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Reflection roadmap and action plan analysis 2019-2020

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Contents

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Abbreviations

Term	Description
ARCADE	EU H2020-DT-ART-2018-2019/H2020 CSA project Aligning Research & Innovation for Connected and Automated Driving in Europe, GA number 824251
CARTRE	EU H2020 ART06 CSA project Coordination of Automated Road Transport Deployment for Europe, GA number 724086
CAD	Connected Automated Driving
CCAM	Cooperative Connected and Automated Mobility
Thematic areas	The Joint Stakeholder Network established in CARTRE identified 10 Thematic areas to break up the huge domain of CAD, i.e. medium- to long-term Research & Innovation needs, and produced Position Papers for these thematic areas, which served as a basis for the STRIA CART Roadmap. In ARCADE, these thematic areas were re-defined into 12 thematic areas, and grouped based on ERTRAC groups: "Technology & Vehicles", "Systems & services" and "Society"

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Executive Summary

One of the ARCADE goals is dedicated to create a strategic alignment between member states with a common European (regulatory) approach for Connected and Automated Driving (CAD) while taking into account national specific conditions. A first step into this direction is to explore the variety, differences and commonalities of roadmaps and national action plans on CAD. Such an effort was undertaken in 2018 which is reported in CARTRE Deliverable 2.2 Overview and analysis of ART stakeholder groups and initiatives. This report summarises the results of an update of the analysis based on roadmaps and actions plans that were published in 2019 and 2020. It is also an effort aimed at updating the online connectedandautomateddriving.eu knowledge base which provides an overview of roadmaps and action plans that aim at bringing automated driving to the roads.

In the current analysis a total of 41 new publications were found out of which 31 were selected for further review. The non-selected documents only address connected and automated driving indirectly or are annexes of one of the selected documents. The collection of 31 documents has served as the basis for the so-called matrix analysis where all the documents have been analysed and categorised according to the ARCADE thematic areas. It shows how often certain topics were addressed in various documents and provides an insight into areas where strategic alignment across member states and stakeholders could have added value. An overview of the documents is given in Annex A of this report and the documents are sub-divided in the following categories:

1. Roadmaps EU countries (8)
2. Roadmaps non-EU countries (7)
3. Roadmaps platforms (12)
4. Roadmaps industry (4)

Analysis of roadmaps and action plans

In a first analysis a matrix was created to indicate to what extent each thematic area is addressed. For some documents it was difficult to assess which thematic area is addressed, implicit or explicit, as there seems to be some overlap in the thematic areas. The results of this first analysis can be found in Table 3. The percentages represent the number of documents that address the thematic area divided by the total number of documents per category and overall. The absolute numbers are provided in the mapping tables in Annex A.

Table 1 Matrix analysis

Normalised by category	Policy and regulatory needs, European harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, societal acceptance and ethics	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New shared and automated mobility services	Human factors	Connectivity	Deployment, Production and industrialisation	Freight and logistics
Roadmaps EU countries	75%	63%	75%	63%	50%	38%	38%	50%	63%	38%	50%	13%
Roadmaps non-EU countries	71%	57%	86%	43%	86%	57%	71%	43%	29%	57%	57%	43%
Roadmaps platforms	75%	63%	88%	25%	75%	25%	25%	38%	38%	25%	75%	63%
Roadmaps industry	100%	0%	50%	50%	50%	50%	0%	50%	0%	75%	75%	50%
Average	78%	52%	78%	44%	67%	41%	37%	44%	37%	44%	63%	41%

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All thematic areas were addressed, so there is not one missing which could have been a good pointer to focus on for upcoming initiatives. The percentages in Table 3 result from a quantitative analysis and therefore it is not possible to draw conclusions about the (extra) effort needed in certain areas (with low percentages). In other words, there is no explicit need to put effort in making everything "green", the quality depends on the actual efforts. On the other hand, it seems that topics that have a high frequency (high percentages) are very suitable for (strategic) alignment.

The documents across all categories relate the strongest to the thematic area of "Policy and regulatory needs, (European) harmonization" and "Safety validation and roadworthiness testing", followed by "Digital and physical infrastructure" and "Deployment, Production and Industrialisation". This is in line with expectations. The "Human factors" and "Big data, AI and their applications" thematic areas are least discussed, closely followed by "Freight and logistics", and "In-vehicle technology enablers". Lastly, all industry roadmaps address the thematic area "Policy and regulatory needs, (European) harmonization". This notion is remarkable, as it might indicate that industry would benefit from a policy and regulatory framework.

In 2018, a similar analysis has been conducted by CARTRE (see aforementioned D2.2). The results of this analysis can be found in Table 4. Like in the previous table, the statistics provide a snapshot of the current state, i.e. in 2018 and 2020. In 5 years from now other themes might be dominant.

Table 2 Matrix analysis (CARTRE, 2018)

Normalised by category	Policy and regulatory needs, European harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, societal acceptance and ethics	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New shared and automated mobility services	Human factors	Connectivity
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Roadmaps non-EU countries	92%	38%	69%	31%	54%	31%	38%	31%	23%	46%
Roadmaps platforms	82%	55%	45%	45%	73%	55%	18%	27%	36%	27%
Roadmaps industry	44%	44%	44%	22%	22%	56%	11%	11%	0%	22%
Average	**71%**	**42%**	**58%**	**31%**	**46%**	**35%**	**29%**	**17%**	**17%**	**44%**

Comparing both matrix analyses leads to the following most clear findings:

- In 2020 two thematic areas have been added: "Deployment, production and industrialisation" and "Freight and logistics".
- Now, all percentages (except "Connectivity") are increased compared to 2018, meaning that on average, roadmaps are now addressing more thematic areas than in 2018.
- The documents in which the thematic area "New shared and automated mobility services" is addressed saw the largest rise, with an increase of 27% point.

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- There is no significant difference in the thematic areas "Connectivity", "In-vehicle technology enablers", "Policy and regulatory needs, European harmonisation", and "Big data, AI and their applications".

Conclusion

After analysing the documents, it became evident that there seems to be some overlap in the thematic areas, making it difficult to assess which thematic area is addressed, implicit or explicit. Furthermore, quite a broad playing field is addressed by the selected documents, sometimes even within one document. As a result, the abstraction level for the topics discussed in most documents is rather high. Especially for roadmaps, the abstraction level for a single thematic area is rather high, and therefore it is difficult to assess whether strategic alignment is possible. Most content is of exploratory nature and concrete actions, conclusions or directions are often lacking. This makes it hard to assess similarities and differences. However, three topics are addressed in different documents regularly and could be considered similarities:

- Close cooperation between all public and private stakeholders involved in Cooperative Connected and Automated Mobility (CCAM) is considered a key enabler towards CCAM.

- CCAM should take a key role in European, national, and local transport policies, since it can support several of their objectives. Authorities should look at planning for CCAM as an element of a more fundamental change process: proactive action to get ready for the new challenges like mobility planning towards CAV deployment. Furthermore, cities and regions have to accept their responsibility to shape the future and cannot wait until issues are fixed at higher policy levels and/or until the new technologies have already been deployed.

- Noteworthy is a comment in the Levitate project's Deliverable 5.1 [26], in which market penetration of technologies has been researched. They discovered that the technological roadmaps they have looked into are generally focused on when a particular technology will be available, but not on its market penetration. This notion also applies to many of the 31 analysed documents, as often only attention is given to the final image and not to intermediate steps.

While it seems to be difficult to go to a lower abstraction level (a step towards concrete actions and recommendations), the following documents stand out in a positive manner:

- The "UK Connected and Automated Mobility Roadmap to 2030" [10] provides a single vision towards 2030, and four themes and sub-themes (called "streams") are defined to further specify the topics which should be taken care of until 2030. Furthermore, each theme and stream consists of concrete actions and milestones (e.g. a process (activity to be undertaken), output (tangible deliverable) or outcome (result of a process and/or output).

- The "National land transport technology action plan 2020-2023" [9] sets out short-to-medium term national priorities based on Australia's Policy Framework for Land Transport Technology. The action plan consists of concrete actions over the next three

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years by and for Australian governments to avoid duplication and encourage greater collaboration and sharing of key learnings.

These two documents differentiate from the other 29 documents by providing multiple concrete actions. Moreover, the UK and Australia also stand out with the structured approach they have implemented. One organisation/department provides a vision, another organisation/department sets out concrete actions to work towards the vision, and again another organisation/department executes the action. This approach underlines a key statement in ‘Roadmap and action plan to facilitate automated driving on TEN road network - version 2020’[16]: “It would be advisable to converge the large number of roadmap activities in Europe towards a smaller number of dedicated work streams.”

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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 84 consortium and associated partners (to date) from 34 countries within and outside EU, who form the backbone of the Joint CAD Network of over 450 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.

One of the ARCADE goals is dedicated to create a strategic alignment between member states with a common European (regulatory) approach for Connected and Automated Driving (CAD) while taking into account national specific conditions. A first step into this direction is to explore the variety, differences and commonalities of roadmaps and national action plans on CAD. Such an effort was undertaken in 2018 which is reported in CARTRE Deliverable 2.2 Overview and analysis of ART stakeholder groups and initiatives. This report summarises the results of an update of the analysis based on roadmaps and actions plans that were published in 2019 and 2020. It is also an effort aimed at updating the online connectedandautomateddriving.eu knowledge base which provides an overview of roadmaps and action plans that aim at bringing automated driving to the roads.

1.2. Purpose of the document

The first edition of this report[2] (overview of roadmaps, pilots and test sites in the field of Connected and Automated Driving) was published as part of the EC-funded CARTRE European project, based on the work initiated by the Dutch Knowledge Agenda for automated driving[3]. The present update has been prepared in the framework of the EC-funded ARCADE European project and is the result of the analysis of roadmaps and action plans published in 2019 and 2020. In the current analysis, a total of 41 new publications were found out of which

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[1] COM (2018) 283

[2] https://knowledge-base.connectedautomateddriving.eu/wp-content/uploads/2019/10/WP2_D2.2_OverviewARTStakeholder_FollowUp_V1.0_appendix8.5_Overview_ART_roadmaps_pilots_testsites_v1.1.pdf

[3] Now findable on the website of Dutch Mobility Innovations: https://dutchmobilityinnovations.com/landing-en

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31 were selected for further review [4]. The non-selected documents only address connected and automated driving indirectly or are annexes of one of the selected documents. Also a reflection on the newest literature items has been completed. This reflection shows the variety, differences and commonalities of the newest roadmaps and national action plans on CAD and gives a follow-up of the CARTRE work.

[4] The complete list is published in the CAD Knowledge Base at https://www.connectedautomateddriving.eu/roadmaps/list-strategies/

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2. Analysis of roadmaps and action plans

The collection of 31 documents that has served as the basis for the so-called matrix analysis, has been analysed and categorised according to the ARCADE thematic areas. It shows how often certain topics were addressed in various documents and provides an insight into areas where strategic alignment across member states and stakeholders could have added value. An overview of the documents is given in Annex A of this report and the documents are sub-divided in the following categories:

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Table 3 Matrix analysis

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Table 4 Matrix analysis (CARTRE, 2018)

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- Close cooperation between all public and private stakeholders involved in Cooperative Connected and Automated Mobility (CCAM) is considered a key enabler towards CCAM.

- CCAM should take a key role in European, national, and local transport policies, since it can support several of their objectives. Authorities should look at planning for CCAM as an element of a more fundamental change process: proactive action to get ready for the new challenges like mobility planning towards CAV deployment. Furthermore, cities and regions have to accept their responsibility to shape the future and cannot wait until issues are fixed at higher policy levels and/or until the new technologies have already been deployed.

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2.2. Thematic areas

In the following pages the most characteristic statements from the 31 documents have been categorized in the thematic areas. The number between brackets at the end of each statement, refers to the source number (see Annex).

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2.2.1. Policy and regulatory needs, European harmonisation

Policy and regulatory alignment are vital: coordination between actors involved in the deployment of connected and automated mobility is needed to bring many traditionally separate industries closer together to converge vehicle connectivity and infrastructure. There is a consensus that it is not possible to test all real-world scenarios before allowing vehicles to test on live roads. Therefore, governments should facilitate live road environment testing to gain live road experiences. In addition, industry and academia should be stimulated to share pilot test data as guidance to support policy and investment decisions on technology in the road transport sector. Finally, well-balanced end-to-end regulation for the commercial deployment of automated vehicles should be a priority.

> Uncoordinated competition among service providers and a lack of leadership by transport authorities could lead to more traffic problems and an unbalanced provision of capacity. [3]

> Without good preparation and planning, CCAM implementation could actually amplify the urban mobility problems that cities are currently already facing, and lead towards increases int the number of travelled kilometres, urban sprawl and congestion levels. [5]

> Policy and regulatory alignment is vital; a patchwork inhibits innovation and is not in the public interest. [13]

> Cities should also be aware of the various opportunities, and challenges that arise from CCAM deployment. A structured & well-informed decision-making process, through holistic frameworks, is required to ensure sustainable and affordable services that align with local policy goals and respond to user needs. [17]

> Connected Automated Driving must take a key role in the European Transport policy, since it can support several of its objectives and societal challenges, such as road safety, congestion, decarbonisation, social inclusiveness, etc. [18]

> It is necessary to establish reflexive planning and governance concepts in which the possibility of revision is an integrated part of the planning process. [19]

> Cities and regions have to accept their responsibility to shape the future and cannot wait until issues are fixed at higher policy levels and/or until the new technologies have already been deployed. [19]

> Regulators are influencing deployment: Proactive regulation is attracting companies, but the balance of light vs. heavy regulatory approaches may impact this. [30]

2.2.2. Socio-economic assessment and sustainability

The main topic addressed in this thematic area is that efforts should be directed at identifying the impact of automation for road authorities and operators. Proactive action is needed to get ready for the challenge of mobility planning towards connected and automated mobility deployment. For these planning processes, strategically defined Key Performance Indicators related to local policy goals are seen as added value for supportive tools, such as a common impact assessment framework and connected and automated mobility modelling functionalities. Finally, the largescale uptake of automated vehicles has the potential of considerably impacting the labour force in sectors related to traffic and transport. The number

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of high-skill jobs in data and digital technology sectors Is expected to increase at the expense of demand for professional drivers.

Pilots and capacity building constitute a key initial measure to raise awareness and prepare the cities to respond to upcoming challenges. Pilots should be the result of a scenario building process including stakeholder engagement and assessing benefits of pilots. [5]

For several road transport projects, the research is based on the development of Apps. Future research should ensure that the latest state-of-the-art data sources and data processing techniques are used, as well as facilitating largescale trials and pilots. [8]

Safety and security are an underlying theme of the majority of demonstration projects. Therefore, it would be beneficial to build upon the research undertaken by previous European-funded projects, as well as working alongside the private sector, to ensure that research is being optimised and to dissuade the development of repetitive projects, which do not establish a step change in the field. [8]

2.2.3. Safety validation and roadworthiness testing

Although it is commonly acknowledged that connected and automated mobility will enhance safety, safety aspects - for example road safety, human factors and the training of users - are not always a basic principle in the design process right from the start. Therefore, there is a need for an elaborated vision on the required level of safety in relation to the desired extent and direction of innovation for connected and automated mobility.

Common methodologies and tools need to be developed to enable the verification and validation of CCAM systems in industrial development processes. [2]

There is no elaborated vision on the required level of safety in relation to the desired extent and direction of innovation for ADAS. [6]

Road safety is not a basic principle in the design process right from the start and insufficient account is taken of the driver who is required to operate the innovation. [6]

Although the development of automated vehicles is a competitive area, many issues must be addressed industry-wide to ensure safety. [15]

Close and constructive dialogue between road authorities and vehicle manufacturers is needed. [23]

2.2.4. User awareness, societal acceptance, and ethics

Public awareness campaigns should inform people about the safety benefits, as well as the vulnerabilities and risks of automated vehicles. Moreover, to achieve public acceptability the public must be engaged along the journey through trials, pilots and deployments, and designing services which meet true customer needs. For example, user-relevant and informative human-machine interfaces with a distinction made in end user groups, as for example driver comfort has a totally different meaning for private car drivers than it has for professional (freight transport) drivers.

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If connected and automated vehicles are set to play an important role to achieve the European policy objectives in the transport field, efforts will be needed to raise awareness of the options and their implications, and to engage citizens and build their trust with respect to this innovative type of technology. [4]

2.2.5. Digital and physical infrastructure

Consistency between on-board vehicle capabilities, physical infrastructure characteristics and support from the digital infrastructure is needed, as connected and automated mobility will have an impact on the role of digital and physical infrastructure. Therefore, cooperation between many traditionally separate public and private parties is needed to identify the Operational Design Domain (ODD). Specifically, for the digital infrastructure, it is necessary that up-to-date road information is available for automated vehicles.

Some projects have researched the role of physical infrastructure in facilitating connected and automated transport. Since there are relatively few projects under this sub-theme that utilise data to improve physical infrastructure design with connected vehicles in mind, this could be an area for further research. [8]

2.2.6. In-vehicle technology enablers

Current technological advancements of in-vehicle technology are focused on improving performance and accuracy and can be divided into three domains: sensing, localization, and cognition. Firstly, sensor development is vital for the uptake of automated vehicles, therefore innovation in camera-based systems as well as sonar, radar, and lidar applications should continue to be supported. Secondly, improvements in geospatial localization, in combination with the creation of digital twins and high-quality maps, can lead to a more accurate representation of the physical surroundings of automated vehicles. The third domain involves cognitive processes and includes the formation of knowledge, memory, processing, evaluation, and decision making. This is closely related to the thematic area of “Big data, AI, and their applications”. The basis of in-vehicle technology enablers should continue to be road safety and casualty reduction.

Most projects covered by the analysis are at the early stages of development, at basic research. Therefore, many of the projects have set the foundation for further development. [8]

2.2.7. Big data, AI, and their applications

Actors in the automated vehicle industry recognize the need for AI technology, especially for understanding traffic scenarios, predicting behaviour, and determining driving manoeuvres and strategies. However, its usability and competitiveness are limited due to the current ratio between system functionality and cost. State-of-the-art applications still partly rely on reactive rule-based control systems, whereas future AI systems should be predictive. Moreover, validation of existing AI techniques is a bottleneck: it requires huge amounts of data that must representative for the training of these techniques.

There are some inherent difficulties in supporting the ODDs as the ODDs depend on the capabilities of the sensors and software including artificial intelligence (AI) of the automated vehicles, and these capabilities are improving quite quickly with the evolution of related technologies. [21]

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2.2.8. New shared and automated mobility services

Without good preparation and planning, connected and automated mobility implementation could amplify the urban mobility problems that cities are currently already facing, and lead towards increases in the number of travelled kilometres, urban sprawl, and congestion levels. In addition, flexible options should be well-integrated into the public transport system, as otherwise flexible options may remain out of the reach of the more price-sensitive segments of the population.

> New transport technologies on their own will not spontaneously make our lives better without upgrading our transport systems and policies to the 21st century. [3]

> Flexible options may remain out of the reach of the more price-sensitive segments of the population unless they are well integrated into the public transport system. [3]

> Not only do all the actors involved need to cooperate but public authorities will need to play the role of an 'orchestra conductor' to ensure that all the players contribute to a more efficient transport system. [3]

> It is crucial that the new EU institutions continue focusing on creating the right enabling conditions across the EU to accelerate the deployment of new mobility solutions, leveraging both connectivity and automation. This supports the competitiveness of both the automotive and non-automotive companies, which have become active players in this new mobility ecosystem. [31]

2.2.9. Human factors

The explicit focus on designing inclusive and accessible technology in mind stands out, as does engaging and involving the public throughout the phases of automated vehicle development chain. This means that automated vehicle development must respond to the needs of all users, including those with special requirements and a lower socioeconomic status. The interaction between human drivers or passengers and the automated vehicle as well as between the automated vehicles and other road users must be explored. Another concern is the possible degradation of driving skills of vehicle drivers as they will have less operational driving tasks.

> The rules are lagging behind in respect of a number of safety aspects - for example human factors and the training of users - because manufacturers and government simply pay less attention to these aspects. [6]

> In order to achieve public acceptability public must be engaged and involved along the journey through trials, pilots and deployments, as well as designing services which meet true customer needs. [10]

2.2.10. Connectivity

Connected and automated mobility systems must be cyber-secure and fail-safe. The advent of automated vehicle technology in road vehicles has increased the number of external digital connections and therefore has increased cybersecurity risks. These risks, in combination with the large amount of sensitive data that automated vehicles must process, creates conflict with data ethics and privacy principles, and ultimately public trust.

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Projects that show deeper integration between fully or partially automated vehicles and connectivity with infrastructure, other vehicles and other connected devices and users (V2X) should be encouraged; especially those can have a positive impact on safety. [8]

Three main elements are part of the 5G Strategic Deployment Agenda: (i) Deployment Objectives; (ii) Cooperation Models; (iii) Regulatory Innovation. [28]

Avoid favouring one technology over another based on political priorities. Instead adopt a technology-neutral approach in which market-forces drive innovation and deployment. [31]

2.2.11. Deployment, production, and industrialisation

Establishing a network of 'European living labs' is one way to create a right environment in which innovative mobility solutions are tested and rolled out with the direct involvement of people. Also pre-competitive collaboration among European industry and research providers and knowledge sharing between different parties would contribute to creating the right environment. Such an environment could foster implementation of proven technologies, approaches, and policies throughout the transportation system, demonstration of the benefits of emerging technologies for improving the transportation system, and maintenance of technologies and policies to realize the full potential of benefits across all surface transportation modes.

It is premature to commence deployments unless road authorities and operators are certain that the solutions invested in will not become obsolete in the short term. [16]

Research and deployment should go hand in hand. [16]

The focus for the coming 10-year period in the development paths will be on highly automated vehicles (SAE L4) in mixed traffic. [20]

A combination of open and closed test site environments is desirable to gain the positive effects of respective environments. [27]

The role of the different stakeholders has to be defined in order to assure a clear contribution to the common good while at the same time guaranteeing a competitive market. [29]

2.2.12. Freight and logistics

Automation technologies will re-shape the future of road freight transport with considerable potential for new freight transport patterns as well as organisational structures, processes and business models for the sector. Connected and automated mobility will assist developments towards improving the efficiency of transport operations in the medium and long term.

The consensus was that collaboration between freight operators should be enforced by facilitating data sharing, utilising consolidation centres, and improving the last mile solutions. This statement is not limited to CATS applications. [24]

Freight vehicles can be regarded as tools and driving is a job. Therefore, driver comfort has a totally different meaning and commercialisation of automated freight vehicles has different driving factors than automated passenger cars. [24]

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3. Conclusion

After analysing the documents, it became evident that there seems to be some overlap in the thematic areas, making it difficult to assess which thematic area is addressed, implicit or explicit. Furthermore, quite a broad playing field is addressed by the selected documents, sometimes even within one document. As a result, the abstraction level for the topics discussed in most documents is rather high. Especially for roadmaps, the abstraction level for a single thematic area is rather high, and therefore it is difficult to assess whether strategic alignment is possible. Most content is of exploratory nature and concrete actions, conclusions or directions are often lacking. This makes it hard to assess similarities and differences. However, three topics are addressed in different documents regularly and could be considered similarities:

- Close cooperation between all public and private stakeholders involved in Cooperative Connected and Automated Mobility (CCAM) is considered a key enabler towards CCAM.

- CCAM should take a key role in European, national, and local transport policies, since it can support several of their objectives. Authorities should look at planning for CCAM as an element of a more fundamental change process: proactive action to get ready for the new challenges like mobility planning towards CAV deployment. Furthermore, cities and regions have to accept their responsibility to shape the future and cannot wait until issues are fixed at higher policy levels and/or until the new technologies have already been deployed.

- Noteworthy is a comment in the Levitate project’s Deliverable 5.1 [26], in which market penetration of technologies has been researched. They discovered that the technological roadmaps they have looked into are generally focused on when a particular technology will be available, but not on its market penetration. This notion also applies to many of the 31 analysed documents, as often only attention is given to the final image and not to intermediate steps.

While it seems to be difficult to go to a lower abstraction level (a step towards concrete actions and recommendations), the following documents stand out in a positive manner:

- The “UK Connected and Automated Mobility Roadmap to 2030” [10] provides a single vision towards 2030, and four themes and sub-themes (called “streams”) are defined to further specify the topics which should be taken care of until 2030. Furthermore, each theme and stream consists of concrete actions and milestones (e.g. a process (activity to be undertaken), output (tangible deliverable) or outcome (result of a process and/or output).

- The “National land transport technology action plan 2020-2023” [9] sets out short-to-medium term national priorities based on Australia’s Policy Framework for Land Transport Technology. The action plan consists of concrete actions over the next three years by and for Australian governments to avoid duplication and encourage greater collaboration and sharing of key learnings.

These two documents differentiate from the other 29 documents by providing multiple concrete actions. Moreover, the UK and Australia also stand out with the structured approach they have

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implemented. One organisation/department provides a vision, another organisation/department sets out concrete actions to work towards the vision, and again another organisation/department executes the action. This approach underlines a key statement in ‘Roadmap and action plan to facilitate automated driving on TEN road network - version 2020’[16]: “It would be advisable to converge the large number of roadmap activities in Europe towards a smaller number of dedicated work streams.”

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Annex A: list of references and mapping table

Roadmaps EU countries	Policy and regulatory needs, (European) harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, user and societal acceptance and ethics, driver training	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New mobility services, shared economy and business models	Human factors	Connectivity	Deployment, Production and industrialisation	Freight and logistics
[1] STRIA Roadmap on Connected and Automated Transport: Road, Rail and Waterborne (DG RTD, 2019)	x	x	x		x	x	x	x	x	x	x	
[2] CCAM Strategic Research and Innovation Agenda v1.0 (European Commission, 2020)	x	x	x	x	x	x	x	x	x	x	x	x
[3] The future of road Transport – Implications of Automated, Connected, Low-carbon and Shared Mobility (JRC, 2019)	x	x		x				x				
[4] Expectations and Concerns from a Connected and Automated Mobility (JRC, 2020)				x					x		x	
[5] Road vehicle automation in sustainable urban mobility planning - Practitioner Brief (EU Platform on SUMPS, 2019)	x	x	x	x	x			x				
[6] Who's in control? Road safety and automation in road traffic (Dutch safety board for Dutch ministry of transport, 2019)	x		x	x			x		x		x	
[7] Onderzoek naar systeem verantwoordelijkheid van de zelfrijdende auto (in Dutch, Twynstra Gudde on behalf of Dutch ministy of transport, 2019)	x		x									
[8] Research and innovation in connected and automated transport in Europe (JRC, 2019)		x	x		x	x			x	x		
Total	6	4	5	5	3	2	2	3	4	2	4	1

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Roadmaps non EU countries	Policy and regulatory needs, (European) harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, user and societal acceptance and ethics, driver training	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New mobility services, shared economy and business models	Human factors	Connectivity	Deployment, Production and industrialisation	Freight and logistics
[9] National land transport technology action plan 2020-2023 (Transport and Infrastructure Council, 2019)	x		x		x		x	x		x	x	
[10] UK Connected and Automated Mobility Roadmap to 2030 (Zenzic, 2019)	x	x	x	x	x	x	x	x	x	x	x	x
[11] Intelligent Transportation Systems (ITS) Joint Program Office: Strategic Plan 2020–2025 (U.S. DoT, 2020)						x	x			x		
[12] A CAV Roadmap for Scotland (Transport Scotland, 2019)	x	x	x	x	x	x	x	x	x	x	x	x
[13] Automated and Connected Vehicles Policy Framework for Canada (Policy and Planning Support Committee, 2019)	x		x	x	x							
[14] Ensuring American Leadership in Automated Vehicle Technologies Automated Vehicles 4.0 (U.S. DoT, 2020)	x	x	x		x		x					
[15] SIP-adus R&D Plan (Japan Ministries, 2020)		x	x		x	x					x	x
Total	5	4	6	3	6	4	5	3	2	4	4	3

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Roadmaps platforms and projects ** the MANTRA publications 21-23 and Levitate publications 24-26 have been taken together in the analysis.*	Policy and regulatory needs, (European) harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, user and societal acceptance and ethics, driver training	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New mobility services, shared economy and business models	Human factors	Connectivity	Deployment, Production and industrialisation	Freight and logistics
[16] Roadmap and action plan to facilitate automated driving on TEN road network - version 2020 (EU EIP, draft)	x				x			x			x	
[17] Guidelines How to become an automation-ready road authority (CoExist project, 2020)	x	x	x								x	
[18] Connected Automated Driving Roadmap (ERTRAC, 2019)	x	x	x	x	x	x	x	x	x	x	x	x
[19] Automatisierter und vernetzter Verkehr: Entwicklungen des urbanen Europa (in German, AVENUE 21, 2020)	x	x	x		x							
[20] CAD consolidated roadmap Year 1 v1.1 (ARCADE, 2018)	x	x	x	x	x	x	x	x	x	x	x	x
[21]Vehicle fleet penetrations and ODD coverage of NRA relevant automation functions up to 2040 (MANTRA, 2018)* [22] Consequences of automation functions to infrastructure (MANTRA, 2019)* [23] Road map for developing road operator core business utilising connectivity and automation (MANTRA, 2020)*			x		x						x	x
[24] Defining the future of freight transport (Levitate, 2019)* [25] Defining the future of passenger car transport (Levitate, 2019)* [26] Defining the future of urban transport (Levitate, 2019)*	x		x								x	x
[27] Practical learnings from test sites and impact assessments (STAPLE, 2020)		x	x		x				x			x
Total	6	5	7	2	6	2	2	3	3	2	6	5

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Roadmaps industry	Policy and regulatory needs, (European) harmonisation	Socio-economic assessment and sustainability	Safety validation and roadworthiness testing	User awareness, user and societal acceptance and ethics, driver training	Digital and physical infrastructure	In-vehicle technology enablers	Big data, AI and their applications	New mobility services, shared economy and business models	Human factors	Connectivity	Deployment, Production and industrialisation	Freight and logistics
[28] 5G Strategic Deployment Agenda for Connected and Automated Mobility in Europe (5G PPP, 2020)	x					x		x		x	x	
[29] Roadmap for the deployment of automated driving in the European Union (ACEA, 2019)	x			x	x			x		x	x	x
[30] The Future of autonomous vehicles Global Insights gained from Multiple Expert Discussions (Future Agenda, 2020)	x		x	x		x					x	x
[31] Manifesto – Roadmap (European Automotive and Telecoms Alliance, 2019)	x		x		x					x		
Total	4	0	2	2	2	2	0	2	0	3	3	2

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Annex B: mapping of thematic areas and CCAM cluster

The 12 thematic areas of the ARCADE knowledge base will gradually be replaced by the 7 clusters of the CCAM Strategic Research and Innovation Agenda (SRIA). Both are shown in the figures below.

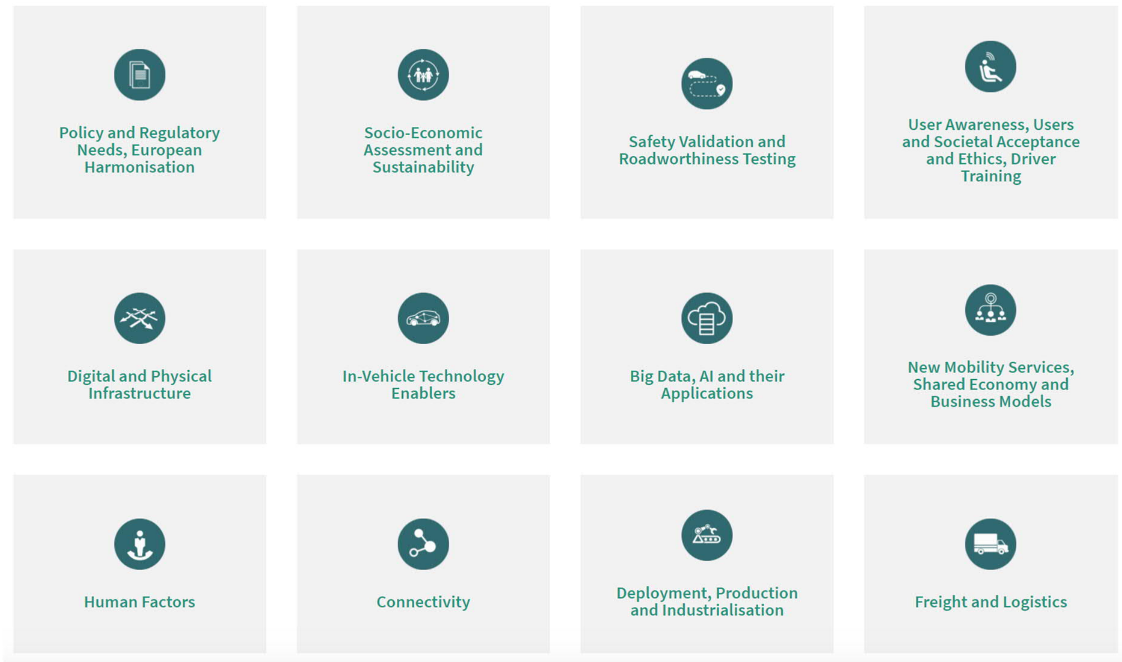

Figure 1: thematic areas ARCADE (connectedandautomateddriving.eu)

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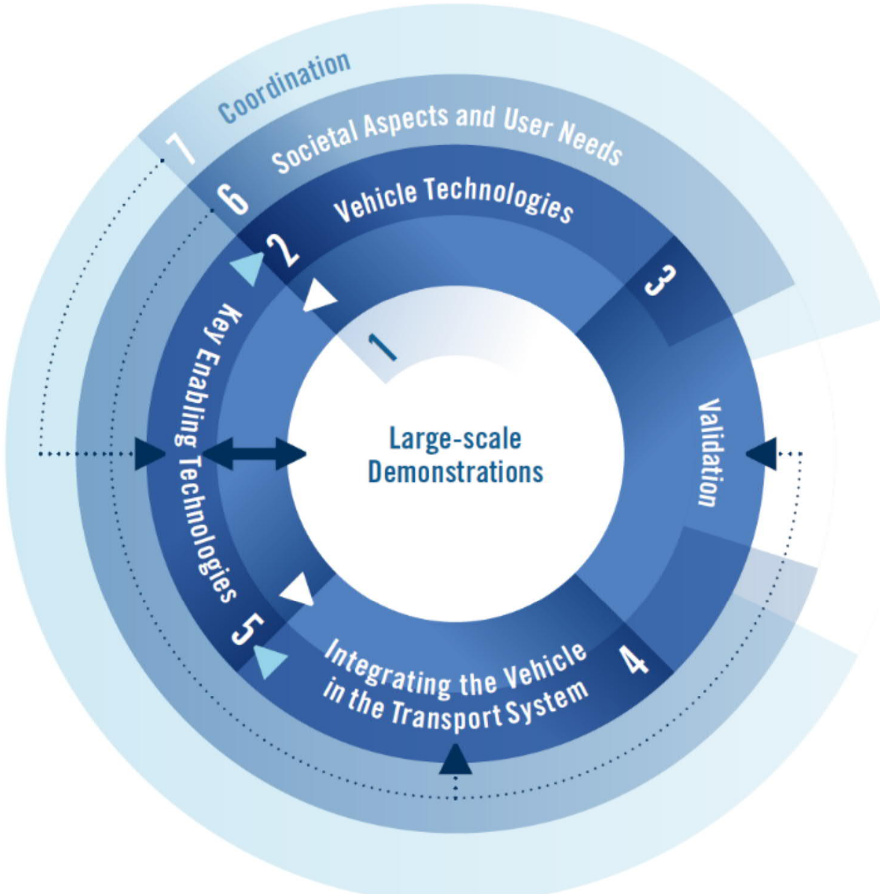

Figure 2: clusters CCAM Strategic Research and Innovation Agenda (SRIA)

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In the figure below the 12 thematic and 7 clusters have been mapped.

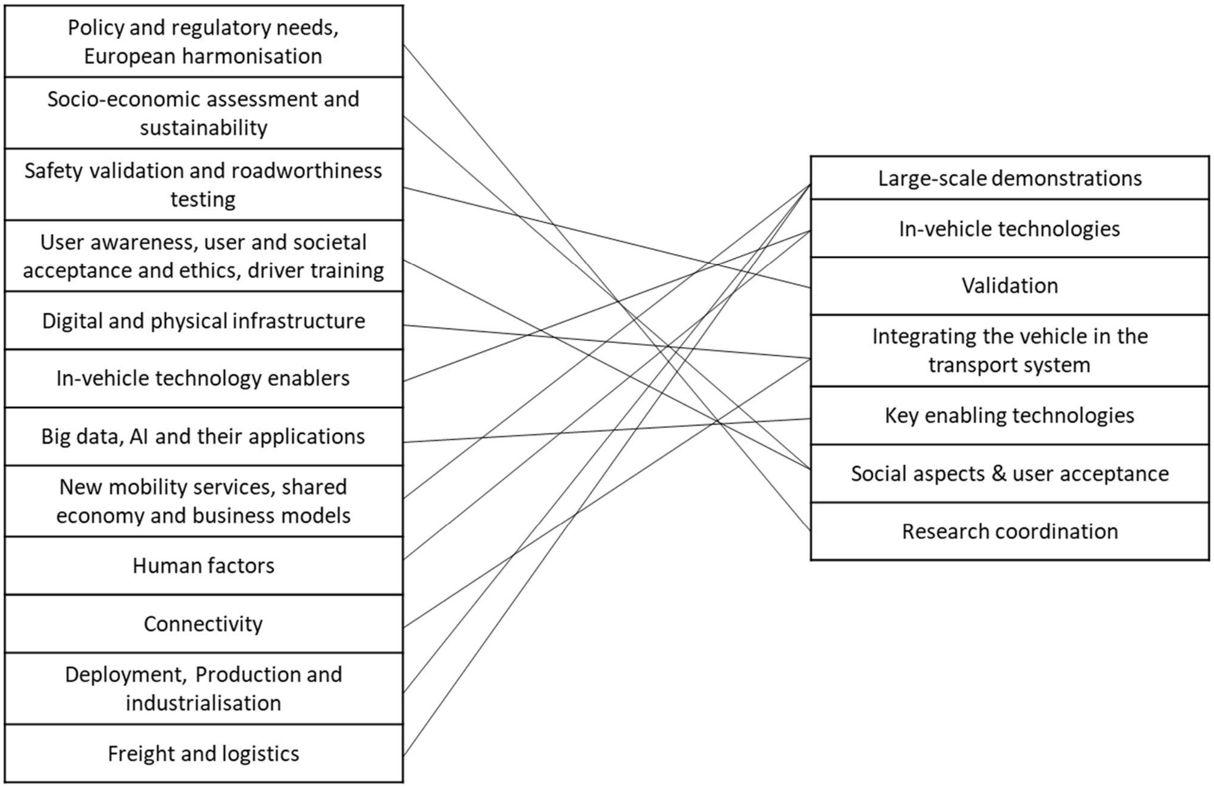

Figure 3: mapping of 12 thematic areas and 7 clusters

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