Ref. Ares(2018)5352198 - 18/10/2018

MAVEN

Managing Automated Vehicles Enhances Network

Deliverable nº: 8.4
Transition roadmap report (initial version)

Dissemination Level: PU

Version	Date	Release	Approval
0.6	10-10-2018	Florinda Boschetti, POLIS	Robbin Blokpoel (Dynniq)

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Document Log

Version	Date	Comments	Name and Organisation
01	09-11-2017	Initial version – document structure	Florinda Boschetti, Polis
02	22-12-2017	First draft version	Florinda Boschetti and Suzanne Hoadley, Polis
	2-02-2018	Input from partners	All partners
03	05-02-2018	Updated draft for comments	Florinda Boschetti and Suzanne Hoadley, Polis
	9-02-2018	Input from partners	Dynniq, Helmond, and CTU
04	16-02-2018	Updated draft for comments	Florinda Boschetti, Polis
	27-02-2018	Input from partners	Dynniq, Helmond, LGB, MapTM
05.1	**28-02-2018**	**Draft initial version submitted**	**Florinda Boschetti and Suzanne Hoadley, Polis**
06	10-10-2018	Braunschweig input added	Julian Schindler, DLR

List of Partners

Beneficiary nº	Partner	Country
1	DLR - Deutsches Zentrum Fuer Luft - und Raumfahrt EV	Germany
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Executive Summary

This document is the initial version of the MAVEN Transition Roadmap. The report presents the MAVEN project's expert views and recommendations for the transition of traffic management at signalised intersections along urban corridors from the present conventional transport world into a connected, cooperative and automated world. This vision is delivered by the MAVEN consortium.

From a road authority's perspective, the transition path to a cooperative, connected and automated world looks uncertain. Inevitably, conventional, Cooperative Intelligent Transport Systems (C-ITS) and automation equipped vehicles and roadside equipment will co-exist for some time. Vehicles will also co-exist with other types of non-motorised road users, such as pedestrians and cyclists.

The Roadmap aims to assist local authorities in determining their role and responsibilities, giving special attention to the role of traffic management and its level of guidance at various phases of the transition.

The Roadmap considers political, institutional and organisational aspects, and identifies priorities related to the safety and comfort of special category road users such as public transport vehicles, vulnerable road users, logistics vehicles, and emergency vehicles. Moreover it identifies steps to be taken by policy-makers, road-authorities, standards-development organisations and other stakeholders on the route to a high penetration of highly or fully infrastructure-supported automated vehicles.

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Abbreviations and Definitions

Abbreviation	Definition
ANPR	Automatic number-plate recognition
AV	Automated Vehicle
CACC	Cooperative Adaptive Cruise Control
CAM	Cooperative Awareness Messages
CPM	Cooperative Perception Message
C-ITS	Cooperative Intelligent Transport Systems
ETSI	European Telecommunication and Standardisation Institute
GLOSA	Green Light Optimal Speed Advice
ITS	Intelligent Transport Systems
LTE	Long-Term Evolution
RSU	Road Side Unit
SAE	Society of Automotive Engineers
SAPS	System Activated Plan Selection
VRU	Vulnerable Road User
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle-to-everything communication

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1 Introduction

1.1 Scope

The objective of this Roadmap is to be a discussion and position paper that addresses the management of intelligent and highly automated vehicles in cities in general, the role of traffic management and its level of guidance at various phases of the transition more specifically. Furthermore, it presents important considerations, and steps to be taken by road-authorities, standards-development organisations and other stakeholders.

The MAVEN Transition Roadmap consists of the following sections:

- **Chapter 2** describes the scope of the MAVEN project and its approach to connected automated vehicles and urban road traffic management through the MAVEN use cases;
- **Chapter 3** sets the scene by illustrating in broad terms what changes the introduction of Cooperative Intelligent Transport Systems (C-ITS) will bring to city traffic and city traffic management;
- **Chapter 4** focuses on the MAVEN system and describes what needs to be done to introduce it into an existing city traffic management system. This section covers key aspects such as infrastructure requirements; societal, economic and environmental requirements; organisational and traffic management requirements; and operational traffic management requirements.
- **Chapter 5** introduces two MAVEN cities examples: the city of Helmond, the Netherlands and Digital Greenwich Cities, Royal Borough of Greenwich, London, United Kingdom. Two other cities' approaches to AVs are presented.
- Finally, **Chapter 6** presents some conclusions about what role traffic managers should have in the shift towards a new urban mobility scenario, and steps to be taken by local authorities who are confronted with increasing automation in road transport.

The first part of this document (Chapters 2 and 3) looks at the bigger picture of automation in transport, Cooperative ITS (C-ITS) as the enabling technology, what direction the future of urban road transport is taking and what city transport policy context is necessary to enable C-ITS. It also tries to position MAVEN by describing what C-ITS is and how we understand it, and which high technology vehicles we are considering. The second part (Chapters 4, 5 and 6) focuses on the specific MAVEN system and its recommendation to local authorities.

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2 The MAVEN project

2.1 Background

Automated vehicles (AVs), connected with an intelligent environment, could significantly contribute to meeting the EU objective of reconciling growing transport demand and mobility needs of people and goods with more efficient transport operations, lower environmental impacts and increased road safety in an integrated urban mobility system.

The coming years will see growth and investment in fully automating current driving tasks and the introduction of AVs, with the role of the human driver diminishing. At the same time, the deployment of Cooperative Intelligent Transport Systems technology (C-ITS)[1] will not only be a key enabler for distributed coordination of AVs but, combined with intelligent traffic management and control applications, will also enable the road infrastructure to monitor, support and orchestrate vehicle movements.

Though there are many vehicle technologies related to ITS, fully or partial AVs receive most of the attention of the general public. The foundation of the MAVEN project is that infrastructure applications will continue to play a vital role in the management of the traffic network. Similar to today's operation of traffic networks, traffic management and traffic control systems will have a coordinating, orchestrating and sometimes dictating influence on traffic flows and dynamics, in support of societal and collective objectives. For example, infrastructure applications may organize the formation of dynamic platoons, set targets for such platoons, but leave the details of its progress to the platoon as a self-organizing unit.

In this context, the MAVEN project is developing and testing cooperative automated driving applications at the crossing of:

- **Infrastructure versus vehicle systems' authority;**
- **Global versus local and societal versus individual users' objectives;**
- **Traffic light optimization versus vehicle trajectory and manoeuvre optimization.**

2.2 Definitions

MAVEN is considering different types of vehicles, which vary in their automation and connectivity capabilities:

[1] Standardised platform for communication between vehicles and vehicle-infrastructure.

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- **Cooperative non-automated vehicles** are assumed to be ETSI ITS G5 equipped vehicles without level-4 automated driving capabilities. In MAVEN, cooperative non-automated vehicles use V2X communication to announce their presence, status and dynamics to other cooperative vehicles and to the cooperative intersection, i.e., an ETSI ITS G5 equipped intersection. A cooperative non-automated vehicle can be any type of vehicle, for example a car, bus or truck and any vehicle class, for example a regular passenger vehicle, priority vehicle or emergency vehicle.
- **Automated Vehicles** are assumed to be equipped with level-4 Advanced Driver Assistance Systems (ADAS) which can perform all aspects of the driving task with or without the attention of the human driver. Automated Vehicles use vehicle-sensors to monitor the near surroundings of the vehicle.
- **Cooperative Automated Vehicles** are assumed to be ETSI ITS G5 (ETSI EN 302 663) equipped vehicles with level-4 automated driving capabilities at signalised intersections. In this sense, they are improved versions of cooperative non-automated vehicles. Cooperative Automated Vehicles use vehicle sensors and V2X receivers to monitor the surroundings of the vehicle, and V2X communications to interact with other cooperative vehicles and with cooperative intersections. A cooperative automated vehicle can be any type of vehicle, for example a car, bus or truck and any vehicle class, for example a regular passenger vehicle, priority vehicle or emergency vehicle. Multiple Cooperative Automated Vehicles may form a platoon and assume one out of two roles: platoon leader or follower. The platoon leader interacts with the environment on behalf of the platoon, whereas the followers primarily interact with the platoon leader. Within MAVEN this vehicle category can also be referred to as highly automated vehicle.

2.3 The MAVEN approach

The US Society of Automotive Engineers' (SAE) standard provides and defines the six levels of driving automation, from no automation to full automation. Some of the lower levels of automation are already being offered in newer cars today, through systems such as adaptive cruise control or parking assistance. Rather than providing full autonomy, these systems were designed to support the driver, who remains in full control of the vehicle.

MAVEN is developing solutions for **managing level 4 highly automated vehicles at (urban) signalised intersections,** including **algorithms for infrastructure-initiated guidance of highly automated vehicles** using negotiation protocols between vehicles and the

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infrastructure. Iteratively, highly automated vehicles receive advice and/or commands from the road infrastructure to adjust their trajectory and manoeuvring policies, while the infrastructure dynamically adapts the traffic light timing of single or multiple signalised intersections based on the anticipated vehicle arrival pattern. The project will build a system prototype that will be used both for field tests and modelling. Furthermore, it will contribute to the development of enabling technologies, such as telecommunication standards and high-precision maps.

Based on the project findings and views obtained from stakeholder consultation meetings[2] with local authorities, road authorities, and other urban road stakeholders, this Roadmap for the introduction of **infrastructure-supported road transport automation** is being developed, to support road authorities in understanding potential **future changes in their role and in the tasks of traffic management**.

Finally, a **Guide on the "management of automated vehicles in a smart city environment" will position the MAVEN results in the broader perspective of transport in smart cities** and embed these with the principles and technologies for smart cities, as well as service delivery.

2.4 MAVEN use cases

A use case defines interactions and desired behaviour of the system and external actors under the specification of system boundaries and usage scenarios. Use cases clearly formulate the high-level functionality and expectations of the MAVEN project, and are meant to be understood by different stakeholders, namely technology companies and Local Authorities. They are further broken down into particular requirements, so they form the basis of the MAVEN functionality. A short overview of the topic-clustered MAVEN use cases follows.

[2] The first MAVEN stakeholder consultation with local authorities and urban road stakeholders took place in Barcelona on 15 November 2016, and a joint CoEXist / MAVEN / TransAID workshop on the implications of vehicle automation for city and regional authorities in Brussels on 10 October 2017.

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Use cases cluster	Description
Platoon management	These 6 use cases (1-6) are needed to form a platoon; joining, travelling and leaving a platoon; platoon break-up and termination.
Speed change advisory (GLOSA)	Calculating speed advice based on signal phase and timing information.
Lane change advisory	Distributing vehicles over the available lanes to make optimal use of the road capacity.
Emergency situations	Mitigating the risks of unexpected events and to ensure traffic safety.
Signal optimisation	These 5 use cases (10-14) are needed to balance the priorities according to the policies set by the road operator; Queue length estimation; Local level routing; Green wave; and Signal optimisation.
Negotiation	Performing a bidirectional exchange of information for negotiations using communications from infrastructure and vehicles and back.
Detect non-cooperative road users	Detection and characterization of complementing non-cooperative road users (vulnerable road users, non-cooperative vehicles) for their inclusion in relevant use cases.

Table 1: MAVEN use cases

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3 Setting the scene

Vehicle automation is receiving a significant amount of attention in the press and media, at policy level and increasingly from the general public. Automated vehicles will have an impact on several aspects of daily life, such as accessibility of services and locations, road safety, environment, congestion and economic growth. Local authorities will need to take account of vehicle automation in their policy making and longer-term strategic planning. **MAVEN can make a valuable contribution in terms of traffic management**, including the respective roles and responsibilities of the traffic manager.

3.1 Urban mobility, economic & environmental policy today

Automated vehicles have the potential to significantly impact and change how people travel in the broadest sense, including key **policy making areas.** There will necessarily be different policy implementations in different cities, however, there is significant value in cities evaluating their automated vehicle deployments against this common framework to ensure that policies can be delivered well and maximum value extracted from their implementation. More details about a city transport policy context and MAVEN's vision can be found in Chapter 4.3.

In Chapter 0 some cities (Helmond, Royal Borough of Greenwich, and two more to be selected) give their view on these aspects in relation to automated vehicles. This will make clear that different cities will have different views, but all agree that **city authorities should think about the future of the mobility systems as a consequence of automated vehicles and should incorporate this in the city policy plans**.

3.2 Traffic management today

The main purpose of urban traffic management is **to optimise the flow of people and goods on roads, essentially using different traffic signal configurations** to maximise vehicle throughput at signalised intersections. In addition to traffic signals, the traffic manager can use other tools, notably **Intelligent Transport Systems (ITS)**, to influence driver behaviour by providing information such as travel times, route guidance, roadworks/congestion warnings or special events.

Such optimisation has to be aligned with a range of transport policies and other policies, such as emissions reduction, safety of all road users, especially vulnerable road users, economic regeneration and social cohesion. For instance, the traffic manager must now seek to integrate

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public transport priority and improved road access for pedestrians and cyclists into their task as well as measures to reduce air pollution from vehicles.

Furthermore, a combination of market developments and new internal policies mean **the traffic manager is no longer alone in managing the roads and guiding vehicles**. For instance, growth in in-vehicle navigation systems has meant that the driver can choose the route that is best suited to their needs independently of the traffic manager's preferences. The move to making public data open, including transport data, is accelerating this trend as more and more third party information service providers appear on the market and the role of the city authority as information service provider diminishes.

3.3 C-ITS and cities today

Currently, vehicles are being manufactured with an increasing number of automated systems, but they do not yet interact with each other or with the road infrastructure. This interaction is the domain of Cooperative Intelligent Transport Systems (C-ITS) which will enable all road users and traffic managers to share information and use it to help co-ordinate their actions.

The co-operative element, enabled by digital connectivity between vehicles and between vehicles and transport infrastructure, may lead to improved road safety, reduced congestion and improved comfort of driving by assisting the driver to take the most appropriate decisions and become more adaptable to various traffic situations. As a traffic manager, infrastructure owner and operator, transport operator and information service provider, **city/regional authorities are important users and therefore buyers of ITS**. C-ITS can certainly add to the existing ITS mix.

While the general feeling from Transport Authorities towards C-ITS is one of caution, some cities, notably those involved in European and national pilot projects, are pushing ahead with further piloting and (pre)deployment. Greenwich, for instance, could initiate the move towards deploying C-ITS systems as part of a Connected Autonomous Vehicles test bed that is being built in the borough in 2018-19. Full deployment of C-ITS is still a way off for most transport authorities and cities, but some cities are moving towards this in small steps through active support of smart mobility pilots and showcases such as MAVEN.

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4 Transitioning to the MAVEN approach for connected, cooperative and automated transport

Transitioning to the MAVEN approach means taking the steps (technical, technological, organisational, policy, etc) required to enable the MAVEN use cases to be implemented in a city. This chapter describes in detail the various requirements, with a particular emphasis on the infrastructure requirements, communications or other infrastructure needs relating to traffic signals. Since infrastructure and traffic management are the focus of MAVEN, vehicle requirements are not addressed in this document, except in terms of communication.

4.1 Infrastructure requirements

MAVEN identifies the requirements to deploy level-4 automated vehicles which need to be understood by traffic and road managers. These requirements concern the following domains:

A. **Traffic control requirements:** Target the interaction and synergy between C-ITS use cases and traffic control algorithms;
B. **Sensor requirements:** Assist the system detecting vulnerable road users and non-equipped vehicles during the transition phase from conventional to cooperative and automated driving;
C. **Communications requirements, including road-side units:** Providing access to information from the infrastructure between different infrastructure components;
D. **Physical infrastructure requirements:** Enable automated vehicles to recognise the road topology and its regulations through clear lane markings and traffic signs;
E. **Digital map requirements:** Complement the physical infrastructure requirements by providing a detailed digital map of the environment.

4.1.1 Traffic control requirements

The requirements related to the traffic controller depend directly on the type of control algorithm deployed. There are five types of traffic control, these are fixed time control, actuated control, semi-fixed time control, adaptive control and the newly introduced stabilised adaptive control.

- The most basic form of control is **fixed-time control**. There is **no need for investment in sensors** and **the controller itself needs little processing power**. Operating and investment costs are therefore low. However, if traffic demand changes, a new plan is required. The controller can be upgraded using specific time-of-day plans and some

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sensors can be added to the network for dynamic switching between different static plans.

- For actuated control the algorithm is very simple, but **sensors are required for each lane near the stop line**. This is a significant investment. A green phase can be skipped when no traffic is present. Once a light is green, the sensors continuously check if more traffic is coming and cut off the green phase when this is not the case.
- **Semi-fixed time control** is a hybrid between actuated and fixed-time. Only the last part of a green phase is controlled by sensor status. This helps in maintaining synchronization in case of a green wave and is currently considered most suitable for Green Light Optimal Speed Advice (GLOSA).
- **Adaptive control** relies on a model of the approaches towards the intersection. This means the **investment in sensors is even higher than for actuated control**, because vehicles have to be detected further upstream. This gives the best performance in terms of traffic efficiency and allows the traffic manager to apply policy targets directly to the model instead of having to calibrate green durations. Therefore, it is also possible to add a policy target for plan stabilization to make this control mechanism more suitable for GLOSA. This variant will be called "**stabilized adaptive**".

4.1.2 Sensor requirements

The sensor requirements are assuming a **transition situation where any number of vehicles between 100% and 10% is not cooperative (and automated)**. The sensors can use any technology (e.g. camera, loop detector, radar, etc.) and should indicate the presence of vehicles in an area of road small enough to count vehicles. If the area is too big, multiple vehicles can be detected as one leading to vehicle under-counting

- **Sensors are required for queue modelling** to measure the amount of non-connected vehicles at strategic locations. In general, inflow and outflow towards the intersection is detected at the stop line and at the entry of a link.
- The **queue length in different lanes can be measured with special sensors** to determine which lane has the shortest queue, and therefore advising approaching vehicles.
- Lastly, the **detection of non-cooperative road users** requires sensors that can detect these traffic participants. This focusses on vulnerable road users and requires the detection of presence in a certain defined area where a conflict can occur.

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Queue length estimation, lane change advisory and detection of non-cooperative road users fully depend on sensors. Due to the relatively high cost of ownership, it should be carefully planned where these sensors would be most effective.

4.1.3 Communications requirements

The communication requirements for MAVEN are related to the capability of providing automated vehicles, the traffic light controller and the traffic management centres with the necessary information to execute the MAVEN use cases.

- **Communication requirements for the traffic light controller and the traffic management centre:** The traffic light controller should have a **communication interface to vehicles via a road side unit and another one to the traffic management centre**. This is needed to share all available data such as: traffic light status, prediction for future status, detector status, etc. **Sufficient processing power is required to process data** from the traffic light controller and construct messages to be sent by the road side unit.
- **Communication requirements for vehicles and the traffic light controller:** From a vehicle perspective, the communication requirements deal with the **capability of automated vehicles to be connected with the road infrastructure over the wireless medium**. The interface in this context is V2X communication, namely a road side unit based on the ETSI ITS G5 access technology and using standard-compliant communications protocols on the top of which the MAVEN extensions are built. **Pre-existing RSUs can be used** prior upgrading to the MAVEN extensions.
- **ITS-G5 and other communication channels:** MAVEN infrastructure to vehicle use cases rely on the use of ETSI ITS G5, which is the only V2X technology commercially available and already partially deployed. **As V2X technology evolves in the future, Local authorities will need to input to, and align with, standards adopted by the car and telecommunications industries**. As vehicles become more automated, they will run an increasing number of coexisting services and use case scenarios that will require the use of **additional radio channels**, as well as complementary and/or redundant communication technologies. These technologies will range from **enhancement of IEEE 802.11p to dedicated 5G cellular solutions** ensuring redundancy and quality of service to demanding automated driving applications. This implies that, in the long term, upgrades of the deployed roadside units might include use of additional radio channels (most commercially available roadside units already

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support this capability) and the addition of better performing radio chips or even use of cellular solutions.

As automated vehicles will strongly rely on the information provided by the infrastructure to automatically execute manoeuvres, L**ocal Authorities will need to ensure that the deployed road side units are capable of operating in compliance with reference specifications and minimum performance requirements,** and select suppliers that have passed commonly recognised conformance tests and hence can be trusted by the vehicles.

4.1.4 Physical infrastructure requirements

Local authorities must make sure that the road infrastructure provides:

- **Quality of lanes and lane markings:** All lanes need to be marked clearly and to a high quality. Although vehicle sensors and automation system's hardware are designed for robustness, they are nevertheless sensitive components. The risk of failing components gets higher the lower the quality of the lanes is. The most important part of the lanes for automated vehicles is a standardised (dependent on the country) way of using lane markings.
- **Usability of Traffic signs:** All traffic signs (static and dynamic) need to be clearly readable, fully unhidden and in compliance with national laws.
- **Availability of reference points:** Conventional satellite positioning systems do not have the absolute accuracy needed for automated driving. This is especially true in street canyons, tunnels or in general on roads with limited free view to the sky. Therefore, further systems for triangulating the exact position of the vehicle are used. Most of these systems are based on landmarks. In some cases, landmarks might not be present in the needed frequency. Therefore, additional landmarks have to be identified and/or placed within the roadscape. Nevertheless, such landmarks are not standardised currently, making it difficult to formulate precise requirements.

4.2 Digital map requirements

Digital high precision maps are used in automated vehicles so they can understand their broader surroundings, match their position in it, and plan the correct trajectory and route. This leads to three major requirements for future mapping products and services:

- **Precision:** The digital map needs to be of high precision;
- **Reliability:** The digital map needs to be always up to date;

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- **Localization possibility:** Localization of the vehicle on the digital map needs to be possible.

To ensure these requirements are met, **Local Authorities need to interact with digital maps providers to support the provision and maintenance of the road network mapping with features and conditions suitable for automated driving systems**. This includes ensuring consistency of actual lane markings within high precision maps, ensuring the consistency of provided information (e.g. speed limits, C-ITS MAP lane/signal group ids), as well as proactively providing info to high precision map providers regarding road reshaping plans.

4.3 Transport policy requirements: Societal, economic and environmental

Automated vehicles have the potential to significantly impact and change how people travel in the broadest sense, including the following **policy making areas**:

A. Road Safety

This is a key aspect in a city's transport policy. Significant progress has been made over multiple decades towards "Vision Zero" (zero fatal accidents in traffic), but there is more work still to do to realise this vision. Even in countries such as the Netherlands, with an active policy on improving road safety, more than 600 people are killed in road traffic accidents per year. That figure has been rising in recent years, potentially due to factors such as aging population and more use of electric bikes.

Automated vehicles should contribute to increased road safety, and increased road safety should be achieved for all road users, including vulnerable road users, not only car drivers. MAVEN would need to demonstrate equivalent, ideally improved, safety for pedestrians, cyclists and motorcyclists at signalised junctions. This would require vehicle OEMs to demonstrate their AVs are at least as safe as human driven cars. MAVEN could further enhance this level of safety through grid-to-vehicle and vehicle-to-vehicle communication of hazard detection, leading to platoons having greater knowledge of the environment as a whole compared to individual vehicles.

B. Traffic efficiency and environmental impact of transport

There is a strong correlation between traffic efficiency and the environmental impact of traffic. In general, cities are aiming at optimising the use of existing infrastructure before building large scale new infrastructure. Optimal flows of traffic with minimum congestion at a network level will also have a positive impact on mitigating the environmental impact of traffic.

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Automated vehicles should contribute to increased traffic efficiency and minimal environmental impact.

C. Modal split

Cities have different policy views on modal split. Some cities have the concept of co-modality, which is aiming at using the most optimal mode of transport for a specific goal, without limiting freedom-of-choice and mobility opportunities of the citizens. Other cities do want to actively promote more sustainable modes of transport, such as walking, cycling and public transport.

Cities shall consider:

- The impact of AV's on the modal split, by means of simulation studies;
- Opportunities of AV's to make a shift to more sustainable modes of transport (e.g. automated shuttles for last mile services, car sharing concepts)
- Be aware of possible negative impact of AV's on modal split (e.g. more use of private cars).

D. Urban planning and urban land use

AVs present significant long term opportunities in terms of land use and spatial planning. If AVs can help reduce private car ownership and single occupancy journeys, then the reduced need for road space allowing for land to be re-purposed towards pedestrian / cycle / environmental use over time. To avoid the converse (more private car ownership and increased single occupancy journeys), policy makers need to explore ride-sharing opportunities and plan urban developments and re-developments in such a way as to reduce the need for AV journeys in the first place.

E. Accessibility of work places and services

Cities want to have good and sustainable access to work places and services (schools, social institutions, shops and so on). Automated vehicles could help to improve this accessibility by offering last mile mobility services such as automated shuttles.

The deployment of AV's shall be evaluated against the improvement of accessibility of important location within and outside the city.

F. Innovation & economic growth

Innovation is key to ensuring the continued competitiveness of the Europe Union, European cities and businesses. Facilitating R&D, testing and deployment of AV's will strengthen innovation and create sustainable economic growth in our cities. There are also risks

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associated with the roll-out and adoption of AVs, specifically around potential job-losses for taxi and truck drivers.

Automated vehicles should contribute to sustainable economic growth, taking into account possible side effects.

G. Social inclusion and public acceptance

Automated vehicles are expected to increase mobility opportunities for elderly people, and disabled people and create the opportunities for social inclusion.

Cities shall try to evaluate impact of AV's on social inclusion of all citizens.

The acceptance and compliance of drivers are crucial, as it emerged from the MERGE (AV Rideshare) and the GATEway trials in Greenwich[3].

Additionally, an online survey will be prepared including video material that captures the concepts of MAVEN to evaluate the opinion of the general audience. Additionally, citizens of the pilot cities will be invited to drive in the test vehicles as a passenger.

Finally, and also at the pilot sites, the acceptance of drivers in unequipped vehicles surrounding the automated ones will be assessed by asking participants to follow and observe the behaviour of the test vehicles.

In order to address the driver perspective and evaluate end-user satisfaction, end user surveys will be conducted. This includes participants of the field tests (drivers of automated vehicles, as well as drivers of unequipped vehicles) as well as general public, especially citizens on the participating cities. The survey will be conducted in order to be able to address qualitative aspects of the MAVEN project.

4.4 Traffic management requirements

This Roadmap has identified some questions that MAVEN will try to answer by the end of the project: Who decides to make platooning happen? What is the role of the authorities and road operators? What influence does it have?

Traditional traffic management activities performed by or under the governance of public authorities have been being strongly affected by a combination of technology developments and private initiatives, meaning that the traffic manager is no longer alone in managing the roads and guiding vehicles. The increasing growth and acceptance of traveller information and

[3] GATEway project website: https://gateway-project.org.uk/

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navigation services, created a new situation where private organizations have increased influence on the performance of the mobility system and it impacts on the public policies. These shift of influence from public to private also occurs with the increased level of automation in vehicles, where manoeuvring decision making on the roads is transitioning from the driver (regulated by public rules) to vehicle algorithms, developed and governed by private automotive industry.

Unless a strong public regulated mobility system will be implemented to face this situation, it is most likely that in the near future, a new concept of traffic management will be developed, which will based on a public- private collaboration, where different operators jointly manage the traffic based on available resources and ruled by trade off commercial agreements.

This concept applied to the MAVEN use case Platoon management could mean that the decision of creating, joining or leaving a platoon is a “negotiated decision” primarily between public authorities (collective interest) and the vehicle service provider (client preferences), and secondly (optionally) accepted/confirmed by the driver. The level of influence on the decision making can vary with the context and situations. For example, on situations with high impact on the collective interests like road safety threats or calamities scenarios, the public authority could have more (or full) control on the decision making. On other regular situations, only affecting traffic efficiency for example, the service provider could have the freedom to decide.

4.4.1 Organisational aspects: the role of the traffic manager in the future

Transport professionals[4], including traffic managers themselves, accept and acknowledge the role of traffic management in the city of tomorrow as it is becoming increasingly linked to policy: it is no longer just about managing cars but about delivering accessibility. Traffic management is becoming a **strategic tool for delivering a whole range of transport policies**, and the ultimate goal of becoming a liveable city, which is a qualitative rather than quantitative notion, i.e. it is more of a personal perception (less congestion, better air quality, walkable city).

While more operational decisions will be made by systems, these will be guided by policy. The focus of traffic management systems will still be on larger urban centres and cities, smaller towns are less likely to need such complex systems.

[4] City traffic managers convened at the MAVEN stakeholder consultation workshop in Barcelona in November 2016.

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The goals of road safety and efficiency will remain in the future but traffic managers will have different resources to achieve them:

- The traffic system will be composed by **a mixed network of intelligent nodes** (either vehicles or infrastructure nodes) as well as drivers and pedestrians. The overall traffic system will be enabled with more intelligence to be able to better assess situations (due to increased sensors and digital infrastructure) and decide autonomously on the manoeuvres and movements of vehicles against a set of pre-defined policies, regulations and individual preferences.
- **Policies will be defined from a societal/collective perspective** and can be also adjusted to specific local conditions or communities. Vehicle policies will take into consideration regulations and individual drivers/travellers preferences. The traffic manager will need to be able to configure policies at the system level, but also the negotiate and orchestrate the interaction between the policies and individual preferences of drivers embedded in vehicles future mobility services.
- The future of traffic management may be moving towards stronger **public-private collaboration** where different operators jointly manage the traffic based on their own available resources and potential commercial trade off agreements. The traffic manager will nevertheless continuously monitor the performance of the traffic system (network) as well as the impact of each of the vehicles and travellers services against its pre-defined policies, with the ability to intervene to "influence" the operation of those services if required.

Nonetheless, it should not be overlooked that traffic management centres are mainly installed in big cities; smaller cities do not tend to have them.

4.4.2 Operational aspects: the impacts of different mixes of vehicles on traffic patterns

The linking of two or more vehicles in convoy using connectivity technology and automated driving support systems is defined platooning. **Platooning may in general have impacts on traffic flow and emission**, and can be indicated by:

1. Reduction of the number of stops at traffic lights;
2. Reduction of control delay time;
3. Decrease of produced emission;
4. Reduction of the overall fuel consumption or
5. Better use of the capacity of the existing infrastructure.

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Expected impacts of different mixes of vehicles on traffic patterns cover:

- Speed advice based on signal phase and timing information should be calculated to enable a vehicle or platoon to pass a signalised intersection in the most efficient manner. The **expected impacts are a smoother vehicle trajectory while passing a signalised intersection**, which reduces stops and emissions. In case of a stop the start delay is expected to decrease as the start of the green phase is known in advance. As the driving speeds and the signal phases and timing will be optimized synchronously, the delay times at the signalised intersection are expected to decrease.
- The vehicles should be distributed over the available lanes to make optimal use of the road capacity. **The expected impacts are a smoother vehicle trajectory and improved traffic flow, which reduces stops, emissions and delays.**
- Improved queue length estimation can be coupled with a better control strategy of the traffic lights. **The signal optimization will result in more accurate speed advice for GLOSA. This in turn will improve traffic flow and reduce emissions.**
- A **dynamic green wave for automated vehicles in close cooperation with GLOSA speed advice** with less impact on other traffic than traditional green wave systems should result in **less travel time and pollutant emissions**.
- **Improve controller performance** (reduced average delay and stops for all traffic) by using the new data and functionality. The resulting optimal signal plans and the proper management of automated vehicles will result **in less travel time and emissions**.
- A bidirectional exchange of information for negotiations using communications from infrastructure to vehicles and vice-versa will create the basis to optimize traffic management in the context of connected automated traffic at road intersections.
- The detection and characterization of complementing non-cooperative road users (vulnerable road users, non-cooperative vehicles) will ensure continuity in the generation of safety and traffic efficiency by providing the basis to react to situations in which the presence of non-cooperative road users could disrupt the implementation of the MAVEN functionalities.

4.4.3 The effect of the MAVEN system in different traffic scenarios

Local Authorities are focussed on reducing congestion, unnecessary delays and accidents. **Building a new infrastructure is for most cities not the first option**, due to a lack of space, financial constraints and the unwanted environmental impact of creating even more car journeys.

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Examples in the city of Helmond (NL) showed a 20 % increase of road capacity by optimisation and innovation of the traffic light network. Optimisation of the road network will remain a key focus in the coming decades, with the introduction of automated vehicles and in view of the fact that cities are increasingly reassigning road space to other modes (cyclists, public transport, pedestrians, etc.).

- Adoption of the MAVEN approach will offer **cities**:
  - Improved traffic flow and lower environmental impact while supporting growth;
  - Improved safety, lowering societal costs and increasing attractiveness to prospective residents
  - Increased network performance reducing the need for extra physical road infrastructure.
- **Public Transport** could also benefit from MAVEN style guidance through the city road network and thus increase the attractiveness of public transport for users while lowering operational costs.
- Also, **heavy goods vehicles** could be handled as special road user types with a special level of priority. Better flow of heavy goods vehicles on main corridors through the city could improve network performance. On the other hand, lower priority for heavy goods vehicles on undesired routes could be an effective way to manage traffic flows according to the city's mobility policy without the need of a costly enforcement.
- **Vehicle drivers and road users** will experience:
  - Improved quality of driving and fuel saving through enhanced traffic flow;
  - Improved comfort for individual drivers due to automated and more homogenous driving on urban corridors and
  - Improved safety for drivers and other road users (e.g. VRUs) throughenhancedsensor ranges built in to AVs.
- **Vehicle-makers will be able to provide new safety, efficiency and comfort functions** for their customers and enhance competitive advantage. Offering MAVEN-compliant services to customers will result in a better reputation as a provider of enhanced functions for safety and comfort to enjoy the time spent in a car.
- **Infrastructure service providers will enter a higher value business** compared to a classical hardware-oriented business and will be able to offer intelligent intersections as a service based on Service Level Agreement (SLA) in line with their policy objectives.

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4.5 Operational traffic management requirements

MAVEN is developing automation functionality over the course of the initial project (and beyond).These functions will need to take into account a mixed traffic composition, including non-AVs as well as AVs with different capabilities and automation levels, and even different communication techniques. As the MAVEN consortium researches progresses, all types of vehicle will be classified in a 'traffic hierarchy' built into the MAVEN approach. Critical to this will be the ability to share information between the vehicles and infrastructure so as to enhance the overall safety and efficiency of all participants on the road.

A key enabler for information sharing within MAVEN is ITS G5 communication. It is used for transmission of vehicle-related information such as position or speed as defined in the ETSI ITS standard for Cooperative Awareness Messages (CAM) to enhance the vehicle detection by other vehicles (V2V) or the infrastructure (V2I). In MAVEN, V2V and V2I will also be used to implement the MAVEN use cases (e.g. platooning, cooperative road user detection, etc.).

What happens in case of **system malfunction?** MAVEN targets at vehicle automation developments between SAE level 3 and 4. The developed message sets can be used for both levels. Nevertheless, the system behaviour will be different in both levels. An automation of SAE level 3 will simply try to get the driver back into the loop. A SAE level 4 vehicle will perform minimum risk maneuvers on its own.

Nevertheless, the developed functions are including several safety measures, as not all system malfunctions need to result in the complete loss of the automation functionality.

More detailed information about system malfunctions, minimum risk states and targeted behaviour of AVs in an hierarchical traffic management can be found in the project deliverables of H2020 TransAID[5].

[5] TransAID project website: https://www.transaid.eu/

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5 MAVEN cities examples and other cities' approach to AVs

5.1 City of Helmond, the Netherlands

Helmond is a medium sized city in the south of the Netherlands, with a current population of around 90,000 inhabitants. Helmond is part of the Brainport area, one of the three most important economic areas in the country. Innovation is the key-word here and for Helmond the focus lies on innovation on the fields of automotive and mobility.

Helmond is home to the Automotive Campus, where over 35 companies work on innovative mobility solutions. With the Automotive Campus, Helmond presents itself as a knowledge and innovation centre for mobility solutions and as "City of Smart Mobility". Though a relatively small city Helmond receives internationall recognition for its ambitious goals and the realisation of innovative mobility solutions in the city. The Brainport region will host the ITS Europe 2019 Congress, where the active role of Helmond as a Living Lab for ITS will be showcased.

5.1.1 Transport challenges

In addition to the congestion and pollution problems that every modern city is faced with, Helmond has specific problems related to being a medium sized city. Outside the rush hours the demand for transport is too low to justify a dense and frequent public transport system. This is particularly the case for the small villages that surround the city as well as for some hot spots in the city itself. The automotive campus, for instance, cannot be reached comfortably with public transport during a large part of the working week and not at all during weekends. Last mile transport is therefore a focal issue in developing innovative mobility solutions.

In Helmond, a main east-west traffic artery cuts right through the heart of the city-center. This artery is a four-lane road controlled by traffic signals. The amount and composition of the traffic, especially during rush hours, causes traffic jams and pollution. The city tries to implement innovative solutions to address these congestion and pollution issues.

5.1.2 Strategy

In its policy document: "Helmond Verbonden", (Helmond Connected) the city presents its vision on mobility for the years 2016 – 2025. Key-elements concerning smart mobility are:

- To work together with authorities, industrial partners and knowledge institutes to further develop Helmond's position as leader in smart mobility.

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- Helmond focuses on cooperative mobility and believes that the future of autonomous driving will depend on communication with other road users and the infrastructure. On these fields Helmond presents itself as a Living Lab, where new mobility technologies can be tested in real life circumstances, even if these technologies are still in a test phase.
- Active support of (national and European) smart mobility projects and showcases. Innovative solutions, not only concerning vehicle technology, but also in data, traffic management and road-side equipment must be tested, and Helmond wants to actively accommodate such tests.

Based on this mobility policy, as well as focusing on the efficient use of space and road infrastructure, Helmond has invested in a state-of-the-art network of connected and intelligent traffic lights and traffic management systems. These systems will also enable the management of connected automated vehicles, which is the goal of the MAVEN project.

The city aims to involve inhabitants and the local industry in the developments on the field of smart mobility. The commitment of local stakeholders is key to success, as is a strong policy base and political support. The city actively plans to introduce an innovative people mover system as a connection between the heart of the city and the Automotive Campus. The city is also planning Brainport Smart District, a new city suburb, where innovative solutions for living, working and playing will be implemented, with an innovative mobility plan as one of the key elements.

5.1.3 Examples

Helmond was a partner in the FREILOT project[6] and the results of the project are implemented in the city today. Helmond must deal with a large volume of heavy goods vehicles on the main road through the city (3.000 trucks per day). This results in many stop-and-start maneuvers, noise, emissions, and a negative impact on traffic efficiency. The city used FREILOT C-ITS for priority for trucks at intersections and speed and time-to green advice to drivers. The outcome of the pilot was 13% fuel savings, 13 % less CO2 and better traffic throughput.

[6] FREILOT was an Europen co-funded Pilot that started in April 2009 for a duration of 2 years and an half. The project aimed to increase energy efficiency in road goods transport in urban areas.

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Image 1: FREILOT 14 equipped intersections in the urban zone. City of Helmond.

After FREILOT, Helmond has been an active partner in the Compass4D project, with the aim of scaling up the results of FREILOT and making the transition towards large scale deployment of these C-ITS services easier.

Helmond plays an active role in many EU projects, which can be separated in two main groups:

1. **Contribution to large scale deployment of C-ITS**

- **C-MobILE** aims to stimulate/push existing and new pilot sites towards large-scale, real-life C-ITS deployments interoperable across Europe.
- **Capital** aims is to design and deliver a collaborative capacity-building program comprising of training and further education for practitioners in the public and private sector in the field of C-ITS deployment.
- **C-The Difference** pilot project will assess the impact of C-ITS services in a real life urban transport environment.

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2. Preparation for the introduction and deployment of Automated Vehicles

Project	Description
MAVEN	MAVEN focuses on the cooperation between individual automated vehicles and an intelligent infrastructure specifically at signalized intersections and signalized corridors
AUTOPILOT	The objective of AUTOPILOT is to bring together relevant knowledge and technology from the automotive and the Internet of Things value chains in order to develop Internet of Things-architectures and platforms which will bring Automated Driving towards a new dimension.
CoEXist	CoEXist will develop "AV-ready" transport models and road infrastructure for the coexistence of automated and conventional vehicles
FABULOS	The goal of FABULOS is to deliver a systemic proof-of-concept on autonomous last mile public transport as part of the urban areas' existing transport system, based on use of autonomous self-driving minibuses for transporting people.

Table 2: Autonomous Vehicles Projects in Helmond

5.1.4 Conclusion

For Helmond the added value of MAVEN is a clear connection between traffic management and AV's. This is exactly what Helmond is looking for: automated vehicles as part of a connected and sustainable mobility system, with a good balance between individual mobility needs and societal goals.

5.2 Royal Borough of Greenwich, United Kingdom

Greenwich is one of 33 London Boroughs, and is situated south of the river Thames to the east of Central London. It is designated as one of London's 'Growth Boroughs' and its current population of 255,000 is estimated to grow by 43% in the next 10 years.

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5.2.1 *City transport policy today*

Longer term, major transport infrastructure schemes such as Crossrail and River Crossings are undertaken by TfL as the regional lead, however the Borough is a primary stakeholder, consultee and contributor to the development of schemes and they form part of RBG's emerging draft Transport Strategy; this is designed to provide a framework which allows RBG to prioritise and promote the transportation investment required to meet a number of objectives, including the Borough's broader growth and poverty alleviation objectives.

RBG is responsible for producing a Local Implementation Plan for Transport (LIP). This document is written in conformity with the London Mayor's Transport Strategy (MTS) and Spatial Strategy (the London Plan), as well as with the Borough's own wider strategies, aims and aspirations.

The current Mayor of London consulted on a new MTS in 2017 with a view to publishing a revised strategy in early 2018, after which RBG will be required to produce a new LIP.

The LIP has a dual role. In the short term it looks at the priorities and deliverables which will be implemented in the next 3-year Spending Period, however it also acts as a sign-post to RBG's medium and long-term transport ambitions and concerns which will be quantified in the developing Transport Strategy.

The LIP programme is funded by the Mayor via Transport for London (TfL).

In addition to the LIP and its spending plans RBG has an adopted Cycling and Parking Strategies, and annually produces a Road Safety Plan and Child Road Safety Audit (which help prioritise the schemes delivered through the LIP programme).

RBG's primary land use policy is its Local Plan, produced by the local planning authority, need to be in general conformity with the London Plan, and the policies guide decisions on planning applications.

The Local Plan provides greater detail, evidence and policies than are contained within the Opportunity Area Planning Frameworks (OAPFs) and has greater material weight in the determination of planning applications. Royal Greenwich's Local Plan consists of:

- **The Core Strategy** – the key strategic planning document for the Royal Borough of Greenwich;
- **A policies map** – sets out the policies and site allocations in Royal Greenwich; and
- **The site allocations plan** – identifies particular sites in Royal Greenwich for specific uses such as housing or education.

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5.2.2 Traffic management today

The majority of the road network is under the control of RBG. Approximately 5% of the network – main arterial routes through the borough - are composed of the TfL managed Transport for London Road Network (TLRN).

Arterial and primary routes are also managed by RBG – the Strategic Road Network (SRN) – however all works on this part of the network must be completed in consultation with TfL. TfL are also responsible for all traffic signals and their timings in London whether on the TLRN or borough controlled roads.

RBG's Traffic Management team are also responsible for co-ordinating and licencing all street works. Additionally, the Borough is tasked with managing and maintaining highways assets (including street furniture, signage and street lighting as well as delivering the Winter Service Plan.

Existing transport networks shape current travel patterns in RBG. TfL's Public Transport Accessibility Level (PTAL) measure provides a detailed and accurate measure of the accessibility of an area to the public transport network taking into account walk access time and service availability.

The PTAL scores for the borough are shown below. They indicate that, although Woolwich town centre (and to a certain extent Greenwich town centre) has very good access to public transport, accessibility is poor for large parts of the rest of the borough.

These poor levels of public transport accessibility discourage the use of public transport and contribute to higher levels of car use as discussed in the previous section Private vehicle use accounts for roughly a quarter of trips by out-commuters and likely indicates those seeking to travel to locations immediately north and south of the borough, which are less well served by Underground and rail links.

In contrast, the results for those commuting to the Borough for work show a dependence upon private vehicles, which is likely to be due to a combination of factors associated with the origins of individuals' commutes, but could include low accessibility to public transport and shift-working patterns of employees. The highest number of in-commuters to Greenwich live in Bexley. Sixty-six percent of these individuals drive to work whilst the most popular form of public transport is the bus (18%).

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The promotion of active and sustainable travel, the reduction of single vehicle occupancy car journeys, and addressing congestion and road based emissions remain priorities for the Council.

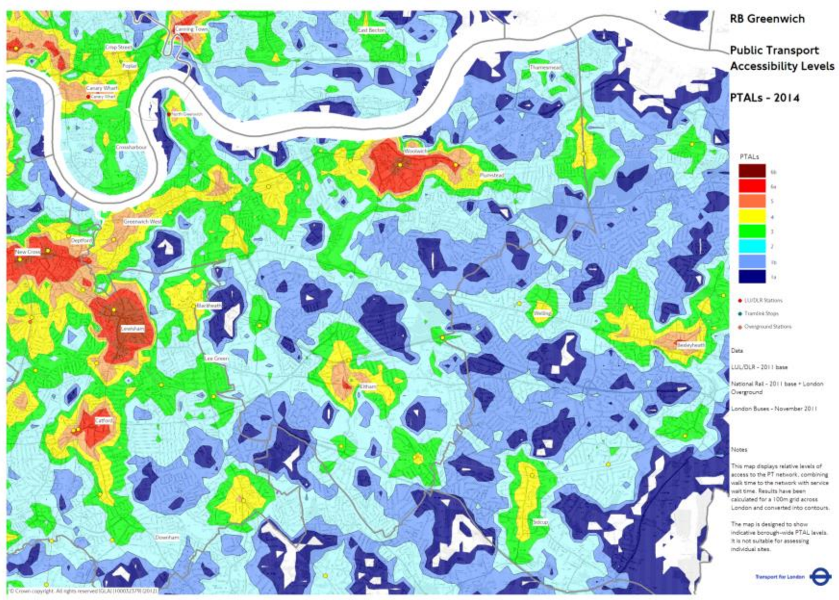

Image 2: RBG Public Transport Accessibility Levels -PTAL (2014)

5.2.3 Smart Cities and Autonomous Vehicles Projects

DG Cities, on behalf of the Royal Borough of Greenwich, is undertaking multiple projects within the smart cities and autonomous vehicles space. These efforts align with tackling some of the challenges outlined above, particularly reducing private vehicle ownership, reducing single occupancy journeys and promoting walking, cycling and the use of public transport. A sample of these projects is listed below:

Project	Description
GATEway	This project is focussed on understanding the human factors around specific AV applications, including ride sharing in driverless pods, valet parking and last mile deliveries to individuals. The learnings so far are significant, highlighting the following benefits and barriers: o **Technology readiness** - a significant amount of work has still to be done to ensure truly safe and reliable driverless vehicles. The

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	market is still nascent and there is a lack of standardisation requiring bespoke integration of sensors, AI and vehicles. ○ **Public engagement and acceptance** have been very high and positive. This is potentially due to the novelty of AVs at the moment but does give significant confidence that there is demand for AVs from the public at large ○ It has also informed the **timescales** over which we can expect AVs to penetrate the market, with realistic estimates looking towards 2040 or later for a majority AV vehicle fleet
MERGE	This project is focussed on exploring ride-sharing models that increase accessibility within areas poorly served by public transport as well as giving users preferences for who they share rides with to increase their confidence in any potential future services.
AV Testbed	This is a significant project that will, with partners, create a physical, on-road testbed for AVs in Greenwich. It is one of 4 testbeds in the UK. Communications and IT infrastructure will be deployed to enable C-ITS and MAVEN style applications as well as providing a framework for testing and validating AVs, AI and Sensor technology so that it can be certified as safe for the UK roads.

Table 3: Smart Cities and Autonomous Vehicles Projects in RBG

These investments place Greenwich as a forerunner in both smart cities and AV applications and make Greenwich an ideal partner for transitioning MAVEN from concept to a commercial reality.

5.2.4 Conclusion

MAVEN provides the framework for the borough to be able to increase the efficiency of it's current road network, alongside other C-ITS applications, and therefore the design and ultimate deployment process for MAVEN is of key importance to the consortium as a whole.

5.3 City of Braunschweig, Germany

Braunschweig, also called Brunswick in English, is the second largest city of Lower Saxony, located in the northern part of Germany. It has a population of about 250,000 and is one of

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Europe's important regions for science and research, hosting several research organisations of different domains, e.g. physics, biology, aviation and transportation.

5.3.1 Transport research

In the context of transport research, three research organisations are active in Braunschweig and its vicinity. These are:

- The Technical University of Braunschweig with the Institute of Automotive Engineering and the Institute of Control Engineering which participated at the DARPA Urban Challenge in 2007 and which is active in several research projects involving the automation of vehicles, like e.g. Stadtpilot.
- The German Aerospace Centre (DLR), esp. in terms of the Institute of Transportation Systems, which is active in the field of vehicle automation, human-machine interaction, communication, data acquisition and interpretation, infrastructure, traffic simulation etc. With its Application Platform for Intelligent Mobility (AIM), DLR has created a research infrastructure for future intelligent transportation and mobility services . Therefore, large parts of the inner city of Braunschweig have been equipped with Road Side Units for communication and other hardware to enable testing of future systems.
- The Automotive Research Centre of Lower Saxony (NFF7), which bundles the research activities around mobility in Lower Saxony. Currently, 20 professors from the universities of Braunschweig, Hanover and Clausthal as well as the German Aerospace Center are full members of the NFF.

All of the three research organisations are performing research in the city of Braunschweig independent of each other, although some projects are done in cooperation. Depending on the scope of the different projects, only parts of the city are affected by the research activities, and only temporarily. The city of Braunschweig up to now is informed about the activities but is mostly not included as a partner.

Nevertheless, the role of the City of Braunschweig itself changes, as traffic management and the inclusion of future means of transportation become more relevant for medium sized cities like Braunschweig.

5.3.2 Projects

Some example projects taking place in the area of Braunschweig are listed below:

[7] https://www.tu-braunschweig.de/forschung/zentren/nff/start?lang=en

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Project	Description
Testbed Lower Saxony	The Testbed Lower Saxony is a large-scale research platform for the development and evaluation of connected and automated mobility. This covers the entire tool chain from simulation to real testing. Tests can be carried out on country roads and motorways or directly in the city. It is extending the AIM test site located in the city centre of Braunschweig.
MENDEL	The German research project MENDEL aims to minimize the total operating costs of electrically powered bus fleets. This includes a cost reduction for the construction and operation of charging infrastructures by minimizing the load on the power grid, as well as a reduction of the energy consumption of vehicles in operation. The project combines the two fields of Smart Grids and Intelligent Transportation Systems (ITS) to a prototypical system concept.
SIRENE	The project SIRENE (Secure and Intelligent Road Emergency Network) aims at the optimization and protection of the routing for emergency vehicles. Traffic predictions of cooperative infrastructure implemented in AIM are used for this purpose in a centralized (by using back-ends) and distributed (by using V2X communication) way.
DK4.0	The aim of DK 4.0 ("Digitaler Knoten", "digital pivot") is to realise automated driving (SAE level 4) at urban intersections considering mixed traffic situations including automated as well as non-automated vehicles, cyclist and pedestrians.
TransAID	The project TransAID (Transition Areas for Infrastructure-Assisted Driving) aims at developing traffic management solutions for automated vehicles which are in the need of performing transitions of control. A subset of the measures is going to be implemented on public roads in the City of Braunschweig.

The projects MAVEN and AUTOPILOT are also active in Braunschweig, but have been introduced in the description of Helmond already.

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Figure 1: Testbed lower saxony, and the linking to AIM test site in Braunschweig

5.3.3 Conclusion

Braunschweig is very active in the field of research of new technologies in the domain of transportation. Nevertheless, the field of traffic management is currently very much limited to this kind of activity, related to the projects and the project durations. In terms of sustainable traffic management for all, the city of Braunschweig is facing the same issues than any other city of that size, and therefore still standing at the beginning, although a lot of infrastructure is already in the field.

5.4 City case study 4

City case study to be selected for the final version of the Roadmap.

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6 Conclusions and steps to be taken

It is clear that the world of transport and traffic is on the verge of some major changes. The advance of Intelligent Transport Systems challenges everybody involved in this world to look again at the way transport and traffic are organised and managed. The MAVEN project focuses on traffic management at signalised intersections along urban corridors, but the conclusions and recommendations can be valuable for most other traffic environments and certainly the general recommendations can give guidance in environments where cooperative ITS systems will be introduced.

This Roadmap is a first version of a final report, that will be presented at the end of the MAVEN project. Many of the conclusions and recommendations presented in this document may be changed or influenced by the experiences during the course of the project. Some others, however, and mainly the more general ones, are based on the simple fact that change is going to come and that adaptation to the changing environment is needed.

Many of the issues discussed in this document do not have a final solution or conclusion. It is not always possible to foresee exactly what the future will bring. In January 2007, when the first iPhone was presented very few people would have believed the all-important role smart phones play in our lives today, hardly 10 years later. Therefore, the most important role of this document is not to give detailed answers to questions, but to create awareness of the changes that are going to come, to indicate where adaptations are needed and to start discussions on how to adapt to these changes.

6.1 The roles and responsibilities of traffic managers and other stakeholders

Chapter 4 describes the requirements for the transition from the present situation to the MAVEN approach. It focuses on infrastructure, transport policy, organisational traffic management and operational traffic management.

6.1.1 Infrastructure

MAVEN identified the requirements needed to deploy level-4 automated vehicles which shall be understood by traffic and road managers. These requirements concern the following domains: traffic control requirements; sensor requirements; communications requirements, including road-side units; physical infrastructure requirements; digital map requirements.

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6.1.2 Transport policy

Automated vehicles have the potential to significantly impact and change how people travel in the broadest sense, including the following policy making areas: Road safety; travel efficiency and environmental impact of transport; modal split; urban planning and urban land use; accessibility of workplaces and services; innovation and economic growth and social inclusion.

6.1.3 Traffic management

Traffic managers of the future will have the same goals as the present ones: road safety and efficiency but will have different resources to achieve them. Traffic management will become more strategic in the future, translating policy goals into operations. Policies will be defined from a societal/collective perspective and can be also adjusted to specific local conditions or communities.

MAVEN aims for the development of automation functionalities in the upcoming years. Therefore, all the developed functions need to take into account mixed traffic, including non-AVs as well as AVs with different capabilities and automation levels, and even different communication techniques.

6.2 Special category road users

At present, the complexity of taking part in our hectic (urban) traffic can be a great challenge for special category road users, like vulnarable road users (the disabled, the very young and very old; cyclists), emergency vehicles and even logistcs vehicles and public transport vehicles. C-ITS technology enables traffic management to take the safety and comfort of such road users in consideration far better than presently is possible. Emergency vehicles and public transport vehicles can be given preference at intersections, for instance by managing the time lights are green when such vehicles are detected or are part of a approaching platoon. Vulnarable road users do not have to make instant decisions, because the system (infrastructure and vehicle) will guide them and will increasingly make decisions for them.

6.3 Steps to be taken

In the early phases of a development it is difficult to decide on concrete steps that must be taken to cope with the consequences of such a development. Certainly, where investments in equipment and personnel are concerned it is easy to make wrong decisions when the consequences of decisions cannot yet be understood in detail. On the other hand, waiting until

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it is clear what developments are going to bring could be a loss of time and will cause others to move faster and reap the economic benefits of developments before European stakeholders do.

There are initiatives that policy-makers, road-authorities, standards-development organisations and other stakeholders can take, even at present, to be better prepared for the changes that are going to come.

6.3.1 General

Awareness and education: Whether or not the introduction of new technology is going to be a success depends strongly on the acceptance of the stakeholders at all levels. And the acceptance of stakeholders depends strongly on whether or not they are well informed about the changes and their consequences. Every change meets with hesitation and resistance, but a well-organised information campaign can at least minimize hesitation and resistance. This goes for stakeholders at all levels. Policy makers, traffic managers, policeman and women and the general public. Information campaigns should be set up targeting each of these particular groups of stakeholders.

Standards and laws traditionally follow technological developments. The consequence is often that technology ready to be introduced on the market cannot be introduced because existing standards and laws prohibit the introduction. In 2016 all EU Member States endorsed the Declaration of Amsterdam. Jointly with the European automotive industry the European Union will move to clear the way for connected and automated driving in 2019. If succesfull this would clear the way as far as laws are concerned. It is important for the success of the MAVEN system to investigate what standards are being used in other C-ITS developments and to coordinate in order to be certain that MAVEN systems can be integrated with other CITS systems.

More details will be provided in the final version of this document.

6.3.2 Steps to be taken regarding infrastructural requirements

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6.3.3 Steps to be taken regarding transport policy.

Since automated vehicles have the potential to significantly impact and change how people travel in the broadest sense, authorities (local as well as national as well as at a European level) should reconsider existing mobility plans and think about the consequences of the introduction of C-ITS on issues as the environment; modal split; land use; priorities for special category road users, etc. Based on their particular situation (in megacities the effect of the introduction of C-ITS may be strongly different from the effect in smaller cities and villages) a short term and long-term plan could be made: the short-term plan with concrete actions and the long-term plan with considerations and studies.

More details will be provided in the final version of this document.

6.3.4 Steps to be taken regarding traffic management

Traffic managers are the people who are going to be in the front line when the MAVEN system is introduced. It is therefore essential that they have knowledge about the all aspects of C-ITS. In many cities C-ITS is not a factor of interest yet and it must be assumed that he knowledge of traffic managers is restricted. It is therefore important that at short term courses and information material will become available. At this point the CAPITAL project should be mentioned. The aim of the CAPITAL project is to design and deliver a collaborative capacity-building programme (comprising of training and further education) for practitioners in the public and private sector in the field of (Cooperative) ITS deployment

A very important issue for traffic management in the transition period towards a world where C-ITS is common is co-existence. During the transition period automated vehicles will co-exist with non-automated ones. The interactions between automated and non-automated vehicles should be studied as a art of the education of traffic managers.

More details will be provided in the final version of this document.

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