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VIENNA 2018 TRA
A digital era for transport
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Proceedings of 7th Transport Research Arena TRA 2018, April 16-19, 2018, Vienna, Austria

Automation-ready framework for urban transport planning

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Abstract

The mission of the H2020 CoEXist project is to enable mobility stakeholders to get "Automation-ready" – which CoEXist currently defines as conducting transport and infrastructure planning for connected and automated vehicles (CAVs) in the same comprehensive manner as for existing modes such as conventional vehicles, public transport, pedestrians, and cyclists, while ensuring continued support for existing modes on the same network. This definition will be fine-tuned through stakeholder engagement processes. The H2020 CoEXist project started in May 2017 and will run until April 2020. This paper introduces this project and covers its progress until January 2018, with a focus on the methodology of the "Automation-ready framework" that provides a planning framework for urban road authorities to prepare for the introduction of CAVs on the road network. The framework includes elements about strategic urban mobility planning for CAVs and a clear guide for urban transport planners with a list of concrete actions that cities can do now to plan for CAVs on their road network.

Keywords: Transition to Automation, Transport Modelling & Simulation, Use Cases, Education / Training / Skills for Future Transport Technologies

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Nomenclature

CAV connected and automated vehicle
CV conventional vehicle
SUMP sustainable urban mobility plan
Vissim a microscopic traffic simulation software developed by the PTV Group used for the evaluation of impacts on a detailed level
Visum a macroscopic transport modelling software developed by the PTV Group used for the strategic impacts on a city's transportation network

1. Introduction

Connected and automated vehicle (CAV) manufacturers are planning for the market introduction of vehicles with increasingly automated functionalities. For example, Renault, a partner of the H2020 CoEXist project, will launch a range of at least ten models equipped with newly developed automation technology by 2020. But although steps towards the deployment of AVs are progressing fast, the success of the transition towards CAVs may be determined by the acceptance of stakeholders that have so far mostly not been part of the debate: local authorities and others with a stake in urban transport planning and road infrastructure. Consequently, most European local authorities are ill-prepared for the introduction of this "new mode" on their road network, because their road infrastructure (physical and digital) is only designed for conventional vehicles (CVs). Automation-ready transport and infrastructure planning in cities is a key precondition for fulfilling the promises of CAVs to reduce road space demand and improve traffic efficiency and safety – without it, CAVs could simply increase the urban mobility problems that local authorities are currently facing.

The mission of the H2020 CoEXist project is to systematically increase the capacity of local authorities and other urban mobility stakeholders to get ready for the transition towards a shared road network with increasing levels of CAVs, both in terms of vehicle penetration rates and levels of automation (SAE International, 2016) using the same road network as CVs. CoEXist will enable mobility stakeholders to get "Automation-ready" – which CoEXist currently defines as conducting transport and infrastructure planning for CAVs in the same comprehensive manner as for existing modes such as conventional vehicles, public transport, pedestrians, and cyclists, while ensuring continued support for existing modes on the same network. To achieve its objective of building the capacity of road authorities and other urban mobility stakeholders to get ready for the transition and coexistence period, CoEXist is conducting several stakeholder engagement activities. The definition of Automation-ready and its integration with overall sustainable urban mobility goals will be tested and adjusted during these consultation workshops.

CoEXist will address three key steps to achieve Automation-ready transport and road infrastructure planning:

- Automation-ready transport modelling: Develop a validated extension of existing microscopic traffic flow simulation (PTV Vissim) and macroscopic transport modelling (PTV Visum) tools to include various types of CAVs (passenger cars/light-freight vehicles, automation levels).
- Automation-ready road infrastructure: Create a tool to assess the impact of CAVs on traffic efficiency, safety, and space demand and development of design recommendations for Automation-ready infrastructure.
- Automation-ready road authorities: Elaboration of eight use cases in four European local authorities, to demonstrate the above tools and to develop concrete Automation-ready infrastructure and policy action plans and recommendations for local authorities.

Findings from these three steps will be combined to develop the main deliverable of CoEXist, the "Automation-ready framework", which is a comprehensive guidance document that empowers European local authorities to plan for a future with increasing numbers of CAVs on their network. The technological scope of the framework aims to provide recommendations that are "scenario-neutral", as it acts under the assumption that European cities will experience a very wide range of CAV deployment due to unique local circumstances with regards to the mode share between privately, shared or collective CAVs.

The H2020 CoEXist project has 16 partners and an overall budget of 3.5€million[1]. This paper covers the project progress until January 2018 and mainly focuses on the methodological steps in the development of the Automation-ready framework.

2. The need for the Automation-ready framework

In the paper by Jones (2014) '*the evolution of urban mobility: the interplay of academic and policy perspective',* three evolutionary stages of urban transport policy are described, starting at the period of wide scale deployment of the private motor vehicle. Each of the stages describe a 'paradigm shift' on how urban mobility is understood.

Stage one describes the period where urban economic growth led to a rapid increase in car ownership and use, and a resulting policy focus on meeting the 'inevitable' major growth in motor vehicle traffic, to avoid the city 'grinding to a halt'. The solution to this problem is often seen in engineering and scientific terms as requiring investment in major urban road building programmes and measures to maximize vehicle capacity on the entire network. This approach, with its obvious flaws, led to a policy impasse: how to cope with the pressures for traffic growth, if major road building is not an option? The major breakthrough comes by redefining the problem — the first paradigm change. The second stage: rather than catering for unlimited vehicle movement in urban areas, the primary objective switches to cater for growing person movement instead. This enables road traffic growth to be contained, while increasing overall levels of mobility. From a person trip perspective, the policy focus switches to one of moving people (rather than vehicles) from their origin to destination, in the most efficient manner, so the mode by which this movement takes place becomes of secondary importance. In the third stage, a much greater emphasis on cities as centres of activity and on associated urban quality of life issues. From this perspective, it is meeting people's activity participation requirements which is of primary concern, and movement is secondary — a means to an end, rather than an end in itself.

The three stages can also be understood in a way how cities have dealt with the last time a disruptive technology (i.e. the private motor vehicle) entered the urban area in an uncontrolled manner. In European cities it took over two generations to develop a suitable reaction to cope with the disruptive technology.

Considering the predicted technological advancements (ERTRAC, 2017) in CAVs, the CoEXist consortium believes that we are entering a new stage of urban mobility. An uncontrolled deployment of CAVs in cities is likely to lead to conflicts between CAV users and non-users, for example due to conflicting transport planning needs resulting in a conflict between liveable vs. CAV-/Automation-ready cities. Currently, it is unclear with what measures cities should react to these changes. Only the future can tell whether European cities are entering into a stage four due to CAVs, but today it is clear that local authorities do not seem prepared. The inaction of transport planners towards considering CAVs could be an indication that they rather avoid unpredictable trends in their currently developed transport planning strategies until CAV deployments become clearer and radical technological developments of CAVs become stable. For example:

- Two CoEXist partner cities, Gothenburg (Hellberg et al., 2014) and Stuttgart (Oehler et al., 2014), do not mention CAVs in their strategic urban mobility plans once, even though Gothenburg's plan covers a period until 2035 and Stuttgart until 2030 when the deployment of CAVs are already expected to start; although Gothenburg's plan broadly covers the consideration of innovation.
- In a survey of the 24 largest German cities (Heinrichs and Hasse, 2017), a general finding is that cities and public transport providers are currently not dealing with CAVs and rather see this topic as being relevant only in 10-15 years.

The result of this inaction is an urban mobility policy vacuum that does not provide a clear strategy for dealing with CAVs, which can lead to potential future conflicts and the threat of a solely CAV-oriented development of future transportation services and products by the automotive and technology companies (Heinrichs and Hasse, 2017). The recent conflict between Transport for London and UBER in London[2] can be considered as a harbinger of how potential conflicts between local authorities and providers of automated mobility services could emerge, as a result of not being proactive in planning.

[1] Please visit CoEXist website for further information about the project: www.h2020-coexist.eu
[2] https://tfl.gov.uk/info-for/media/press-releases/2017/september/licensing-decision-on-uber-london-limited

Some cities are taking matters proactively and are starting to consider the impact of CAVs in their planning processes. For example, Seattle (Bellinger et al., 2017) and Amsterdam have developed strategies to deal with the potential impacts of CAVs. Both documents provide some guidance for the cities, but the main aim is to kick-start a debate within the local authority administration and other stakeholders around the topic of CAVs.

The CoEXist project believes that CAVs will lead to an ascent of a new paradigm in urban transport planning, i.e. possibly a fourth stage or a modified stage three in Jones' (2014) "Transport Policy Development Cycle". Through the Automaton-ready framework, CoEXist aims to support local authorities to prepare for this potential fourth stage. Hence, a main significance of this framework is to elaborate and comprehensively outline the numerous potential impacts instigated by the introduction of CAVs within the road transport networks of cities, while providing recommendations on policies and measures to incorporate CAVs into integrated and sustainable strategic transport planning. This is also important, as governments and relevant mobility stakeholders make significant investment in planning considering the long term, i.e. 30-40 years, infrastructure and societal implications (Bessoudo, Labrèche, and Pye, 2016)

2.1. Objectives of the Automation-ready framework

The aim of the Automation-ready framework is to provide guidance and empower local authorities to make critical and reasonable decisions about the introduction of CAVs into their road networks. It is a transport planning framework for urban road authorities to prepare for the introduction of CAVs on the road network. The framework will include elements about strategic urban mobility planning for CAVs and a guide for urban transport planners with a list of concrete actions that cities can do now to plan for CAVs. With this background, the objectives of the framework within CoEXist are as follows:

- Develop and test a vision and definition for Automation-ready local authorities during the transition phase.
- Develop and demonstrate tools for the analysis and evaluation of Automation-ready infrastructure (traffic modelling and impact assessment).
- Develop detailed Automation-ready infrastructure and policy actions and recommendations for local authorities that can be summarised in Automation-ready action plans or integrated in strategic transport plans (e.g. SUMPs).

All aspects of the Automation-ready framework will be developed and tested with the four CoEXist partner cities and with an extensive list of urban transport stakeholders in order to make it as practical and applicable as possible within the urban transport sector.

3. Methodology in developing the Automation-ready framework

The methodological steps to develop the Automation-ready framework are illustrated in Fig. 1. Initially, through a multi-stakeholder engagement process the Automation-ready vision and definition are identified. Followed by the development of Automation-ready tools, covering traffic modelling and impact assessment. These tools are then applied to eight traffic modelling use cases in four cities; considering "scenario-neutral" CAV deployments, meaning most cities will have the flexibility to identify their deployment methods according to the automation deployment triangle which illustrates three corner stones of private vehicle, shared, and collective transport. The results of the applications on the eight use cases will then be summarised in individual action plans for each city. The lessons learned from cities are consolidated in a generic guidance document on how cities can become Automation-ready with specific action plans and recommendations.

3.1. Vision and definition

CoEXist sees a clear need for cities to develop a vision for Automation-ready cities. It sees itself in line with other visions developed for urban mobility, e.g. CIVITAS Declaration (CIVITAS Initiative, 2014). These are developed through multi-stakeholder engagement processes to gather the input from stakeholders of relevant sectors, i.e. OEMs and their suppliers, local authorities, road research authorities, decision makers, researchers, policy makers, and mobility consultants, among others. The stakeholders will be engaged through workshops, focus group meetings and online surveys. Initial results are summarised in section 5.

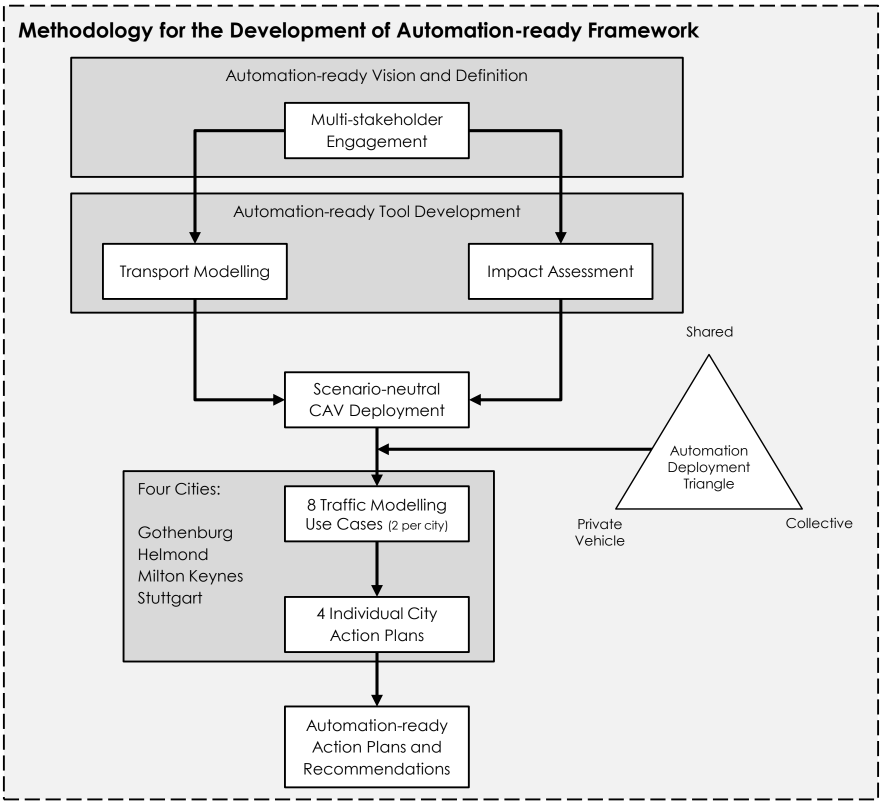

Fig. 1 Methodology for the development of the CoEXist Automation-ready framework

3.2. CoEXist tool development

Current transport assessment tools (e.g. transport modelling and impact assessments) are designed for modelling vehicles with no automation or with limited driver assistance systems. This means local authorities and transport planning consultants are not able to accurately assess the impact CAVs might have on the traffic in their road networks. As part of the Automation-ready framework development, the CoEXist project is overcoming this problem by developing extensions for the most widely used micro- (PTV Vissim) and macroscopic (PTV Visum) traffic models. Moreover, an impact assessment is being developed that feeds on the results from the Automation-ready models to assess the likely impacts of CAVs on traffic efficiency, safety and space demand. This enables transport planners without profound knowledge or experience with CAVs to simulate them and assess their impacts.

Automation-ready transport modelling

CoEXist will overcome the technical limitations that currently exist in transport modelling, by developing default parameter sets and values for CAVs. This enables transport planners who do not have access to a CAV control logic to model CAVs with either realistic or assumed driving behaviour of CAVs.

This is achieved by creating a closed-loop connection between two CAV control logics (provided by Renault and Vedecom), a CAV-simulator (PreScan) and a microscopic traffic simulator (PTV Vissim). Through the connection with the CAV control logics, the microscopic simulation tool can be used to extract CAV behaviour parameter sets for sub-models (incl. lane change, car following and lateral positioning, reaction on signals) inside PTV's microscopic traffic flow simulation software (PTV Vissim). These parameter sets in turn are used as model input and primarily describe the behaviour of vehicle-driver units, i.e. the capabilities of the vehicle (e.g. maximum speed) as well as the preferences of the drivers (e.g. desired speed). By implementing CAV-compliant sub-models for vehicle following or lane changing within the microscopic simulation tool, it is possible and convenient for the software users to change the behaviour of the CAVs according to their own assumption. This is necessary, since it is not possible to predict all characteristics of future CAVs and of changes in the traffic code. Table 1 shows a brief overview of the likely changes for the CAV behavioural parameters:

Table 1. Overview of possible changes of behavioural parameters

Behavioural parameter	Possible changes for CAV
Temporary lack of attention	Reduction to a probability of zero if no sensor malfunctions occur
Number of observed vehicles	Decrease or increase depending on capability of sensor suite and environmental conditions (weather)
Headway time	Reduction or increase, dependent on driver logic and traffic code
Maximum deceleration for lane change	Unclear, could be a decision of the CAV-user
Maximum speed difference for overtaking on two lane highways	Depends on rules of the traffic code
Reaction to amber time	No crossing on red for all CAVs
Maximum acceleration and deceleration	Probably no changes
Desired acceleration and deceleration	Could be a setting of CAV-user, since the comfort strongly depends on this
Desired speed	No speeding for all CAVs

CoEXist tools: Impact assessment for Automation-ready road infrastructure

Within CoEXist, Automation-ready road infrastructure is an infrastructure that allows the coexistence of CAVs and CVs and other modes, i.e. an infrastructure that can handle introduction of CAVs without significant decline in traffic performance, space efficiency or safety.

Micro- or macroscopic modelling tools outputs (e.g. average speed, travel times, queue lengths, links flows and travel times) do not provide answers to whether or not the road transport infrastructure is Automation-ready. To allow for a systematic analysis of whether an infrastructure is Automation-ready or not, these outputs need to be transformed into CAV-context relevant metrics on traffic performance, space efficiency and safety. That together with additional criteria can be used to conclude whether the infrastructure is Automation-ready or if adaptation is needed. Initial results for this tool will be available in mid-2018.

4. Demonstration of CoEXist tools in eight traffic modelling use cases

The developed CoEXist tools will be practically applied by four road authorities to eight traffic modelling use cases (see Table 2) to support their path to Automation-ready transport and infrastructure planning. The application results from the tools are fed into and aligned with the existing planning, working and stakeholder processes of the road authorities. As shown in the methodology in Fig. 1, the experiences from the four road authorities will each be documented into individual action plans and a compilation of the action plans will be summarised in a 'Guideline: How to become an Automation-ready road authority?', which contains Automation-ready actions and recommendations for cities.

4.1. Selection of traffic modelling use cases

The use cases represent examples of critical urban road infrastructure for the deployment of CAVs. For the evaluation of impacts on a detailed level, microscopic traffic simulation with PTV's Vissim will be conducted, while for strategic impacts on a city's transportation network, macroscopic transport modelling with PTV's Visum will be utilised. The simulation of CAVs in the use cases helps the project to identify potential conflicts arising from the introduction of CAVs, and enables evaluation of potential measures to reduce these conflicts. CoEXist has identified eight use cases in four cities (Gothenburg, Helmond, Milton Keynes, Stuttgart), i.e. two use cases per city.

The selection of use cases is based on several discussion rounds, among the CoEXist consortium partners and cities, about the practicality and fit with regards to the specific context conditions in cities. These use cases will be specified further through upcoming workshops with regards to evaluating alternative changes or reallocation of infrastructure, changes of traffic control, changes of the public transport system, changes or introduction of policy measures, or changes of regulation or rules. These could for example include different lane divisions and configurations, changes to junction design, CAV-only lanes, and cooperative traffic signals.

To test potential impacts within the environment of the use cases, different traffic share scenarios will be developed in the coming year. The scenarios describe the "demand side" variables which include the traditional traffic composition (traffic flow and modal composition), CAV-specific variables such as penetration rates of CAVs, levels of automation, levels of connectivity, and other CAV-specific variables that will be specified in the project.

The selected use cases, as shown in Table 2, constitute a comprehensive collection of traffic environments that CAVs could face in the future.

Table 2. Overview of CoEXist use cases.

City	**Use Case**	**Modelling approach**
Gothenburg, Sweden	1) Shared space	Micro
	2) Accessibility during long-term construction works	Macro
Helmond, Netherlands	3) Signalised intersection including pedestrians and cyclists	Micro
	4) Transition from interurban highway to arterial	Micro
Milton Keynes, England	5) Waiting and drop-off areas for passengers	Micro
	6) Loading and unloading areas for freight	Micro
Stuttgart, Germany	7) Impacts of CAV on travel time and mode choice on a network level	Macro
	8) Impact of driverless car- and ridesharing services	Macro

4.2. Gothenburg, Sweden

4.2.1. Use case 1: Shared space (microscopic modelling)

Automated last mile services (levels 4-5 (SAE International, 2016)) integrated with the public transport system is an interesting solution to increase the accessibility of the city centre. However, the city centre of Gothenburg contains several areas with shared space characteristics; both areas that formally are shared spaces and areas with conventional traffic regulations but dominated by large volumes of pedestrians. The use case is focused on estimating the traffic effects of shared spaces when an automated last mile service is introduced, and to investigate the effects of potential measures to improve the traffic efficiency without reducing the quality of service for pedestrians and cyclists.

4.2.2. Use case 2: Accessibility during long-term construction works (micro- and macroscopic modelling)

During an upcoming period of long-term construction in Gothenburg, a lot of strain will be put on the existing infrastructure, which would limit the accessibility to the city centre. Through the application of the Automation-ready macroscopic modelling tool, the aim of this use case is to estimate to what extent the introduction of CAVs (levels 3-5 (SAE International, 2016)) may improve the traffic conditions during extended construction periods. The effects of the introduction of CAVs on the traffic conditions, e.g. route choice effects of changes in the traffic dynamics on road links and at intersections, will be investigated. Also, various possibilities to route CAVs, e.g. by allowing CAVs to pass construction areas on narrow temporary lanes or links or allowing bidirectional CAV traffic in a tunnel tube and add extra lanes by making the lanes narrower.

4.3. Helmond, Netherlands

4.3.1. Use case 3: Signalised intersection including pedestrians and cyclists (microscopic modelling)

This use case will explore the traffic management impact of junction and traffic light controller design for mixed

CAV and CV traffic. Pedestrians and cyclists will be included, as well as HGVs. The focus will be on traffic management impact with advanced traffic light controllers that support traffic optimisation based on loops and other detectors, which can prioritise in real time based on type of traffic. A central question to investigate in this use case is how the potential increase in intersection capacity induced by the introduction of CAVs may be redistributed to pedestrians and cyclists.

4.3.2. Use case 4: Transition from interurban highway to arterial (microscopic modelling)

Evaluate the impact of automated driving on a road that transitions from an interurban highway between Helmond and Eindhoven to an arterial as the road enters Helmond. The focus will be on speeding problems at the junctions at the end of the highway. Special attention will be paid to the impact of providing Intelligent Speed Adaptation (ISA) to the CAVs compared to non-equipped vehicles.

4.4. Milton Keynes, England

4.4.1. Use case 5: Waiting and drop-off areas for passengers (microscopic modelling)

The focus of this use case is ton evaluating the impact on existing and future infrastructure by creating waiting & drop off areas for CAVs. Many road authorities are looking for ways to decrease motorized traffic in the city centre in order to enhance air quality and reallocate car parking space to other purposes. Restricting vehicle access to the city centre is assumed to require facilities for CAVs to drop off / collect users at the roadside and or at origins/ destinations. The last mile will then be undertaken by connection to other modes as walk, cycle or a dedicated CAV POD service and maybe a higher capacity shuttle service. How the vehicles behave at the waiting and drop-off zones is critical with regards to dwell time, approach speeds, and reliability of pick-up/human interface, as well as for traffic performance at the roads and junctions at the edge of the city centre.

4.4.2. Use case 6: Loading and unloading areas for freight (microscopic modelling)

The modelling will look at how freight and deliveries impact city traffic operations, what are the infrastructure requirements for loading/unloading. With the growth of light freight deliveries, the impact of current operation on traffic is growing; currently a big impact on bus reliability is delivery vehicles blocking bus routes. This use case is an extension of use case 5 focusing on freight deliveries and pick-ups instead of passenger drop off or pick-up.

4.5. Stuttgart, Germany

4.5.1. Use case 7: Impacts of CAV on travel time and mode choice on a network level (macroscopic modelling)

CAVs may increase the capacity of road infrastructure. Using the Stuttgart region travel demand model, CoEXist will estimate how the road capacity increase which is expected to be higher on motorways than in urban areas will affect travel time and mode choice on a network level. The hypothesis is that increased capacity and higher safety will reduce journey time and increase travel time reliability. This may also improve the general utility of the car, as drivers can use their in-vehicle time more efficiently. Introduction of CAV-certified road sections / road network or introduction of “geofenced” CAV-ready areas are measures that might be investigated.

4.5.2. Use case 8: Impact of driverless car- and ridesharing services (macroscopic modelling)

Driverless cars of level 5 will provide new choices to travellers as car- and ridesharing services can be organized in new ways which even may affect urban public transport. An extended version of the existing travel demand model of the Stuttgart Region will be used to examine the potentials of driverless cars for automated car- and ride-sharing services and their impact on public transport and urban traffic flow. In addition to this the use case will also investigate differences in impacts of public vs. private ridesharing services and how many privately owned cars can be replaced by a high-performing car- or ridesharing service.

4.6. Methodology outputs: Automation-ready actions and recommendations

Planning road infrastructure for a mode that does not exist yet (i.e. CAVs) can appear rather abstract for urban mobility stakeholders who are not directly involved in the debate about CAVs. Important stakeholder groups such as emergency services, schools, cyclist groups or the mobility impaired need to be involved early in the planning processes to identify problems associated with an increasing amount of CAVs. Therefore, each CoEXist local authority will organise an 'Automation-ready Forum' that will present the results from the application of the CoEXist tools on the traffic modelling use cases to local and national stakeholder groups. Findings from these events will directly feed into the development of Automation-ready action plans, which give detailed guidance on steps road authorities have to take for a future with Automation-ready infrastructure and transport planning. For example, the plan will include guidance on road infrastructure design recommendations, staff development and strategic urban mobility goals that can be addressed in different timeframes (e.g. 5 years, 10 years or 15 years). Findings from the action plan could be integrated into the other planning documents, such as Sustainable Urban Mobility Plans (SUMPs).

Table 3. Initial results from stakeholder engagements (see section 5): Key measures to be taken in the next 15 years categorized into different aspects of mobility

Mobility aspect	0-5 years	5-10 years	10-15 years
Policy	• Liveability as top priority • Support testing activities and research incl. legal and regulatory activities	• Incorporation of CAVs into city mobility goals • Mobility pricing for "SPAM" roaming cars • Avoid segregation or prioritisation of CAVs over public transport & active modes	• Taxation changes for mobility • (Potential) area and vehicle occupancy based road pricing
Infrastructure	• Preparation of physical and digital infrastructure • Digital infrastructure needs to transition to open access	• Reallocation of on-street parking to green and public spaces	• Land use changes • Modifications to infrastructure and accompanying traffic code (e.g. lane markings, minor changes of infrastructure designs, speed limits, lane width)
Planning	• Proactive planning • Planning for adaptability and flexibility to technology • Stakeholder engagement process to encourage cross-sectoral collaboration and coordination	• Update travel demand models and evaluate road capacity needs • Assess public transport plans and fleet requirements considering CAV first and last mile solutions • Integrate solutions in mobility: electric, intelligent, automated, shared, inclusive	• Integration of solutions in mobility: electric, intelligent, automated, shared, inclusive • Assessment of required land use changes based on integrated land use and transport modelling tools
Capacity Building for Transport Authorities	• Stay educated on mobility technology progress	• Reassessment of strategic mobility plans; incorporating new mobility forms	• Training for traffic management and public transport operations • Restructuring of internal departments (e.g. information technology department, Mobility as a Service (MaaS) department)
Traffic Management	• Road authorities need to be more involved in the discussion and	• Back office for data exchange in traffic management	• Defining data management responsibility with new management schemes • New schemes of deploying municipal services, maintenance and logistics traffic at night in the urban area, if autonomous functionality is available

5. Automation-ready Stakeholder Engagements

This section presents a summary of the initial results from two stakeholder consultation workshops that have been conducted. CoEXist held workshops during the CIVITAS Forum 2017 and in a joint workshop with the H2020 MAVEN and TransAID projects on the implications of vehicle automation on urban roads. Over 70 people in total participated in the two workshops that have been conducted thus far, with attendees from local authorities, regional authorities, research institutes, consultancies, car manufacturers, and other urban transport stakeholders. Below are the key results of the consultation process:

- The key measures identified for the next 15 years are summarised into five categories in Table 3.
- There are uncertainties in the technology of CAVs and thus making it difficult for local authorities to develop concrete deployment plans.

- The top priority for cities is liveability and thereby measures for public transport, cycling, and walking will remain as the backbone to achieve urban mobility goals. Automation needs to be integrated as a means to sustainable mobility.
- The policy-making challenges need to be addressed on the same pace as technology, if not faster.
- In the discussion of Automation-readiness, transport and infrastructure planning should include digital infrastructure alongside physical infrastructure, especially considering the fact that most of the benefits of automation would only be attained if automated vehicles would be connected (i.e. V2V, V2I/I2V, or V2X).

These results will be fed into CoEXist's final action plans and recommendations document.

6. Automation-ready Framework

Findings from the above activities will be summarised and presented in the Automation-ready framework as generic findings for any local authority that aims to prepare for the introduction and increasing levels of CAVs. Based on the findings from CoEXist, a detailed overview of Automation-ready actions will be prepared that will be structured in implementation stages. Each implementation stage recommends a list of actions that local authorities can take to prepare for the increasing numbers of CAVs in their city traffic streams.

7. Conclusion

This paper describes the methodology that is applied by the H2020 CoEXist project in developing the Automation-ready framework. The framework is developed by creating a vision and defining Automation-readiness from a local authority perspective through a multi-stakeholder engagement process. Further assessment tools (Automation-ready modelling and impact assessment) are being developed to assess the impact of CAVs on eight traffic modelling use cases. Findings from the application of the CoEXist tools and a local engagement process will create local Automation-ready actions plans, which can provide generalised advice to cities who are starting to plan for CAVs on their road network. The first version of the Automation-ready framework will be published in January 2018. Findings from this will be incorporated in an updated version of this TRA paper. The final version of the Automation-ready framework will be published in March 2020, just in time for the TRA 2020.

Acknowledgements

We would like to express our gratitude to all CoEXist consortium partners and the following people for their contributions in the first CoEXist results presented in this paper: Frank van den Bosch, Mikael Ivari, Lina Svensson, Nina Galligani Vardheim, Brian Matthews, Ammar Anwar, John Miles, Gisa Gaietto, Charlotte Flèchon, Peter Sukennik, Alexander Dahl, Suzanne Hoadley, Nadège Faul, Thierry Goger, and Adriano Alessandrini.

8. References

Bellinger, Matthew, Ryan Calo, Brook Lindsay, Emily McReynolds, Mackenzie Olson, Gaites Swanson, Boyang Sa, and Feiyang Sun. 2017. 'Driverless Seattle: How Cities Can Plan For Automated Vehicles'. Tech Policy Lab University of Washington. http://www.mobility-innovation-center.uwcomotion-sites.com/wp-content/uploads/2017/02/TPL_Driverless-Seattle_2017.pdf.

Bessoudo, Karina, Stéphane Labrèche, and David Pye. 2016. 'Mobility: Transport Planning in the Age of Autonomous Vehicles'. WSP Parsons Brinckerhoff.

CIVITAS Initiative. 2014. 'CIVITAS Forum Network Declaration'. CIVITAS Initiative. http://civitas.eu/cities.

ERTRAC. 2017. 'ERTRAC Auotmated Driving Roadmap'. European Road Transport Research Advisory Council. http://www.ertrac.org/uploads/documentsearch/id48/ERTRAC_Automated_Driving_2017.pdf.

Heinrichs, Dirk, and Felix Hasse. 2017. 'Digital Mobil in Deutschlands Städten'. PricewaterhouseCoopers GmbH Wirtschaftsprüfungsgesellschaft.

Hellberg, Sofia, Per Bergström Jonsson, Magnus Jäderberg, Malin Sunnemar, and Hans Arby. 2014. 'Gothenburg 2035: Transport Strategy for a Close-Knit City'. City of Gothenburg.

Jones, Peter. 2014. 'The Evolution of Urban Mobility: The Interplay of Academic and Policy Perspectives'. *International Association of Traffic and Safety Sciences* 38: 7–13.

Oehler, Stephan, Arne Seyboth, Susanne Scherz, and Marietta Wortmann. 2014. 'Das Verkehrsentwicklungskonzept Der Landeshauptstadt Stuttgart 2030 (The Transport Development Concept of Stuttgart 2030)'. Landeshauptstadt Stuttgart Amt für Stadtplanung und Stadterneuerung Abteilung Verkehrsplanung und Stadtgestaltung.

SAE International, 2016. SAE Standard J3016, Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles.