Enhancing intelligent urban road transport network and cooperative systems for highly automated vehicles

Newsletter No. 3 (April 2018)

Introduction

MAVEN (Managing Automated Vehicles Enhances Network) was launched on 1 September 2016. The project investigates future traffic management of connected, cooperative and automated transport. It will provide:

- management regimes for automated driving in urban areas;
- monitoring, support and orchestration of movements of road users to guide vehicles at signalised intersections; and
- further enhancement for ADAS (Advanced Driver Assistance Systems) and C-ITS (Co-Operative Intelligent Transport Systems) applications.

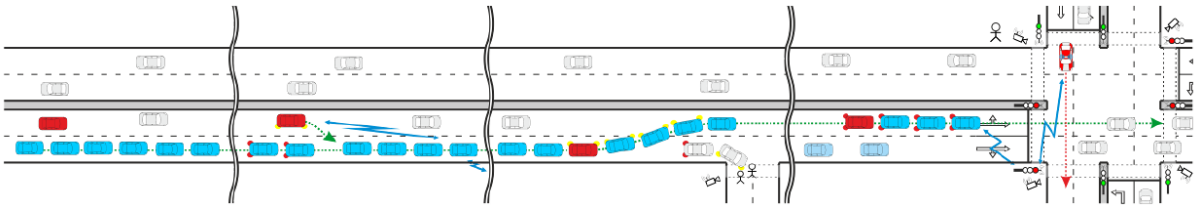
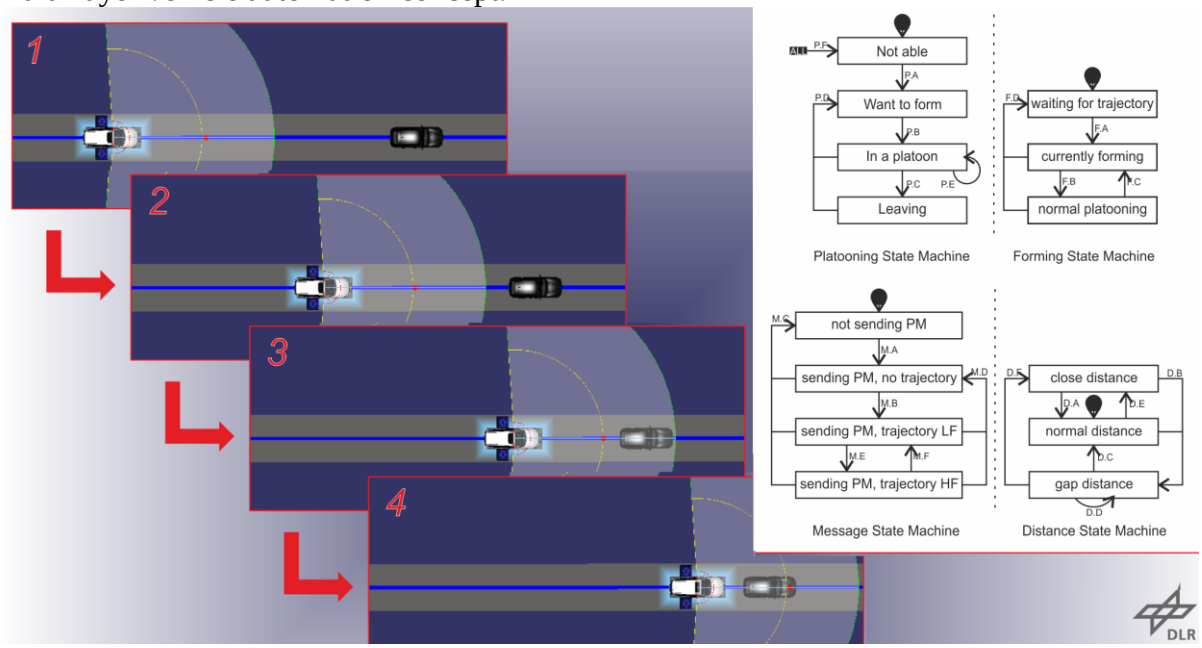


Illustration of MAVEN use cases

Recent achievements of MAVEN

Vehicle automation

The figure below shows the platooning state machine, which is part of the newly developed multi-layer vehicle automation concept.



Platooning state machine for fully-automated cooperative vehicle

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This multi-layer concept splits the automation into two levels. The trajectory planning ensures the vehicle drives an optimal path within the lane on a short horizon. The tactical level takes input from Vehicle to Vehicle or Infrastructure (V2X) communication and platoon algorithms to control the vehicle on a higher level. This is where platooning, lane changes and optimal speed for approaching an intersection are the main targets. For platooning a detailed algorithm based on a state-machine and supported by the new message sets was developed.

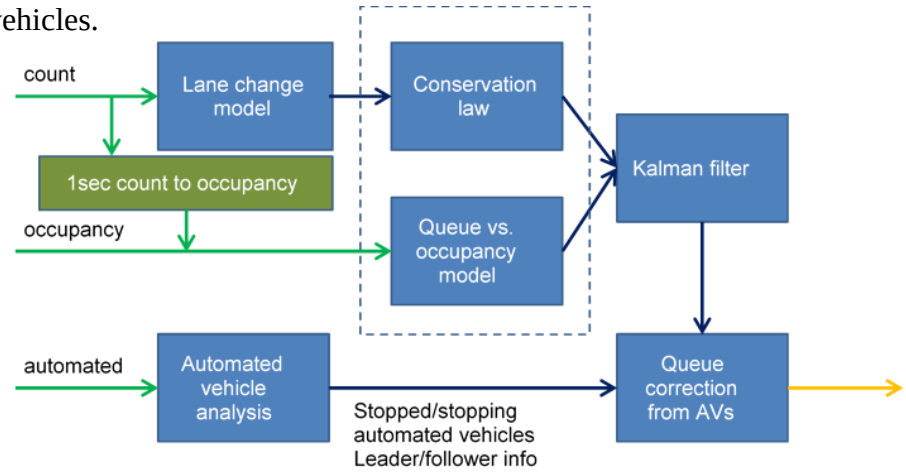
In addition to the detailed development and implementation, the simulation platform "Dominion" has been prepared for simulating the automation behaviour in the defined 16 MAVEN use cases (UC1-UC16). The table below presents MAVEN use cases and their categorisations. The automation functionality, including all desired interfaces, procedures for trajectory planning and vehicle control is under development.

Platoon management	Longitudinal and lateral management	Signal optimisation	Intersection and other road user management
UC1: Platoon initialisation **UC2**: Joining a platoon **UC3**: Travelling in a platoon **UC4**: Leaving a platoon **UC5**: Platoon break-up **UC6**: Platoon termination	**UC7**: Speed change advisory (GLOSA - Green Light Optimal Speed Advisory) **UC8**: Lane change advisory **UC9**: Emergency situations	**UC10**: Priority management **UC11**: Queue length estimation **UC12**: Local level routing **UC13**: Network coordination – green wave **UC14**: Signal optimisation	**UC15**: Intersection negotiation **UC16**: Detect non-cooperative road users

Infrastructure automation

Simpla has been developed and released as open source by MAVEN, and allows users to simulate automated vehicles in SUMO (Simulation of Urban MObility). The extended Lcal Dynamic Map (LDM) enables the exchange of new essential information elements for the MAVEN use cases and the position simulation adds random noise to GPS (Global Positioning System) measurements from simulation for realistic queue modelling simulations.

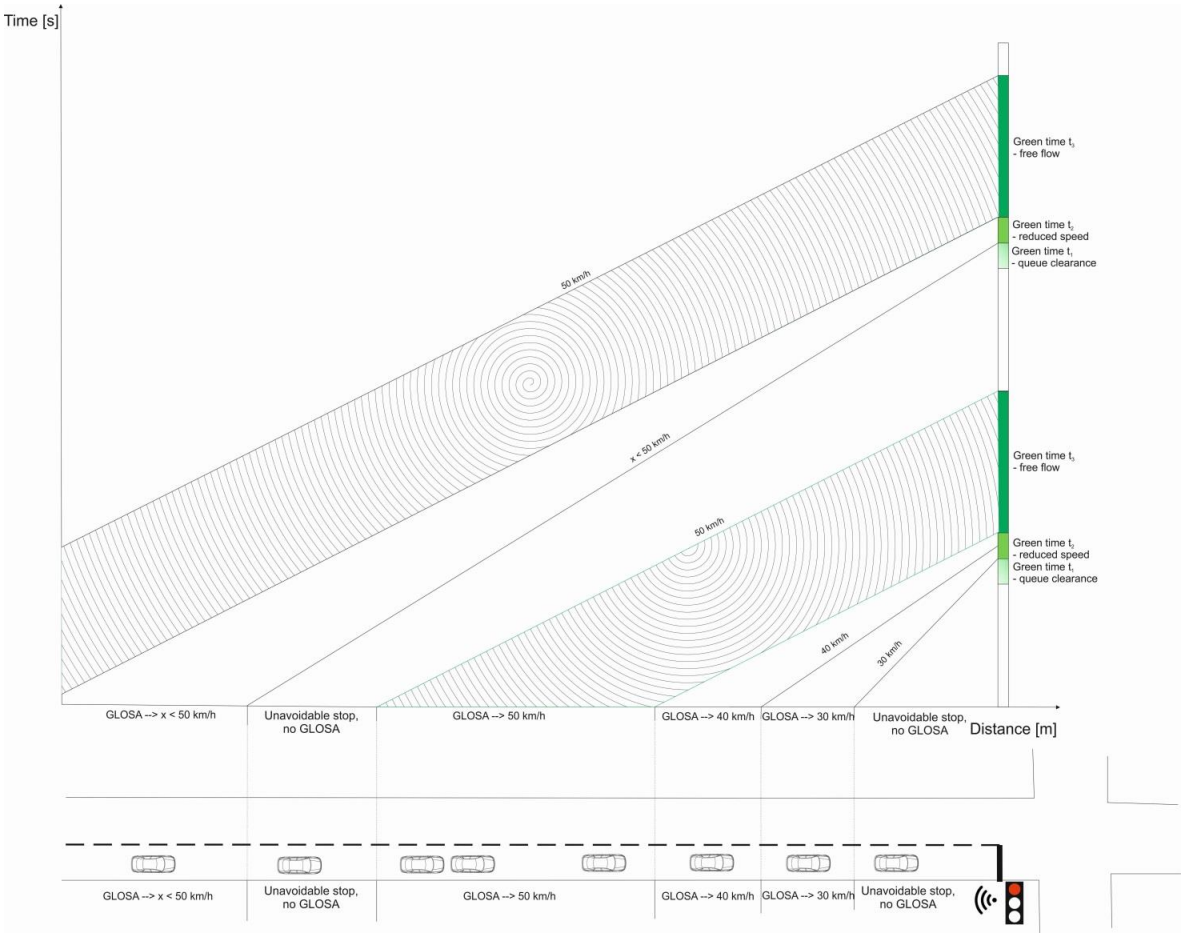
The research in queue modelling showed that data fusion of information from traditional detectors and automated vehicles resulted in up to 40% reduction for the average error of the queue length estimation. The largest benefits were visible for high traffic volumes, because the chance of receiving vehicle information increases. Having better queue model information, results in both more efficient traffic control and more accurate speed advice for automated vehicles.



MAVEN queue length model schematic structure

Another important factor for speed advice is the predictability of the control plan. A new stabilisation cost function was added to the adaptive control algorithm, which resulted in 25% reduction of average prediction error, while maintaining similar traffic efficiency. More advanced parameters were added to combat specific side effects, like the prediction stagnating at a certain value due to a green extension. This resulted in a small further improvement, but most notably in a solution for the stagnation problem. A patent was requested and granted for the solution of stabilizing the control by means of a new cost function for the algorithm.

The MAVEN consortium has also worked on actuated control, which is the most common form of traffic control in Europe, but is also known to be very unpredictable due to the ad-hoc decisions. MAVEN has developed solutions to provide measurements for the reliability of the forecast. With priority schemes for automated vehicle platoons, negotiations elements were added that can take several parameters into account. Both the actuated and adaptive control strategies developed in MAVEN show automatic formation of green waves when platoons progress through the network and controllers get connected to each other.

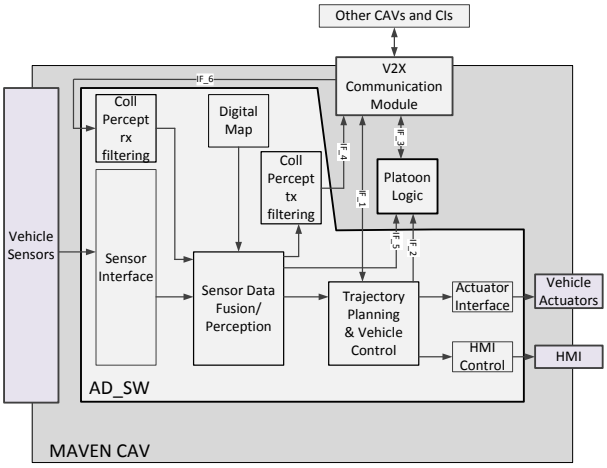


Actuated traffic control with GLOSA

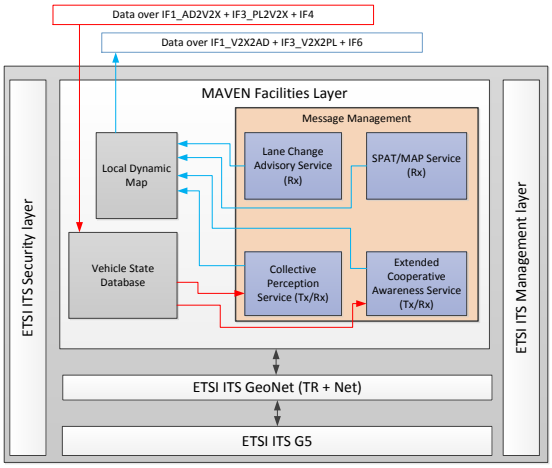
V2X communication for automated driving

To enable automated driving solutions, MAVEN-suitable V2X communication schemes and message sets have been developed. These include several contributions: for the cooperative infrastructure, an I2V Lane Change Advisory service and a dedicated profiling of the SPaT (Signal Phase and Time) and MAP (topology) for lane-specific GLOSA were developed. For the cooperative automated vehicles, extensions of standard CAM (Cooperative

Awareness Message) messages have been designed to allow interaction with cooperative intersections and to support management and control of platoons. Finally, the currently under standardization Collective Perception service has been adapted to the needs of MAVEN to support the applications of cooperative and automated vehicles aimed at increasing the safety of VRUs (Vulnerable Road Users) and vehicle drivers. The developed schemes are backward compatible as required by the car industry and to foster their future deployment. They are provided in terms of ASN.1 (Abstract Syntax Notation One) definitions and detailed message data specifications that can be openly accessed. The aforementioned communication schemes have been tested in small test benches aimed at evaluating the technical functionality of the developed solutions from a communication point of view, and hence their suitability for integration in infrastructure and vehicle prototypes. MAVEN has actively contributed to the European ETSI standardisation in this area, especially for the collective perception definitions. In addition, the rest of the aforementioned communications schemes were presented for further consideration in standardization and specifications organizations like the ETSI (European Telecommunications Standards Institute) ITS and the C2C CC (Car2Car Communication Consortium) in dedicated events.

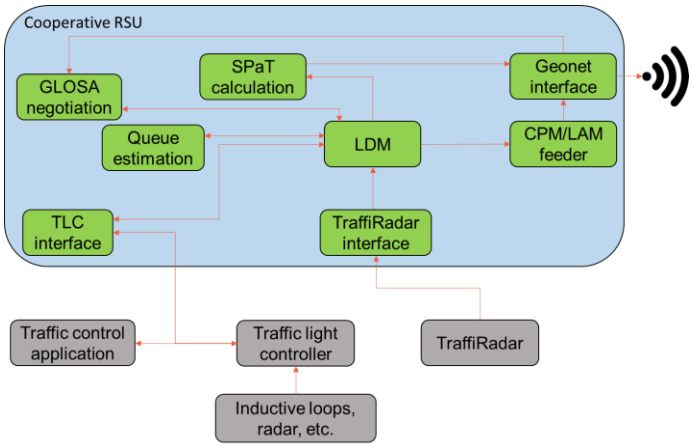


MAVEN cooperative and automated vehicles communication architecture and interfacing

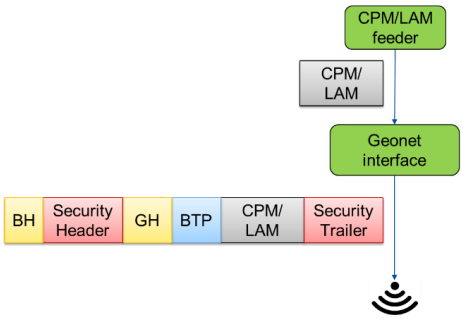


MAVEN V2X communication module architecture

Another technology under study within MAVEN is ADAS functions for VRUs and driver protection on MAVEN vehicles. Work has been done in the definition of the concept for ADAS inclusion in more generic automated driving frameworks. First, it was jointly agreed not to consider ADAS solutions based on retrofitting VRUs with C-ITS technology to let them cooperatively advertise their presence. Due to positioning limitations of these retrofitting solutions, the resulting ADAS would not be reliable and create uncertainty in the automated driving algorithms' reactions. Second, it was agreed that ADAS functions in the context of automated driving cannot be treated as separate functions but have to be integrated in the overall algorithms for environmental perception and path planning. For example, ADAS functions relying on cooperative sensing (collective perception) can be seen as complementing extensions of functions relying on on-board sensors. System reactions will be directly influencing the path planning (e.g. slow down and braking) when the confidence of the advertised detected object is good enough to justify them, or when the advertised object was not yet present in the environmental perception module databases because no local sensor has detected it yet.



Intersection communication architecture

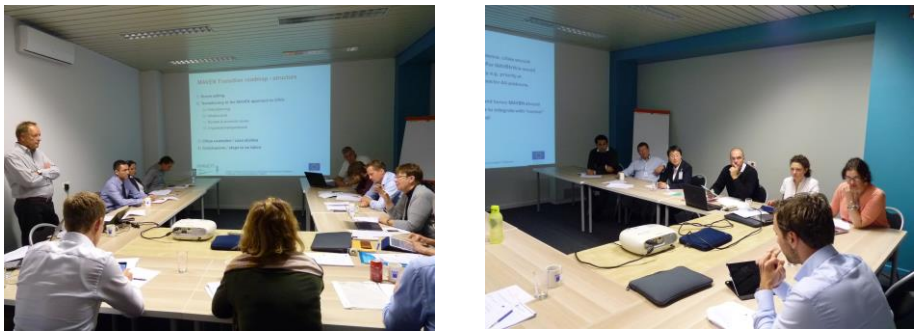


Geonet interface overview

The third technology investigated in MAVEN is HD (High Definition) maps and their usage to optimally support the MAVEN use cases. In this context, MAVEN started using the HD maps provided by TomTom, analysed the current format and identified suitable improvements. A dedicated workshop was held, and the definition of a process to evaluate the capability of extended HD maps to support MAVEN automated driving was agreed. MAVEN will further investigate how the extended HD map formats can enable trajectory planning (or improve its quality), focusing on complex scenarios like road intersections, where current HD maps not always provide all the data needed by automated driving algorithm implementations. Dedicated HD maps extension requirements, including standardisation aspects have been developed.

MAVEN transition roadmap

MAVEN hosted the second stakeholder consultation "Vehicle automation: implications for city and regional authorities" on 10 October 2017 in Brussels, Belgium, which was a joint action together with two related EU-funded projects TransAID and CoEXist, to gather the views and requirements of local authorities and other urban transport stakeholders.



The second MAVEN stakeholder consultation "Vehicle automation: implications for city and regional authorities" on 10 October 2017 in Brussels - Joint Workshop with TransAID / CoEXist

In the initial version of the MAVEN transition roadmap, 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 are presented. 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, VRUs, 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. The initial transition roadmap will be completed and available for public at the end of the MAVEN project in August 2020.

Main (joint) events plan

The main upcoming (joint) MAVEN events are:

- MAVEN Special Session on "Automated transport for smart cities" in May 2018 at IEEE (Institute of Electrical and Electronics Engineers) Smart Cities Symposium Prague (SCSP), Prague.
- The third MAVEN stakeholder consultation "Vehicle automation: implications for city and regional authorities", August/October 2018. (TBC)
- Joint Workshop with TransAID, C-MobILE and IEEE 5G Initiative on "Cooperative and automated driving" at IEEE ITSC (Intelligent Transportation Systems Conference on 4 November 2018, Hawaii.
- Joint Demo with TransAID, in conjunction with European Congress on Intelligent Transport Systems on 3-6 June 2019, Eindhoven/Helmond. (TBC)
- Joint Workshop with TransAID, in conjunction with IEEE IV'19 (Intelligent Vehicles Symposium) on 9-12 June 2019, Paris. (TBC)

MAVEN Consortium

Contact

For more information about the project, please contact:

Robbin Blokpoel (Dynniq) *T. +31 33 454 1731*
Technical Coordinator, MAVEN *E. robbin.blokpoel@dynniq.com*

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- Web site: www.maven-its.eu
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