European Platform
on Sustainable Urban
Mobility Plans

PRACTITIONER BRIEFING

ROAD VEHICLE AUTOMATION

in sustainable urban mobility planning

Imprint

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Authors:
Wolfgang Backhaus, Siegfried Rupprecht and Daniel Franco, Rupprecht Consult – Forschung & Beratung GmbH

Contributing authors:
Suzanne Hoadley (POLIS); Frank van den Bosch (City of Helmond); Mikael Ivari (City of Gothenburg); Brian Matthews (Milton Keynes); Ammar Anwar, John Miles (University of Cambridge); Gisa Gaietto (Stuttgart City); Charlotte Fléchon, Peter Sukennik, Alexander Dahl (PTV Group); Nadège Faul (VEDECOM); Thierry Goger (FEHRL); Johan Olstam (VTI); Markus Friedrich (University of Stuttgart); Adriano Alessandrini (University of Florence); and Nikolas Thomopoulos (COST WISE-ACT).

Peer reviewers:
Wulf-Holger Arndt (Technische Universität Berlin), Marko Jandrisits (European Commission), and Geert Van der Linden (European Commission).

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Design and Layout:
Saydrina Ann Govender

Contacts:
Rupprecht Consult – Forschung & Beratung GmbH
Wolfgang Backhaus (w.backhaus@rupprecht-consult.eu)
Clever Straße 13-15, 50668 Köln, Germany
www.rupprecht-consult.eu

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List of Abbreviations

AV	Automated Vehicle
CAD	Connected and Automated Driving
CAV	Connected and Automated Vehicle
CCAM	Cooperative, Connected and Automated Mobility
C-ITS	Cooperative Intelligent Transport Systems
FUA	Functional Urban Area
KPI	Key Performance Indicator
SUMP	Sustainable Urban Mobility Planning
SWOT	Strengths, Weaknesses, Opportunities and Threats analysis

Guide to the reader

This document provides guidance on a specific topic related to Sustainable Urban Mobility Planning (SUMP). It is based on the concept of SUMP, as outlined by the European Commission's Urban Mobility Package and described in detail in the European SUMP Guidelines (second edition) .

Sustainable Urban Mobility Planning is a strategic and integrated approach for dealing with the complexity of urban transport. Its core goal is to improve accessibility and quality of life by achieving a shift towards sustainable mobility. SUMP advocates for fact-based decision making guided by a long-term vision for sustainable mobility. As key components, this requires a thorough assessment of the current situation and future trends, a widely supported common vision with strategic objectives, and an integrated set of regulatory, promotional, financial, technical and infrastructure measures to deliver the objectives – whose implementation should be accompanied by reliable monitoring and evaluation. In contrast to traditional planning approaches, SUMP places particular emphasis on the involvement of citizens and stakeholders, the coordination of policies between sectors (transport, land use, environment, economic development, social policy, health, safety, energy, etc.), and a broad cooperation across different layers of government and with private actors.

This document is part of a compendium of guides and briefings that complement the newly updated second edition of the SUMP Guidelines. They elaborate difficult planning aspects in more detail, provide guidance for specific contexts, or focus on important policy fields. Two types of documents exist: While 'Topic Guides' provide comprehensive planning recommendations on established topics, 'Practitioner Briefings' are less elaborate documents addressing emerging topics with a higher level of uncertainty.

Guides and briefings on how to address the following topics in a SUMP process are published together with the second edition of the SUMP Guidelines in 2019:

- Planning process: Participation; Monitoring and evaluation; Institutional cooperation; Measure selection; Action planning; Funding and financing; Procurement.
- Contexts: Metropolitan regions; Polycentric regions; Smaller cities; National support.
- Policy fields: Safety; Health; Energy (SECAPs); Logistics; Walking; Cycling; Parking; Shared mobility; Mobility as a Service; Intelligent Transport Systems; Electrification; Access regulation; Automation.

They are part of a growing knowledge base that will be regularly updated with new guidance. All the latest documents can always be found in the 'Mobility Plans' section of the European Commission's urban mobility portal Eltis (www.eltis.org).

1 Annex 1 of COM(2013) 91

2 Rupprecht Consult - Forschung & Beratung GmbH (editor), 2019 Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan, Second Edition.

Executive summary

Vehicle manufacturers have already started with the introduction of vehicles with more and more connected and automated functionalities. But although steps towards the deployment of cooperative, connected and automated mobility (CCAM) are progressing fast, the actual benefits of

the transition towards CCAM for a city's mobility, will largely be determined by the introduction this new driving technology into existing sustainable urban mobility planning processes.

Yet, most European local authorities have a lot of uncertainties about the introduction of CCAM on their road network and are missing guidance on how they can ensure its alignment with their policy goals. Many cities question whether CCAM implementation will fulfil the promises of reducing road space demand, improving mobility for all and improve safety. Without good preparation and planning, it could actually 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. As part of the updating process of the European Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan (2019), the aim of this practitioners' briefing is to provide guidance and best practice examples in order to increase the capacity of cities to introduce CCAM into their sustainable urban mobility planning processes. This will include a detailed consideration of CCAM from a planning perspective, mapping for the main uncertainty factors and providing guiding principles on how to mitigate them. Further, it will deliver recommendation on how the eight SUMP principles can be applied in the context of cooperative, connected and automated mobility.

1. Introduction

After the initial technological euphoria that predicted the deployment of cooperative, connected and automated mobility (CCAM) by the end of the decade, most vehicle manufacturers and transportation network companies had to readjust the dates they are planning to introduce fully automated vehicles that can operate in all or most operational design domains (i.e., the specific conditions under which a given system or feature is designed to function). Some vehicle manufactures have even started questioning whether fully automated vehicles (AVs) are actually possible and it became widely accepted that AVs will be relying on extensive connected services to even operate in lower levels of automation, thus affirming the need to focus on a holistic Cooperative, Connected and Automated Mobility deployment strategy.

The ERTRAC Automated Driving Roadmap (ERTRAC, 2019) provides a comprehensive overview of the different functionalities of Connected and Automated Vehicles (CAVs) and their expected market introduction. The Connected Automated Driving Europe site, currently coordinated by the ARCADE project, provides an extensive library of the latest developments in the fast-changing field of connected and automated driving (ARCADE, 2019). Even though the deployment of CCAM is not as fast as some anticipated, it is clear that more and more vehicles with automated functionalities are being deployed and that enabling technologies, such as 5G and ITS G5, will significantly increase the ability of CAVs to handle more complex operational design domains. The initial fear that cities will be overrun by this technology has luckily not materialised yet, but this is not a justification for local authorities to continue with a "wait and see approach". The time should be wisely used to better prepare for the deployment of CCAM and exploit opportunities to engage positively with the technology's developing and implementation processes, in order to guide them in desirable directions.

Cooperative, Connected and Automated Mobility (CCAM) will have significant impacts on most transport and urban planning related activities of a city. The Polis policy paper on "Road Vehicle Automation and Cities and Regions" (POLIS, 2018) provides a structured overview of the most pressing impacts expected to result from CCAM's implementation. The paper focuses on the analysing how it could affect road safety, traffic efficiency, infrastructure, socioeconomic aspects, travel behaviour and spatial planning. Still, there is a high degree of ambiguity surrounding the assessment of these impacts as nobody, at this stage, can really predict how the technology will be used and whether the positive aspects will out-weight the negative ones. Many local authorities are overwhelmed by the sheer scale of the uncertainties surrounding the deployment of CCAM, which results in a dangerous form of inertia. Local authorities need to take a leading role in dealing with the topic's complexities and undefined features in a structured way to break out of this inertia.

To ensure that the roll out of CCAM is in line with sustainable urban mobility goals, local authorities will have to play a key role and should take the lead with proactive planning approaches. This begins with planning for the introduction of CCAM as early as possible, to minimise the potential negative impacts and more importantly make the most of the opportunity to influence the paradigm shift into a more sustainable urban mobility vision. The UITP Policy Brief on 'Autonomous vehicles: a potential game changer' (UITP, 2017) clearly sets out that cities need to now foster a culture of sharing to avoid single occupancy or empty CAVs in city centres in the future. An uncontrolled deployment of CCAM in cities could lead to conflicts between CAV users and other road users, due to opposing transport planning needs when prioritizing liveability and not just CAV-friendliness in cities.

The promises of CCAM to improve traffic and space efficiency, enhance safety and improve mobility for all, will only be fulfilled when local authorities have the capability to shape the deployment of CAVs to their needs. Without it, CCAM could certainly worsen the urban mobility problems that local authorities are currently facing.

There is a clear need for considering Connected and Automated Driving in Sustainable Urban Mobility Planning processes, but its purpose should not be misunderstood as endorsing the disruptive technologies surrounding CCAM and their impacts, but rather empowering the local authorities to critically review the anticipated technological changes and shape the future according to their expectations.

This is defined in the CoEXist project as 'Automation-readiness' (CoEXist, 2018), i.e. the capability of making structured and informed decisions about the comprehensive deployment of CAVs in a mixed road environment, and it requires:

- A clear awareness of the technology underpinning CAVs, the different functional uses and business models for CCAM and a high-level understanding of the impacts different deployment scenarios can have on traffic, quality of life and stakeholders involved in local transport planning.
- The institutional capacity to plan for a future with CCAM by using tools that accurately represent CAV behaviour in order to identify the impacts of different deployment scenarios.
- A strategic approach in planning a wide range of measures that will ensure a deployment of CCAM, which supports higher level mobility goals, which can be achieved by following the SUMP concept and its principles.

This document aims to serve as a guide for practitioners and other stakeholders on integrating connected and automated road vehicles in their sustainable urban mobility planning processes. It is heavily based on CoEXist's Automation-ready framework (CoEXist, 2018).

2. The 8 SUMP principles in the context of Road Vehicle Automation

1. Plan for sustainable mobility in the 'functional city'

Despite the uncertainties, authorities are afforded an opportunity to reflect already today on how they would like to use CCAM to serve their mobility objectives. However, policy makers at EU and national level should provide regional and local authorities with clear regulatory frameworks to start thinking about local/regional policies to best exploit positive impacts of CCAM. It could on the one hand transform the way in which people travel, e.g. people would travel greater distances with faster, more efficient and comfortable vehicles, and on the other hand, also change several aspects of urban mobility planning, e.g. with more data-related planning or a shift in curb side management, which might become more important to plan pick-up and drop-off zones for CCAM services. To manage these transformations, authorities need to understand their nature and consequences, in order to make informed decisions, and learn how to prepare for and influence them as a local or regional authority.

Relevant questions:

- How do institutional and governance structures in local authorities need to change to address CCAM?
- On which institutional level does CCAM needs to be addressed in order to effectively respond to the challenge? And in that sense, how to define the 'functional city', if (1) actions are needed at higher levels (national, regional), and (2) travel behaviour might change, with longer commuter distances, which would expand current Functional Urban Area (FUA)?

2. Develop a long-term vision and a clear implementation plan

Authorities today already have to deal with the topic of road-vehicle automation despite the persistent high levels of uncertainties. They should think ahead, clearly define goals (e.g. road space allocation, public transport prioritisation) and link the introduction of CCAM, from the beginning, to their overarching mobility objectives to avoid negative developments that are difficult to change afterwards. A city worth living in must remain the vision. The introduction of CAVs is not an end in itself, but shall serve this vision.

Relevant questions:

- How should measures and policies towards managing CAD deployment be implemented, when there are so many uncertainties on how this deployment will unfold?
- How does automation align with different institutional goals and with the city's vision?
- CCAM could introduce various social challenges and affect liveability. How would this affect the city's vision and policy goals?
- How could liveability, including equity and accessibility, in cities be affected by CCAM? What can cities do mitigate potential issues?

3. Assess current and future performance

Due to the lack of experience with CCAM in urban areas and reliable data, assessing the impact of CAVs is more like crystal ball reading. While it may bring some benefits, such as improved traffic performance, increased space efficiency and less accidents, there is also the possibility that it could lead to increased congestion, negative environmental and health impacts, and the discouragement of public transport, walking and cycling. Methodologies like SWOT analysis and scenario development foster discussions and consensus on potential impacts of CCAM, but they require appropriate tools to analyse its effects in urban mobility. Fortunately, more and more research projects dealing with the topic, are developing methods and functionalities to enable modelling transport with CAVs and the evaluation of its impacts.

Relevant questions:

- Considering the high degree of uncertainties, how should CCAM be considered in transport assessment today?
- What are the basic scenarios that should be considered in SUMP 2.0 and European cities?
- How can cities develop base scenarios for CCAM deployment?
- How to consider/assess the effects of CCAM in traffic flow and travel demand? How can it be modelled and what obstacles/difficulties arise?

4. Develop all transport modes in an integrated manner

CAD should be included into an integral mobility strategy, with high capacity public transport as a backbone and encouraging walking and cycling. Based on such a balanced and coordinated multimodal mobility offer, CCAM can support excellent options for sustainable door-to-door mobility. In this way, the safe interaction with other road users is a key issue, and positive impacts like traffic efficiency gains may only materialise in the medium to long-term, once CAVs are well tested and the penetration rate is high. The interim transition phase might then prove less beneficial, as CAVs face pedestrian crossings with pedestrians, conventional vehicles, or other road users. Furthermore, it is not inconceivable that a potential growth of shared services with CAV-fleets, may herald the end of public transport as we know it today. Consequently, a transformation of public transport, aiming to exploit the advantages of CCAM (e.g., significant reductions in operational costs), with new business models and mobility services, needs to be considered. In such scenarios where CCAM leads to fewer privately owned cars and public transport services, and accordingly to less revenues from parking fees and fines, as well as from public transport tickets sale, authorities would need to create new streams of public income and fitting business models, thus ensuring adequate provision of public transport services and relevant city infrastructure.

Relevant questions:

- How does CCAM relate with, and affect, each different transport mode, and which changes could it bring to urban mobility and accessibility?
- How to assess the interactions of automated vehicles with conventional vehicles and other road users, in a mixed road environment?
- How does it affect the business/operating models of other modes of transport (both public and private)?

5. Cooperate across institutional boundaries

CCAM based mobility needs a system approach and cannot be planned by transport authorities alone. It is important that authorities re-assess the required competences to enable the planning of a sustainable urban mobility offer based on CCAM. In addition, cross-department cooperation, including for example urban/spatial planning, environmental, economic affairs departments, is needed. New institutional structures like horizontal working groups / departments or even cross-border urban mobility managers (that allow the integration and coordination of public transport, new mobility services and platforms), as well as new skills and competences, e.g. data handling and analysis, are needed to plan and introduce CCAM.

Relevant questions:

- How do institutional structures in local/regional authorities need to change to address CCAM?
- What are promising cooperation and governance models to address CCAM, considering the rising significance of data availability and management?

6. Involve citizens and relevant stakeholders

CCAM can help to develop a transport offer in FUAs combining high capacity collective and individual services that responds to citizens needs and delivers on public goals like accessibility, inclusion and liveability. Authorities should lead this path, discuss solutions and create synergies with various groups of relevant stakeholders, such as vehicle manufacturers, technology and transport service providers. Authorities should also involve citizens by polling their acceptance and promote their active involvement through awareness raising and informative activities (e.g. WISE-ACT open events: https://wise-act.eu). Pilot demonstrations are also a valuable tool in this regard, and help illustrate more clearly the challenges and benefits of CCAM.

Relevant questions:

- How do you facilitate a participatory social dialogue about such a complex and technical topic with so many uncertainties?
- How to allow an effective/beneficial discussion around automation, considering low levels of awareness and knowledge of the topic, and the complexity of handling the related ambiguities?
- Who are the stakeholders that should be involved in planning for CCAM and new mobility services, e.g. CCAM service providers? And how should authorities engage with them?
- How can business opportunities effectively serve citizen needs?

7. Arrange for monitoring and evaluation

Cooperative, Connected and Automated Driving, and the transformation of urban mobility through its implementation on different transport modes (both public and private, and for passenger as well as freight transport), should be evaluated in the same way conventional modes and technologies are: by monitoring it's impacts on overall mobility objectives, e.g. modal split shift towards sustainable modes, and ensuring a better quality of life. However, the technological differences in CCAM do require the identification of adequate metrics to assess its impacts, and cities need to consider changes in their planning practices to ensure its monitoring and evaluation is done correctly. Considering the its potential effects on urban mobility, KPIs for such evaluation could be traffic flow efficiency, space efficiency or safety. Besides, authorities should be prepared to collect relevant data for the CCAM performance monitoring. Therefore, it should be ensured that different mobility services can communicate to avoid closed systems.

Relevant questions:

- Considering the high degree of uncertainties, how should CCAM be considered in transport assessment today?
- What indicators best measure the impact of CCAM, in accordance to each city's policy goals?

8. Assure quality

Following the SUMP process and answering the relevant questions listed in the present document itself can be considered as a quality assurance approach. In addition, exchanging knowledge and experience with FUAs that made already experiences with CCAM pilots and trials should be encouraged. Authorities should adapt given regulation to allow testing of CAVs to take advantage of insights and learnings based on CCAM-related innovations.

Relevant questions:

- How to plan effectively and make informed decisions on an uncertain and still developing topic?
- How to plan for innovations (even before their deployment)?
- How to ensure CCAM deployment and resultant mobility services are in line with the overall SUMP objectives?

3. SUMP steps for Road Vehicle Automation

Figure 1. The SUMP 2.0 Cycle (Rupprecht-Consult, 2019).

This section reflects in the main factors and key questions that need to be considered to effectively include connected and automated road vehicle in the SUMP process, aiming to support and empower planning practitioners and mobility stakeholders, to take on the challenge of actively addressing CCAM in their mobility planning practices. By reducing uncertainties and sticking to the core planning principles, local authorities can take a leading role, rather than merely being observers of the technological developments

3.1 Preparation and analysis

3.1.1 Initial commitment and setting up working structures

The success of the transition towards higher penetration levels of CAVs will largely be determined by integrating them into existing sustainable urban mobility planning processes (i.e. SUMPs). However, today there are hardly any strategic transport plans in Europe that properly address the technology and the resulting impacts. Incorporating CCAM into SUMP processes, requires an explicit decision and a strong commitment to address the challenges and opportunities that it generates, and adequately prepare to handle them.

A broad participatory approach is key to ensure that CCAM is being deployed to the benefit of all and not the few. Not one single actor is able to find the answers to all these complex issues. An effective working structure needs to be established, ensuring the active participation of citizens and key stakeholders, whilst steering institutional cooperation and coordination at different government levels. Furthermore, structured coordination and information exchange among cities, at the national, European and global scales, is fundamental to establish consolidated needs and harmonize markets, allowing the creation of economies of scale that ensure the optimal development of new mobility services. The European Commission strongly supports such exchange, and has set up an informal group of experts, the Single Platform for open road testing and pre-deployment of cooperative, connected, automated and autonomous mobility consisting of up to 100 experts and appointed for a period of three years, which will provide advice and support to the Commission in the field of testing and pre-deployment activities for Cooperative, Connected, Automated and Autonomous Mobility – CCAM (European Commission, 2019).

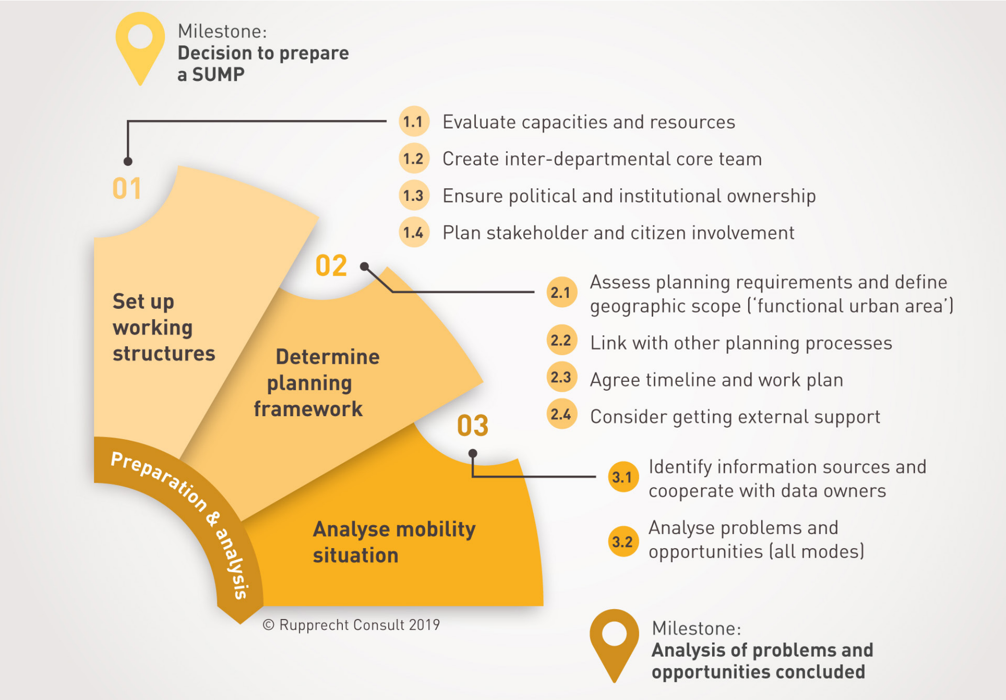
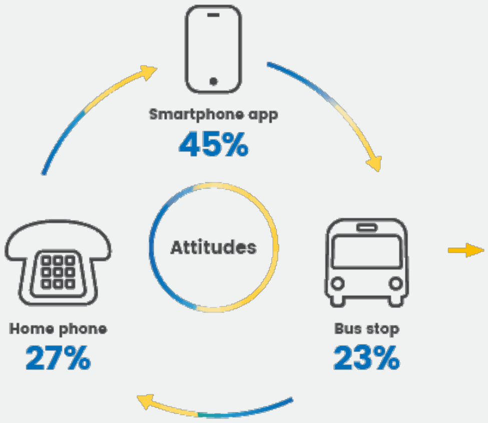


Figure 2: SUMP 2.0 Phase "Preparation and analysis" ((Rupprecht-Consult, 2019)

Citizen participation helps to understand the needs of the future users of the system and to cater to them, also giving an opportunity for the municipality to understand how mobility services can be improved, and in particular, how connected and automated vehicles can be of help in the future transport systems by improving accessibility and equity of services. Providing a platform for citizens to be heard, increases acceptability and furthermore, the perception of users gives an insight about the possible threats (e.g. reduction in the value of travel time, since it can actually be a productive time and increase comfort of CAV usage) and enhances proactive mitigation strategies (e.g. pricing schemes) by engaging citizens as part of developing a common solution. An example of this is the UK Autodrive project (UK Autodrive, 2017) that conducted a public attitude survey (see case study below) or the WISE-ACT citizen survey across Europe conducted in 2019.

Involving Citizens

A key to developing novel solutions to tackle mobility challenges in cities is to gather the acceptance of the general public. Hence, involvement of citizens is vital to enhance take up. A good practice example is the UK Autodrive project's public attitudes survey. As part of the project, the University of Cambridge carried out a national survey of public attitudes towards self-driving vehicles (SDVs). The survey was conducted in October-November 2016, comprising 49 questions, and gathered 3000 responses. The results of this survey were used as basis for a deeper exploration of public attitudes through local focus groups.



Further Details: http://www.ukautodrive.com/survey-finds-uk-public-still-open-minded-about-self-driving-vehicles/

Planning for AVs and reducing uncertainties also requires the involvement of stakeholders that are not traditionally part of mobility planning. Municipalities alone cannot solve mobility challenges and thus need to collaborate with mobility service and technology providers from the private sector. Engaging with OEMs, technology companies, and new mobility service providers is an important aspect in co-creating solutions that benefit all: businesses, government, operators, and people. This also helps in developing a common vision between often conflicting objectives of different organisations, when planning for the future of mobility in cities. Cities and authorities will get a chance to have a better understanding of the topic, and increase their capacity to implement the right policies and regulations to support innovation and restrict unfair competition. Examples of platforms bringing together stakeholders from different areas are Antwerp's Marketplace for Mobility (Van Der Pas, 2017), Gothenburg's DriveME (City of Gothenburg, 2017) (see Figure 4) or – on a higher level - the German platform for urban mobility (Plattform Urbane Mobilität, 2017) which involves cities and OEMs for developing jointly mobility solutions for the future. Bringing together different stakeholders' knowledge will foster innovation development in terms of the application of new technologies and opening up new markets for building win-win-situations for the involved stakeholders. Still, besides the involvement of cities and industry partners, the participation of civil society groups is

Establishing an innovation platform (Gothenburg)

Engaging with stakeholders.

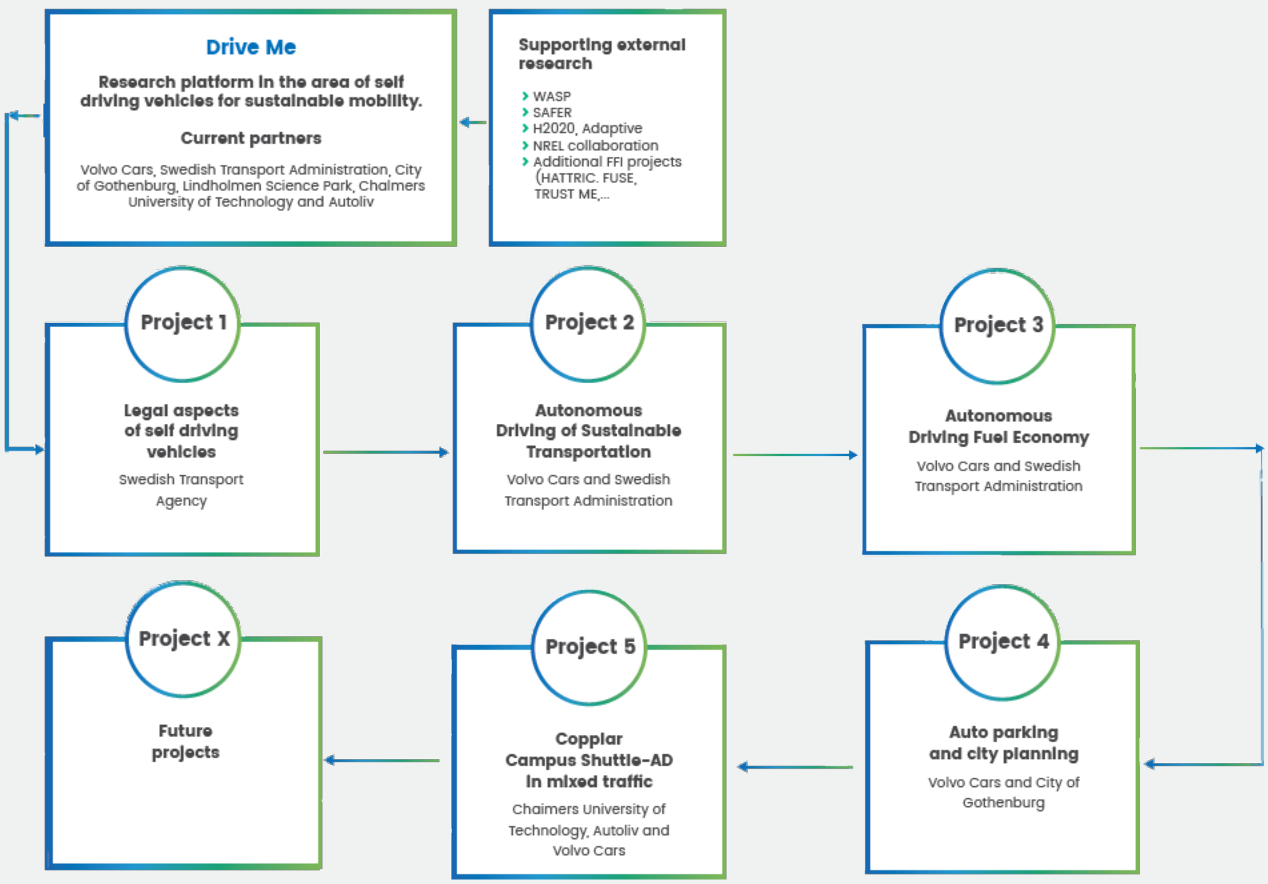


Figure 4: Framework of Drive Me innovation platform for Gothenburg (CoEXist, 2018)

important to increase acceptability and help co-create solutions that are user-centric.

3.1.2 Assessing available resources and planning requirements

Planning for such an innovative field involves becoming aware of the technological advancements and capabilities of connected and automated vehicles (and the associated features) and understanding the opinions, needs and concerns of the citizens at an early stage. The key here is to develop an awareness of what the deployment of automated vehicles and resulting impacts means from a local authority perspective.
Besides, innovations for sustainable urban mobility solutions are more often based on data (and linked information and knowledge) than on concrete or physical infrastructure. Planning of sustainable urban mobility, in particular in a data-heavy environment of CCAM-based solutions, needs to be aligned and should keep up with technological advancements to be able to effectively and proactively plan for future technological changes that impact mobility in cities.
Local practitioners responsible for planning and managing mobility in cities, will have to develop new skills and competencies regarding modelling and impact assessment of automated road transport, data analysis and management, the later of particular relevance considering the General Data Protection Regulations – GDPR (Contantini, et al., 2020). More and more new technologies available for deployment in supporting traffic management, e.g. C-ITS, will become available and authorities and cities need to ensure that technical capacities are up to the level to be capable to use new tools and deploy state-of-the-art measures. Lessons learned from activities in other projects and cities, also allows to reach a better understanding of the related challenges and opportunities. The ARCADE project holds an inventory of all CCAM related activities at EU level (ARCADE, 2019). Developing and using common terminology is of paramount importance and initiatives such as the WISE-ACT Glossary contribute in meeting these objectives.

CAPITAL ITS and C-ITS e-learning

The main aim of the CAPITAL project is to create a collaborative capacity building community and deployment programme to support public and private stakeholders implementing cooperative and Intelligent Transport Systems (ITS & C-ITS) with training and educational resources, while also raising awareness of the services and benefits available. Over nine e-learning courses are available on www.its-elearning.eu.

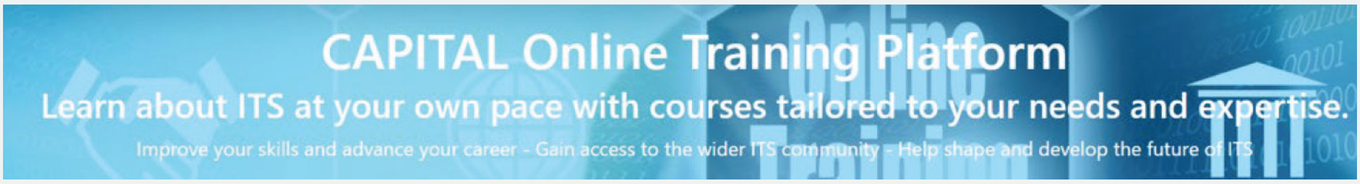


Figure 5: Extract from the CAPITAL project website (CAPITAL, 2018)

3.1.3 Analyse problems and opportunities

When talking about CCAM, it is vital to recognise the context of generalised uncertainty that currently characterises it particular planning conditions. In this sense, the focus lies much more on flexible and diverse scenario development and the assessment of their potential impacts, than when dealing with other modes of transport. CCAM also poses a higher technological-focused context, which calls for additional knowledge.
The described conditions, commands for a detailed analysis of the effects CAV could have on the current mobility situation, and its relation with all modes of transport. The potential (positive or negative) effects on public transport need to be carefully considered. Besides, it requires the knowledge of state-of-the-art developments in the field and learning from relevant experiences of other cities in their attempts to address CCAM. Still for several years to come, cities will have to manage a mixed-road environment, where CAVs and conventional vehicles will need to co-exist, and also safely interact with other road users. This will raise not only technical and operational challenges, but also in terms of the normative context. It is also important to

perform an analysis of the current legal framework and its relation to CCAM, identifying gaps in the regulation (Contantini, et al., 2020) and steering the discussion across political levels.

Automated drivability: assessing urban street networks

With the deployment of CCAM keeping below initial expectations, it became apparent that CAVs are going to be fit for some roads earlier than for others. As part of the research project Avenue21 at the TU Wien, an index was developed to assess the suitability of existing streets spaces for automated driving systems from a technical-infrastructural perspective. Although intentionally modelled similar to "walkability" or "bikeability" indices, the "automated drivability" does not represent a development goal in itself (i.e., higher automated drivability being more desirable), but is an analytical tool for urban mobility planning, capable of taking the distinct local context into account. The index provides evidence for critical challenges transport infrastructure planning will face, if CAVs are deployed unevenly in metropolitan regions (Mitteregger, et al., 2019).

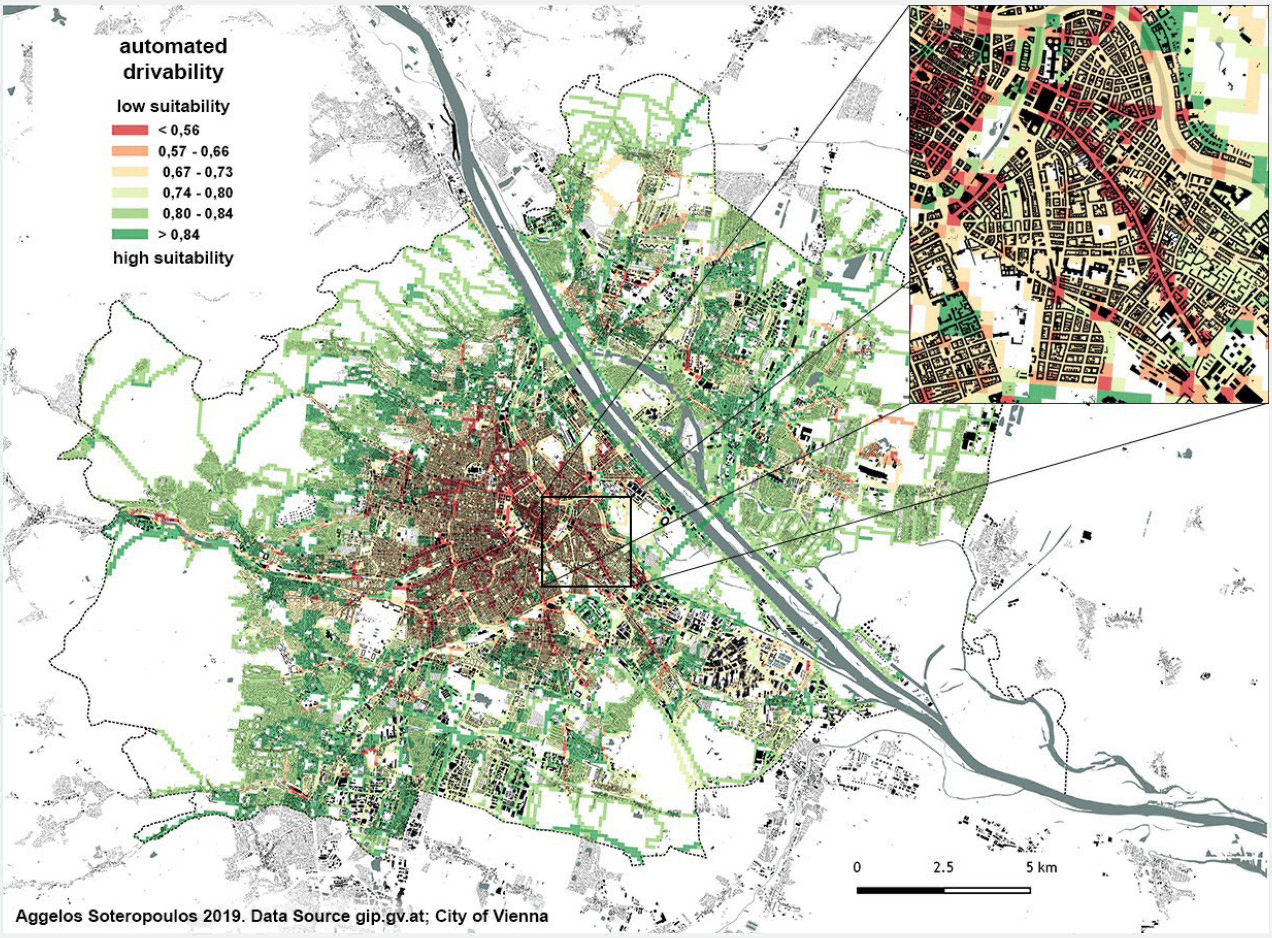


Figure 6: Automated drivability assessment for the City of Vienna (Mitteregger, et al., 2019).

3.2 Strategy Development

Figure 7 : SUMP 2.0 Phase "Strategy development" (Rupprecht-Consult, 2019)

3.2.1 Layout the different potential futures of the mobility in your city with CCAM.

When drawing up the potential future mobility conditions in the city, in relation to a field with such unclear perspectives as CCAM, it is important to consider various possible scenarios, reflecting on the variety of factors and dimensions define them (such as, for example, proactive planning, car-ownership, individual travel behaviour and ride-sharing), and then comparing the benefits and threats against each other.

To do so, it can be helpful to consider the perpectives of each different impact group, such as citizen's, local authorities, transport operators, and other businesses, among others. Table 1 (Thomopoulos & Givoni, 2015) presents the expected impacts benefits and threats of a future deployment of AVs, for users, businesses and governments.

Developing and illustrating possible future scenarios is a step towards understanding the potential benefits and drawbacks of introducing a certain technology into the transport system. Prioritising certain future scenarios can also be a guide on how to develop policies and pilots to reach that scenario.

Table 1: Expected impacts on future mobility facilitated through CCAM, per impact group (Thomopoulos & Givoni, 2015)

Impact Group		Benefits
	User	Travel time is not driving time, so disutility decreases and comfort increases.
	User	Travel time may be used for other work/leisure activities.
	User	AVs can allow the integration of culturally diverse users in cities globally.
	User	AVs can enhance demand for travel allowing passengers of any age to reach their destination safely
	User	Transport related social exclusion may be eliminated
	Government	Increased safety due to less accidents (mainly in the era when only AVs will be on the roads)
	Government	More parking space will become available and it may be used for other purposes by city authorities.
	Government	If AVs are eco-friendly, there could be reduced air pollution and lower energy use from the transport sector.
	Government	Accessibility can improve for all travellers, including the elderly and disabled.
	Business	Significant business opportunities will arise for automotive manufacturers, particularly for conventional ones which decide to enter this innovative market.
	Business	Expanding databases and innovative use of Big Data will allow the emergence of business opportunities and new business models, creating value for stakeholders.
	Business	Logistics and supply chain business will reduce (congestion, time) costs through eco-driving, better route planning, V2x communication and platooning.
Impact Group		**Threats**
	User	High cost of 'smart' infrastructure (V2I) to accommodate AVs.
	User	Local congestion may increase if the aggregate number of journeys increases.
	User	Cost of emerging mobility patterns can lead to social exclusion of certain groups if high.
	User	Identifying and assigning responsibility for car accidents may become fuzzier.
	User	'Digital divide' can lead to increased social exclusion.
	User	Better use of travel time may increase travel time e.g., daily commute, resulting in higher aggregate energy demand at local and national level.
	User	Widespread use of AVs can reduce walking and cycling, increasing obesity and negative health impacts.
	User	Unintended consequences will arise such as privacy, surveillance and data management issues linked with ICT for transport or the threat of wireless hacking to gain unauthorised control of AVs.
	Government	The adjustment period when both conventional human driven and autonomous cars co-exist on roads could impose more car accidents.
	Government	Deciding on the optimal route will be a challenge particularly during extreme events and principles may differ across cities complicating inter-urban journeys.
	Government	Emergence of diverse technologies by competing actors may lead in lack of coordination and common legislation.
	Government	Reduced employment demand for drivers and car technicians, increasing government costs for retraining and/or unemployment benefits.
	Business	Better use of travel time may increase travel time to travel through routes with greater journey comfort leading to increased congestion.
	Business	Development of competing technologies by diverse actors may lead to inefficient use of resources and the evolution of competing standards internationally.
	Business	Vehicular communication network needs high transmission capacity equipment and proper penetration rate to achieve optimal transport performance.

3.2.2 Set a vision for your mobility ambitions with CCAM and ensure commitment for realising this vision.

Setting a vision clarifies the priorities that you will have as a city. Clearly addressing new mobility solutions based on CCAM does not just set a path to exploring new solutions in tackling current and future challenges in mobility, but also makes the ambitions of a city clearer to other stakeholders and potential independent developers interested in becoming part of the solution. Examples for identifying different potential governing scenarios of CAV rollout and prioritising scenarios that are desirable in relation to the sustainable mobility goals of a country are documented – inter alia – for Austria (bmvit, 2016), Sweden (KTH Royal Institute of Technology, 2017) and Germany (BMVI, 2015).

An example of a city developing a vision for the future with CCAM is Milton Keynes, UK (Milton Keynes, 2018). Milton Keynes developed a Mobility Strategy as a reference point for how the town wishes to maintain, improve and develop its transport system up to 2036. It also shows how Milton Keynes wishes to begin investing in the short term in the development of the town's long-term future transport system to 2050 to ensure connectivity to new infrastructure projects. The strategy includes the ambition to *"develop and promote a 'First Last Mile' culture for future technologies such as autonomous and connected vehicles and sustainable connectivity"*.

Vision for mobility with CAVs: Mobility Strategy for Milton Keynes 2018 - 2036

Autonomous 'last mile' deliveries: Collaborative approach between the Council, Freight Quality Partnership, Transport Systems Catapult and the Open University to follow and possibly trial emerging autonomous delivery opportunities for the 'last mile' delivery. In liaison with industry partners consider the establishment of a Protocol for Personal Direct Delivery (PDD) trials to establish Milton Keynes as the centre for innovation and testing of new transport concepts on its local transport network (CoEXist, 2018).

3.2.3 Agree on measurable targets and co-create the city's mobility strategy

Once a vision has been agreed upon, cities should define detailed mobility objectives, targets and indicators that will guide the planning process, and co-create a 'mobility strategy' with stakeholders and citizens, considering all modes of transport in the entire urban area. In the case of CCAM, this raises various challenges, as cities might struggle with the definition of realistic strategies, measurable targets and adequate indicators to assess progress of such an unknown and complex field. These are some of the question that the CoEXist project attempts to answer, defining metrics to assess the impacts of CCAM in urban transport, in regard to traffic performance, space efficiency and safety. Furthermore, in its goal of supporting cities to make structure and informed decisions about the comprehensive deployment of CAVs, CoEXist has developed an Automation-ready framework, which recommends a series of phases, and concrete measures, to facilitate the reduction of uncertainties and to ensure a smooth transition into the sustainable deployment of CCAM in cities. An overview of these guiding factors to be considered in the city's strategy development is presented in the figure below.

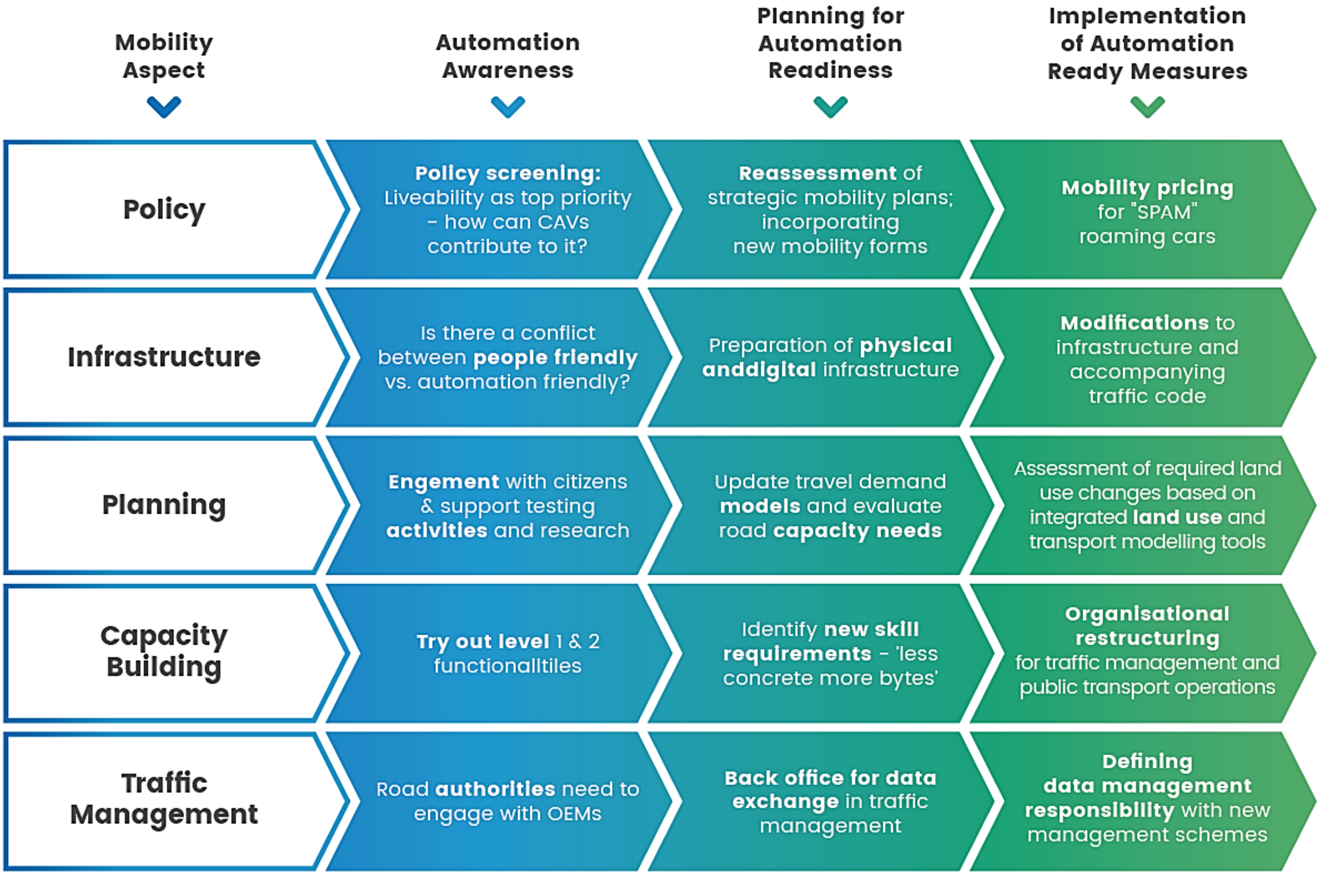


Figure 8: CoEXist's overview of phases towards automation-readiness, with measure examples (CoEXist, 2018)

3.3 Measure Planning

Measures that should be considered towards an effective and comprehensive deployment of CCAM range across various fields of action, including institutional transformation, adaptation of transport planning practices, development collective mobility services, optimisation and strengthening of public transport, setting an adequate policy framework, and the potential adjustment of the city`s infrastructure design to better exploit the advantages of CCAM (e.g., pick-up/drop-off areas and high-quality public space instead of parking spots). It's worth noting that the adaptation of the road infrastructure should not be required for correct functioning of automated road vehicles, but strategic changes might allow to fully exploit the benefits of this technology.the improvement of air quality, the decrease of greenhouse gas emissions and the reduction of noise emissions (2). Those indicators can include e.g. (1) the number of EVs (also per vehicle category), the number of EVs per 100 vehicles, the number of charging points, the number of charging points per 100 EVs; and (2) CO2 emissions, pollutant emissions (NOx, PM10), noise emissions and number of residents impacted by pollutant and noise pollution. The use of the second type of criteria must be made carefully as the direct impact of e-mobility on those is not necessarily direct (other emission sources, etc.).

3.3.1 Institutional adjustments

Institutional adjustments are expected to happen in the future due to the changes that are likely to happen in relation to the increased deployment of intelligent transport systems, CCAM and MaaS services within the transport network of cities. This can be within institutions or agencies or maybe an entirely new department, and will heavily depend on the nature of the policies and regulations and the measures that are adopted in relation to connected and automated vehicles. For example, if CAVs are to operate as fleets controlled by operators, perhaps a new setup for traffic management units would be required. Government agencies could also be needing internal information and technology departments to deal with technical communications necessary with such traffic management or control units. Furthermore, issues of privacy and cyber/security should not be neglected when planning such institutional adjustments.

3.3.2 Infrastructural adjustments

Infrastructure adjustments, whether physical or digital, will likely be necessary in order to improve traffic efficiency and safety for all modes in the transport network, as CCAM is deployed and higher penetrations rates are reached. Specific infrastructure adjustments need to be made in accordance with the mobility requirements in the different heterogeneous sections of the network. For instance, there might be changes needed for transition zones, where vehicles have to shift from an automated to manual mode. Transport models can test the necessary infrastructure adjustments that are needed to make transport networks more efficient and, in many cases, to make mobility safer for all modes. An AV-ready modelling environment will support sound decision-making.

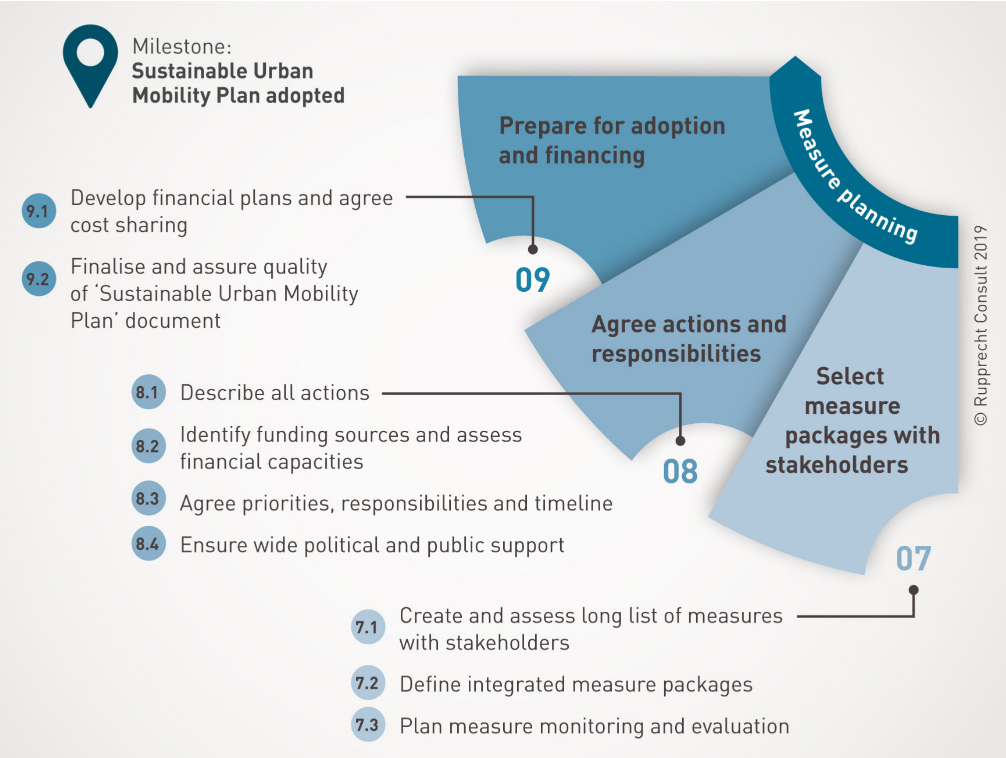


Figure 9: SUMP 2.0 Phase "Measure planning"((Rupprecht-Consult, 2019)

3.3.3 Collective mobility services

In the future, services will be more integrated and multimodal. It is important that despite the comfort of CAVs, collective high occupancy shared mobility services should be encouraged and become the priority over privately owned or single occupancy CAVs to reach sustainable urban mobility goals in cities. New multimodal collective mobility services should also be subsidised as early as possible, if costs are to remain competitive, but this will mostly be determined by the business models that are to come in conjunction with such services. The UITP Policy Brief on 'Autonomous vehicles: a potential game changer' (UITP, 2017) clearly sets out that cities need to support collective and inclusive mobility solutions for CAVs and a culture of sharing to avoid an uncontrolled deployment of CCAM leading to single occupancy or empty CAVs in city centres in the future.

3.3.4 Policy measures

Authorities need to develop new regulatory frameworks to lead the transition to the new mobility era of sustainable and interconnected mobility with CAVs. New policies need to be adaptive and anticipatory, and based on a balanced governance. These could include pricing of empty runs, occupancy-based pricing of services, etc. Authorities need to (re)assess and monitor the necessary characteristics and requirements of regulatory schemes and policies to accommodate new CCAM services while meeting cities' economic, political and social ambitions These policies will highly depend on the technological maturity in the next 15-20 years (or even more) and also on the economic conditions of the city and country, and their data management policies.. The ongoing H2020 project GECKO, investigates these challenges. For more information, visit: h2020-gecko.eu (GECKO, 2019).

3.4 Implementation and monitoring

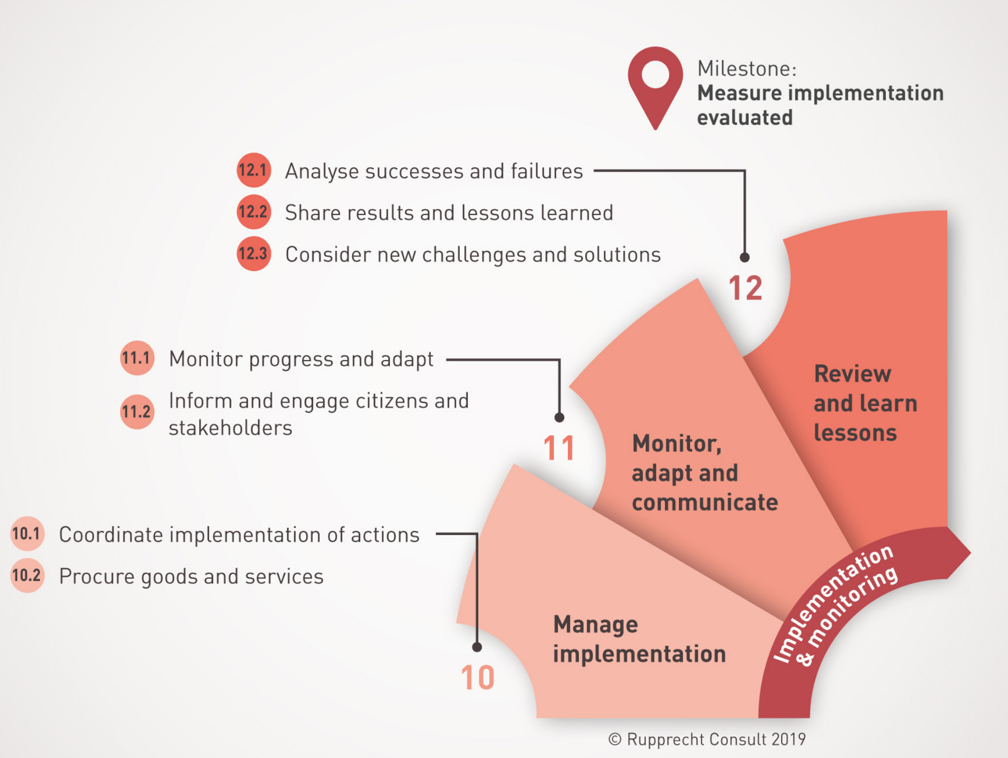


Figure 10: SUMP 2.0 Phase "Implementation and monitoring" (Rupprecht-Consult, 2019)

At this stage of the SUMP process, the implementation of resultant strategies and measures is planned and coordinated in detail. The innovative character of CCAM-related actions, and their inherent degree of uncertainty, result in a complex implementation process which may not be any longer performed by the 'SUMP team', but by technical departments with a mostly quite specialised focus; therefore, the overall coordination of the implementation process requires particular attention.

Moreover, continuous monitoring, evaluation and reflection is especially relevant, when taking measures to handle automation in urban transport, as strategies might require adjustments in response to new developments in the field, and results from current implementation will help reduce uncertainties and guide future actions. Such a monitoring concept will allow to determine whether things are not going according to plan – and take corrective actions if necessary. Active participation is absolutely key at this stage, since implementing of innovative mobility schemes can be a great disruption (as well as a great benefit) for the daily travellers. Understanding public opinion, based on an active two-way dialogue, is crucial for a successful implementation process.

4. Key aspects of CCAM planning

Besides following the SUMP principles and methodology, as well as the specific considerations described in the previous section, there are some key tools and activities that need to be taken into account to successfully address CCAM in urban mobility planning.

4.1 Learn about and experience road vehicle automation

Pilots and capacity building constitute a key initial measure to raise awareness and prepare the cities to respond to upcoming challenges. Many cities worldwide who have an edge in mobility, look into conducting pilots of different technologies, e.g. cooperative intelligent transport systems (C-ITS) or autonomous shuttles/last mile services, such as in the CityMobil2 project (CAD, 2018), as part of their public transport system. Initiatives are increasing globally as most cities see the benefit in upscaling and shaping the development of AV technology, which opens up other innovation opportunities. However, before conducting a pilot, other measures from this early stage should be considered in advance as well. Pilots should be the result of a scenario building process including stakeholder engagement and assessing benefits of pilots. Furthermore, training is needed to ensure safe operations, as well as post-pilot sharing of outputs at European level, e.g. through the WISE-ACT Atlas (WISE-ACT COST Action, 2019).

CityMobil2 Pilot

Pilots in Sardinia (Italy) led by the CityMobil2 project, tested automated vehicles in real-life urban environments. Two driverless buses, carrying up to 12 passengers each, have been piloted on a busy pedestrianised seafront promenade in Oristano. The route was about 1.3 km long and had seven stops. Passengers were allowed to travel for free but had to register first; minors were allowed on board, but only if the registration was signed by an adult. The pilot was organised in partnership with the Municipality of Oristano, the Regional public transport operator ARST, and the transport planning consultancy Company MLAb (CAD, 2018).

Figure 11: Automated buses test in Oristano, Italy (CityMobil2 Pilot)

4.2 Traffic flow and transport demand modelling

Many transport planning decisions affecting urban mobility and road infrastructure are based on the results of traffic flow and transport demand modelling. For this purpose, the availability of adapted simulation software is necessary, including new features and functionalities to allow for more accurate modelling of CAVs.

Micro- and macroscopic simulation of the coexistence of automated and conventional vehicles

Within the H2020 CoEXist project, significant progress has been made on the macro- and microscopic simulation capabilities to model CAVs and their interactions with conventional vehicles and other road users. Co-simulations integrating CAV driving logics (VEDECOM), vehicle dynamics (PreScan) and traffic simulators (PTV Vissim), were undertaken to derive behavioural parameters of CAV. The results were validated and calibrated using empirical data collected from real AV's on DICTM test track in Helmond (NL). PTV Vissim, microscopic simulation software, was further developed to enable the simulation of CAV-behaviour, considering the differences in car-following distances, simple communication aspects (V2V and V2I) and acceleration behaviour, among other aspects.

The results of the validated CAV-ready microsimulation model, were used to create assumptions for the supply-side of macroscopic models, which in turn, have developed functionalities to consider the relevant differences in CAV user's perception of travel time and Volume-Delay functions, among other parameters, to study more accurately the impact of automated road vehicles on a city's travel demand.

For more information: www.h2020-coexist.eu

Figure 12: Simulation of AVs within conventional traffic flows with PTV (PTV Group, 2018).

4.3 Assessing the impacts of CAVs in urban mobility and road infrastructure

The capability of making structured and informed decisions about the comprehensive deployment of CCAM in a mixed road environment, requires a high-level understanding of the impacts different deployment scenarios can have on traffic, quality of life and stakeholders involved in local transport planning. It also commands institutional capacity to plan for a future with CCAM by using tools that accurately represent CAV-behaviour in order to identify the impacts of different deployment scenarios.

But, how can we get reliable evaluation results of socio-economic and sustainability impacts of CCAM? Given that an ex ante evaluation is required, how can we build and assess realistic future scenarios for the evaluation? The availability of accurate modelling tools, as seen in the previous section, is thus a key pre-requisite for such impact assessment.

Similarly, identifying key performance indicators to measure the impact of CAVs in urban mobility, is a vital step in evaluating the suitability of different implementation scenarios. In this regard, the EU Horizon 2020 project LEVITATE aims to provide valuable input, covering the impact assessment cycle from methodology to analysis and evaluation, including guidance for the implementation (For more information, see https://levitate-project.eu/).

Among the different impact assessment approaches that are being currently tested, CoEXist is evaluating the 'automation-readiness' of urban road infrastructure in eight use cases implemented in its four partner cities: Gothenburg, Helmond, Milton Keynes and Stuttgart. To determine whether the studied infrastructure allows the coexistence of automated vehicles, conventional vehicles and non-motorized road users, the project is evaluating whether it can handle an introduction of automated vehicles without significant decline in traffic performance, space efficiency or traffic safety (CoEXist, 2018).

CCAM's potential for GHG emission reduction

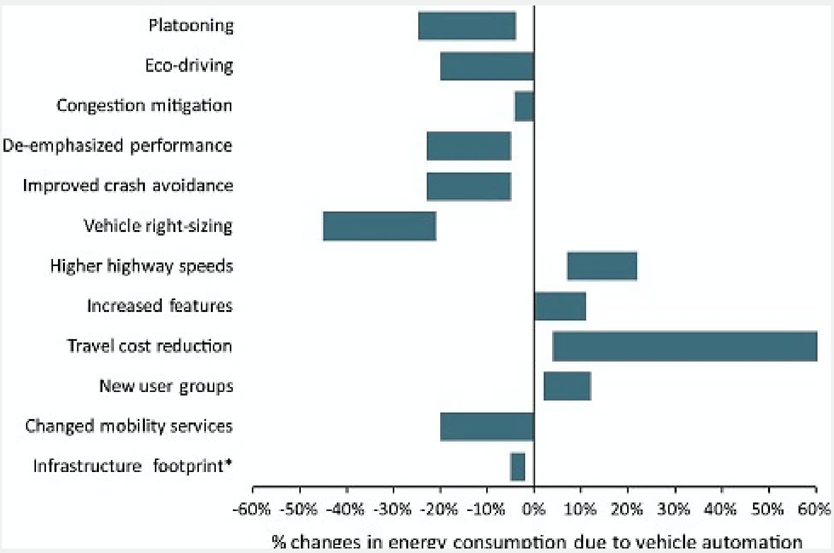


Figure 13: Estimated ranges of operational energy impacts of vehicle automation through different mechanisms (Wadud, MacKenzie, & Leiby, 2016)

Although CCAM is not expected to directly affect energy consumption, it is likely to significantly facilitate a number of functionalities that could alter energy expenditure and GHG emissions related to transport. For instance, CAVs "may enable the adoption of energy-saving driving practices, and facilitate changes in the design of individual vehicles or the transportation system as a whole that enable reductions in energy intensity" (Wadud, MacKenzie, & Leiby, 2016).

Nevertheless, there is a close relation between energy saving potential and travel impacts resulting from different levels of automation. At low levels of automation, various energy intensity saving mechanisms could be implemented, likely outweighing slight increases in travel activity. However, as previously explained, high-automation levels could lead to substantial increases in travel demand and, accordingly, in energy consumption. Figure 13 presents the estimated impacts on energy expenditure of different mechanisms enabled by vehicle automation.

4.4 CCAM and Public Transport

Although new technologies and new services enabled by CCAM have the potential to positively contribute to current societal challenges, there is still uncertainty about how the deployment of CAVs will unfold and what its impact will be. The possible various scenarios strongly depend on how CAVs are to be used and regulated. The implemented business models, normative, and resultant user-behaviour, could lead to more traffic, urban sprawl and congestion, or could *"contribute to shaping sustainable and liveable cities, the regaining of urban space, less vehicles on the road and a higher quality of life"* (UITP, 2017).

Public transport remains the only available solution to respond to the high-levels of transport demand that arise in dense urban environments, in an efficient and space efficient manner. Which is why, as stated in UITP's Policy Brief on automated vehicles, *"the arrival of driverless autonomous vehicles represents a unique opportunity for a fundamental change in urban mobility and could lead to healthier, more competitive and greener cities – but only if public authorities and public transport companies take an active role now and integrate AVs into an effective public transport network"* (UITP, 2017).

CAVs could dramatically enhance public transport, through car-sharing schemes and innovative services, such as shared 'robo-taxis' and mini-buses, by complementing rather than directly competing with it. Moreover, adopting AV technology in public transport services, e.g. autonomous buses and shuttles, could result in a significant reduction of operational costs, through effective PPPs (Thomopoulos & Nikitas, Editorial, 2019),and enable an extended supply of mobility services.

Nonetheless, as stated earlier, there is an essential need for structured coordination and information exchange among cities, at the national, European and global levels, in order to define consolidated needs, allow for market harmonization, markets, and enable the creation of economies of scale that ensure the optimal development of these new mobility services.

4.5 EU-funded projects for the development of automated driving

The European Union has strongly supported collaborative research contributing to automated driving, by funding numerous projects in the areas of: Networking, Coordination & Support, Infrastructure, Connectivity and Cooperative Systems, Driver Assistance Systems and Partial Automation and Highly Automated Road Transport. Figure present an overview these projects (ERTRAC, 2019).

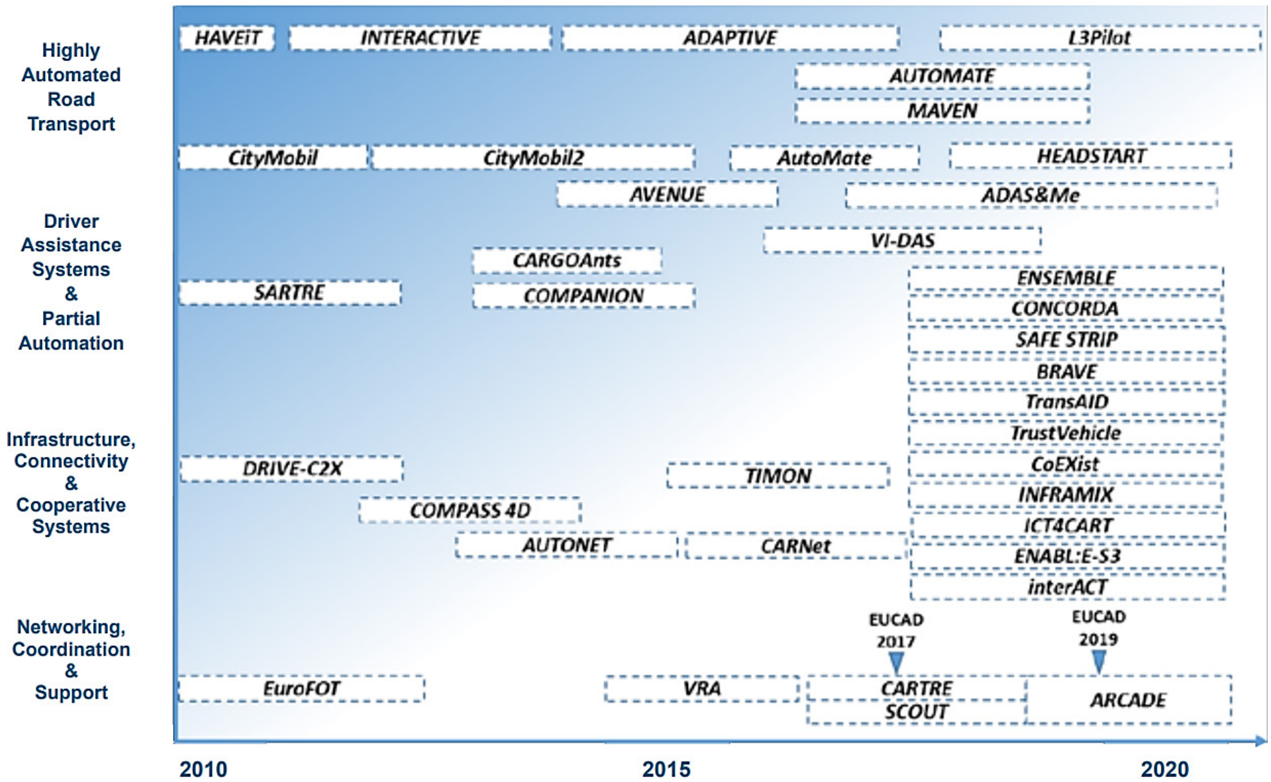


Figure 14: Overview of a subset of EU funded projects that support development of automated driving (ERTRAC, 2019)

Reference List

ARCADE. (2019). Connected Automated Driving Europe. Retrieved from Library: https://connectedautomateddriving.eu/library/

BMVI. (2015). Strategy for Automated and Connected Driving. Federal Ministry of Transport and Digital Infrastructure - Germany, Berlin. Retrieved from https://www.bmvi.de/SharedDocs/EN/publications/strategy-for-automated-and-connected-driving.pdf?__blob=publicationFile

bmvit. (2016). Automated - Connected - Mobile: Action Plan Automated Driving. Executive Summary, Austrian Ministry for Transport, Innovation and Technology, Vienna. Retrieved from http://www.smart-mobility.at/fileadmin/media_data/services/Thematisches/Actionplan_automated_driving.pdf

CAD. (2018). Citymobil 2. Retrieved from Connected Automated Driving Europe: https://connectedautomateddriving.eu/project/citymobil-2/

CAPITAL. (2018). CAPITAL Online Training Platform. Retrieved from https://www.its-elearning.eu/courses

City of Gothenburg. (2017). DriveME self driving cars for sustainable mobility. Retrieved from https://international.goteborg.se/smart-cities-and-sustainable-solutions/driveme-self-driving-cars-sustainable-mobility

CoEXist. (2018). Automation-ready framework. Retrieved from https://www.h2020-coexist.eu/wp-content/uploads/2018/12/D1.1-Automation-Ready-Framework-Preliminary-version-1.pdf)

Contantini, F., Steibel, F., Curl, A., Lugano, G., Kovacikova, T., & Thomopoulos, N. (2020). Data protection in a GDPR world: An inter-continental comparison of implications for AVs. In D. Milakis, N. Thomopoulos, B. van Wee, & (Eds) (Ed.), Policy Implications of Autonomous Vehicles. Elsevier (forthcoming).

ERTRAC. (2019). Connected Automated Driving Roadmap. Retrieved from https://www.ertrac.org/uploads/documentsearch/id57/ERTRAC-CAD-Roadmap-2019.pdf

European Commission. (2019). Open call for applications for the single platform for open road testing and pre-deployment of cooperative, connected, automated & autonomous mobility. Retrieved from https://ec.europa.eu/transport/modes/road/news/2019-02-26-call-applications-single-platform_en

GECKO. (2019). GECKO: Governance for new mobility solutions. Retrieved from http://h2020-gecko.eu/

KTH Royal Institute of Technology. (2017). Future scenarios for self-driving vehicles in Sweden. Integrated Transport Research Lab, Stockholm. Retrieved from https://www.kth.se/polopoly_fs/1.735829.1550158521!/Pernestal%20Brenden%20etal%202017%20Future%20scenarios.pdf

Milton Keynes. (2018). Transport Policy. Retrieved 2018, from Milton Keynes: Highway & Transport Hub: https://www.milton-keynes.gov.uk/highways-and-transport-hub/policy-and-strategy-hub/transport-policy

Mitteregger, M., Bruck, E. M., Soteropoulos, A., Stickler, A., Berger, M., Dangschat, J. S., . . . Banerjee, I. (2019). AVENUE21. Automatisierter und vernetzter Verkehr: Entwicklungen des urbanen Europa. TU Academic Press (in print).

Plattform Urbane Mobilität. (2017). Deutsche Automobilindustrie und Städte im Dialog über urbane Mobilitätslösungen von morgen. Retrieved 2018, from Plattform urbane Mobilität: https://www.plattform-urbane-mobilitaet.de/

POLIS. (2018). Road Vehicle Automation and Cities and Regions. Brussels, Belgium. Retrieved from https://www.polisnetwork.eu/uploads/Modules/PublicDocuments/polis_discussion_paper_automated_vehicles.pdf

Rupprecht Consult - Forschung & Beratung GmbH (editor). (2019). Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan. (Second Edition (Draft for Review, 14 May 2019)).

Thomopoulos, N., & Givoni, M. (2015). The autonomous car - a blessing or a curse for the future of low carbon mobility? An exploration of likely vs. desirable outcomes. Eur J Futures Res, 3(14).

Thomopoulos, N., & Nikitas, A. (2019). Editorial. Int. J. Automotive Technology and Management, Vol. 19(Nos. 1/2).

UITP. (2017). Autonomous vehicles: a potential game changer for urban mobility. Policy Brief. Retrieved from https://www.uitp.org/sites/default/files/cck-focus-papers-files/PolicyBrief_Autonomous_Vehicles_LQ_20160116.pdf

UK Autodrive. (2017). Survey finds UK public still "open minded" about self-driving vehicles. Retrieved from http://www.ukautodrive.com/survey-finds-uk-public-still-open-minded-about-self-driving-vehicles/

Van Der Pas, J.-W. (2017, October 20). Case Study: Antwerp's Marketplace for Mobility: partnering with private mobility service providers. Retrieved from ELTIS: The urban mobility observatory: http://www.eltis.org/discover/case-studies/antwerps-marketplace-mobility-partnering-private-mobility-service-providers

Wadud, Z., MacKenzie, D., & Leiby, P. (2016). Help or hindrance? The travel, energy and carbon impacts of highly automated vehicles. Transportation Research Part A: Policy and Practice, Volume 86, 1-18.

WISE-ACT COST Action. (2019). WISE-ACT Atlas. Retrieved from WISE-ACT: https://wise-act.eu/wise-act-atlas/