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ARCADE

Aligning Research & Innovation for Connected and Automated Driving in Europe

D3.4: Systems and Services thematic areas: challenges and scenarios

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1 Contents

Executive Summary

ARCADE is to coordinate consensus-building across stakeholders for sound and harmonised deployment of Connected, Cooperative and Automated Driving (CAD) in Europe and beyond. The Thematic Areas (WP3) work on content creation leading to consensus-based positions, needs and scenarios. As defined in the Project Plan, this report is addressing the corresponding scenarios and challenges regarding the layer of "technologies & vehicles", in parallel with the reports on "systems & services" and on "users & society".

Derived from the preceding project CARTRE, four scenarios were defined (0, A, B and C). Scenario 0 describes comprehensively short-term issues. Scenario A "Disruption through market-driven services" and B "Authority driven with focus on collective transport" are deeply looking into the development of shared mobility services and public transportation as well as policies and the role of transport authorities. Scenario C is comprehensively looking into privately owned automated vehicles.

The thematic areas within Systems & Services in ARCADE are defined to be:

- Physical and Digital Infrastructure (the digital representation of the road environment).
- New Mobility Services based on connected and automated vehicles, (SAE L3 or L4): integrated in the city transport network and MaaS platforms, accessible via public transport or private operators' platforms or apps.
- Big Data and Artificial Intelligence: all data, from traffic related data gathered from road infrastructure sensors, to weather database, to feed the machine learning algorithms driving the improvement of AI based CAD systems and services towards higher-level automation
- Freight and Logistics cover research, development and pre-deployment activities ranging from confined areas, automated hub-to-hub freight transport, open road transport, truck platooning to last mile delivery

After analyzing challenges and enablers in the different scenarios, key actions per area have been identified.

Physical and Digital Infrastructure

A high priority should be given to the development of EU standards for digital infrastructure description: the harmonisation of data specifications and frameworks, and the classification of PDI support levels. Actions are required to support the development of simulations and assessment of PDI-supported automation effects on traffic efficiency and safety, and on new traffic management concepts. New research programmes are required to foster the development of (automated) PDI-quality on road network in terms of maintenance of road infrastructure, as well as studies and concepts regarding business models in order to assess and simulate investment and operation of services.

New Mobility Services

Closer cooperation should be encouraged between European and national projects, and of course, among EU funded projects, to foster the sharing of methodologies, results through the creation of a common knowledge base, encourage studies and concepts regarding business models, and organize large-scale experimentations to assess the impacts on the long term.

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Big Data & Artificial Intelligence:

Research and investment in the development of AI techniques should be supported, including the data storage and maintenance facilities. As public trust in Artificial Intelligence is not granted yet, defining the data sharing model and the frameworks for privacy, security, trust, respect of legal constraints, and payment are important topics requiring research actions.

Concerning freight and logistics, it has been established that this area should be integrated into one of the existing development paths and decided to convert the thematic area into a horizontal application area; (See ARCADE deliverable D2.1 Consolidated Roadmap 2019)

This deliverable will together with the deliverables on “technologies & vehicles” and “users & society” be the baseline of the further ARCADE developments in year 2. The methodology of the project will provide the opportunity to iterate the discussions on some of the subjects treated in the present document as well as any new subjects that might evolve from future discussion.

The next steps, plan for ARCADE WP3 year 2, will focus on additional scenarios, approaches, impacts and proposed steps; 2 joint stakeholder network workshops; thematic input for the EUCAD symposium at TRA in April 2020 in Helsinki and consolidation of the year 2 input to the thematic areas and provide input to the knowledge base (WP4).

These steps will lead to three updated reports at the level of Society, Systems and Services and Technology and Vehicles (September 2020).

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1 Introduction

1.1 About ARCADE

ARCADE is an EC-funded Action that supports the commitment of the European Commission, European Member States and the industry (cf. the Amsterdam Declaration, GEAR 2030 final report, EC Communication on automated mobility[1], High-Level Structural Dialogue on connected and automated driving) to develop a common approach to development, testing, and validation of Cooperative and Automated Driving (CAD) in Europe and beyond.

The mission of ARCADE is to coordinate consensus-building across CAD stakeholders to develop this common approach. ARCADE involves 70 consortium and associated partners (to date) from 22 countries within and outside EU, who form the backbone of the Joint CAD Network of experts and stakeholders. This Network is composed of organisations from the public, industry and research sectors, stakeholder associations or individual experts, and was first established by the CARTRE Support Action (2016-2018).

In an annual cycle, ARCADE positions the Joint CAD Network (WP2) and Thematic Areas (WP3) centrally. The Network brings together the CAD stakeholder community at national, European and international levels while thematic areas work on content creation leading to consensus-based positions, needs and scenarios. The Knowledge Base (WP4) consolidates the CAD knowhow baseline and serves as a one-stop shop overview of CAD-related information. WP1 coordinates the project. These main activities are depicted in Figure 1.

The main expected results of ARCADE are:

- Knowledge Base including CAD European, national and international R&I projects, roadmaps, regulations, standards and testing methodologies.
- Better understanding of challenges, enablers and research gaps on 12 thematic areas related to CAD and recommendations for next steps and actions.
- Exchanges and harmonisation of R&I approaches across EU, US, Japan and other countries outside Europe.
- Awareness raising and promotion of national, European and international CAD R&I activities and results.

ARCADE capitalizes on CARTRE legacy, including tools developed by the project such as the https://connectedautomateddriving.eu website, the work done in the thematic areas and of course, the Joint Stakeholder Network, which ARCADE will leverage and further grow.

[1] COM (2018) 283

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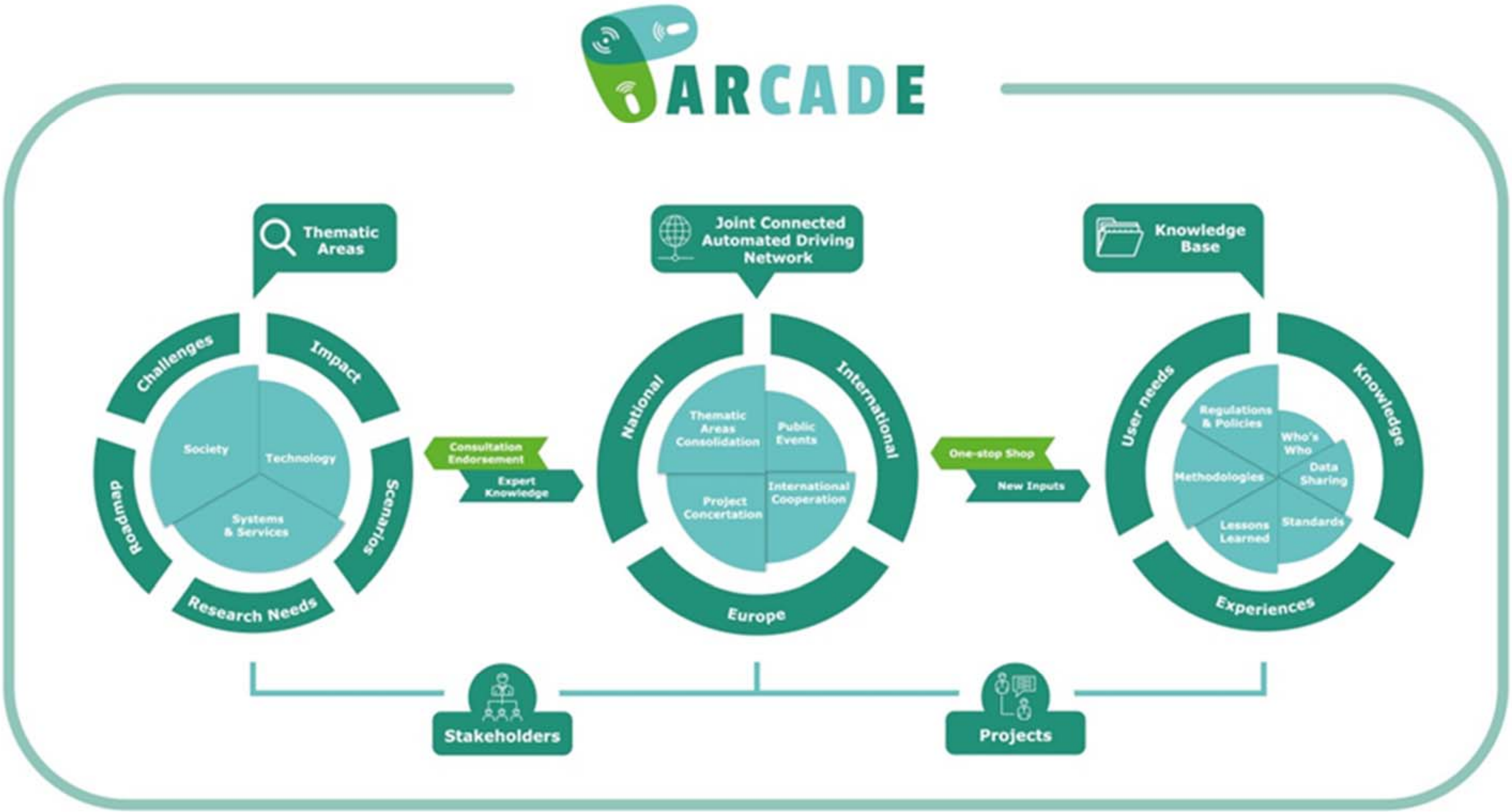

Figure 1: ARCADE main activities

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1.2 Purpose of the document

Work package 3 deals with the thematic areas and has the goal to deliver the research content. At the end of year 1, ARCADE provides three reports in parallel, one by each task combining work from several thematic areas. The structure of all 3 reports is similar. The focus for year 1 is for all 3 tasks on challenges and scenarios: what is blocking fast and good introduction of CAD or may create a negative impact? What should be solved to create a positive impact? In what diverse ways could CAD evolve in the period up to 2035? Year 1 Deliverables are the first step with scenarios as a means to better reach the full bandwidth of research. It does not mean that the selected scenarios are a prognosis of the reality in the future, they only show the possibilities. This first version will be enhanced during Year 2 and 3 by additional aspects and updates to the current content.

This document addresses these challenges and scenarios for the layer of “systems & services”.

1.3 Intended audience

The document is addressed to the European Commission to give a full picture on the research themes and their challenges. It is also addressed to the stakeholder community for detailed understanding of research needs including but not limited to STRIA, CCAM and ERTRAC.

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2 Description of scenarios

2.1 The CARTRE scenarios

The preceding project CARTRE[2] determined four alternative scenarios for making expert assessment of the socio-economic impacts of automated driving [reported in Rämä et al. 2018 on which this chapter is based]. Scenarios were plausible descriptions of the future; they can be seen as stories of different alternatives for what could happen and for what the transport system could look like. All the scenarios focused on transport of people (and less on freight). The CARTRE expert assessment work covered eight impact areas and multiple KPIs in all of them.

The CARTRE scenarios were not mutually exclusive but they helped to look at different impacts of CAD from different perspectives.

The short-term scenario (scenario 1) refers to the near future (not 'tomorrow'), up to around 2025. The long-term scenarios (scenario 2, 3 and 4) are still fairly close timewise – somewhere around 2035. Current technology paths cannot be extrapolated much further without creating large uncertainty. On the other hand, since the lifecycle of development and use of vehicles is quite long, it can be expected that vehicles that are developed today are partially still on the road in 2035. The average age is 11.1 years for cars and 12 years for heavy commercial vehicles[2] which can even reach to 15 years[3]. Annually, about 20% of cars is replaced by a new one[4].

In the short-term scenario (scenario 1), the focus was on gradual extrapolation of automated services with no radical changes to the current. The same automated vehicle technologies and their maturity was assumed in all the long-term scenarios. In addition to the time aspect and maturity of technology, the development of shared mobility services and the locus of control (role of public authorities) were identified as the main differentiating factors between the scenarios. Specifically, the first of the long-term scenarios described a transport system in which automation emerges parallel to shared mobility, and the fleets of automated vehicles are market operated. The second long-term scenario pictured a future in which shared automated transportation is authority driven. In the third long-term scenario, automated vehicles are mostly privately owned and shared mobility has not succeeded. A summary of the scenarios and their main differences is illustrated in Table 1.

[2] Rämä, P., Kuisma, S. (2018). Societal impacts of automated driving. CARTRE Deliverable D5.3

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Table 1 Summary of assessment scenarios (CARTRE)

	SHORT-TERM SCENARIO (~2025)	LONG-TERM SCENARIOS (~2035)		
	Scenario 1 *Gradual extrapolation of automated services*	**Scenario 2** *Market-operated fleets of shared automated vehicles*	**Scenario 3** *Authority-driven shared automated transportation*	**Scenario 4** *Proliferation of private automated vehicles*
Automated vehicle technology	Gradual introduction of automated functions	Mature SAE L4 automated vehicles, penetration >50% in mixed traffic		
Use of shared mobility services	High interest, early adopters use	High	High	Low
Locus of control	Cautious but enthusiastic public support for automated vehicles & mobility services	Private	Authority-driven, public-private collaboration	Private

For the scenario-based assessment of the socio-economic impacts CARTRE suggested that in the short term, the impacts of automated driving would be minor or moderate. In the assessment of the long-term scenarios, the two scenarios that included shared mobility showed the more benefits from automated driving compared to the scenario with private automated vehicles.

2.2 Selection of scenarios for ARCADE

In ARCADE, we use scenarios to explore the implications for the various thematic areas in the sense of challenges, enablers and actions to be taken. Therefore, a selection of the CARTE scenarios was made that would suit the exploration best. The selected scenarios are meant to explore the variety of developments. They are not recommended or desired scenarios, just possible scenarios. As scenario 1 was used for the short term within the previous project, and time has progressed, the team agreed to use it with less priority with one comprehensive chapter and named scenario 0. With regards to scenario 4: after many experts´ dialogues, it was found that with evolving technology the views on it have changed. It states that owning AV is affordable for most people, as a base thought. When researching scientific publications on AV sensors and computers, it is common sense that a full 360° coverage of all three sensor principles (Camera, Radar and Lidar) is needed for Level 4 with a corresponding on-board supercomputer for real-time raw data fusion. This means that cost per vehicle will stay extremely high for a long period of time. That is why in this deliverable it is assumed that scenario 4 is evaluated to be very optimistic. Furthermore, the working assumption is that the role and focus of the authorities is too narrow and not any more realistic in scenario 4. That is why this scenario is only looked at in one comprehensive chapter and named scenario C.

The remaining two scenarios are named scenario A and B and are described in more detail in this report. As Level 3 Highway Automation is expected to be rolled out (as announced by many OEMs) in the first half of the 2020s and according to the ERTRAC Roadmap, this deliverable focuses on Level 4. The same automated vehicle technologies and their maturity is assumed in

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both scenarios. In addition to the time aspect and maturity of technology, the development of shared mobility services, the availability of public transportation and the locus of control (which actor controls the development most) were identified as three main differentiating factors between the scenarios (Brenden & al 2017, Milakis & al 2017, POLIS 2018). The differentiation of scenarios is for showing the possible range of the consequences of how technology will be applied to society and how systems and services are controlled. For scenario A the focus is on vehicle sharing and ride hailing for persons and goods on a more privately and individually organized system. For scenario B, the focus is on ride sharing strongly linked with an overall traffic management and public transport.

Future AD technologies are going to be built on the existing partial automation and related experience. In long-term SAE L4, functions in use include highway autopilot, urban and suburban pilot, and automated shuttles and buses in mixed traffic. The freight vehicles path includes SAE L4 HAVs (Highly Automated Vehicles) on dedicated and open roads and highway pilot platooning. It is also assumed that light goods vehicles (vans) for deliveries and services have automated L4 functionalities. The occurrence of automation differs, however, depending on the area, ODD of functions, willingness to use, adoption rates, etc. In these scenarios, we assume that SAE L4 functions are broadly available and mostly mature. Traffic will have mixed levels of automation. In addition, shared ownership and high technology solutions for vehicles may speed up the rate of fleet renewal.

2.3 Scenario 0: Short term Gradual extrapolation of automated services

Following the gradual launch of new automated functions, new cars have at least optional SAE L2 automation functions such as traffic jam assist, lane keeping assist and parking assist in addition to the SAE L1 ACC and Stop & Go assist. For freight vehicles, cooperative-ACC truck platooning is commonplace. SAE L2 AD functions for cars and SAE L3 functions were launched some time ago and are now spreading out.

This implies for the Systems and Services thematic area:

The existing technology allows shuttle and automated SAE L4 buses to operate at very low speed, which does not match the expectations of both users and operators for a wide deployment. However, some specific functions like automated maneuvers in depots, or automated docking require SAE L2 technologies and are available. Positive effects are expected on the operators’ costs, and to build up the first trainings for drivers. These functions can also improve slightly the accessibility of public transports for all users (vulnerable, elderlies, people with disabilities). A few services built upon SAE L2 functions can be imagined (such as automated fleet balancing, automated parking for car-sharing fleet). The remaining challenge is to be able to operate without the safety driver onboard, which requests an evolution of the legal framework, the elaboration and standardization of the infrastructure support levels for automated driving (ISAD), and the availability of the systems (vehicle and infrastructure) validation framework.

Physical and digital infrastructure: The relationship between ODD and L2 automation needs to be improved by elaborating and standardizing ISAD (infrastructure support levels for automated driving). Any progress towards standardized European lane markings will help (but is probably hard to realize given national regulations and conventions).

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New mobility services: a tighter integration of mobility on demand services (like Uber) with existing public transportation is needed to avoid disruptions. Navigation may be extended with find-a-parking-place services on short notice.

Big data and artificial intelligence: for reaching high reliability of machine learning algorithms, consistent access to data sources is needed. Validation of AI and consensus on acceptable performance levels need to be established.

Freight and logistics: L2 functionality can greatly assist professional drivers and enhance safety. However, only if this changes work and rest times, this will be reflected in a business case.

2.4 Scenario A for 2035: Disruption through market-driven services

In the following, Scenario A is described regarding two aspects: the development of shared mobility services and public transportation as well as policies and the role of transport authorities.

2.4.1 Development of shared mobility services and public transportation

Shared mobility services have broken through and became mainstream. Shared mobility Services include ride sharing, vehicle sharing and ride hailing, possibly covering several mobility modes. They are reliable and convenient in most cases. Fleets of shared and automated vehicles are market operated. Operators are competing against each other for customers, and different levels of service are available. Premium subscribers gain access to better and faster services than basic subscribers. These privately-operated fleets of vehicles have partly replaced traditional public transportation, especially on short distance trips and in densely populated areas.

Shared mobility is mainly based on the provision of vehicles and services, giving less attention to multimodal travel and integration with public transport services are not really multimodal, as cooperation is not optimized, travel chains do not cover all modes well. New services and business models for public transportation are continuously being developed in parallel with private mobility services. An increase of driverless buses is reducing the costs of bus travel.

2.4.2 Policies and the role of transport authorities

Since market-operated fleets of shared and automated vehicles competes and complements traditional public transportation, road authorities aim to promote social equity by regulations and subsidies to ensure a minimum level of mobility services to all people. Transport authorities affect market-operated transportation through regulations and subsidies that clarify responsibility issues and encourage private operators towards lower emissions, increased road safety and intelligent use of urban space. Privately owned vehicles are not subject to a special policy.

2.5 Scenario B for 2035: Authority driven with focus on collective transport

In the following, Scenario B is described regarding two aspects: the development of shared mobility services and public transportation as well as policies and the role of transport authorities.

2.5.1 Development of shared mobility services and public transportation

In this scenario, there is a system of driverless vehicles providing demand-responsive public transportation for selected routes. There has been a proliferation of commercially explored

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automated public transportation systems (e.g. buses, shuttles, pods, delivery). The main private operators of public transportation have invested in creating these systems, which have been subsidized by the public sector. The main use of the systems is for access and egress of major public transport hubs and for lower-density areas. Most of the people have accepted and been used to sharing trips and vehicles. Travel chains are well functioning and intermodal.

2.5.2 Policies and the role of transport authorities

Shared and automated mobility is part of the integrated planning process, which is based on public-private collaboration. Transport authorities are proactive and, ensure social equity. They also keep strategic control of the transport network. Privately owned vehicles are being discouraged, both centrally and locally for example through road price charging and parking charges. Physical and digital infrastructure has been built in (part of) the strategic network.

2.6 Scenario C for 2035: Privately operated fleets and low governance

This scenario is focused on private ownership of highly automated vehicles, similar to today's situation. The cost price of the vehicles will rise due to expensive sensor systems required for SAE L4 vehicles. In this scenario, people do not want to share automated vehicles together strangers and without a driver present. Thus, sharing remains marginal, not many systems have broken the barrier to being commercially explored by private companies, and public companies are not adopting them. Authorities have not been able to get public acceptance to govern the use of private automated vehicles, especially in urban areas. Policies focus on reducing emissions, managing urban space effectively, and increasing the safety of automated vehicles. This implies in comparison to Scenario A and B for the Systems and Services thematic area: The deployment of new mobility services will remain low, if any. The public authorities will not be involved in the governance, resulting in a low deployment of Physical and Digital Infrastructure, and a low level of integration in the Public Transport. A few dominant private services might try to arise, with severe negative side effects (increased number of vehicles, low accessibility, low integration in the existing transport grids...).

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3 Scenario detailing for systems and services thematic areas

Scenarios A and B take into consideration the work that was carried out in ARCADE thus far with several stakeholder workshops. These stakeholder workshops aimed at identifying possible bottlenecks and challenges, and enablers related to different scenarios.

In order to have a thorough understanding of the scenarios described above from a systems and services point of view, the following ARCADE thematic areas gave input to this deliverable:

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. A common understanding of the PDI role for CAD, specifications of required infrastructure and its interfaces as well as piloting the interaction between vehicles and infrastructure are needed to fulfill the requirements of connected and automated driving in 2035. Physical and digital infrastructure can support in a broad variety of use cases, from the support of vehicles (e.g. in lane merging) to advanced traffic management measures (e.g. interactions with vehicles on strategic or tactical level). The requirements towards the physical and digital infrastructure are strongly dependent on the specific use case. A harmonized approach of how to describe scenarios and use cases is also required in order to put road operators in the position to install appropriate sensors and to supply the communication channels with the needed data and its quality.

The “**Digital Road infrastructure**” may be defined as “the digital representation of road environment as needed for Automated Driving Systems, C-ITS and Advanced Road/Traffic Management System”. Based on the activities in CARTRE, it can be understood as the integration of multiple geo-located information layers containing:

- Static - Basic Map Database (e.g. Digital cartographic data, Topological data, Road Facilities)
- Semi-static - Planned activities and forecast (e.g. traffic regulations, road works, weather forecast)
- Semi-dynamic - Traffic Information (e.g. accidents, congestion, local weather) – Smart Traffic Management Center
- Dynamic - Information through Vehicle to X communication (e.g. surrounding vehicles, VRU, traffic signals, other infrastructure)

New mobility services

New mobility services are services based on connected and automated vehicles (SAE L3 or L4): operated on demand or in a scheduled way, integrated in the city transport network and MaaS platforms, accessible via public transport or private operators’ platforms or apps.

They will be completing the existing Public transport offers in low density/low demand situations and could be complementing or competing them in high density/high demand areas, depending on the deployment scenario. The services may be disruptive in some cases, e.g. Uber taxi transportation. They may use any kind of vehicles: pods, passenger vehicles, shuttles, or buses, and be operated in segregated, dedicated lanes, or in open traffic.

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Big data and Artificial intelligence

The utilization of Big Data and Artificial Intelligence (AI) techniques is essential for the developments of CAD systems and CAD related services, however it introduces several challenges in various domains.

Sensors of Connected and Automated Driving systems continuously produce Big traffic Data. In addition, related traffic data is also gathered from other sources such as road infrastructure sensors (e.g. cameras) and weather databases. By now, the creation of huge amounts of data is a given. Especially for privately owned data, access is limited. Access is not obvious due to the competitive value of the data and privacy.

Big Data feeds the machine learning algorithms (i.e. AI Algorithms) that drive the continuous improvement of AI-based CAD systems as well as CAD services towards higher-level automation.

The use of Big Data and AI for the developments of CAD systems introduces several challenges in various domains which will be discussed in the next section.

Freight and Logistics

Connected automated freight transport and logistics cover research, development and pre-deployment activities ranging from confined areas, automated hub-to-hub freight transport, open road transport, truck platooning to last mile delivery. These activities are not solely limited to technological aspects. Harmonisation of legislation along with the future role of the driver pose equally important challenges to the sector. It is also essential to ensure integration into logistics flows and processes for increased efficiency, improved network utilisation and enhanced safety and security.

The input provided by each thematic area is combined with suggestions from other stakeholders during past workshops.

One of ARCADE's main objectives is to further develop the work carried out in CARTRE relating to the thematic areas. In order to do so, a single approach was defined for WP3 and the three different thematic area groups: technology, systems and society related.

Important note for the understanding of the structure of this Deliverable: Scenario A is used to describe all aspects of Systems & Services, represented by the above mentioned four thematic areas. In order to avoid doubling parts, Scenario B only highlights the difference to Scenario A. No significant difference between the scenarios was found with regards to relations of ongoing activities outside of ARCADE. Therefore, the activities are described in the relevant chapter for both scenarios.

3.1 Scenario A: Disruptions through market driven services

The impact of market-driven services could allow the mobility ecosystem to further develop in terms of technological advances. Various stakeholders competing against one another might attract users by providing them with a wide selection of services. On the other hand, having no concrete regulation in place could lead to a fragmented and vulnerable environment in which users' rights are overlooked.

Scenario A predicts that there will be disruptions through market-driven services. For this reason, several bottlenecks and challenges were identified that touch upon the system and services related thematic areas. Consequently, enablers corresponding to the bottlenecks and challenges are proposed and analysed.

3.1.1 Bottlenecks and challenges

Physical and Digital Infrastructure

In scenario A, deployment will be driven by the market demand. New services will be taken to market by new operators and platforms, and the high demand of new shared and sustainable mobility services will require quick and focused deployment of infrastructure to support the services deployment. The 2035 vehicles will need support from Infrastructure like today. The existing technologies deployment would require a geo-fence to assure safe operation in a closed, well-defined infrastructure, which not likely to be done at a large scale in cities.

Localization, maps:

In the context of physical and digital infrastructure, static map database should be available for all Europe. Local Dynamic Maps will be required at certain positions (intersections, merging situations, etc.) wherever there will be a need to support service set-up and deployment. Solutions for Augmented GNSS (replacing satellite-based solutions by a local high precise and reliable solution, e.g. by pseudo satellites) or additional land stations (RTK) will be necessary. In addition, physical landmarks (with sensor reflectors or beacons) may be needed for positioning support (see also Deliverable 3.1, chapter 3, In-vehicle enablers).

Connectivity: Complete connectivity will be necessary to provide the dynamic and semi-dynamic data to support vehicle automation. This may require installation of fibre optic cables along some roads to provide the necessary connectivity.

Traffic signs: A virtual representation of most traffic signs will be available, Smart road elements for localisation and guiding the automated vehicles will be installed at dedicated points. Virtual signs remain a bottleneck for non-automated vehicles pedestrians so physical signs remain.

Road markings: Consistent lane markings of good quality and visibility will be needed by vehicles utilising cameras as the vision system. Special marks for easier RADAR and LIDAR sensing may be introduced.

Safety bays: Roads without wide enough paved shoulders need to be equipped with safety bays for L4 vehicles in case of temporary termination of ODD to allow a fail-safe end of automation service.

Passenger pick-up/drop-off points: In order to have well-operating system of shared automated vehicles, the road and street networks need to have kerbside facilities for managing picking up and dropping off passengers in a safe manner. These should be equipped with sheltered waiting space at locations with high passenger demand.

Traffic management: Identification of the level of traffic management required for cooperative manoeuvres. New measures will be necessary: Interactions with vehicles on tactical level as described above but also strategic interactions with other operators (road, public transport, fleet operators and providers of MaaS). Road works need to be managed in a harmonised and rather

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standardized manner with regard to the markings, management processes and digital information.

Winter maintenance: To facilitate automated driving also on snowy and icy roads, winter maintenance and especially snow removal and de-icing need to be enhanced in countries and regions with frequent occurrence of ice and snow on roads.

Decision making: In the context of physical and digital infrastructure, tactical information supporting automated vehicle manoeuvres by local online data in real-time will be required at strategically important locations and stretches (at the high-level road network but also in cities). The recent ISAD approach (Infrastructure Support Levels for Automated Driving) as developed within the INFRAMIX project (see Road infrastructure support levels for automated driving, Anna Carreras, Xavier Daura, Jacqueline Erhart, Stefan Ruehrup; https://www.inframix.eu/wp-content/uploads/ITSWC2018-ASF-AAE-Final-paper_v4.pdf) may help to make the quality of the PDI manageable in combination with an ODD and a vehicle automation level.

Reliability and affordability of data: One challenge is to define the right level of information required to ensure the operations reliability. The other will be to ensure the robustness and constancy of the data quality and reliability. This is a critical safety issue. It is essential to provide reliable static maps, in 100% of the areas within the ODD. The underlying question is to clearly identify who is responsible for this reliability towards the drivers. The last challenge will be linked to the availability of the ODD data in the digital infrastructure, which cannot be taken for granted before 2035. Providing consistent information to the OEMs of the level of infrastructure is a key challenge.

Standardization: A standardized EU set of traffic signs (physical and digital) and road markings would greatly help CAD and extend the length of the ODDs. From a policy perspective, a minimal quality level for PDI could be set.

New mobility services

Users' acceptance: In the scenario A, the high level of competition between private platforms will bring a high level of service design and adaptation to users' needs. Therefore, the users' acceptance will have reached a very good level, operation and business models will be well understood. One of the major remaining uncertainties and challenges is the willingness to share the trip**.** The willingness to share depends on the trip purpose, the travel time, the comfort, the traveler itself and the service reliability (and it is understood that the robustness and quality of available data will have a strong impact on the service quality and reliability). In addition, by sharing the trip, passengers accept to waive the travel privacy to a large extent. Personal safety could be another concern when sharing the car with someone you do not know. One inherent challenge will be then to create privacy areas within sharing mobility models. Possibly, distinguishing between a premium sole trip and a shared trip might make the economic advantage of a shared trip visible and accepted. More generally, the privacy is an issue which is closely related to the data sharing objective, which could partly be solved through the involvement of public authorities in data collecting and sharing.

Services deployed: The services deployed will be mostly operated in point-to-point situations and in high demand/high density environment, basically in city centres, urban and peri-urban areas. They may be using dedicated infrastructure to some extent and will allow to build and test business models that would be relevant for all stakeholders. Solutions addressing hybrid

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people and goods transport in urban areas will be tested. Mobility hubs will start to be deployed. At this stage, the services should be operated without human supervision on-board, but relying on remote control systems. Deployment in rural areas is still difficult (see also Deliverable 3.1, chapter 3, Deployment).

Secondary services (unrelated to mobility) might arise such as food/goods delivery to your taxi, meeting space in a vehicle or even mobile personal care, coaching or wellness services.

Data management: Open source platforms will be needed, with the use of shared data to design and improve services and service operations. The data governance and sharing will be organized through federated platforms, which will allow their members to access to relevant data. In this highly competitive environment, cooperation will be difficult to establish, though, and might take the form of new consortia and meta-operators to build the trust. A sound business case usually makes sharing data easier. It is possible that new kind of players, mobility integrators, be required or may become very powerful.

Governance: In this scenario**,** Public authorities might not be involved in early stages of the deployment, although they might be required to ensure the balance between economic interests (e.g. jobs creation, profit of operators) and social needs (e.g. accessibility, public health, etc.). Several services providers could operate in the same territory. Regulation and some standardization of these competing services would limit their negative externalities (e.g. congestion, pollution, higher fares, etc.) but would also contribute to increase the required trust between operators to work together.

Urbanism: The deployment of those services might cause more urban sprawl, and the technology evolutions could be swifter than the current urban planning processes. One of the challenges will be to manage the evolution towards a more agile urban planification, and to increase the knowledge and awareness of (national, regional, and local) public authorities regarding the technologies' potentials and impacts. But this scenario will not foster the engagement of public authorities in the development of new urban development models.

Finally, the lack of involvement of public authorities will not foster intermodality through a unified ticketing system and to create a common and interoperable service.

Availability of fleets for large-scale testing: assessing the real potential and impacts of new mobility services requires large-scale and long-term experimentations and living labs. The users' behavior (e.g. evolution of mode choice on a long period) will only take place after months of experimentations, provided that the quality of service reaches the expected level. Such experimentations require a relevant size of fleets, and adequate funding.

Big data and artificial intelligence

The swift deployments of services in scenario A require an extensive exchange and analysis of data from vehicles, physical and digital infrastructure, and citizens. The availability of the data is granted throughout cooperation between platform operators, and citizens. The analysis and processing of this Big Data can only be realised by employing and developing Big data analytics and AI techniques.

Data sharing, privacy and security: Data sharing between main collaborators is essential for the development of the services of Scenario A. However, competition between the involved services developers limits both the sharing of the data and AI developed techniques. Well

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defined framework (policy and regulation) for data ownership and liability is needed to encourage the different parties (including services users) to share their data. As data sharing has a significant impact on privacy and security, policies and rules are needed to ensure appropriate use of the shared data. A sound level of security measures and mechanisms needs to be in place to avoid vehicles becoming controlled by malevolent actors.

Data management and data quality: For the development of different tools that are enabling the services of Scenario A, one challenge is to define which data is necessary for each tool, and in which quantities. It is also necessary to check the quality of the collected data.

Not every bit and byte of the data is useful. It is also necessary to check the quality of the collected data. An efficient data management solution/system is required to ensure the availability and guarantee the quality of the shared data.

Training and Validation of AI algorithms: Development of AI algorithms and models requires huge amount of data for training and validation to ensure the operational safety of these technologies. The lack of policies and standards of data sharing, have an impact on the availability of data needed train and validate AI algorithms, and consequently limits the development on AI. Beside ensuring the availability of data, a harmonised and common procedures for training and testing (and validation) of complex AI functionalities is required to overcome this problem. Furthermore collaboration between different stakeholders is needed for sharing models in which to train the AI, and on the availability of testing sites (both in closed environments and in open test-beds). (see also Deliverable 3.1, chapter 3, In-vehicle enablers).

New AI concepts and techniques: Toward high level of automation, automated driving functions as well as related services (scenario A) are becoming more and more complex. AI techniques should be developed to operate on increasingly high volumes of data coming from different sources, e.g. vehicles sensors, infrastructure, geographies and whether, to allow anticipatory decisions. Current AI techniques are limited and not able to cope with these accelerating developments and fulfil their challenges and responsibilities. It is essential to establish and encourage new initiatives working on developing new AI concepts and techniques that fulfil future automated driving functionality and services (including transparency and traceability) especially in the research and academic sectors.

Harmonisation of AI investments developments: Currently, massive parallel investments are made in machine learning and AI technologies which result in a broad scattered range of developed techniques. This situation has a negative impact on the citizens' trust in AI technologies and in the decisions made based on AI. Making policies and sharing investment will accelerate AI-based developments and naturally leads towards harmonisation which an essential step forward towards users trust and acceptance.

Freight and Logistics

Increasing demand of goods: Increasing freight transport demand will be a challenge for Europe due to an already congested road network. The EU (European Commission, 2011, p.12) forecasted that freight transport is expected to increase, compared to 2005, by approximately 40% in 2030 and by around 80% by 2050. This overall increase will represent a challenge for freight transport operators and the overall supply chain. In this scenario, the presence of players in the sector will increase due to competition between operators due to the absence of concrete regulation. A combination of increasing demand and absence of dedicated regulation will result

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into a fragmented and unregulated environment which could ultimately lead to unfair competition.

Congestion: In Scenario A, congestion on dedicated and open roads, highways and in cities with urban freight delivery services will increase. According to the EC (European Commission, 2011, p.13), costs related to congestion will increase by 50% by 2050. In addition, the latest EU forecast (source) on levels of urbanisation has shown that in 2050 it will reach approximately 83.7% from today's 74%. Consequently, without proper regulation and the predominance of market-driven services, goods will have a harder time reaching urban areas and congestion will harm the overall supply chain.

Lack of unified regulation across EU borders: Traffic rules are the responsibility of the Member States. Freight transport and logistics operations will suffer from different rules applied at national level, penalising the sector as a whole in particular for cross-border operations. Liability regimes risk to be unclear in case of an accident and with higher levels of automation present in trucks, drivers will have to be made fully aware of their responsibilities. In addition, legislation regulating driving and rest time rules for drivers need to be adapted and fleet operators will have to plan to change their transport operations accordingly. In the case of hub-to-hub freight transport, different regulations that are governing different segments of roads will cause uncertainty. Similarly, urban freight deliver services will have difficulties interpreting different rules regulated at city level.

Social impact on drivers: There will still be a demand for professional drivers and the shortage of drivers will remain a critical problem for the industry. It has been forecasted that 6.5 million truck drivers are needed across Europe and the United States by 2030 (ITF-OECD, 2017, p.38). Despite having commercial vehicles with SAE Level 4 functionalities, drivers will still be needed. Furthermore, an increasing technology evolution will be difficult to handle for smaller fleet operators, which will find it challenging to compete against bigger players in the transport and logistics sector. Fleet operators owning on average 2-3 trucks will struggle to follow the trend. Retraining will represent additional costs for European fleet operators. Driver training will have to be revisited especially since a majority of European drivers have held their licence for 18-20 years. The role of the driver will change with additional new skills while at the same time higher levels of automation will cause job losses. Drivers' acceptance of new technologies will be critical for the sector.

Cybersecurity: The lack of a harmonised and interoperable ecosystem in terms of cybersecurity will cause freight transport flows to suffer and, as a result, hacking will increase. In addition, definition and regulation on the minimum requirement for data sharing from OEMs and from businesses will still be unclear. From the commercial road transport perspective, transitioning from paper to digital transport documents (eCMR) for example will represent a major challenge this respect. By transitioning to electronic freight documents, there is a higher risk of cybercrime. In addition, there is a lack of ad-hoc regulation addressing liability issues related to cybersecurity and hacking.

Traffic safety: A mixed traffic environment with automated and non-automated vehicles might create unclear circumstances and will be a challenge. An urban environment with several different road users ranging from pedestrians to cyclists will cause problems to urban freight delivery services. Regarding highways, Europe currently lacks enough safe and secure truck parking spaces. This will be an even greater problem when automated trucks will be deployed

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at a greater degree. Moreover, an additional issue is the interaction with the infrastructure and the communication that takes place with truck platoons. Infrastructure development will still be lacking across Europe with some EU Member States being ahead and some lagging behind.

3.1.2 Enablers to speed up processes

Physical and Digital Infrastructure

Road authorities are a very important source and provider of digital information, and there is much room for improvement. For new roads, it is essential to build digital and physical infrastructures together. Concerning the existing ones, there is a need for national actions and government support to optimize the processes, which need to be initiated by the EU.

Additionally, digital information could come from private providers. However, common PDI representation, and data quality standards need to be defined. It is difficult by market forces alone to make all Public Authorities agree on same representations of PDI, and this requires an important investment. On the other hand, since digital road information is relatively new, the coming years present an opportunity for a harmonized approach. Therefore, it would be essential to enhance close cooperation between public and private organizations.

Regulation on the provision of data is necessary to ensure the availability of reliable and accurate data. Legal instruments are already available, in particular the ITS Directive 2010/40/EU.

Regulation could help in to maintaining the quality and reliability of physical infrastructure. The EuroRAP program with road quality criteria could be used (e.g. in summer some signs are obscured by vegetation from private property).

Additional investments will be needed to implement the additional physical infrastructure, traffic management, and maintenance activities required by highly automated vehicles (satellite position support, fibre optics cabling, road marking and winter maintenance, standardized road works management, passenger pick-up/drop-off facilities, safety bays).

New mobility services

The involvement of public authorities in the early stage of deployment is crucial to create trust. Still, the cities and public authorities are in the phase of getting acquainted with those new services. The multiplication of experimental projects will help to develop new skills of cities, as well as the citizens' confidence in technology, based on their own experience. It is crucial that all stakeholders understand that the point is not to replace the existing competences, but to develop new skills. New ecosystems, new types of partnerships, new business models in the fields of services and infrastructures are necessary and should be fostered.

It is important to design the coming experiments to address the questions raised by cities on congestion, use of urban space, air quality and noise pollution, acceptability, and the development of new urban planning processes

Experimental programmes should focus on use cases that bring real value to the citizens, whilst not competing with existing soft modes such as walking and cycling. Intermodality, common and interoperable services across cities and countries will accelerate the acceptation and adoption processes.

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In this scenario, the availability of SAE L4 passenger cars might encourage the development of peer to peer sharing. In this case, private vehicles could become a resource for the mobility needs.

Lastly, the availability of harmonized frameworks and regulations is highly necessary. They should go beyond the sheer regulations for road safety, and embed the ethical and societal aspects, such as:

- Data sharing and quality check, privacy and security, storage and accessibility.
- Proper procedures for procurement, allowing a sustainable development path for the providers, and confidence for the citizens.
- Constraining by-effects such as cannibalising public transportation, walking or cycling, increasing commuting distances, decreasing urban air quality or exploding parking prices.

As public bodies are following and not the leading actor in this scenario, guarding public interests will be the main role.

Big data and artificial intelligence

- EU policies for data sharing and EU ethics for appropriate data use are required to stimulate and encourage car manufacturers, other institutions and even individuals to share their data. This has a great impact on the re-usability of data that has been collected or aggregated. The importance of data sharing is underlined by its relevance for data-hungry machine learning algorithms.
- Hardware and software technologies for data storing, management, and computing are one of the main enablers for the deployment of different services. Data is collected from many different sources, by different parties and in different formats. Technically the storage and accessibility of this data will become a real challenge at some point. This may require developing new data storage solutions as well as new strategies for data management and reduction.
- Common procedure for training and validation of AI-based functions. This includes the harmonisation of test cases and training data sets for AI functions and the question of completeness of training scenarios. This will accelerate the development of AI technologies and improve the user acceptance.
- Harmonization of AI-based technologies investments and developments will accelerate the development and support users trust and acceptance.

Evolution of new AI techniques is needed to fulfil the future automated driving functionality and services. This can be achieved by encouraging new initiatives working on developing new AI concepts and techniques (including transparency and traceability) especially in the research and academic sectors.

Freight and Logistics

Common rules, standardisation and regulations in Europe harmonising national and regional freight traffic, in particular for the CAD domain, will contribute to creating a clear legal framework. Homologation and type approval issues being discussed in parallel between the UNECE WP.29 and UNGRVA and the EC will avoid fragmentation of the application of regulation. Moreover, the adoption of digital transport document solutions such as eCMR will enable more seamless

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operations. However, specific legislation aiming to ensure cybersecurity of such transport operations will be key. This is particularly applicable to the transport of dangerous goods.

It is important to continue with real world testing and large-scale pilots. The European transport infrastructure network landscape is profoundly diverse. Real world testing in different circumstances and realities across Europe will enable policymakers to have an overview of different realities on the road. The ENSEMBLE project will provide the enabling standards to perform future testing multi-brand truck platooning under real world traffic conditions. Freight transport operators need to be involved in real world testing and consider their role as end users in real logistics operations.

Establishing a stronger cooperation with ITS would ensure that operations are conducted in an organised and efficient manner when considering long distance, regional and urban freight delivery services. Real-time traffic management could reduce delivery times, improve ETA (estimated time of arrival) and reduce congestion for last mile services. Cities need to be involved so that they are adequately prepared for a multitude of automated freight vehicles on the road. Enhancing collaboration among different stakeholders is essential to improve supply chain management.

Driver training programmes need to include technological advances and train drivers accordingly. If trained appropriately, fleet operators could be able to attract young drivers to the profession given the attractiveness of technology. At the same time, legislation must be adapted in order to cover aspects related to liability and driving and rest time regulation. Highly automated trucks could enable drivers to rest and balance driving and rest times. For this reason, the driving and rest time regulation needs to be amended accordingly.

Several pilot operations need to experiment for hub-to-hub freight transport flows, linking terminals and freight, and increasing transport corridor utilisation. Some transport flows will operate with unmanned vehicles, mainly in hubs and in selected dedicated hub-to-hub operation of highly automated vehicles. This will translate into a higher efficiency and increased use of resources. At the same time, costs will decrease for fleet operators given the presence of higher levels of automated. However, considering that the driver's responsibilities will change, retraining must be mandatory in order to avoid job losses.

Truck platooning promises to enhance freight transport in Europe. Road operators need to cooperate with vehicle manufacturers and fleet operators piloting truck platoons in order to establish a free flow traffic area to operate smoothly. To fully explore the benefits of truck platooning, the role of vehicle-to-infrastructure cooperation needs to be further investigated. Interoperability, cross border, data sharing are a few elements that have to be addressed. Shippers and large corporations are seeking the most cost-efficient way to transport a collection of shipments from a set of starting points (A) to a set of arrival points (B). It is important to differentiate between automation in different segments in the logistics chain: confined areas, hub-to-hub, open roads and last mile due to the difference in authority, vehicles and operators. To this end, service providers could be interested in providing road authorities the necessary tools.

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3.2 Scenario B: Authority driven with focus on collective transport (difference to Scenario A)

3.2.1 Bottlenecks and challenges

Physical and Digital Infrastructure

Public authorities remain in the centre of infrastructure challenges, but, in scenario B, they will play a stronger role in supporting the deployment of the services, hence pay a greater attention to the requests and needs related to the support for infrastructure. There should be more actions and incentives to create the stakeholder's ecosystems able to develop the missing building blocks, but, more important, there should be greater efforts to foster the deployments of infrastructure, and the upgrading and adaptation of the existing ones, wherever the services are required.

The public authorities' actions will facilitate the research of solutions in liability problems, and the implementation of standards which are necessary for fluent cross-border operation and consistent or at least known quality of PDI and for the support of data quality and availability.

The challenges listed for scenario A remain valid, but the momentum to solve them should be much more adapted in scenario B. Interoperability requirements will be at a high level right from the early stages of deployment. The infrastructure technology will have to be accessible to all vehicles.

The pressure on deployment global costs (including maintenance) will be higher.

Interaction with public transport will be higher in this scenario, and multi-mobility will be more developed. The result will be an increased complexity of the digital infrastructure to deploy combined with an improved eco-efficiency.

New mobility services

Services driven by authorities should focus much more on the balance between social benefits and target a much higher integration of new mobility services in the city transport plans and MaaS platforms.

Integration with public transport will be mandatory, as well as the accessibility to vulnerable and disabled users, which will increase the constraints on service and vehicles design. The initial focus will be made on deployments in low-demand and peri-urban areas, where the technical challenges are easier to address.

Smooth integration within the traffic management systems should be addressed from the early stage, as well as the evaluation of impacts on the citizens, the urban planning and land use, the modal choice, and the socio-economic impacts on the city as whole. Citizens acceptance (users' and non-users') will be studied more carefully, at the early stages of implementation. The timeframe necessary for service implementation should be negatively impacted by this higher level of expectations.

Respect of privacy and data-usage will be under higher control. The data governance will be supervised by public authorities who may act as a trusted third party. The current GDPR already covers this topic and will be implemented with more rigor than in scenario A.

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The development of services based on SAE L4 passenger cars might be slower in this scenario. There could be however an interest from public authorities to foster the use of individual cars as an additional transport capacity, through the implementation of incentives to share vehicles (for example: access to priority lanes for shared vehicles). In that case, the public policies would have an effect on the demand for SAE L4 service vehicles.

Big data and artificial intelligence

The challenges listed in scenario A remain valid, but the expectations from public authorities will be higher, as the expectations in terms of data quality, validation, and sharing. The privacy, security and usage of the shared data is managed by public authorities which reflect positively on the users' acceptance. The harmonisation of AI-based technologies is easier in this scenario and comes along naturally.

Freight

The challenges do not differ from Scenario A. Through a higher level of harmonisation, cross-company mobility of goods may be more feasible and efficient. For example, transport competitors might collaborate on filling empty trucks on a return ride.

3.2.2 Enablers to speed up processes

Physical and Digital Infrastructure

The difference with Scenario A should be found in a higher level of support from the Public Authorities to develop the missing building blocks, but mostly to accelerate the rhythms of deployment.
A more consolidated approach should be in place, at national but also at European levels.

New mobility services

The local and international political support to data providing and sharing should reinforce the citizens trust.

In this scenario, public authorities will lead the deployment, instead of supporting it. Experimental projects will be initiated by public authorities, and incentives for vehicle sharing will be easier to test and deploy.

Finally, the involvement of public authorities, even leading to a higher level of requirements in the integration of the services to the cities, should make the smooth and sustainable deployment easier for the service operators, and all the stakeholders. Rhythms of deployment could be longer, but more sustainable.

Big data and artificial intelligence

Enablers do not differ from scenario A. The realisation of these enablers is highly dependent of the public authorities. This make them on one hand easier and closer to be achieved.

Freight and Logistics

Enablers do not differ from Scenario A.

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3.3 Relations to ongoing activities outside of ARCADE

EU Projects

The table below is composed of relevant EU R&I projects that are related to CAD, in particular to the Systems & Services layer of thematic areas.

Project Name	Duration	Website	Challenge addressed
AUTOPILOT	01/2017 – 12/2019	https://autopilot-project.eu/	HD maps and database for automated driving vehicles Driverless car rebalancing and route optimisation
INFRAMIX	06/2017 – 05/2020	https://www.inframix.eu/	Design and upgrade existing infrastructure Simulation and impact on existing traffic Novel signalling and visualization elements Traffic safety
AVENUE	05/2018 – 04/2022	https://h2020-avenue.eu	Development of new innovative services, addressing user acceptance, safety validation and socio-economic impacts
COEXIST	05/2017 – 04/2020	https://h2020-coexist.eu	Increase the capacity of road authorities to successfully plan the introduction of AVs in the existing infrastructure
ICT4CART	09/2018 – 08/2021	www.ict4cart.eu	the requirements of connectivity for higher levels of automation, combination of information from various sources to improve localisation, the new business models for infrastructure
FABULOS	01/2018 – 12/2020	https://fabulos.eu	Build a pre-commercial procurement process and guidelines for cities Assess the maturity of existing solutions
T-TRANSPORT	01/2017 – 07/2019	www.transformingtransport.eu	The use of big data to create value in transport : data sharing approach, big data best practices and the impact on operational strategies and business models
MAVEN	09/2016 – 08/2019	https://maven-its.eu	Infrastructure capacity, traffic efficiency management, by structuring the negotiations processes between vehicles and infrastructure
5GMOBIX	11/2018-11/2021	https://www.5g-mobix.com	Match the benefits of 5G technology with advanced CCAM use cases, to enable previously unfeasible automated driving applications
ENSEMBLE	06/2018 – 05/2021	https://platooningensemble.eu	Road approval requirements taking into account the impact of platoons on the road and infrastructure
AEROFLEX	10/2017 – 02/2021	https://aeroflex-project.eu/	Aerodynamic and flexible trucks for next generation of long distance road transport
AEOLIX	09/2016 – 08/2019	http://aeolix.eu/	Data exchange platform for logistics

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Ongoing initiatives

There are various ongoing initiatives taking place at EU and international level on CAD. The purpose of the section below is to give an overview of the relevant activities in each thematic area by explaining their function.

- All topics:
  - Trilateral US/Japan/EU – working group PDI and Connectivity, Next Generation Transport (New mobility services), Impact assessment (New mobility services)
  - STRIA:
  - Contributions to documents related to PDI
  - Contributions to documents related to New Mobility Services
  - Big data and AI working group
  - ERTRAC - Roadmap and Strategic Research Agenda – Exchange concerning:
  - Infrastructure elements and vehicle requirements,
  - New mobility services, shared economy and business models,
  - Long-Distance Freight transport, WG LDFT (provides an important multi-stakeholder environment for CAD freight vehicles solutions)
  - Working Group for Connected Automated Driving provides the common enablers for CAD
  - CCAM Expert Platform:
  - PDI and Connectivity working groups
  - WG2 Coordination and Cooperation of R&I and testing activities
  - WG1 Develop an EU Agenda for testing
- Physical and Digital Infrastructure
  - CEDR Working Group for Connected Automated Driving provides the important link to the Road Operator and Authorities dimension.
  - MANTRA project supports the CAD WG with assessment of road operator core business changes due to highly automated driving
  - C-Roads Platform – joint initiative of European Member States and road operators for testing and implementing of C-ITS services for cross-border harmonisation and interoperability.
  - NordicWay2 – C-ITS harmonisation in Nordic countries Denmark, Finland, Norway and Sweden – part of C-Roads
  - FEHRL – preparing Europe’s road network for automated driving
  - C-ITS platform and further platforms for connectivity such as 3GPPP and 5GAA
  - 5G Momentum ecosystem (Finland) promotes the development and implementation of 5G services by creating a new type of cooperation network for 5G trials. Trials and tests aim at facilitating new services and innovations based on 5G technology.
  - EU EIP (CEF-funded project) with activity on Facilitating automated driving providing operational level recommendations to road authorities and operators on how to facilitate automated driving
- New mobility services
  - UITP activities on new mobility services and projects (SPACE project)
- Big data and AI
  - Data Task Force – joint initiative of European Commission, European Member States as well as OEMs and service providers for C-ITS interoperability

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    - Reviewing (through AI Alliance) the Draft Ethics Guidelines for Trustworthy AI, drafted by High-Level Expert Group on Artificial Intelligence.
- Freight & Logistics
    - The ALICE ETP provides an important network with the logistics service provider network, to elaborate on the freight automation needs and opportunity.
    - IRU activities related to freight transportation
    - EUCAR Strategic Group for Commercial Vehicles

3.4 Actions to be taken

Actions have been identified in all thematic areas, with the relevant stakeholders and the level of priority. The actions have been derived for all 4 scenarios.

Physical and Digital infrastructure

- For scenario 0: Coordination actions to elaborate and standardize ISAD (infrastructure support levels for automated driving) and lane marking
- Definition/Specification of smart road elements (landmarks, radio beacons, augmented GNSS satellites etc.), and harmonization of data specifications for each map layer (static, semi static, semi dynamic, dynamic). Developing EU standards for digital infrastructure description is probably the most urgent action needed, considering the investment required.
- Define the classification of PDI support levels as a base for further development. This will allow to share and better understand the results of tests and projects.
- Traffic management: Simulations and assessment of PDI supported automation effects on traffic efficiency and safety, and its effects on new traffic management concepts.
- Maintenance: Development of (automated) PDI-quality on road network in terms of maintenance of road infrastructure (regarding ISAD levels).
- Business models: Studies and concepts regarding business models in order to assess and to stimulate PDI investments and operation of services.

New mobility services

- For scenario 0: research actions are necessary to investigate the business models, and enable the introduction of costly SA2 L2 functions in the fleets of vehicles.
- Research actions in the investigation in new services concepts: develop and test new concepts of high-quality services for all users, set up large scale experimentations to assess the impacts (including socio-economic impacts, the impacts on traffic and transport flows, the use of public space, wider economic impacts.)
- Research action and large-scale experimentations to develop the future business models, and identify the relevant ecosystems of new mobility services.
- Coordination action to raise the public authorities' awareness, develop the integration in the cities' existing governance, define the framework to foster and accelerate the implementation, and involve the local authorities in the early stages of development.
- Coordination action to share the testing and assessment methodologies.
- Coordination action to define and share the most valuable use cases and application areas
- Research action to explore the possibilities of automated urban delivery

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Big data/ AI

- For scenario 0: coordination action to establish a consensus on AI validation and acceptable performance levels, as well as data sharing framework.
- Development and harmonisation of data specifications and frameworks. Sharing common data formats is necessary to rationalize investments, ensure the compliancy to privacy protection regulation (GDPR) and gain the citizens' trust. Key objectives will be to ensure provision of high quality and well-documented datasets, co-operate on a technical reference platform with other data sharing initiatives, encourage data re-use and establish win-win situations to keep the balance between privacy/IPR and availability.
- Facilitate (centralized) data storage technologies and their maintenance.
- Support research and development on AI techniques to meet the remaining challenges of CAD in all types of environment, for all use cases (passenger cars, freight and logistics, and urban mobility solutions). Highly automated solutions will be addressed in different levels (vehicle, services, mobility and traffic system).
- Research actions on new AI concepts for cyber-physical traffic systems.
- Support research and innovation to develop the concepts, techniques and models of artificial intelligence, and provide the harmonisation needed for development and validation.

Freight and logistics

- For scenario 0: research actions to investigate the impacts of low level automation on the drivers' work organization and the business models.
- Provide the regulation framework regarding liability issues.
- Clarify the regulation framework concerning the driving time.
- Develop and prepare the hub-to-hub transport corridors for tests, pilots and pre-deployment activities
- Investigate new logistics services, and assess the business needs for AD

On top of the actions requested specifically for each thematic area, transversal actions have been identified, which are shared by all areas:

- There is a common need to consolidate the knowledge acquired by European and national projects, and to encourage closer cooperation to share methodologies (including the description of use cases and experiments descriptions) and results. Therefore, it is recommended to encourage national projects to join the European knowledge base.
- This recommendation is valid for all thematic areas. For instance, AVENUE, Drive Sweden, Autopilot, Fabulos could significantly contribute to the New Mobility services area development. In the area of Freight and logistics, combining the results from the ongoing projects; ENSEMBLE, AEROFLEX, AEOLIX and other projects, would allow relevant further actions, projects and common initiatives.
- The second recommendation shared by all thematic areas is to consolidate the stakeholders' views: Foster the dialogue with the logistics sector, primarily through ALICE and ERTRAC LDFT, foster the dialogue with the road infrastructure providers, e.g. through CEDR and ERTRAC, and with the major European truck OEMs through EUCAR.
- Clarifying the new roles and responsibilities of the stakeholders in the context of AD development and deployment is also shared by most thematic areas: research on business and financing models, new governance and responsibilities is needed.

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- Promoting the use of common glossaries and definitions in all thematic areas: PDI definitions, use cases, scenario descriptions, service terminologies across the various roadmaps is necessary to ensure a quicker appropriation by common stakeholders and share of results.

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3.5 Key actions, Prime actors and Priority

In the below table, priority actions from the previous section are summarized with the prime actor involved.

Key action	Prime actor	Priority
Define common EU standards for the interaction of PDI and AVs	EU, Standardization	High
Define how to use ISAD for commercial freight vehicle operation	Research	Medium
Define Classification of PDI	EU, Authorities,	Medium
Create living labs with PDI	EU, research	Medium
Prepare PDI for AV-ready road planning and self- explaining roads	EU, operators, Authorities	Medium
Identify new infrastructure business models and financing tools to support deployment	Research, Authorities, research, operators	High
Define the involvement of public authorities in the early stage of deployment to create trust among stakeholders	EU, Authorities, Policy	High
Create the actions to raise the awareness of public authorities of the new role of services and systems, their integration and operation	EU, Authorities, Research	Medium
Foster the development of new ecosystems, new types of partnerships, new business models in the fields of services	EU, Operators, authorities, OEMs, Research	High
Develop and test use cases for new mobility services that bring real value to the citizens, whilst not competing with existing soft modes such as walking and cycling	EU, Operators, authorities, OEMs, Research	High
Integration of new services with existing services (e.g. public transport) from start	EU, Operators, authorities, OEMs	Medium
Develop intermodal, common and interoperable services within and across cities and countries	EU, Operators, authorities, OEMs, Research	Medium
Further develop urban delivery AD solutions	EU, authorities, research	Medium
Explore the opportunities of peer to peer sharing	Operators, OEMs, Research	Medium
Ensure the availability of automated fleets for tests, pilots and FOTS	OEMs, EU	Medium
Pilots and FOTs to validate business case, operational models and specifications	EU, Operators, authorities, OEMs, Research	High

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Develop 'standard' model for sharing data that ensure data privacy and security	EU, Standardization	High
Develop new AI-concepts for cyber-physical road traffic systems	EU, Operators, authorities, OEMs, Research	High
Standardised data storage and management facilities (Hardware and Software) to enable data sharing	EU, OEMs, Research	Medium
Harmonisation, alignment needed for development and validation of AI functionalities for AV	EU, Operators, authorities, OEMs,	High
Develop new AI Concept, techniques and models to fulfil the challenges of CAD functionalities and responsibilities for all development paths	EU, Research (universities & research institutes)	Medium
Provide clarity about relaxed driving time regulation for automated truck driving	Policy	High
Draft ad-hoc regulation related to liability for the different automation levels	Policy/Research	Medium
Identify the impacts of AD on the freight and delivery business models (TCO)	EU, Research, OEMs, operators	Medium
Prepare and equip hub-to-hub corridors for AD truck	EU, Research, operators	High

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4 Conclusion and recommendations

Looking at research and innovation, technologies will come to the market as soon as they are mature enough to fulfil customer needs and will be applied to vehicles connected to the cloud and used. That is why the consequences of the scenarios do not differ strongly in D3.1 (Vehicles and Technologies), but with growing understanding of the capabilities of vehicles with such technology, systems will be able to be defined clearer and clearer and new services will lead to new businesses around them and for the sake of their providers. This leads to slight differentiation of the scenarios in D3.4, without leading to different actions. Depending on how these systems and services are controlled and rolled out, there is clear differentiation for the individual user and his or her needs of comfort and time efficiency as well as for the society and its needs of safety and environmental efficiency in D3.7 (Society).

The priorities and actions resulting cover both specific and generic needs (see section 4). The recommendation to align stakeholders on common methodologies, vocabulary, data format, use case descriptions, and architectures is common to all areas, as well as the need for large-scale testing. The link with existing initiatives and EU projects has been made. It is also recommended to foster the integration of national projects and that the consolidation of results should be made through the knowledge base (WP4).

This is the result of the joint work in WP3 through the succession of sprints and workshops organized during the first year and consolidated during the September 1-3 2019 workshop. The results have been integrated in the ARCADE consolidated roadmap 2019 (D2.1).

This document will be updated annually and enriched with the results of ARCADE year 2 and 3 research. It delivers the analysis of the main challenges, enablers and actions required within different scenarios researched during the year 1 of ARCADE.

The key differentiation factor between the developed scenarios lays in the level of support and involvement of the public authorities. The impact of this variation being important on the ability to deploy the systems and services in an optimal way, it is recommended to continue and intensify Large-Scale Pilots and FOTs, to demonstrate the benefits of the new mobility services, and convince the local authorities. It is necessary to maintain the service on long periods to evaluate the evolution of acceptance and behavior in time. Service, systems and operation conditions will have to be developed together with transport authorities and transport operators. This will also ensure integration with public transport.

The actions requested to address the identified technical and business challenges are complex, costly, and need to be initiated at a European level. More testing, experiments, sandboxes, will be required to gain knowledge, and higher levels of maturity. Therefore, aligning the methodologies and establishing a sound cooperation between existing EU and national projects must become a priority. This concerns the harmonisation of Physical and Digital infrastructure descriptions, but also the methodologies for services description, testing procedures, impact assessment…

Lastly, gaining the public trust in the technology, the safety, and the ethics of the future systems and services also requires a strong policy in the field of data sharing and quality, and IA algorithms availability. A clear policy framework (including measures on the privacy issues), and additional research projects are necessary.

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4.1.1 Recommendations

The recommendations for further actions are listed in **Error! Reference source not found. Error! Reference source not found.** and 3.5 Key actions, Prime actors and Priority.

4.1.2 Next steps

The next steps, plan for ARCADE WP3 year 2, will focus on the following activities;

- Organise the thematic work for year 2 in 4 sprints, focussing on additional scenarios, approaches, impacts and proposed steps (T3.1)
- Perform 2 joint stakeholder networks workshops with WP2 to further consolidate, elaborate, develop and rank the key priorities as identified in the D2.1. This is planned for February and Spring 2020 (Task 2.3)
- Define additional scenarios, approaches, impacts and proposed steps for the thematic areas (T3.2, T3.3, T3.4)
- Provide thematic input for the EUCAD symposium at TRA in April 2020 in Helsinki and partially lead the sessions (WP3).
- Consolidate the year 2 thematic areas and provide input to the knowledge base (WP4)

These steps will lead to three updated reports at the level of Society, Systems and Services and Technology and Vehicles (September 2020)

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Overview of ARCADE Deliverables Year 1:

Deliverable	Topic
D3.1	Technical thematic areas: challenges and scenarios
D3.4	Systems & Services thematic areas: challenges and scenarios
D3.7	Society thematic areas: challenges and scenarios

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6 Glossary: Acronyms and definitions

Term	Description
AD	Automated Driving
AI	Artificial Intelligence
ARCADE	EU H2020-DT-ART-2018-2019/H2020 DT-ART2018 CSA project, GA number 824251
ART	Automated Road Transport
AV	Automated Vehicle
CARTRE	EU H2020 ART06 CSA project CARTRE, GA number 724086
CAD	Connected Automated Driving
CEF	Connecting Europe Facility
C-ITS	Cooperative Intelligent Transport Systems
eCMR	Digital CMR (Convention relative au contrat de transport international de Marchandises par Route)
EC	European Commission
ERTRAC	European Road Transport Research Advisory Council
ETP	European Technology Platform
EU	European Union
EuroRAP	European Road Assessment Programme
FOT	Field Operational Test
GNSS	Global Navigation Satellite System
ITF	International Transport Forum
ISAD	Infrastructure Support levels for Automated Driving
L	(automation) level
LDFT	Long-Distance Freight transport
LIDAR	Light Detection and Ranging
MaaS	Mobility as a Service
ODD	Operational Design Domain
OECD	Organisation for Economic Co-operation and Development
OEM	Original Equipment Manufacturer
PDA	Personal Digital Assistant (handheld device)
PDI	Physical and Digital infrastructure
PT	Public transport
R&D	Research & Development
RSU	Roadside unit
RTK	Real-time kinematic (positioning) is a satellite navigation technique
SAE	Society of Automotive Engineers
SEC	Identifier for EC documents: now used only for internal documents of the European Commission, which are not published on EUR-Lex and replaced by “SWD” for “Staff and joint staff working documents” (Staff working documents had the identifier SEC prior to 2012)
STRIA	Strategic Transport Research and Innovation Agenda
TA	Thematic Area
UNGRVA	United Nations’ Working Party on Automated/Autonomous and Connected Vehicles
VRU	Vulnerable Road Users
WG	Working Group

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