validation of connected and automated vehicle technology, and accelerate the development of voluntary standards.



http://www.acmwillowrun.org/

Contra Costa Transportation Authority (CCTA) & GoMentum Station

- create a stronger economic future for Contra Costa County by building partnerships that make transportation safer, more reliable and increasingly efficient.
- Rather than exclusively trying to “build our way” out of congestion, CCTA’s vision centers around the use of emerging technologies and public-private partnerships to meet transportation demands and reduce greenhouse gas emissions in Contra Costa County.
- the nation’s largest secure testing facility for autonomous and connected vehicle technology
- GoMentum Station’s unique and varied terrain and infrastructure allows for the latest developments in transportation technology to be safely tested in similar conditions found on public streets.
- Located in the San Francisco Bay Area enables easy access to the world’s top technology companies.
- GoMentum Station is built on a public/private partnership model, allowing the private sector space to innovate and test and allowing the public sector to have access to new technologies as they are being developed. This helps facilitate informed policy, regulation and planning decisions.
- Research and testing at GoMentum Station currently includes private, shared, and commercial vehicles, in a multimodal environment.

Strategy centered on:

- Creating jobs to increase the region’s economic competitiveness
- Partnering with our communities to improve safety, mobility and the environment
- Creating a world-class CV/AV test bed with active industry and government participation

http://gomentumstation.net/

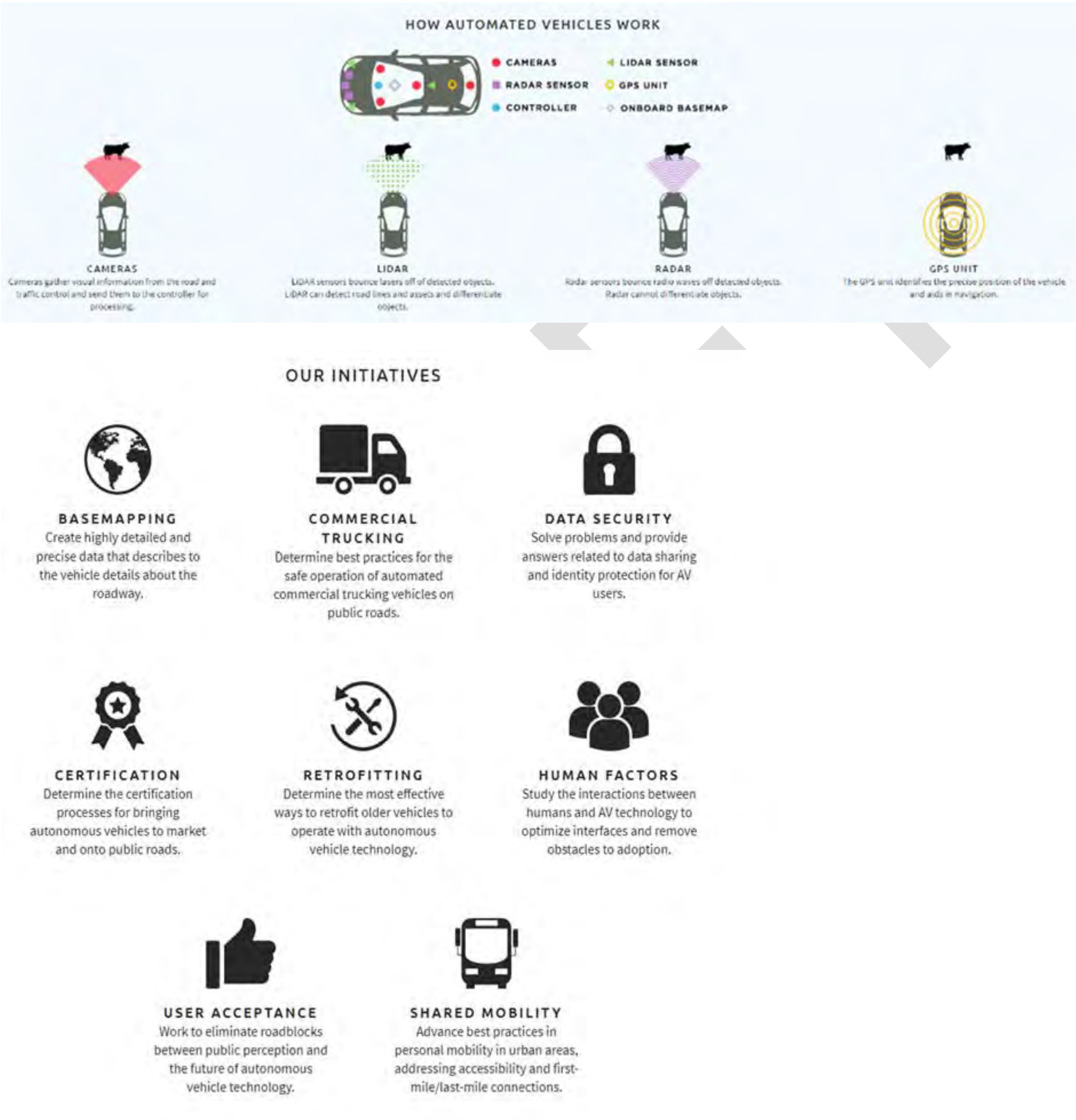
Iowa City Area Development Group

- National Advanced Driving Simulator and
- the University of Iowa, a world-class research university with global-leading experience in Human Factors, Vehicle Safety, and Computer Simulation and Modeling.
- The Iowa City area allows you the greatest freedom for testing and operations. We offer real-world testing variables, including weather, terrain and surface conditions.
- Access to virtual testing at the University of Iowa National Advanced Driving Simulator
- Access to on-road testing throughout Johnson County
- Access to closed course testing
- Strategic linkages to a host of engineering resources, insurance providers and transportation fleets
- Research collaborations with the University of Iowa
- Help with SBIR/STTR programs and project development
- Access to public and private investment capital

http://www.iowacityareadevelopment.com/about/autonomous.aspx

University of Wisconsin – Madison

- provide a path to public road evaluation by contributing to the safe and rapid advancement of automated vehicle development and deployment,
- providing a full suite of test environments, coupled with research, open data, and stakeholder communication.
- paramount safety, followed by best practice tenets of security and open data.



https://wiscav.org/

Central Florida Automated Vehicle Partners

An alliance of Florida's resources to shape the future of mobility and transportation

Five models of travel:

1. Automotives
2. Freight
3. Transit
4. Bike-ped
5. Space

SunTrax testing site

- includes a 2.25-mile, oval track on a 400-acre site in Polk County, centrally located between Tampa and Orlando.
- multiple scenarios such as single lane, multiple lanes, and parallel toll and express lanes
- the infield of the track will be dedicated to controlled automated and connected vehicle (CV) testing for arterial environments

Driver Assisted Truck Platooning (DATP)

- includes a study and pilot test that will run truck platoons using proven and safe connected V2V technology in a 143-mile segment of the Turnpike Mainline (SR 91) from Orlando to Palm Beach
- one of the segments of the Turnpike System with the largest movements of trucks

http://centralfloridaavpg.com/

Testfeld Autonomes Fahren Baden-Württemberg, 2018

- 2,5 miljoen Euro
- opportunity for businesses and research institutes to test technologies and services
- making sure legal preconditions are met

https://taf-bw.de/

Testfeld Niedersachsen

- Testfield for automated and connected driving
- 280km track
- parts of the A2, A7, A39, A391, B3, B6 en B243 as well as parts of the city of Brunswick

http://www.mw.niedersachsen.de/aktuelles/presseinformationen/autonomes-fahren---startschuss-fuer-das-testfeld-niedersachsen-151791.html

Helmond Smart Mobility Living LAB, The Netherlands

As part of the Helmond Smart mobility Living LAB the TASS International A270 testbed and PreScan virtual testing toolsuite are unique testing environments for the development of automated and connected driving, which is pivotal in the positioning of The Netherlands as the test location for Automated Driving testing. Our motivation to join the SMTE partnership is to attract more businesses to The Netherlands for their testing activities.

The TASS International A270 testbed has been used in many field operational tests in the past 6 years. European and National research projects have demonstrated their proof-of-concepts with the help of our facilities, which are focused on vehicle localization, timing and communication between vehicles and infrastructure. Also OEMs and TIERs have tested their sensing and actuating (sub)systems for Automated and Connected Driving.

The TASS International PreScan virtual testing toolsuite is used by the majority of the industry that is developing ADAS and Automated Driving systems to virtually design and test the perception and control algorithms for these vehicles.

Facilities:

- 6 km highway, 2 km urban road & 2 traffic light controllers
- 20 ITS G5 roadside units (802.11p)
- 56 cameras for real-time vehicle detection and tracking
- 11 dome cameras
- 3G Communication
- Integration of your party hardware and software systems for testing
- Control room, laboratory &simulation toolsuite
- Test fleet: Instrumented vehicles with extendable in-car platforms; Vehicles with radar, camera, lidar; DSRC, GPS, 3G; Software toolkit to rapidly create and test application software

https://www.smartmobilityembassy.nl/a270-testbed-and-prescan-virtual-testing/

https://www.drivenbyhelmond.nl/business-portal/helmond-living-lab

Austrian Light Vehicle Proving Region for Automated Driving

Testing environment created by an alliance of automotive supplier companies (AVL, Magna) and scientific partners (Joanneum Research, TU Graz, Virtual Vehicle)

Including:

- public roads,
- proving grounds
- facilities for data recording and processing
- comprehensive virtual testing environment
- unique test laboratory

https://www.alp-lab.at/

Initial analysis: implications for governments and road operators

[hieronder de eerste analyse die Jaap destijds heft gemaakt op basis van de eerste roadmaps]

General

- Public awareness and acceptance
- Common definitions of connected and automated driving
- The expansion to other modes of transport and the interfaces between the various modes of transport
- The integration of electrical and environmentally efficient drive systems

Collaboration

- For a targeted European action it is fundamental that the Commission takes a leadership role the approach towards an introduction of automated to fully automated vehicles. The respective DGs of the European Commission and the involved stakeholders should collaborate in developing a joint implementation strategy e.g. in the framework of the Strategic Transport Technology Plan (STTP).
- Actions by European Commission
    - Develop European strategy
    - Continuation of C-ITS platform
    - Adapt EU regulatory framework
    - Research and innovation activities
- Moreover, there is a significant need for creating synergies between involved sectors (i.e. vehicle manufacturers, energy, communication services and providers, transport, IT and smart systems sectors, as well as users) that are coming together in the novel value chains for auto-mated vehicles.
- The industry, utilities, infrastructure providers, academia and public authorities should join their efforts in specific Public-Private Partnership and joint programs horizontally covering all aspects of automated driving including re-search and innovation. These should be supported by targeted coordination and support actions, e.g. on technology transfer from robotics and semiconductor technologies, or on the assessment of global value chains in automated driving from a European perspective.
- International cooperation, stronger international networking and collaboration
- Dissemination and communication of the results and impacts of the application scenarios
- Create a network of expertise to share knowledge and experiences, and to enable developers to work together, rather than compete

Legal issues

- Liability
- Regulatory law
    - Coherent international, European and national rules
    - The continuous adaptation of the legal framework in close coordination with international legislation
    - Amend Vienna convention, definition of driver
    - Increase max speed automated driving and allow automated lane change, steering equipment
    - Review and adapt national regulation: facilitate driver → system control
    - Learner driver training regulations and driver licensing regulations
    - Definition of the AV
    - Permission of tentatively driving the AV on the public roads only for testing

- Procedures to request tentative driving the AV
  - AV requirements for safe-driving conditions
  - AV limited to the passenger cars
  - AV functions controlled by driver
  - AV malfunction detected and warned automatically
  - AV required of installing the driving recording device
  - AV marked for notifying other drivers
  - AV tested only on designated roads
- Security
  - Develop/adopt guidelines (industry obligations) for protection against non-authorized external access
- Standardisation
  - V2V and V2I communication
- Ensure privacy and data protection
  - Influence data minimalization, purpose limitation, anonymization and pseudonymization techniques
- Certification and verification

Testing

- A vital obstacle that needs to be overcome is the lack of an appropriate legal framework for both testing and use of higher degrees of automated driving in Europe.
- Additional significant effort is required to create new concepts and test-systems for validation of complex AD system in simulated environments.
- Also Field Operational Tests are of the high importance particularly for showcasing safety, security and reliability of highly automated driving at SAE levels 3 and 4.

- Create appropriate testing areas with industry and academia
- Testing Roads designated for driving the AV
- Designation criteria
  - Consider both driving safety and testing efficiency
  - Consider homogenous physical design and easy maintenance

Broader societal issues

- access equality – optimising mobility for older people and people with disabilities
- education of end users, other road users and vulnerable road users
- impacts on traffic and congestion and network planning
- land use planning
- urban parking
- public transport demand
- ridesharing and taxi reform
- issues related to changing job opportunities
- environmental impacts, including the potential for higher carbon emissions resulting
- from highly intensive on-demand passenger services.

- Co-existence of automated vehicles with other road vehicles, including powered two wheelers and emergency vehicles

- The vehicle can safely manage:
  - responding to temporary speed zones (such as roadworks)
  - responding to traffic controls (such as stop signs, variable speed signs and traffic lights)
  - all likely road conditions (such as unsealed roads)
  - all likely environmental conditions (such as dust storms or flooding)

  - interaction with trains and light rail (such as railway level crossings)
  - interaction with vulnerable road users (such as compliance with one metre clearance for cyclists)

Infrastructure, operations and traffic management

- Infrastructure
  - Gradual deployment of road network for automated driving
  - Deployment of communication infrastructure
  - Availability of data from back-office systems
  - Location data for automated driving
  - Impact on traffic management strategies
  - Design guidelines for junctions
  - Railway level crossings
  - Movable roadside infrastructure (for roadworks, special events, etc.)
  - Guidelines and verification of road network for automated driving
  - Radio frequency allocations
  - Availability of communication infrastructure

- Road Superstructure and Equipment
  - Visibility and condition of road markings and traffic signs
  - Consequences on road structure and surface wear
  - Sensors or beacons embedded into road pavement
  - Posts and poles for guidance and positioning
  - Alternative routes and detours

- Services and Functions
  - Test areas
  - Impact assessment
  - Activation of and support for stakeholders in testing and piloting
  - Automation in travel chains
  - Required quality of real-time traffic information services
  - Test vehicles and fleets
  - Truck and bus platooning
- Requirements physical infrastructure not yet clear
- The infrastructure performance (visibility, state of repair, etc.) regarding traffic signs, signals and road markings to support higher levels of safe and reliable automated driving have to be recognised
- Nationally-consistent road network infrastructure, including temporary and electronic road signage
- Impact on asset management and maintenance planning need to be reduced to a minimum
- Higher levels of automated driving shall also be supported by adjustments of the existing road infrastructure, for example providing a simplified and logical environment that can support the vehicle to avoid situations of many stops (cross sections, pedestrians-/bicycle crossings, etc…).
- Additional information from other road users and from the infrastructure (connectivity, digital infrastructure) can increase the performance of automated driving

- Access to accurate and timely road infrastructure data, such as temporary speed zone data
- Make available traffic-related mobility and spatial data in open-source approach

- Types and quality of
  - the physical infrastructure

  - the digital infrastructure
  - the traffic management/ control/ information centres
  - real-time information systems and services
  - traffic management and circulation plans, etc.

- Digital infrastructure: broadband role-out, especially at motorways

- Key Issues for Next Three Years on Road Operations / Infrastructure
  - Determining operational changes required to support use of AVs, including on-demand mobility services on our roads.
  - Motivating government agencies to create and share key operational data real-time (traffic signals, roadworks, other).
  - Increase cooperation between vehicles and roadside
  - Improve traffic prediction

- Changeover to digital radio and universal network coverage
- Interlinking road signs, signals like traffic lights and telematics systems

- Conclusion: direct benefits to governments small compared to C-ITS. Traffic management could be the main incentive (e.g. dedicated lane, priority to groups, car ownership)
- Traffic management can then intervene cooperatively at different levels of the driving task, e.g. navigation and vehicle guidance, including:
  - Interaction of on-board-navigation with information from traffic management centre
  - Arbitration (negotiation between driver, on-board automation and traffic management centre)
  - Distributed traffic management
  - Supervision of automation by traffic management centres
  - New logistics applications
  - Traffic management system optimizing for mix of cooperative and standard vehicles

- Operational aspects of supporting automated vehicles:
  - the design, maintenance and operation of road networks
  - evaluating the safety benefits of automated and connected vehicles
  - the registration of vehicles, and the training and licensing of drivers.

- The Impact of AVs on Infrastructure
  - AV developers are focusing on making AVs that can exist with our current infrastructure, rather than relying on the development of new infrastructure to accommodate them.
  - After they are introduced, AVs will force us to redefine our infrastructure needs and adapt our infrastructure investment to take full advantage of the AVs' capability.
  - Major transportation infrastructure investments are typically planned with 30-year time horizons in mind. As AVs are certain to be part of our lives well within that time frame, it makes sense to begin anticipating their impacts on those investment needs now.
  - AVs will also make shared fleets more attractive, as they can reposition themselves. This may have a large impact on the rate of individual car ownership.

- Potential implications for Main Roads

 - Transition period (have an important role in facilitating the introduction of AVs and managing the transition risks)
 - Full saturation (and 2nd/3rd order effects on the transport system)
 - Implications for today's planning and investment decisions (consider robust sensitivity testing to explore 'what-if' scenarios around the implications of AVs)
 - State strategy (develop a strategy to facilitate the adoption of AVs)
 - Opportunities and risks for Main Roads (essentially proactive versus reactive)
 - Leadership and capability development (building up the organisational capability will be critical for successful transitioning, including setting the required standards, policy and regulatory frameworks, and ITS architecture)

- The following are likely implications for Main Roads during the transition period:
  - Roadside units need to be in place to enable V2I communication. Road agencies are likely to come under increasing pressure to develop corridors and precincts that enable vehicles to communicate with infrastructure, which will need to include sensors, transmitters and cabling to enable a connected network. New roads will need to be future proofed in this regard (Jacobs, 2013d).
  - New ITS devices such as VMS, VSL and other warning systems will need to be able to directly communicate with vehicles through V2I.
  - Road signs and markings need to be conspicuous and legible to the AV sensors as well as to human eyes.
  - All traffic and incident information will need to be in an acceptable standard and format for digital transmission, such as RDS-TMC.
  - Road mapping and databases may need to be maintained to a higher standard with up-to-date information (this could be facilitated through private sector providers).
  - Traffic signals will need to be able to directly communicate with vehicles through V2I.
  - Dedicated lanes for AVs in freeways and high volume arterial roads may be required as the proportion of Avs increases.
  - Strategic transport models will need to consider changed lane/road capacity, perhaps on the basis of sensitivity tests, given the uncertainty about the impacts on capacity.
  - Transport models will need to include a combination of traditional vehicles and AVs with updated car following and lane changing algorithms incorporating AV behaviour.
  - Along with other road agencies, collaboration will be required with auto-makers and technology companies to understand the technical requirements and infrastructure modifications required for AVs, and timelines for implementation.

Actions

- Six key governmental roles, which can hinder or drive the deployment of platooning:
  - Vehicle type approval
  - Digital tachograph, driving and resting time legislation
  - Develop financial incentives for platooning
  - Road infrastructure management
  - Use public-private collaboration for platooning Development
  - Local, national and international policy coordination

- Actions by member states:
  - Publish a Code of Practice
  - Close cooperation in EU-ECE

- Review and amend legal and regulatory framework
- Clarification of liabilities
- Amending national regulations on vehicle use
- Promoting safety
- Liaise and amend international legislation

- Type approval of European standards
- Encourage and facilitate testing on a national level
- Learning by experience
- Information high-level structural dialogue

- Actions to stimulate:
  - Funding
    - Direct investment
    - Stimulate with economic means, e.g. tax incentives
  - Facilitation
    - Help manage liability issues, e.g. via an insurance fund
    - Legal adjustments
    - Political commitment
    - User acceptance
    - Evidence of benefits (e.g. via studies)
  - Technical involvement
    - Provide piloting grounds (e.g. via infrastructure)
    - Provide a common roadmap
    - Stimulate standards
  - Roadside infrastructure adjustments

- Develop standards and implement them within the scope of future structural maintenance, upgrading and construction projects

Funding & investment

- Develop test beds and provide research funding
- Further technological progress in smart systems for automated driving is needed and should be supported through the funding of focused industrial and academic R&D projects.
- Road manager commitment to, and investment in, vehicle-to-infrastructure connectivity
- Investment in satellite-based augmentation systems to improve the accuracy and integrity of global navigation satellite system (GNSS) location data

Organisation

- Build an (internal) organizational capability to:
  - Enable alignment of agency goals and desired outputs
  - Enable strategic, transparent decisions around program and research efforts
  - Bring increased accountability, productivity, and capacity building
  - Provide data to inform necessary adjustments, improvements, or changes
  - Make it possible to accurately report progress, milestones, and obstacles to internal and external stakeholders
  - Better enable the agency to demonstrate its value in multiple areas
  - Enable management of the inter-dependencies between education, communication, research, development, and adoption
  - Optimize allocation of resources

Roles and principles

What Role for Government?

- Policy leadership:
    - provide a clear, nationally coordinated approach across different levels of government, being responsive to changes in the technological environment;
    - facilitate collaboration between parties, including industry and researchers;
    - raise public awareness and acceptance of beneficial new technologies; and
    - efficiently manage transitions between old and new technologies (such as between human-controlled and automated vehicles). This includes considering flow-on effects to other transport modes and related policy areas such as urban planning.
- Enabling:
    - ensure that the private sector is able to bring beneficial new technologies to market, including by supporting investment in digital infrastructure and/or data streams (such as highly accurate geo-positioning systems and real-time information on road conditions); and
    - support private sector innovation in the transport sector, such as by providing open and consistent access to transport data. Where practical, data will be aggregated to the national level.
- Supportive regulatory environment:
    - ensure that community expectations of safety, security and privacy are appropriately considered in new technology deployments;
    - remove regulatory barriers to new technology in a proactive fashion;
    - wherever possible, provide certainty about future regulatory requirements.
- Investment:
    - invest in research, development and real-world trials that benefit the entire transport network customer base or provide a sound basis for government decision-making (including in collaboration with the private sector).

- Governments seek to ensure that they do not regulate too early – which could create artificial barriers to emerging technologies – or that they regulate too late and stop proven safety related technologies from being deployed.

- Principles for Government Action
    - 1. Government decision-making on transport technologies will be based on capacity to improve transport safety, efficiency, sustainability and accessibility outcomes.
    - 2. New technologies should be implemented in a way that is consumer centric (i.e. designed to meet the needs of those using the service). This includes consideration of:
        - a) options to deliver transport information and services in a way that is consistent and familiar, and
        - b) the diverse needs of travellers, in particular travellers with a disability, vulnerable road users such as cyclists and pedestrians, and users of multiple modes of transport.
    - 3. Where government investment is required to support the deployment of new technologies, that investment will be evidence based, consistent with long-term strategic planning and will deliver value for money.
    - 4. Where feasible, government agencies will avoid favouring particular technologies or applications, in order to encourage competition and innovation. New applications should support interoperability, backwards compatibility and data sharing, and should account for possible future transitions to other technology platforms.

- 5. Planning for transport technologies will build on existing infrastructure networks (including public transport) and seek to leverage existing consumer devices (such as smart phones) where appropriate.
- 6. When considering regulatory action, governments will consider low cost approaches such as collaborative agreements or self-regulation before pursuing formal regulation.
- 7. If required, best practice regulatory approaches will be adopted to ensure regulation is cost efficient, transparent, proportionate to the risk, fit for purpose and done in consultation with affected stakeholders. This includes adopting relevant international or regional standards, unless there is a compelling reason for a unique Australian requirement.

Potential New Tools and Authorities

- Authorities:
  - Authority I: Safety Assurance
  - Authority II: Pre-Market Approval Authority
    - Current Self-Certification System
    - Possible NHTSA Use of Pre-Market Approval
    - Hybrid Certification/Approval Processes
  - Authority III: Cease-and-Desist Authority
  - Authority IV: Expanded Exemption Authority for HAVs
  - Authority V: Post-sale Authority to Regulate Software Changes
- Tools:
  - Tool I: Variable Test Procedures to Ensure Behavioral Competence and Avoid the Gaming of Tests
  - Tool II: Functional and System Safety
  - Tool III: Regular Reviews for Making Agency Testing Protocols Iterative and Forward-Looking
  - Tool IV: Additional Recordkeeping/Reporting
  - Tool V: Enhanced Data Collection Tools
- Agency resources:
  - Resources I: Network of Experts
  - Resources II: Special Hiring Tools