connected automated driving.eu

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SOCIETAL CHALLENGES – SMART, GREEN AND INTEGRATED TRANSPORT

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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 Project concertation workshop

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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 more than 60 consortium and associated partners from 22 EU and non-EU member states, who form the basis of the joint CAD network of experts and stakeholders established by CARTRE. The Joint Network is composed of organisations from the public, industry and research sectors, 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 2nd stakeholder workshop of ARCADE Joint CAD Network. The workshop was held on April 4, 2019 in Brussels, Belgium (La Chaufferie).

ARCADE thematic areas[1] have started investigating key uncertainties blocking fast introduction of CAD, creating negative impact, and resulting scenarios for 2030 – 2050. A first

[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.

workshop[2] was held February 5-6, 2019 to solidify the findings for three categories of use-cases (passenger car, freight vehicles and urban mobility vehicles).

This second Stakeholder workshop[3] of the Joint CAD Network focused on ART R&I initiatives results, challenges and gaps in the context of ARCADE thematic areas. The purpose was to identify future research needs as well as areas of mutual interest for collaboration between the projects.

[2] https://connectedautomateddriving.eu/mediaroom/arcade-ertrac-workshop-on-connectivity-and-automated-driving/

[3] https://connectedautomateddriving.eu/mediaroom/cad-network-stakeholder-workshop/

2. Final agenda

09:00 Stakeholder Workshop introduction

- Objectives of the workshop
- Presentation by INEA / EC (Recent policies, R&I)
- ARCADE Introduction
- ERTRAC roadmap & ARCADE roadmap overview

10:00 Coffee break and projects "speed-dating"

3 slides per project are displayed as "posters" in the meeting room for participants to find out more and engage with projects representatives present for more details

10:45 Thematic areas overview

Introduction of the scenarios per thematic areas cluster and of participating projects main related contributions (according to projects mapping prepared ahead)

- Society & Users
- Systems & Services
- Technology & Vehicles

12:00 Lunch break

13:00 Interactive workshop, parallel breakout sessions for projects contribution to the thematic areas

Session 1: Society & Users

- Human Factors
- User awareness, users and societal acceptance and ethics, driver training
- Policy and regulatory needs, European harmonisation
- Socio-economic assessment and sustainability

Session 2: Systems & Services

- New mobility services, shared economy and business models
- Freight & Logistics
- Big data, artificial intelligence and their applications
- Physical and Digital Infrastructure including Connectivity

Session 3: Technology & Vehicles

- In-vehicle technology enablers
- Connectivity
- Safety validation and roadworthiness testing
- Deployment

17:00 Wrap-up and Conclusions

- Identified Gaps & Overlaps
- Next steps and workshops

17:30: Meeting close

3. Introductions

The 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 and the objectives of the workshop. He also briefly introduced the projects involved. (All presentations are available from: https://connectedautomateddriving.eu/mediaroom/cad-network-stakeholder-workshop/).

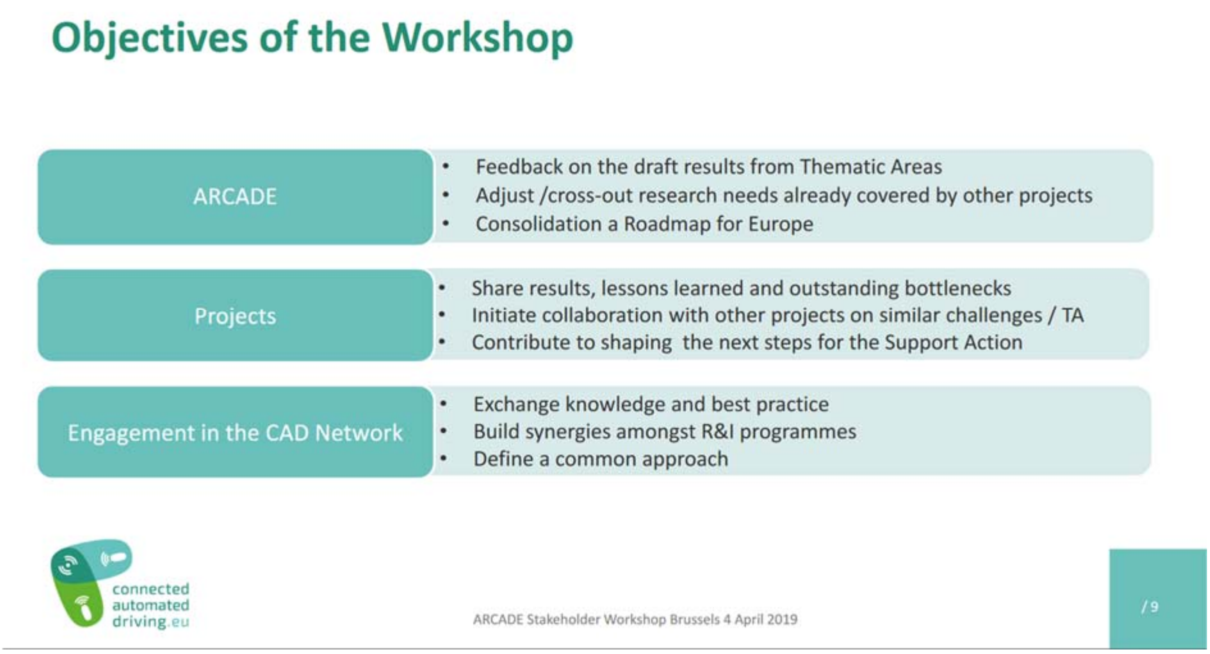

Figure 1: Objectives of the workshop as presented during the session

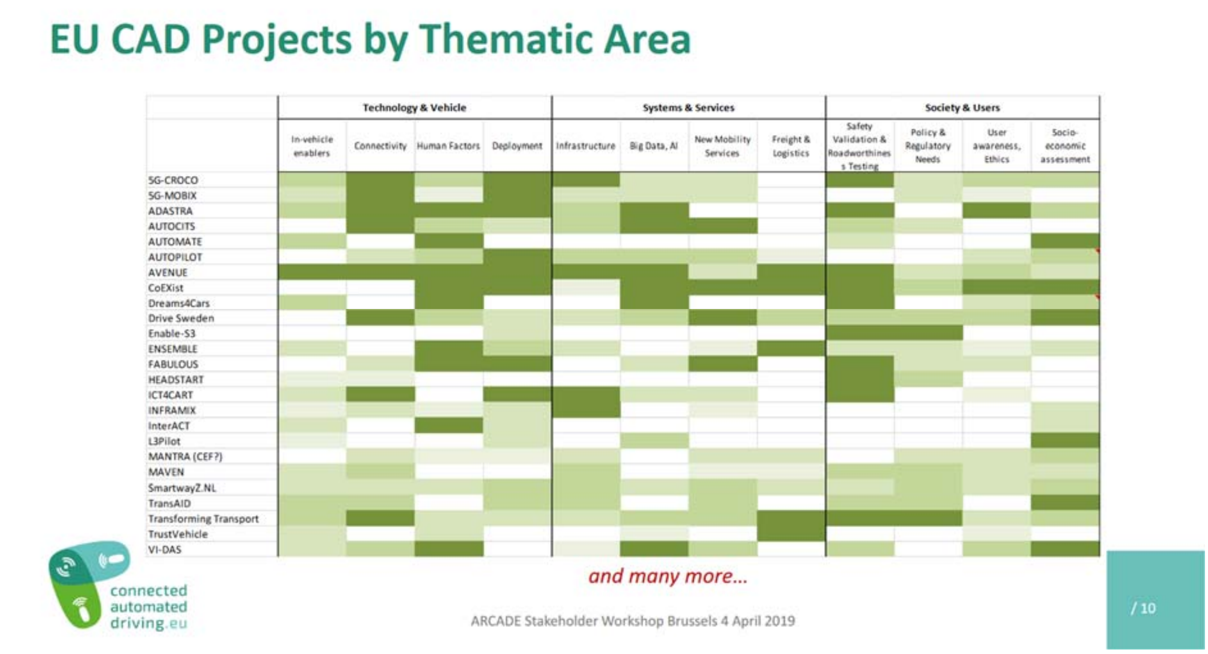

Figure 2 Relevant projects introduced in the workshop

Tom Alkim of DG Research & Innovation introduced the Roadmap on Connected and Automated Transport, the European platform on large scale testing and the Expert group on ethical issues raised by CAD. He introduced a number of projects from the 2018 call and ongoing and planned large scale pilots.

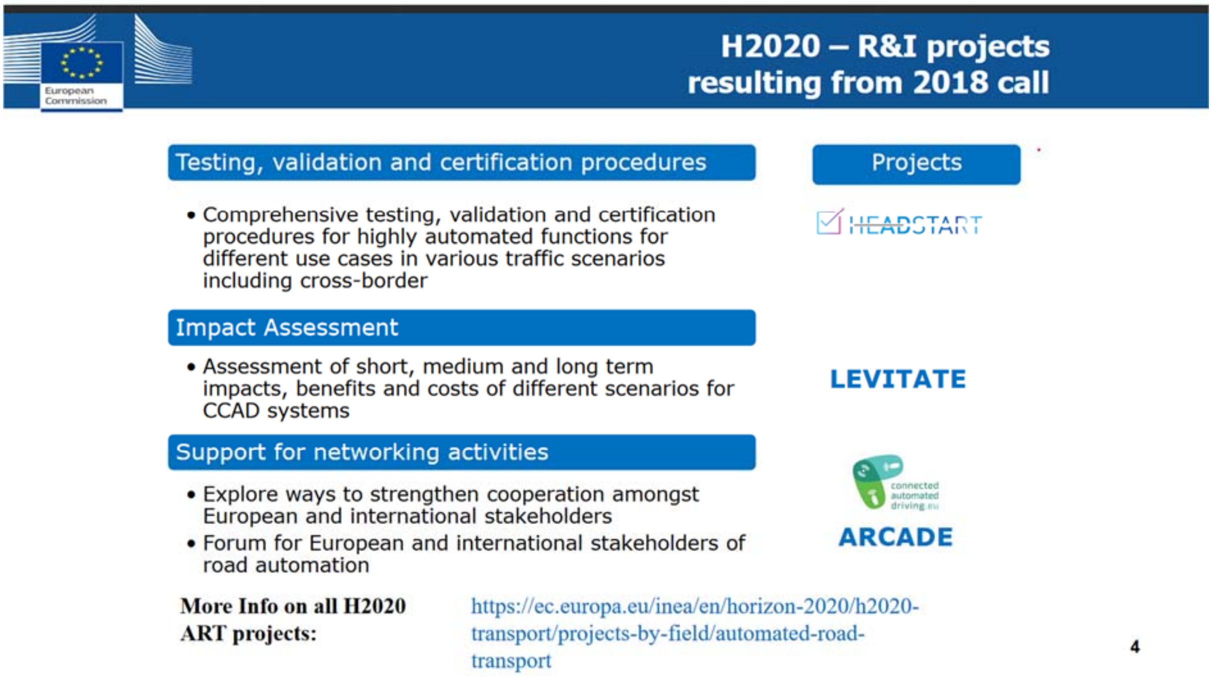

Figure 3: Projects from H2020 ART 2018 call

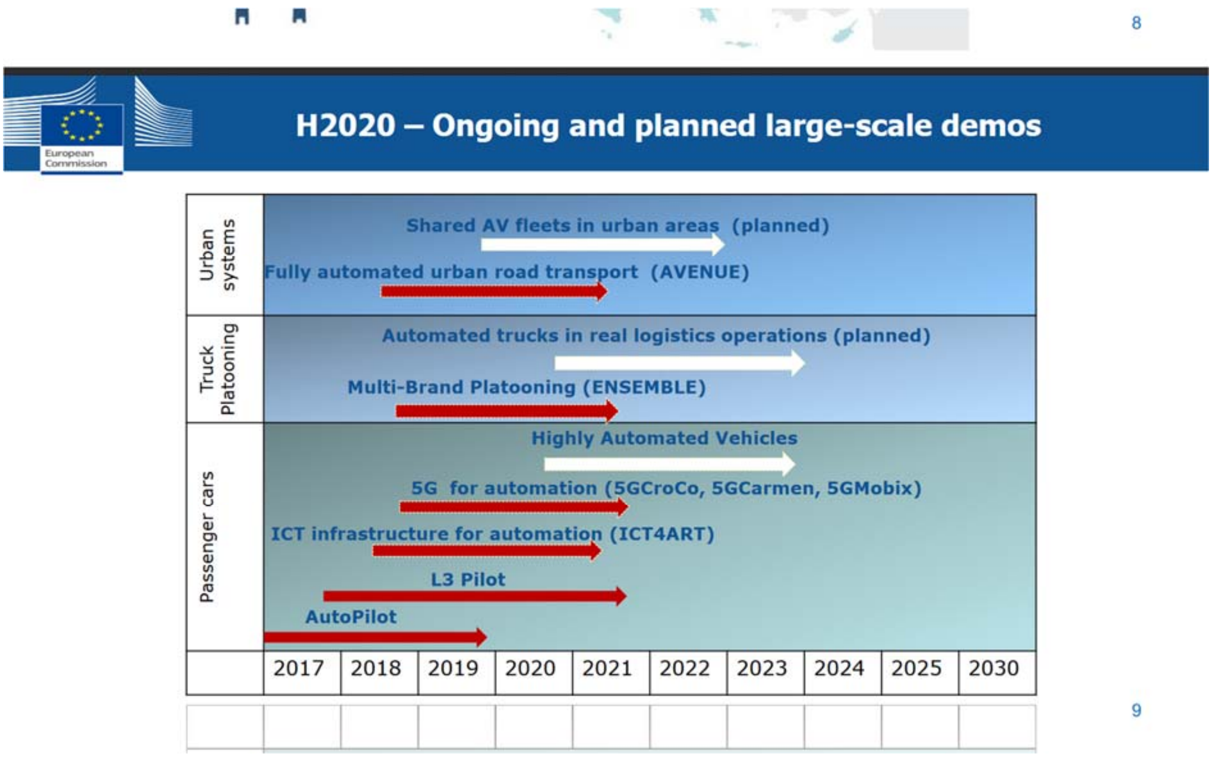

Figure 4 Large scale pilots in H2020 ART program

Project officer Georgios SARROS of INEA –Horizon 2020 Transport Unit introduced the most relevant projects in a large overview, organised by research topic (the full presentation is available on the CAD website). He also introduced projects and initiatives besides H2020.

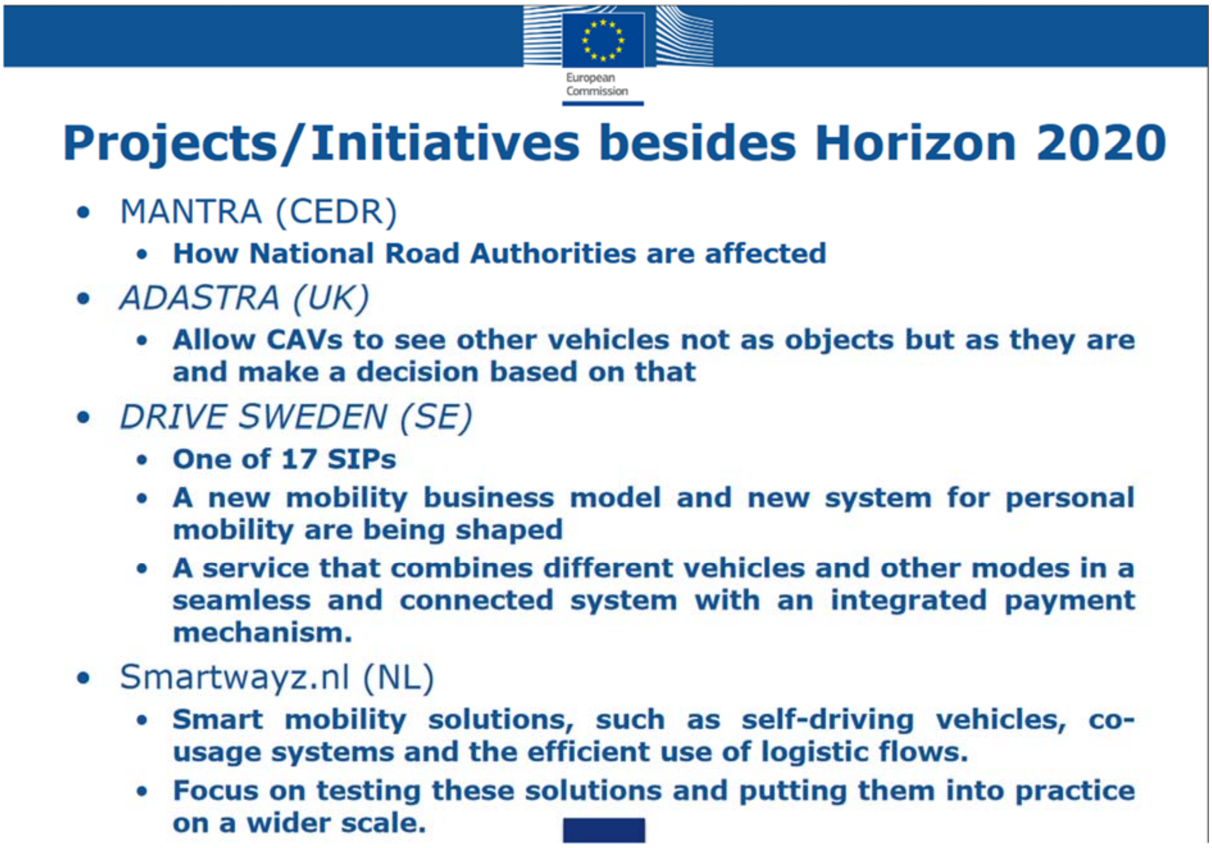

Figure 5 Project/initiatives besides Horizon 2020 (partial)

Mats Rosenquist (ERTRAC, Volvo) then introduced the ERTRAC roadmap[4] version 8 and the ARCADE roadmap outline supporting that.

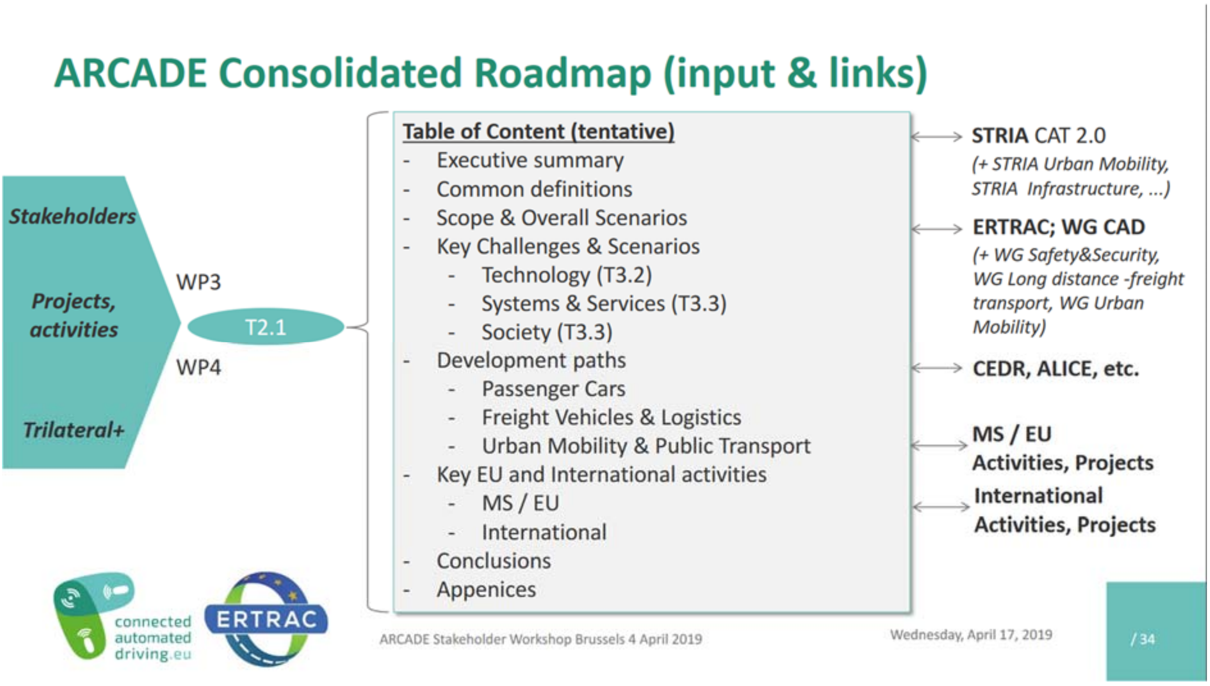

Figure 6 ARCADE consolidated roadmap outline

He also introduced the ISAD levels of infrastructure support for CAD which works together with the vehicle ODD (operational design domain).

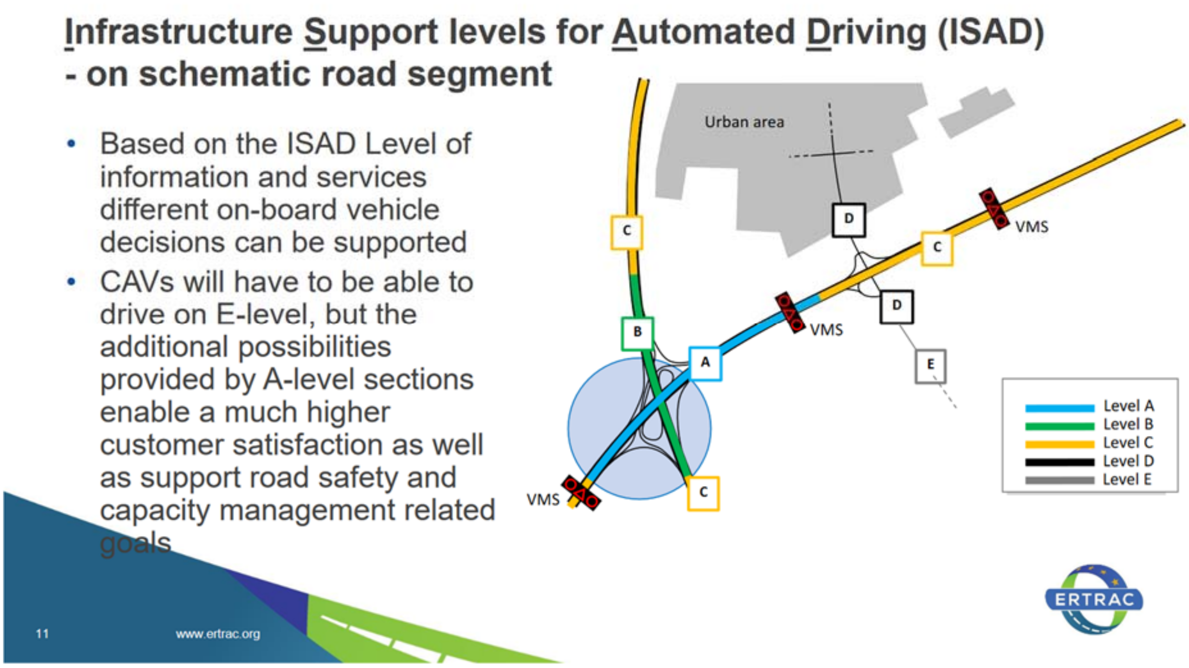

Figure 7 Infrastructure Support levels for Automated Driving (ISAD)

[4] https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf

4. R&I project speed dating

Using 3 slides per project, the relevant EU projects were shown during the coffee break and participants could approach the project representatives to identify synergies.

Takahiko Uchimura of ITS Japan introduced Japanese projects[5], challenges and Japanese conditions for CAD vehicle types and automation levels. He also introduced various Japanese FOTs.

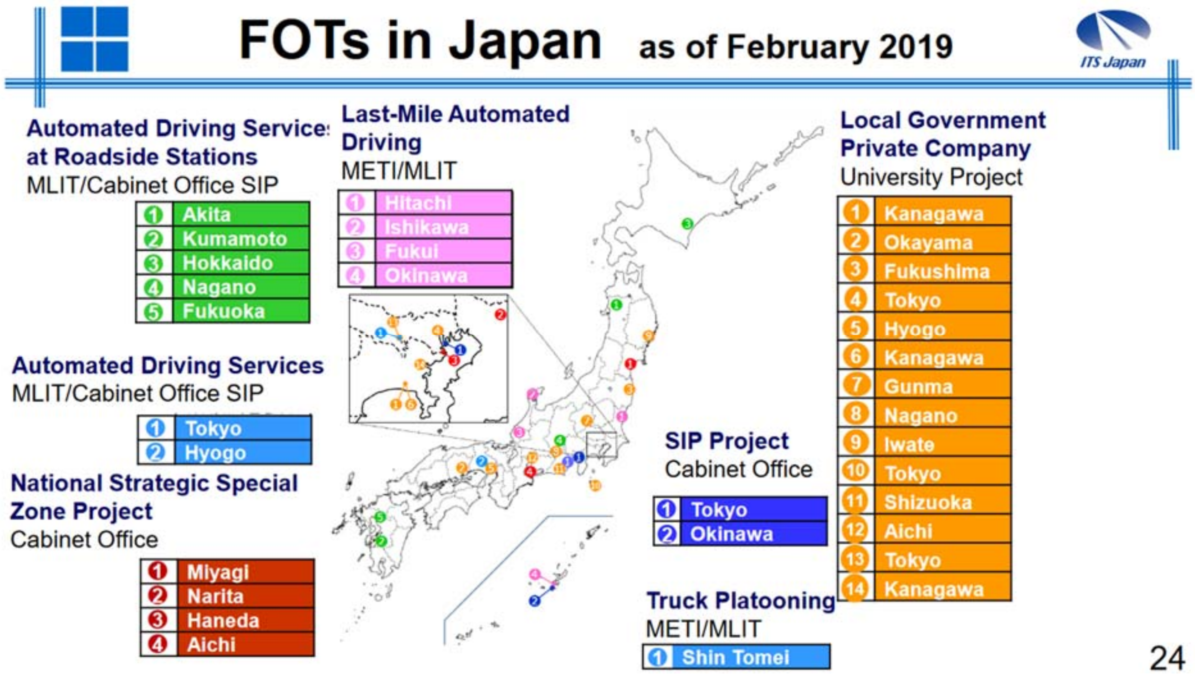

Figure 8 Field operational tests in Japan

5 https://connectedautomateddriving.eu/wp-content/uploads/2019/04/5.-ARCADE_WS_EUCAD2019_JP_Uchimura.pdf

Kevin Dopart (ITS USA, US DoT) presented two projects as examples of the US DoT cooperative automation research program[6]: CARMA and Cooperative Automation Taxonomy.

Figure 9 Use cases within CARMA project

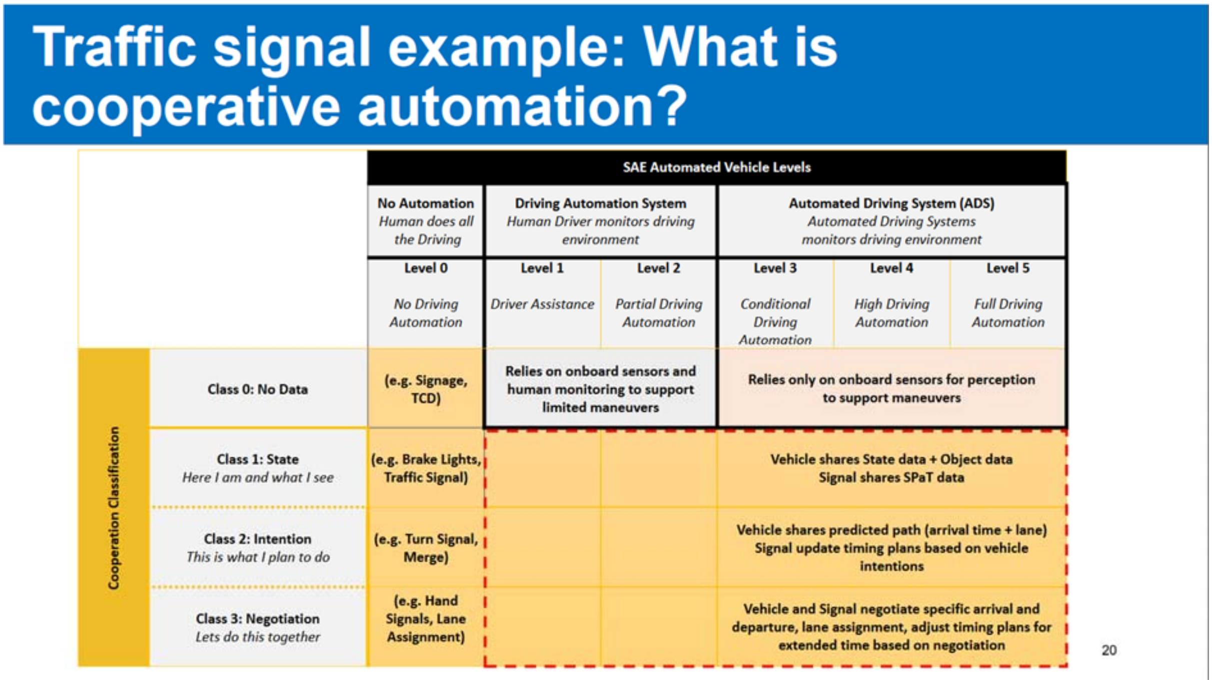

Figure 10 Cooperative automotion taxonomy applied to traffic signal

[6] https://connectedautomateddriving.eu/wp-content/uploads/2019/04/6.-ARCADE_WS_EUCAD2019_US_Dopart_public2.pdf

5. Interactive workshop for project contributions to the thematic areas

Three clusters of thematic areas were introduced and discussed in parallel sessions:

Session 1: Society & Users (Yvonne Barnard, University of Leeds & Carlo Giro, IRU)[7]

- Human Factors
- User awareness, users and societal acceptance and ethics, driver training
- Policy and regulatory needs, European harmonisation
- Socio-economic assessment and sustainability

Session 2: Systems & Services (Guido Di Pasquale, UITP & Nadege Faul, Vedecom)[8]

- New mobility services, shared economy and business models
- Freight & Logistics
- Big data, artificial intelligence and their applications
- Physical and Digital Infrastructure including Connectivity

Session 3: Technology & Vehicles (Julien Bou, Bosch)[9]

- In-vehicle technology enablers
- Connectivity
- Safety validation and roadworthiness testing
- Deployment

The following sections will discuss the session results in detail.

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[7] https://connectedautomateddriving.eu/wp-content/uploads/2019/04/7.-20190404_ARCADE_Stakeholder-workshop-Task-3.4.pdf

[8] https://connectedautomateddriving.eu/wp-content/uploads/2019/04/8.-20190404_ARCADE_Stakeholder-workshop-Task-3.3.pdf

[9] https://connectedautomateddriving.eu/wp-content/uploads/2019/04/9.-20190404_ARCADE_Stakeholder-workshop-Task-3.2.pdf

5.1. Society & Users

5.1.1. Scenarios developed in ARCADE

The ARCADE Thematic Area leaders kicked off the discussion by describing key enablers and challenges related to the 2030 and 2050 scenarios that were previously presented.

On the **regulatory** side, it was highlighted that national regulations and technological needs are not always in line leading to potential fragmentation. As a result, there should be clarity in terms of interpreting the rules (liability and traffic rules) as digital systems need them to operate safely and efficiently. In addition, questions were raised regarding the definition of ODDs and what can be done by vehicle manufacturers and authorities to address this issue.

Moreover, **safety validation** was addressed and the challenge of how it will be clear that what is placed on the market is safe and secure. A key enabler is validating AI and ensuring that it reacts according to the type of traffic it encounters. Lastly, cybersecurity, safety methods, standards and functional safety were all presented as enablers in order to achieve user **acceptance**.

Socio-economically, there is still a lack of knowledge on how CAD will **impact** the daily lives of users, especially the indirect and long-term impacts are difficult to assess. A key enabler is to define a **multi-dimensional evaluation methodology** to clarify what added value CAD will bring on a socio-economic level.

Lastly, **users** expect an increasing level of safety from the deployment of CAVs. Users want clarity on liability and only once a clear framework is defined then it will ultimately lead to building **trust**. Furthermore, involving users and citizens is key in order to obtain significant feedback.

The scenarios proposed were situated in 2030 and 2050:

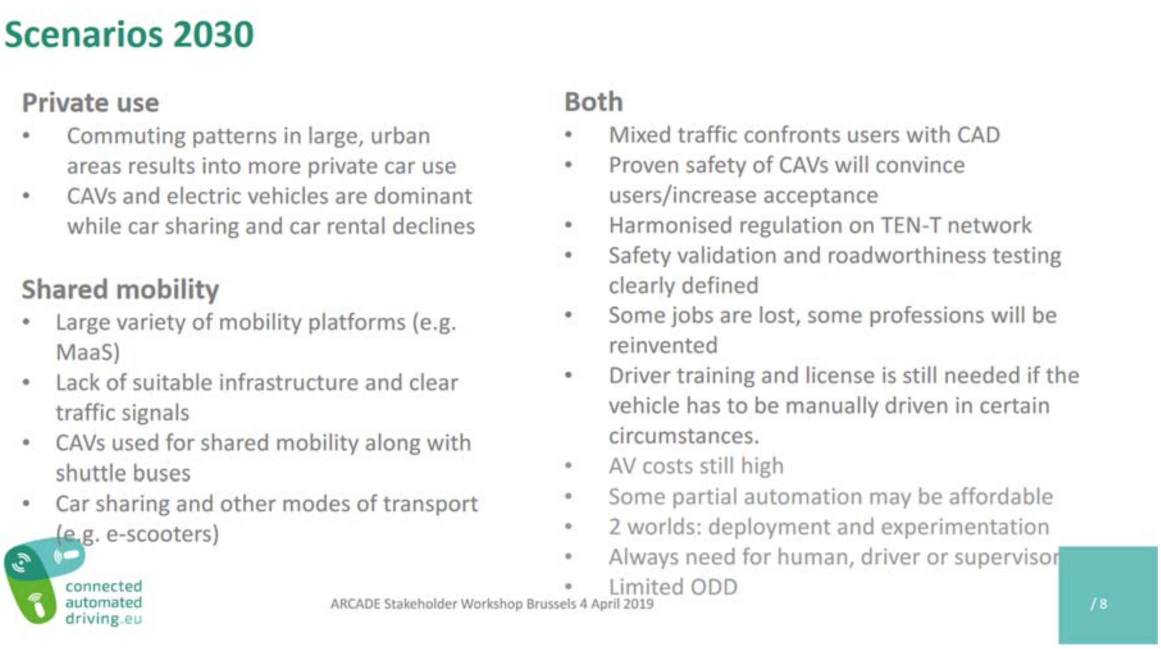

Figure 11 Scenarios for 2030

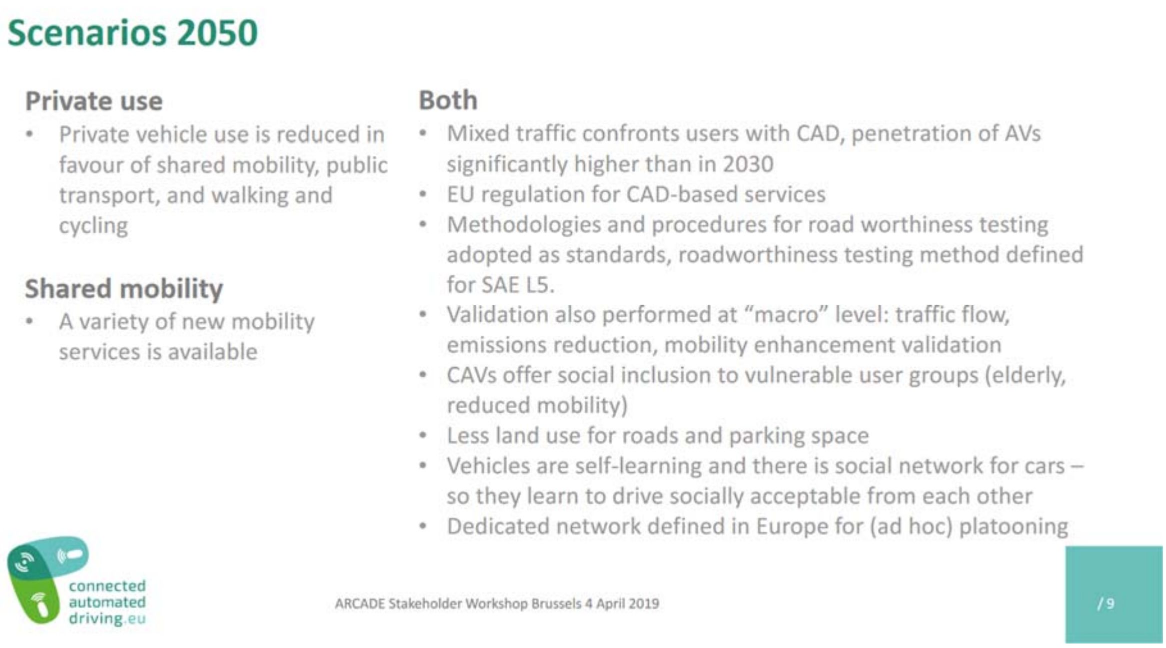

Figure 12 Scenarios for 2050

5.1.2. Participant feedback on the ARCADE proposed scenarios for 2030 and 2050:

The following elements are missing:

- Local authorities and their role (difficult to proceed without them)
- Local transport planning
- Access vehicle design standards
- Distinguishing between local policies and highway code
- Difference between use and ownership
- Congestion taxes

Validation and the billion km problem are technological problems, not a society and users' problem

5.1.3. Discussion on main challenges and enablers

The floor was opened to participants to highlight the challenges and enablers that arise from the introduction of CAD.

Challenges

Various challenges were raised during the discussion.

- The coexistence between vehicles that are automated and not automated and vehicles that have different levels of automation.
- Trust and user acceptance were addressed the most with concerns related to trusting AI and liability. It is necessary to build a user-centred approach in order to build trust progressively, ensure acceptance and feeling of safety perceived by the driver or passenger.
- In particular, non-verbal communication between CAVs and vulnerable road users was raised as an issue.
- Moreover, it will be challenging to frame CAVs as an attractive solution answering societal needs by providing workable business models. Local authorities will therefore have an important role in determining the efficiency of CAVs by allowing shared mobility and reorganisation of public spaces.
- In terms of regulation, national rules could risk hindering technology advances. At the same time, a further challenge is to ensure faster access to automation to the public.

From a socio-economic point of view, impacts are dependent, not only on technological solutions but also on political decisions and of public acceptance. Impacts will be different for different regions and for different persons.

Enablers

For CAD to be embedded into society and accepted by users, policymakers have to translate public policy into machine-readable, digital information that can be used to feed algorithms. This is interlinked with the need for policies and legal rules that shift liability from the driver to the system. Local/municipal traffic management and regulation will determine how sustainability benefits can be achieved.

On the technical side, standards should be designed for inclusive mobility. Consequently, these can be used by authorities to proactively promote local policies to reduce congestion, improve safety and enhance social inclusion. New generations will be more open to adopt the CAD ecosystem in their habitual travel behaviour.

Cooperation between industry, service providers and authorities

To understand what other projects and stakeholders are working on and the cooperation that they have with the industry, service providers and authorities, the discussion shifted to a roundtable in order to gather some insights. A representative from the 5GCroCo project stressed that it is challenging to get in contact with authorities when testing in cross-border corridors and wider testing. It varies country by country and EU Member State road authorities have competences that are different from one another. In addition, a representative from the CoExist project claimed that without cooperation between relevant players, it will be difficult to achieve an AV-ready public authority framework. In general terms, it was noted that city authorities are usually not engaged or not ready. A representative from the city of Helmond pointed out that it is challenging to engage with other cities as they lack to identify the benefits that CAVs could bring. It was also mentioned that traffic lights and speed limits on every road have to be digital. This was followed up by the thought that there will be different impacts in different geographical areas and vary per region. Some regions do not have a congestion problem and then CAD would target another aspect such as a lack of modal share.

Representatives from overseas such as Japan stressed that technology is a tool to deliver something and is not a goal. It was also claimed that in Japan each region has a specific need given their diverse environment and surrounding. In the US, motivation varies when it comes to working with CAD in local communities. Some are progressing and show their openness and are interested in future trends. In Australia, the central government nominated a contact person responsible for CAD which is contacted by interested stakeholders. There is a predominant focus on carrying out tests in rural areas. The city of Helmond stressed that authorities should make an inventory of the challenges they face and then assess what CAD can solve. It is necessary to communicate to cities and better prepare them also taking into account transparency about the risks associated with the technology and its implementation.

Recommendations by the participants:

An element that stood out from the discussion is making sure that communication is clear towards government authorities and the general public. Experts should also communicate about the advantages of CAD in a clear manner in order for local authorities to then raise awareness among the general public. Inventories should be drawn up to identify the needs and challenges that cities face and how CAD can address them. Communication on CAD should also be done at an international level so that messages can be aligned and consistent. Consequently, negative communication by the media was regarded as being troublesome. Important to involve citizens in public debates and not leave it to the media.

An additional way to raise awareness that was addressed by participants is to create general guidelines at EU and national level and empower local initiatives to have a say, review and synthesise. In Japan for example, there are numerous governmental bodies which have a say on the implementation. These include one national government, 47 prefectural governments and 1741 local municipal governments. To successfully introduce CAD on a large scale, the real needs and demands of ODDs have to be addressed and finding out real, workable sustainable business cases or business models. In addition, how and where CAVs are deployed will be of key importance.

Cooperation between similar (local) projects which aim to answering similar needs should be fostered more. Also projects should be working on identified common challenges and clarify the values and benefits of CAVs.

Promoting successful cases could lead to a creation of templates for CAD implementation. Cities and other stakeholders should set up single information contact points for CAD as this will result into being more efficient than dialoguing with many partners. Cities should also map classify the road status, with respect to availability to use L3, L4 and L5 vehicles (e.g. Graz in Austria).

An additional point that was raised is that automated public transport should have higher priority over automated passenger car to enhance deployment.

Thematic Area: Policy and regulation (Renault, RWS)

RWS shortly introduced the thematic area and its sub-themes. Participants were given several minutes to think about this thematic area and write down their ideas on post-it notes into the following framework:

Sub themes / categories:	What are you doing already?	Challenges & questions	Lessons learnt
Type approval	1	2	3
Political process & policy	4	5	6
Traffic regulations	7	8	9
International harmonisation	10	11	

The following input was received from different projects by means of a questionnaire filled in before the workshop:

Cell 1 (Type Approval – What are you doing already)

- Selection of real-world scenarios for virtual validation with defined coverage metrics *Enable S3*
- Development of driver's license for self-driving cars *The Netherlands*
- Truck platooning exemptions *ENSEMBLE*
- Running pilots in different countries on L2 systems *L3Pilot*
- Virtual homologation/validation of simulated model for virtual validation *Enable S3, TUV-AVL etc*
- Creation of an expert group on type-approval *HEADSTART*
- Tyre pressure of trucks / build ecosystem to give information to transport companies in order to prevent accidents/PCP for making public traffic management schemes (from May 2019) /how to digitalise in a way that serves service providers use it *Smartwayz, The Netherlands*

Cell 2 (Type Approval – Challenges and Questions)

- How to make safety assurances in a cost-effective way that fits current and future UNECE procedures and needs
- Differentiate between type-approval and allowing to test on open roads
- Type approval is mostly done by private companies like TUV/ how to motivate them to join projects? Extra funding? Obligation by government? Very attractive sub contract?
- Permission of AVs on open roads for pilots was solved locally. Would be better to have (inter)national regulations

Cell 3 (Type Approval – Lessons learned)

- Take into account all possible scenarios in ODD including weather conditions, degradation of sensors, security in vehicle homologation
- Necessary to have stable regulations L3Pilot
- Combination of real-world validation & virtual validation needed JRC-EC technical *working group*

Cell 4 (Political process & policy – What are you doing already)

- Formulation of requirements towards CAVs for them to contribute to transport policy objectives/screening CAD scenarios for compatibility with existing policy *Vienna/AT*

Cell 5 (Political process & policy – Challenges and Questions)

- Driver vs. system responsibility
- Framework around use of data

Cell 6 (Political process & policy – Lessons learned)

- It is not clear which CAD technology will emerge as successful. Currently it is very challenging to define regulatory needs (or policy positions) *Vienna/AT*
- Political processes will lead to a rapid advancement

Cell 7 (Traffic regulations & policy – What are you doing already)

- Framework for requirements on public infrastructure data *The Netherlands*
- Instructions to test CAD prototypes on open roads have been available since 2015 *DGT-Spanish road authority*

Cell 8 (Traffic regulations & policy – Challenges and Questions)

- Local traffic regulation rule not yet present in Japan
- Difficult to define traffic regulations as long as technology services/behaviour effects are not clear
- Public authorities must better support real-life testing on open roads

Cell 9 (Traffic regulations & policy – Lessons learned)

- Licence exemption *ETPC project*

Cell 10 (International harmonisation – What are you doing already)

- C-ITS standards in the C-Roads platform
- Work at trilateral level/feedback to UNECE *HEADSTART*

Cell 11 (International harmonisation – Challenges and Questions)

- Digital maps are not ready and may jeopardise CAD
- Standardised road infrastructure needs to set the basis for CAD

Additional input by participants:
Work is being carried out at UNECE level (WP.1 and WP.29) to define international harmonisation of regulation. Contracting parties implement what is being developed at the UNECE into national legislation. WP.1 is developing standards for type approval which Australia for example follows closely. Moreover, Australia's National Transport Commission ran a project that investigated what problems road rules create for the deployment of CAVs.

Participants noted that driver vs. system responsibility remains one of the biggest challenges. After a take-over, the system must be responsible while for OTA updates, the driver must be aware of the novelties of the update. In addition, regulation is lagging behind, and results being obtained with pilots cannot be put into use. There is a need for a stable type approval system. For example, in L3Pilot, regulations in countries are changing and getting test vehicles on the road may be affected by such changes. In the future it is important to have mutual recognition for the same basic rules for testing on the road.

Lastly, it was highlighted that society allows inexperienced (new) drivers to drive since there is a general intuition that the driver will become more experienced. Participants said that society accepts a higher temporary risk and the question was raised if the same could be allowed with CAVs. Professional drivers also have to re-do their driving tests regularly.

Thematic Area: Safety validation & roadworthiness testing (IDIADA, RDW)

Testing and (safety) validation takes place with different frameworks and different scenarios. A compilation of the common grounds and differences for the projects present is provided below.

1. Projects that are testing different scenarios
   - ODD specific: tunnels, platooning, highways, urban driving, valet parking, obstacle/VRU detection *AUTOPILOT, L3Pilot, ENSEMBLE*
   - User tests *L3PILOT, HEADSTART*
   - Specific and standards for scenarios, database for real world scenarios, test planning tool to create scenarios segment for ODD and ADAS function *Enable S3*

2. Projects that are virtually testing scenarios
   - Methodology, *HEADSTART*
   - Simulation is not being carried out *5GCroCo*
   - Sensor stimulus for combined virtual/real AD-vehicle testing (Radar, video, GPS, steering) *Enable S3*
   - Framework for virtual validation tools (standard proposals for architecture and interfaces) *ENABLE S3*
   - Virtual validation under adverse weather conditions *RobustSENSE*
   - Sensor model validation and development *SENSE*
   - Brainstorming a driving licence for self-driving cars *The Netherlands*

- Trustworthiness assessment of data driven service operators

3. Projects carrying out test track testing
   - *AstaZero (Sweden)*
   - *UTAC CERAM (France)*
   - Montlhéry (test track) *5GCroCo*
   - *AUTOPILOT*

4. Projects carrying out tests on open roads
   - Public road L2/L3 tests, problems encountered with driver responsibility *L3Pilot*
   - Strategic innovation program – SIP ADUS, OEMs and some universities in limited areas in Japan
   - European cross-border corridor along France, Germany and Luxembourg, Munich city centre, German A9 Highway, city of Barcelona *5GCroCo*
   - FOT-NET Data: Field Operational Test Networking and Data Sharing Support →FESTA handbook
   - Other: ASAM (Association for Standardization of Automation and Measuring Systems), non-profit organization that promotes standardization for tool chains in automotive development and testing. https://www.asam.net/about-asam/our-vision/

Driver behaviour impacts (VTT)

VTT gave a brief introduction on challenges related to measurement of driving or driver and driving behaviour impacts. Specifically, those were the non-maturity of prototype phase of the automated vehicles with which the tests are being made and the small penetration rate of automated vehicles in the traffic. The participants were asked to propose solutions how to overcome these challenges.

Participants identified two solutions related to driver behaviour impacts: testing on prototypes and the interaction between drivers in cars and automated vehicles. Best practices and key enablers included driving simulators giving a better experience of how the vehicle will behave and how do drivers adapt their behaviour when an automated vehicle enters traffic – CAVs need to blend in and act as ‘normal cars’. Since systems are not mature, questions have to be asked about ideal systems.

For example, how would the system handle adverse weather conditions and Wizard of Oz vehicles may be one solution with a safety driver actually taking over instead of the ADAS. Driving simulators may help encounter more difficult situations and give a better experience of how the vehicle could behave. Despite this, current tests are for short (e.g. 20 minute) periods.

The discussion was concluded by stating that multiple methods are still needed: naturalistic, simulators, Wizard of Oz and many others and that one needs to understand the strengths and weaknesses of different methods. A strong recommendation was also given to the analysts to be honest in what can and cannot be measured meaningfully.

Conclusion

Participants concluded that they welcomed the initiative to gather projects on CAD in order to share opinions and views. They reiterated that sharing tangible results would be ideal and to build relations between the different CAD projects. The role of the CAD Knowledge Base was identified as being of extreme importance. Updating and keeping information easily accessible will facilitate knowledge sharing between stakeholders. ARCADE can help by providing knowledge of regulations at national level given the difficulty encountered to perform tests. It was also highlighted that ARCADE can facilitate dialogue with national authorities and compile best practices and guidelines to make it easier to get in touch with the relevant players. Participants asked ARCADE to take lead on establishing an expert taskforce on functional safety and harmonising KPIs so that projects can refer to them. Lastly, partners from Japan reiterated the importance of international collaboration and ensuring that novelties are made communicated.

5.2.System and Services

5.2.1. Introduction of Task 3.3

Systems and services will follow a continuous path of development, facing technological, governance, policy and business challenges to provide the conditions for deployment of CAD vehicles at the right time, and with the right level of reliability.

Successful deployment of automated vehicles will rely on the ability to align the different roadmaps in a coordinate and efficient effort.

Task 3.3 is understood in this context to consist of 4 Thematic areas:

- **Physical and Digital Infrastructure**: The adaptation of physical infrastructure and its link with the digital infrastructure is becoming a key factor for the deployment of connected and automated vehicles of higher levels of automation. It may be defined as “the digital representation of road environment required by Automated Driving Systems, C-ITS and Advanced Road/Traffic Management System”.

- **New mobility services**: electrification, connectivity, automation and sharing vehicles are key enablers to address new challenges, such as accessibility, safety, security, impact on environment, quality of public transport, increasing demand, need for additional funding and cost sharing models.

- **Data and Artificial Intelligence**: Sensors of Connected and Automated Driving systems continuously produce Big traffic Data. In addition, data is gathered from road infrastructure sensors, such as cameras.

- **Freight and logistics**: Automated freight transport technologies has the potential to address some of challenges that are related to the increase of demand, driver shortage and freight transport utilization. Automation may also re-shape the future of road freight transport with considerable potential for new freight transport patterns as well as organisational structures, processes and business models.

5.2.2. Scenarios 2030/2050

Physical and Digital Infrastructure (PDI)

Scenario 2030

- Fully HD Map coverage in Europe for static map database

- Complete Connectivity in terms of dynamic and semi-dynamic data to support vehicle automation

- A virtual representation of most traffic signs is available, Smart road elements for localisation and guiding the automated vehicles are installed at dedicated points
- Virtual signs for pedestrians
- Tactical information (supporting automated vehicle manoeuvres by local online data in real-time) is provided at strategic and tactical important locations and stretches (at the high-level road network but also in cities)
- LDM (Local Dynamic Map, distributed locally in real-time including high precise dynamic objects) is available at certain positions (e.g. intersections, merging situations, etc.)
- Solutions for Augmented GNSS (replacing satellite-based solutions by a local high precise and reliable solution, e.g. by pseudo satellites) are available
- New measures are used for traffic management: Interactions with vehicles on tactical level as described above but also strategic interactions with other operators (road, public transport, but also with fleet operators and providers of MaaS)
- The role of road operators as part of the ecosystem: New meta-operators.

Scenario 2050

- All traffic signs & road markings are available virtual (but at least for pedestrians' physical signs have to be available) and are connected to traffic participants by common solutions of connectivity
- Automatic self-organization of manoeuvres is established between all types of vehicles and manufacturers
- In case of complex and operator-owned intersections a local management services takes over control of vehicles

Additions and comments from EUCAD BO Workshop

- **The order of implementation** is important and should be realistic: First traffic flows real-time reporting and analysis, then building HD maps of the environment, and finally reporting tactical information (e.g. trip travel information, fleet management, dynamic route guidance, etc.).

  Traffic flows => HD Maps => Tactical Information
- **Virtual signs for pedestrians**: Pedestrians should not be ignored. They are a crucial part of the smart ecosystem. A digital infrastructure which is addressed to pedestrians, in interaction with connected vehicles, is important.
- **Augmented GNSS**: A single positioning technology is not sufficient for automated driving. It lacks necessary accuracy and robustness for safety critical applications. The adoption of the GNSS represents an unprecedented innovation backed by the important economic benefits and the contribution to improve the safety especially in low densely populated areas where human errors may be fatal. However, given that the positioning accuracy of standalone GNSSs is of the order of a few meters, it is

important to make use of augmentation systems and differential techniques to drive the accuracy down as low as a couple of meters and maximize continuity and integrity. The augmented GNSS would thus provide real-time corrections and high integrity for GNSS receivers. They will replace satellite-based solutions by a local high precise and reliable solution, e.g. by pseudo satellites

- **Local Dynamic Map (LDM)**: It provides the cars with centimetre accurate references to all geographic objects in its surrounding. In addition, these maps should be dynamic, constantly provided with updates from a remote server. Thus, LDM enables driving capabilities of the automated vehicle in terms of safety and comfort for the passengers that could not be obtained while only relying on the cars own inbuilt sensor equipment.

New mobility services (NMS)

Scenario 2030

- User acceptance, operation and business models understood
- Opensource platform being deployed
- CAD services based on shared data, using dedicated infrastructure, accessible by persons with reduced mobility
- The emergence of new players, meta-operators (mobility integrators).
- Federated platforms instead of open data platforms
- New services to passengers
- Business model will be used to be technology neutral
- Business model will depend on new technology
- Solution for both goods delivering and mobility needs at the same time: Mobility hubs
- Agile planning

Scenario 2050

- Services deployed in all contexts, including rural areas
- Integration in the multimodal universe, single access for ticketing across Europe
- Integration into urban planning finalized

Additions and comments from EUCAD BO Workshop

- **New players: meta-operators or mobility integrators**: The upsurge of new shared mobility services and the development of the urban mobility landscape have led to the emergence of MaaS (Mobility as a Service), as a concept that helps users, given all existing options, to find the most suitable mobility solution. However, this role is strategic. In fact, the core business is formed by multiple transport operators, who trade their capacity to MaaS operators and provide access to their data and application programming interface (APIs). Although many MaaS initiatives are currently being built at a local level (e.g. Mobility Inside initiative in Germany), we observe also the emergence of national and even global MaaS platforms (Google Maps, Free2Move).

- **Federated platforms instead of open data platforms**: Since mobility resources are owned and managed by different mobility providers, we argue that the economic model of MaaS markets could not be based on open data platforms. In fact, one would hardly expect that an operator would accept to share his data with its competitors without pre-defined rules. Then, it is argued that the the MaaS markets will be led by federations of providers, each trading its mobility resources. In such a federated market, MaaS operators dynamically partner with each other whilst preserving their individual autonomy and without a centralised regulation authority.

- **New services to passengers**: Thanks to autonomous cars, people will have more free time while traveling or commuting. Several services are explored by operators, OEMs and/or cars' manufacturers: for instance, head unit applications, table and chairs, lounge, beds, etc.

- **Technology neutral business models**: Business models have to be driven by services accepted by the consumer. They should not privilege the use of one technology over another. However, in practice, mobility-based business models are specific due to economic concerns.

- **Hybrid services, for persons and goods**: autonomous vehicles would allow for fast and cheap delivery as self-driving cars would eliminate the need for grocery stores to pay or protect drivers. Consequently, the same vehicles will often transport people and goods simultaneously or sequentially. In fact, off-peak cars' utilization will allow for very inexpensive delivery options (e.g. at night).

- **Agile planning**: The speed of urban development will likely require shorter update cycles for planning or more agile use of "out-of-cycle" plan updates. In addition, a strong collaboration between departments, agencies and all stakeholders is critical at the planning and policy stage to achieve a successful implementation of AV and AV sensor infrastructure.

Data and Artificial Intelligence

Scenario 2030

- Collaboration between vehicles, PDI (Physical and digital infrastructure) and citizens (Big Data)
- Adapting to the needs of each other,
- Adapting to their current situation (AI)
- Available technological building block for seamless communication and computation on vehicles, cloud, etc.

Scenario 2050

- Liability issues solved
- Appropriate CAD regulation secured and in place
- Achieved user acceptance and trust for AI-based AD systems

Additions and comments from EUCAD BO Workshop

Nothing added.

Freight and logistics

Scenario 2030

- CACC truck platooning will available on highways, enabled by multi-brand platooning standards solutions
- There will be several pilot operations for hub-to-hub freight transport flows, linking terminals and freight consolidation hubs increasing transport corridor utilization rates
- There is still a demand for professional drivers and shortage is generally a not a critical problem for the industry even if the demand still is considerable. The role of the driver is under development with new skills required. Automation has enabled the drover role to evolve further.
- Some transport flows operate with unmanned vehicles, mainly in hubs and in selected dedicated hub-to-hub operation (L4).
- Traffic safety has increased further due to increased utilization of more advanced and automated driver support functions and partial automated driving (L1-L3).
- Highly automated driving is tested in pilots in dedicated operational flows (L4).
- Scenarios can come earlier than 2030/2050 (MANTRA)
- Debate on level of maturity for deployment of truck platooning.

Scenario 2050

- Fully automated logistics is available as alternative in most freight transport corridors where financially beneficially.
- Fully automated freight solutions if available in urban areas for last-mile deliveries.
- The physical internet is deployed to maximize freight transport network utilization meeting demands for zero carbon emissions.
- Road infrastructure on main highways is equipped to facilitate cooperative automated truck operation.
- Cooperative automated truck platooning and vehicle convoy is required in selected areas due to increased safety, transport efficiency and transport corridor utilization.
- The role of the professional driver has evolved to meet new demands from shippers and new logistics services provider needs. Remote driver supervision of transport operation is common for logistics operation.

Additions and comments from EUCAD BO Workshop

- **Scenarios can come earlier than 2030/2050**: Autonomous trucks may come before autonomous cars. In fact, the demand for the potential benefits of driverless trucks are incredible. The purchase of a truck is a business decision and is justified by the potential labour savings of Level 4 and 5 autonomy, allowing great returns on investment. On the other hand, self-driving trucks will avoid congestion issues by being operated on the highway, which might be highly profitable.
- Debate on level of maturity for deployment of truck platooning.

Bottlenecks and challenges

Additions and comments from EUCAD BO Workshop *in italics*

Safety/Trust:

- Need to demonstrate increased road safety
- Ensure resilience towards meeting cybersecurity demands and trust
- Capacity to manage privacy issues and GDPR
- Guarantee the reliability of information and the quality of data,
- Trust to enable logistics actors' willingness to invest
- Align verification and validation methods
- Quality assurance tests and certification
- *Secure liability (Insurance)*

Data:

- Need for data sharing policy and standards, and robust data quality.
- *The coordination needs sharing data in the infrastructure and the vehicle*
- *Trustworthiness of companies owning data*
- *Willingness to share data: what type of data to share? And how? We do not need all data but only that enabling interoperation / interfaces.*
- *Increase the variety of data in freight*

Acceptance:

- Willingness to share, and user acceptance of AI not reached yet, as well as the acceptance from the drivers
- Evolution of the role of the professional driver, including new salary models

Technology:

- Limitation of AI techniques, not all technology on place for data storing, computing, truck parking for CAD and charging,
- Specification of digitized infrastructure and dynamic models,
- Mixed traffic operations.
- *Achieve common specifications and regulation in a competitive market*

Business:

- Balance between economic interests and social needs,
- Competition limits the sharing of both data and AI development/techniques, need to speed up time to market, and shape the aftermarket activities
- Logistics sector low cost demand for freight transportation
- Freight data transparency in balance with logistics sector interests

Governance:

- Cross domain clarification of roles and responsibilities
- *Match urban planning process (slow) with technology process (fast): Urban planning will change and be more agile. Authorities will have to be trained and are not ready yet*
- Need for logistics sector standardisation, EU and Global, to enable automated solutions.

Key Enablers to speed up processes

Additions and comments from EUCAD BO Workshop *in italics*

Business:

- New ecosystems and business models (B2B, B2C) in both service, new vehicles and infrastructure areas

Acceptance:

- Inter-modality, common and interoperable service across countries, decarbonizing the freight sector

Technology:

- *Cooperative truck platooning*
- *Connectivity*

Infrastructure:

- Definition of infrastructure support levels, common layer model including specifications of interfaces and ODDs, aligned with deployment

Data:

- Availability of digital freight information (e-CMR)
- *Access to cloud-based data / services.*

Governance:

- Involvement of public authorities in the early stage of deployment, to create trust. European multi-stakeholder platform to coordinate pilots and deployment
- *Increase of knowledge*

Harmonized Frameworks, policy, regulation:

- Ethical, Legal, Liability, Societal framework, Data sharing and quality check, privacy and security, storage and accessibility, ITS EU model, aligned with 5G deployment, Investment for developing CAD functions using AI.

Interactions with other European Projects

In addition, the Workshop allows to identify the European projects that have common interests with the topics of the TA "Systems and Services". Table 1 summarizes these interactions.

Table 1 European projects working on topics of "Systems and Services" Thematic area (X: high interest, O: low interest).

	PDI	NMS	Data / AI	FREIGHT
AVENUE	X	X	O	
AUTOCITS	X			
COEXIST	X		X	
DRIVE SWEDEN	X	X		X
ICT4 CART				
5GC ROW				
AUTOPILOT	X	X	O	
DREAM4CARS				
FABULOS	X	X	X	
T-TRANSPORT		X	X	X
VIDAS	X		X	
MAVEN	X			

5.3.Technology & Vehicles

5.3.1. Overview

Technology is understood in this context to consist of 4 Thematic areas: **In-vehicle enablers** like sensors, environment model and driving strategy are precondition for all. **Human Factors** are a challenge for all automation levels and their applications (passenger cars, trucks) and also highly relevant to all use cases and levels, while **Connectivity** is considered as an important factor enhancing further the benefits of automated driving in terms of safety, traffic efficiency and comfort. **Deployment** is the crucial phase of bringing technology to the people and society.

Those Thematic areas have different challenges depending on concrete CAD applications: Passenger cars, trucks and buses, urban mobility.

5.3.2. Scenario 2030 / 2050

The following comments were received about the Scenario approach of "Technology and Vehicles"":

1. Use of parameters to define a "common base" was well received by participants
2. Scenario seems to be based on optimistic tech assumptions, maybe too optimistic.
3. Parameter set for scenario could be extended to further aspects → stich with scenarios done in other tasks.

Current Set of parameters for scenario 2030

- Automation penetration rate
- Exposure to automation
- Role of driver and interior design
- Connectivity coverage
- Vehicle architectures
- Safety meets Security
- Industrialization learning curve
- Usage of AI for CAD

Updated Scenario for 2030 during the workshop (updates in italic)

1) **Automation penetration rate:** Multiple level of automation simultaneously deployed on the roads, from L0 to 4. L4 passenger vehicles are available in limited ODD for most EU markets, L4 Freight vehicles (Trucks and freight-movers) in operation in several freight EU corridors as well as in confined areas, L4 Urban

Mobility vehicles (shuttles, buses and PRTs) in operation in several EU cities. Number of vehicles with L0/1/2 automation is still the big majority.

2) **Exposure to automation:** Many traffic participants remain unexposed to automation. *Vulnerable users are included in the design process from the start.*

3) **Role of driver and interior design:** Vehicles will run with a human controller as back-up (in vehicle or remotely). There will 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. The interior design of automated vehicles will be adapted to driver state (e.g. attention level) and personal preferences.

4) **Connectivity coverage:** Most automation application from and above L3 is using connectivity V2V or/and V2X including infrastructure *sometimes. One of the reasons justifying our estimation of not extensive deployment of V2I connectivity is the cost entailed for cities/road operators/investors agnostic communication technology in place. A hybrid communication solution will be the most probable scenario (cellular and G5).*

5) **Vehicle architectures:** Vehicle from L3 and above are using dedicated systems of systems architectures, which became unavoidable to address system complexity, redundancy, and safety. From perception to actuation. Fusion of technologies and equipment is expected to transform perception systems allowing more powerful, accurate data usage.

6) **Safety meets Security:** System *cyber*security became a must, is standardized and largely deployed

7) **Industrialization learning curve:** Significant field experience is gathered for L3 and above, enabling higher maturity levels (embedded systems, human factors, …)

8) **Usage of AI for CAD:** Explainable / *Inspectable* Ai is solved and usable to validate AI based driving functions *(perception, decision making, actuation(?)),* but AI based understanding of complex driving situation still requires a very high amount of sensors and is highly energy consuming

Current Set of parameters for scenario 2050 - not reviewed during the workshop

- Automation penetration rate
- Exposure to automation
- Role of driver and interior design
- Connectivity coverage
- Vehicle architectures
- Safety meets Security
- Industrialization learning curve
- Usage of AI for CAD

***Scenario 2050* - not reviewed during the workshop**

1) Automation from L3 and above is broadly deployed, both on Highway and urban, for trucks, buses and passenger cars. Number of vehicles with L0/1/2 automation

became a minority within metropole areas. L3 applications decreased or it is possible to switch between L2,3,4 within a vehicle according to user wishes.

2) High amount of traffic participants are continuously exposed to automation of various levels during their mobility experience.

3) Impaired users and children will easily access certain types of vehicles where there is no human driver and will be regular users in specifc ODDs.

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

5) Connectivity V2V and V2X including infrastructure is available everywhere needed for all applications, at vehicle level and a fleet level. Traffic is managed as a system by connectivity, and this is reflected within vehicles and infrastructures

6) Vehicle architectures to support automation have been simplified, thanks to significant technologies breakthrough, especially energy consumption became in between an issue and result is requirements to consolidate computing powers and have extremely high energy efficient components in reduced amount to cover same/better function.

7) System security has nothing to do with what is known in 2030. Completely new requirements are applicable and concepts in place Security standards from 2030 are outdated, and easily breakable leading to new threats to be addressed. Automotive functional safety will depend on advanced failure prediction and will evolve from reactive to proactive.

Key Challenges - Updated during workshop

- Transformation of the automotive sector into a software driven industry complexity, functional growth, continuous software online updates and cyber-security.
- Speed up "time to market" for early market deployment of new solutions
- 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
- Calibrated level of engagement and attention state, human adaptation e.g. loss of driving skill. Interaction design in order to create clear understanding and ability to handle multiple LoA within same vehicle and/or between brands and vehicle types.
- Remote control

Additions from EUCAD break-out 'Perception Systems for AD':

- Complexity of scene understanding is increasing when we consider urban application of automation. At the same time, requirements to perception systems also increase when we consider high speed applications. This leads to a huge set of requirements applicable to a high number of perception systems variants needed to cover those applications. Higher robustness, reliability, reliability, but also safety computing power and validation are the main impacted requirement areas expected to strongly evolve in the next decade.

- Defining the most efficient Sensor sets and Sensing technology mix for automated driving applications is still a major challenge. There is no one standard solution. There will be trade off to be made between the amount of sensors we could embedded in the automated vehicle and the realistic computing power that can be embedded in those vehicles for data fusion and scene understanding. This diversity of possible solutions also comes with a huge integration challenge, as there is no real standardization for sensors yet established, leading to each sensor describing the vehicle surrounding in its own “dialect”.

- AI and Machine Learning are impacting the whole perception chain, from sensors, sensing to scene understanding. We have to remain realistic with real capabilities of AI based perception algorithms. Validating that they work with needed accuracy is still an unsolved problem needing a lot of future research and cooperation among research and industry.

- Robust and reliable scene understanding under harsh conditions has been improving but still there are major challenges, especially when one tries to extract knowledge about possible intentions of traffic participants to derive from it appropriate driving decisions.

- Cooperation between research, OEMs, TIERs will be needed to define common and appropriate validation methods, and especially expand the usage of simulation to cover some part of the validation of perception systems.

- Perception systems will also need to generate knowledge about what is happening within the vehicle, to generate understanding about the state of the passengers and the engagement level of the driver. This will be needed for all applications where automation in introduced, from passenger cars to buses.

- Perception systems need to be combined with highly accurate localization systems and extended by using information provided with low latency and robust precision by connectivity services.

- Integration of information from infrastructure or from other vehicle for perception task will be needed to expand perception capabilities of automated vehicles. This comes with a whole new set of requirements towards those external information providers. Concepts to validate and secure the information coming from infrastructure of other vehicles need to be define to be able to consider connectivity as an additional sensor for perception.

- Cybersecurity will become a major challenge also applicable to perception systems. Concepts will be needed to prevent data manipulation leading to taking wrong driving decisions due to corrupted understanding of a traffic scene

Additions from workshop for Thematic Area Deployment:

- Costs of the technologies, and thus of the vehicles

- The perception from road users, the potential fear to new technologies and to changes in the traditional driving system

- Training and education (this is possibly very relevant in the case of professional drivers, somehow more complex for private citizens)

Additions from workshop for Thematic Area Connectivity:

- Technology pace of connectivity is 2-5 years cycle while law adaptation cycle is 10 years (or even more)
- The main challenge is to ensure robustness and redundancy in connectivity
- An important factor is trust: how to deal with a communication channel sending faulty information
- It is important to understand the role of connectivity: how to use connectivity? for which purpose?, etc.
- Ensure a certain level of performance with connectivity
- The frequency band allocation for automated driving is another topic we need to tackle: For example, in Japan there is a 10MHz band reserved for automated driving, but is this enough?
- In the following list, some challenges per project are outlined:
    - MAVEN: V2X message sets for future traffic management are not yet defined; how to manage a platoon in order to cross an intersection efficiently (creating, dissolving the platoons); connection to the TMC needs further work;
    - TransAID: How to keep automation level high without many handovers; merging with mixed traffic and how to solve the coordination between connected and non-connected vehicles are important challenges;
    - AUTO C-ITS: They don't check what happens in case of erroneous/faulty data sent through communication, but they think this is an important challenge to be tackled in the future;
    - ICT4CART: hybrid connectivity (not only in terms of HW) is a major challenge. How the handover is done and which info (in case they are contradictory) is reliable to use in order to take a decision is a significant challenge;
    - AUTOPILOT: In this project the main concept is that data will be gone through the cloud to provide analytics, AI etc. Data should not be processed within the vehicles. This means that the requirements of a middleware, the definition of standards for data and device management for connectivity are important challenges;
    - 5G-Mobix: The “roaming” situation in case of 5G is blocking seamless connectivity. Data must be able to cross the border, which is an issue of MS authorities and telecom providers. Proper requirements on 5G and also addressing specific use cases are key challenges;
    - L3Pilot: A big challenge is the cost related to the deployed technology. We need to keep the cost low and this is challenging in order to ensure reliable performance.

Key Enablers - Updated (in italic) during workshop

In vehicle enablers

- ***Sensors:*** *New sensors, new technologies for sensors, failure tolerant systems,* fail operational and *degradation concepts, higher sensing resolutions, robustness increase against harsh conditions. Cost optimized for targeted application complexity. Standardization of sensor interfaces to facilitate integration. Sensors are protected from hacking, and provide non-corrupted information.*

- ***V2V:*** *development and standardization of information exchanged by V2V to enable multi-brand communication.*
- ***ODD:*** *Improve domain modelling to generate domain models containing domain information that is more meaningful. The amount and level of information needed to describe a domain efficiently with a reasonable amount of data is still a research topic at the moment. Develop robust Dynamic / Physical / Behaviour models of objects in traffic scene, include à priori knowhow in those models, develop methods to update those models after new experience. This step is critical to achieve better performances in decision making and planning. Those improved models are needed to perform better on perception, planning or simulation tasks with realistic reduced amount of data.*
- **Perception**: increase of robustness *and speed of perception. This may lead to faster and more robust shuttle travel and hence increase acceptance. Achieve correct road sign recognition in all locations under all (hence also bad) condition*. Advanced AI & data fusion control units. *SW Architecture and redundancy.*
- **Decision making *and planning*:** extensive use of explainable AI, scalable concepts & architectures, *Robust integration of* non-traffic-rule-compliant traffic participants, *robust methods to distinguish between dangerous non-traffic-rule-compliant situations and situation where ego vehicle has to take a non-traffic-rule-compliant action to solve an otherwise unsolvable or critical driving situation. Robust estimation of vehicle's own capabilities at a given time, include critical setups in this estimation like vehicles with trailers. Robust understanding about the ODD in which vehicle is currently evolving.*
- ***Motion control* /Actuation**: fail operational actuation architectures, *while redundancy when need should remain affordable*
- ***Localization:*** *precise, accurate and robust localization of ego vehicle and other traffic participants & objects. Reliable and precise localization of information received by V2V from other traffic participants.*
- **Maps:** Real time update of HD maps available, robust update *and update validation mechanisms for Maps, definition and standardization of Maps layers, certification procedures for maps contents. Reduce gap between Map content and real condition.*
- ***Security***: standardization of security concepts and of validation methods *for those concepts*
- ***Data Bus:*** *Appropriate Data bus communication system able to cope with amount of data exchange within vehicle*
- ***Power:*** *Successful trade-off between embedded technology needed to reach functionality and overall computing power and power consumption*
- ***Remote driver / control:*** *Definition and Standardization of remote driver roles and capabilities, securization of remote control*
- ***Validation:*** *Define Methods and tools for affordable and feasible validation. Define standards, methods and tools to share testing scenarios for safety, for security, to support validation of a function, component and vehicle level. Defined tailored approaches for validation and certification of a system within a geofenced area.*

- ***Simulation**: Develop usage of virtualized testing and release, with simulation and vehicle in the loop to enable a shift of validation effort from in-vehicle to simulation. Develop standards and tools to support usage of simulation for validation.*
- ***SW updates over the air**: develop SW architectures and mechanisms to enable seamless SW updates in vehicle, Develop Methods for validation of those SW updates after market introduction.*

Connectivity

- Future evolution: emergence of 5G and higher networks ("Mission critical services"), evolution of ITS G5, hybrid connectivity (convergence)
- Ensure interoperability: usage of standardized C-ITS messages and message sets (e.g. for manoeuvres)
- Connectivity aspects of CAD: be aware of geographical and digital location in relation to stakeholders
- Stakeholders in NRA data exchange: NAP, TCC, C-ITS, ITS Service Providers

Human Factors

- Driver state assessment technology and harmonized design strategies to ensure proper engagement levels and safe transitions of control.
- **Design strategies** clearly and intuitively indicating the ODD(s) and system(s) limitations/capabilities as well as good affordance to guide for intended use.
- **Interaction design** indicating state and intention of AV to other traffic participants (manually driven vehicles as well as VRUs) through vehicle movement profile and possibly additional output devices.
- Different user groups, design for different capabilities for adoption of different technologies
- *Possibly* **training** of users and general public for different purposes, e.g. increased adoption.
- RnD of alternative seating positions (passive/integrated safety, motion sickness etc).
- ***Purpose of automated vehicles** - Design from a society point of view – which mobility do we want to see in 2030 and what technology could be used for that? Currently, the discussion in this session is very technology driven; Strong need to form it from a society point of view – adjust and align the traffic infrastructure – what do we want from mobility as society*
- *Idea: Personal freight – automated freight transport – put your bags on an automated carrier, and then walk or cycle, this could change mobility in cities if you are free to walk/cycle without your freight that you need to transport*
- ***Design process** - Automated driving could bring a lot of benefits for people who are currently excluded from mobility; Inclusive design process needs to be achieved early – include disabled people, industry just designs for the average; If this is not pushed by the commission, industry will not change; HMI adaptability is important, inclusive design and personalization very important; Reliability of the system needs to be ensured for disabled people*

- ***On-board users*** *– Be simple, Raise awareness what is automation, what can it do, what is the driver responsible for, Migration paths from traditional systems toward higher levels of automation need to be considered, it already hard for sales people to explain ACC box, will there be an automation box in the future?, how to ensure correct mental models when there are continuous software updates e.g. Tesla, Training issues, training might be needed*
- ***Shared vs. owned AV*** *- Passenger in the automated vehicle – important! Different interaction concepts needed, raise understanding, wide spread public transport being automated, this could be used first to make people aware of vehicle automation; Shared automated vehicle would be completely different from your own car, if you have different automated vehicle service provider, we also need HMI for service provision; assumption that AVs in urban areas are going to be shared*
- ***Interaction with surrounding traffic participants*** *– Need for individualization in the car but standardization for HMI outside, two options: Provide tech to the people to interact with AVs vs. put all tech to the vehicle and keep people tech free; do we need/can allow change in the infrastructure if the vehicles are smarter and can react to other traffic participants e.g. without using traffic lights?*

Project perspective:

AutoMate *– Focus: Driver on board of the AV, cooperative driving, extension of i2x of driver take-over compared to normal only sensor based detection; driver input for the automation that is stuck - approval/confirmation need by driver; driver states monitoring camera; driver is distracted during manual driving, offers automation; → what do drivers learn from it – bad behaviour, the automation will take over in all cases*

ADAS&ME *– Focus: Driver on board of the AV, driver state, driver state detections 5 states, adapt the HMI and automation levels to driver states, busses, truck, motor-cycles, passenger vehicles, specific user groups; mix of simulators and vehicles, range anxiety*

interact *– Focus: Communicating with the onboard user and the surrounding TPs, implicit behaviour of the vehicle and explicitly**,** social behaviour, legally not allowed to, challenge; AV have to behave in a human way but this is not the legal way, compromise in what is technical possible, liability issue, user needs, passengers, other TPs,*

National university project Ireland: *elderly, driver states, OEM project, strong social force to stop people driving; buddle of sensors; trade-off standardization vs. personalization; difficult to adjust to different user groups*

ESEMBLE Truck Platooning *– Human Factors for truck drivers; communication with cars that the trucks are in the platooning mode; Volvo Trucks; sensor development, pedestrian recognition*

Deployment

- Establish a European multi-stakeholder platform to coordinate open road testing, pilots and deployment of connected automated mobility

- Perform large-scale tests and pilots towards deployment of connected automated in all applications - **passenger vehicles**, heavy **commercial freight** vehicles and **urban mobility** vehicles – and in mixed traffic conditions for improved safety and efficient road transport
- *Lessons learned of deployment tests are shared, data exchange needed for this is possible, results flow back to standardization and regulations*
- 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. New services: new business models need to clarify their data management and their integration with digital and physical infrastructure
- Rules and regulation, support and harmonization
- *Aftermarket for needed parts and maintenance, recalibration, delta-validation concepts are scaled to system complexity*
- *Improved mapping of automated function to automation / cooperation levels, for passenger cars, trucks, buses and all applications.*
- *Large testing pilots / FOTs, these should include:*
  - *For Passenger Cars, Commercial Vehicles and Urban Areas*
  - *In all weather conditions*
  - *In mixed traffic conditions*
  - *Taking into account socio and regional differences within EU*
- *Technology should always work, 360° vehicle awareness is a must.*
- *Changing acceptance to adoption, which also implies:*
  - *Explaining to the consumer/user*
  - *Convincing of the CAD benefits*
- *Ethics should be out of the discussion and outside of the software development*
- *The driver/user awareness of the level of automation and the expectations on when it is automated and when it is not*
- *Exposure: show and demonstrate the benefits to the public to ensure/reach adoption of CAD*
  - *Communication on how it works should be done at several levels, depending if the audience is the general public, professional drivers, etc.*
  - *This could be done by experience, allowing a certain amount of people to try/test/drive the vehicles, then finding ways of multiplying this effect (since we cannot make every citizen to test/try the CAD)*
- *The technology should be affordable, and included/integrated in non-premium vehicles, to be able to reach mass rollout and the higher benefit for society*
  - *Maybe a system of incentives (to include automated functions in all cars and then providing funding or incentives)*
  - *Promoting by regulation (Safety type approval)*
  - *Clustering sensors to lower the prices*

    - *Etc*
- *Communication technologies should be persuasive*
    - *Sensors on the roads/infrastructures always available*
    - *Traffic management in urban environments (cities could be an easy deployment case, since they could improve traffic flow and reduce congestion)*
- *A detailed impact assessment of all automation technologies will help identifying which ones have the biggest impact on reducing accidents, reducing congestion, etc…*
    - *Stakeholders that should be specially interested in this assessment: OEMs, Insurance Companies, Road Authorities, Municipalities.*
    - *Another argument discussed: as opposite to people, automated vehicles will always respect the speed limits, traffic signs, and will always be aware of VRU ➔ safety of all is improved when compared to human drivers*
- *Regarding the road infrastructure no big changes are expected for 2030 (in the physical infrastructure), those are expected in the digital infrastructure.*
    - *Possible use cases for investments and early adoption:*
        - *Cities for the impact on congestion and for traffic management*
        - *Toll highways/motorways, as an added value or premium service*
- *HD mapping (multi-layered and progressive), with static features (geography and roads) and dynamic ones (traffic situation, vehicles, VRU). Some of these layers will be available in the short term, other will be gradually incorporated to the HD maps*
- *For the adoption, the technologies will be gradually implemented (the so-called minimal viable product, which is the minimal service that will allow to sell the technology/vehicle). Possible starting points for introducing the CAD technologies and improving society adoptions are:*
    - *Small ODDs (e.g. trucks for professional drivers)*
    - *In car sharing schemes (e.g. relocating cars by night)*
- *There is a suggestion to explore the Euro NCAP approach of dividing the levels of automation into Assisted, Automated and Autonomous, it is a simpler way to explain the levels of automation to the general public.*

6. Conclusion and next steps

The second ARCADE workshop was well attended by more than 100 participants from over 40 different organizations. The workshop was organized in parallel to the ERTRAC Conference at the same location to allow participants to follow parts of both events.

After introductions on coverage of Thematic Areas by projects, large scale demos, the ARCADE roadmap, ODD and ISAD (Infrastructure Support Levels for AD), the EU projects were introduced briefly and Japanese projects and FOTs were introduced. This created a common ground on project knowledge for the remainder of the day.

In three very interactive thematic sessions, the project interest and views were used to expand and consolidate the Thematic Areas and link to most relevant projects. This led to the following main conclusions:

Society

- Regulatory: the definition of ODD for a given vehicle type needs to be further detailed by manufacturers and authorities.
- Acceptance and trust: users and drivers' express strong concerns about safety levels and cyber-security of CAD. Liability should be made clear by authorities and insurance companies.
- Acceptance: the Japanese approach provides a good example how consultation of many governmental bodies with attention for local needs provides implementation that is supported broadly.
- Safety validation & roadworthiness testing: harmonisation of safety KPIs across projects would be valuable and could be arranged by ARCADE.
- Socio-economical: there is a need for a multidimensional evaluation methodology as all impacts are dependent on many factors. Large scale pilots are essential to elaborate and test such a methodology.
- Communication: there is a need for clear and consistent multi-level communication on the status and benefits of CAD to balance negative press coverage.
- The ARCADE knowledge base is considered valuable by the participating projects, for example for regulation and best practices.

Systems and services

- Physical and Digital Infrastructure: Full HD Map coverage and augmented GNSS are needed for European static maps. This complements GNSS systems to reach centimetre level accuracy.
- Regions: The role of local authorities, traffic management and local transport should be further elaborated by ARCADE. Needs and wants for CAD will vary per region (e.g. Japan, US).
- Monitoring and guidance of traffic flow is the first priority, before HD maps and exchanging tactical information (supporting manoeuvres with local V2I data).

- Physical and Digital Infrastructure: Virtual traffic signs are needed for pedestrians as much as for cars as this allows for digital interaction with connected vehicles.
- New mobility services: to achieve seamlessness in multi-modal mobility, meta-operators and mobility integrators will play a key and dominant role.
- New mobility services: federated platforms will orchestrate availability of mobility resources across mobility providers. This includes dynamic ad-hoc partnering and agile planning while keeping brand autonomy and reducing TCO.
- New mobility services: technology neutral business models are less dependent of technology changes and hence provide more resilient services.
- Freight and logistics: autonomous trucks have a strong business case and are pushed by the lack of drivers. They may arrive before autonomous cars.

Technology & Vehicles

- Scenario parameters: A number of important scenario parameters was defined that determine how fast a scenario will become realised. This approach might be relevant for further impact analysis in year 2.
- Security will become a must and will merge with safety methods and tests in the development processes.
- Sensors: The optimal sensor set and sensor technology is depending on the driving application and will become more complex for urban automation. AI and machine learning have a major impact on the full perception chain and still need successful validation methods.
- Decision making: we need to develop robust methods to distinguish between dangerous non-traffic-rule-compliant situations and situations where the ego vehicle has to take a non-traffic-rule-compliant action to solve an otherwise unsolvable or critical driving situation.
- Human factors: Define and standardise remote operator roles and capabilities.
- Human factors: the system design should inform, invite and guide for appropriate use of the ODD and system capabilities (affordances).
- Human factors: current CAD development is very technology driven. We should design from the societal purpose: what mobility do we want to stimulate and what technology could we use for this?
- Deployment: Since attention is mostly focused on Passenger cars, further work should also follow the ERTRAC development paths Freight Vehicles and Urban Mobility Vehicles.
- Deployment: many aspects can only be studied in large-scale tests and pilots. Perform large-scale tests and pilots towards deployment of connected automated driving in passenger vehicles, heavy commercial freight vehicles and urban mobility vehicles – and in mixed traffic conditions.

Annex – Participating organisations

Organisation	Country
ADAC e.V.	Germany
Applus IDIADA	Spain
ASFINAG	Austria
AustriaTech	Austria
AVL List GmbH	Austria
BMW	Germany
Cartell.ie	Ireland
Center for Spatial Information Science, University of Tokyo	Japan
City of Helmond	Netherlands
CLEPA	Belgium
Denso Automotive Deutschland GmbH	Germany
DLR	Germany
Drive Sweden	Sweden
Dynniq	Netherlands
EC - INEA	Belgium
EC DG RTD	Netherlands
ENEA	Italia
Ericsson Research	Germany
ERTICO - ITS Europe	Belgium
EUCAR	Belgium
European Union Road Federation	Belgium
FCA-CRF	Italy
FEV Group Gmbh	Germany
FHWA	USA
FIA	France
Forum Virium Helsinki	Finland
Heich Consult GmbH	Germany
HiTec	Austria
INDRA	Spain
INDRA	Spain
Institute of Communication & Computer Systems (ICCS)	Greece
International Road Federation	USA
IRU Projects	Belgium
Italian Association of Road Safety Professionals (AIPSS)	Italy
ITS Japan	Japan
MAP traffic management	Netherlands
Mazda Motor Corporation	Japan
Ministry of Economy, Trade and Industry	Japan
National Police Agency Of Japan	Japan
National Transport Commission	Australia
NILIM, MLIT	Japan
POLIS	Belgium

Provincie Noord-Brabant (SmartwayZ.NL)	Netherlands
Railenium	France
Rijkswaterstaat	Netherlands
Robert Bosch GmbH	Germany
Rupprecht Consult	Germany
SAE International	Belgium
SAFER	Sverige
Sumitomo Electric Industries	Japan
Technical University of Munich	Germany
TNO	Netherlands
Toyota Motor Europe	Belgium
Traficon	Finland
Trinity College Dublin	Ireland
United States Department of Transportation, Volpe Center	USA
United States Department of Transportation, Federal Transit Administration	USA
UITP	Belgium
University of Bologna	Italy
University of California PATH Program	USA
University of Geneva	Switzerland
University of Leeds	UK
University of Trento	Italy
University of Tsukuba	Japan
VDI/VDE-IT	Germany
VEDECOM	France
Vias Institute	Belgium
Vicomtech	Spain
Vienna City Administration	Austria
Virtual Vehicle	Austria
Volvo	Sweden
VTI	Sweden
VTT	Finland