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ARCADE

Aligning Research & Innovation for Connected and Automated Driving in Europe

Proceedings of the joint workshop of ARCADE CAD Stakeholder Network and ERTRAC Working Group on "Connectivity and Automated Driving"

5-6 February 2019, Brussels

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Contents

1. Introduction

The mission of ARCADE is to coordinate consensus-building across stakeholders for sound and harmonised deployment of Connected, Cooperative and Automated Driving (CAD) in Europe and beyond. ARCADE supports the commitment of the European Commission, the European Member States and the industry to develop a common approach to development, testing, validation and deployment of CAD in Europe and beyond.

ARCADE involves 23 partners from 11 EU Member States, approximately 30 associated partners and approximately 2.000 subscribers, jointly forming the CAD network of European experts and stakeholders from the public, industry and research sectors, with international outreach. Associated partners can be organisations from the private or public sector, research, stakeholder associations or individual experts.

ARCADE uses a dual approach to identify and overcome bottlenecks and in parallel maximise consensus and synergy between stakeholders. Using a road metaphor, ARCADE focusses on "removing road blocks, paving the road, prevent traffic jams and providing navigation to a common destination".

In an annual cycle, ARCADE positions the CAD Network (WP2) centrally which brings together the CAD community at national, European and International levels. The Thematic Areas (WP3) work on content creation leading to consensus-based positions, needs and scenarios. The Knowledge Base (WP4) consolidates the CAD knowhow baseline and serves as public one-stop shop overview of CAD.

This report provides the proceedings of the 1st stakeholder workshop of ARCADE Joint CAD Network, organised with ERTRAC Working Group on "Connectivity and Automated Driving". The workshop was held on 5-6 February 2019 in Brussels, Belgium.

ARCADE thematic areas[1] have started investigating key uncertainties blocking fast introduction of CAD, creating negative impact, and resulting scenarios for 2030 – 2050 (from the different angles of the respective themes). The workshop aimed to get feedback on their initial findings, using as a focus the three categories of use-cases (passenger car, freight vehicles and urban mobility vehicles).

Based on the workshop results, the draft scenarios should be refined and consolidated into a roadmap. This roadmap, which will be continuously updated in the course of the project, will be used as input to the new ERTRAC roadmap on Connected and Automated Driving. The objective is to finalize and present the results at the EUCAD2019 Conference on 2-3 April 2019 as well as the ERTRAC annual conference on April 4th.

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[1] In-vehicle enabler, Connectivity, Human factors, Industrialisation needs, Digital and physical Infrastructure, Big data/ artificial intelligence, New Mobility Services, Freight and logistics, Safety validation/ roadworthiness testing, Policy and regulatory needs, User acceptance & Training, Socio-economic assessment and sustainability.

2. Final agenda

5 February 2019

14:00 Joint Stakeholder Workshop Day 1, Welcome – Stéphane Dreher, ERTICO - ITS Europe (ARCADE Coordinator)

14:10 Joint Stakeholder Workshop Day 1, Introduction (plenary)

- ERTRAC Roadmap on Automated Driving update: status and time-plan - Xavier Aertsens, ERTRAC
    - Specific focus of the updated roadmap on Infrastructure and Connectivity sections: definition and impact of ODD (Operational Design Domain) and the ISAD (Infrastructure Support for Automated Driving) – Manfred Harrer, ASFINAG
- ARCADE Roadmap outline - Mats Rosenquist, VOLVO

15:25 Coffee break

15:40 Parallel breakout sessions

1. Passenger Car use cases	(Armin Gräter, BMW)
2. Freight Vehicles use cases	(Mats Rosenquist, VOLVO)
3. Urban Mobility Vehicles use cases	(Eckard Steiger, BOSCH)

16:40 Review, discussion and consolidation from the parallel break-out sessions (plenary)

17:15 End of Day 1

6 February 2019

09:00 Joint Workshop Day 2, Introduction (plenary)

- ARCADE Thematic Areas: background and methodology – Carmen Rodarius, TNO
    - Technology-related Thematic Areas – Armin Gräter, BMW
    - System & services-related Thematic Areas – Guido Di Pasquale, UITP
    - Society-related Thematic Areas – Yvonne Barnard, University of Leeds
- HEADSTART project: introduction and proposed cooperation with ARCADE Thematic Areas – Annie Bracquemond, Vedecom/ Adrian Zlocki, IKA

09:30-11:00 Interactive workshop, parallel breakout sessions per thematic areas

09:30 Introduction scenarios technology-related Thematic Areas – Armin Gräter, BMW

Breakout for Thematic Area groups:
- Human Factors
- In-vehicle technology enablers
- Deployment
- Connectivity

10:00 Introduction scenarios system & services-related Thematic Areas – Guido Di Pasquale, UITP

Breakout for Thematic Area groups:
- New mobility services, shared economy and business models
- Big data, artificial intelligence and their applications
- Physical and Digital Infrastructure
- Freight & logistics

10:30 Introduction society-related Thematic Areas – Yvonne Barnard, University of Leeds

Breakout for Thematic Area groups:
- User awareness, users and societal acceptance and ethics, driver training
- Policy and regulatory needs, European harmonisation
- Socio-economic assessment and sustainability
- Safety validation and roadworthiness testing

11:00 Coffee break

11:15 Consolidation (plenary)

12:15 Meeting close & lunch

3. Day 1

The first day started in a plenary set up and was opened by the ARCADE project coordinator Stéphane Dreher (ERTICO) with a brief introduction to the ARCADE project that follows up the activities of the recently closed CARTRE project. The mission of ARCADE is to coordinate consensus-building across stakeholders for sound and harmonised deployment of Connected, Cooperative and Automated Driving (CAD) in Europe and beyond. ARCADE and its predecessor project CARTRE have been supporting the EC since 2016 with the main objective to accelerate the harmonized deployment of CAD in Europe.

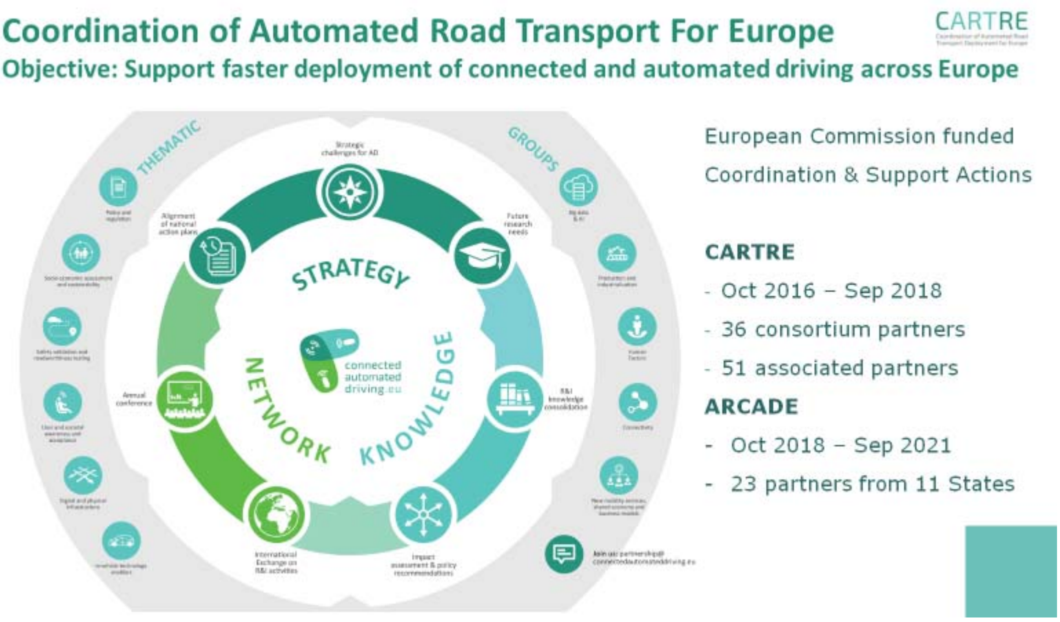

Figure 1: Introduction slide to the ARCADE project as presented during the workshop

Xavier Aertsens (ERTRAC) introduced the status and time-plan of the update to the ERTRAC Roadmap on Automated Driving which will be ready for distribution at the EUCAD conference in April 2019.

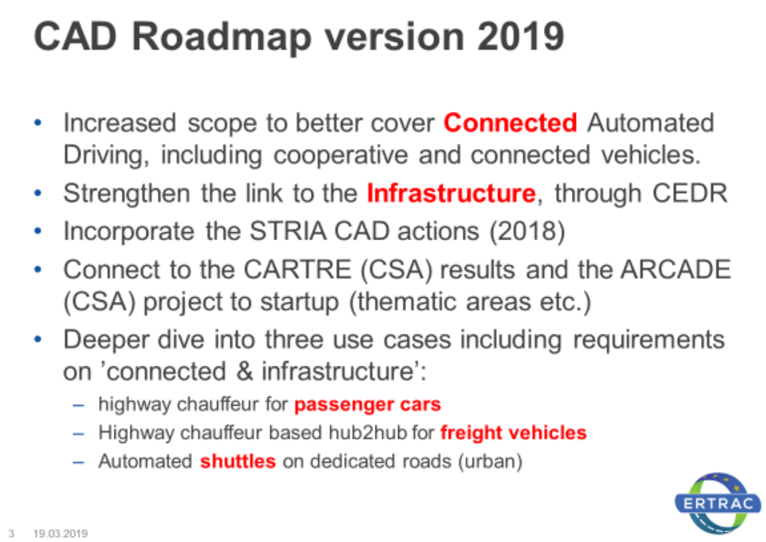

Figure 2: CAD Roadmap version 2019 slide as presented during the workshop

Manfred Harrer (ASFINAG) outlined the specific focus of the updated roadmap on Infrastructure and Connectivity sections: definition and impact of ODD (Operational Design Domain) and the ISAD (Infrastructure Support for Automated Driving)

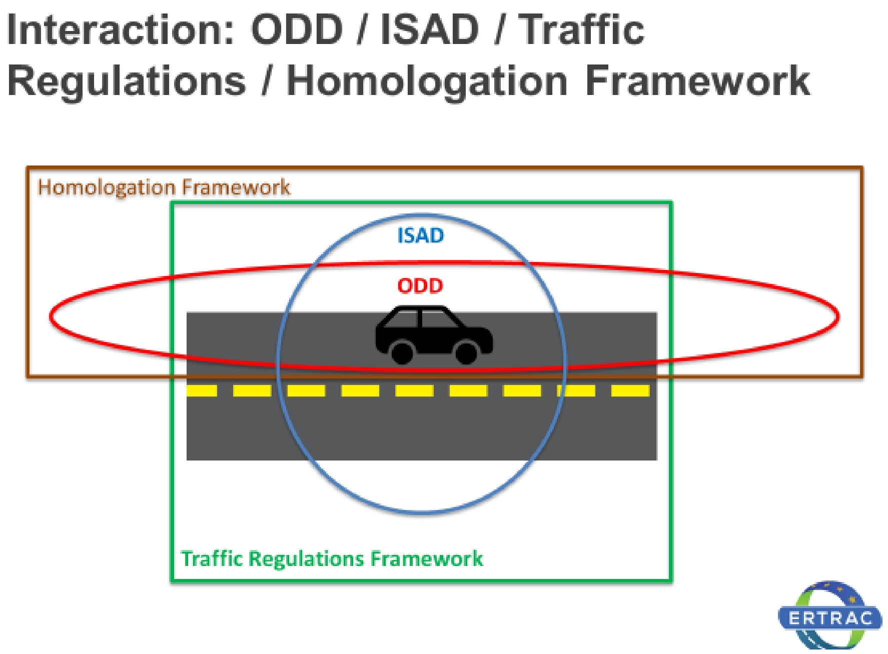

Figure 3: Interaction of ODD, ISAD, Traffic Regulations and Homologation Framework as presented during the workshop.

This presentation was followed by a first vision for the ARCADE roadmap – presented by Mats Rosenquist (Volvo). This consolidated roadmap has not yet been established and shall be delivered in a first draft version after the first year of running ARCADE.

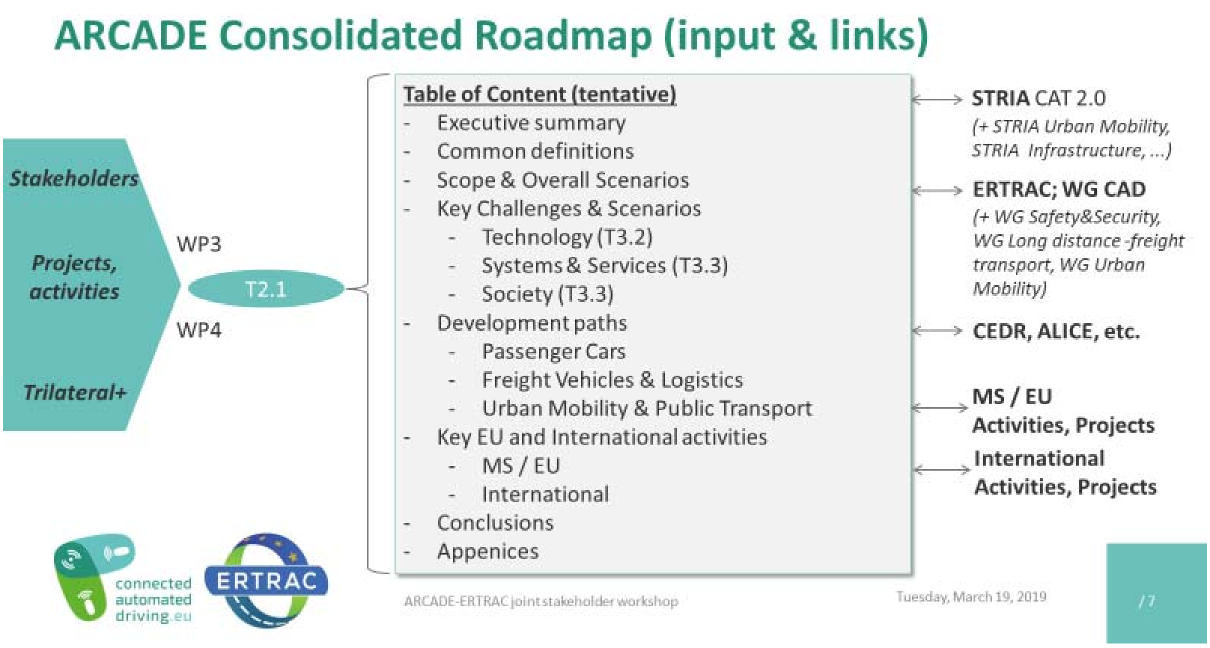

Figure 4: ARCADE Roadmap outline as presented during the workshop

This plenary session was followed by a parallel breakout session. 3 breakouts were held in parallel:

1. Passenger Car use cases (Armin Gräter, BMW)
2. Freight Vehicles use cases (Mats Rosenquist, VOLVO)
3. Urban Mobility Vehicles use cases (Eckard Steiger, BOSCH)

The main findings of these breakouts are detailed in section 3.1 to 3.3.

3.1.Passenger Car use cases (Armin Gräter, BMW)

To start the session and inform the participants, Armin gives an overview and introduction on the topic.

Safety systems and other QoL services like parking assistance are very well developed, function with low speed and restricted environment. Also, reaction time requirement and uncertainty level are low.

Perception, planning and driving are main points to ensure that the vehicle can drive fully automated. Currently, technology still requires driver to be alert, in the future with better systems, it will be possible for “drivers” to take a nap and let the vehicle drive by itself.

A discussion round with the participants follows.

The first spark is provided with a question: While reducing hard shoulders, what happens when the AV has to stop?

Being on the move might be safer than staying at the side of the road as a fail-safe mechanism. Safe stops on rush hour lanes cause new problems. The Introduction of new risks is not wanted. Self-driving cars should not cause new problems but solve existing ones. Minimum risk conditions should be in place. The vehicle could leave the motorway instead. It has to choose the right manoeuvre depending on the complex situation.

The Discussion of weighting advantages and disadvantages of AD continues. Main questions revolve around: Is having the benefits without any disadvantages of AD even possible? How will society deal with the risks of AD and how can we minimize those? The focus of the discussion shifts to the infrastructure support. One major point about this is the trust in and reliability of the data.

Latency is also regarded as important. All parties involved in AD are required to work together. A safe ecosystem is necessary, redundancy and fail-safe mechanisms will have to be in place. The responsibility should not only be with one party.

Service providers can support, but giving an example: HERE has all the fleet data from BMW, Audi and Daimler, but still their digital map is not enough for even level 3. This raises the question, if AV even can rely on external data? The industry leans towards a strict “no”, which puts the road operators on the line to make themselves relevant.

Possible solutions to resolve this issue are to compare the reliability of the systems and see if the on-board sensors are enough. This raises further questions: Can artificial intelligence support this process? What do they learn from? Is deep learning feasible? So far, AI is regarded as a mean to develop the technology, but not something for the end-user vehicle. Also doubts on the capability of current self-learning systems are raised.

The focus goes back to the information chain and how the single sources are interlinked and how they can support one another. Validation and reliability as well as secure data is regarded a very important topic to tackle. Is it better to rely on the vehicle on recognizing traffic signs or wouldn't it be better to receive this information von road operators instead? Technology supports both sides, like QR-codes embedded in the foiling of signs, but also traffic signs and other infrastructure could start to communicate with vehicles.

While talking about the current development of AD, the quite important point is raised, that expectation formed due to heavy marketing should be kept low. The rollout of technology should not be left for Silicon Valley to do.

But we don't need to start with full automation implementation. Information and experience gained through implementing Level 2 systems could prepare society for higher levels. The public view on the topic and their observance of the test fleets are relevant and should be taken into account. Still, how to go from public acceptance to public desire for the technology? Teaching of the topic and proper instructions could support this, as raising awareness is very important. Starting from different points and angles to introduce this new technology might prove beneficial.

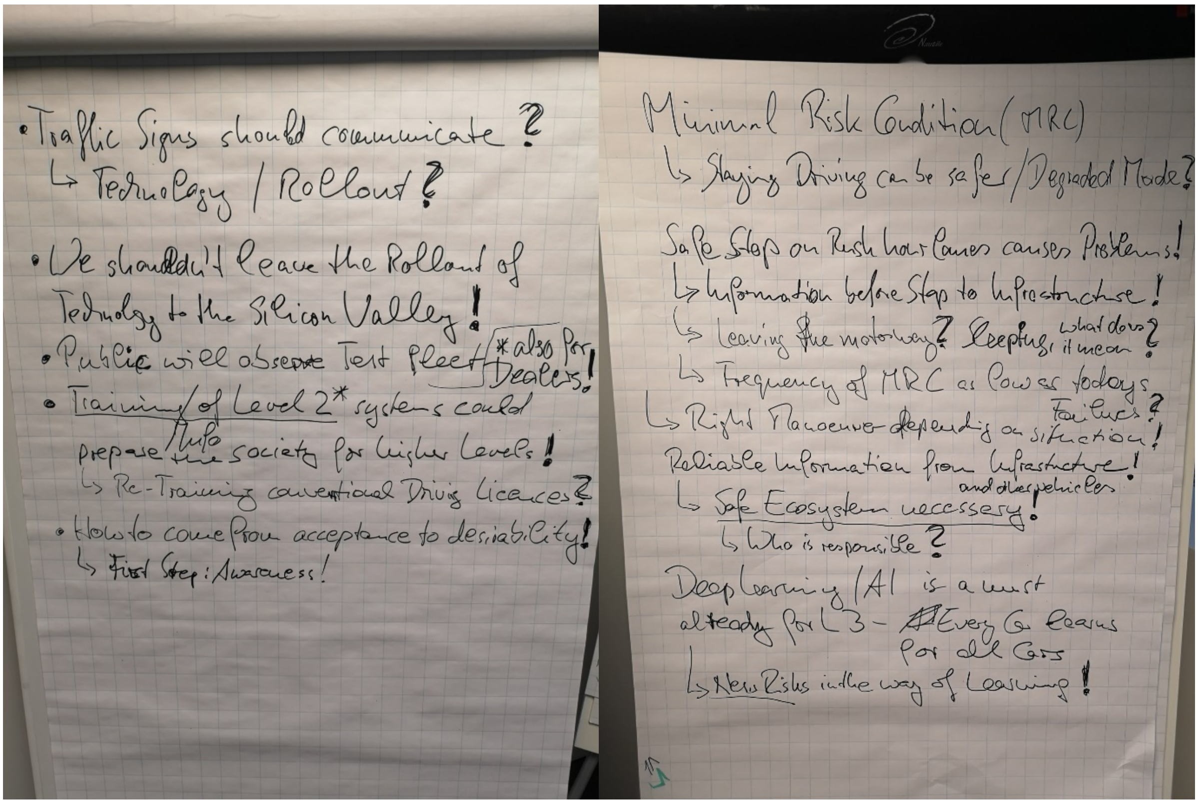

Figure 5: Pictures of the flip-charts used during the discussions

3.2.Freight Vehicles use cases (Mats Rosenquist, VOLVO)

This use case session covered the freight vehicles challenges and objectives with particular focus on level 4 automation. The starting point was the ERTRAC CAD roadmap development paths and the following use cases;

- Highly Automated Vehicles on Dedicated and Hub-to-Hub Roads
- Highly Automated Vehicles on Open Roads.

Two type of vehicle concepts where discussed;

- Manually driven (manned) highly automated vehicles, evolving from full truck concepts. This approach is similar for highly automated passenger cars.
- Unmanned highly automated vehicles remotely monitored and controlled.

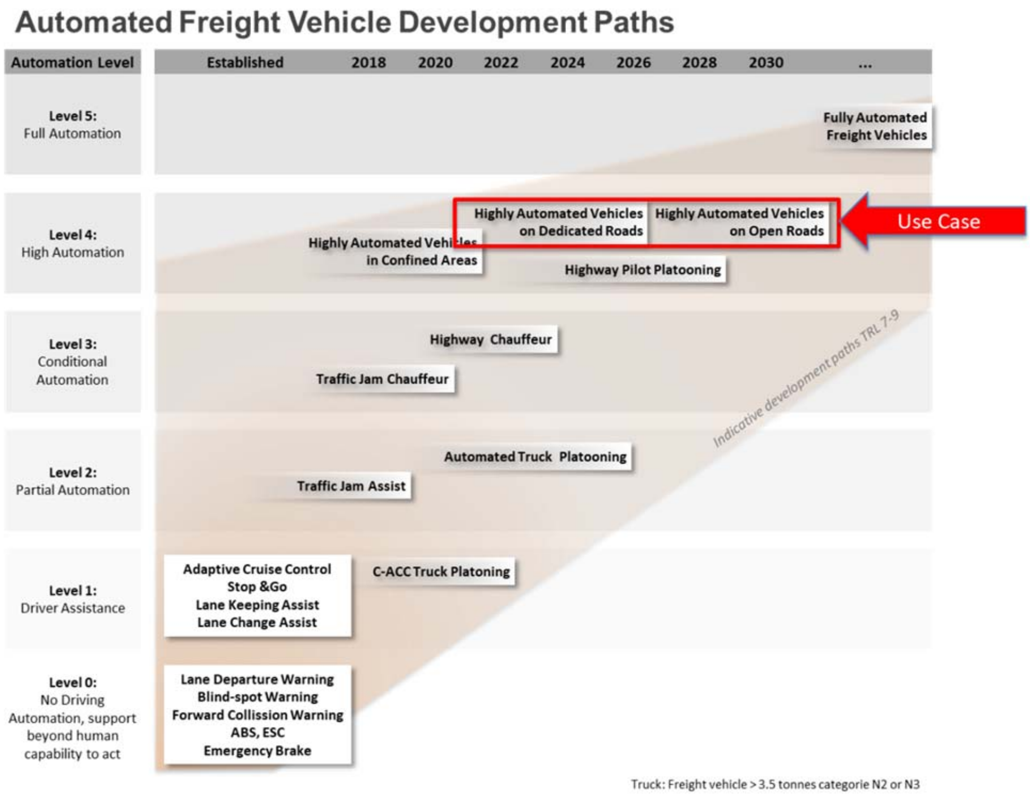

Figure 6: Automated Freight Vehicle Deployment Paths as presented in the ERTRAC CAD Roadmap

The breakout group was represented by; road operators, research institute, OEMs, transport operator, government, system suppliers, research providers and development centre and an Austrian platooning project leader.

After a discussion the following statements and challenges where concluded;

- The increasing freight transport need is a challenge for Europe due to already congested road network. There is a vast amount of freight traffic both internally and externally EU. The European fleet operators are in addition very fragmented. Fleet operators have in average 2-3 trucks.
- There is a need for common rules, standardisation and regulations in Europe harmonizing the national and regional freight traffic - in particular for the CAD domain. Homologation and type approval going back and forth between UNECE and EC
- It is important to continue with real world testing and large-scale pilots. The alpine region and transport network in Austria was mentioned as a 'melting' point given the geographical area linking east-west, north-south. European landscape of transport network (infrastructure) is diverse throughout Europe

- Road tolling system and the interaction with automated vehicles was discussed as a both a challenge and an opportunity area.
- Truck platooning will be an opportunity for enhancing freight transport in Europe. The ENSEMBLE project sees different stakeholders collaborating with each other in order to reach maximum benefit for the industry. Platooning in relation to road tolling need to be investigated. There is also national projects results to consider, e.g. in Austria, the Nederland's and in Sweden. Interoperability, cross border, data sharing are a few elements related to truck platooning. ENSEMBLE: finalised specifications and requirements platoon level A which is the first level (B, C), V2V to V2I. Road operators want to know how the OEMs plan to establish a free flow area in order for the platoon to operate smoothly. Follow-up on the interaction between road operators and ENSEMBLE in order to take the project to a different level in terms of infrastructure. Traffic rules are competences of MS and truck platooning can be hindered because of it
- Highly automated trucks could enable drivers to rest and driving and rest times. The driver time regulation needs to be amended. Shippers and large corporations are seeking the most cost-efficient way to transport from point A to point B. Important to focus on automation in different segments in the logistics chain; confined areas, hub-to-hub and open roads due to the difference is authority, vehicles and operators. Service providers could be interested in providing road authorities the necessary tools. Supply chain management (ODD, avoiding disruption on roads by trucks) and the role of automation throughout the entire logistics chain, traffic management
- Driver training has to be revisited especially since a majority of European drivers have held their licence for 18-20 years.
- Traffic Safety can be improved through enhanced interaction with other road users (e.g. personal cars) to capture the opportunities of CAD.

3.3.Urban Mobility Vehicles use cases (Eckard Steiger, BOSCH)

In this session, two use cases were discussed, one for individual use (the so called robo-taxi application) and one for collective use (shuttles). For both use cases SAE Level 4 (no driver) was assumed.

Collective use - Shuttles:

- Integrated with Public Transport
- Safety issues/passive safety requirement: would be people wear belts in such vehicles? Accessibility to such AV
    - Accessibility: do users need to be fully capable, drunken users allowed?
    - Digibus Austria example: perceived safety and security feeling.
    - Matter of liability of the vehicle: for example: 2 persons fighting. AV gets out of ODD resulting in need for exception management, what does it mean from technical point of view, e.g. supervision, safe stop?
    - Example of NL: there are cameras inside. The experience is good.
    - Social ODD requirements: if it should be good for elderly and disabled, you will need someone to help them.
    - Need for an operator for the societal aspect. A supervision control.
- Currently speed is very low, for acceptability reasons (City Mobility). Where do you put the intelligence and the costs? In vehicle or infrastructure?
- Acceleration and deceleration: need to find a new concept because if speed is increased, comfort and security of standing passengers is doubtful.

- Cyber security is an issue if you want to control them remotely.
- Passenger safety: shuttles today do not have safety features. It should be essential part of the future vehicles.
- Control centres will play a relevant role. Should we put more effort and technology on the back end?
- Need for energy efficiency: it can be achieved by single vehicles, but to go more efficient, the role of a centralised control of such AV is more effective and has more potential.
- This kind of AV is also meant for rural area, as seen more efficient then a bus.
- Use case: rural to urban. Out of scope here.
- Link with the infrastructure is very important, because it needs to be adapted to the needs of the shuttles. Digitalisation of the roads: Will a HD map be available from the city or will the manufacturer have to build the HD map? Who will pay for this?

Individual use, premium application:

- A business model that can compete with Public Transport (PT)
- They should also be integrated in the PT planning, part of MaaS.
- First step is rebalance of car sharing
- Dual use depending on the demand.
- Dispatching centre is important.
- Benefit of robot-taxi vs shuttles is that you have higher degree of comfort, can easier put luggage and reach the destination faster.
- It is important to understand how those vehicles behave. It makes sense only if they are at the same flow / speed as other vehicles.
- Today there are no AVs with speeds above 30Km/h
- The shuttles involve more stakeholders because it is a public service. While robot-taxi is more like Uber.
- Fleet operator involvement is needed and a robot-taxi should be part of the mobility system. Number of taxi is regulated by the city. Also Uber is regulated now in some cities. It is a regional competence, that’s why they all come to the city centre.
- Regulation topic/ price is too low: if it is too convenient to go with a robot taxi, then there is no hope for intermodality and soft modes. People will complete the trip with the taxi.
- Who is paying for the infrastructure that is required for a robot-taxi?
- New concepts of vehicles: e.g. small pods that can be combined and platooned.
- These AV ride around empty looking for demand. like uber today. With the automated fleet, there is no single interest by the driver, so the fleet can be optimised easier.
- Algorithm: prediction of demand, optimisation for charging.
- Space is very important for cities: only collective use of robot taxi can have a future, integrated with mass transit.

4. Day 2

Where the first day was more focusing on inputs to the ERTRAC CAD roadmap, the second day was more dedicated towards the ARCADE. An introduction to the work for day 2 was given by Carmen Rodarius (TNO) including short pitches presenting the ARCADE WP3 (Thematic Area) tasks by the task leaders:

- Technology-related Thematic Areas – Armin Gräter, BMW
- System & services-related Thematic Areas – Guido Di Pasquale, UITP
- Society-related Thematic Areas – Yvonne Barnard, University of Leeds

3 parallel breakout sessions including 4 topics each were held. For each session, a poster was prepared to gather input from the workshop participants. Impressions of the posters are available in section **Error! Reference source not found.** (Appendix A). The sessions were started with short presentations by the task leaders presenting a possible CAD scenario including the respective thematic areas. It should be noted, that these scenarios were not intended as representation of established work by ARCADE nor were they necessarily representing the vision of the presenter. They were merely intended as kick-starter for the discussions around the posters. In the following sections, the main findings per breakout session are presented.

4.1. Human Factors

Transportation type and ODD

Types of vehicle (passenger cars, shuttles, freight transportation, with or without cab/pedals/steering wheel) running in different operational design domains obviously pose very different *challenges*. It is not possible to create *one* ideal scenario for 2030 and 2050.

Driving environment

The group was quite in agreement that there will for sure still be vehicles with Level 3 and lower on the roads both 2030 as well as 2050. Both due to the challenges the different ODD will be posing (traffic complexity, weather, road conditions etc) on safety but also still for perhaps a smaller proportion of people who want to the actual freedom to drive. For some ODDs there could be conflict between safety and freedom where it might be safer to only allow non-manually driven vehicles.

User groups

Impaired users and children will easily access AVs where there is no driver and will be regular users *in specific areas*. According to some it's more or less already the case however it very much depends on the ODD and the type of vehicles. The challenges might be related to the start and end of the trip where a driver today is the key enabler to make sure people can access the vehicle. It most likely also depend very much on the culture/city/country (see for example the different attitudes today to allow young children to use public transportation or not on their own.'

Role of the human

Automated Vehicles will still run with a human controller as back-up (either in the vehicle or remotely) in 2030 and there will definitely be mixed traffic in most ODDs. In some dedicated areas the human control can be shifted to remotely controller (e.g. freight) but for *passenger* transport *in most ODDs* there need to be controls (steering wheel, pedals, buttons) due to the possible rapid change of the ODD due to weather and other conditions.

Concrete design options

The interior design of automated vehicles will have changed completely compared to today's vehicles due to the rapid technological development with regards to actuators, I/O devices etc.

To some extend switches and visual indication should be standardized still with the ability to follow new possibility to create improved interaction design. Form could be seen as secondary but the design strategies could be shared (see e.g. the AdaptIVe design requirements). R79 legislation is already stipulating timing and modality of hands-on requests etc. It will be increasingly important to clearly indicate how to present ODDs for the driver. Driver need to clearly understand the limitation and ability of a random vehicles (e.g. car sharing) and what will happen when the vehicle pass back control in the end of an ODD.

Challenges from brainstorming

- Criticality of transitions of control
- Awareness for ODD and AV capabilities
- Misuse vs. unintended use (design for good affordance and restrict possibility of obvious misuse)
- Interaction with other traffic participants (manually driven vehicles as well as VRUs)
- Different user groups, design for different capabilities for adoption of different technologies
- Tuning of AVs to different users, regions, use cases
- Social acceptance, user acceptance (no 100% safety), awareness, trust
- Training of users (for different purposes, e.g. increased adoption).

4.2.In-vehicle technology enablers

Scope

This TA aims to understand the existing in-vehicle technology landscape and envision the short term future in terms of related challenges and blockers.

Main discussion point

CAV is not one piece of technology. In fact there are bits and pieces of other technologies contributing to their development. Therefore it is essential to decompose this TA into specific technology groups.

- Map
- Sensors
- Perception software
- Decision making
- Driving software
- Actuators

Key challenges and/or blocking issues to get there

- Revolutionize vehicle digital development
- Validate and detect performance errors
  - Enable smarter and safer vehicles
- Sensor fusion
  - Price (more affordable sensor solutions),
  - Reliability (robust sensing capabilities)
- Regulated market
  - Services on top (cloud-based connected car services)
  - Shift towards shared services (model of car ownership is all set to change)
  - Understand the value of opportunity from vehicle data
    - Setup monetization options to capture the opportunity
- HD Maps
  - How to bring high precision localisation, environment perception, planning and decision making functions to the market
- Perception software
  - AI to support perceiving real-life objects and make quick decisions about what to do
- Driving software
  - On board computer to be able to follow traffic laws

Ideal situation in 2030

- Standardisation should follow closely the developed technology
  - Future proof standards
  - Hybrid certification/approval process
- Scalable and more open architecture
  - Flexible testing/piloting
  - Each layer of technology adding safety refinements
- Boost of C-ITS
  - Enhance interoperability for CAD

Ideal situation in 2050

- An elastic transportation ecosystem
- Multi-modality
  - All traffic actors working as one system
  - Serving diverse demands
- MaaS
  - More options for the citizens and the travellers (based on real-time conditions throughout the network)
  - Decreased cost of transit
  - Making urban areas more liveable while accommodating growth

Way forward

- All the points discussed here above will be reviewed by the TA group during the next sprint.
- Further related Technology session will be organised during EUCAD 2019.

Summary and conclusion

It is expected the capabilities of both the vehicles and the road conditions in which they operate will increase over the next period.

Standardisation and legal/policy frameworks will act as enablers and ease the development of new technologies while also paving the way for AI.

Key question

- Should we consider for the near-term future CAD or eCAD?

4.3. Deployment

Introduction: The overall ambition is "to make Europe a world leader for the deployment of connected and automated mobility making a step-change in Europe in reducing road fatalities, reducing harmful emissions from transport and reducing congestion". Successful deployment of automated vehicles and mobility services is the result of the combined efforts of the thematic areas all together, addressing a number of challenges

Key challenges and / or blocking issues

- Speed up "time to market" to enable early market deployment of new solutions
- Transformation of the automotive sector into a software-driven industry complexity, functional growth, continuous software online updates and cyber-security.
- Production and end-of-line tests, quality assurance tests and certification
- After-market sector and after-market products and services, maintenance concepts, calibration, diagnostics, field-support, fleet-monitoring

Key enablers

- Establish an European multi-stakeholder platform to coordinate open road testing, pilots and deployment of connected automated mobility
- Perform large-scale tests and pilots towards deployment in the different application domains;
    1. Deployment of connected automated passenger vehicles in mixed traffic conditions for improved safety and efficient road transport
    2. Deployment of connected automated heavy commercial freight vehicles in mixed traffic for improved safety and efficient road transport
    3. Deployment of electric, connected and automated urban mobility vehicles in mixed traffic for improved safety and efficient road transport
- Alignment with the deployment of C-ITS in balance with 5G deployment. Connectivity and cooperative systems is an important enabler for higher level of automation.
- Alignment with physical and digital infrastructure development
- Rules and regulation, support and harmonization
- User acceptance and user desire for automation

- Societal and Business benefits in balance

Scenarios in 2030

- Completed, successful and comparable tests, pilots and FOT of highly automated (L4) vehicles in different locations and ODD:s representing typical users in Europe
- Highly automated (L4) Passenger vehicles are available in limited ODD for most markets in the EU.
- Highly automated (L4) Freight vehicles (Trucks and freight-movers) in operation in several freight corridors in the EU.
- Highly automated (L4) Urban Mobility vehicles (shuttles, buses and PRT:s) in operation in several cities in the EU

Scenarios in 2050 (=ERTRAC SRA 2018)

- Fully multimodal mobility offerings including trip planning, pricing and payment.
- Connectivity everywhere and at any time with stable connection and data rates.
- Communication between vehicles and infrastructure to optimize traffic flow, traffic management and safety.
- Mobility as a service regardless of ownership.
- Predicted demand from individual behaviours, enabling appropriate modal capacity and demand management.
- Digital technology for vehicle access regulation, fee payments and prioritization.
- Data privacy and international standards for data exchange and connectivity.
- Highly automated vehicles for the inclusion of vulnerable users and people with reduced mobility (PRM).
- Accidents and delays are extremely rare and delays automatically resolved.
- Harmonized legal frameworks for automated vehicles.

4.4.Connectivity

Connectivity is generally not deemed as necessary but an important enabler to ensure a fast introduction of AD. It adds to safety, efficiency and comfort. The idea of the session is to highlight the ideal situation for the stakeholders in 2030 and 2050. At the same time, key challenges faced today and blocking issues should be identified.

Highlights of Ideal situations for 2030 and related uncertainties or challenges mentioned by the participants are:

- 5G European wide connectivity is essential. There are still many gaps today. A proposed Vision for 2030 would be to have full 5G coverage. If it is not available, a safe backup is needed, e.g. with satellite connectivity. It will however be 6G already in 2030 as the evolution cycle is 10 years. 5G is planned in waves and releases.

There is a gradual evolution of technologies and services. Today with LTE we can already do more. It is important to start with what is available, build services on top of it and gradually see the services that can be added with next releases. In EU, we are too much focused on Day 1-1.5 services and we have not yet defined the services beyond it. There is no agreement on Day 2 or 3 as well as on hybrid Use Cases and the needs for connectivity. There are still 2M cars doing LTE without LoS. A step by step approach is very good but there needs to be an approach for EU Use Cases. What does 5G availability mean?

- A European solution with a European governance, both policy and market driven. There are technical, economic and legal frameworks that are necessary to make use of these connectivity technologies. Policy is needed for level playing field, but the market advances if there is competition.
- Presence of interconnected clouds. Cloud to cloud interfaces will happen, but we need to make sure they are defined, thus interoperable.
- C-ITS: there is a need for interoperable implementation of Messages for e.g. maneuvers. There is always room for interpretation. If it is more open, it will be deployed faster.
- Of course an evolution of ITS G5 is also envisaged for the ideal situation in 2030 to enhance the hybrid connectivity approach.

Key challenges:

- Data sharing is still an issue. Marketplaces are required as well as regulation (trust, reliability). The problem is that the car manufacturers do not trust information provided by infrastructure. There is a lack of cooperation of OEMs with road infrastructure providers.
- Cybersecurity needs to be implemented across the whole value chain
- Data privacy by design is necessary
- Cross border issue is related to regulation; it has nothing to do with technology. Cross border is required with a given SLA for applications and Use Cases. The question is who is financing all this?
- Rail and road need to cooperate. The focus is a lot on vehicles. There is a lot of room for improvement especially on trams. Connectivity is required with e.g. Trams, pedestrians, etc. Many operators are interested in C-ITS messages for Trams.
- What is the offer/role of the service provider and the connectivity provider for these services? The issue is if connectivity is there but not guaranteed. MNOs are connectivity providers, they are working with the automotive today and there are guarantees for mobile network. But the European Services need to be defined. And who is guaranteeing that I can use services and connectivity when travelling in Europe. It is important to make the analogy with Tolling, with the EETS (European Electronic Tolling System) and REETS (Regional European E Tolling System). In tolling, the market is changing. Road operators are becoming mobility service managers, with the role of not only maintaining a road but also to provide services,

maintain both the physical and digital infrastructure. There is however a lack of knowledge and operators are not ready for this role.

- Need balancing between supply and demand of connectivity. Most is currently on supply.
- Need for an ITS –G5 evolution.

Ideal situation for 2050:

- New business models to maintain and allow seamless connectivity everywhere.
- Full M2M connectivity. All moving objects, and roadside, will be connected.
- Providers for EU CAD Services.

4.5.New mobility services, shared economy and business models

As a result of the discussion between experts, the ideal situation of evolution of new mobility services has been identified for the 2030 and 2050 scenarios. In parallel, we pointed out the main challenges and key barriers.

Ideal situation in 2030

In 2030, it is expected to see deployed shuttles in several European suburban and / or urban areas. These shuttles will be mainly using dedicated infrastructure and will allow to build and test business models that would be relevant for all stakeholders.

In addition, aiming to increase the accessibility of people – in particular disabled ones, these services will be probably equipped with devices that make the access and egress to vehicles without the need of a human support.

Finally, one of the major achievements in 2030 will be the share data using an opensource platform.

To synthesize, in 2030 we expect to have AV-based shuttles, based on shared data, using dedicated infrastructure and accessible by persons with reduced mobility.

Ideal situation in 2050

In 2050, AV-based mobility services will be deployed in all contexts: urban, suburban but also rural areas. These services should be integrated in the multimodal universe, allowing interaction with other modes and using one single access for ticketing. In 2050, the interoperability across EU and /or the globe should be also achieved.

On the other hand, the development of AV-based mobility services in different urban contexts and at a large scale could favorize the urban sprawl and /or increase the congestion on roads. Consequently, urban planners will be involved and will have deployed a harmonized urban planning with suitable strategies to control and regulate the urbanism.

Key challenges and blocking issues

One of the major challenges of such mobility services is the willingness to share the trip. The willingness to share depends on the trip purpose, the travel time, the comfort and the service reliability. In addition, by sharing the trip, passengers accept to waive the travel privacy. One inherent challenge will be then to create privacy areas within sharing mobility models. More generally, the privacy is an issue which is closely related to the data sharing objective, which should be overcame through the involvement of public authorities in data collecting and sharing.

Public authorities should also be involved in early stages of the deployment of these services in order to ensure the balance between economic interests (e.g. jobs creation, profit of operators) and social needs (e.g. accessibility, public health, etc.). This public involvement is all the more crucial as several services providers could operate in the same territory. Regulation of these competing services would limit their negative externalities (e.g. congestion, pollution, higher fares, etc.) but would also contribute to increase the required trust between operators to work together.

Finally, the involvement of public authorities is a prerequisite to ensure intermodality with a unique ticketing system and to create a common and interoperable service across countries of the Globe.

4.6.Big data, artificial intelligence and their applications

Scope

As CAD is expected to go mainstream in the near future Big Data will become increasingly more important. Vehicles will need to tap into a larger information network to communicate with one another. An automated vehicle requires the ability to represent knowledge, so it comes as no surprise that AI will need to back this up.

Main discussion point

- Bigger big data the greater the potential for CAD technology
- Liability
  - Automated vehicles give rise to new liability issues,
  - Should it be a binding constraint on CAD?
- Need for AI?
  - Big data needs AI for analytics on the other hand Big data is what powers AI systems
  - AI is needed to take over driver tasks
  - The more the data the more intelligence
  - AI should not be limited to human capabilities. How to reach that?

Key challenges and/or blocking issues to get there

- How data is shared
  - Data-driven services remain the top opportunity for automotive makers
  - Identify correlation between multi-sourced data, specific critical cases and accident analysis
  - New regulation should emerge to regulate data analysis and sharing
  - Data sharing standers, frameworks are needed
- Data quality
  - Gather as much data to help the machine learning algorithms make smarter decisions
  - How data quality will be measured?
  - Define automated evaluating methods
- Understand the data

  - Important for prediction (can't test every situation!)
  - Important for traffic planning
  - Leveraging real-time information and transform the way people drive
  - More centralised control
- Technology to be in place
  - Real-time processing (computing) power
  - Data capture, control and storage of high bandwidth content
- Modular based approach to secure CAD
  - Enabler for gathering large quantities of diversified data
  - Develop better data concepts
  - Data for both levels signal vehicle and fleets (networks)
- Decision making approach does not exist. It is required to
  - Make real-time decision with AI driven recommendations
  - Evaluate trade-offs
  - Current AI techniques are rather limited as required by the automated driving functionality. An evolution might it be needed
  - Develop explainable AI, solution steps towards liability issues

Ideal situation in 2030

- Data collection techniques gain maturity
  - Data mining can help support safer driving,
  - Traffic mitigation, positional awareness

Ideal situation in 2050

- Liability issues
  - Where liability should reside in order to secure the appropriate type of regulation

Way forward

Revise input collected and compile one document which will be used at a later stage during the EUCAD breakout sessions

Summary and conclusion

During the next years the industry will focus on how to connect things with each other. Better vehicles with AI using machine learning and deep learning dictating systems to react to use cases based upon streaming data.

Therefore, the most important issue needing to be addressed is how to process such a massive amount of data in real-time, how AI techniques will help in handling this data and realising the automated driving functions.

Key question

- How liability will be allocated when Level 5 automated vehicles (full autonomous) will be realised?

4.7.Physical and Digital Infrastructure

Two use cases for the contribution of Infrastructure are proposed at the start of the session to steer the discussions:

- Infrastructure to support the vehicles: if the Infrastructure information on roadwork and lane markings are not valid anymore, the vehicles need know it in advance to organize a handover and adapt the ODD.
- Infrastructure for Traffic efficiency. Inframix for example is looking into measures from the Traffic Management side to improve the situation in bottlenecks.

An important question is what will vehicles need in future from the Infrastructure and on the other hand, what should the infrastructure provide. In particular, the ODD and ISAD concepts should be taken into account.

The following visions for 2030 regarding PDI have been mentioned:

- In 2030, HD Maps should be availability and reliable.
- In 2030, Physical and Digital Infrastructure should mirror each other. It is about IoT, virtualization and discovery of information. It is important to know all information that is available to you. Germany and UK are developing a complete digitalizing approach with the aim to have all information available digitally
- In 2030 there will be Digital information enabling vehicles to drive. The perception will be collective. Maps, localization and information come from Traffic sensor. It is necessary to create an environment for the vehicle to operate. This environment can be created with Physical but also with Digital Infrastructure.
- Harmonisation, standardisation: Today AI is “stupid” but it will not be case in 2030.

Challenges that have been identified to achieve this vision include:

- Current products need support from Infrastructure. To be able to operate on certain roads, infrastructure is required. If a product needs to be developed today, a fence is required, but this is not going to happen in cities.
- The questions today are what information do maps needs, and if providers able to provide the data in digital and standardised form? The ideal situation would be to know which data is needed and have it available.
- As cars will agree among themselves, is digital infrastructure necessary to control intersections or can cars do it on their own? Some level of traffic management in communication options is required.
- A balance needs to be found between operation, reliability and the amount of available information. Information is expensive.

Roles, responsibilities and processes for Digital infrastructure collection and update:

- It is expected that road authorities provide digital information. Today it is however not possible with the current competences. Today the approach should be to build the digital together with the physical infrastructure. But what about existing roads and updates? Older areas need to be collected. The process needs to be changed. Small operators don’t have knowledge and resources. There is a need to have a national push to make it happen, and it needs to come from the EU. Regulations are required to speed up services. It is important to know who is responsible. Operators are not ready today to assume this responsibility and the support of governments is needed. We are not talking about smartphones.

- Alternatively it could be considered that digitalisation could come from private providers who are currently creating the digital infrastructure. However data quality standards need to be defined. It is difficult to make all Public Authorities agree on same representation of PDI and it represents an important investment.
- Therefore, it would be essential to bring together public and private organisations.

Data availability and reliability of Digital infrastructure, ODD

- Regulation on the provision of data is necessary to ensure the availability of reliable and accurate data. We have legal instruments available to enforce that, in particular the Delegated Act. Cars could agree on trajectories.
- The example of ISA has been mentioned. Operators say today that maps are only 90% reliable but it needs to be 100%. Even vehicle manufacturers don't trust their own data. What is safety critical is important. We can't have same level of quality for all cities. The main challenge is if a car drives in another area where the quality is different, the driver will complain to the car manufacturers and not the city.
- By 2030, there might be agreed specifications for the ODD but data will not be there. Availability is key. We need however to be careful with ODD. A road that is good for one OEM is not good for other OEM. It is important to define ODD enablers that can be included in Digital Infrastructure. From the point of view of infrastructure, it is difficult to understand what vehicles need. It should be an enabler but not a prescription. For ODD it has for example to be clearly indicated that the Lane marking is there.
- Legislation and enforcement is needed to maintain the quality and reliability of physical infrastructure: in summer many signs are obscured by vegetation from private property. For emergency road works, the legislation should require for the construction company to put signs back. EURORAP programme with road quality criteria could be used.

4.8.Freight & logistics

Scenario 2030:

From a technical perspective truck platooning will be available and regulatory barriers related to driver rest time rules will be solved. Interventions on infrastructure will have solved issues related to safe and secure truck parking areas which are now a problem all across Europe. Digitalisation is implemented with adoption of electronic documents (eCMR).

Drivers are still needed to take over in some situations.

Remaining issues will be mainly at business, political and social perspective also considering the fact that freight transport will increase (by 280% by 2030 – check source with Mats).

Some of the key challenges identified are related to “acceptance” of drivers and of other road users. In fact mixed traffic could still be an issue especially with platoons of trucks. There will be the need to adapt logistics flows and fleet management to CAD with the involvement of shippers/ forwarders. Infrastructure will have to consider evolution of electrification and the need to recharging facilities in truck parking areas.

Focus on cybersecurity to guarantee trust. Definition and regulation on the minimum requirement for data sharing from OEMs and from businesses could still be an issue. Clear benefits on CO2 reduction still to be assessed.

Scenario 2050:

Physical internet and Fully automated logistics will be the main goals to be achieved.

4.9. User awareness, users and societal acceptance and ethics, driver training

Ethics

Ethics is an important part of all themes, already in product design it should play a role. It is a question what the responsibilities are for governments and for industry. It might be better to treat it as a separate topic, not under user awareness.

Ideas for improving user acceptance

We should not only talk about user acceptance but also look at user desire for a product, and adoption of technology. Does the industry proposes a product or does the user ask for it?

Driver behaviour should be analysed, in order for CAD to mimic the normal behaviour, but of course with putting constraints to improve safety.

People are afraid of what they don’t understand. Therefor more transparency is needed. Users should be able to understand the behaviour of the system.

Protocols are needed to explain to the user what the system is doing, for example why it changes route at some point.

Incentives to enhance user acceptance is not enough, explainability is key.

There is a dilemma related to the use of AI. Rule-based behaviour of the vehicle can be understood by human, if the vehicle makes decisions on the spot based on neural network learning this is not possible. Who sets the rules and in what detail?

Acceptance can only be achieved if users can experience CAD. This is a problem as vehicles in the beginning will be expensive. However, it may be possible to create opportunities to provide experience for the general public.

If CAD improves safety, acceptance will increase.

Social acceptance

New stakeholders come into play and need to be trained about CAD, such as legal and insurance experts. Professional drivers are an important category.

Users are everyone, not only “drivers”.

Media play an important role in forming public opinions about CAD.

Legal and privacy issues

User awareness is linked to the liability question. Information campaigns may need to be created to inform about who is liable, so that users are ready when CAD vehicles are coming on the market.

Will users accept system failures? A legal system needs to be in place to make clear where the liability lies.

In case of accidents evidence is needed, who will have access to the data? At the moment data goes to OEMs, but what about the police? This also brings up the question how reliable the data is.

Privacy is an important issue, especially with share mobility. Can people influence the use of their data? Even if users do not always value their privacy if they want to have a service or a vehicle, it should be possible to have a choice (and in an easy way) to switch off services. GDPR compliance needs to be built in in the software.

Driver training

Maybe we should talk about user training instead of driver training.

Driver training and license is still needed if the vehicle has to be manually driven in certain circumstances.

If the user is only a passenger training is no longer needed. In case of problems there will also be someone at the back-end, e.g. a remote operator.

However, general traffic education may be needed for everyone.

Scenarios

In 2050 there might still be a lot of mixed traffic.

It is important to gain the trust of users and of the whole society by a step by step approach. However, the transition to general use of CAD may go very fast (compare the adoption of smart phones).

4.10. Policy and regulatory needs, European harmonisation

Ideal scenario 2030

- Harmonised regulation on the TEN-T network as start

Ideal scenario 2050

- Worldwide harmonization
- Dedicated network defined in Europe for (ad hoc) platooning with harmonized rules. Includes/makes possible enforcement on rules for technical working of CAVs
- There is a regulatory basis for reviewing/changing (national) rules to enable deploying CAD services
- Vehicles are self-learning
- There is a social network for cars – so they learn to drive socially acceptable from each other

Challenges

- Front runners – you need them – but their activities lead to differences between countries
- How do we prioritize harmonization, on what locations do we want it?
- Short term legislative enablers may be different within EU in pilot phase
- On what topics do we really need harmonization, and on what topics do we accept differences?
- What is the right forum to discuss this between stakeholders?
- National regulations vs technological needs – not always in line. See cellular coverage (roaming delay when crossing border can technologically be solved but regulations prevent this and that also has its reasons)
- strict and/or challenging rules ? are they hindering or stimulating innovation?
- It's about harmonization + translation of traffic rules towards digital systems (instead of humans) – but traffic will still be mixed
- Ambiguous rules are difficult for digital systems

4.11. Socio-economic assessment and sustainability

The breakout took form as a group discussion around a poster that suggested and listed a few ideal scenarios for years 2030 and 2050, from societal perspectives. Such ideal scenarios for 2030 were, for example, ”shared mobility is widely available as an attractive option” and ”electric vehicles are in common use”.

The group discussion started from possible negative societal impacts of CAD. Some of these impacts have already been speculated in press, such as the case, where automated vehicles might drive around the city centre, while waiting for their owner, instead of paying for parking. Such behaviour would cause congestion and extra emissions when compared against today. However, there will likely be some impacts that are yet difficult to think up and prepare for. Therefore, the group discussed that continuous monitoring will be needed to identify trends that affect our societies. When negative trends are identified, they need to be compensated and such behaviour regulated.

As a second main topic, the group discussed the rise of shared mobility – and how it might happen differently in city centres vs. rural areas. There could be different business models and levels of service.

- A current trend is that city centres cut down car lanes and build bicycle lanes, instead. Public transport is preferred over passenger cars. Now, what if a private company would be able to offer cheap door-to-door robot-taxi services – would that actually work against current city goals?
- Robot-taxies are sometimes suggested as a cost-effective option for offering mobility services for rural areas; for replacing bus lines that are difficult to keep up financially. The group discussed the realism in this: with at least current technology, robotic cars require accurate and up-to-date maps. Maintaining such accuracy for rural areas seems costly as of now.

As a third highlight, the group discussed how the mobility needs themselves and jobs in transport sector can change: teleconferencing can reduce the need for driving and flying, for example. Bus drivers, if no longer needed for driving or selling tickets, might find themselves offering customer services or even security services for passengers.

Other discussion topics included

- ICT training for the elderly in fast technology transition phases
- Electric bike regulations
- Cyclers are there to stay. They want to feel safe and how AD affects that.
- How electric vehicles cause big changes in infra, e.g. charging networks
- Could premium cars get benefits in traffic, even separate lanes?

As key challenges to reach ideal visions, participants posted the following notes on the poster:

- Social inequality
- Overall cost of mobility
- Model services to match demand better
- Reward sustainable mobility (walking and cycling)
- Electric charging infrastructure + services
- Alignment of trends & stakeholders, e.g. TNCs (transportation network companies) and authorities
- Accessibility – digital divide
- Training in ICT skills (elderly people)
- Different density populations means different solutions => different impact
- Jobs creation/loss?
- Go beyond cons: thinking automated transport

4.12. Safety validation and roadworthiness testing

Ideal scenario 2030

- Harmonised regulation on the TEN-T network as start
- IDEAL: A harmonized European approach that serves as state of the art and a model to other regions
- IDEAL: Harmonized database of scenarios

  - Before 2030 fill up the database → After 2030 update the database
  - Put stakeholders all together ← What are the agreed parameters of the scenarios?
- Simulation
  - Reduce amount of driving kilometers by including other tools i.e. simulation
  - Making models scalable and modular
  - Decomposition of testing
  - One platform vs. several ones
  - Harmonized criteria to validate simulation outcome ← Performance levels need TBD
- Challenges
  - Traffic rules: include a traffic rule based approach →Not just safety scenarios
  - How to deal with unforeseen scenarios?
  - How safe is safe enough? ← We need to accept a certain level of risk as perfect safety does not exist
  - Do we get ODD from scenarios or scenarios from ODD?
  - We need to build trust → Then e.g. we can relax some regulations
  - Only in the long term!!!
  - Data sharing is required for many of the topics
  - What to test?
  - OTA updates / Experienced situations
  - The whole vehicle lifecycle
  - Connectivity, positioning, human factors, cybersecurity should be included

4.13. Consolidation

As last item of the workshop, a short 3 minute pitch was presented by the rapporteurs of each session to summarize the discussions for all workshop participants.

5. Conclusion and next steps

The workshop was attended by 60 participants. The workshop was organised jointly with ERTRAC in preparation of the updated version of the ERTRAC Connected Automated Driving roadmap.

Good discussions were held around both the ERTRAC use cases as well as the ARCADE thematic areas. Both, ERTRAC as well as ARCADE were able to get valuable input for their future work.

ARCADE thematic areas have started investigating key uncertainties blocking fast introduction of CAD, creating negative impact, and resulting scenarios for 2030 – 2050 (from the different angles of the respective themes). Based on the workshop results, the draft scenarios will be refined and consolidated into a roadmap, which will be continuously updated in the course of the project. The workshop results have also been used as input to the new ERTRAC roadmap on Connected and Automated Driving, which should be finalized and presented at the EUCAD 2019 Conference on 2-3 April 2019 in Brussels as well as the ERTRAC annual conference and ARCADE second stakeholder workshop on April 4th. Both events are co-located at the same venue to allow for reciprocity and interconnection between the two.

The second Stakeholder workshop of the Joint CAD Network is organised in conjunction with the EUCAD 2019 conference, co-organised by ARCADE. It will focus on R&I initiatives, European and national, their results, challenges and gaps in the context of ARCADE thematic areas. The purpose is to identify future research needs as well as areas of mutual interest for collaboration between the projects.

Annex – Participating organisations

5GAA	Belgium
AIT Austrian Institute of Technology	Austria
AKKA Technologies	Belgium
AlbrechtConsult	Germany
Applus IDIADA	Spain
Aptiv	Germany
ASFINAG / CEDR / ERTRAC	Austria
AustriaTech	Austria
AVL List GmbH	Austria
Cidaut Foundation	Spain
CLEPA	BE
Denso Automotive Deutschland GmbH	Germany
DLR	Germany
Dynniq	Netherlands
ERTICO - ITS Europe	Belgium
ERTRAC	Belgium
European Commission DGCONNECT.H5	Belgium
European Commission Stria Rapporteur - Urban Mobility	Belgium
FEV Europe GmbH	Germany
FIA	Belgium
Globalvia	Spain
HiTec	Austria
IFP Energies nouvelles	France
Institute of Communication & Computer Systems (ICCS)	Greece
IRU Projects	Belgium
LAB	France
Luxinnovation	Luxemburg
MAP traffic management	Netherlands
Polis	Belgium
RDW	Netherlands
Rijkswaterstaat	Netherlands
Robert Bosch GmbH	Germany
RWTH Aachen University (ika)	Germany
TNO	Netherlands
Trinity College Dublin	Ireland
TU Eindhoven	Netherlands
Union Internationale des Transports Publics - UITP	Belgium
University of Leeds	UK
VEDECOM	France
Volkswagen	Germany
Volvo Group Trucks Technology	Sweden
VTT Technical Research Centre of Finland Ltd.	Finland