**EUROPEAN COMMISSION**

**DG Research and Innovation – RTD**

**HORIZON 2020 PROGRAMME**

**SOCIETAL CHALLENGES – SMART, GREEN AND INTEGRATED TRANSPORT**

**Coordination and Support Action – Grant Agreement Number 724086**

# D.6.3: Proceedings of the 2nd ART conference in Europe

| | |
|---|---|
| Deliverable no. | D6.3 |
| Dissemination level | Public |
| Work Package no. | WP6 |
| Main author(s) | Lorena Iglesias, Julie Castermans |
| Co-author(s) | Stéphane Dreher (ERT), Yves Page (REN), Salla Kuisma (VTT), Paddy La Torre (Bosch), Risto Kulmala (Traficon), Stella Nikolaou (CERTH), Gereon Meyer (VDI-VDE), Benjamin Wilsch (VDI-VDE), Alvaro Arrue (IDIADA) |
| Version number | V1.0 |
| Status (F: final, D: draft) | F |
| Keywords | CARTRE, Dissemination, European Union (EU), Horizon 2020, automated road transport |
| Project Start Date and Duration | 02 October 2018, 24 months |

# Document Control Sheet

Main author(s) or editor(s): Lorena Iglesias, Julie Castermans (ERT)

Work area: WP6

Document title: Proceedings of EU CAD 2018 Symposium

Version history:

| Version | Date | Author | Summary of changes |
|---|---|---|---|
| 0.1 | 17-09-2018 | Lorena Iglesias | First version |
| 0.2 | 28-09-2018 | Julie Castermans | Final version for peer-review |

Approval:

| | Name | Date |
|---|---|---|
| Prepared | Lorena Iglesias | 17-09-2018 |
| Reviewed | Beatrice Tomassini, Sytze Kalisvaart | 29-09-2018 |

Circulation:

| Recipient | Date of submission |
|---|---|
| EC | 30-09-2018 |
| CARTRE consortium | 30-09-2018 |
| Public | 30-09-2018 |

## Executive Summary

With the support of the European Commission as well as the ERTRAC European Technology Platform, the CARTRE and SCOUT actions co-organised the EUCAD 2018 event on 19-20 April 2018, in conjunction with the TRA 2018 Conference in Vienna.

Intended as the, follow-up of the 1st EUCAD Conference organised in April 2017, EUCAD 2018 coinciding with the bi-annual Transport Research Arena conference, organised by EC, the event was called *Interactive Symposium on Research & Innovation for Connected and Automated Driving in Europe*.

The rationale was not to "compete" with TRA but rather be complementary to the Connected & Automated Transport (CAD) topic stream at TRA 2018: the event aimed to delve deeper into specific thematic areas related to the development and deployment of Connected and Automated Driving in Europe. For each thematic area, a panel of high-level speakers from different fields shared and discussed positions, visions, and interacted with the audience regarding challenges and research need entailed.

The event was targeted at public and private road transport stakeholders – automotive and telecom industry, users, researchers, operators, regulators, public authorities, representatives from EU Member States and outside Europe – indirectly involved in H2020 funded projects, national projects or ERTRAC Working Group on Connectivity and Automated Driving. It attracted 220 participants, mainly from the research and automotive industry communities.

The event provided an opportunity to learn about European Research & Innovation activities on CAD and for the audience to engage with the panel experts in the different thematic sessions through the interactive online tool sli.do.

A poster exhibition opportunity was also offered to research initiatives that were either attending the Symposium and/ or had been presented at TRA prior to the Symposium.

The event was free of charge and all information in relation was advertised through https://connectedautomateddriving.eu. The EUCAD 2018 dedicated section of the website proposes available for download all presentations, the present proceedings as well as a copy of the exhibition posters.

# Table of Content

# 1. Overview


With the support of the European Commission as well as the ERTRAC European Technology Platform, the CARTRE and SCOUT actions co-organised the EUCAD 2018 event on 19-20 April 2018, in conjunction with the TRA Conference in Vienna.

Originally intended as the second European Conference on Connected and Automated, following-up the 1st EUCAD Conference organised in April 2017, EUCAD 2018 coinciding with the bi-annual Transport Research Arena conference, organised by EC, the event was called Interactive Symposium on Research & Innovation for Connected and Automated Driving in Europe.

Complementary to the Connected & Automated Transport (CAD) topic stream at TRA 2018, the event aimed to delve deeper into specific thematic areas related to the development and deployment of Connected and Automated Driving in Europe. For each thematic area, a panel of high-level speakers from different fields shared and discussed positions, visions, and interacted with the audience regarding challenges and research need entailed.

The event was targeted at public and private road transport stakeholders – automotive and telecom industry, users, researchers, operators, regulators, public authorities, representatives from EU Member States and outside Europe – indirectly involved in H2020 funded projects, national projects or ERTRAC Working Group on Connectivity and Automated Driving.

The event aimed at providing an opportunity to learn about European Research & Innovation activities on CAD and to exchange views on how to shape the future of connected and automated driving in specific thematic areas.

The event was free of charge and all information in relation was advertised through https://connectedautomateddriving.eu.

## 1.1. Motivation

Increased connectivity and automation are major trends that are expected to shape the future of road transport and mobility. They hold the promise of addressing many of the major challenges facing today's transport system, such as user safety, energy efficiency, air quality and traffic congestion, and to enhance the drivers' comfort and convenience.

The combination of advanced connectivity systems and automated vehicles could disrupt the entire automotive ecosystem. Connected and automated vehicles will enable higher level of safety and the emergence of new "mobility-on-demand" services and innovative digital services in the area of entertainment, commerce, vehicle management, etc.

The European Conference on Connected and Automated Driving was successfully organised in April 2017 by the EC with the support of CARTRE and SCOUT H2020 actions. It was decided to organise the next edition of this high-level meeting in 2019. A smaller event in the form of a hands-on workshop was proposed to be organised in April 2018 next to the TRA conference in Vienna. Indeed CAD was one of the topic streams of TRA 2018. With the amount of research and innovation activities around Europe, the Symposium could complement the TRA conference and allow for higher interaction with the attending stakeholders. .

The Symposium thus aimed to address in more details the CAD R&I activities in Europe and show the progress in specific thematic areas. By no means, this event conflicted or overlapped with the policy-driven agenda of TRA; it rather completed the picture with more content on the topics surrounding CAD.

The long term ambition is still to establish this event as an annual event beyond the duration of the supporting projects, alternating bi-annually between a more political event, driven by EC (European Conference in Brussels) and a more R&I-oriented event, led by the supporting project(s).

## 1.2.Format

This event took the shape of a hands-on workshop with focus on discussions around the CARTRE thematic areas related to the development and deployment of Connected and Automated Driving in Europe.

The workshop was held on 19-20 April 2018 in Vienna with 220 participants and started almost directly after the closing ceremony of TRA in the Tech Gate Vienna which is a science and technology park in the City of Vienna.

The workshop consisted of one and a half day with nine thematic breakout discussions within three parallel tracks and concluded with a wrap-up of the breakout sessions by the nominated rapporteur.

An interactive tool, sli.do, was used during the break-out sessions to interact with the audience in two ways: (1) asking questions in the form of polls with several proposed answers to take the pulse of the audience on a particular matter; (2) inviting the audience to post their questions to the panel throughout the session, to be answered at the end of the session (or in this report for the questions that could not be tackled within the session timeframe).

A poster exhibition opportunity was also offered to research initiatives that were either attending the Symposium and/ or had been presented at TRA prior to the Symposium.

Side events organised in conjunction with the Symposium included a SCOUT workshop on “Validation of a cross-sectorial roadmap for connected and automated driving” on 20 April 2018 as well as the EU-US-Japan trilateral meeting on ART on 20-21 April 2018.

## 2. Overall programme of the Interactive Symposium

connected automated driving.eu

### Thursday 19 April

15.30 Registration

16.30 Welcome Introduction

17.00 **Breakout session 1**

- **Shared and automated mobility services** — Auditorium
- **In-Vehicle Enablers** — Business Stage
- **Physical & Digital Road Infrastructure** — Multimedia Stage City

18.30 **Networking cocktail**

### Friday 20 April

08.30 Welcome Coffee

09.00 **Breakout session 2**

- **Socio-Economic Impacts** — Multimedia Stage City
- **Human Factors** — Business Stage
- **Vehicle validation** — Auditorium

10.30 Coffee Break

11.00 **Breakout session 3**

- **Regulation, Legal and Liability** — Auditorium
- **Artificial Intelligence** — Business Stage
- **Connectivity** — Multimedia Stage City

12.45 Wrap up and closing

13.15 Close followed by lunch

14.00 **Interactive SCOUT session** — Multimedia Stage City

#EUCAD2018

@Europe_CAD

connected-automated-driving-in-europe

## 3. Welcome and introduction


Maxime Flament, ERTICO – ITS EUROPE, and Gereon Meyer, VDI-VDE, opened the EUCAD 2018 Symposium with a short presentation of CARTRE/SCOUT support actions. Mr Flament also shortly explained the ambition of the event, transitioning from the TRA Conference that took place right before taking and the CAD Conference 2017. Regarding the latter, Mr Flament referred back to the statement of European Commissioner Violeta Bulc the year before, that Europe needs to lead and shape the future of connected and automated driving and that collaboration is the keyword for the deployment of connected vehicles.

Furthermore, the agenda of the Symposium was presented, as well as the use of the interactive tool sli.do during the event.

Sytze Kalisvaart, TNO, introduced the topics of the thematic areas and the interactions between them, aiming at identifying the so-called “tricky loops” (or “chicken-and-egg” problems). Indeed one of the objectives of the Symposium should be to contribute to their better understanding and the result would be presented in more details in the wrap-up session at the end of the event.

Finally Mats Rosenquist, Volvo, presented the ERTRAC Roadmap and Strategic Research Agenda on Automated Driving.

# 4. Thematic Breakout sessions

The breakout sessions were organised in order to encourage expert discussions on technical or non-technical ART topics and consisted of 90 minutes discussion, supported by short presentations in some cases, within three tracks of three sessions running in parallel.

The thematic areas addressed in the sessions were:

- ✓ Shared and Automated Mobility Services
- ✓ In-vehicle technology enablers
- ✓ Physical and Digital Infrastructure
- ✓ Socio-economic impacts
- ✓ Human Factors
- ✓ Vehicle Validation
- ✓ Regulatory, Legal and Liability
- ✓ Artificial Intelligence
- ✓ Connectivity

These thematic breakouts were organised by recognised experts in the thematic field. The organisers were in charge of selecting the panellists for their breakout as well as defining the structure of the session, the questions to be answered, including the ones to the audience through the sli.do tool, in collaboration with the session moderator (if different from the organiser).

## 4.1.BO-1.1 Shared & Automated Mobility Services

**Organiser/s:** Nadège Faul, Vincent Blervaque (VEDECOM)

**Moderator:** Nadège Faul (VEDECOM)

**Rapporteur**: Gereon Meyer (VDI-VDE)

**Speakers**
Iain Macbeth, Transport for London
Guido di Pasquale, UITP
Sofia Löfstrand, VOLVO
Sami Sahala, Forum Virium
Shinj IItsubo, Ministry of Land, Infrastructure, Transport and Tourism, Japan (MLIT)

**Summary**

Shared and automated mobility services are a unique opportunity to bridge the gap between individual mobility needs and community interests by delivering complementary mobility offer integrated with existing high capacity multimodal public transport. They can contribute to make public transport more attractive, support modal shift and reduce pressure from the use of private vehicles by offering a well-integrated and cost-effective public transport service with a high frequency and short waiting times, at peak and off-peak periods. Introduction of on-demand and door-to-door services will improve accessibility of public transport services

to all users and sustain development of public transport as urban mobility backbone with complementary line services offering viable business models and service flexibility.

Overall mobility and especially in urban and suburban areas faces significant challenges with respect to accessibility, safety, security, environment, service quality of public transport, increasing demand in logistics as well as financing, funding and cost sharing models. Shared and automated mobility services have the potential to address these challenges and to offer concrete solutions which are not technically or economically feasible with conventional public transport systems and long haul/urban freight delivery services.

In order to maximise individual and societal benefits of road automation, it is crucial to think beyond automated vehicle itself and explore new scenarios for mobility services. Shared and automated mobility services are a unique opportunity to bridge the gap between individual mobility needs and community interests by delivering complementary mobility offer integrated with existing high capacity multimodal public transport.

The main challenges to be addressed are:

- How to create the most suitable framework conditions for successful market introduction and sustainable operations of shared and automated mobility solutions.
- Need to adapt regulatory frameworks to facilitate shared and automated mobility services.
- The effects of sharing economy on the mobility organisation.
- The effects of sharing mobility on the economy.
- The impact of automated driving on professional driver services management.
- How automated driving will impact the emergence of new business models for private, commercial and public users.
- Roles of national and local transport authorities.
- Integration of new shared and automated mobility services with existing public transport and “soft” modes (walking, cycling).
- How to foster innovation and creativity.
- How to tackle the issue of social inclusion and mobility for all.
- The impact of the development of transport automation inter-urban logistics mobility in combination with e-commerce.
- Adaptability and upgradability of existing tools and simulation models to analyse mobility demand and to assess impact of new shared and automated mobility services.

In order to make time and cost effective progress towards the deployment of new shared and automated mobility services, future research should address following issues:

- Safety and security assessment of the overall transport system.
- New hybrid and integrated transport models.
- Overall cost/benefit analysis of the shared and automated mobility services and business opportunities.
- Modelling and simulation tools dedicated to new mobility services enabled by automated driving.
- User behaviour and adaptation of new mobility services.
- Role of (local) road operators, e.g. (exemptions) for parking regulation of shared cars or dedicated car parks for shared (automated) vehicles.

- Impact on cities and society and new steering instruments.
- Development of innovative, user centric, reliable, fair and ubiquitous mobility and transport services for the local users based on global standards and systems.
- New models and services for sharing of transport assets.
- Explore the potential of combined people and goods vehicles.
- Connected and self-organised services for Long Distance Freight Transport.
- Large-scale demonstration of integrated bundle of shared and automated mobility services using multi-brand and multi-category vehicle fleets.

All speakers agreed that public and private stakeholders representing demand and supply sectors need to gain more knowledge to get ready for full scale deployment through pilots and demonstrations of shared and automated mobility services in real-life conditions in different urban environments and with different categories of shared automated vehicles.

Furthermore, the panellists agreed that shared automated vehicles would complement public transportation and offer particular benefits for providing inclusive mobility on the country side, an aspect MLIT is exploring in different locations in Japan, currently. At the same time, concerns were raised considering regulation and missing business models as serious bottle neck for connected and automated driving to be mature and safe enough for urban use. In particular the case of self-driving shuttles was faced with scepticism since a top-down safety concept would be needed, at least in the highly complex urban environment. Operators were called to be aware of their responsibility for drivers, passengers, and people on the road. Hence, such vehicles need to adapt to and be included in traffic management systems.

The panellist of this session concluded that, prior to considering new shared services, the citizens' and cities' opinions had to be better understood in order to assess the acceptance of connected automated driving and the expected level of safety. Afterwards, demonstrations and pilots would be needed to make connected and automated driving real and provide citizens with personal experiences.

**Conclusions from session**

- Clear use and business cases of CAD-based smart mobility services are still missing.
- Shared CAD complements collective transport, and offer particular benefits on the country side.
- Regulations are a serious bottle neck for CAD, particularly in terms of functional safety in urban use.
- CAD is providing opportunities for social inclusion – we are all users with special needs at times.
- CAD can and has to adapt to existing traffic management systems.
- Operators should be aware of their responsibility for drivers, passengers, and people on the road.

**Expected Impact**

Research, innovation and deployment of shared and automated mobility services will support competitiveness of European transport industry including vehicle manufacturers, automotive suppliers, public transport operators, freight and logistics, innovative mobility service providers and technology suppliers. It is important to notice that European ecosystem is

composed on many international leading industries working in close cooperation with high innovation potential start-ups and SMEs that have the capacity to take global leadership.

Shared and automated mobility services can contribute to make collective transport more effective and more customized to user needs and therefore support local mobility policies in terms of accessibility, social inclusion, multimodality, environment, safety and reduction of road transport externalities.

## 4.2.BO-1.2 In-Vehicle technology enablers

**Organiser/s:** Paddy La Torre (BOSCH), Ulrich Koehler (HELLA), Prasant Narula (APTIV)

**Moderator:** Armin Gräter (BMW)

**Rapporteurs:** Paddy La Torre (BOSCH), Armin Gräter (BMW)

**Speakers**
David Weidenfelder, BOSCH
Ulrich Koehler, Hella
Armin Gräter, BMW
Prasant Narula, Aptiv

**Summary**

The role of “In-Vehicle Technology Enablers” to realize Automated Driving Automated Driving aims to eliminate driver from the driving loop altogether thus aiming to improve road safety, reduce fatalities helping achieve the goal of European Commission of zero fatalities by 2050. In order to realize this goal, the vehicle of the future needs to become more intelligent. Replacing the eyes and ears, brain and nervous system of human drivers with sensors, embedded computing platforms and fail-operational architectures is quite challenging. In other words, the technologies inside the vehicle need to become reliable, fault-tolerant and stable irrespective of the operating conditions. This makes these technologies key enablers for connected and automated driving (CAD).

The foundation for current developments is driven by decades-long technical advances in Advanced Driver Assistance System (ADAS). These advances have contributed to recent Highly Automated Driving (HAD) developments. HAD will lead to a paradigm-shift in the driver-vehicle responsibility relationship. This shift will result in never-before-experienced demands on internal and external technical components. Additional new social and legal expectations are therefore emerging. The challenge is to cope with these new expectations, to master the growing in-vehicle and external networks complexities, while also reducing costs and time to market.

In-vehicle enabler advancements will impose three main challenges:

- Societal expectation like improved road safety, and reduction of pollution and congestion require a consensus on the application of these new technologies.

- Significant safety relevant system changes and extensions are required, which can lead to a strongly divergent solution space. Standardisation and harmonisation will cut down costs and reduce complexity. However, align developments within the digital/telecommunication and automotive industries through standardisation, which might pose additional challenges
- Avoid that existing, inadequate and varying European regulations slow down development and deployment of automated driving.

The session focused on how suppliers are contributing to build the different elements of the improved architectural layers and platforms towards the full CAD vehicle. Vehicles integrating Internet of Things technology interact with each other and with personal devices, wearables, the cloud to deliver innovative services and applications. This will require a revised view on what the future electronics platform in the car will look like and will consist of secure and reliable communication gateways and networks, data links among vehicles as well as between humans, vehicles and infrastructure.

**Conclusions from session**

- Interoperability and complexity associated with in-vehicle enablers: the high degree of complexity not only impacts technical aspects, but also extends into the legal, policy, and safety fields, to name a few.
- Systems, components and partners should work together to master the rising complexity towards enabling harmonization for technical and non-technical fields.
- Industry is in the lead for handling technical development and implementation for the End2End ecosystem.
- Need to continue and expand collaborations at European level and facilitate global alignment.
- Need to define and consider impact of both verification/validation and data (quantity vs. quality) as there are not yet standards for the industry in these fields.
- Mutual interaction with other thematic areas including, but not limited to, security, safety, privacy, regulations, etc.

<u>Questions (& answer) asked by the audience</u>

- How will data and software updates be handled?
  - ➢ Agreement that updates will need to be handled in a safe manner; strong need for harmonization on this topic (along with many other roll-out details).
  - ➢ Future advances will depend on data (and access to it) by industry and other stakeholders.
- Are the barriers to CAD adoption technical or policy-based? Or both?
  - ➢ From technical perspective, verification and validation are today's greatest barriers; these impact market and customer expectations
  - ➢ Industry role: work with regulatory bodies on clearing technical and policy hurdles and their interdependencies
- European Commission question: what kind of funding is needed?

- Needs to enable European-wide and cross-industry collaborations with focus on technical and legal/policy harmonization; should also address architecture and software challenges

**Impact**

There are potential impacts, which are all dependent on each other. The ongoing developments in CAD will result in crucial changes to the in-vehicle system boundaries. First, highly advanced sensor systems, high performance computing hardware, redundancy of actuators, and cutting-edge algorithms are required. However, these technical advances alone will not be sufficient. Both network and backend layers will expand the vehicle system and its subsystems. Layers only applicable to today´s mobility sector still need to be expanded and should incorporate regulations, methods, and architecture.

In addition to this, the paradigm-shift in the driver-vehicle responsibility relationship will lead to new social and legal expectations that should not hinder user acceptance or market deployment. However, all these developments will have to occur while also reducing costs and time to market.

## 4.3.BO-1.3 Physical & Digital Road Infrastructure

**Organiser/s:** Alina Koskela (FTA), Jacqueline Erhart (ASFINAG)

**Moderator:** Jacqueline Erhart (ASFINAG)

**Rapporteurs:** Risto Kulmala (Traficon)

**Speakers**
Timo Saarenketo, Roadscanners
Manfred Harrer, ASFINAG
Risto Kulmala, Traficon
Jaap Vreeswijk, MAPtm

**Summary**

Currently there are many open issues regarding the deployment, operation and maintenance of physical and digital infrastructure (PDI) for connected and automated driving transport. The roles and responsibilities of multiple stakeholders, likely deployment scenarios and time plans need to be agreed upon by the stakeholders from both the demand and supply side of the infrastructure. Investments in physical infrastructure are long-term investments, implying that they should also consider the possible future needs of road users.

The open issues concern, among others, infrastructure maintenance, security, economic feasibility, business models, differences in operating environments ranging from rural roads in remote areas to busy interurban motorways and from residential areas to central business districts, and the specific problems in the transition phase towards full connectivity and automation.

This session discussed the key issues related to physical and digital infrastructure changes needed for wide adaptation of connected and automated driving (CAD). It is widely agreed that the safety, environmental and cost-saving benefits brought by CAD development will only be reached through wide adaptation of such technologies. In this way, physical infrastructure, from roads and bridges to traffic signals and lamp posts, may need to be updated with regard to its planning, building, maintenance and operation processes, guidelines and practices. The “Digital Road infrastructure” may be defined as “the digital representation of road environment required by Automated Driving Systems, C-ITS and Advanced Road/Traffic Management System”. It can be understood as the integration of multiple geo-located information layers containing:

- Static - Basic Map Database (e.g. Digital cartographic data, Topological data, Road Facilities)
- Semi-static - Planned activities and forecast (e.g. traffic regulations, road works, weather forecast)
- Semi-dynamic - Traffic Information (e.g. accidents, congestion, local weather)
- Dynamic - Information through V2X (e.g. surrounding vehicles, pedestrians, timing of traffic signals)
- Dynamic driving recommendations (e.g. lane change, distance gap)

The session also discussed the most urgent needs for action on the European, national and local scale with regard to accelerating the deployment, coverage and quality of the physical and digital infrastructure to facilitate CAD. A general open issue is whether the vehicle should be expected to cope with any road infrastructure in use via enhancement of sensors and related algorithms, and what demands can be set to adapt the existing physical and digital infrastructure. Specific open issues on road infrastructure elements concern terms, conditions and roles for service provision as well as collection of and access to data from especially automated vehicles. These open issues need to be addressed in order to guarantee the level of quality of information and the safety of mixed traffic. In order to ensure these services, the deployment of hybrid communication needs to be discussed based on different local requirements and roll-out decisions.

The speakers shared their views on the needs of connected and automated vehicles and transport towards physical and digital infrastructure as well as the objectives and plans of the infrastructure providers and operators. These actions covered the domains of research, innovation, deployment, maintenance, operation and service provision.

The concept and complications of Operational Design Domain (ODD) were presented with examples by Risto Kulmala from Traficon Ltd, Finland, representing the European road operators’ EU EIP project and its activity “Facilitating Automated Driving”.

The road operator perspective on physical and digital infrastructure was put forward by Manfred Harrer from ASFINAG, Austria. He highlighted the importance of infrastructure sensors and V2X communications in support of the vehicles’ sensors.

The impact of automated vehicles on road infrastructure was the topic highlighted by Timo Saarenketo from Roadscanners Group, Finland. He discussed especially the problems due to reduced tyre wander resulting from automated driving.

I2V applications for cooperative automated driving and traffic management were addressed by Jaap Vreeswijk from MAP traffic management, the Netherlands. He provided a summary of the findings of two European research projects, MAVEN and TransAID.

**Conclusions from session**

- Coverage and continuity of ODDs are likely crucial for use and user acceptance as the transfers of control between manual and automated driving modes will disturb travel comfort. Limited possibilities to utilise automation will not attract customers to buy automated vehicles. Today, we still lack empirical experience from road users with regard to acceptance of different ODDs, and such should be collected when possible. The whole motorway network, for example, should be covered, but with an optimal solution with regard to benefits and costs, and related to the physical and digital infrastructure.
- There is a need for solutions to prevent, manage, and distribute transfer of control between automated and manual modes in order to minimise the possible safety and flow efficiency problems with Level 3 & 4 automated vehicles.
- Use of infrastructure data is useful to support vehicle sensors and extend the event horizon.
- Most session participants expect the automated vehicle to deal with all current road infrastructures.
- Most participants also expect that we should define infrastructure levels for automation support in an analogous manner with the automation levels for vehicles.
- Road operators and the automotive industry should agree on the parameters defining ODDs for each automation use case, and the threshold values of these parameters.
- The infrastructure and automotive industry stakeholders should work together to define the roles and responsibilities of the different stakeholders for determining the ODDs, and the current ODD of a road section at a specific point in time.
- The optimum way to provide the ODD for each automation use case should be identified, as well as the required physical and digital infrastructure.
- Problems related to tyre wander have to be solved for both trucks (deformations) and cars (studded tyres or polishing).
- Platooning on weak subgrade roads, during spring thaw and after freeze-thaw, should be avoided or prevented (through geofencing/regulation).
- Mandatory reporting and control systems concerning truck total weights and axle weights, tyre pressures, and the use of winter tyres has been proposed.
- Research is needed to produce reliable pavement design models to cope with the impacts of CAD and other future challenges.
- Development of the digital infrastructure is needed to support automated driving by extending the V2X messaging, e.g.
    - V2I – Cooperative Awareness Message (intended vehicle route at intersection, platoon properties, acknowledgments of compliance to lane changes and speed advisory for negotiation);
    - I2V – Lane Advice Message (suggests the lane which a vehicle or platoon should change to at an intersection, target lane, distance to stop line, and time for starting the manoeuvre; combined with lane-specific Green Light Optimal Speed Advisory (GLOSA) and

  - V2X – Collective Perception (sharing abstract descriptions of objects detected by vehicle or infrastructure sensors; improved awareness even with low market penetration).
- Who should pay for the digital and physical infrastructure and the related research: the value for money is guiding all investments and the willingness to pay also depends on the responsibilities – road operators are responsible for the physical road infrastructure, but the vehicles may carry the main responsibility for damaging the infrastructure. There may be a need to have a special road use charge for automated vehicles or truck platoons.

<u>Questions (& answer) asked by the audience</u>

- What ODD is still acceptable to users? Any experiences?
  - No empirical evidence so far, but should be collected in tests and pilots
- How will different equipped roads affect the ODD? Should the advanced road infrastructure cover all regions of a motorway?
  - The latter is the aim, but first we must know what is the optimal way to do it
- How will our decisions on modifications on PDI influence the introduction of SAE level 3 and higher?
  - Perhaps not so much directly on the introduction, but these will likely have an impact on the take-up and use of higher-level automation.
- Should public agencies authorize sale of vehicles with a level 3 AD system or level 4 with limited ODD?
  - There should likely be a regulation making in compulsory to clearly inform the car buyer of the ODD of any SAE 3-4 vehicle.
- New training for professional drivers will be needed to interact in the best way with transitions; this aspect should be considered in related projects
  - Not just for professional drivers but all drivers
- Is there or will there be any study related to driving fatigue in ODD?
  - Not yet to our knowledge, but this can become a relevant issue as well
- Is it necessary to also inform the passengers/drivers about the existence of ODDs and how will they be informed?
  - It is necessary that they would be made aware of this. The exact way of informing during the travel has to be solved together with HMI experts
- Is affordable the implementation of these devices - 5G, sensors, fibre optics etc. in the whole network? What do you think is the best environment to implement them first: the most congested roads or the safest such as highways, considering that the toll plazas are really under-controlled zones?

- ➢ Before we start implementing different sensor and communication technologies on the whole network, we need living labs. The road operators have already studied the costs for new devices, and for this reason the test sites are looking at different solutions, trying to determine the most optimal ones and identify their value added. In Austria we have a fibre glass network on all motorways. But for testing new technologies and work on new solutions to e.g. extend the electronic horizon of an AV or to guide AVs safely through hazard areas, we focus on our about 20km long Test track ALP.Lab

- If penetration of V2X is low, you cannot reliably rely on V2X data in your sensor fusion. You need to use your onboard sensors to guarantee you detect all objects.

  - ➢ Using only the on-board sensors would not guarantee a complete detection of all objects. Therefore it is important to fuse the provided infrastructure data in order to create an outside view of the vehicle. The results can be compared and validated to the data of the on-board sensors.

- Infrastructure data can be used post-testing. What infra data will you provide post-test?

  - ➢ The infrastructure will be provided by the installed sensors on the motor. We can provide Traffic Data, Radar Data, Environment Data, Video Detection Data, Connected Vehicle Data, Traffic Control Data, Weather Information Data, Road Work Information Data, Incident Management Data, Traffic Surveillance & Control Data.

- Any first ideas on the cost of digital infrastructure (DI) roll-out? What about the situation on roads which are not highways? Who should pay for this eventually?

  - ➢ The cost of the C-ITS infrastructure roll-out depends on various factors: 1) Equipment cost and installation cost of road-side stations. This depends on the number of locations, and the infrastructure required at the locations i.e. is mounting position, network and power supply already available; 2) Deployment cost of the Central-ITS-Station. This depends on the software license model of this station; 3) Integration of the C-ITS equipment with the traffic control centre (TCC). This depends on the need to create or adapt software interfaces, provide network connectivity, configure components, etc.

- Roads other than highways also have a responsible operator e.g. federal state, municipality. Who is first in decision making?

  - ➢ Decisions related to the equipment of the road with C-ITS road-side stations, or other digital infrastructure, are normally done by the operators of the roads in question. The Member States have the responsibility to make sure that the equipment is compliant to national, European and global regulations. Naturally the Member States can also make decisions on national deployments including the priorities of the different road networks with regard to deployment.

- Have you tested digital sensors in toll plazas to see if vehicles choose the correct lane?

  - ➢ Within the scope of the project VAMOS, we have tested the assignment of lanes by using and analysing the data of video cameras at a toll plazas. It is possible to detect a chosen lane as well as the pace of vehicles. The Austrian Light Vehicle Proving

Region for Automated Driving or ALP.Lab plans to extend their testing ground at a later stage in order to validate automated driving systems at toll plazas.

- Have you experienced during your trials any kind of interferences with current tolling system/devices?
  - ➢ Coexistence between CEN-DSRC-based tolling systems and C-ITS is ensured by following the coexistence standard ETSI TS 102 792. In C-ITS trials in Austria, protected zone data for all tolling locations within the trial area have been broadcasted via ITS-G5. Participating ITS-G5 equipment vendors have confirmed that their equipment received the protected zone data and switched into coexistence mode. Consequently, no interference was reported.
- How much data will be enough to become confident about the CAD behaviour?
  - ➢ There are many CAD projects, e.g. L3pilot, which try to validate first SAE L3 functionalities and other more traffic management related projects, e.g. INFRAMIX, which try to develop safe systems for managing mixed traffic conditions. It is still a topic of research to identify which data is needed to verify a reliable and confident system or to provide enough information to guide and support AVs in different situations.
- How do road operators decide which kind of PDI equipment is used for testing and which one is needed for the introduction of SAE level 3 and higher?
  - ➢ There is still a need for researching which technology is needed for testing and supporting SAE L3 and higher. First approaches are based on discussions with different local stakeholders in order to use existing and extended sensor data. Additionally, new technologies are tested and enhanced in order to promote new disruptive ideas. While new methods are developed, sensor technology is also advancing. It is unknown which technology or which equipment is needed for L3 and higher, unless it is tested.
- On slide 7, why can the listed C-ITS services not be implemented through the existing 4G mobile network?
  - ➢ C-ITS cannot be reduced to a certain communication channel. The C-Roads platform is currently working towards specifying a solution for C-ITS utilising hybrid communications i.e. the combination of ITS-G5 and cellular communications.
- Do you have any references about the cost of the implementation this technology in a highway per km? Who should pay these devices, operator or the Grantor?
  - ➢ The different test sites are being equipped with different technologies, especially sensors, fusion algorithms and communication technologies. You may not compare costs of test side equipment with the costs of large scale deployment in the future. The pure technology costs at test sites can be estimated currently by approximately 50 - 500k€ per km depending on the quality level and pre-requisites.
- Will tackling challenges per geographical area results only in local solutions and therefore converging towards a global solution become even more challenging?

  - Yes, there is a major risk of this happening. On the other hand, there is a need to tackle also challenges existing on quite specific geographical areas only.

- If you connect the mobile VMS (Variable Message Sign) to the internet as an IoT, everyone could use this data for their apps, not only equipped vehicles.
  - This is true, but we have to distinguish the needs of cooperative and automated vehicles for trusted communication and information and those of app users.

- How do OEMs think about this? Are they simply assuming an autonomous car?
  - OEMs may need to rely on extended environmental perception data which can be provided by the road infrastructure. But to cover all different perspectives of all stakeholders, an interaction of OEMs and road operators is needed.

- Have you tested other kind of pavements? Concrete, for example?
  - Different ones have been tested and concrete pavements perform somewhat better.

- Those who cause the problem of road erosion (i.e. the cars/trucks) should also maybe pay for the extra costs, e.g. some kind of automated car usage tax
  - This should be studied, but we need discussions between the stakeholders to search for the best overall optimal solution. An extra tax creating dedicated lanes would be too expensive to be carried out.

- Do we need special lanes for platooning because of road degradation?
  - We should rather strengthen these lanes to meet the structural requirements.

- Is it possible to reduce the width of lanes because traffic is concentrated in a fixed line?
  - This can be done if pavement structure will be made very strong. But the other option is artificial tyre wander and then we need the wide lanes.

- Which method was used to select the use cases and how is it possible to know how well (metrics used) they represent the vast range of driving scenarios?
  - We reviewed the literature and the disengagement reports from tests to understand what conditions AVs struggle with the most. We tried to aggregate that to a number of illustrative examples which serve a purpose of demonstrating the measures we intend to develop and implement. For example: provide vehicle path information, provide speed, headway and/or lane advice, traffic separation, guidance to safe spot and scheduling of Transition of Control / Minimum Risk Manoeuvre. Clearly, these use cases do not cover all possible driving scenarios, but it is easy to imagine that the measures can be implemented in scenarios which are similar to those selected.

- What SAE level of automation is necessary for applying these systems?
  - First and foremost, the AV should be a CAV. Predominantly level 3 and 4 are in the scope of the MAVEN and TransAID projects. However, it is conceivable that some use cases can be executed with level 2 as well.

- Be careful with the GDPR! The C-ITS data may not be used for any further purpose.
  - GDPR and other privacy and related regulations have to be taken into account, indeed.

**Impact**

The impacts are not known yet, but knowledge of them is essential for the further development of physical and digital infrastructure. They should be determined via real life pilot tests. Moreover, field Operational Tests can help verify the role and uses of connectivity as an element of automation needs.

In order to identify possible impacts, horizontal issues regarding privacy, ethics, security, data management, costs, etc., need to be taken into account. The privacy of drivers and users of automated vehicles needs to be maintained under all circumstances – especially the data that is generated by tracking of the vehicles, which is used by the back office systems, other drivers and stakeholders.

Regarding to the cyber-security issues with the digital infrastructure, they are quite wide-arching from GPS spoofing to taking hostile control of the vehicle or its subsystems. Liability issues involves both physical and digital infrastructure. Who is responsible for the data at all time is necessary to know, and also of the maintenance of the physical and digital infrastructure, among others. Careful preparation of contracts and service level agreements provide at least some solutions to these issues. In addition to that, the assessment of costs will be a key factor to support road operators' decisions. Therefore all measurements and activities regarding automated driving should be planned in coordination with the issues of physical and digital infrastructure.

## 4.4.BO-2.1 Socio-Economic Impacts

**Organiser/s:** Pirkko Rämä, Satu Innamaa (VTT)

**Moderator:** Satu Innamaa (VTT)

**Rapporteur:** Salla Kuisma (VTT)

**Speakers:**
Torsten Geissler, Federal Highway Research Institute (BASt)
Iain Macbeth, Transport for London
Kerry Malone, TNO

**Summary**

Assessing socio-economic impacts and sustainability of automated driving provides valuable insights for drivers/users, OEMs, fleet operators, transport authorities and road authorities making decisions about investments. To make well-reasoned decisions on future

developments, a good understanding is needed of how the benefits for society, sustainability and transport will be reached with increased automation as well as knowing the desired impacts in the transport system. The goal of impact assessment is to provide the information required for the sustainable development paths hence good understanding of impact mechanisms is need. Furthermore, numerical estimates of benefits need to be provided for the cost-benefit analysis. Focus of the session was on impact mechanisms, feasibility to assess and estimate impact for selected impact areas. The use of evaluation results for industry and policy perspectives was also discussed.

The session was divided into three parts. Three speakers gave their insights regarding specific aspects related to socio-economic impacts of automated driving. After every speaker presentation, there was an interactive session, where the focus was on engaging the audience to share their views on impacts related to speaker´s topic. In the interactive session, the audience was given three long-term scenarios shown in the table below, within which the impacts of automated driving were discussed. The scenarios were formed as a part of CARTRE work in a task for assessing socio-economic impacts of CAD and the impacts discussed based on Trilateral Impact Assessment Framework and the Results of Trilateral KPI Survey. In practise, the audience answered to poll questions, in which they were asked in which of the three scenarios the given impacts would be most likely (see Table 1). The results are shown in the ANNEX 3.

**Table 1 Long-term scenarios (2035) for the interactive polls**

| | Scenario 1: 'Shared AVs' | Scenario 2: 'Automated PT' | Scenario 3: 'Private AVs' |
|---|---|---|---|
| **AV technology** | Mature SAE 4 automated vehicles, penetration>50% in mixed traffic | | |
| **Use of shared mobility services** | High | High | Low |
| **Locus of control** | Private | Road authorities; policy driven, private/public collaboration | Private |
| **Basis of transport system** | • Market-operated fleets of shared automated cars<br>• Services reliable and convenient<br>• Different level of service with different price<br>• No multimodal services<br>• Regulations and subsidies to ensure minimum level of mobility services to all people | • Demand responsive public transportation for selected routes<br>• Subsidised by public sector<br>• Mainly between major public transport hubs and for lower density areas<br>• Travel chains are well functioning and intermodal<br>• Privately owned automated vehicles quite heavily taxed<br>• Most of the people are used to sharing their mobility and car | • Proliferation of private automated vehicles<br>• People do not respond well to sharing automated vehicles<br>• Owning automated vehicles is affordable for most people<br>• Policies focus on reducing emissions, managing urban space effectively, and increasing safety of automated vehicles |

Furthermore, several challenges were identified related to assessing the socio-economic impacts of automated vehicles. Some of them are more generic related to impact assessment and field studies, some more specific to automated driving.

It was understood that assessing impacts and sustainability of automation is challenging already in the short-term: trying to cover all possible impacts well and ensuring acceptance of automated driving and tests with the general public having imperative demand on safety and security in piloting phase.

In the long-term, the picture may be even more complicated. The assessment must cover direct and indirect effects, related to each other, and other social trends besides automation influencing the working environment. Parallel with increased automation in road transport other changes in society will happen and should be anticipated; examples are electrification, shared mobility services and job creation.

Automation challenges the traditional approaches and methods used in the assessment of ITS. Impact mechanisms are complex, and to catch all relevant effects updates of models may be required on several levels. New research questions emerge and old ones are getting new content or becoming less important. Overall, high-level automation is going to mean a fundamental change in the road transport system; the objects of research are changing as well as the evaluation approaches and methodologies.

The city perspective was represented by Iain Macbeth, TfL. Cities have an important role in discussing what kind of transport system would be intended in the future and how CAD fits in it. Public authorities are significant users of evaluation results, as policymaking requires knowledge about impacts. Thus, the city view on automated driving is a highly relevant viewpoint regarding socio-economic impacts of CAD.

The impacts on traffic flow and road capacity are important because it is related to huge investment decisions and it is also important for user and stakeholder acceptance. Kerry Malone from TNO discussed how automated vehicles can impact traffic flow, on what that does depend and what kind of knowledge is required for assessing the impacts. Highly relevant issues regarding traffic flow and capacity are increasing penetration rates and levels of automation. Expected impact size over time also depends on mileage. The impacts which we need to get a grip on are vehicle operations / automated vehicle (control) operations including acceleration, deceleration, lane keeping, car following, and lane changing and merging in adjacent lane. With information about lane changes in vehicle operations, the impacts on network efficiency can be explored, meaning lane, link and intersection capacity and throughput, as well as travel time and travel time reliability. Lateral behaviour is the great unknown so we want to increase the ODD while continuing to research the challenging situations.

Torsten Geissler from BASt talked about market penetration information as an essential input to socio-economic impact assessment. Market penetration information can be gained from e.g. sales of passenger car equipment with vehicle safety systems.

**Conclusions from session**

- The societal and city perspective is needed when discussing the future of CAD to ensure that automation developments are not purely industrial policy driven, but also support transport policy and benefit citizens.
- Questions regarding traffic flow and capacity should be incorporated in the set-up of pilots; especially discontinuities, such as lane drops or merging and exiting sections, are relevant situations to test or simulate. We need to define what learning outcomes are wanted from the pilots and experiments.
- Desirable behaviour of AVs needs to be defined (user perspective and efficiency perspective may differ in relation with desirable behaviour).

- Current status needs to be known (baseline), but also a lot of new input is needed for the scaling up
- Policy/authorities led shared automated mobility could enhance many positive impacts but it needs to be discussed how to motivate people for sharing their mobility
- More information and education is needed for the users to have a good knowledge of the capabilities of vehicles and the systems to avoid accidents (people are typically not reading the manuals and having high faith in the vehicle).

Questions (& answer) asked by the audience

- Do you reckon that this change in the mobility patterns- from ownership to car sharing - is going to reduce or increase the number of trips? Do you think that the leisure trips are going to be the first one in plunge?

  - We already see some changes in leisure trips, and this is probably due to changes in the use of leisure time. There seems to be a trend of staying more indoors with new entertainment services, such as Netflix, and not travelling as much as before. We need to be aware that the changes in trips due to AVs can be hard to distinguish from other changes in society.

- How about completely new mobility services already possible at level 3 or 4 automation (e.g. car-sharing + ride-sharing for peripheral trips with self-empty vehicle relocation)?

  - Electrification is a relevant issue here, to which also these completely new mobility services are tied. Electrification of self-empty vehicles could lead to electric charging to be centralized. This is an also an interesting theme to consider when discussing the new mobility services, as we don't wish to encourage excessive empty running.

- Looking at the polls, we need to go to more shared and public transport. How to motivate the drivers for that?

  - There is a whole suite of tools a city can do to enhance public transport, e.g. policies that promote active travel and address air quality, and looking into next generation road user charging and taxation.

- Recent survey showed that road users were very satisfied with the behaviour of Waymo cars. It seemed every Waymo car responded on a traffic situation the same exact way (one brain). This made them very predictable drivers. With your expertise, what did you think of this outcome?

  - It is not a surprise that predictability of AVs was considered desirable. There are two important issues when discussing the desirable behaviour of AVs: would an ordinary human driver react the same way and was it the desired way.

    The desirable behaviour of AVs might also be different depending on the perspective. Users may have different views on what is desirable than road operators, who are looking at the efficiency of the whole transport system.

- Do you have any document/idea/analysis with an estimation of the effect of AVs in the capacity of the roads? Do you think it could be increased?

- ➢ There are some analyses that have looked at the effects of AVs on road capacity in the form of simulations, but the results in these papers are for specific road types e.g. motorways, and there are also critical issues that need to be addressed in order to answer this question fully: more situations need to be examined on a wider variety of road configurations in order to address the capacity impacts of AVs, e.g. heavy traffic on road sections with discontinuities such as weaving sections, on and off ramps etc. Also parameter and setting choices of the AVs (e.g. headway, gap acceptance etc., which may vary between different brands) and penetration rates need to be examined.

  Estimation of effect of AVs on road capacity has been examined in papers such as:

  - S. C. Calvert, W. J. Schakel, and J. W. C. van Lint, "Will Automated Vehicles Negatively Impact Traffic Flow?," Journal of Advanced Transportation, vol. 2017, Article ID 3082781, 17 pages, 2017.
  - TRA 2018 papers:
    - *Connected and Automated Vehicles on a freeway scenario. Effect on traffic congestion and network capacity* (Mattas, Konstantinos; Makridis, Michail; Ciuffo, Biagio; Alonso Raposo, Maria; Toledo, Tomer; Thiel, Christian)
    - *Effects of Automated driving functions on the track availability of the Austrian motorway network* (Hintermayer, Bernhard; Haberl, Michael; Neuhold, Robert; Fellendorf, Martin; Kerschbaumer, Andreas; Rudigier, Martin; Eichberger, Arno; Rogic, Branko)

- How would V2V affect these results?

  - ➢ V2V would affect the results considerably. The question is why / how. V2V communication enables communication of e.g.critical parameters for string stability and of information and warnings, as well as negotiation between vehicles (gap creation, optimal speed for the entire traffic flow).

- If there is a flow and capacity problem in mixed traffic, do we need allocate separate lanes for AVs at some point of fleet penetration?

  - ➢ The need for separate lanes is a benefit-cost decision and an equity question. Separate lanes for AVs come either at the expense of existing lane capacity or need to be built, which are costs. Do the benefits justify the costs? And, if space is specifically allocated to AVs, is that from the standpoint of social equity a desired situation?

- What do you think about some elements of centralized control of CAVs (routing, scheduling) to provide better network efficiency?

  - ➢ This would require the cooperation of many stakeholders to achieve so the barriers are high.

- What research has there been on the observed (not simulated) effects of current L1 systems (e.g., ACC) on motorway traffic flow?

  - In the Netherlands, the A2 study (ACC, Haskoning / DHV); EuroFOT study; the Dutch Driving Assistant ("Rijassistent") pilot. There are probably also other regional or national pilots.

- So far driver assistance systems do not necessarily depend on technical roadside infrastructure. How does the need for V2X communication influence the assumption of penetration rates for AVs?

  - It is good to not use market penetration rates on the vehicle side alone but also how good the coverage is on communication systems. Some aspects of penetration are easier to measure than others.

- Dedicate more investments in connectivity or automation in both short and medium term?

  - Connectivity and automation will go hand-in-hand because they benefit from each other. Investments have to be made (and increased) on both elements, across sectors (private industry, public bodies) in order to co-create the ecosystem around connected and automated driving.

**Impacts**

Examples of future research topics are focusing on long term impacts and welfare in the society:

- Evidence about socio economic benefits in terms of inclusiveness and user-centric activity based mobility solutions
- The influence of citizens and public authorities in order to take the desirable direction for AD
- Long-term studies on how automation supports mobility; assess the long-term effects of automated vehicles on driver behaviour, road safety, future travel needs, and future mobility patterns
- Study and find design solutions for human factor challenges such as misuse, skill degradation, level of trust and acceptance, motion-sickness during non-driving activities in highly automated vehicles
- Research on emerging new mobility patterns
- Research on motivating people to share mobility
- Research on how trust, acceptance and adoption of road automation develop over time and with more exposure and experience with automated systems

Assessment should have strong emphasis on social effects, user requirements, user acceptance and user outreach. The outcomes of research and innovation will only come to rapid deployment, if further efforts are made to reach out to users, analyse their requirements and acceptance with the aim to overcome market deployment barriers.

Besides, socio-economic assessment is seen as a continuous activity taking place in parallel with the development of intelligent, connected and automated road transport system. Assessment goals and methods vary according to the technology readiness level (TRL). In an early phase, for instance, the assessment provides input directly to the design process

whereas on the higher TRLs the focus is more on the evaluation of the benefits and drawbacks.

This means, the assessment results are important for several stakeholders: road authorities and cities, OEMs, mobility service providers, fleet operators, transport and logistics owners, drivers/fleet organisations, media, micro-electronics industry, telecom industry and finance sector. All parties need to be aware of user reactions and impacts in alternative deployment scenarios.

## 4.5.BO-2.2 Human Factors & User Awareness

**Organiser/s:** Anna Schieben (DLR), Stella Nikolaou (CERTH), Olivier Lenz (FIA)

**Moderator:** Anna Schieben (DLR)

**Rapporteur:** Stella Nikolaou (CERTH)

**Speakers:**
Evangelos Bekiaris, CERTH
Satoshi Kitazaki, AIST
Andreas Eustacchio, Attorney at law
Riender Happee, TU Delft
Olivier Lenz, FIA
Arjan van Vliet, RDW
François Fischer, ERTICO – ITS Europe

**Summary**

This session addressed challenges associated with the introduction of automated vehicles in mixed traffic environments, and outlined current progress as well as future research needs. Fundamental Human Factors challenged are to ensure safety, ease of use, trust, acceptance and comfort, for users/passengers of automated vehicles. Likewise, a safe and acceptable interaction with other road users including pedestrians and cyclists needs to be established. In the session, researchers and industrial representatives from ongoing research initiatives and international experts discussed the state-of-the art of Human Factors research for automated vehicles, current design guidelines and evaluation methodologies.

The session addressed five key topics, whereas one of the invited panellists was appointed for each topic to discuss with the audience the presented statements (two statements per topic):

- New HMI developments for AVs: Francois Fischer, ERTICO – ITS Europe
- Driver state monitoring: Evangelos Bekiaris, CERTH/HIT
- Interaction with other road users: Satoshi Kitazaki, AIST
- Societal acceptance: Andreas Eustacchio, Attorney at law
- Testing/Validation procedures: Arjan van Vliet, RDW Netherlands

The role of the driver is often considered to be diminishing when increased degree of automation is introduced in vehicles. However, vehicles today and in the future will offer different levels of automation and will be used in in different traffic environments. This means the proper design of the human-vehicle automation interaction is crucial in order to reach safe introduction of driving automation systems and driverless, automated driving system-dedicated vehicles and to ensure user acceptance and adoption. Besides, initial Human Factors related design recommendations have been suggested in order to support the design of safe, easy to use systems, ensuring positive outcomes from the implementation of driving automation systems whilst safe-guarding against potential downsides.

Key Human Factors research questions related to the above mentioned challenges are the following:

- Understand the interaction between humans and driving automation systems (in-vehicle and outside vehicle) at different levels of automation;
- Understand effects of vehicle automation on humans such as unintended use, skill degradation, trust, and motion sickness;
- Raise awareness and increase acceptance for automated driving;
- Adapt the vehicle automation to human needs and states and to establish adequate driver training;
- Derive interaction design concepts for the driving automation systems so that both the human driver and other humans in the surrounding sufficiently understand the capabilities and limitations of the vehicle;

**Conclusions from session**

- It is important to have a user centred design approach both in research as well as in development instead of designing and then hoping for (and measure) positive user experience, acceptance and high adoption. There is a strong need to study user interaction with vehicles in real world conditions. However, Human Factors research still needs to iterate with more controlled laboratory settings/evaluations.
- There is a paradigm shift from looking at how to minimize secondary task engagement and how different types of secondary effect influence the causation of accidents and critical incidents. The new approach is to look if and how automation can actually be a distraction enabler.
- Take over response time from automation to manual: Human factors research should not be about finding a specific figure of x seconds. Studies are showing ranges from 2-45 seconds or even minutes. It is important to look at quality of take over and what happens after a driver has regained control. A lot of work is on-going trying to find good ways to measure driver alertness and general activation state, response times as well as quality of take over.
- Humans both over-trust automation and under-trust automation. For lower levels of automation drivers are sometimes not using the technology enough (low adoption rates) even though ACC and automatic braking systems have been proven to have a strong safety benefit. Drivers might at the same time over-rely on actual higher level of automation or systems they perceive to offer high level of automation.
- In the session there was disagreement on whether automation in vehicles needs to be clearly indicated to the surrounding environment, other road users etc. There are various pros and cons for indicating that an automated vehicle is driving in automated mode.

- There is strong belief that people will change their behaviour after becoming accustomed to high level of automation in vehicles and that this will change the complete traffic system.

Of the total of ten statements discussed during the Session, two statements were highly rated by the audience (over 80%), two statements received low rating (below 40%) and six statements were fairly supported (~ 60-70%), as seen in Table 2 below.

**Table 2 Rating of the statements discussed in the Human Factors session**

| Human Factors Challenges in AD Statement | Statement acceptance (%) |
|---|---|
| New smart, personalized HMI concepts, designed for high automation, will increase system robustness, user acceptance and overall comfort. | 82% |
| We need new, adapted and fully integrated HMI systems that provide advanced comfort during Level 3+ automation. | 74% |
| Driver state monitoring is a pre-requisite for Level 3 (and lower) automated driving to ensure safe and smooth transitions. | 64% |
| Driver monitoring systems should follow a hybrid approach to reach robust performance and use a combination of driver state, vehicle state, environmental context and personalised driver info. | 77% |
| We need additional external HMI for Automated Vehicles to coordinate actions with other road users. | 70% |
| Automated Vehicles must fully understand the intentions of other road users and react accordingly. | 61% |
| Accident liability should be removed from drivers of conditionally automated cars (SAE Level 3) who show typical and reasonable user behaviour. | 39% |
| People should have the freedom to change options for the decisions taken by the cars (e.g. driving style) | 63% |
| Legal admission of SAE Level 3 automation requires human in the loop evaluation of take-over procedures. | 86% |
| Legal admission of SAE Level 4 automation in vehicles with steer and pedals does not require human in the loop evaluation of take-over procedures. | 26% |

**Impacts**

As a Human Factors community, the goal is to ensure a safe and acceptable introduction of automation on public roads. This will enable a drastic reduction of fatalities and injuries, and a greatly improved mobility and these will only be achieved if Human Factors is well integrated in the design and verification of automated vehicles. Therefore, the active contributions of current and future initiatives helping to achieve key Human Factors insights for higher levels of automated driving are appreciated.

## BO-2.3 Vehicle Validation

**Organiser:** Alvaro Arrue (IDIADA)

**Moderator:** Simon Edwards, RICARDO

**Rapporteur:** Alvaro Arrue (IDIADA)

**Speakers:**
Richard Schram, Euro NCAP
Jürgen Holzinger, AVL
Felix Fahrenkrog, BMW
Annie Bracquemond, Vedecom

**Summary**

Safety validation and roadworthiness testing involve the definition of a comprehensive set of methodologies and tools aiming to verify whether vehicles comply with the regulatory and technological requirements. This verification is one of the building blocks for the safe deployment of automated road transport on public roads. These methodologies and tools should address the whole vehicle lifecycle.

Exhaustive (safety) validation and trustful roadworthiness testing of increasingly complex systems are key elements to both guarantee and promote the successful deployment of safe, socially accepted automated road transport on our roads. There is a need to go beyond current state-of-the-art, taking into account the automated vehicle as another element in a complex system that interacts with a highly dynamic and variable environment populated by heterogeneous road users. Cost-effective solutions are paramount as the CAD validation will grow exponentially due to the inherent complexity associated to an exponential growth of the scenarios that the vehicle will be involved.

For this purpose, Europe's future R&D agenda should take into account research on technical, regulatory and societal challenges, guaranteeing Europe's global competitiveness in CAD development and deployment.

There are many challenges that need to be addressed regarding road automation and its verification/validation. First of all, it is important to perform an initial validation for new systems to be introduced in the market. However, the safety validation must be observed during the whole vehicle lifecycle. These two approaches present different challenges, among others:

- With the current state-of-the art on validation/verification methodologies it is not feasible to physically test all the possible road situations. It is critical to find out a minimum set of tests that provide high enough confidence for public road release. A comprehensive, reliable, balanced and complementary combination of physical tests and simulated tests should be defined in order to guarantee the safety of a vehicle before its deployment to public roads.

- Validation testing of operational and functional safety as part of the development of a new function and/or a whole automation level.
- The human interaction must include the vehicle interaction with the driver as well as with the rest of road users and must be reflected in safety validation.
- Testing should cover several levels of the whole system: component level, vehicle level, system level (including interaction with other road users and infrastructure) taking into account its specific characteristics, commonalities and differences.
- The vehicle hardware and/or software updates that modify its functionalities must be addressed as well as their impact on safety. However, it is important to clearly understand when a new update should be considered different enough to start a new validation procedure or if new, whether different approaches able to deal with the update need to be developed.
- Maintenance of the CAD systems should be followed during the vehicle lifecycle and regular updates have to be considered. The Periodical Technical Inspection (PTI) procedure might also have to be reviewed in terms of periodicity and the tests carried out to check the correct functioning of the automation features (sensors, software) of the vehicle.

The session invited four relevant experts in the field of vehicle testing and validation to give an overview of the different initiatives that are currently taking place at European level and dealing with this highly sensitive topic:

- Dr. Jürgen Holzinger (AVL) presented the ENABLE-S3 project. ENABLE-S3 is targeting the acceleration of vehicle validation through the use of scenario based simulation and consequently reducing the number of necessary driven mileage in several orders of magnitude.

- Dr. Annie Bracquemond (VEDECOM) is coordinating the MOOVE initiative. MOOVE is a national French project in which several thousands of kms have been recorded and assessed in order to extract critical scenarios and their statistical relevance in different driving environments.

- Dr. Felix Fahrenkrog (BMW) introduced the audience the relevance of safety and pilot testing for the CAD impact assessment. CAD vehicles have huge challenges but offer great potential to solve and mitigate current and future problems of safety and mobility. Consequently, we need to move from accident based to traffic based methodologies.

- Mr. Richard Schram (Euro NCAP) showed the current plans of Euro NCAP for consumer testing of ADAS and higher levels of automation. Following the well-known performance based assessment; Euro NCAP will also introduce new features looking forward the user awareness of their vehicles safety capabilities.

**Conclusions from session**

- Virtual Validation needs to be validated itself (in terms of reliability and completeness) and accepted by regulators (more used to physical testing approaches).
- There are several initiatives dealing with the topic but we need to make progress to learn how we can provide full coverage validation.

- Improving procedures to obtain scenarios is needed. Data sharing (at international level) would certainly reduce costs but there is a challenge in terms of property and local differences.
- It is not just about the safety of the function, but how the driver makes use of the vehicle and the evaluation of safety in relation to other users / elements.

**Impacts**

All technical developments are useless if a proper regulatory framework is not in place. Europe's leadership in the automotive sector can be compromised if a fair, trustworthy, harmonized and complete process for safety assessment is not developed. At higher levels of automation, the current approaches do not suffice anymore.

A European-level approach would speed up the development process and reduce the time to market of new automated functions with a higher level of safety of the deployed systems. The enhancement of the safety level of new functions through a consolidated and trustworthy verification / validation methodology would increase the user acceptance of these technologies and contribute to its market adoption.

## 4.6.BO-3.1 Regulation, Legal and Liability

**Organiser/s:**
Yves Pages (RENAULT),
Henning Mosebach (DLR),
Armin Gräter (BMW),
Maxime Flament (ERTICO),
Arjan Van Vliet (RDW)

**Moderator:** Arjan Van Vliet (RDW)

**Rapporteur:** Yves Pages (RENAULT)

**Speakers:**
Joel Valmain, Vice-Chair UNECE/WP 1
Tom Gasser, Bast
Thierry Latelise, Renault
Jessica Uguccioni, Law Commission, UK
Peter Blumer, Allianz

**Summary**

The session aimed to discuss (regulatory) achievements, residual challenges and solutions (from regulation standpoint) for the deployment of AD systems in Europe.

In order to protect the society from unsafe and less environmental friendly motorized vehicles, vehicle registration authorities apply vehicle approval standards. Vehicle manufacturers have to proof that their vehicles are in compliance with those standards. Currently, non-existent, incomplete or multiple national legislative approaches still form a major obstacle on the path to the market introduction of automated and especially

autonomous vehicles. Therefore, the goal of the legislatures should be the creation of a regulatory framework as unified as possible.

The harmonization of the various rules is in the best interests of a functioning European internal market. The right conditions should be put in place so that vehicles can assume tasks that today only the vehicle's driver is allowed and able to perform.

For Europe, digitization of public and private transport and the speed of development of automated driving represent an opportunity to become the worldwide leader in the field. Speed and expertise in development lead to landmark innovation and fast solutions. Regulators need to make basic policy decisions soon so motorists can benefit the most from this technology.

The main challenges in the area of policy and regulatory needs as well as in European harmonization have been defined as follows:

- Today, the work of the Industry and the discussions with national and EU stakeholders (governments and their agencies) concentrate on research, testing and type approval. First activities focussing on the development of traffic rules have started in some countries. However, it is necessary to know what the total scope of affected policy and regulation is.
- Research and testing: the way of bundling and coordinating EU research activities to speed up and not loose in the world-wide competition.
- Type approval regulation: how to set up the regulation quick enough to be in place when the technology will be ready, how to deal with software updates.
- How to, and to which extent, adapt and harmonize traffic rules for a quick introduction of higher automation levels.
- The necessary liability framework to be in place to facilitate market penetration from a legal/liability perspective.

The five speakers were invited to discuss:

- Joel Valmain: The Status of Vienna and Geneva Conventions: what is possible today and what still needs to be done to allow highly and fully automated driving systems usage.

  WP 1 (Global Forum for Road Traffic Safety) is to create a non-binding advisory instrument/draft resolution on the deployment and development of highly and fully automated vehicles; and a sub-group of WP1, dedicated to Automated Driving, is also preparing a discussion paper on "the driver engaged in other activities" whereas "some" automated functions are switched on.

- Tom Gasser: The special case of the German Road Traffic Act (June 2017).

  Here below, we quote two important and self-explaining excerpts of the modifications of the Road Traffic Act in Germany (June 2017):

  *Section 1a.*

  *(1) The operation of motor vehicles by means of a highly or fully automated driving function shall be permissible if this function is used for its* ***intended purpose****.*

*(2) Motor vehicles with a highly or fully automated driving function within the meaning of this Act are vehicles equipped with technology that:*

*1. when activated, is able to control the motor vehicle – including longitudinal and lateral control – to perform the driving task (vehicle control);*
*2. is able, while the vehicle is being controlled in the highly or fully automated mode, to comply with the relevant traffic rules and regulations for operating a vehicle;*
*3. can be overridden or deactivated manually by the driver at any time;*
*4. is able to identify the need for the driver to retake manual control of the vehicle;*
*5. is able to indicate to the driver – by means of a visible, audible, tactile or otherwise perceptible signal – the need to retake manual control of the vehicle with a sufficient time buffer before it returns control of the vehicle to the driver; and*
*6. indicates that use is running counter to the system description.*

*The manufacturer of such a vehicle shall state in the system description, in a binding manner, that the vehicle meets the requirements set out in the first sentence.*

*(4) A person who activates a highly or fully automated driving function [...] shall also be deemed to be a driver.*

*Section 1b*

*(1) While a vehicle is being controlled by highly or fully automated driving functions as described in section 1a, the driver* ***may divert his attention from other traffic and control of the vehicle****; he* ***must, however, remain sufficiently alert*** *that he can comply with the obligation set out in subsection (2) at any time.*

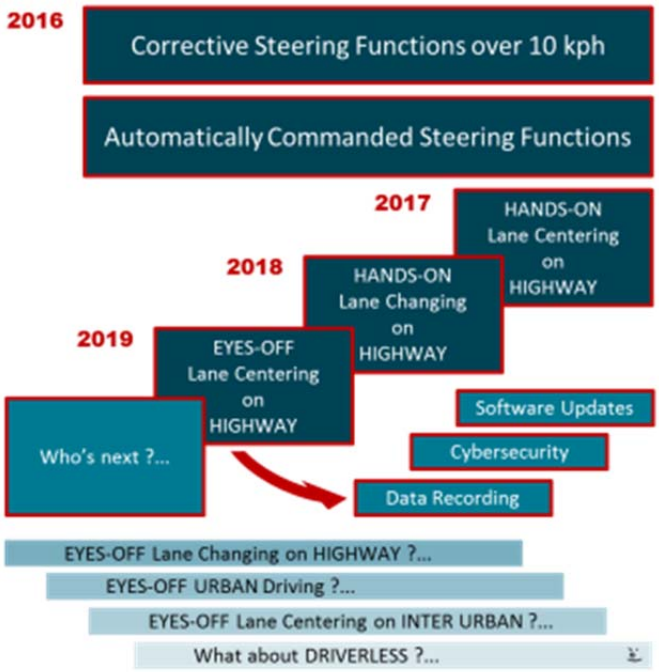
*(2) The* ***driver shall be obliged to retake control of the vehicle without undue delay****:*

1. *if the highly or fully automated system* ***prompts him to do so*** *or*
2. *If he* ***realises*** *or, because of obvious circumstances,* ***must realise*** *that the conditions for using the highly or fully automated driving functions for their intended purposes are no longer being met.*

In short, this law authorizes AD systems SAE levels up to 3 in case they are regulated by technical regulations. The manufacturer has to define the intended purpose.

- Thierry Latelise: The status of technical regulation: achievements in WP29 and roadmap for the next 5 years; challenges for Type-Approval.

Currently, the technical regulations regarding advanced driver assistance systems and automated systems follow the chart below (revision of the UNECE R79 “Steering functions” of the WP29 World Forum for Harmonization of Vehicle Regulations):




As of today, only hands-on lane centring on highways functions are regulated, which correspond to SAE level 2 systems on a restricted Operational Design Domain. Further regulations are on their way with a short term-mid-term agenda, but not really with a very detailed and accurate schedule.

Furthermore, it seems more and more unrealistic to rely only on revision of UNECE R79. It is likely that further regulation (so-called horizontal regulation) will in the future combine physical certification tests, audit (when OEM will have to provide, e.g. Safety concept / functional safety strategy / Simulation and development data to verify vehicle behaviour in thousands of edge cases variations), and real-world test drive.

- Jessica Uguccioni: The implications of the General Data Protection Regulation, the impact of AI on Civil and Criminal liability.

  Liability issues much depend on the Law applicable in different countries. The different civil and criminal liability regimes still should apply for automated driving, especially the rules regarding defected products (Product Liability).

  In the UK, the Automated and Electric Vehicle Bill (new rule for ensuring safe and effective insurance for self-driving car) stipulates that the insurer is liable where an accident is caused by an automated vehicle when driving itself. The bill is currently under process.

  In other countries, and especially Germany, liability is not assigned a priori. It will much depend on the circumstances of the crash, even if the AD system is on (depending on what was requested to the driver, the intended purpose of the function, the misuse, etc.)

- Peter Blumer: The insurance companies´ perspective.

  In general, in case of a crash, the victims are compensated, unless compensation can be reduced if a fault by driver is proved, as of today (e.g. driving under influence of alcohol).

  When automated vehicles are concerned, in case of crash, insurers would like access to data to be able to identify responsibilities by knowing who or what was in charge of driving at the time of the crash, and what were the main facts leading to impact (e.g. whether or not the driver was requested to take over). Definition, Storage and Access to that kind of data is therefore a big challenge for running the compensation and recourse appropriately.

**Conclusions from session**

- Non-existent, incomplete or multiple national legislative approaches still form a major obstacle to market introduction of autonomous vehicles. A unified regulatory framework should be created.Basic policy decisions are needed soon to support the speed of development of automated driving, namely for type approval regulation, which needs to be in place when the technology will be ready.
- It is necessary to understand the total scope of affected policy and regulation, beyond traffic rules.
- It is still unclear how regulation should deal with software updates as well as the introduction of higher automation levels.
- Market penetration will depend on a liability framework being in place. The applicable civil and criminal liability regimes still should apply for automated driving (e.g. Product Liability rules regarding defected products).
- Access to data (e.g. who or what was in charge of driving at time of crash, whether or not the driver was requested to take over) will be required by insurers to determine responsibilities and compensation.
- The new rule in the UK for ensuring safe and effective insurance for self-driving car (“Automated and Electric Vehicle Bill”) stipulates that the insurer is liable where an accident is caused by a self-driving automated vehicle. In other countries where liability is not assigned a priori, it will depend on the circumstances of the crash, i.e. what was requested to the driver, the intended purpose of the function, the misuse, etc.)
- The Road Traffic Act in Germany (updated in June 2017) authorizes AD systems SAE levels up to 3 in case they are regulated by technical regulations.
- Currently only hands-on lane centring on highways functions are regulated, which correspond to SAE level 2 systems on a restricted Operational Design Domain.
- Besides revision of UNECE R79, further “horizontal” regulation) will in the future combine physical certification tests and real-world test drive.

## 4.7.BO-3.2 Artificial Intelligence

**Organiser/s:**
Hala Elrofai (TNO),
Benjamin Wilsch (VDI VDE)

**Moderator:** Hala Elrofai (TNO)

**Rapporteur:** Benjamin Wilsch (VDI VDE)

**Speakers:**
Árpád Takács, AImotive
Philipp Slusallek, DFKi

**Summary**

The focus of the breakout session concerning the CARTRE thematic area "Big Data and AI" was 'Validation of AI and AI for validation' since this is currently a pressing research question in the field, after that the use of AI for CAD functionality was significantly accelerated by the availability of sufficient amounts of data and suitable hardware for algorithm development.

Modern vehicles are equipped with sensors monitoring the state of the vehicle itself and the world around it, thus becoming a source of big data. By applying artificial intelligence like machine learning and deep learning, they become learning devices as well. With the Internet of Things the cars will become a node in the network. In this session some key challenges of cars as sources of big data were discussed.

Verification of vehicle sensors is an essential step towards automated driving, because the decision making in the automated car is based on the sensor output. However, sensor verification itself brings already some big challenges: the sensors produce a massive amount of data, which cannot be sent over the internet but needs to be recorded on a hard drive. This makes data transfer a slow process. In addition, the sensor output needs to be combined into a ground truth. This task still needs to be done primarily by humans, with the aid of suggestions by a deep learning algorithm. Unfortunately re-using information from a previous test is not possible when validating a new sensor, the entire process needs to be redone.

To start the session, the current role of AI in autonomous driving and the prospects and challenges ahead were discussed in a talk from Árpád Takács, Outreach Scientist at AImotive, a company involved in both software and hardware development for AI-based CAD functions.

AImotive's AI-driven approach in each of the three fundamental building blocks for CAD functionality is:

- **Recognition**: In contrast to classical approaches, e.g. Support Vector Machines (SVM), that use heuristic features and binary classification, Artificial Neural Networks allow the system to learn semantic features and to use multi-class classification to arrive at a scalable solution of integrated networks.

- **Localization**: AImotive's semantic feature-based approach aims to develop an "understanding" map, in order to reduce the volume of map data and high mapping efforts involved in the use of dense point clouds for localization.

- **Motion Planning and Control**: The use of AI for motion planning and control builds on the availability of large data sets and provides a scalable solution, thus effectively replacing formal logic based on hard-coded rules which cannot provide the functionality and reliability required to match the diversity and variety of driving scenarios.

For environmental perception, AImotive is following a vision-first approach, supplemented by additional sensor technology. AImotive is currently running real-world tests in Finland (Helsinki), the U.S. (California and Nevada) and Hungary (Budapest), in order to cover a wide range of driving conditions and in order to gain knowledge and experience concerning the different regulatory approaches for autonomous vehicles in the respective countries.

Validation and subsequent certification of AI functions were further discussed by the second panellist, Prof. Slusallek from the DFKI: validation also hinges on the availability of training data and the effectiveness of the training depends on both the quantity and the quality.

Prof. Slusallek explained that the use of synthetic input data generated from real-world models plays an indispensable role in the training of AI systems for critical situations. Critical situations are, by design, rare in real-world scenarios, thus providing insufficient data for AI training. The objective is thus to use synthetic input data as well as a combination of rule-based logical reasoning and simulation to achieve scalable learning methods for AI training, benchmarking and validation. Validation using synthetic data can be considered sufficient to ensure safe and reliable operation if the limits and variability of test scenarios are chosen correctly.

As an example of an open platform for learning, simulation, training and validation of autonomous systems, he presented the Genesis platform, which is currently under development by the DFKI in collaboration with TÜV Süd, and also introduced the REACT project which is concerned with the modelling and simulation of pedestrian behaviour in critical situations.

Prof. Slusallek also highlighted other key challenges that AI development is currently facing, which include:

- A lack of **transparency and traceability** concerning the decision-making process that in turn complicates the resolution of legal or ethical issues;

- A need for **modularity**, in order to facilitate the replacement of individual components of an automated vehicle system, which is currently impeded by the end-to-end nature of learning algorithms;

- an **understanding** of the physical, computational, economical and theoretical **limits of AI technology.**

Finally he underlined the importance of a collaborative Pan-European approach to AI research, especially with respect to the competitiveness of European structures in a global context and given the backing provided by private and public funding and investments in the U.S. and Asia. To address the need for a joint research platform and community, the DFKI

has recently co-submitted a proposal for an EU flagship (Human$^{e}$ AI), which, amongst others, strives for a consolidation of development efforts and the provision of a transparent, open and flexible platform facilitating transfer and exchange of data and algorithms between industrial and academic partners.

During the course of the session, three polls were presented to the audience, the results of which are presented in ANNEX 3. The first poll addressed the question of which methodology should be applied to validate AI-based CAD functions. The majority of the participants voted for simulations as a validation basis, which reflects the focus of the talks. The discussion of the poll results with the audience and speakers did, however, reveal that the poll was missing a fourth option describing a combination of the three test methods, which was the consensus reached in the session. The results of the poll should thus rather be understood as an expression of the importance and perhaps a prioritization of simulations as a validation tool.

The second poll was intended to collect opinions on the scope of AI functionality testing. This poll was only answered by three members of the audience, thus providing an insufficient sample size. Those that did respond to the poll agreed that AI functionality testing should be performed on the system level. This could be explained by the fact that a larger scope of testing is desirable in any case, although, it should be noted that both speakers underlined the need for modularity in autonomous vehicles systems, e.g. to allow for the replacement of individual components without a need to retrain and retest/validate the entire system. It can thus be concluded from the talk and discussions that while the entire AI system should be tested, testing and validation methods for individual components are also desirable.

The third and final question presented to the audience was designed to poll opinions on whether machine learning, which is responsible for the current success of AI applications, will remain the dominant methodology in the long term. This issue is of special interest given the lack of traceability of decision-making processes based on machine learning. This inadequacy provides a possible explanation for the fact that the majority of respondents believe that alternative AI methodologies will emerge in the future. In his reaction to this poll, Prof. Slusallek commented that he thinks machine learning will be the central methodology for many years and that he cannot yet say if and when alternatives could provide similar functionality and performance. He also does not think that the lack of traceability will ultimately pose a major obstacle to CAD development and rather expects that solutions for resulting issues, e.g. concerning liability, will be developed.

The audience also submitted the questions summarized in Table 3 and further had the opportunity to rate each other's questions, which resulted in the question score also provided in the table. The majority of the questions (2, 3, 5 and 6) concerned the validation of AI, in particular using simulation, and where thus answered, in different detail, during the presentations by the speakers. The first question addresses the second element of the session topic and focuses on an application of AI in the CAD field not pertaining to driving control, i.e. the use of AI for the preparation and processing of the large amounts of data generated by the various sensors and components of autonomous vehicles. This data can undoubtedly not be handled without the use of AI functions, but the requirements for storage volume and energy supply should also be considered in the assessment of the feasibility of such applications. AI can then also be employed for further tasks in the vehicle context, e.g. for a personal in-car assistant or driver/rider identification and authentication (a further

possible application for safety state determination is suggested in the eighth question). The seventh question addresses possible conflicts that could arise in mixed traffic between human-controlled and AI-controlled vehicles. This can be answered based on the content of the talks, since the speakers explained, how machine learning is inherently suitable to adapt to and imitate the behaviour of other road users based on training and environment data and not (exclusively) dependent on hard-coded rules.

**Table 3 Overview of questions posed by the audience during the presentations via the interactive tool**

| | Question |
|---|---|
| **1** | How can AI be used to prepare the data form different sources in a way that is informative for AI CAD functions? |
| **2** | How can you be sure your simulation is valid? |
| **3** | Which simulation tool are you using for the AI development and what are your criteria for selecting a simulation environment? |
| **4** | If it is hard to know what AI learnt, is there some optimum when it comes to learning, i.e. can it get worse at some point? Can learning be steered or stopped? |
| **5** | How do you calculate the readiness (risk) when taking AI software from the simulator onto the road? |
| **6** | If AI is supporting (but not executing) critical decisions, they are still creating a situation where each decision for similar scenarios could be different - how do you validate safety of these systems? |
| **7** | If we have to give the AI models the rules to learn: how do we learn the AI algorithm that sometimes (as we human drivers do) disobeying the (e.g. traffic) rules is the best thing to do (e.g. because it will save lives? Big challenge in “defining the rules of the game” in traffic and priorities!) |
| **8** | How can AI be used to determine the safety state of the vehicle in its environment? |

**Conclusions from session**

- There is a necessity to complement real-world testing with simulation for AI training, since this provides the opportunity to significantly increase the scope, diversity and completeness as well as the speed of testing.
- Predominant machine/deep learning approaches must be integrated with traditional AI techniques such as logical and statistical reasoning.
- Regarding AI validation:
    - Learning from simulation requires the creation of adequate models of the real world and the generation of the required input data from the models.
    - Benchmarking the development process calls for reproducible and standardized test scenarios, scalable and fast simulation as well as an open architecture for the integration of different models and simulations.
    - Validation of the learned behaviour should then cover the calibration of synthetic data against real data, the identification and adaptation of insufficient and missing models and, ideally, the creation of a virtual homologation agency for autonomous vehicles.
- Testing and validation methods are desirable for individual components as well as for the entire AI system.

**Impacts**

The world of Big Data and AI applications is not only rapidly growing but also very dynamic. The push towards increasing levels of automation of automated driving systems forces the market to accelerate the development of new automated driving services, activities and applications including (but not limited to):

- Driving patterns can be identified through the development of Big Data analytics tools (for extracting meaningful information from mixed data), which will lead to improved insights.
- Validation of AI functions in CAD systems through the definition of scenario-based assessment methodologies, including the classification of real-life scenarios, development of CAD functions, safety monitoring. Furthermore, AI techniques accelerate the software development and product cycles.
- Improving situational awareness using AI techniques:
    - prediction models for other road user behaviour (especially complex behaviour like pedestrians)
    - building accurate maps for on-road concurrent mapping and navigation
- Improve the quality of the performance of CAD functions by self-improving mechanisms, possibly shared across cars.
- Open new fields of applications such as taxi services, car sharing or find-a-parking-spot services.

## 4.8.BO-3.3 Connectivity

**Organiser:** Maxime Flament, ERTICO – ITS Europe

**Moderator:** Maxime Flament, ERTICO – ITS Europe

**Rapporteur:** Stéphane Dreher (ERTICO – ITS Europe)

**Speakers:**
Mikael Fallgren, ERICSSON
Francois Fischer, ERTICO – ITS Europe
Jaime Moreno, Directorate General for Traffic of Spain
Angelos Amditis, ICCS
Christian Rousseau, RENAULT

**Summary**

This thematic area identifies the future needs for connectivity of higher levels of automation. Vehicle-to-everything (V2X) connectivity, in its various forms, will act as an additional enabler for the highly and fully automated vehicles. Industry efforts to develop V2X for highly and fully automated vehicles have accelerated significantly and will eventually lead to 5G.

The break-out session on connectivity included presentations on connectivity seen from the perspectives of an OEM (Christian Rousseau, RENAULT), a Road operator (Jaime Moreno, DGT) and a telecommunication supplier (Mikael Fallgren, ERICSSON). In a second part, the activities of three EU-funded projects have been introduced: AUTOPILOT focusing on IoT applied to AV driving scenarios (Francois Fischer, ERTICO - ITS Europe), AutoNet2030 and ICT4CART focusing on V2X connectivity and a hybrid communication approach for Automated Driving (Angelos Amditis, ICCS). Furthermore, the focus was on the current activities and challenges related to the digital IT Infrastructure to support the deployment of connected and automated vehicles. All the aspects related to connectivity were discussed including different technologies (ITS G5, LTE-V2X, LTE-advanced, 5G) and referring in particular to the challenges posed by the requirements of connected and automated vehicles e.g. safety, latency, reliability, localization, digital IT infrastructure, etc.

Connectivity for Automated Driving is characterised by a complex landscape of technologies that can be used for the different communication aspects: Car to Backend, Car to Car (direct communication or communication within the Network cell), Car to Infrastructure, Infrastructure to Backend and Car to other Road Users. Attempts have already been made to define the type of communication technology necessary to support for example Day-1 to Day-4 applications.

All cars are already connected to different clouds and already propose apps based on cellular communication, which are addressing navigation and guidance and different technical services (e.g. remote diagnostics). There is a nearly complete coverage of the road network for mobile phones already. With eCall, 90% of cars in 2020 may have aftermarket solutions. The cost of exchanging data is dropping. Connectivity is already in the cars but services are generally not provided directly to the customer. There is a need to focus on services, not on technology.

Connectivity would contribute to improve road safety by notifying about potentially dangerous situations, assist in reducing congestion through optimal routing, improve traffic flows using speed recommendations, reduce environmental impacts by optimising power train management and avoiding unnecessary stops, etc.

The 5GCar project has selected 5 Use Cases: lane merge, network assisted Vulnerable Pedestrian Protection, See through, remote driving for automated parking and HD local map acquisition. Requirements have been derived for automotive (e.g. localization), network (availability, range, rate, latency, etc.) and quality (cost, power consumption, etc.).

The AUTOPILOT project approach (cloud IoT-based) is connectivity-agnostic and enables augmented data to be provided as a service, enhancing driving environment perception. Different devices are involved in the automotive environment and there is no need to be connected directly to these devices: only the status of the device is required and therefore a connection to the cloud would be sufficient.

AUTOPILOT has been looking at the two following Use Cases so far: enhancement of the driving environment perception for the AD Dynamic Driving Task (DDT) and Real-Time HD maps updates; provision of SaaS / PaaS for mobility (OEM vehicle management platform or MaaS). Future usages for IoT for Automated Driving will be driven by future IT features in the Cloud (e.g. AI) and enabled by future Cellular network performances.

EC-funded project ICT4CART aims at designing, implementing and testing a flexible, technology-agnostic ICT infrastructure that enables different types of cloud solutions in order to investigate performance and whether ICT infrastructure is really needed for higher levels of automation.

EC-funded project AUTONET2030 is looking at pure sensor-based automation with V2X. It seeks to answer the questions about:

- the needs for data broadcasting;
- the actual data and the necessary quality required for cooperative automated driving;
- the data needed for Level of Perception (Network and Transport Stacks).

There are still remaining challenges to be addressed and questions to be answered to create the most suitable framework conditions for successful market introduction and sustainable operations of connectivity for CAD:

**Challenges**

- Defining hybrid communication;
- Collaboration between automotive and telecom industry;
- Achieving reliability (as a basis for latency);
- Achieving coverage;
- Defining the locations for Road Side Units;
- Spectrum availability (cellular V2X communication)

**Questions**

- Back-end connectivity: whether it is needed for L2 CAD, whether it solely can rely on its own sensors, what about L4 and above and if yes, what performances are required and what happens in case of failing the communication.
- Where geo-located traffic information from vehicles or/and from traffic operators should be published and disseminated.
- How privacy and security can ensure in order to build up trust among the users, whether V2V data can be considered as another sensor.
- Functional safety: how a CAD vehicle can integrate V2V data in its safety-critical decisions.
- How safety of all road users can ensure and how pedestrians, bicyclist and bikers can participate in the V2V short-range ecosystem.

Polls have been conducted between the different presentations over the course of the session in which the public has been asked to indicate their level of agreement on several recommendations from the CARTRE connectivity position paper. The results are provided in ANNEX 3.

For most of the questions, the audience largely agreed with the position paper statements. A more mixed response has however be obtained for the statement related to the need for a next generation of V2V-V2I protocols and communication technologies, for which still 30% of the audience rather disagree.

On the questions regarding lower levels of automation and whether they should wait for wider penetration of the V2V/V2I short range communication, the speakers insisted on the

fact that OEMs should not wait for Member States to all agree and should start with what is available. The difficulty to define the real business case should not be underestimated.

Regarding current C-ITS standards, Angelos Amditis mentioned that some groups already are discussing the extension of CAM, but current standards do not yet answer the needs for higher levels of automation and safety critical applications. Christian Rousseau referred to the Scoop Project and indicates that for cybersecurity, a large part of the standards needs to be changed due to requirements from authorities. The only way to learn is to put the cars on the roads and investigate.

Questions (& answer) asked by the audience

Among the questions from the moderator and the public, two have triggered strong statements from the speakers:

- Should the list of Day-1 services be updated? How much of these apps can be done with mobile connectivity?
  - The speakers replied that most can already be done. It is important not to look at the vehicle, but at the driver to understand connectivity. An open “white label” model like the neutral server concept can be used to connect different silos only for relevant data. D1 apps are achievable with this model and exiting connectivity. The strategy should however not be defined based on D1.
- Is there a risk that EU and Member States will invest billions in a G5 (802.11p) road infrastructure that will be hardly used?
  - This risk is on the table. We do not know yet which technology will be the winner. There is no reason to massively deploy roadside units. The market has to decide. The limitations of the technologies are known. There is a need to speak about value as it is about a product being sold.

**Conclusions from session**

- Vehicle clouds as an extension of the vehicle on-board sensor platform and their interfaces to the service clouds will offer a viable solution to the connectivity with traffic managers, road operators and other services of public interest.
- There is a need for a next generation of V2V-V2I protocols and communication technologies e.g. short range secured exchange of sensor and manoeuvring data with high degrees of reliability and quality control.
- Data privacy, cyber security, data access, service discovery, etc. should be addressed in cooperation with ICT especially IoT communities and avoid designing specific road transport solutions.
- Lower levels of automation cannot wait for wider penetration of the V2V/V2I short range communication
- New standards are needed taking into account the requirements for higher levels of AD.
- There is a need to focus on services required by the user, not on technology.

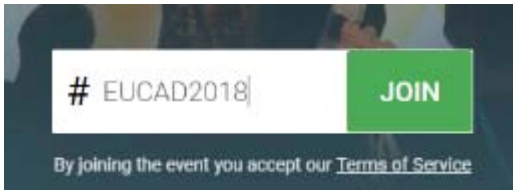
## 5. Online tool for interaction during the sessions

The EUCAD 2018 Symposium was called “interactive” because of the focus the organisers wanted to put on interaction for participants during the event.

The online tool “sli.do” (www.sli.do) was used during the thematic break-out sessions to provide that interactive element. The participants were able to answer polls live on specific statements. The panellists could then comment the live results from these polls and answered some of the questions that participants could also submit through the tool.

The selected tool sli.do is not an app that participants had to download, but a website. Participants could join in less than a minute by entering the dedicated event code, using their phone, computer or tablet:

1. Go to www.sli.do
2. Enter event code #EUCAD2018
3. Click on event name to start using it
4. Select the thematic session you wish to join




Moreover participants could cast their *ball-ot* to answer some quiz questions and meet some of the experts at specific locations in a “speed dating” exercise during the networking event.

## 6. Exhibition

Finally participants had the opportunity during breaks to explore the posters exhibition and discuss the related topics with the present representatives.


Next to the CARTRE thematic area posters, other projects were present with posters as well as some of the posters on specific topics presented at TRA:

- MAVEN project
- TransAID project
- ADAS&ME project
- Framework for assessing the impacts of automated driving
- Impacts of cooperative safety-related traffic information system
- Assessing the impact of automated driving: needs, challenges and future directions
- Automation-ready framework for urban transport planning
- How do traffic participants interact in current urban scenarios (interACT project)
- Automated vehicle interactions in urban traffic (ethnography-based design insights to tackle communication between automated vehicles and vulnerable road users in mixed and urban traffic situations)
- INFRAMIX project
- Improved trustworthiness and weather-independence of conditionally automated vehicles in mixed traffic scenarios (TrustVehicle project)
- End to end latency in HAD applications

- Advancing active safety towards the protection of vulnerable road users by evolution of ADAS solutions that meet real-world deployment challenges (PROSPECT project)
- Recommendations on regulatory framework & standardisation proposals (Companion project)
- The Artic challenge – the role of infrastructure in connected and automated driving development for all conditions
- Automated vehicles in a major European city – a technical perspective on urban transport policy options: the case of Vienna

# 7. Conclusions

The Interactive Symposium on Research & Innovation for Connected and Automated Driving in Europe (EUCAD 20418) attracted 220 participants from private and the public road transport sectors, the majority of which from the research sector, followed by the automotive industry and public authorities (road, ministry, region, city). The main nationalities represented were unsurprisingly German and Austrian, due to the location of the event, followed by Italians and Japanese (the trilateral WG meeting was organised in conjunction with the Symposium).

The event provided an opportunity to learn about European Research & Innovation activities on CAD, show the progress and exchange views on how to shape the future of connected and automated driving in 9 specific thematic areas. For each thematic area, a panel of high-level speakers from different fields shared and discussed positions, visions, and interacted with the audience regarding challenges and research needs entailed.

The audience responded positively to the introduction of the interactive tool, sli.do, used during the sessions to interact with the audience in two ways: (1) participants could indicate their opinion in polls related to the specific topics discussed at that point in time during the session; (2) participants could post their questions and comments throughout the session (or even afterwards) reacting to the panellists' presentations or to the thematic area position papers, which were also shared through the tool. Some questions were answered at the end of the sessions; others are answered in this report. The results of the polls and comments received were taken into account in the final version of the position papers.

A poster exhibition was also offered to research initiatives that were either attending the Symposium and/ or had been presented at TRA prior to the Symposium: 16 posters (on top of the nine CARTRE thematic area posters) were presented.

The main conclusions and identified next steps from the different thematic break-out sessions are provided below. Some commonalities stand out across the different sessions' comments:

- The need for continued and extended collaborations across the different sectors involved, at European level and globally;
- The need for real-life testing and demonstrations;
- The need to analyse the overlaps and interactions across different thematic areas.

## 7.1.Shared and Automated Mobility Services

<u>Main conclusions</u>

- Clear use and business cases of CAD-based smart mobility services are still missing;
- Shared CAD complement collective transport, and offer particular benefits on the country side;
- Regulations are a serious bottleneck for CAD, particularly in terms of functional safety in urban use;

- CAD is providing opportunities for social inclusion – we are all users with special needs at times;
- CAD can and has to adapt to existing traffic management systems.

Next steps

- Level of safety expected from CAD by citizens needs to be clarified;
- Citizens' and cities' opinions have to be better understood in order to assess acceptance of CAD;
- Demonstrations are needed to make CAD real and provide citizens with personal experiences.

## 7.2.In-vehicle technology enablers

Main conclusions

- Systems, components and partners work together to master complexity;
- Industry handling technical development and implementation for End2End ecosystem (extended to and incl. V2X);
- Quantity vs. quality of data: currently gather as much as possible to learn as much as possible; reduce as soon as possible, emphasize corner cases and create a catalogue
- Continue collaborations at European level and facilitate global alignment.

Next steps

- Establish standards for all functions & partners in the ecosystem in close collaboration with regulatory bodies
- Need to define/consider verification vs. validation impact;
- Further discussion should take place with the interacting CARTRE themes including, but not limited to, security, safety, regulations, etc.

## 7.3.Physical and Digital Infrastructure

Main conclusions

- Coverage and continuity of ODDs are likely crucial for use and user acceptance;
- Need of solutions to prevent/manage/distribute transfer of control automated versus manual mode;
- Use of infrastructure data is useful to support vehicle sensors and extend event horizon;
- Most expect the automated vehicle to deal with all current road infrastructures;
- Most expect that we should define infrastructure levels for automation support.

Next steps

- We need real life tests to explore impacts and to understand the capabilities of AVs;
- The role and uses of connectivity as an element of automation needs to be verified;
- More research is needed on ODDs – the parameters defining them, and their threshold values; acceptance; optimisation of ODDs;
- Development of reliable pavement design models and tyre wander solutions to cope with AVs.

## 7.4.Socio-economic impacts

Main conclusions

- Intended goals of automation need to be defined, i.e. what desirable outcomes would be;
- Desirable behaviour of AVs needs to be defined (user perspective vs. efficiency perspective);
- Current status needs to be known (baseline for impacts), but also a lot of new input is needed for the scaling up;
- Policy/authorities-led shared automated mobility could enhance many positive impacts but it needs to be discussed how to motivate people for sharing their mobility.

Next steps

- Definition of the desirable outcome of vehicle automation;
- Start testing different concepts of automation to learn, cooperate with the local transport operators to ensure common views on goals and how to achieve them;
- Research on motivating people to share their mobility is needed.

## 7.5.Human Factors

Main conclusions

- New HMI developments for AVs: it is difficult to conceptualise the L4 HMI user requirements; personalization is key;
- Driver state monitoring should be a must but not be fully relied upon to avoid driver misuse; focus on all road vehicles;
- Interaction with other road users: consideration if the pedestrian over-relies (or takes advantage) of AD vehicle;
- Societal acceptance: if the AD car has a black box, who has access to the data;
- Testing/Validation procedures: human-related behaviour should be included in L3 test procedures.

Next steps

- Understand the interaction between humans and driving automation systems (in-vehicle and outside vehicle) at different levels of automation;
- Understand effects of vehicle automation on humans such as unintended use, skill degradation, trust, and motion sickness;
- Raise awareness and increase acceptance for automated driving;
- Adapt the vehicle automation to human needs and states and to establish adequate driver training;
- Derive interaction design concepts for the driving automation systems so that both the human driver and other humans in the surrounding sufficiently understand the capabilities and limitations of the vehicle.

## 7.6.Vehicle Validation

Main conclusions

- Virtual Validation (using simulation) needs to be validated and accepted by regulators;
- We need to learn how can we provide full coverage validation;
- Procedures to obtain scenarios need to be developed; data sharing (at international level) would certainly reduce costs but there is a challenge in terms of property and local differences;
- It is not just about the safety of the function, but how the driver makes use of the vehicle and the evaluation of safety in relation to other users and road elements.

Next steps

- Sharing of scenarios can hugely reduce costs but technical and organisational issues need to be solved;
- We need FOTs / Pilots to improve physical/virtual testing.

## 7.7. Regulatory, Legal and Liability

Main conclusions

- Objectives of regulation: safety and protection for consumers and producers
- Civil liability is not expected to change much. Insurance will pay. Recourse actions will be made more complicated. This leads to a wish for data recording and access to data in case of issue: who was in charge of driving in case of a crash? Why did the crash occur?

Next steps

- UNECE WP1 to create a resolution on deployment of HFAV and also a discussion paper on side activities;

- Technical regulation: horizontal regulation (across testing cycle, e.g. physical test, audit, test drive) is coming;
- Define what an AD data recorder should do and who should have access;

## 7.8.Artificial Intelligence

Main conclusions

- Data and hardware for efficient AI training are now available, so that the focus can shift to algorithm development;
- Although AI outperforms humans at task like game playing, the current solutions are not comparable in complexity to life-critical applications in CAD;
- Validation of AI functions must be a combination of simulation and real-world data.

Next steps

- Definition of the scope of validation for the learning of critical situations;
- Collaborative approach for the benchmarking of the AI development process.

## 7.9.Connectivity

Main conclusions

- Connectivity for Automated Driving is still in its infancy but is already in the cars;
- There is no guarantee of full penetration of V2X on which automated vehicles can rely;
- New standards will be needed taking the requirements of higher levels of AD into account;
- Concept of Extended Vehicle and neutral server will prove to be a great support for the next CAD deployment steps.

Next steps

- Use existing technology and focus on services for customers;
- Define a clear statement on hybrid communication;
- Focus on real-life testing.

## 8. References


1. The Interactive Symposium on Research & Innovation for Connected and Automated Driving in Europe, CARTRE link: https://connectedautomateddriving.eu/2018_symposium/

2. CARTRE Thematic Areas link: https://connectedautomateddriving.eu/thematic-working-groups/

3. All presentations of the workshop are accessible on CARTRE website: https://connectedautomateddriving.eu/symposium2018-speakers-presentations/

4. Photos of the Symposium are accessible on: https://connectedautomateddriving.eu/photo-gallery/

5. High Level Roundtable on Connected and Automated Driving; More information available at: https://ec.europa.eu/digital-single-market/en/news/eu-commissioner-oettinger-holds-roundtable-automated-driving-frankfurt

6. High Level Group on Automotive Industry 'GEAR 2030'; https://ec.europa.eu/growth/sectors/automotive/policy-strategy_en

## 9. Glossary: Acronyms and definitions

| Term | Description |
|---|---|
| ADAS | Advanced Driver Assistance System |
| AI | Artificial Intelligence |
| ART | Automated Road Transport |
| C-ITS | Cooperative – Intelligent Transport System |
| CAD | Connected & automated driving |
| CAM | Connected & automated mobility |
| CARTRE | EU-funded CSA project “Coordination of Automated Road Transport Deployment for Europe” |
| CSA | Coordination & Support Action (type of project) |
| DI | Digital infrastructure |
| ERTRAC | European Road Transport Research Advisory Council |
| HAD | Highly Automated Driving |
| MOVE | European Commission Directorate General for Mobility & Transport |
| ODD | Operational Design Domain |
| PaaS | Platform as a Service |
| PDI | Physical & Digital Infrastructure |
| SaaS | Software as a Service |
| SCOUT | EU-funded CSA project “Safe and Connected Automation in Road Transport” |
| TRA | Transport Research Arena |
| TRL | Technology Readiness Level |
| WG | Working group |

## ANNEX 1: Participating organisations' list

| Company |
|---|
| 3D Mapping Solutions GmbH |
| Aalborg University |
| ADAC e.V. |
| ADAS_Management Consulting |
| Almotive |
| AISCAT (Italian Association of Toll Motorways and Tunnels Operators) |
| Allianz Germany |
| ALP.Lab GmbH |
| ANDATA |
| ANSR |
| Applus+ IDIADA |
| Aptiv |
| ASFINAG |
| A-to-Be |
| Austrian Federal Ministry for Transport, Innovation and Technology |
| AustriaTech |
| AVL List GmbH. |
| BASt |
| bmvit-Austrian Transport Ministry |
| BMW |
| Bosch |
| CCAV |
| Center for HCI, University of Salzburg |
| CERTH/HIT |
| Cidaut Foundation |
| CLEPA |
| Connecting Austria |
| Coventry University |
| CTAG |
| Delft University of Technology |
| Delphi Technologies |
| DENSO TEN EUROPE GmbH |
| Deutsches Forschungszentrum für Künstliche Intelligenz |
| Directorate General for Traffic. Government of Spain |
| DLR |
| Drive Sweden |
| Enteprise Ireland |
| Ericsson |
| ERTICO - ITS Europe |

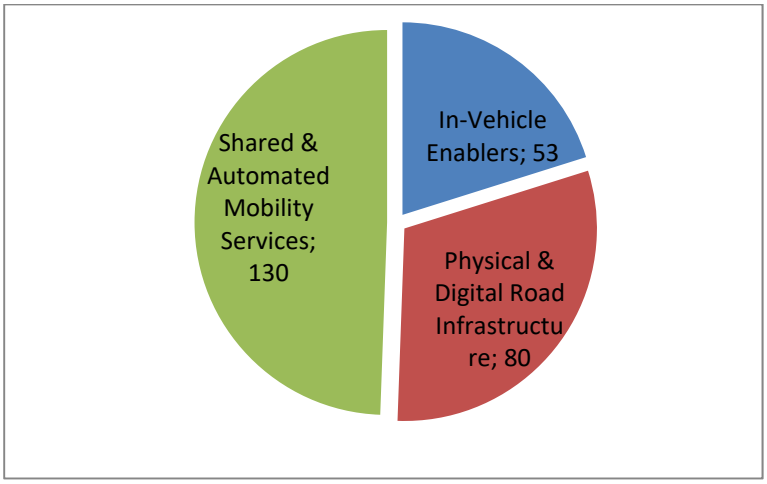
| Company |
|---|
| ERTRAC |
| EUCAR |
| Euro NCAP |
| European Commission |
| EUSTACCHIO Rechtsanwälte |
| Federal Highway Research Institute (Germany) |
| Ferrovial Servicios |
| FEV Europe GmbH |
| FHWA |
| FIA |
| Finnish Transport Safety Agency (Trafi) |
| Ford |
| Forum Virium Helsinki |
| Fujitsu Laboratories Ltd. |
| Globalvia |
| Globalvia |
| Globalvia |
| GMV |
| Graz Linien |
| GSMA |
| HASSELT UNIVERSITY |
| HELLA GmbH & Co. KGaA |
| HIDO |
| HiTec / Connecting Austria |
| ICCS |
| Ideas & Motion Srl |
| IMT |
| INDRA |
| Innovate UK |
| IRU |
| ISERD |
| Italdesign-Giugiaro |
| ITS Japan |
| Japan Automobile Research Institute |
| Joint Research Centre |
| Kalny Future Business Beteiligungs- und Beratungsgesellschaft mbH |
| Kapsch TrafficCom AG |
| KFV (Kuratorium für Verkehrssicherheit) |
| KTH |
| Law Commission |
| Lero - University of Limerick |

| Company |
|---|
| **Lewis Silkin LLP** |
| **Luxembourg Automobility Cluster** |
| **MAP traffic management** |
| **Massachusetts Institute of Technology AgeLab** |
| **MAZDA Motor Corporation** |
| **Ministry of Enterprise & Innovation, Sweden** |
| **Ministry of Infrastructure, Poland** |
| **Ministry of Transport, Czech Republic** |
| **Ministry of Transport, Romania** |
| **Mitsubishi Research Institute** |
| **MOL Group** |
| **National Institute of Advanced Industrial Science and Technology, Japan** |
| **National Police Agency, Japan** |
| **National Research Council Canada** |
| **National Technical University of Athens** |
| **NEC Laboratories Europe GmbH** |
| **Netherlands Enterprise Agency** |
| **NILIM MLIT JAPAN** |
| **Nissan** |
| **ÖAMTC** |
| **ONU-ECE-WP1** |
| **PaulsConsultancy BV** |
| **RDW** |
| **RENAULT** |
| **RICARDO** |
| **Rijkswaterstaat (Ministry of Infrastructure and Watermanagement, the Netherlands)** |
| **RISE Viktoria** |
| **Roadscanners** |
| **Robert Bosch GmbH** |
| **Rupprecht Consult GmbH** |
| **Savari GmbH** |
| **SERNAUTO** |
| **Sumitomo Electric Industries, Ltd.** |
| **The Centre for Connected and Autonomous Vehicles** |
| **T-Mobile AT** |
| **TNO** |
| **Toyota InfoTechnology Center** |
| **Toyota Motor Europe NV/SA** |
| **Toyota Research Institute** |
| **Traficon Ltd** |
| **Transport for London** |

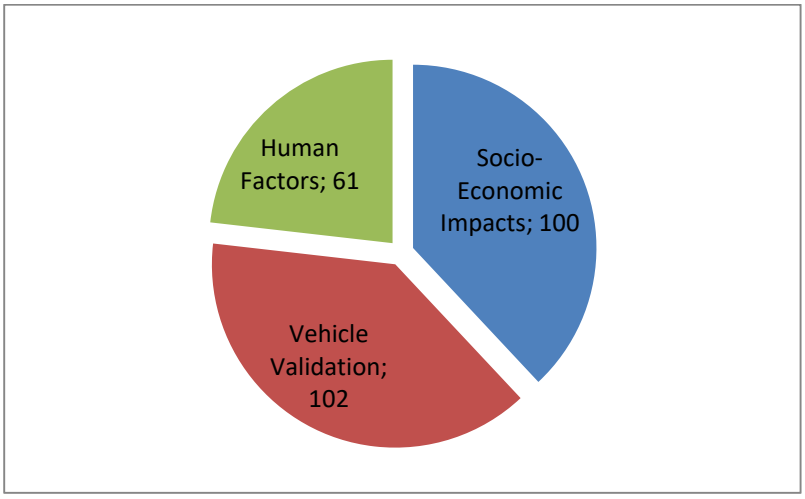
| Company |
|---|
| TTTech |
| TU Delft |
| TU Vienna |
| TU Wien |
| U.S. Department of Transportation |
| U.S. Department of Transportation /NHTSA |
| U.S. Department of Transportation / Volpe |
| Ubiwhere |
| UITP |
| Universita di Bologna |
| University California, San Diego |
| University of California PATH Program |
| University of Catania |
| University of Genoa |
| University of Genova |
| University of Groningen |
| University of Innsbruck |
| University of Leeds |
| University of South Carolina |
| University of Surrey - TrustVehicle Consortium |
| University of Tokyo |
| University of Tsukuba |
| University of Warsaw |
| University of Zagreb |
| VDI/VDE-IT |
| VEDECOM |
| Vienna City Administration |
| Volvo Group |
| VTT |
| Waterford Institute of Technology |
| WU Vienna |

## ANNEX 2: Analysis (registered) participants statistics

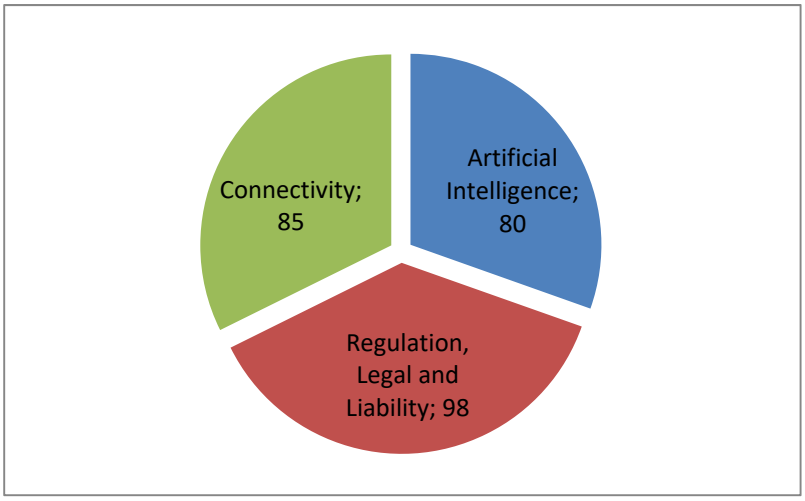
**Count of Session 1**: I would like to attend the thematic session on



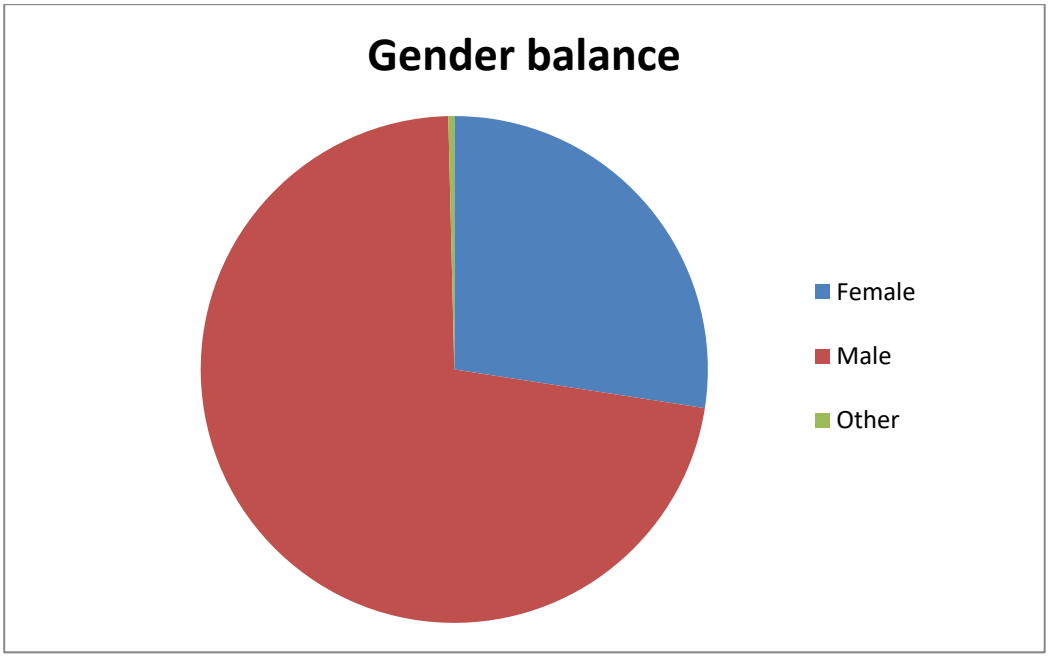

**Count of Session 2:** I would like to attend the thematic session on



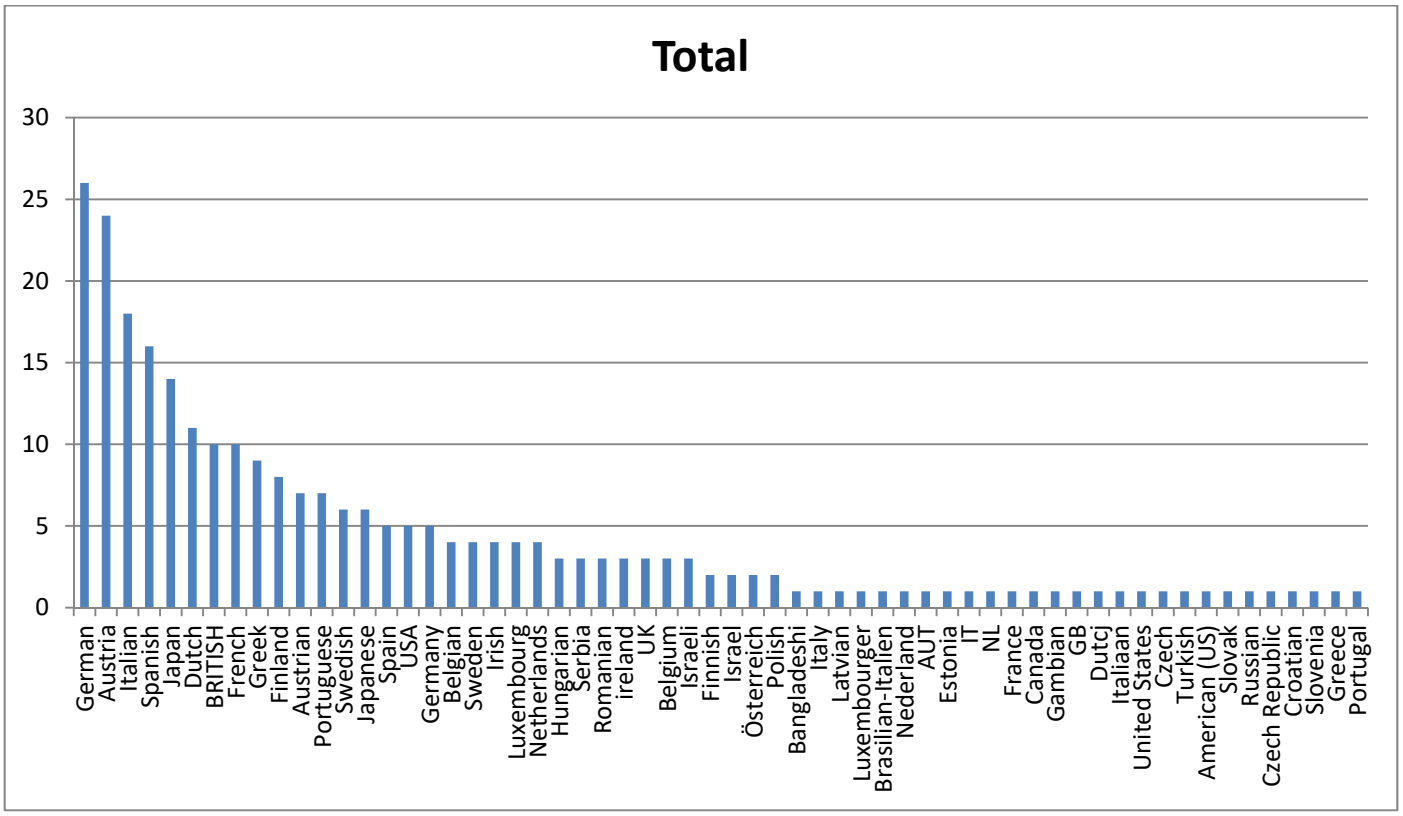

**Count of Session 3**: I would like to attend the thematic session on



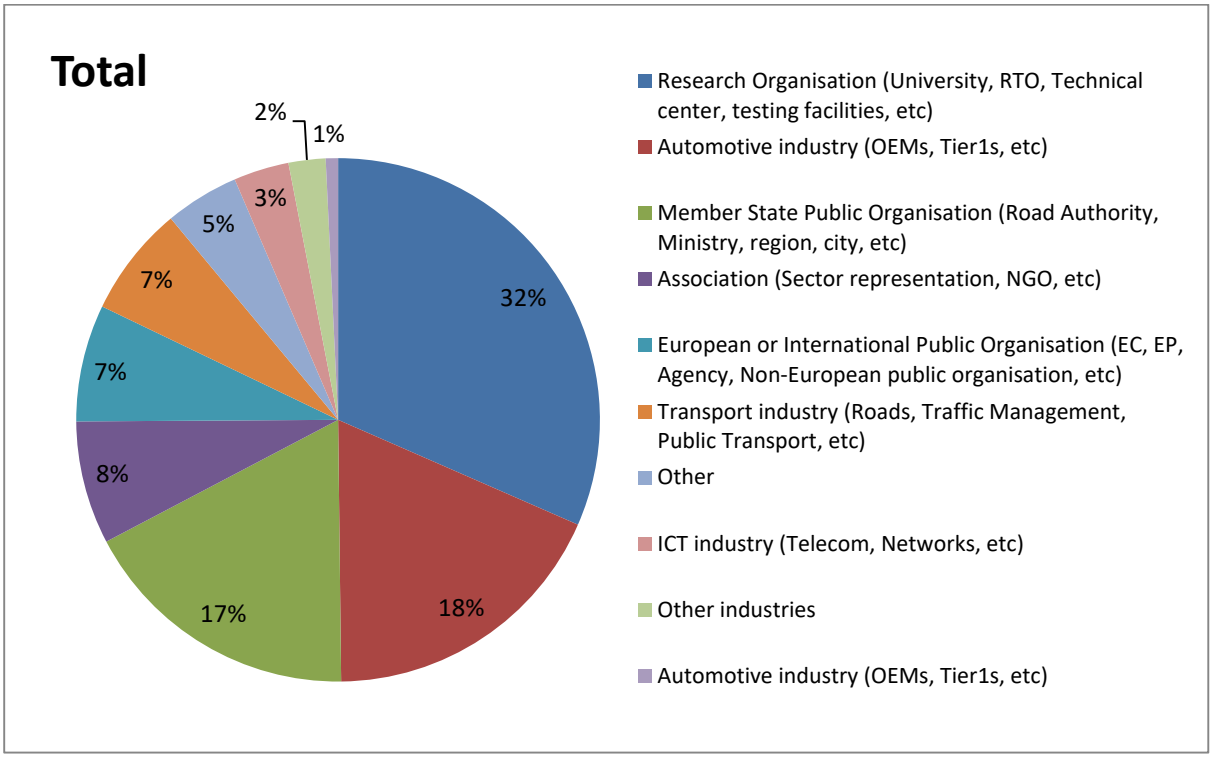

**Count of Gender**




**Count of Nationality**



**Count of Organisation type**



## ANNEX 3: Sessions Survey Statistics (Polls taken form the attendees)

- **Session 1.1 - Shared & Automated Mobility Services**

| Q1: Are new mobility services going to change the existing business models and foster win-win collaboration between public and private actors? | |
|---|---|
| **YES** | 82% |
| **NO** | 5% |
| **DON´T KNOW** | 13% |

| Q2: Will new mobility services appear spontaneously, driven by Market forces and creativity? | |
|---|---|
| **YES** | 83% |
| **NO** | 17% |

| Q3: Will new mobility services transform operations of automated vehicle fleets into a profitable business? | |
|---|---|
| **YES, definitely** | 14% |
| **POTENTIALLY** | 62% |
| **TOO MANY UNKNOWNS** | 24% |

| Q4: Will the capacity to remove the on-board driver/steward be the next key milestone in the path to market? | |
|---|---|
| **YES, definitely** | 21% |
| **NO, this will never happen** | 6% |
| **It could, if we were ready for that** | 73% |

| Q5: Can new mobility services become a reality without strong policies and incentives? | |
|---|---|
| **YES, the market will take care of that** | 31% |
| **NO, it will have to be regulated** | 69% |
| **DON´T KNOW** | 0% |

| Q6: Can the transition to highly automated urban mobility be realised by one stakeholder only? |
|---|

| | |
|---|---|
| **YES, a strong offer can match a real need and have a strong impact** | 12% |
| **NO, this requires a complete ecosystem** | 79% |
| **YES if the stakeholder is a public authority** | 9% |

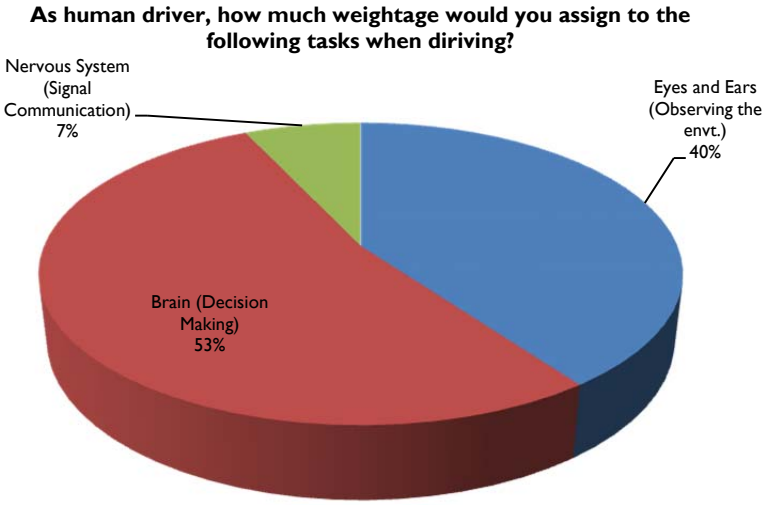
| **Q7: Could new mobility services save the attractiveness and vitality of our city centres?** | |
|---|---|
| **YES, they would be safer, less polluted, less noisy, and with a better quality of life** | 66% |
| **NO, it would only add more disorder as long as conventional vehicles occupy the space** | 28% |
| **There is no relation all** | 6% |

| **Q8: Will new mobility services blur the boundaries between collective and individual services?** | |
|---|---|
| **YES, automated vehicles will be shared to maximise the social benefits** | 68% |
| **NO, private and collective service will remain very distinct** | 26% |
| **At that time, there might be no need for individual services anymore** | 6% |

| **Q9: Will new mobility services change the citizens behaviour towards vehicle sharing, or will strong incentives and policies be necessary?** | |
|---|---|
| **New shared services will be so attractive that there will be no more reluctance** | 37% |
| **NO, people do not want to stand the uncertainty and constraints of shared mobility** | 63% |

| **Q10: Will safe, secure and reliable operations of automated vehicle fleets be imagined rely on supervision systems in a near future?** | |
|---|---|
| **YES, it is the best way to operate and control a fleet** | 85% |
| **NO, it will not be necessary** | 15% |

- **Session 1.2 - In-Vehicle technology enablers**



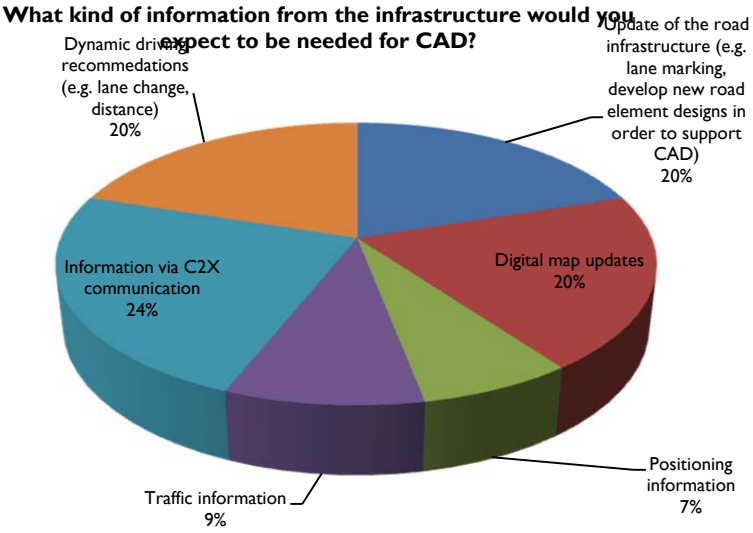

| Q2: Developing common safety assessment methodologies and regulations, which merge simulation, test tracks, and field operational tests with real-world data-to maximize safety and mitigate liability risks | |
|---|---|
| **YES** | 96% |
| **NO** | 4% |

| Q3: Accelerating European-wide legal harmonisation process and establishment of standards to foster development and deployment | |
|---|---|
| **YES** | 100% |
| **NO** | 0% |

| Q4: Developing cutting-edge, reliable, and cost efficient perception, cognition and actuation systems considering redundancy | |
|---|---|
| **YES** | 88% |
| **NO** | 12% |

| Q5: Fostering collaboration, standardisation, and harmonisation between digital/communication and automotive industry | |
|---|---|
| **YES** | 94% |
| **NO** | 6% |

- **Session 1.3 - Physical & Digital Road Infrastructure**

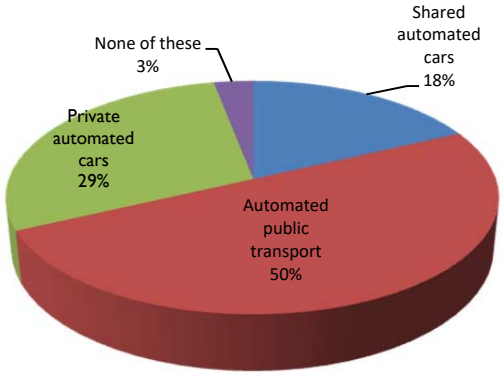



| Q2: Should a vehicle be expected to cope with any road infrastructure in use via enhancement of sensors and related algorithms? | |
|---|---|
| **YES** | 67% |
| **NO** | 33% |

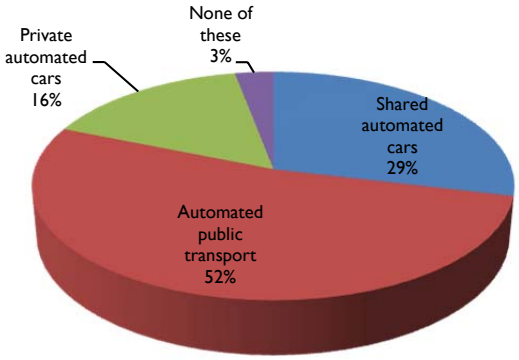
| Q3: In relation to vehicle SAE levels of automation is there a need to define levels of automation for physical and digital infrastructure? | |
|---|---|
| **YES** | 80% |
| **NO** | 20% |

- **Session 2.1- Socio-Economic Impacts**

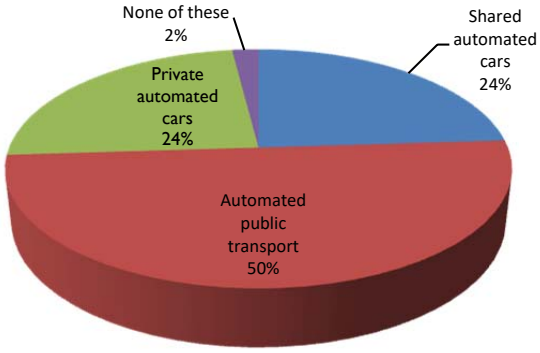
**Select the scenario in which "decrease in stress caused by travelling" is most likely (compared to current situation)**



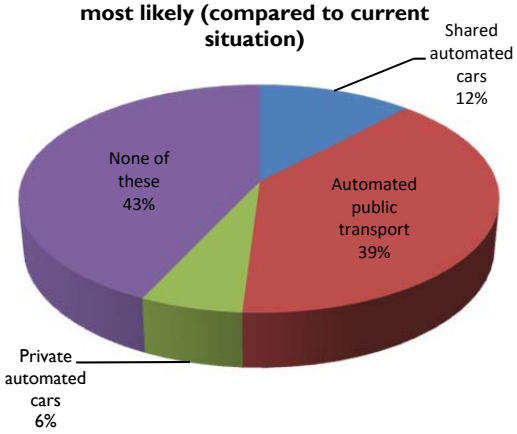

**Select the scenario in which "better accessibility of lower density areas (better regional equity)" is most likely (compared to curren situation)**



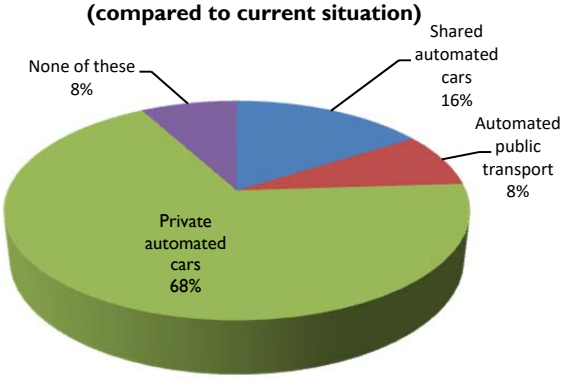

**Select the scenario in which "better accessibility for disadvantaged or impaired travelers" is most likely (compared to current situation)**



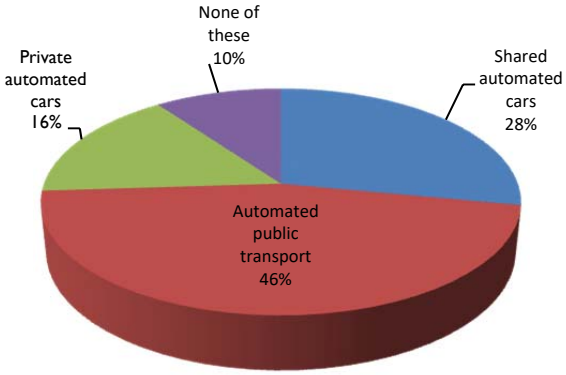

**Select the scenario in which "increase in active mode use like biking & walking" is most likely (compared to current situation)**



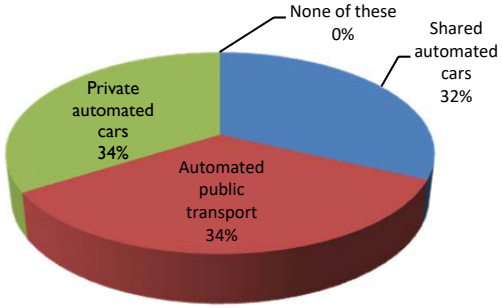

**Select the scenario in which "increase in traffic volume in terms of vehicles/day (due to changes in number trips/routes/mode)" is most likely (compared to current situation)**



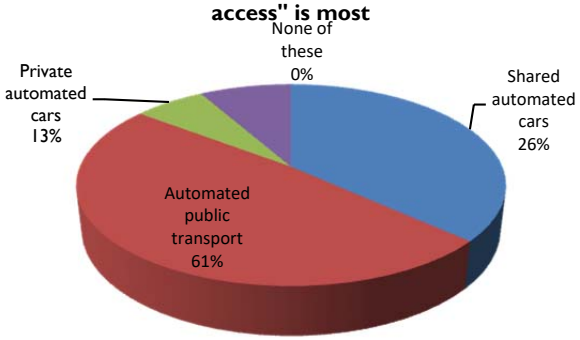

**Select the scenario in which "decrease in travel time per kilometer traveled" is most likely (compared to current situation)**



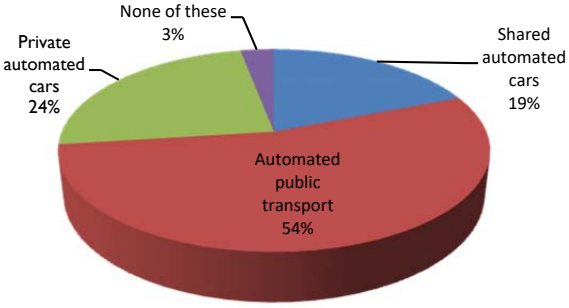
**Select the scenario in which "increase in travelling during peak periods (due to less harm caused by delays)" is most likely (compared to current situation)**



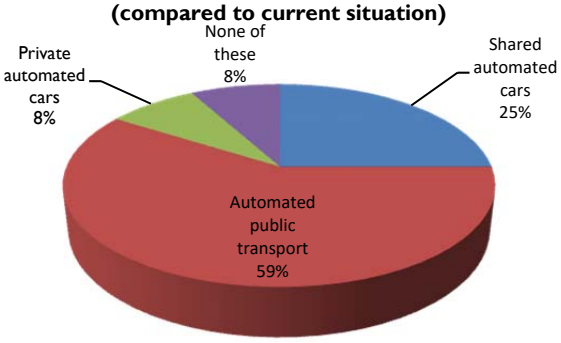

**Select the scenario in which "creation of new areas with transportation infrastructure designed specifically for AV access" is most**



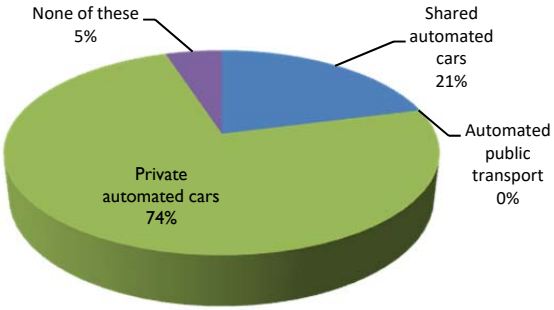

**Select the scenario in which "increase in investment cost for physical infrastructure" is most likely (compared to current situation)**



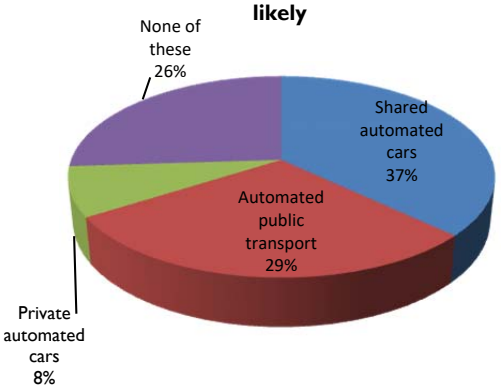

**Select the scenario in which "decrease in travel cost per trip for user" is most likely (compared to current situation)**




**Select the scenario in which "decrease in value of time spent travelling (due to ability to work or relax during automated driving)" is most likely (compared to current situation)**




**Select the scenario in which "new job creation in transport sector (to replace decreasing number of driver jobs" is most likely**



- **Session 2.2- Human factors & user awareness**

| Q1: New smart, personalised HMI concepts, designed for high automation, will increase system robustness, user acceptance, and overall comfort | |
|---|---|
| **AGREE** | 82% |
| **DISAGREE** | 18% |

| Q2: We need new, adapted and fully integrated HMI systems that provide advanced comfort during Level 3+ automation | |
|---|---|
| **AGREE** | 74% |
| **DISAGREE** | 26% |

| Q3: Driver state monitoring is a pre-requisite for Level 3 (and lower) automated driving to ensure safe and smooth transitions | |
|---|---|
| **AGREE** | 64% |
| **DISAGREE** | 36% |

| Q4: Driver monitoring systems should follow a hybrid approach to reach robust performance and use a combination of driver state, vehicle state, environmental context and personalised driver info | |
|---|---|
| **AGREE** | 77% |
| **DISAGREE** | 23% |

| Q5: We need additional external HMI for Automated Vehicles to coordinate actions with other | |
|---|---|
| **AGREE** | 74% |
| **DISAGREE** | 26% |

| Q6: Automated Vehicles must fully understand the intentions of other road users and react accordingly | |
|---|---|
| **AGREE** | 61% |
| **DISAGREE** | 39% |

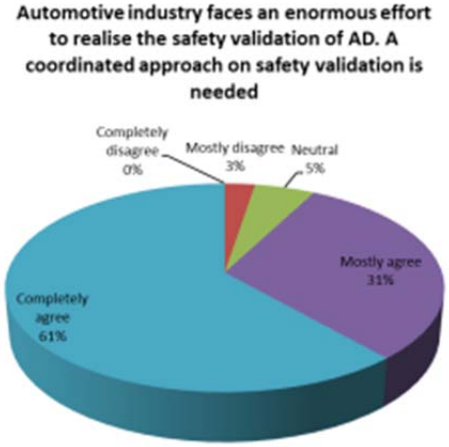
| Q7: Accident liability should be removed from drivers of conditionally automated cars (SAE Level 3) who show typical and reasonable user behaviour | |
|---|---|
| **AGREE** | 39% |
| **DISAGREE** | 61% |

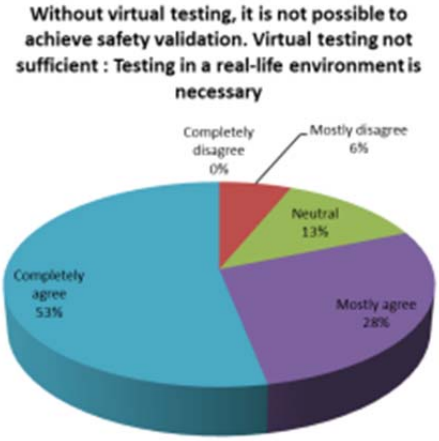
| **Q8: People should have the freedom to change options for the decisions taken by the cars (e.g. driving style)** | |
|---|---|
| **AGREE** | 63% |
| **DISAGREE** | 37% |

| **Q9: Legal admission of SAE Level 3 automation requires human in the loop evaluation of take-over procedures** | |
|---|---|
| **AGREE** | 86% |
| **DISAGREE** | 14% |

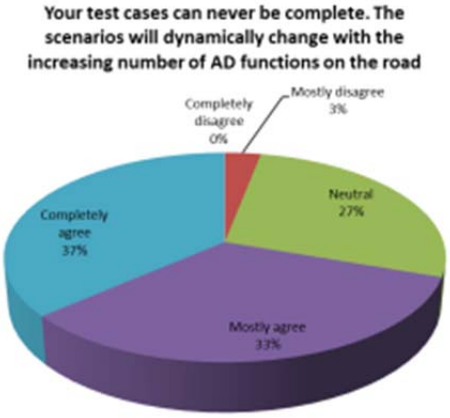
| **Q10: Legal admission of SAE Level 4 automation in vehicles with steer and pedals does not require human in the loop evaluation of take-over procedures** | |
|---|---|
| **AGREE** | 26% |
| **DISAGREE** | 74% |

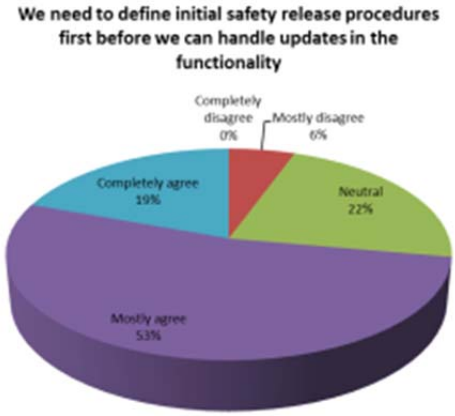
- **Session 2.3 – Vehicle Validation**







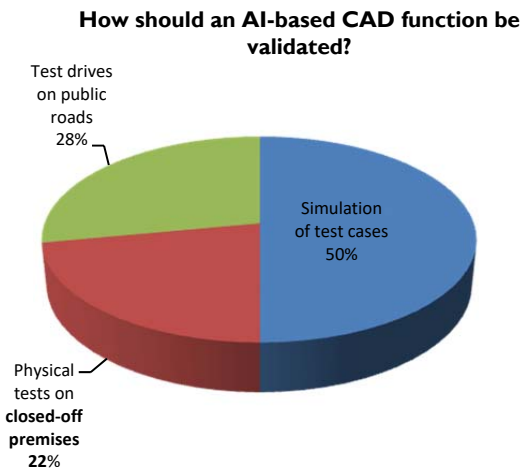
- **Session 3.1- Regulation, Legal and Liability**

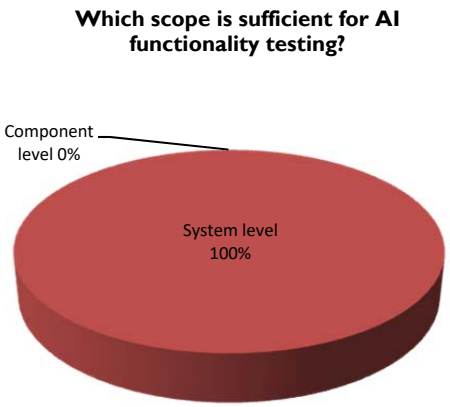
| Q1: To your knowledge, the amendment of the Vienna Convention of March 2016 allows for driving SAE level 3 and SAE levels 4 AD systems? | |
|---|---|
| **YES** | 39% |
| **NO** | 61% |

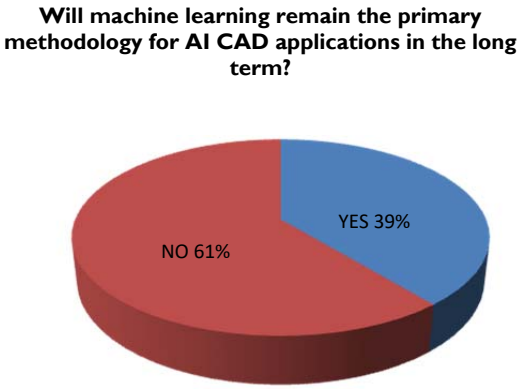

| Q1: To your knowledge, the amendment of the Vienna Convention of March 2016 allows for driving SAE level 3 and SAE levels 4 AD systems? | |
|---|---|
| **YES** | 39% |
| **NO** | 61% |

| Q1: To your knowledge, the amendment of the Vienna Convention of March 2016 allows for driving SAE level 3 and SAE levels 4 AD systems? | |
|---|---|
| **YES** | 39% |
| **NO** | 61% |


- **Session 3.2- Artificial Intelligence**

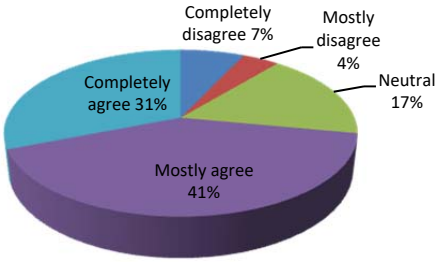


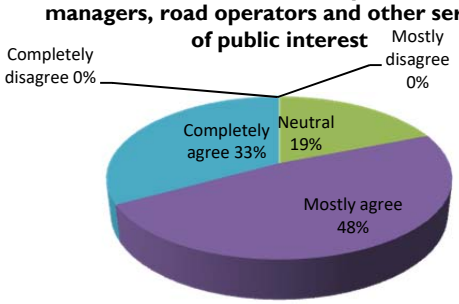



- **Session 3.3- Connectivity**

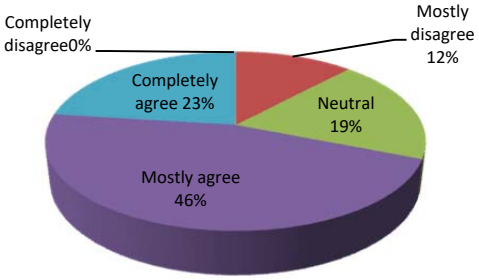
**Level 2 automated vehicles will rely essentially on their onboard sensors and may additionally include Internet connectivity to connect to a backend service (e.g. vehicle cloud)**



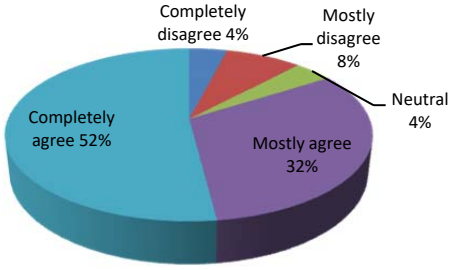

**Vehicle clouds as an extension of the vehicle on-board sensor platform and their interfaces to the service clouds will offer a viable solution to the connectivity with traffic managers, road operators and other services of public interest**



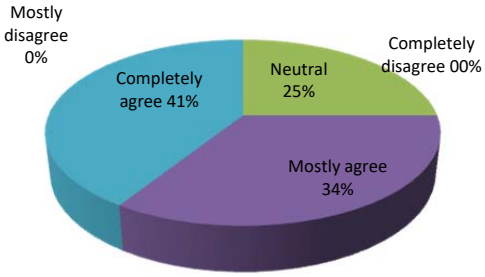

**There is a need for a next generation of V2V-V2I protocols and communication technologies e.g. short range secured exchange of sensor and manoeuvring data with high degrees of reliability and quality control**



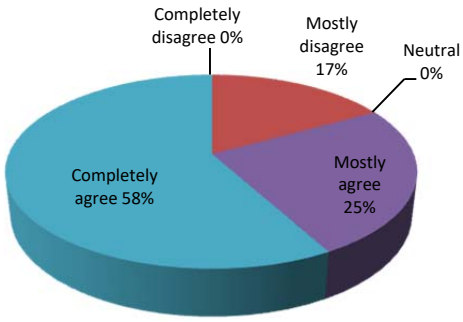

**Data privacy, cyber security, data access, service discovery, etc. should be addressed in cooperation with ICT especially IoT communities and avoid designing specific road transport solutions**

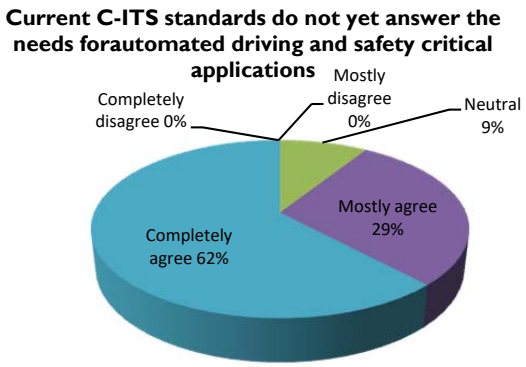



**Connectivity reliability, quality, coverage will always remain an issue today or in 2040 but for different QoS. Connectivity needs a long-term roadmap considering gradually higher levels of automation as new communication technologies become mature.**




**Lower levels of automation cannot (and will not) wait for wider penetration of the V2V/V2I short range communication**




Current C-ITS standards do not yet answer the needs forautomated driving and safety critical applications
Completely disagree 0%
Mostly disagree 0%
Neutral 9%
Mostly agree 29%
Completely agree 62%