Visualization of European Roadmap for Connected and Automated Driving

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## Consortium

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1 Introduction

This document describes the final result of the co-creation, validation and visualization of the roadmap for high level connected and automated driving, i.e. level 4/5 automation or self-driving functionality, carried out in the EU-funded Coordination and Support Action “Safe and Connected Automation of Road Transport”.

This deliverable is building upon the discussion about vision, state of the art and gaps during the first phase of the project, and it is particularly referring to two drafts of the roadmap that were developed at workshops on 7 March 2018 in Brussels and on 20 April 2018 in Vienna. These drafts are explained in much detail in deliverables D 5.2 and 5.3. As described previously, a number of lessons have been learned in the process of roadmap development, therefore, the focus of those deliverables is rather the experience made during this process than the final roadmap itself.

As for the previous work and deliverables in the SCOUT project, the roadmap for CAD will also be based on the five-layer model introduced by Prof. L. Eckstein to provide a structure for the analysis of the diverse influencing factors and fields of CAD development as well as of their interactions. This model links the technical layer to the non-technical layers concerning societal, legal, economic and human factors. The interaction between driver, vehicle and environment is also considered for all individual layers.

This final step of the roadmap development process, which was mainly performed at an internal workshop of the consortium on 19 June 2018 led to five use-case and goal-oriented specific (sub-) roadmaps that have been visualized and validated at the final public event on 29 June.

Based on the findings of the development process, policy recommendations are given at the end of this document for both the considered use cases and CAD in general which should be considered by the EC when determining new actions for the further promotion and implementation of CAD technologies in Europe.

2 Methodology

As describe before, the creation and the validation of the level 4/5 CAD roadmap on the five technical and non-technical layers turned out to be a very complex task, which requires a comprehensive and coordinated approach of experts in different layers of actions (technical, legal, societal, economic and human factors). Gaps between state of the art and vision were recognized and actions were easily identified for each layer, linked to actions in other layers, and aligned on the time scale. The outcome was a close-to-complete list of research, innovation and framework needs that complemented one another, however, it lacked coherence completely. In contrary, the links that the experts indicated in between the actions, revealed that technical and non-technical challenges are highly related to each other with many actions requiring the outcome of others before they can start. The many interdependencies lead to locked-in situations, creating a kind of Gordian knot. This indicates that the development and deployment of level 4/5 CAD may be heavily delayed if it is not comprehensively coordinated. This is a typical feature of complex innovation processes that comprise a number of technical and nontechnical dimensions.

The SCOUT project consortium concluded that for delivering useful indications, the roadmap approach needed to be distinct not just for the five layers but for specific use cases, and
focused on well-defined milestones on the way towards the vision. Moreover, the “Gordian Knot” of interdependencies seems to be avoidable and the innovation process could be accelerated if roadblocks are anticipated and agile shortcuts are taken between the five layers of action.

Fig. 1. Simplified structure of 5-layer roadmap for the highly interlinked innovation process in connected and automated driving. Sequences of actions on different layers are determined by necessary links creating delays: (1) invention – e.g. a new robotic driving feature, (2) customer demand – e.g. readiness to pay more for the feature, (3) business model – e.g. sharing concept to operate the car and generate revenues, (4) user needs – e.g. requirements by other road users, (5) product design – e.g. new functionalities for communication with pedestrian, (6) norm – e.g. expected safety level of automated road transport, (7) regulation – e.g. approval for operation of new vehicle. The process may be accelerated by creating agile short cuts: (a) demonstration – e.g. automated driving pilots allowing the public to experience the pros and cons, (b) sandboxes – e.g. hackathons to develop new digital financing schemes, (c) co-creation, e.g. sessions applying universal design rules, and (d) living labs e.g. experimental legislation and standardization.

In order to properly address the complexity of the comprehensive innovation planning process for level 4/5 connected and automated driving, the SCOUT project thus developed a simplified and use case specific roadmap template covering (a) a story map with hurdles and opportunities on the way from state of the art to future vision, (b) goals in terms of milestones on the timeline towards the vision, and (c) a plan of timely sequenced actions in the five layers back-casted from one of the milestones. It is assumed that the actions in the roadmap trigger each other, e.g. by an invention, customer demand, business model, user needs, product design, norm or regulation. As this helps to anticipate time sinks and risks for delays in the innovation process, opportunities for taking agile shortcuts between the layers should be incorporated into the design of the action, e.g. demonstrations, sandboxes approaches, co-creation session, and living lab (figure 1).
3 Use-case specific roadmaps

Following this methodology, and taking into consideration the expert inputs on gaps and necessary actions gathered at the public project workshops the template has been used to establish roadmaps for five different use cases and specific milestones of level 4/5 CAD, namely:

- Automated on-demand shuttle
- Truck platooning
- Automated valet parking
- Delivery robot
- Traffic jam chauffeur

These roadmaps were published in the context of the Automated Vehicles Symposium 2018 in San Francisco, CA (USA) and the AMAA 2018 in Berlin (Germany).
D5.4 – Visualization of the European roadmap for connected and automated transport

**ROAD MAP 1**

**USE CASE:** LEVEL 4/5 AUTOMATION
AUTOMATED ON-DEMAND SHUTTLE

**STORY MAP**

**Opportunities**
- Easy access
- Cost effective
- Rural lab
- Transfer to freight

**STATE OF PLAY**
- First tests
- Fixed routes
- Low speed
- Controlled environment
- Stewards

**TECHNICAL LAYER**
- Safety expectations
- VRU
- Certification
- System integration

**LEGAL LAYER**

**HUMAN FACTORS LAYER**

**ECONOMIC LAYER**

**SOCIAL LAYER**

**Hurdles**

**VISION**
- Fully integrated
- Part of the transport system
- On-demand

**MILESTONES**
- In public on selected lanes
- Mixed traffic: everywhere
- Fully automated traffic

**GOALS**

**PLAN**

- Development of intelligent vehicles
- Establish management system for fleet, traffic emergencies
- Service regulation
- Adapt traffic rules and certification
- Ensure awareness of other drivers and pedestrians
- Shared mobility business cars on-demand
- Consider citizens concerns about road safety
- Adapt city and traffic planning

**TIME**
D5.4 – Visualization of the European roadmap for connected and automated truck platooning

**ROAD MAP 2**

**USE CASE:**

**LEVEL 4/5 AUTOMATION**

**TRUCK PLATOONING**

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**STORY MAP**

**Opportunities**

- Reduced emissions
- Increased efficiency
- Driver comfort and health
- Extention to all vehicles
- Better traffic management

**STATE OF PLAY**

- First demonstrations
- Supervised vehicles
- Limited length
- Temporary exemptions

**Hurdles**

- Awareness of other road users
- Harmonised regulation
- Safety concerns
- Job market effects
- Common logistics concepts of competitors
- Mobile communication

**VISION**

- Fully integrated
- Part of the transport system
- Modular
- Independence of brand

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**MILESTONES**

- Simple first platoon (minimum viable product)
- 6-truck platoon (cross-border, inter-brand)
- Driverless platoon
- Fully automated traffic

**GOALS**

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**PLAN**

**TIME**

- Reliable V2V communication
- Enhanced vehicle intelligence
- Exemptions for trial implementation
- Adapt traffic rules and certification
- Driver training
- Co-create logistics concepts
- Promote benefits
D5.4 – Visualization of the European roadmap for connected and automated

**ROADMAP 3**

**USE CASE:** LEVEL 4/5 AUTOMATION VALET PARKING

**VISION**
- Fully integrated
- Part of the transport system
- Ubiquitous

**STORY MAP**

**Opportunities**
- New options for urban planning
- Suitable for fleet operators
- Transferability
- Simplification of parking
- Well-defined, low speed

**STATE OF PLAY**
- Mature technology
- Solutions with and without V2I communication
- Lack of applications

**HURDLES**
- Demand
- Business model
- Trust
- Liability
- Optimisation

**MILESTONES**
- Fully private system
- Public parking off-street
- Self-parking on-street
- Fully automated traffic

**GOALS**

**PLAN**

- Interoperability between car parks and vehicles
- Standardisation for multi-brand integration
- Define liability
- Ensure safe VRU interaction
- Establish user trust in system
- Develop profitable business models
- Safeguard beneficial implementation

**TIME**
D5.4 – Visualization of the European roadmap for connected and automated

**ROAD MAP 4**

**USE CASE:**
- Level 4/5 Automation
- Delivery Robot

**STORY MAP**

**Opportunities**
- Service quality
- Large variety of applications
- Automation
- Use independent from employment regulation
- Use on sidewalks, sufficient at low speed

**STATE OF PLAY**
- Prototypes being tested
- First deployment ideas
- Limited speed

**Hurdles**
- Operation in public space
- Access to locations
- Liability for goods, damage, accidents
- Trust of user
- Misuse and manipulation

**VISION**
- Fully integrated
- Part of the transport system
- Accepted as logistics services

**MILESTONES**
- Full service demonstration in public space
- Large-scale use in public and private space, long distance
- Full integration in traffic and logistics systems

**GOALS**

**PLAN**
- Reliable, intelligent vehicles, reliable communication
- Clarification of liability
- Harmonisation with traffic legislation
- Develop VRU and customer interaction models
- Establish trust in system
- Develop profitable business models
- Ensure responsible usage

**TIME**
D5.4 – Visualization of the European roadmap for connected and automated vehicles

**ROADMAP**

**USE CASE:** LEVEL 4/5 AUTOMATION
TRAFFIC JAM
CHAUFFEUR

**STORY MAP**

**Opportunities**
- Less fatalities
- Added value to vehicles
- Less stress

**STATE OF PLAY**
- Traffic jam assist available
- Low usage rate

**VISION**
- Fully integrated in all vehicles
- Safer traffic
- Routinely used by drivers

**Hurdles**
- System availability
- Liability
- Limited trust and experience

**MILESTONES**

**GOALS**
- Majority of vehicles equipped
- All relevant vehicles equipped → traffic jam platoon

**PLAN**

- Further technical refinement
- Certification
- Making system mandatory
- Driver education
- Reduction of cost
- Advertising and acceptance

**TIME**
5 Policy Recommendations

Based on their experiences and lessons learned with creating the use case specific roadmaps for level 4/5 connected and automated driving described in this deliverable and Deliverable 5.3, the members of SCOUT have drawn a number of general conclusions for the innovation process in this domain:

- The five layers model describing technical, economic, social, human factors and legal aspects helps to identify roadblocks and accelerators in innovation.
- Given the disruptive character of level 4/5 technologies, roadmaps become a “Gordian Knot” if not focused on use cases and intermediate goals.
- Opportunities for taking agile shortcuts between the layers should be incorporated into the design of planned actions, e.g. demonstrations, sandboxes approaches, co-creation session, and living lab.
- It is essential to quickly gain practical experience, therefore minimal viable products should be aimed for.

This is reflected in the five use-case and goal-centered roadmaps that have been described and visualized in this deliverable based on the consultation processes described in Deliverable 5.3.

5.1 Use-Case Specific Recommendations

The actions suggested in the bottom parts of the roadmaps (labeled “Plan”) cover the steps to achieve the respective milestones in both technical and non-technical terms. If further elaborated in terms of content, instrument, responsibility and timing, they form the SCOUT project’s recommendations for policies and actions to drive level 4/5 connected and automated driving. Due the 5-layer structure applied, these recommendations are comprehensive in covering technology focused advice, also on the accelerated deployment of infrastructure (technical layer), the complementing harmonised installation of regulatory frameworks and standardisation (legal layer), and advise for handling of other critical issues like e.g. gathering of big data vs. cybersecurity and privacy (societal layer) and others (economic and human factors layers). In the following, the suggested actions are explained in detail with reference to the roadmaps and layers and in a consecutive manner. Proposed responsibilities, types of action and time frames are indicated in brackets. Topics of highest relevance have been printed in bold.

Roadmap 1: Automated On-Demand Shuttle

Milestone: Mixed traffic everywhere

Technical: Development of intelligent vehicles

- Fund industrial and academic research and development focused on sensor suites and control algorithms meeting the society’s safety expectation from a level 4/5 automated vehicle on the road (EC, RIA, short term)

Social: Consider citizens’ concerns on road safety

- Perform a study to exploit citizens’ expectations regarding the safety of self-driving vehicles for various locations in Europe and in different groups (age, gender, disabilities..) and to co-design safety standards (EC, tender, short term).

Economic: Shared mobility business – cars on demand

- Organize a competition to develop business ideas for shared mobility services and cars on demand, awarding the best ideas with seed funding to turn them into a business plan and a reality test. (EC, prize, short term)
• Develop concepts to ensure that new mobility forms are integrated in the overall transport system with an added value and without damaging existing sustainable and performant forms of transport. (EC/MS, ERA-NET, short term)

Legal: Service regulation

• Develop a EU-wide model legislation for on-demand mobility services in preparation for automated and non-automated offers such as ridesharing. (EC, directive, short term)

Human Factors: Ensure awareness of other drivers and pedestrians

• Fund research to develop and test (both virtually and in real world) measures that make other drivers and pedestrians unambiguously aware of the automation status of a vehicle, taking into account findings about social expectations. (EC, RIA, short-mid term)

Legal: Adapt traffic rules and certification

• Have the EU coordinating Member States and consolidating/develop new or modify existing conventions for traffic rules (e.g. need of a driver (Art. 8 VC, technical requirements for a vehicle (Art. 39 VC), regulation regarding steering system (UN-R 79) and certification in view of level 4/5 automated shuttles, considering newly developed awareness measures (UN-ECE, conventions, mid term)

Social: Adapt city and traffic planning

• Let cities develop plans for the sustainable integration of new mobility forms in their urban transport system and city development masterplans and award best plans with a prize for pilot funding, at the same time trust that any plans that don’t get an award still will be implemented, and follow up by platform for best practice sharing (EC, prize / tender for platform, mid term)

Technical: Establish management system for fleets and for traffic emergencies

• Foster cooperation of national traffic and road management agencies to share best practices, prepare standards and perform field trials for level 4/5 on-demand shuttle deployment and the necessary communication infrastructures (MS, platform, mid-long term)

Roadmap 2: Truck Platooning

Milestone: 6-truck platoon (cross-border, inter-brand)

Technical: Reliable V2V communication

• Fund industrial research focused on the development reliable and redundant V2V communication for truck platooning which enables standardized cross-border and inter-brand deployment building on the European Truck Platooning Challenge and the ENSEMBLE project. (EC, IA, short term)

Economic: Co-Create logistics concepts

• Fund research into viable deployment cases in cross-border logistics environments involving diverse stakeholder interests. (EC, CSA, short-mid term)

Legal: Exemptions for trial implementation

• Define framework conditions for legal exemptions for cross-border and multi-brand truck platooning and deploy them in living labs on cross-border corridors. (MS, bi- and multilateral agreements, short-mid term)

Social: Promote Benefits

• Stage showcases of practical deployment on corridors with logistics business integration involving the vehicle and logistics industries. (EC, CSA, short-mid term)

Human Factors: Driver training
- Develop driver training curriculum according to defined deployment cases. Integrate training measures into general driver training programmes. (EC, CSA, mid-term)

Legal: Adapt traffic rules and certification
- Fund research into the generation of traffic rules and technology certification on order to enable a safe system operation. (MS, CEDR action, mid-term)
- Have the EU coordinating Member States and consolidating/develop new or modify existing conventions for traffic rules (e.g. required distance between vehicles (Art. 13 VC))

Technical: Enhanced vehicle intelligence
- Fund advanced research into expanded platooning concepts on motorways including all types of vehicles and towards driverless platoon. (EC, IA, long term)

Roadmap 3: Valet Parking
Milestone: Public Parking Off-Street
Technical: Interoperability between car parks and vehicles
- Industrial research cooperation between carpark equipment providers and the vehicle industry on the creation of interoperable products. (Industry, standards, short term)

Economic: Develop profitable business models
- Stage pilot implementations for specific use cases in public and private car parks. (Public and private operators, business plans, short term)

Legal: Standardisation for multi-brand integration
- Work items for standardisations should be launched on product and interface standardization. (ETSI / CEN / ISO, standards, short term)

Human Factors: Ensure safe VRU interaction
- The experience from other VRU-related research projects should flow into respective industrial products. (EC, IA, mid-term)

Social: Safeguard beneficial implementation
- Develop concepts for the integration the functionality in useful use cases (e.g. at airports, at car rental companies, in city car-parks) (Trade Association, common concepts, mid-term)

Human Factors: Establish user trust in system
- Stage demonstrations with user involvement and public relations work. (Operators, PR, long term)

Roadmap 4: Delivery Robot
Milestone: Full service demonstration on public space
Technical: Reliable, intelligent vehicles, reliable communication
- Industry-driven development of vehicle intelligence. Funding should focus on providing ubiquitous reliable communication infrastructure, first in cities then in the countryside. (EC, RIA, short term)

Economic: Develop profitable business models
- Provide a forum for exchange between active trials that compares profitability and sustainability of business models with the objectives of reducing current traffic volume and ensuring positive impact on cities. This could also be supplemented by a competition to identify sustainable business models. (EC, CSA or prize, short term)

Human Factors: Develop VRU and customer interaction models
Develop interactions models that allow joint use of sidewalks, e.g. using dedicated spaces/lanes (EC, RIA, mid term)

Legal: Harmonisation with traffic legislation

Have EU Member States develop new or modify existing conventions for traffic rules and certification for on-street and sidewalk applications (UN-ECE, conventions, mid-term)

Social: Ensure responsible usage

Human Factors: Establish trust in system

Promote benefits of delivery robots and raise awareness to ensure safe introduction into traffic and avoid misuse (EC, living lab, mid- to long-term)

Roadmap 5: Traffic Jam Chauffeur

Milestone: Majority of vehicles equipped

Legal: Clarification of responsibilities

Agreement should be reached among stakeholders in order to regulate responsibilities, liability and insurance issues. (EC, CSA, short term)

Human Factors: Driver education

Information campaigns should be initiated via retailers, automobile clubs, media and driving schools in order to inform and train drivers. Driving schools should include the topic in their education programmes. (EC, CSA, mid-term)

Technical: Further technical refinement

The vehicle industry should complete the product as part of their driver assistance functionality. (Industry, standards, mid-term)

Economic: Reduction of cost

The cost should be reduced by market uptake and integration of the functionality into the driver assistance product. (Industry, product development, mid-term)

Legal: Certification

Develop a certification framework for traffic jam chauffeur systems. (UNECE, certification, mid-term); adaption of existing conventions/regulations needed in terms of steering system etc.

Social: Advertising and acceptance

The vehicle industry should be responsible for advertising and make the product safe and attractive to the drivers. (Industry, marketing, mid-term)

Legal: Making system mandatory

Research should be funded in order to investigate the safety gains in the case that almost all vehicles are equipped. (EC, directive, long term)

5.2 General Recommendations

In addition to the use-case specific recommendations summarized under 5.1, the following general recommendations for policies in support of level 4/5 connected and automated driving can be drawn from the roadmap development processes in SCOUT:

Safety is of primary concern related to level 4/5 automation, it refers to all five layers and deserves particular attention. The opportunities to ensure safety solely by vehicle-based sensor and control systems are limited. Therefore, connectivity with other vehicles and infrastructure based
perception and management needs to be fostered as a necessary condition for a safe and convenient system.

- Technology oftentimes also is part of the economic equation as it responds to business models, e.g. for shared automated vehicles. Therefore, new business models should be understood as an opportunity to trigger innovation and thus be a matter of funding.

- Cyber security and safe operation have to be ensured by developing appropriate data and hardware-based keys and encryption methods. These need to be harmonized and proof for the lifetime of a vehicle, and thus require standardization and regulation, making functional security mandatory like functional safety (ISO26262).

- Large scale demonstrations are not just a way to collect experience with new technology but also an essential way to achieve societal acceptance. Particularly, the introduction of level 4/5 (driverless) automation should be supported by demonstrations in real-life environments.

- In order to improve interoperability and to allow to process the sensor data and received messages in an identical manner across heterogeneous platform a standardization activity on a global data model and/or translation mechanisms between different specific models for the ITS is recommended.

- With increasing connectivity already happening today, data protection is a key, as the information send are very sensitive and it is already one of the main concerns for users. Therefore, principles like “Privacy by Design” have to be considered while building up a regulatory framework comparable to something like a “GDPR for CAD”.

- Standardization is key for the development and implementation of CAD (functions), which is why a common approach in this matter across the EU is important to ensure a consistent way of development in the future. In order to improve interoperability and to allow to process sensor data and received messages in an identical manner across heterogeneous vehicle platforms, a standardization activity on a global data model and/or translation mechanisms between different specific models for the ITS is recommended.

- Groundwork for a framework on liability has to be carried out, as there are several diametrically opinions/interests between the stakeholders regarding this matter and translate the findings into a regulation/directive afterwards.

- In terms of legal frameworks, in general the Vienna Convention needs to be modified in order to reflect level 4/5 automation; also the passenger transport legislation has to be amended, and liability issues need to be solved. This requires close cooperation between the European Member States.

Both the use-case specific and the general recommendations made by the SCOUT project will be used directly in the context of building the implementation plan for the EC’S Strategic Transport Research and Innovation Agenda (STRIA) on connected and automated transport which is currently being edited and will be finalized by the end of 2018 – several SCOUT partners are directly involved in that process (e.g. BMW, Bosch and VDI/VDE-IT). The results may also be taken into account for the update of the roadmaps on connected and automated driving by the European Technology Platforms ERTRAC and EPOSS. The approach taken by SCOUT won’t replace the development of specific roadmaps in the involved industrial sectors, though, but give inputs to them. Thus, the implementation of these recommendations should be monitored actively, e.g. by an overarching watchdog project in the future.