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TM2.0 evolution towards multimodality: Turin SHOW Pilot

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Abstract

This paper addresses the potential interactions between the collaborative traffic management services (TM2.0), automated vehicles, roadside, and traffic management infrastructure. Its aim is to foster cooperation between the actors involved, defining, on the one hand the TM real time information that needs to be made available and accessible to AVs in a secure manner, to facilitate their integration in real traffic. On the other hand, it works to also define the feedback information the vehicles could provide to gain the maximum benefits at network level. In this context, within the SHOW consortium, the primary audience are pilot site leaders and those involved with proving traffic management services and the automated fleets at the sites. The document should help opening up the discussion and cooperation between the industry and road authorities and operators. This is key to address the necessary developments of traffic management in the era of automation.

Keywords:

SHOW, Collaborative Traffic Management, TM2.0, Autonomous Vehicle, Turin.

Introduction

In the past, only road authorities and operators gathered data. Over the last 20 years, more and more data sources have emerged from car manufacturers, navigation system suppliers, telecom operators and specialised service providers. The amount of data available has increased massively and this trend will continue with the widespread deployment of Connected and Automated Vehicles (CAVs).

The sensors of CAVs are expected to provide a lot of data on the traffic and environmental conditions along their route. Such data would be extremely useful to the road operators and traffic managers. On top of that, the introduction of automated driving, creates new opportunities. For instance, the origin and destination information, which is assumed known for all automated vehicles, can facilitate effective routing of the vehicles, providing as well as improved knowledge of the travel patterns and enabling the identification of the limiting factors in the current transport system and city or community design. New operation models for traffic management could be built upon these travel pattern insights, with the aim of improving network efficiency.

However, to exploit the full benefits of these data sources, data needs to be shared and combined and,

at the moment, there is no certainty of such sharing taking place. To achieve this goal, on the one hand, collaborative traffic management services will need to be well-orchestrated, as they depend on combined efforts from those involved in the service value-chain, both from the public or private sector.
On the other hand, win-win-win business models for all actors in the traffic management eco-system (i.e., road users, public traffic management centres, private service providers) need to be created.

In this context, the objective of SHOW is to leverage on the TM2.0 concept and work to actively include AVs in the traffic management loop. The basic assumption is, that automated vehicles are also connected vehicles capable of communication with traffic management.

TM2.0 Concept

Traffic management provides guidance to travellers and road users, providing information on the traffic status and on the conditions of the road network. It detects emergencies and incidents, which can be unforeseeable or planned (e.g., accidents, road works, adverse weather conditions, strikes, demonstrations, major public events, holiday traffic peaks etc.) and implements response strategies to ensure safe and efficient use of the road network, also across borders.
Traffic Management is currently facing a deep transformation, mainly pushed by the improvement of the existing infrastructure, by the gradual introduction of new generation vehicles, and by the development of new technological systems, governance, and procedures to better manage traffic operations and to offer new types of passenger and freight services.

The concept of Traffic Management 2.0 (TM2.0) is the evolution of current traffic management practices, which are based more on loop detectors and static traffic data used by traffic management centres. It builds upon the deployment of connected vehicles and travellers to achieve convergence of mobility services and traffic management, combining actions of the individual travellers with the collective mobility. This way, TM2.0 connects the innovative developments in the vehicle and on the road while improving the value to the legacy systems and, at the same creating new business opportunities.

The TM2.0 platform was launched in 2011 by SWARCO and TomTom and formally established in 2014 under the ERTICO umbrella of activities.
It now comprises 40 members from all ITS sectors (government, industry, research), focusing on new solutions for advanced interactive traffic management.
The objective of TM2.0 is to provide a discussion forum on interactive traffic management for stakeholders in the entire Traffic Management process value chain. Basic aims are to:

- Use a set of common interfaces, principles, and business models to facilitate the exchange of data between vehicles and Traffic Management Centres (TMC).
- Improve the entire value chain for consistent Traffic Management and Mobility services with the aim to avoid conflicting guidance information on the road and in-vehicles.

TM2.0 stands for a collaborative concept for Traffic Management and Control, in which travellers and goods, by using new technologies and sensors, become entirely part of the data supply chain.
It offers great new opportunities, making Traffic Management and Control, on one side, cheaper and more efficient for road operators, and, on the other side, more custom, friendly, and acceptable for users. This is accomplished by combining effectively data collected by the infrastructure and from the mobility services in the vehicles and smartphones.
In the current traffic management practice, TMCs do not have a direct collaboration with in-car data providers and OEMs. Traffic management is directed one way – e.g., a road authority informing road users on its traffic management measures or plans (TMPlans) via Variable Message Sign (VMS) or other dynamic signalling. TMPlans are not part of the dynamic traffic information that is delivered via in-car or mobile devices and individual vehicle behaviour (as available from the route guidance system) is not made available to the traffic management system. Consequently, on the one hand, traffic control strategies do not address individual road users. On the other hand, navigation systems are missing the information related to traffic circulation strategies, traffic regulations or prioritized routes put in place by the TMCs. Sharing this type of information would improve the efficiency of the whole network, especially in case of extraordinary planned or unforeseen events (e.g., important sport or cultural events, demonstrations, constructions, or public transport strikes) but also when specific plans need to be enforced (e.g., in cases of smog warnings, evacuation alerts, or low-emission zones).
Several road stakeholders are called to cooperate into providing a more holistic traffic management experience. Ultimately, the vision of TM2.0 is to combine intelligently the individual driver objectives (individual users' optimization) together with network wide management strategies (system optimization and equilibrium) in a win-win scenario. (Figure 1).

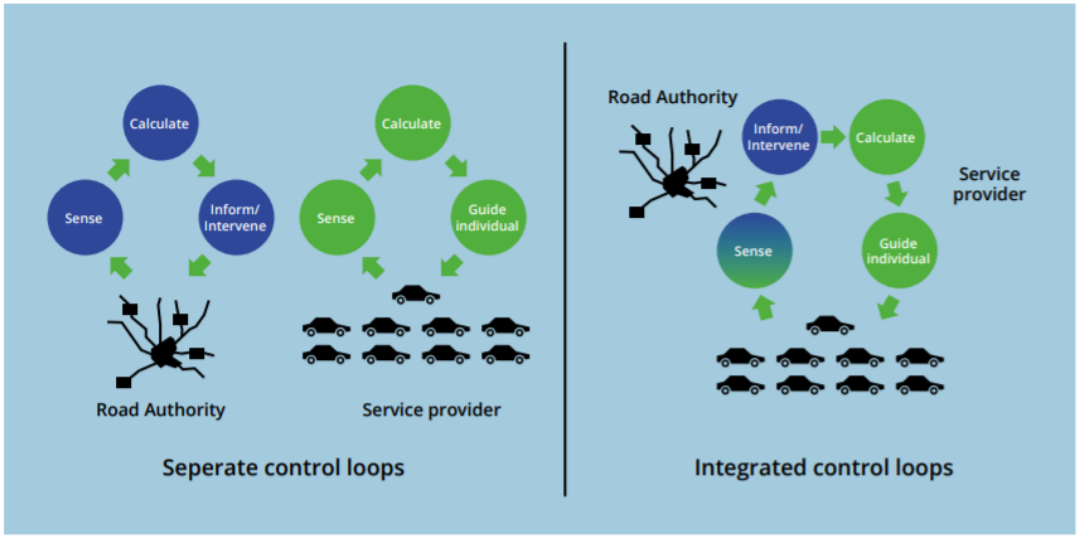

Figure 1 - TM2.0 concept (source: SOCRATES2.0)

TM2.0 and SHOW

As part of the SHOW project, TM's activities concern operations within the transition period, in which

both automated and legacy vehicles will coexist in mixed traffic environments, within regulating the increased interaction between vehicles, road and infrastructure. Its purpose is to define on the one hand how Real-time TM information and plans must be made available and accessible in hybrid systems characterized by an arbitrary combination of AV and human-driven safely, using standard interfaces, to facilitate the smooth integration of the latter in real traffic, while reaping the maximum benefits from this introduction. The definition of the interfaces is based on the TM2.0 concept, where the vehicle is considered an active part of the TM loop and therefore communication must be based on similar technical and functional quality levels for both vehicle categories, taking into account their differences (e.g. AVs are assumed to possess shorter response time and greater braking capacity, but still at the intersection level they both need to achieve the same goal by leveraging different communication / implementation channels).

In order to do so, activities have been focused on identifying collaborative services and on defining interfaces for regulating the required interactions between vehicles, roadside and central infrastructure. In particular, the use of standard interfaces has been fostered to ease the integration of feedback data provided by the vehicles. This feedback should include not only raw probe vehicle data but also information on road and traffic conditions generated from the large number of sensors integrated by the AVs, thus making the TM services more efficient.

This section presents a brief description of the methodology used to define the TM2.0 services and their interactions with the pilot sites of the SHOW project. The methodological approach followed included three main phases.
First, an in-depth analysis of the Traffic Management infrastructure available at the pilot sites was carried out. This was mainly done to know the level of infrastructure available in the various Italian and European geographical areas.
Secondly, based on TM2.0 experience, TM2.0 services have been identified that could be implemented in the SHOW project and potentially implemented in pilot projects to be tested through practical demonstrations. Traffic management services with varying degrees of interaction between vehicles and road infrastructure were included in order to accommodate sites with low-traffic management capabilities available as well.
The final step was the actual implementation and integration of the services at the selected pilots and the Turin satellite site is one of them.

Turin Pilot Site

Turin, an Italian city in the north of Italy, represents a high-level scientific pole in the Italian panorama and is often the site of demonstrations and use cases regarding ITS and CCAM services. The area of interest for the SHOW project is close to the City of Health and Science and the objective of the pilot project is to integrate a Demand Responsive Transport (DRT) service into the existing Traffic Management Center of Turin. Two autonomous shuttles will provide flexible public transport services

in the pilot area to special categories (e.g. people with chronic diseases, the elderly, etc.). To demonstrate this use case two traffic management services are under development and will be deployed at the Turin pilot site, in the framework of the SHOW project: the traffic light assistant and the green priority services. These services have the purpose to assure punctual transportation and the same time minimise emissions. Both services will also make the use of public transport more comfortable and attractive to the public. The interactions between the automated shuttle buses and the road infrastructure will indeed reduce the delay of the vehicles at signalised intersections, therefore improving the efficiency of AV operations. Figure 2 represents the overall architecture and information flow for the provision of these two services.

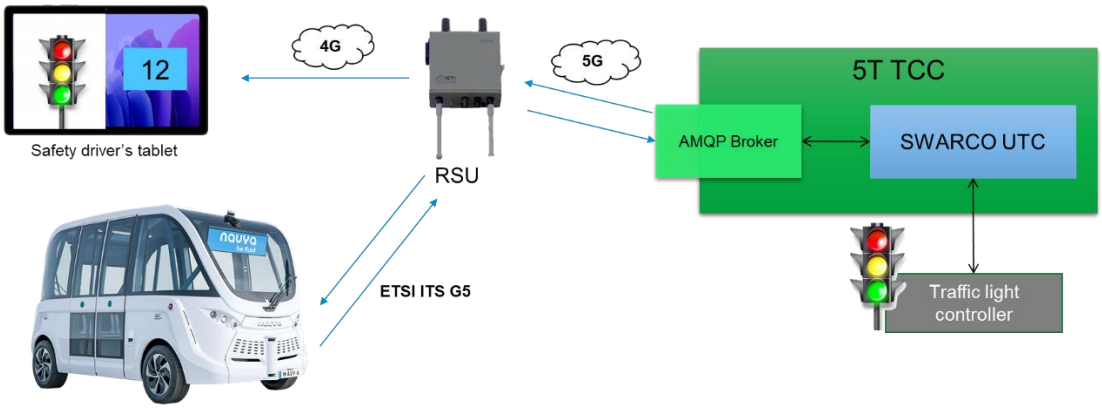

Figure2 - Turin pilot site architecture

The RSU will periodically collect the CAM messages broadcasted by the shuttle buses on the ITS-G5 communication channel. Thanks to the information contained in the CAM messages, the RSU will constantly monitor its position. As one of the shuttle buses is moving towards one of the connected intersections, the RSU will generate a Signal Request Extended Message (SREM) to be sent to the 5T Control Centre (TCC) on its behalf, via 4G or 5G. The SREM message, requesting public transport priority, will include information about the intersection approached and shall be transmitted two minutes in advance, to provide the centre enough time to process the request.

The Control Centre can therefore process the request and either accept it (e.g., the shuttle is eligible to get priority) or reject it (e.g., other priorities are granted). In either case the TCC will send feedback to the shuttle bus, through the RSU. More specifically, a Signal request Status Extended Message (SSEM) will inform if the priority request has been granted or not. The RSU will forward the answer to the vehicle, which will be displayed on an in-vehicle display information (a tablet located on the shuttle bus), where the safety drive will be able to see it early enough.

In addition, the TCC will also provide for two signalised intersections (Figure 3) forecasts on upcoming traffic light phases (SPATEM). This information will be forwarded by the RSU either on the safety driver's tablet and/or directly to the shuttle bus, which will be able to minimise sudden stops, deceleration, and acceleration.

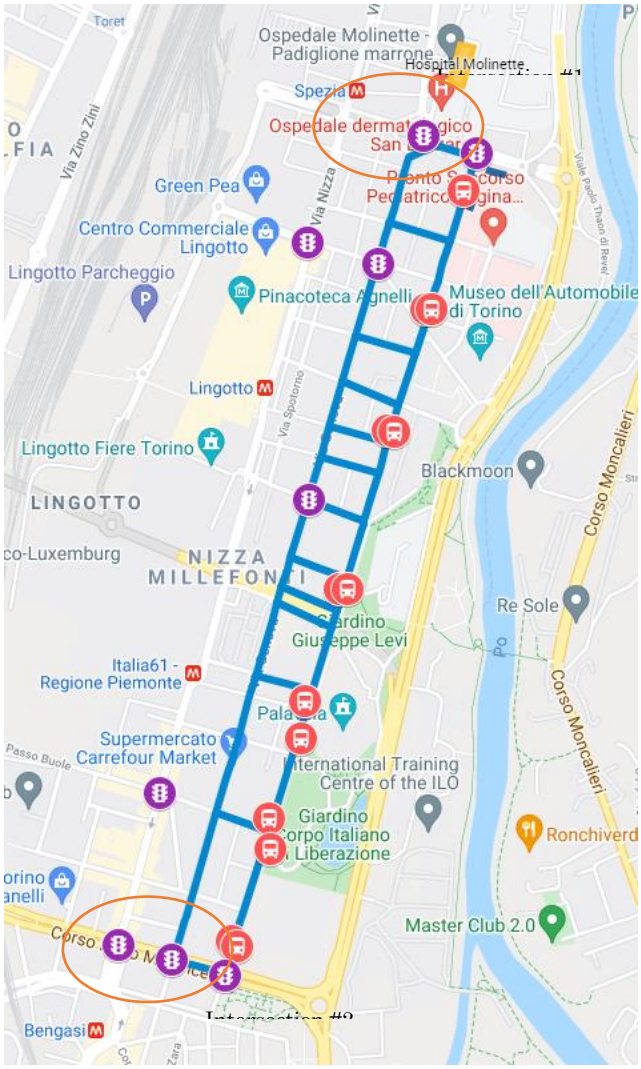

Figure 3 - Turin pilot site signalised intersections

Figure 4 - Turin pilot site – Intersection #1, Corso Spezia

Figure 5 - Turin pilot site – Intersection #2, Corso Maroncelli

Conclusion

Connected and automated driving is pushing for an evolution of the traffic management systems. Especially highly automated vehicles need to be aware of everything happening on the route ahead, also beyond their own sensors, therefore, in the future, traffic management should be able to support when needed their interaction and communication with their surroundings, providing the necessary data to increase road safety and efficiency. Connected and automated vehicles, with their advanced sensing systems, are also expected to enable the provision of more reliable, effective, and efficient traffic management services, with high quality and detailed data on the status of the road network (e.g., road conditions, traffic state and incidents that they encounter while driving, etc.).

The vision is to work towards establishing collaborative traffic management practices. Overall, this requires a strong cooperation of the public and private sectors working in the traffic management ecosystem. Traffic management related data needs to be exchanged and translated into intelligent decisions and into high-quality reliable and safe services, with the overall goal of enhancing the safety and efficiency of traffic for all road users. In this context, the objective of SHOW was to promote the development of efficient and valuable interactions between vehicles, roadside, and traffic management infrastructure. To reach this goal, functional specifications for collaborative traffic management services have been defined and the creation of cooperation at SHOW pilot sites' level has been promoted. While we have managed to implement some cooperative services, more is certainly needed to achieve full cooperation.

There is a strong need for more digital infrastructures, enabling connected communication, and modular, scalable, replicable and flexible tools for the provision of traffic management services. Furthermore, the digitization of traffic management plans and strategies and the harmonization of exchangeable data should be further promoted, locally and internationally, to enable the development of reliable common tools for automated driving.

Recommendation for the future development

Recommendations for working towards collaborative traffic management can be summarized as follows.

1. Co-create a common vision, elaborating win-win scenarios

A prerequisite for the provision of collaborative traffic management services and for the improvement of the quality of the traffic information provided, is that the stakeholders involved – i.e., drivers and OEMs governing the data created by the vehicles, service providers and road operators governing the data generated and monitored by the road infrastructure – are all willing to share the data.
In general, data sharing can only be accomplished based on voluntary cooperation, except for specific vehicle-based safety-related data which are mandatory.

The co-creation of a shared vision, generating benefits and value for all stakeholders in the traffic management ecosystem can help achieve this cooperation. If individual and common goals addressing problems and needs are established, then high-level benefits for each stakeholder involved can be identified, and data sharing agreements are more likely to be signed. Specifying and agreeing on suitable terms and conditions for data exchange and usage, while at the same time guaranteeing sustainable and attractive business are key for successfully opening up the access to data sources.

2. Availability of high-quality data

Of course, collaborative traffic management needs data to be available for successful implementation. Availability refers to data and information that makes digitalised Traffic management possible, i.e., data about the traffic state (e.g., traffic volumes and speeds), triggering conditions (e.g., events, air quality) and corresponding Traffic management measures. Such data and information usually lie in different hands and in different formats.

For collaborative traffic management to happen, data and information about any transport infrastructure elements needs to be available. Looking at the SHOW pilots, a solid traffic management infrastructure is often missing, and related information is not digitalised sufficiently, or even not existent. Therefore, a stronger investment to upgrade the infrastructure should be considered. Additionally, quality of data and data security cannot be overlooked. The reliability and safe operation of the traffic management services may be negatively impacted by poor or varying data quality. High system performance and necessary to build trust between the cooperating parties. In particular, this may be key to allow a smooth exchange of data with highly automated vehicles, which has sometimes been an issue within the SHOW pilots, working with commercial systems (e.g., Turin pilot site).

3. Data standards

To enable sustainable exchange of data, the use of commonly accepted standards is also a prerequisite. The development of standards which are interoperable and trusted for automated driving is crucial to foster cooperation between the different players and enable effective collaborative services. More

specifically, traffic management strategies and practises need to be harmonised, and traffic management plans digitalised into standardized exchangeable data. This way the plans can be well communicated, understood and, when required, timely executed.

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