Possible actions for public authorities to facilitate automated driving

Jaap Vreeswijk, Mariken Weijs (both MAPtm), Tom Alkim (Rijkswaterstaat)

CARTRE and SCOUT are funded by the European Union Horizon 2020 Work Programme

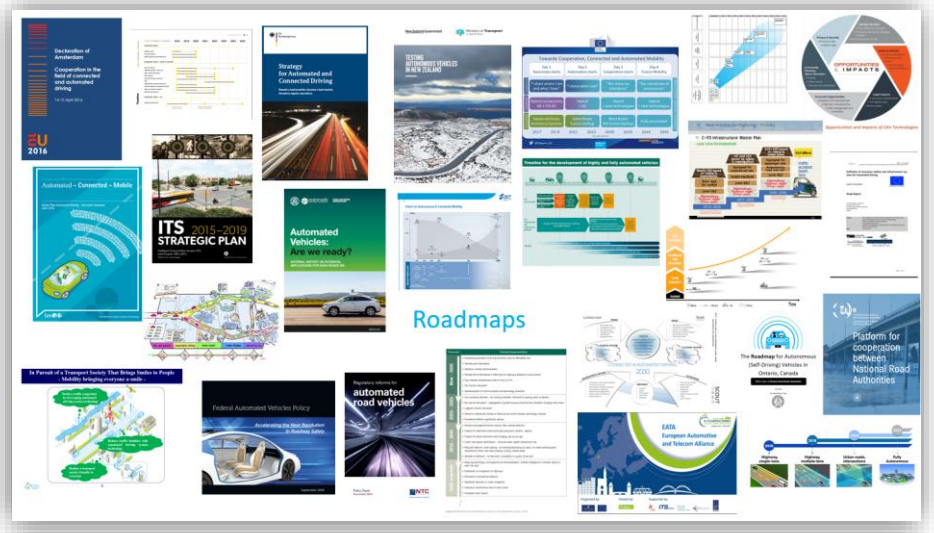
Motivation

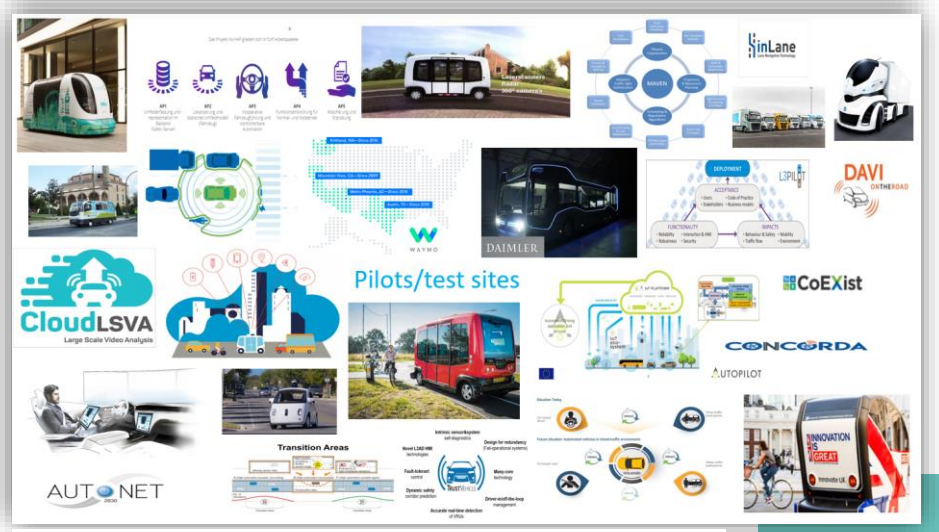
- What can public authorities do to *anticipate* automated driving?
- What can public authorities do to *facilitate* automated driving?
- What can public authorities do to *accelerate* the development automated driving?

Approach

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- +/- 50 roadmaps from around the globe
- +/- 80 pilots/test sites from around the globe
- Extracted aspects relevant to road authorities (+/-300)
- Assigned these to CARTRE 10 thematic areas
- Introduced sub-themes for clustering
- Determined frequency of thematic areas and sub-themes
- Assigned to authority level (EU, national, regional / local)
- Assigned to department level (policy maker, road operator)
- Consolidated the aspects (interpret, merge, edit)
- Resulting in 54 aspects





Link to roadmaps overview
Link to pilot sites overview

connected automated driving.eu

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Categorisation of actions

By activity:

- Stimulate development
- Knowledge building
- Guidelines & strategies
- Roads, systems and data
- Societal outreach

By authority level:

- European
- National
- Regional / Local

And department:

- Policy maker
- Road operator

By theme:

- Policy and Regulatory Needs, European Harmonisation
- Socio-Economic Assessment and Sustainability
- Safety Validation and Roadworthiness Testing
- User Awareness, Societal Acceptance and Ethics
- Digital and Physical Infrastructure
- In-Vehicle Technology Enablers
- Big Data, AI and their Applications
- New shared and automated mobility services
- Human Factors
- Connectivity

Which themes do roadmaps / pilots address?

CARTRE
Coordination of Automated Road Transport Deployment for Europe

Normalised by category	Policy and regulatory needs, European harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, societal acceptance and ethics	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New shared and automated mobility services	Human factors	Connectivity
Roadmaps EU countries	63%	37%	63%	26%	37%	16%	37%	5%	11%	63%
Roadmaps non-EU countries	92%	38%	69%	31%	54%	31%	38%	31%	23%	46%
Roadmaps platforms	82%	55%	45%	45%	73%	55%	18%	27%	36%	27%
Roadmaps industry	44%	44%	44%	22%	22%	56%	11%	11%	0%	22%
Average	**71%**	**42%**	**58%**	**31%**	**46%**	**35%**	**29%**	**17%**	**17%**	**44%**
Pilots EU countries	28%	67%	67%	33%	22%	39%	11%	17%	17%	33%
Pilots non-EU countries	0%	60%	80%	10%	20%	50%	40%	40%	0%	10%
Project	30%	13%	61%	26%	39%	65%	13%	4%	43%	39%
Test sites	12%	16%	64%	12%	20%	24%	16%	24%	12%	40%
Average	**20%**	**33%**	**66%**	**21%**	**26%**	**43%**	**17%**	**18%**	**21%**	**34%**

	Aantal	Policy and regulatory needs, European harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, societal acceptance and ethics	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New shared and automated mobility services	Human factors	Connectivity
Roadmaps EU countries	19	12	7	12	5	7	3	7	1	2	12
Roadmaps non-EU countries	13	12	5	9	4	7	4	5	4	3	6
Roadmaps platforms	11	9	6	5	5	8	6	2	3	4	3
Roadmaps industry	9	4	4	4	2	2	5	1	1	0	2
Sum	52	37	22	30	16	24	18	15	9	9	23
Pilots EU countries	18	5	12	12	6	4	7	2	3	3	6
Pilots non-EU countries	10	0	6	8	1	2	5	4	4	0	1
Project	23	7	3	14	6	9	15	3	1	10	9
Test sites	25	3	4	16	3	5	6	4	6	3	10
Sum	76	15	25	50	16	20	33	13	14	16	26

connected automated driving.eu

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Discussion roadmap/pilot overview

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- In some cases difficult to assess whether thematic area is included, implicit or explicit.
- All thematic area's are addressed, there's not one missing. Roadmaps and pilots focus on different themes.
- Especially for roadmaps, the abstraction level for a thematic area is rather high, difficult to assess whether strategic alignment is possible. Need to go one abstraction level lower, e.g. to understand meaning of 'x'.
- No need to put effort in making everything "green". Quality depends on the actual efforts.
- For (dark) green cells harmonization efforts may be needed (next call?).
- Big data/AI + New shared and automated mobility: not on the (near) horizon yet? Relatively new topics.
- Human factors + User awareness and acceptance: residual topics, intangible, not well assigned?
- Pilot matrix feeds into roadmaps matrix finally strategic aligment mainly at High Level Meetings.

A grasp of the topics addressed by the actions

location data | traffic information | traffic data | quality | prediction | data access points | digital maps | I2V communication | connected infrastructure | investments | guidelines | security | cooperation | negotiation | new infrastructure | industry requirements | road conditions | public transport | contracts | safety | sensors | broadband | road markings | traffic signs | platooning | weather | research | road design | road surface | funding | road capacity | maintenance | roles | expectations | routing | eligibility | intersections | design | traffic management | driving task | traffic control | transport models | city planning | awareness | training | accessibility | testing | permissions | transition | architecture | platooning | investment

connected automated driving.eu

Examples of actions

- Provide open and consistent access to real-time traffic and infrastructure data of required quality (accurate, tim… …frastructure data includes: traffic flow… …, dynamic geometric/spatial (map) data, traffic signals, roadworks, weather, incidents and events.
- Estimate and anticip… …rtation infrastructure investments, e.g. cha… …emand, car ownership, decrease of parking space, urban sprawl, etc.
- Stimulate the use of automated vehicles in new transport concepts and make sure people can use them easily. If ne… …nt the diverse needs of travellers, in particul… …such as cyclists and pedestrians, and users of multiple modes of transport.

Roads, systems and data

Knowledge building

Stimulate development

connected automated driving.eu

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Frequency thematic areas and sub-themes

CARTRE
Coordination of Automated Road Transport Deployment for Europe

Policy and Regulatory Needs, European Harmonisation

Digital and Physical Infrastructure

Safety Validation and Roadworthiness Testing

Big Data, AI and their Applications

In-Vehicle Technology Enablers

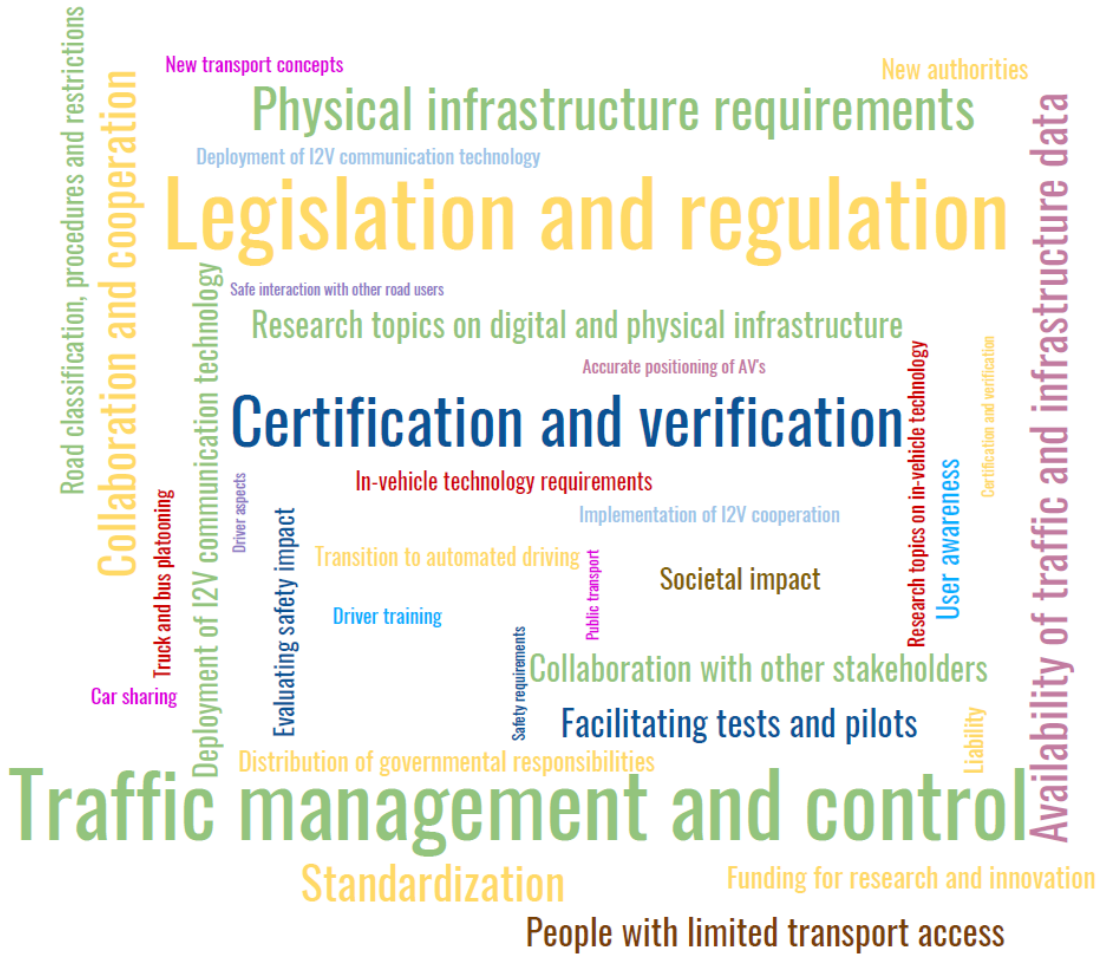
User Awareness, Societal Acceptance and Ethics

New shared and automated mobility services

Socio-Economic Assessment and Sustainability

Connectivity

Human factors



connected automated driving.eu

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Friday, 23 November, 2018

Assessment by authority level

CARTRE
Coordination of Automated Road Transport Deployment for Europe

	#	European	National	Regional / Local
Stimulate development	11	10	10	1
Knowledge building	14	8	12	6
Guidelines & strategies	18	14	15	3
Roads, systems and data	8	2	7	6
Societal outreach	3	3	3	1

Observations: most actions with central authorities; many actions are on exploration and policy, less on deployment; EU and national authorities share many actions; national and regional/local authorities get more involved when actions become less planning and more doing; involvement regional/local authorities relevant for application to their specific case.

Expectation: weight will move from top-left to bottom-right.

connected automated driving.eu

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Assessment by department level

CARTRE
Coordination of Automated Road Transport Deployment for Europe

	#	Policy maker	Road operator
Stimulate development	11	11	
Knowledge building	14	12	4
Guidelines & strategies	18	17	2
Roads, systems and data	8	4	6
Societal outreach	3	3	1

Observations: actions are mostly at the policy level, but road operators are needed to make it happen; actions from road operators might feed into policy (i.e. practice, experience, local specifics, etc.).

Expectation: once the policy framework is defined, actions will shift to execution.

connected automated driving.eu

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

Assessment by authority & department level

CARTRE
Coordination of Automated Road Transport Deployment for Europe

	#	European	National	Regional / Local
Policy maker	47	36	40	10
Road operator	13	4	12	12

Observations: policy-making is mainly at the European and national level, whereas road operation is more at the national and regional/local level; national authorities are the link between central policy-making and regional/local deployment; regional/local authorities next to operations also have a role in policy-making.

Expectation: common views on how to anticipate, facilitate and accelerate automated driving will become vital, not just at the European level, also among regional/local authorities.

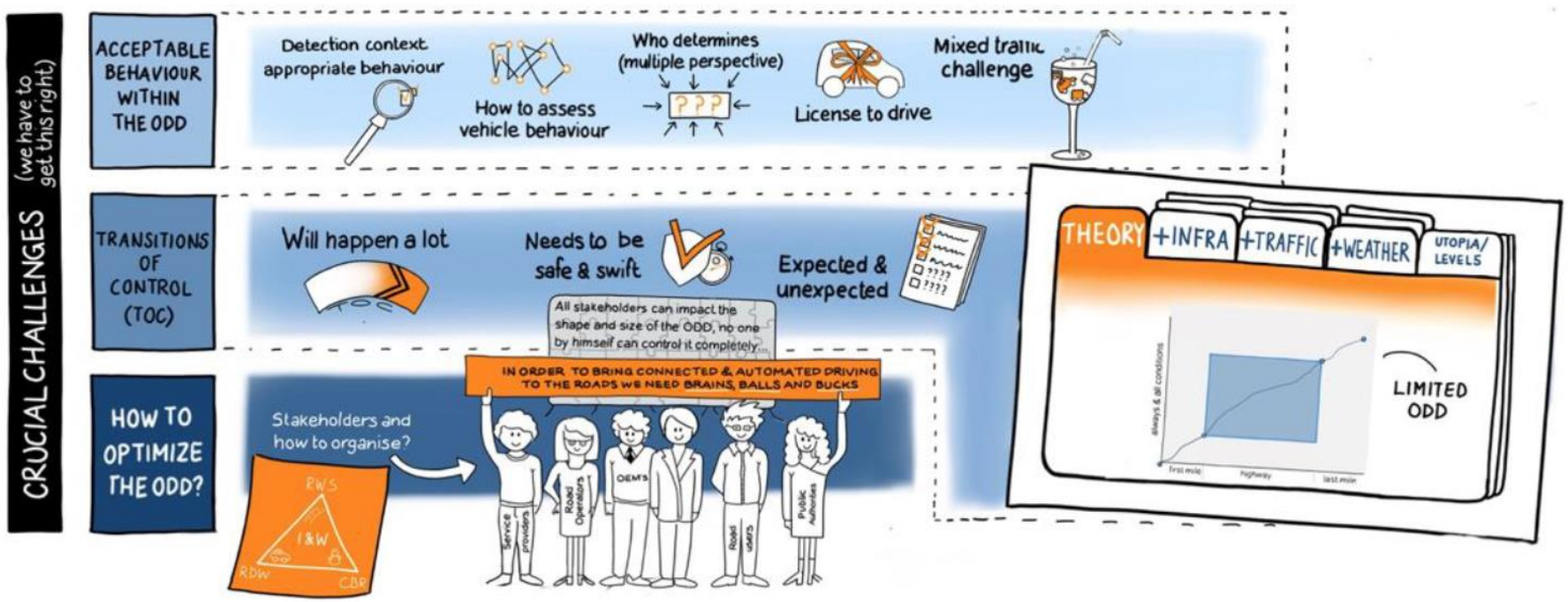
Discussion actions for authorities

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- This list of actions is not exhaustive, neither are the actions prioritised. Validation of the actions and prioritisation of the themes and actions would be a logical next step.
- The statistics provide a snapshot of the current state. In 5 years from now other themes might be dominant and actions are expected to shift towards decentralised authorities and road operators.
- It is in line with expectations that digital & physical instructure, safety validation and policy & regulatory needs are the major themes for road authorities currently.
- Smaller themes require less action by authorities but are not necessarily less important. Actions might be required by industry, research, etc.
- Timing, impact, complexity and effort/cost of the actions are not estimated. Logically such information would imply a certain order which can be formalised in an action plan.

Next steps

- Validation of the actions and prioritisation of the themes and actions.
- Estimate timing, impact, complexity and effort/cost of the actions.
- Add traceability to the original roadmaps / documents where they were obtained.
- Identify which actions directly contribute to the most crucial challenges (see here).



connected automated driving.eu

connected automated driving.eu

We hope you find this useful!
Feedback is welcome to further improve.
Please contact me to receive the database.

Dr. Jaap Vreeswijk, *MAP traffic management*
+31 6 4164 7985 | jaap.vreeswijk@maptm.nl

MAP TRAFFIC MANAGEMENT

Rijkswaterstaat
Ministry of Infrastructure and the Environment

CARTRE and SCOUT are funded by the European Union Horizon 2020 Work Programme

Big Data, AI and their Applications

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Accurate positioning of AV's:
  - Invest in further development and improvement of affordable and accurate positioning of automated vehicles.
- Availability of traffic and infrastructure data:
  - Provide open and consistent access to real-time traffic and infrastructure data of required quality (accurate, timely, etc.) as defined by the guideline. Traffic and infrastructure data includes: traffic flows (actual & predicted), road conditions, speed limits, dynamic geometric/spatial (map) data, traffic signals, roadworks, weather, incidents and events.
  - Define guidelines for types and quality of traffic and infrastructure data and motivate government agencies to create, share and maintain such data. Ensure open and consistent access and provision through a single access point at national level.
  - Define a strategy on data quantity and handling; how to collect, share and store the appropriate data, to ensure (technical) continuity of traffic and infrastructure data provisioning.

Connectivity

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Deployment of I2V communication technology:
  - Make sure roadside ITS, e.g. traffic signals, VMS, VSL and other warning systems, are equipped with infratructure-to-vehicle communication technology.
- Implementation of I2V cooperation:
  - Develop a strategy that stimulates road managers to increase the cooperation between automated vehicles and infrastructure (roadside and traffic management centres), with consideration of security and standardisation.

connected automated driving.eu

Digital and Physical Infrastructure (1)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Collaboration with other stakeholders:
  - Ensure that infrastructure needs, expectations and actual state are commonly known. Therefore, seek collaboration with automotive industry to identify (technical) requirements for infrastructure and together establish an implementation roadmap for new infrastructure necessary for AD.
  - Ensure continuity of viable infrastructure by building on existing infrastructure and consumer devices, and sustaining robust long-lasting agreements and contracts with relevant stakeholders.
- Deployment of I2V communication technology:
  - Deploy a universal (digital) communication infrastructure that ensures network coverage, supported by a broadband communication network linked to digital traffic systems and central telematics systems, with consideration of allocated radio frequency and protocols for AV's

connected automated driving.eu

Digital and Physical Infrastructure (2)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Physical infrastructure requirements:
  - Define and/or update guidelines to ensure and maintain good state of physical infrastructure, e.g. visibility, consistency and condition of road markings, traffic signs, signals, etc., also in adverse weather conditions.
  - Assess the need for investment and thereafter gradually deploy infrastructure to enable automated driving, such as sensors or beacons embedded in the road pavement, dedicated posts and poles for guidance and (highly accurate) geo-positioning and special road infrastructure for platooning.
  - Ensure and maintain good state of physical infrastructure, e.g. visibility, consistency and condition of road markings, traffic signs, signals, etc., also in adverse weather conditions.
  - Define guidelines and verification methods for types and quality of digital and physical infrastructure.

connected automated driving.eu

Digital and Physical Infrastructure (3)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Research topics on digital and physical infrastructure:
  - Assess the trade-off of requirements for lane markings and maintenance of lane markings (e.g. reflectivity, contrast, width) for camera-based vision systems versus increased precision of geo-positioning.
  - Stimulate (scientific) research on changes to the road geometric design at different penetration levels of AV's and the effects on throughput, traffic safety, safety perception, etc.
  - Explore the effects of AD, platooning specifically, on pavement damage and the implications on the load of bridges and their structural safety.
- Road classification, procedures and restrictions:
  - Establish an extensive inventory and classification of the road network to specify routes, detours and restrictions for automated driving.
  - Define guidelines for industry regarding the use of automated vehicles at intersections, junctions, railway level crossings etc.

connected automated driving.eu

Digital and Physical Infrastructure (4)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Traffic management and control:
  - Develop new guidelines and practices for (distributed) traffic management and traffic control, which stimulates the interaction of in-vehicle systems at different levels of the driving tasks such as navigation and vehicle guidance, e.g. as part of scheduling algorithms for adaptive traffic light control.
  - Estimate and anticipate the impact of AD in urban planning and transportation infrastructure investments, e.g. changed lane/road capacity, dedicated lanes, traffic demand, car ownership, decrease of parking space, urban sprawl, etc.
  - Implement procedures and quality controls for the design, maintenance and operation of road networks to ensure that the expected level of service is consistently reached. Consider using vehicle and/or service provider data.
  - Include a combination of traditional vehicles and AV's with updated car following and lane changing algorithms in transport models and optimize traffic management strategies for a mix of automated and standard vehicles.

connected automated driving.eu

Human factors

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Driver aspects:
  - Create funding for research regarding human limitations such as the acceleration and deceleration forces that humans can tolerate (motion sickness) or technologies to tackle driver distraction.
- Safe interaction with other road users:
  - Define guidelines to ensure that automated vehicles are minimally as safe as human driver to other road users, including interaction with powered two wheelers and emergency vehicles, and human acceptance of gaps in traffic with overtaking, merging and crossing intersections.

connected automated driving.eu

In-Vehicle Technology Enablers

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- In-vehicle technology requirements :
  - Set up regulations and requirements for new in-vehicles technology enablers. Possible requirements could be protection against non-authorized external access to data, supervision of automated vehicles in control centres, the extent to which the technology is consumer-centric, support of interoperability, backwards compatibility, data sharing, and resilience to possible future transitions to other technology platforms.
- Research topics on in-vehicle technology:
  - Stimulate technology development used for automated driving such as environmentally efficient driving systems, technology required for platooning and multi sensing and information for scene understanding an prediction.
- Truck and bus platooning:
  - Provide internationally consistent policies, regulations, vehicle type approval and financial incentives for truck and bus platooning.

connected automated driving.eu

New shared and automated mobility services

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Car sharing:
  - Anticipate the impact of shared automated vehicle fleets on the transport system and consider overseeing these fleets, as currently happens with taxis.
- New transport concepts:
  - Stimulate the use of automated vehicles in new transport concepts and make sure people can use them easily. If necessary, adjust the urban planning. Take into account 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.
- Public transport:
  - Explore possibilities to use automated vehicles for public transport and monitor changes in public transport demand.

connected automated driving.eu

Policy and Regulatory Needs, European Harmonisation (1)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Certification and verification:
  - Make sure vehicle type approval is done at European level. Given that procedures will probably be more complex and expansive to design, this would avoid replicating costly work both for manufacturers and public stakeholders.
- Collaboration and cooperation:
  - Create an international or global platform to share knowledge and experiences regarding automated driving. This makes it possible to accurately report progress, milestones, and obstacles to internal and exernal stakeholders.
  - Stimulate and coordinate (inter)national collaboration and cooperation between all parties involved in automated driving. Involved parties are e.g. different sectors in industry, utilities, infrastructure providers, academia, public authorities.

connected automated driving.eu

Policy and Regulatory Needs, European Harmonisation (2)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Distribution of governmental responsibilities:
  - Agree on the tasks and responsibilities for European and national governments and create guidelines that can serve as a sound basis for government decision-making on transport technologies, with the objective to improve transport safety, efficiency, sustainability and accessibility outcomes.
- Funding for research and innovation:
  - Provide funding for research and innovation activities regarding automated driving and stimulate provision of funding by economic means (e.g. taxes). Let allocation be based on transparant decisions and avoid favouring particular technologies or applications, in order to encourage competition and innovation. Make sure that investment will be evidence based, consistent with long-term strategic planning and will deliver value for money.

connected automated driving.eu

Policy and Regulatory Needs, European Harmonisation (3)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Legislation and regulation:
  - Draw up and regularly adapt a coherent European legal framework for both testing and use of higher degrees of automated driving in order to provide certainty about future regulatory requirements. E.g. amend the Vienna convention, allow system control, specify the modes of transport in which automated vehicles are allowed, define functions that have to be controlled by the driver, set up rules for malfunction detection and automatic warnings, oblige AV markings for notifying other drivers, ensure privacy and data protection, create specific traffic rules if needed, adjust driving and resting time legislations, make sure authorities are allowed to use vehicle data in traffic management.
  - Consider different ways to regulate. E.g. consider low cost approaches such as collaborative agreements or self-regulation before pursuing formal regulation or adopt best practice approaches 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 requirement.

connected automated driving.eu

Policy and Regulatory Needs, European Harmonisation (4)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Liability:
  - Define liability terms and conditions to make sure it is always clear who is responsible for the actions of the car, especially when the manufacturer, driver and road authorities all influence them.
- New authorities:
  - Explore the possibilities for new authorities such as a safety assurance authority, an insurance fund for possible liability issues, a pre-market approval authority, a cease-and-desist authority, an exemption authority for automated vehicles and a post-sale authority to regulate software changes.

Policy and Regulatory Needs, European Harmonisation (5)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Standardization:
  - Create European or preferably global definitions, strategy and standards for connected and automated driving in order to ensure crossborder interoperability and consistency between networks. E.g. standards for (high)way design, procedures to request tentative driving of automated vehicles, ITS architecture, traffic and incident information, temporary and electronic road signage, future structural maintenance, upgrading an construction projects.
- Transition to automated driving:
  - Develop a clear, nationally coordinated approach across different levels of government for facilitating the introduction of automated vehicles and managing the transition risks, that is responsive to changes in the technological environment.

connected automated driving.eu

Safety Validation and Roadworthiness Testing (1)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Certification and verification:
  - Set up a framework for cerficitation and verification of automated vehicles. Make sure the procedures are flexible to ensure they are forward-looking and responding to necessary adjustments, improvements, or changes. Consider homogenous physical design, efficiency, easy mainenance, requirements for responding to temporary speed zones, traffic controls, all likely road conditions, all likely environmental conditions and interaction with vulnerable road users, trains and light rail.
  - Ensure that community expectations of safety, security and privacy are met.
  - Set up additional recordkeeping and invest in enhanced data collection tools to check that requirements are met.

connected automated driving.eu

Safety Validation and Roadworthiness Testing (2)

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Evaluating safety impact:
  - Evaluate the safety benefits of automated and connected vehicles.
  - Invest in research, development and real-world trials that benefit the safety of automated driving and the interaction with vulnerable road users.
- Facilitating tests and pilots:
  - Encourage and facilitate testing and piloting of automated vehicles and platooning in areas with special conditions, such as road work or traffic jam, especially in sensitive locations, like weaving sections, on-ramps, and off-ramps.
  - Grant permission for automated vehicle testing on public roads.
  - Provide funding for (simplified) test areas designated for automated vehicles.
- Safety requirements:
  - Ensure that the industry members have incentives to design automated driving systems with road safety as a key and overruling requirement.

connected automated driving.eu

Socio-Economic Assessment and Sustainability

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- People with limited transport access:
  - Explore possibilities to enhance accessibility to persons with limited transport access such as elderly and people with disabilities.
- Societal impact:
  - Carry out an impact assessment of automated driving, i.e. to investigate environmental impacts, socio-economic aspects, effects on public finances, changing value of travel time, changing job opportunities and employment issues, and possible increase of social division and inequality.

User Awareness, Societal Acceptance and Ethics

CARTRE
Coordination of Automated Road Transport Deployment for Europe

- Driver training:
  - Educate end users, other road users and vulnerable road users on the use of and interaction with AV's. Set up a registration of vehicles, and regulations for training and licensing of drivers.
- User awareness:
  - Increase public awareness and acceptance of beneficial new technologies, by demonstrating and providing evidence of the benefits of AD in multiple areas. For example, facilitate field operational tests for showcasing safety, security and reliability of automated vehicles, or publish research results.

connected automated driving.eu