TF Deployment Steps

Final Report

25 Nov. 2016

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1. Purpose of this report and intended audience

The purpose of this TM 2.0 report is mainly to define the necessary steps to deploy solutions for interactive traffic management. This is done by giving examples from a few representative cities in relation to the challenges that traffic managers have to face, the different types of solutions (technical and non-technical) that can be adopted, the necessary engagement of key private and public stakeholders, the definition of a possible common approaches making TM 2.0 roll-out in real-life and on a large scale, including the references on the market of relevant mobility services.

This document is the result of the work of a pool of people with very different expertise (traffic, policy, technical, research and business). As a consequence, the information is given in a non-expert way, so as to allow people with limited or no experience in the field to read and benefit from it. Each chapter of the report can be read **independently** from the others, so that readers can choose whether to read only the parts which are of specific interest or the entire report.

The report is intended for public authorities and key actors in the transport and mobility value chain (traffic managers, content and mobility service providers, road transport operators, etc.) at local and European level.

We wish you an enjoyable read, hoping that you will find this document useful.

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2. Introduction

TM 2.0

Traffic Management 2.0, alias TM 2.0, is an Innovation Platform established in 2014 by the ERTICO Partnership. The vision of TM 2.0 is to enable interactive traffic management become a reality and create synergies between individual and collective mobility needs, while providing new connectivity and information services for vehicles and travellers and reducing ICT infrastructure costs for traffic managers thanks to innovative ITS solutions. Being open to all interested public and private stakeholders, as of 2016 it comprises over 30 members from all ITS sectors, such as public authorities (at national, regional and local level), road operators, traffic and transport industries, service providers, research establishments, users associations, and OEMs. The concept of TM 2.0 and its evolution from a more or less static traffic management (TM 1.0) through the adoption of new technology solutions and the interaction between service / content providers, road operators and public authorities is schematically shown in Figure 1 and explained here below.

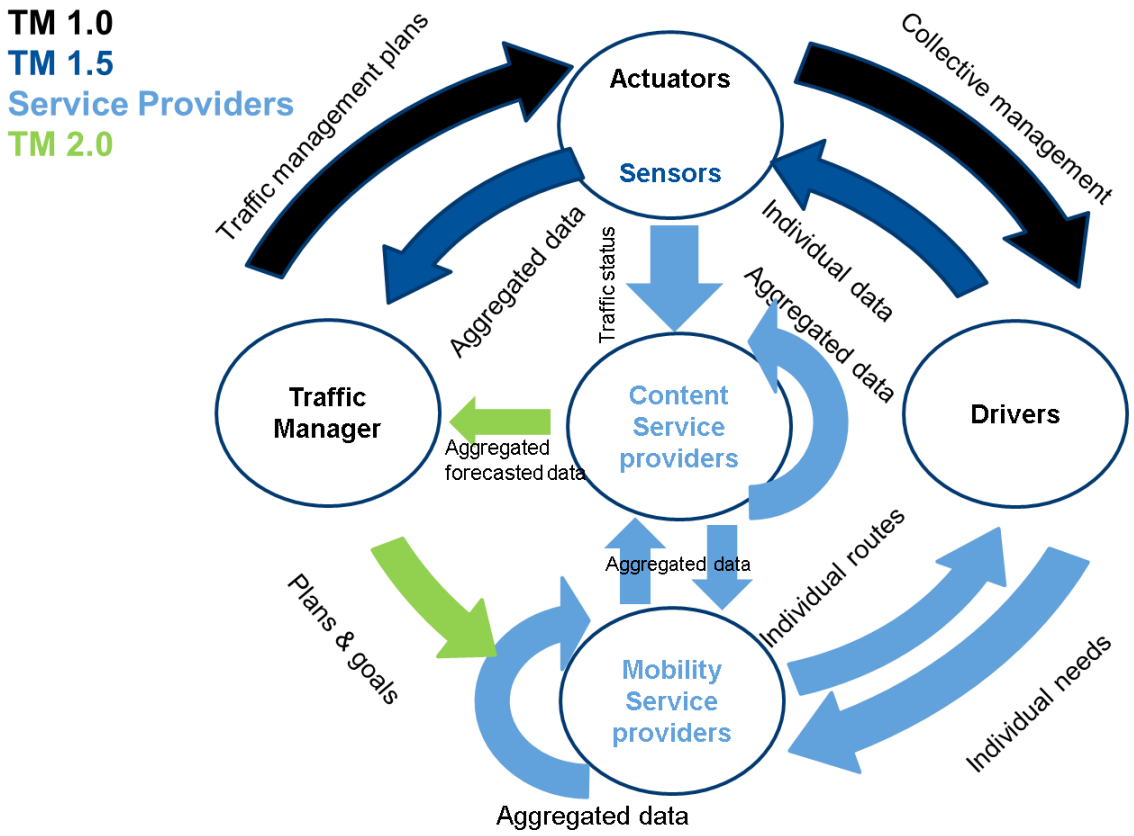

Figure 1: Transition from static to dynamic, interactive traffic management

In Figure 1 TM 1.0, represented by the black arrows, was enforced by traffic managers to the entire community of drivers and road users, mostly based on historical data. Through the implementation of new sensoring technologies, this has gradually evolved into TM 1.5, represented in Figure 1 by the blue arrows. The improvement in TM 1.5 lies the use of road-side infrastructure such as cameras, loop detectors, etc., which collect real-time information about vehicles' traffic and contribute to elaborate more accurate traffic management plans and also aid in traffic forecasting in order to adjust traffic flow and the implementation of contingency plans in real time. Service providers have built their services on this model and improved the quantity and granularity of data used to provide vehicle's routing information. In addition, mobility and safety information as well as an increasing

number of information and services have been made available for different kind of purposes, such as leisure and business. This is schematically represented by the light blue arrows in Figure 1. The objectives pursued by service and content providers to deliver better, more competitive services to their customers and the way these have been implemented has resulted in the proposition of new "smart" solutions, which however are often in conflict with solutions elaborated and implemented by traffic managers to address the increasing congestion and pollution issues in metropolitan areas. The green arrows represent the further evolution towards dynamic, interactive TM 2.0, which can be realised by sharing (open) data from different sources / owners and traffic management plans, by establishing new cooperation and business models, and by elaborating plans and goals conjugating individual and collective mobility needs through sustainable yet competitive mobility solutions.

The Task force on Deployment Steps in the context of TM 2.0

As part of TM 2.0, this Task Force has addressed the steps that can be taken to achieve an interactive and dynamic TM 2.0 by undertaking the following tasks:

- Identify candidate areas (cities / regions) for the implementation of TM 2.0
- Provide an overview of TM status and of the deployment steps needed to realise TM 2.0 in different representative cities / regions
- Present the future plans and next steps towards further implementation of TM2.0

This Task Force does not engage in the deployment tasks but supports the TM2.0 members and candidate areas by providing guidance through a common framework, supporting local deployment plan and approach. It is important to note that this Task Force looks only at the deployment steps, leaving other aspects such as the identification of data, benefits, best practices, business models, contractual aspects, etc. to be addressed by other TM 2.0 Task Forces.

A common framework is seen by the TM 2.0 members as an important instrument for achieving a shared understanding of the benefits and challenges involved in the implementation of TM 2.0. It supports the identification and description of the relationships and interdependencies between ITS stakeholders involved in traffic management, and that includes the distribution of roles and tasks, and win-win situations sought to be achieved with the delivery of a specific TM 2.0 service solution. It also facilitates an efficient exchange of knowledge between different TM 2.0 deployment areas, allowing these cities and regions to capture and understand lessons learnt from each other.

3. Potential deployment areas

As a first step, the Task Force has defined the key criteria for the selection of a TM2.0 deployment area. A candidate area can be a city, metropolitan area or region leading the way towards new transport and mobility paradigms, which can be a reference and an ambassador towards other areas having to face comparable challenges in similar settings (road network configuration, traffic pressure and mobility challenges, geographical setting, etc.). The main criterion for selection has been identified in the possibility to establish a **functioning partnership** between the mobility service actors and the road operators. To this end, representatives from candidate cities / regions have been requested to provide a description of existing and potential interactions and cooperation with the different local stakeholders using the organisational reference architecture defined in the frame of the another TM 2.0 Task Force, namely the Task Force on Viability Analysis, which is shown in Figure 2 and has been developed to illustrate the following aspects:

- Stakeholders' groups: identification of logical functional groups; description of roles and tasks;
- Stakeholders' interactions: current and future perspectives from different groups and regions;
- Identification of synergies and win-win situations as well as current and future value chains.

Depending on the use cases and local market distribution of roles and tasks, one organization/party may belong to one or more stakeholder groups identified in Figure 2, the following definitions apply:

- Authorities: administrations operating the road-side systems; implementing the TM plans; collecting traffic data and providing information to drivers by means of road-side systems.
- Road Infrastructure Owners: cities, regions, national road authorities; concessionaires; responsible for TM goals and/or plans (including safety, efficiency and comfort aspects).
- Road-side / Content Service Providers: data broker and/or aggregator of different data sources.
- In-car Service Providers / Telecoms Providers: OEMs, telematics and navigation service providers, mobility mobile apps; managing interaction with consumers inside the vehicle.
- Service Consumers: professional and private drivers.

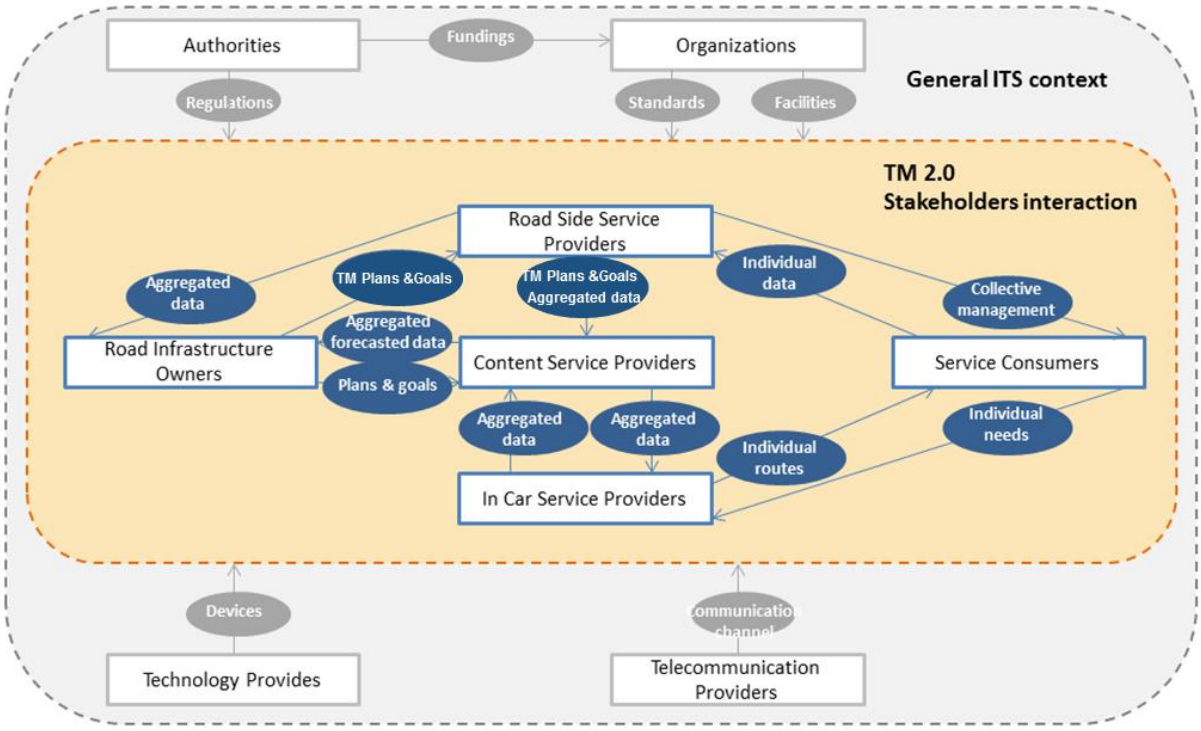

Figure 2: Organisational Reference Architecture defined within the TM 2.0 Task Force on Viability Analysis

Based on the above, the candidate areas selected are the cities and regions of BrabantStad (NL), Ghent (BE), Salzburg (AT), Thessaloniki (GR), Verona (IT) and Vigo (ES). Due to their characteristics (geographical setting and wider extra-urban road-network, urban environment and transport modes, main traffic issues and management approach), briefly described here and in the reports of other TM 2.0 Task Forces, these areas can be considered as representative of the wide range of European cities that can benefit from realising TM 2.0.

As a second step, this Task Force has then focused its work on identifying the factors that are essential for triggering an interest from the regions themselves in order to understand the steps needed for convincing the decision makers to engage in a cooperation scheme between Traffic Managers and Mobility / Content Service Providers. How should the problem be approached and who should take the first steps? This report aims to explain from a city-led point of view, **what** are the TM challenges and envisaged solutions, **who** are the stakeholders that shall be engaged, **how** the TM 2.0 deployment can be realised. Other cities / regions interested or shortly embarking on deploying a TM 2.0 approach may use the information available here to understand possible approaches and steps, independently from the technology solutions adopted.

4. Implementation plans and steps

BrabantStad (NL)

TM status overview

BrabantStad is an administrative network for five municipalities and the province of North Brabant. The geographical area consists of the five medium-sized cities of Breda, Eindhoven, Helmond, 's-Hertogenbosch and Tilburg and of a scattered pattern of smaller cities and villages. BrabantStad aims to improve traffic management in the coming years by optimising the existing infrastructure instead of extending their road network. This will be done by integrating as much as possible new ITS technologies into operational traffic management. To this end, the partners of BrabantStad will offer their roads as a living lab for ITS development, testing and validation, with the ultimate goal to integrate proven solutions into TM 2.0. Thanks to projects like FREILOT[1] and Compass4D[2] in Helmond, "shockwave mitigation" in Brabant, "in-car III" on the A67, and the "shockwave pilot" on the A58 highway, the BrabantStad partners have already acquired wide experience and know-how.

Key challenges and bottlenecks have been identified within urban areas, at the interfaces between highways and city borders, in the corridor Amsterdam-Eindhoven-Maastricht (A2), and the logistic corridor Rotterdam-Brabant-Venlo, connecting the main port of Rotterdam with Germany. To address them, BrabantStad has identified four main themes in its TM plan 2015-2017:

1. Quality: the road network must suitable for current and prospective traffic demand and concerns in terms of both physical and digital infrastructure (among others TM data);
2. Optimization: technical improvements to the systems and traffic information are involved;
3. Innovation: new ITS services such as in-vehicle speed advice and time-to-green will be further tested and then implemented / integrated into operational traffic management;
4. Organization: coordination on network level.

The ambition of BrabantStad is to become a leading economic region with good accessibility and high innovation power, which encompasses new forms of Smart Mobility achieved by e.g.:

- offering a Living Lab for developing, testing, validating and deploying smart mobility and new mobility concepts;
- improving road traffic and assessing mobility impact for users and related businesses changes;
- establishing smart public-private partnerships, including new forms of collaborations and initiatives originated from the society

To this end, BrabantStad will use a wide range of measures to ensure comfortable public transport and safe and well-maintained infrastructure for cyclists, pedestrians, drivers, logistics and ITS. BrabantStad will have special focus on ITS and is already testing on a wide scale C-ITS services.

In this context the Innovation Traffic Management Centre (ITMC) plays a crucial role. Using the same data sets and tools of the operational TMC, the ITMC is a key asset to assess and deploy new ways of managing traffic. The ITMC will offer a real life testing environment for innovative solutions and ITS services, before real-time, real-life interaction with operational traffic and road users take place.

Stakeholders roles and engagement

The ITS Agency BrabantStad is the public cooperation of the above-mentioned cities and province, plus the federal road authority of Rijkswaterstaat. ITS BrabantStad closely cooperates with both the operational and innovation TMC, the National Data Warehouse for Traffic Information (NDW) as well as with industry and research centres. The organisational reference architecture for BrabantStad is shown in Figure 3. The BrabantStab platform is open to all (public and private) stakeholders as well as to professional and private end users.

[1] http://cordis.europa.eu/project/rcn/191865_en.html
[2] www.compass4d.eu

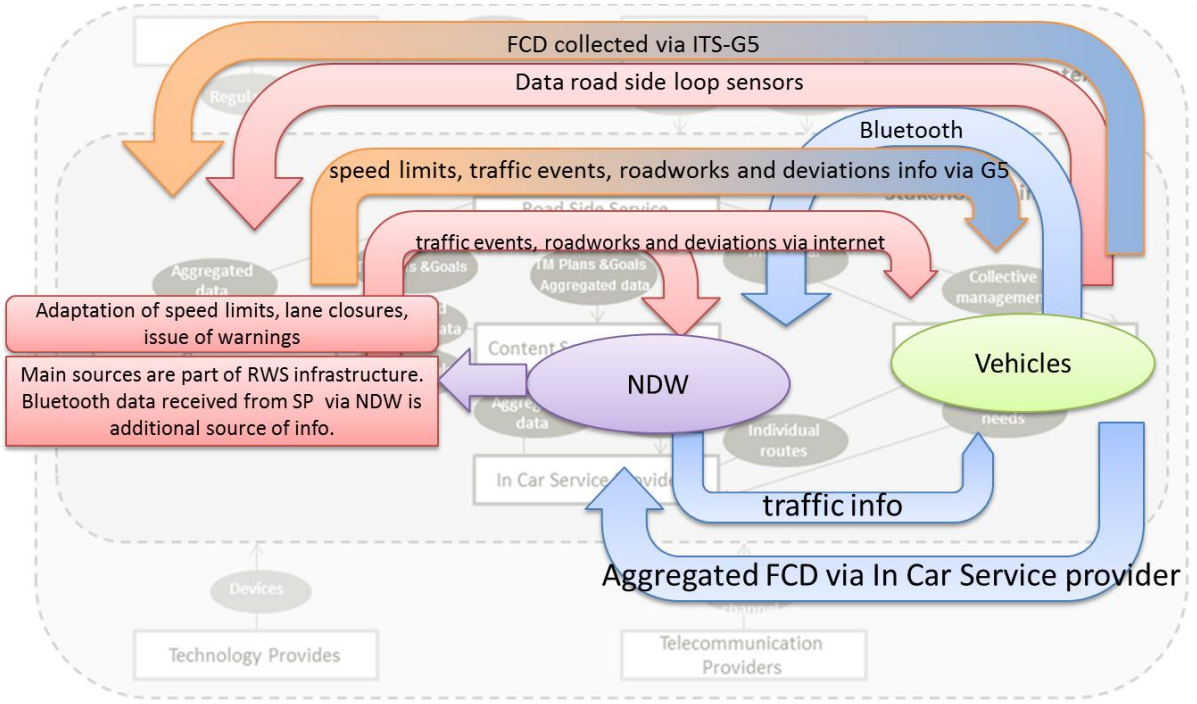

Figure 3: Organisational reference architecture for BrabantStad

Future plans and next Steps

ITS deployment and traffic management are recognised by BrabantStad as being closely related. The main ambition is to move from local test pilots deployed in recent years towards coordinated pilots and large scale deployment in the next years. Up-scaling and full integration of C-ITS services in the operational traffic management process is a key step, since (cooperative) ITS solutions were not originally conceived to address TM needs, but are now seen a key option to enable interactive and adaptive TM, in line with TM 2.0.

Plans to realise TM 2.0 in the mid-long term (about 3-4 years, until 2020):

1. "Evergreen on Bike" in Breda

Information about the presence of a cyclist is provided via smartphone well ahead an intersection or at a traffic light: drivers receive an early notification; traffic lights are managed to provide priority to cyclists; cyclists receive info about faster / slower bikes and can adapt their speed to get green light.

2. C-ITS deployment in Helmond

Helmond has already invested in a state-of-art traffic network system enhanced with C-ITS services, a.o. resulting from EU-projects such as FREILOT and Compass4D. Over the next years, both the type and the number of services as well as users will be significantly increased.

3. TM system in the ring-road of Breda

Based on policy goals, the City of Breda will invest in a TM system enabling to steer traffic towards the ring-road, depending on actual traffic situation and environmental impact. Initially information will be provided to the users via VMS, and then a transition will be made towards in-car information.

4. A58 Shockwave Mitigation

In the frame of a Pre-Commercial Procurement (PCP) action, private and public sector parties and knowledge institutions have jointly developed services to mitigate shockwave traffic jams on A58 based on innovative Talking Traffic techniques. In this project the technical, organisational and process-based challenges of the collaboration between private and public sector are becoming clear. This PCP stimulates private sector parties to develop innovative solutions and it sets the right

conditions for free market processes. A key outcome of this project is an open architecture for ITS solutions, which can also be used as a basis for numerous other mobility services. Building on this, hybrid solutions (based on wireless ITS-G5 and mobile 4G/5G) will be implemented to achieve large scale deployment.

5. Compass4D deployment in Tilburg

Tilburg will invest in ITS-G5 technology and C-ITS services to better manage logistics flows. The City has defined a new mobility policy to reroute trucks as much possible towards the ring-road by offering to trucks as incentive a certain level of priority on the ring-road.

6. High Level Architecture (HLA)

A group of Dutch companies in close cooperation with national and regional authorities have developed a fully operational cooperative infrastructure based on a service independent high level architecture (HLA), clearly specified interfaces supported by a wide range of suppliers while using European standards (ETSI, CEN). The Dutch HLA includes measures to protect drivers' privacy and system security (PKI) and has already proven suitable for the realisation of additional use cases such as Road Work Warnings.

7. Total network management

A Traffic Management Centre operates the highways as well as main urban and interurban roads.

Next steps in the short-medium term (about 1-2 years, until 2018):

Create a Hybrid test-bed early 2017 with the goal of offering a real-life environment equipped with cooperative and connected functionalities based on latest technology solutions so to facilitate rapid exchange of data between vehicles and road-side systems. The main goals and ambition are:

- to accelerate the (technology) developments and anticipate future evolutions;
- to improve mobility thanks to smart, clean, reliable, safe and comfortable travel conditions;
- to establish BrabantStad as THE region for innovation in C-ITS / Smart Mobility by offering a top economy location with competitive advantage and international opportunities;
- to consolidate The Netherlands as a test environment for (new) mobility solutions.

The Hybrid test-bed will offer unique testing facilities with urban, interurban roads and highways from Tilburg to Helmond (see Figure 4) equipped with both cellular and ITS-G5 communications. Several services will be deployed for selected user groups, such as shockwave mitigation speed advice on highways, signal phasing and time-to-green information in urban areas.

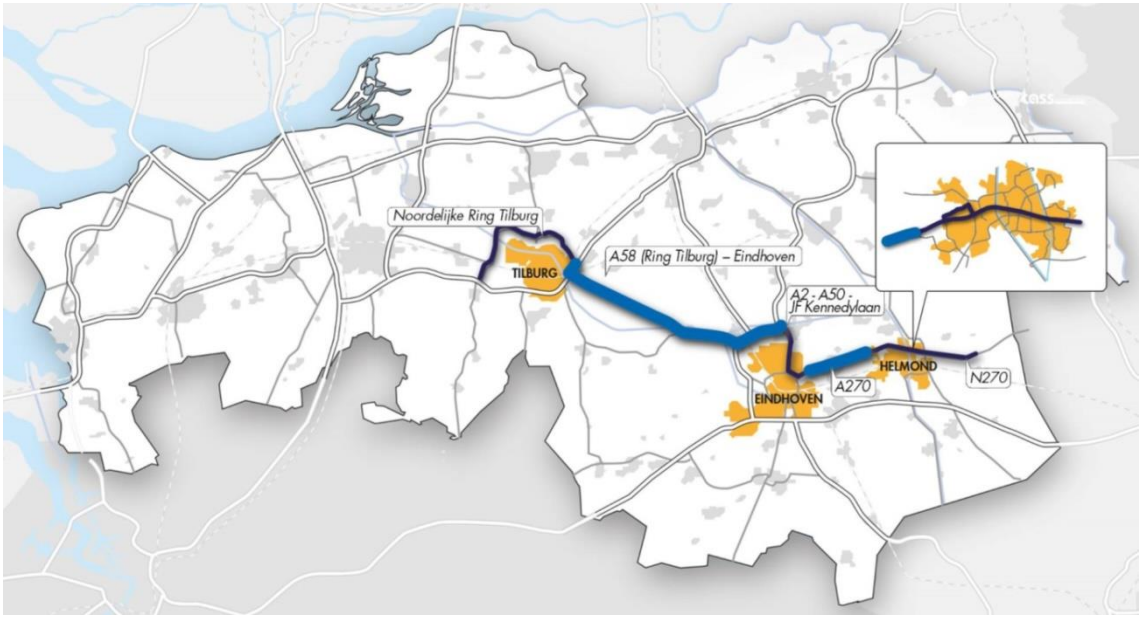

Figure 4: BrabantStad and its main C-ITS and TM implementations

Ghent (BE)

TM status overview

The approach developed by the City of Ghent for traffic management relies on a virtual cooperation platform based on three elements / steps described here below and schematically shown in Figure 5.

Input information:

- Cooperation with data providers, mobility communities and governmental agencies, and re-use of open data API's (see stakeholders' description);
- Currently available: weather, Tweets, travel times, bus - tram – train (incl. delays), parking occupancy, bike counting, road works (from external notifications), accidents, traffic jams, road hazards;
- To be done: off-street parking, road works (from City administration), pedestrian counting.

Information processing:

- Currently available: IoT platform configured to automatically process different data sources and generate notifications when something deviates from expectations;
- To be done: coherent storage of raw input data.

Output information:

- Currently available: 1) open data API where all real-time events are made publicly available (https://data.stad.gent/datasets/verkeersmeldingen-actueel); 2) automated Twitter account (@VerkeerGent); 3) "traffic management" App on tablet (only for internal use by operators), which gathers all notifications and shows them on map, partly replacing the TM control room;
- To be done: a) individual notifications, based on a Beta version already defined with Univ. of Ghent (see Github: "personalised moblility information"); and b) a (personalised) dashboard.

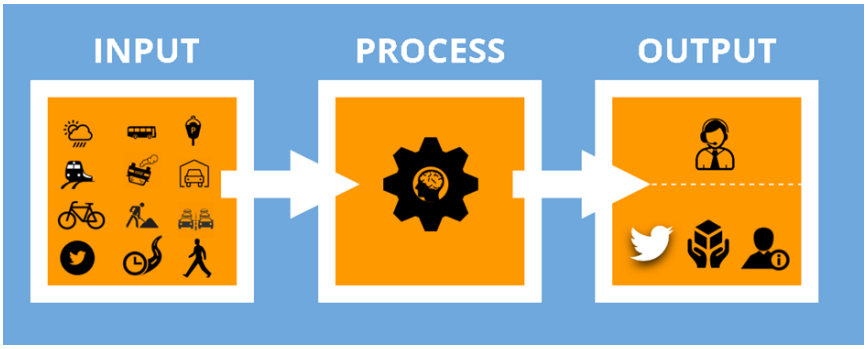

Figure 5: Virtual Traffic Management Platform of the City of Ghent

Envisaged solutions, Pros & Cons, feasibility

Most parts of the virtual platform have been set up and are currently working. This platform will be extended with personal notifications and a dashboard and "big data" storage of raw data sources. This should be feasible by end of 2018. At the same time, the City of Ghent is trying to transfer the "off-line" / "infrastructure-based" TM towards a cloud based TM "as a service" concept. This would make it also possible for other cities to subscribe to such a platform and would be highly beneficial for many other cities worldwide[3]. A final step will be to include into the system the management of the traffic lights, but this is not a priority as most lights are managed by the region, and investments vs. effect ratio can perhaps be higher in other areas.

[3] See concept presentation at http://slides.com/pietermorlion/eurocities-tampere.

Stakeholders roles and engagement

The Mobility department of the City of Ghent is very active in setting up partnerships with public and private organisations, including commercial ones, to exchange information and data on traffic and mobility. The current stakeholders' engagement can be summarised as follows:

- Other City departments: good informal cooperation;
- Police: informal cooperation at operational level, but information exchange is quite difficult;
- Region (national roads, infrastructure owners): common vision and policy; good collaboration for the management of traffic lights, road works, etc.
- Public transport (tram & bus operator): contracts to exchange data; operational cooperation;
- Public transport (train operator): contracts to exchange data; use of unofficial open data API;
- Citizens: difficult to reach out, engage and collect feedback;
- Data providers: good relationships, starting to create open data ecosystem;
    - Waze: agreement as part of the Connected Citizens Program;
    - Coyote: agreement to use their travel time data;
- Service consumers: difficult to reach out;
- Car industry: no collaboration yet;
- Technology industry: limited collaboration (project-based) on mobility, smart city, data, etc.

The roles and interaction of the different public and private stakeholders is schematised in Figure 6.

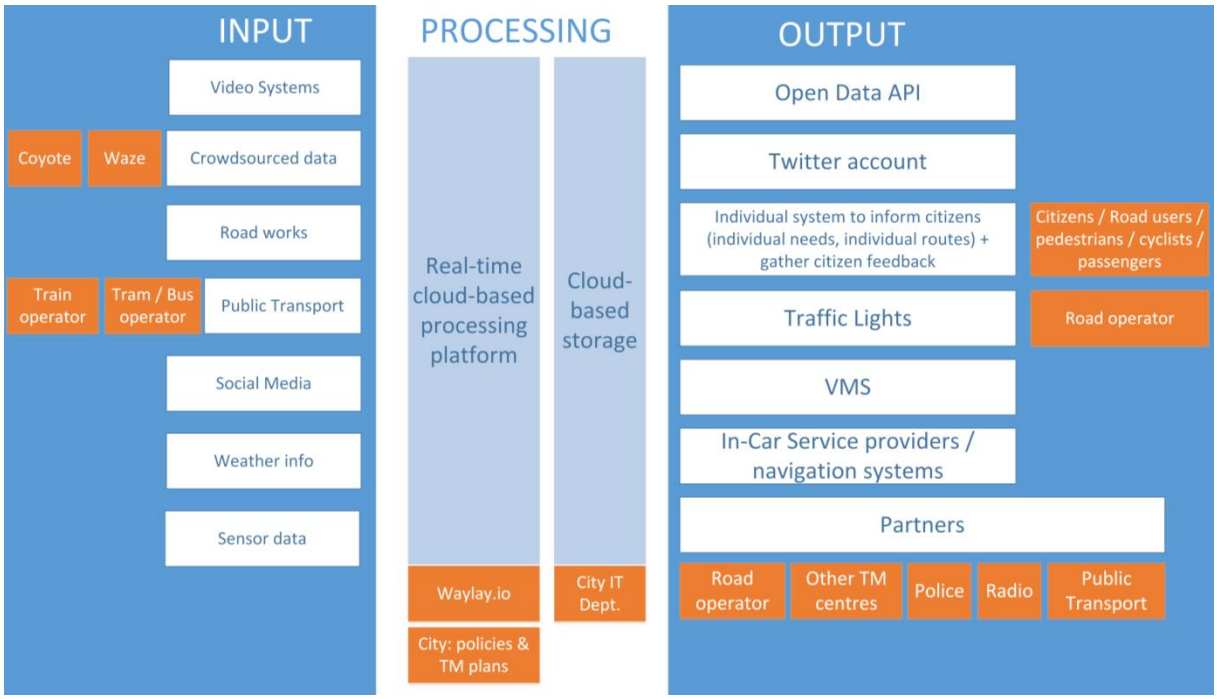

Figure 6: Organisational reference architecture for the City of Ghent

The measures identified to engage stakeholders and resolve collective vs. individual mobility are:

- Create long-lasting relationships with other public authorities;
- Engage organizations in the region that unite stakeholders around mobility / transport topics;
- Enhance communication to engage citizens and create a community of "smart citizens";
- Develop tools to improve data exchange and communication towards end users;
- Ensure all partners involved follow the open data regulations.

Future plans and next Steps

Managing the transition from actual TM practices towards TM 2.0:

- TM has been implemented in Ghent through policy shaping and enforcement measures. As a consequence there are none or very few legacy systems, and Ghent is ready to deploy TM 2.0.

Next steps in the short-medium term (about 1-2 years, until 2018):

- Strengthen and extend public-private stakeholders partnerships;
- Find additional financial resources and employees with relevant skills;
- Increase data sources and storage capability for big data;
- Increase communication channels for citizens and road users.

Plans to realise TM 2.0 in the mid-long term (about 3-4 years, until 2020):

- Implement automated connection with traffic lights.

Salzburg (AT)

TM status overview

Current TM implementation: status and challenges

Salzburg is one of the nine federal states of Austria. It is located in the north-western part of Austria, immediately adjacent to the German border. The Federal State's capital is the City of Salzburg, a medium-sized city with an historical centre selected by UNESCO as world heritage site. With high commuter traffic from the northern parts of the federal state reaching the city on weekdays, Salzburg has to tackle also a significant share of touristic traffic with limited possibilities to optimize traffic capacities due to the historical road network configuration. The main public transport infrastructure in the city is a trolley bus system with a share of 14.7% of all trips. Bicycles count for a share of ca. 19.6%, while 20% of all trips are walking trips[4].

Over the last years several initiatives on implementing intelligent traffic management have been realised:

- Region-wide real-time traffic state estimation system using the Floating Car Data Testbed Salzburg[5], which also covers public transport;
- Region-wide network of loop detectors;
- Adaptive traffic lights in the city of Salzburg;
- Traffic-adaptive network control (provided by Gevas software GmbH)[6];
- Dynamic speed adaptation and VMS on the city ring-road (A1 and A10 operated by ASFINAG).

The traffic management challenges for Salzburg are mostly related to the summer touristic season, when TM 2.0 can bring added value as compared to the existing solutions. On rainy days during the summer a high number of tourists reach the historical city centre by private car. Due to its limited road and parking capacity of the inner city centre, this high number of private vehicles causes traffic collapses, also for the public transport, since in many roads there is no space for dedicated bus lanes and hence trolley buses share the road with private cars. Closing the city centre to foreign cars (based on number plate selection) is not an optimal solution. Therefore, the TM strategy on these days is generally to guide tourists to P+R facilities outside the city centre connected to the city centre by a bus line. However, this strategy does yield the desired effects because most tourists are

[4] Herry, M. and Tomschy, R. (2014). Vergleich der Mobilitätserhebungen 2004 und 2012 und Überprüfung auf Plausibilität, Salzburger Verkehrsverbund GmbH.
[5] http://www.fcd-modellregion.at/home?lang=en
[6] http://www.gevas.eu/1/news/news/article/sens-netzsteuerung-in-salzburg/

guided by navigation systems and cannot be fully and efficiently informed by local VMS signs. Most of the times, tourists are guided to P+R facilities at police checkpoints, but leave the indicated route at the next junction and follow the route to car parks in the city centre again as indicated by their navigation system. Such systems however are not aware of the city's traffic circulation plans and sometimes route users to closed roads, with negative effects on the traffic. This phenomenon has worsened over the last years with the increased penetration rate of navigation systems in vehicles.

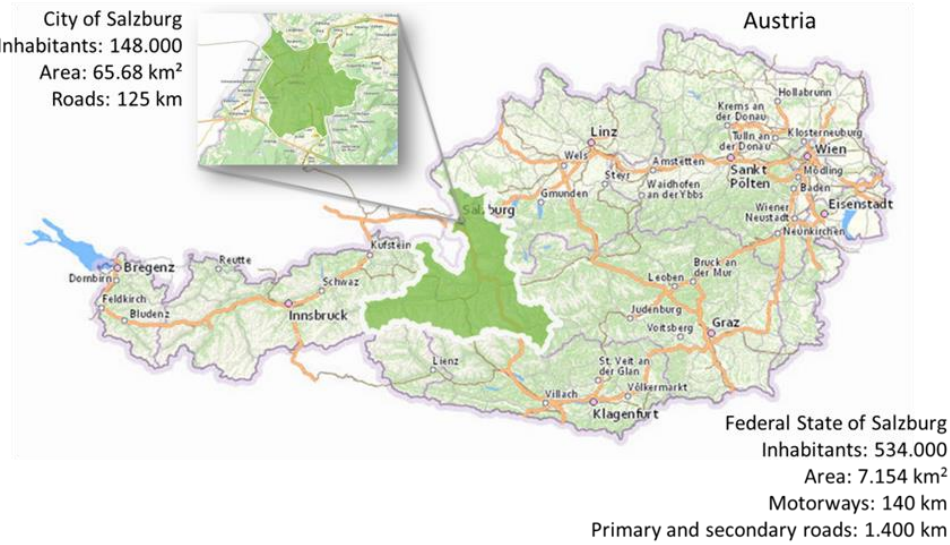

Figure 7: The Austrian Federal State of Salzburg with the City of Salzburg

Envisaged solutions, Pros & Cons, feasibility

Shifting from traditional traffic management to TM 2.0 in Salzburg means to establish a link between public authorities and in-car service providers to improve routing and traffic information. By sharing their traffic management strategy and circulation plans with services providers, public authorities can close the loop "informing-guiding-managing traffic". The information reaches the driver directly via an on-board device (either embedded in the vehicle's dashboard or portable). The challenges for the city administration have already been identified. The road operating authorities have to agree on a standard format (preferably a common European one) for sending information to different service providers. Possibly the national access points, as these are set by the EU Delegated Regulation on Real-Time Traffic Information[7], can deliver the information to different service providers.

Information and recommendations will be provided by the Local Traffic Management (City and Federal State Administration) via a standardised interface (DATEX II). This interface will be realised by Salzburg Research and opened to all traffic information providers. Since TM plans are already available and standard formats will be used for data exchange, no feasibility issues are expected.

Stakeholders roles and engagement

The Organisational reference architecture is shown in Figure 8. The Traffic Management Centre receives floating car data (FCD) from public and private fleet operators (e.g. public transport busses, commercial fleets) as well as data from road-side sensors and generates a real-time traffic picture. Real-time traffic information together with route recommendations, e.g. upon park and ride facilities, are delivered to public traffic information service providers (e.g. VAO, OE3), transport service providers (e.g. public transport operators) and fleet and road operators (e.g. ASFINAG), but

[7] http://ec.europa.eu/transport/themes/its/news/doc/2014-12-18-rtti/swd(2014)356.pdf

also, via an app, directly to end-users. It is envisaged that all involved stakeholders get the same traffic information.

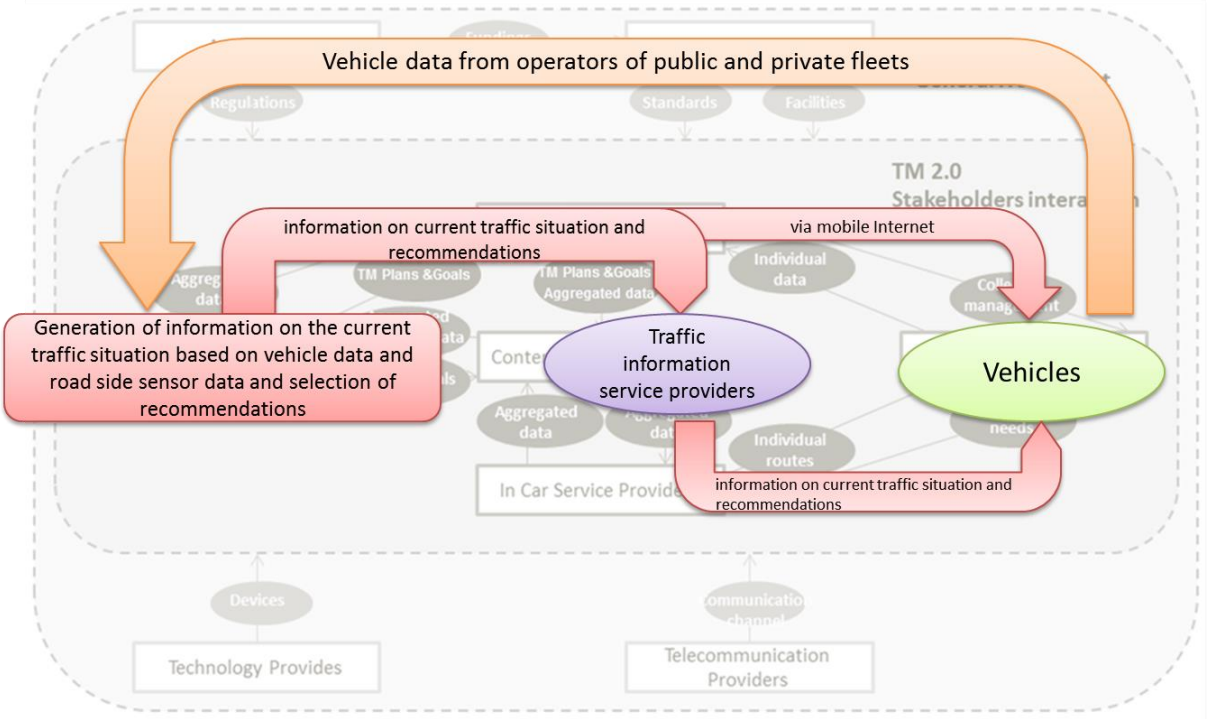

Figure 8: Organisational reference architecture for the Federal State and the City of Salzburg

The main stakeholders involved are:

- The Federal State of Salzburg and the City of Salzburg: responsible for defining the traffic management plans and for providing related information via a standardised interface; traffic management procedures are enforced by the local police;
- Salzburg Research: coordination of the process for implementing TM 2.0 as well as the traffic management procedures and the data exchange with mobility information service providers;
- Mobility information service providers: TomTom and BMW have already shown interest
- Commercial and private drivers.

Stakeholders	**Benefits of TM 2.0**
Federal State of Salzburg, City of Salzburg	• Avoiding congestion and traffic collapse • Avoiding unnecessary emissions (smoother traffic flow) • Improve traffic management plans (FCD complementing or replacing loop detectors and enhancing accuracy in traffic information) • Traffic management plans measures are reaching the driver directly (in-vehicle) • FCD-enabled traffic management being easily scalable to roads where there is currently no ITS infrastructure installed with very little investment, maximizing the benefits of the overall system
Drivers	• Avoiding congestion: more relaxed driving • Receiving in-vehicle relevant regional / urban traffic information • Improved road safety through smoother traffic flow • Best route options aligned with traffic management plans

Stakeholders	Benefits of TM 2.0
Traffic information service providers	• Provide the best route option to the destination for their customers (not just the fastest or shortest one, but possibly conflicting with traffic circulation plans) • Provide added value to their customers with information that goes beyond congestion (potential for new business opportunities) • Provide a solution (= best route option) not the problem (= congestion information) well in advance • Combined urban and regional information becomes part of an integrated service • New business opportunities with the public sector (traffic managers)

In summary, the main stakeholders listed above are already actively involved as described and interested to implement the described TM2.0 solution (at least in form of a pilot).

Future plans and next Steps

Plans to realise TM 2.0 in the mid-long term (about 3-4 years, until 2020):

The aim is to fully deploy TM 2.0, in case of positive assessment of the pilot implementation. In the long term, the traffic management information should be provided via the National Access Point.

Managing the transition from actual TM practices towards TM 2.0:

It is planned to realise a pilot implementation, so that the effectiveness of the solution can be assessed. Based on the results of this assessment, necessary adaptions will be further implemented. Additionally, based on the assessment results, new business models shall be also developed.

Next steps in the short-medium term (about 1-2 years, until 2018):

The very next step for realisation is to set up a pilot implementation. Salzburg Research will develop a respective DATEX II interface to provide traffic management information in a standardised format. Once the traffic information is publically available, it can be used by content and service providers. TomTom and BMW, having already shown interest in using this data, would then have to integrate this information in their routing recommendations shown in the vehicles.

Thessaloniki (GR)

TM status overview

Thessaloniki, the second largest city in Greece, accommodates nearly 1 million citizens and plays an important social, financial, and commercial role in the national and greater Balkan region. The transportation system within the city's limits caters for a total number of more than 777,544 vehicles (including private cars, heavy vehicles and motorcycles). Challenges for the city are shown by research findings, according to which 47.6% of the total trips are for business while 26.8% for leisure. The modal split analysis shows that for the majority of trips private vehicles are used (67% private cars, 4% motorcycles and 4% taxis), while public transport is used in 23% of the cases and 2% of the trips are executed by using non-motorized transport modes. With single occupancy for 65% of the vehicles, only 28% and 6% of the vehicles travel with 2 and 3 passengers, respectively. Peak hours (08:00-09:00 and 16:00-17:00 on typical work days) are indicative of the role of commercial hub played by the city in the Balkan area.

Currently there are three TMCs in Thessaloniki, hosted and managed by the Region of Central Macedonia (RCM). RCM is the authority responsible for the management of the traffic lights and the surveillance systems in the urban and peripheral ring-road network. In addition, Thessaloniki has implemented two cooperative services: the Green Light Optimal Speed Advice (GLOSA) in the city

centre provided through 3G/4G; the Road Hazard Warning Service along the ring-road provided through ITS-G5, where road-side units (RSU) have been installed.

The Hellenic Institute of Transport of the Centre for Research and Technology Hellas (CERTH-HIT) has implemented and operates a mobility management centre. Data from several sources is assimilated, including Floating Car Data (FCD) from a fleet of 1,200 taxis providing real-time traffic information (speed) across the entire road network and more than 40 Bluetooth detectors tracking in real time users along the main routes of the city in order to estimate travel times. In addition, data from social media (geo-located tweets and Facebook check-in events) is being collected and will be added soon to the MMC data fusion engine.

The added value of TM 2.0 for Thessaloniki is that TM2.0 can structurally establish the link between the service providers (and the FCD they collect through their users) and the traffic managers (setting traffic management measures). As a result, traffic managers will have a more complete and in real-time view of the urban traffic conditions and will better monitor the traffic status in the road network, while providing, in advance, to service providers information on the traffic management measures they plan to implement. This way, the traffic managers can ensure that the road users act without conflicting with their plans. On the other hand, traffic information service providers can further enhance the quality of their services and products, as the information provided will take into account the measures to be implemented by road authorities in various traffic conditions.

More specifically, traffic managers will enhance:

- their congestion management and avoid traffic collapse (and consequently CO_2 emissions);
- their understanding of the city's traffic status through the collection of FCD;
- their performance of the execution of the traffic management plans.

Drivers' will benefit from:

- avoiding congestion and traffic collapse;
- better decisions based on more accurate and real-time information.

Service providers will be able to:

- provide better traffic and navigation services to their customers.

Stakeholders roles and engagement

The stakeholders' interaction in the area of Thessaloniki is schematically shown in Figure 9.

Current stakeholders' engagement:

For the case of Thessaloniki a good level of stakeholders' engagement has been achieved. CERTH-HIT, as an active partner of TM 2.0, has managed to engage both RCM and the Municipality of Thessaloniki, which are the owners of the road infrastructures and major responsible for the traffic management. Moreover, taxi companies in the region already provide their content for realizing TM 2.0. Also, service providers, like Infotrip, are extending their current services to account for TM2.0.

Measures to engage stakeholders and resolve collective vs. individual mobility needs:

The next steps include the engagement of technology providers, communications providers as well as the city's public transport authorities, in order to conclude to more efficient TM 2.0 concepts that are feasible to be implemented in the future. The already established dialogue among the local ecosystem stakeholders will continue, so as to achieve the transition towards TM2.0.

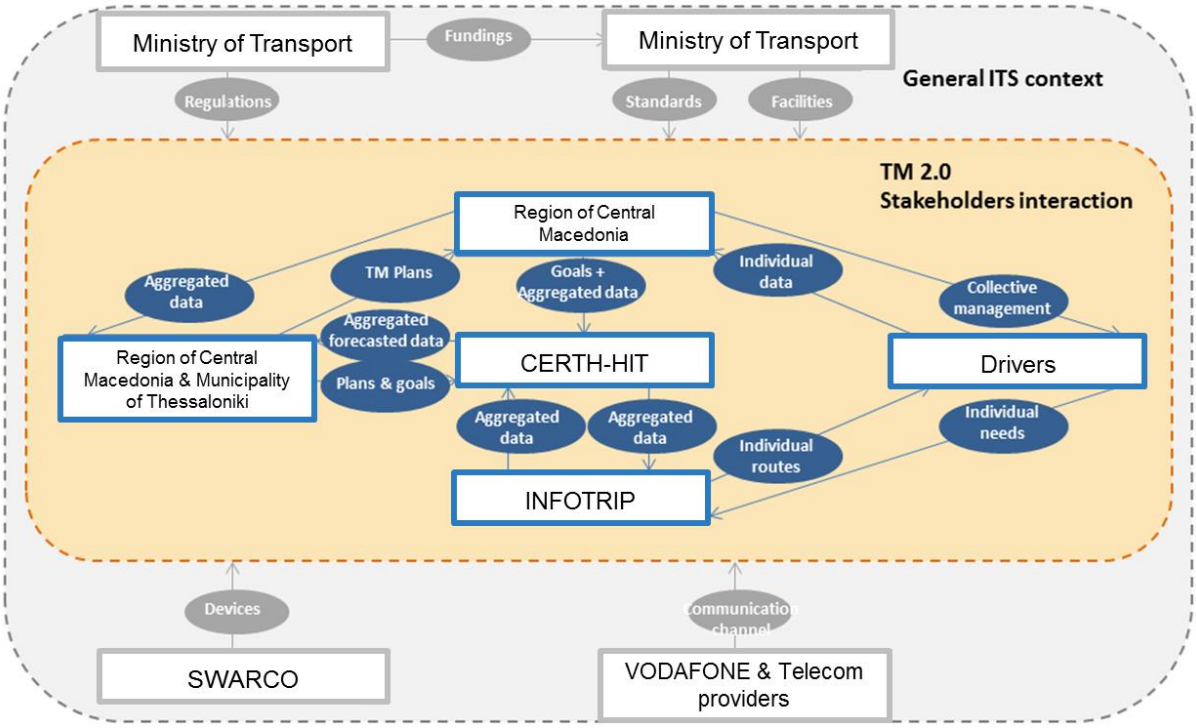

Figure 9: Organisational reference architecture for the City of Thessaloniki

Future plans and next Steps

The shift from TM 1.5, which is what is currently being used to manage traffic in Thessaloniki, to the evolved concept of interactive traffic management, TM 2.0, will take place by connecting the drivers with the traffic managers and thus providing them with the measures of the traffic management plans along selected parts at urban / inter-urban interfaces, including the peripheral ring-road in a first stage, and within the city centre in a second stage.

Various components are already in place since they have been developed and implemented through research and deployment projects and will be used for the TM 2.0 pilot activities. In addition, data collection and analyses will be done using existing data loggers and monitoring tools.

Next steps in the short-medium term (about 1-2 years, until 2018):

- Technical feasibility assessment;
- Connect all TMCs with road-side equipment from different vendors and existing services.

Plans to realise TM 2.0 in the mid-long term (about 3-4 years, until 2020):

- Large scale pilot operation of TM 2.0;
- Technical validation and operational release.

Verona (IT)

TM status overview

Current TM implementation: status and challenges

In October 2008, the City of Verona joined the Covenant of Mayors, sponsored by the European Commission as part of the Campaign for Sustainable Energy in Europe. Verona is moving fast to deliver solutions to improve urban mobility and address challenges to face climate change, energy policy issues, air quality and congestion in line with European directives and national strategies. In

April 2011 the municipality of Verona adopted an environmental and energy plan defining strategic objectives and providing guidelines in the field of energy, followed by an Action Plan for air quality and remediation in October 2011. To meet these objectives, the City of Verona has introduced in the traffic management centre (TMC) a complex and fully integrated advanced platform. Furthermore, other ITS solutions were already implemented to support the evolution of Mobility Management in Verona:

- UTC: centralization of 62 traffic lights stations with more than 600 sensors in the urban area;
- AVI: 13 electronically controlled ways to control goods access and bus paths, with all events managed by operators and sent to info mobility channels (social networks, web, sms, etc.);
- Control room: special integration platforms like the "City supervisor" to monitor more data sources and represent them on a map;
- A Parking Guidance and Information, a Parking identification System;
- AVC: 13 traffic stations for continuous collection (round the clock) traffic data;
- VMS: 7 panels in restricted access areas, 13 panels to access the urban areas, 6 in the internal road network, and 52 panels with parking information;
- SOS: 13 SOS columns and 1 emergency lay-by in the new underpass "Galtarossa";
- VDS: 32 CCTVs on road network.

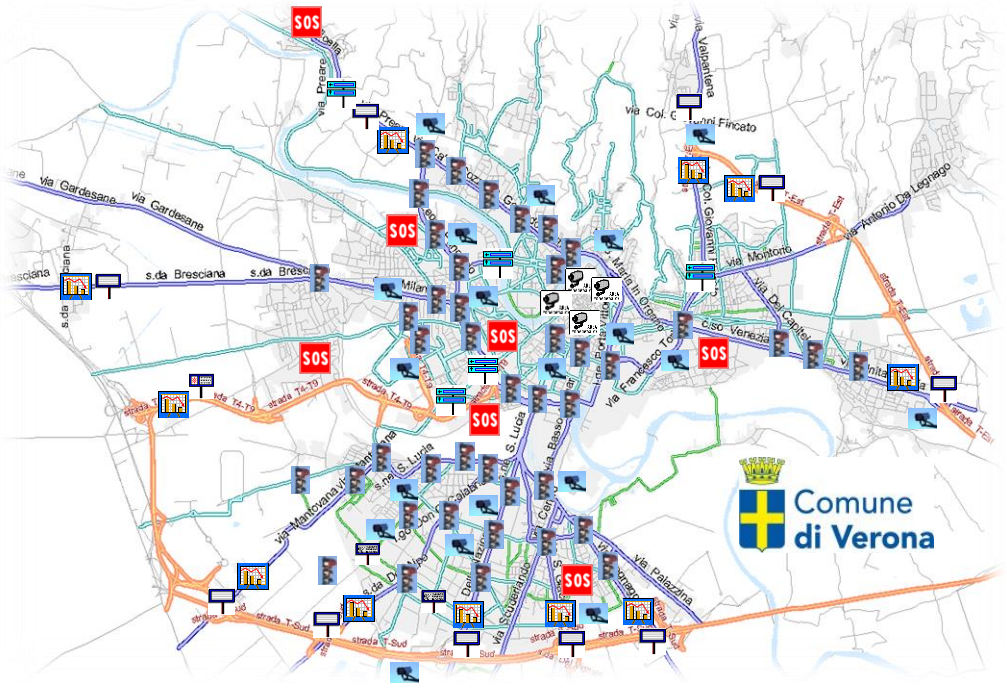

Figure 10: ITS deployment the City of Verona

The infrastructure in the urban road network will also need to be updated so to support all transport modes in an integrated way and to obtain the optimal overall Level of Service in the controlled area.

Envisaged solutions, Pros & Cons, feasibility

Solution	Pros	Cons	Feasibility
Improvement of Public Transport performances	Increase of public transport (PT) speed and comfort, incentive for public transport usage and an increase of security.	Increase of the number of reserved lanes, which is a disadvantage for the private drivers, the need to implement	Connected to EU funds for Regional Development

Solution	Pros	Cons	Feasibility
		a wider enforcement policy.	(2017-2019)
Prioritisation of Emergency Vehicles	The City of Verona received regional funds for implementing a service dedicated to emergency vehicles. Based on this service, the traffic light signals shall become all red when an emergency vehicle (e.g., an ambulance) is approaching the intersection, so as to prevent accidents and improve safety while crossing at full speed.	Update of TLC regulators, firmware updates of TRLM devices, logical integration of conflict management for centralized/ decentralized conflicts.	Regional funds PNSS Regione Veneto 2015 (on going)
RTTI extended from urban to regional level (incl. C-ITS)	Sharing of traffic information at the level of Province and Region	Implementation of the data exchange node in every major city (open service interface already developed by the City of Verona); implementation and sharing of standard communication protocols for V2I information.	Connected to EU funds for Regional Development (2017-2019)

Stakeholders roles and engagement

In order to successfully implement TM2.0, there is a need of new collaboration schemes among mobility stakeholders, such as the reference architecture for the city of Verona shown in Figure 11.

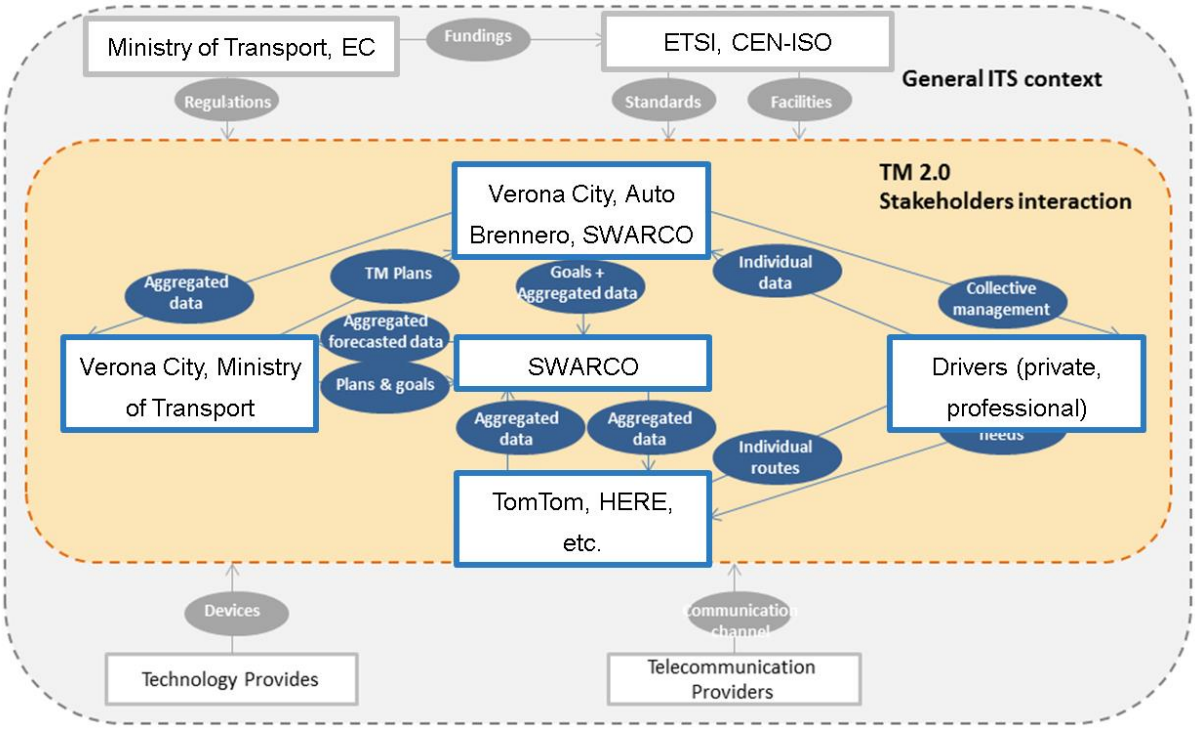

Figure 11: Organisational reference architecture for the Veneto Region the City of Verona

The current stakeholders' engagement in the area of Verona is as follows:

- Road Infrastructure Owners: the Municipality (City of Verona) in the urban area and the Italian Ministry of Transport in extra-urban arterials;
- Road Service Providers: either the Road Infrastructure Owners (i.e. the City of Verona, the A22 highway operator AutoBrennero) or the Infrastructure Service Providers (such as SWARCO);
- Content Service Providers: e.g. SWARCO;
- Service Consumers: travellers and drivers (both professional and private) as well as fleet managers (e.g. taxi companies, public transport operators, etc.)
- In Vehicle Service Providers: e.g. TomTom, HERE or other.

Other stakeholders such as telecoms providers or support organizations could enrich the reference organisational model, but nevertheless additional stakeholders are not considered mandatory for TM 2.0 deployment.

Future plans and next Steps

Plans to realise TM 2.0 in the mid-long term (3-4 years, until 2020)

- Large scale deployment of connected mobility (e.g. C-ITS) at regional level.

Managing the transition from actual TM practices towards TM 2.0

- Adaptation of TM systems to the new technologies (e.g. Adaptive Traffic Control fed by mixed data sources: floating car data and road-side detectors), and implementation of new mobility solutions for travellers based on the "connected" concept.

Next steps in the short-medium term (1-2 years, until 2018)

- Strategies for implementation of new mobility services and extension of existing solutions from both technological and geographical point of view.

Vigo (ES)

TM status overview

Current TM implementation: status and challenges

The City of Vigo is addressing since years mobility challenges to raise the sustainability and comfort level for citizens through reduced trip time and an improved traffic flow. Combined with innovative strategies and innovative exploitation of existing physical infrastructures, the real-time monitoring and management of mobility information gathered from users is a key point to move from current traffic management practices towards TM 2.0. In the context of sustainability, clean mobility and reduced CO_2 emissions have been addressed also through strategies and projects leading to electric vehicles deployment. Some examples of ITS technologies deployed for TM in Vigo are:

- ITS infrastructure deployment and centralization in Mobility Management Centre;
- Optical fibre network connection in 90% of the city road network;
- Around 200 centralized traffic light controllers (TLC);
- 50 cooperative ITS intersection providing GLOSA, RHW and priority services;
- 43 inductive traffic detectors;
- 50 cameras for real-time monitoring managed from the city's traffic control centre;
- 60 Bluetooth sensors for real-time flow traffic monitoring, trip matrix calculations and feeding of traffic status to mobility users;
- 8 VMS panels showing to drivers estimated time to main destinations, to allow opting for alternative routes;

- A Beta version of a Citizen App offering real-time traffic status, route calculation, access to traffic cameras, parking availability and routing.

Envisaged solutions, Pros & Cons, feasibility

In the table below the different solutions deployed and planned are described.

Solution	Pros	Cons	Feasibility
Centralised traffic light control system supported by traffic sensors	The management of timing and traffic regulation strategies is faster and easier	The centralised system needs to be supported by traffic sensors	The timing and regulation strategies for TM are faster and easier
CCTV control over most of the key roads	Very valuable tool for real-time management and fast identification of issues, traffic jams, accidents	CCTV requires investment on infrastructures and implies costs of personnel operating the system	Yes, depending on investment capacity (now implemented in the city)
C-ITS services deployment to key users: 1) GLOSA 2) RHW 3) Priority to buses, trucks, emergency vehicles	- Demonstrated improvements in safety, efficiency and traffic flow - Use of data collected from users as an input for TM strategies	- Lack of consolidated business models - Need investments on road-side infrastructure and in-vehicle technology - Technology adaptations and interoperability not trivial issue - New policy and legal adaptations required	- Good results from Compass4D & CO-GISTICS pilots, but high penetration rate is difficult in the short term - Proof of benefits and policy & legal issues need to be addressed to convince decision makers
Traffic monitoring and information to users through Bluetooth sensor system	- TMC gathers valuable trip info (origin-destination) useful to analyse main trip fluxes in Vigo - Real-time monitoring of traffic density is made possible - Provision of direct information to users about estimated time to relevant destinations	- Reliability depends on number of users with Bluetooth system activated on their mobile phone or vehicle - The real number of users cannot be accurately estimated	Feasible with an appropriate level of investment
Strategy to enable turbo roundabouts. Manoeuvres in roundabouts regulated in line with given criteria	Improvement of traffic flow and reduction of accidents in roundabouts has been demonstrated	- Adaptation period and presence of agents needed during the first period of use - Horizontal traffic signs at roundabout's accesses to be extended to inform properly the drivers on which lane to take for desired manoeuvres	Feasibility will depend on the configuration and number of accesses to the roundabout

Stakeholders roles and engagement

A successful TM strategy needs to have a clear involvement of all mobility key stakeholders in the city. During the last years, the key stakeholders defining and deploying innovative ITS solutions and strategies in Vigo and the surrounding area have been:

- Road authorities: the Municipality for the urban roads and the national traffic authority (DGT) for access and surrounding roads;
- Public transport companies: VITRASA has contracted with the city the public bus transport services; the RadioTaxi company is also involved in the pre-deployment C-ITS services; their involvement is important since many TM2.0 strategies involve public transport (C-ITS services, citizen app, priority, etc.);
- User representatives: CEAGA represent Automotive Cluster, which is, together with the port of Vigo, one of the main economic engines of the city and region; they are involved especially to improve the management of heavy vehicles traffic in the city through innovative solutions as priority or restricted routes;
- Industry partners and service providers: CTAG, ESYCSA and Little Cars offering respectively innovative solutions, infrastructure management background, and the perspective of clean vehicle manufacturers.

The organisational reference architecture for the city of Vigo is shown in Figure 12.

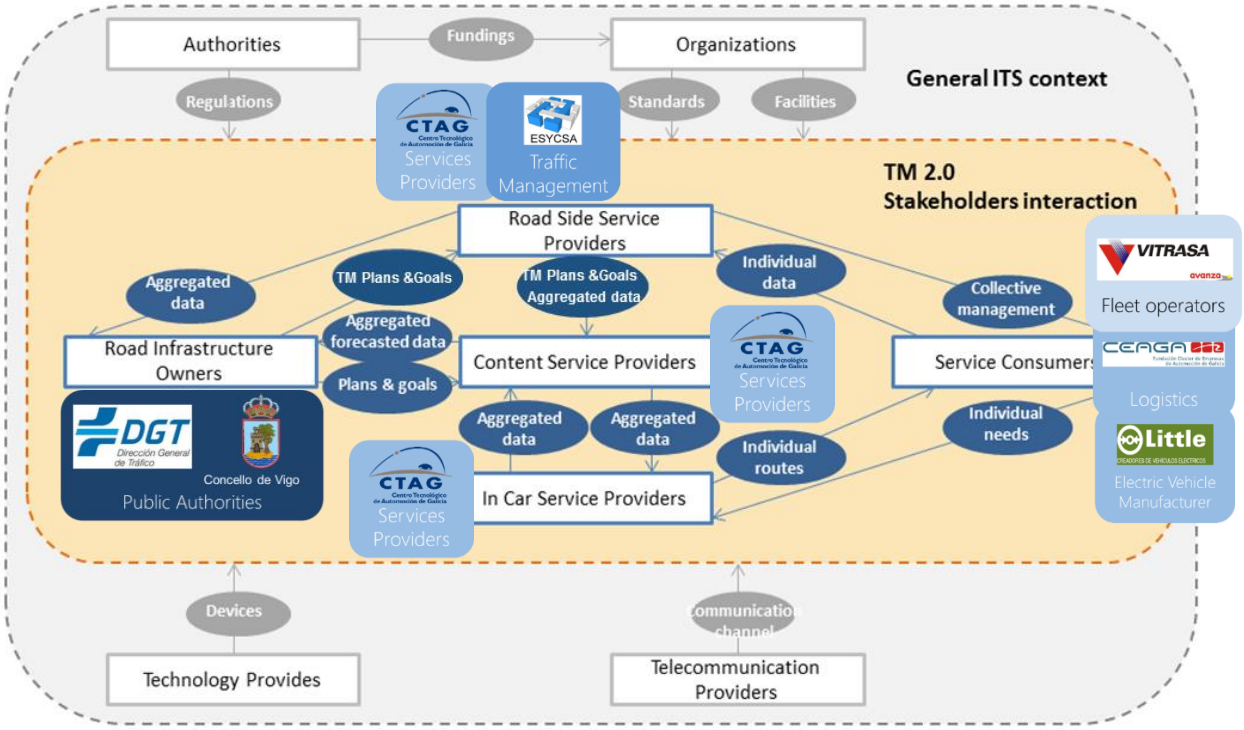

Figure 12: Organisational reference architecture for the City of Vigo

Additional key stakeholders are needed to realise TM 2.0, namely:

- Private users: their involvement in connected mobility services is difficult if they have to buy specific equipment; initiatives are being considered through a Citizen App, but privacy aspects have to be carefully addressed.
- Port of Vigo: the port is in the city centre and hence the Port Authority and operators are key stakeholders in terms of mobility and their involvement is being defined; as the Port Authority belongs to a different administration, in some cases this can be a barrier to collaboration;
- Emergency vehicles (further than local fleets): their involvement in C-ITS deployment is crucial to improve traffic circulation and safety by providing priority at traffic lights and alerts to other drivers; however, necessary changes to legal and policy frameworks are not immediate;

- Vulnerable road users: (VRU): various solutions are being tested, such as Bluetooth activation of acoustic signals for pedestrian green light and in-vehicle alert of VRU presence via C-ITS;
- Parking: parking booking and routing will reduce the traffic by avoiding vehicles circulating in search of a parking space;
- Electric vehicles: incentives and charging infrastructure shall be addressed in medium term;
- Bicycles (conventional and electric): people make little use of bicycles due to the orography of the city and surrounding areas and to the lack of ad-hoc infrastructures; this means that an overall approach has to be defined to have bicycles as a real option for mobility, which shall consider electric bicycles as a must;
- Telecom operators: a direct collaboration on connected mobility solutions is currently missing.

Future plans and next Steps

Plans to realise TM 2.0 in the mid-long term (3-4 years, until 2020)

- Large scale deployment of C-ITS solutions piloted in the frame of Compass4D and CO-GISTICS, the benefits of which have been already demonstrated;
- Piloting of new innovative connected and automated mobility solutions, so to demonstrate their benefits and convince local stakeholders and decision makers.

Managing the transition from actual TM practices towards TM 2.0

- Continuation with the current strategy of implementing and adapting new mobility solutions, of assessing and demonstrating their benefits, and then of maintaining and extending the solutions deployed at large scale.

Next steps in the short-medium term (1-2 years, until 2018)

- Implementation of improved strategies for connected mobility through the deployment of new solutions and the extension of current mobility services to additional users groups.

5. Conclusion and perspectives

The cases described in Chapter 4 can be considered as representative of a large number of medium-sized cities across Europe, which are called to handle traffic and mobility related challenges, such as pollution, expansion of their urban areas related land use issues, economic and sustainability factors at (inter-) regional level, especially in areas concerned by maritime and/or cross-border transport, main highway corridors, or intense touristic flows.

The conclusions that can be drawn from such examples are manifold, and can be summarised here below together with some recommendations for TM 2.0 deployment, which is increasingly targeted by these front-runners as well as by many other cities around Europe.

1) Traffic Management status and solutions:

- To improve the quality of road transport and mobility services, and ultimately the quality of life in urban areas, traffic management shall be approached in a different way as compared to how it has been handled in the past. By upgrading the existing physical infrastructure and investing on an innovative digital infrastructure (including Internet of Things, and "smart" solutions), rather than expanding the road network, it will be possible to improve the cost-effectiveness, increase the transport efficiency and road utilisation capacity, also in the prospective of moving towards the use of autonomous vehicles and of the up-take of MaaS [8];
- Investments on the physical and digital infrastructures shall be considered in a strategic and balanced way, with digital and technology solutions to be deployed using common standards and reference architectures, which can support retrofitting as well as technology evolution, thus catering for the needs of human road users as well as of future automated vehicles;
- Solutions implemented in different cities / regions / corridors are mainly based on cooperative ITS – with different telecommunications technology (e.g. wireless ITS-G5, mobile 4G/5G) and their hybrid combination, while other ICT solutions are also being deployed – especially web-based, such as cloud computing, social media and others. However, there is a need for technology-neutral solutions and for making different types of technology and service solutions work together in a seamless way, so as to avoid lock-in and fragmentation and achieve seamless service continuity for different end-user categories (drivers - professional and non, vulnerable road users, travellers, etc.);
- Open data sharing and management (supported by Big Data techniques and increased computational power) as well as harmonised evaluation methodologies of services deployed (including clearly defined Key Performance Indicators to compare impacts and benefits resulting from different implementations) are key elements to move from pilots to large scale deployments; these elements are crucial both for improving the service level and for engaging with large numbers of public and private stakeholders, including end-users;
- Need to spread know-how and define best practices about (cooperative) ITS solutions among local traffic managers and other value chain actors about: installation work → OBU / RSU configuration → programming → maintenance / upgrade, use of open standards for interoperability (some of these aspects will be addressed by the new H2020 funded project CAPITAL – "Collaborative cApacity Programme on Its Training-educAtion and Liaison");
- Need to extend Traffic Management to all transport modes, so as to reach an optimal balance across the entire road network for all road users / travellers; preliminary steps in this direction include the establishment of close cooperation between different road authorities in a region (e.g. integrating TM of highways and cities) based on new political/organisational agreements;
- Need to involve individual travellers as an active element of the Traffic Management loop (e.g. by crowd-sourcing), in which users and the TMC share information e.g. via cooperative V2X systems or IoT to achieve individual and collective mobility goals in an optimal way;

[8] Mobility as a Service (see http://maas-alliance.eu/).

- More in general, TM 2.0 will imply a change of roles among public and private stakeholders, where policy goals and objectives will continue being an exclusive domain of public authorities, while running TM could very well be performed by private companies in a (semi-) automated way (conversely to current practices in most countries, according to which TM operation is task performed manually by public authorities at the city TMC control room).

2) Stakeholders engagement:

- Stakeholders engagement may depend on the type of TM strategy and technology solution adopted by the public authorities of the city or region; the following elements are seen as essential to be addressed by TM 2.0 members as well as by other public administrations:
  - Clearly defining the key stakeholders needed, their role and area of interest / action (including their limitations), so as to establish truly functioning public-private partnerships, address governance structures and also exploit legal aspects on how to overcome deployment fragmentation, and hence address needs of heterogeneous stakeholder groups in the frame of city-led business and market roll-out;
  - Raising policy makers and end users awareness and changing approach to and perception of traffic management aspects (with focus on mobility, not on individual vehicle driver) is crucial; in this sense, key stakeholders can play a crucial role as ambassadors to expand the basis of stakeholders groups and the end-user penetration rate;
- The current learning-by-doing approach pursued by the front runners shall lead to clear and coherent reference organisational architectures (defining roles, responsibilities, etc.) that can be commonly adopted in deploying the TM 2.0 Centre of the future.

3) Deployment steps and future perspectives:

- Cooperative ITS solutions have reached a high level of technology maturity and have proved their benefits to improve road traffic efficiency (in terms of time and fuel savings) and safety; V2X cooperative systems and services now need to be integrated with TM procedures and systems in order to serve the aim of deploying the TM 2.0 Centre of the future;
- Existing physical infrastructure will be increasingly “virtualised” thanks to V2X communication systems (wireless ITS-G5 and mobile 4G/5G), digitalisation as well as crowd-sourcing; for example, the information displayed nowadays on VMS panels around a city (in a quite static fashion, being often manually fed by operators at TMCs) will be provided to a driver directly on a vehicle’s dashboard or to a traveller on various personal devices (e.g. a smartphone, which could be also connected and synchronised with the vehicle dashboard through systems such as Android Auto, MirrorLink or CarPlay) or to the control module of an automated vehicle; in this scenario, both traffic managers and other connected users in the vicinity will be able to feed real-time information; the transition from “road-side” based collective information towards “individual device” based personalised information is crucial to enable information exchange with automated vehicles; traffic / travel information will be more precise, personalised and useful for all the end-user categories, even those not connected;
- However, integration and implementation will require, among others, to:
  - Address governance and regulatory aspects to be defined at European level and enforced by public authorities, so as to ensure data sharing and accessibility are in line with common standards and the correct use of data (who can access and/or provide what data?);
  - Define a common framework for data privacy and (cyber-) security, so as to prevent any abuse or disruption (also in relation to “post-truth”[9] generated by social media);
  - Evolution from real-time to predictive traffic management through novel techniques in the field of data intelligence and big data, which new challenge.

  These are a crucial aspects to allow traffic managers being able to perform their duties also in the evolving context of end users’ needs and wants as well as available transport solutions;

[9] Post-truth definition: "Relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief”. Source: Oxford Dictionaries 2016.

the latter includes, among others, multi-modal transport solutions for both people and goods linked to mobility services already established (such as Uber) as well as emerging ones (such as MaaS), including new forms of vehicle sharing linked e.g. to automated vehicles' driving, their coexistence with conventional traffic service level agreements and business models;

- These radical changes and the new tools available through personalised information sharing (such as dynamic payment, availability / accessibility management, etc.) will need to be sustained by a sound, future-proof TM 2.0 regulatory framework;
- It is ripe time for a common pan-European testing programme including validation in real-life conditions of existing solutions in different settings (urban, interurban, cross-border) in complex environments (highly dense or sparse population, compact cities with widespread outskirts, isolated or rural areas) and with large, different end-user groups (i.e. drivers, pedestrians, cyclists, etc.);
- Reference implementation measures shall be defined in the current transition phase towards TM 2.0; phase in which policy / legislation enforcement and infrastructure deployment are expected in the medium-long term, while operational implementation measures (such as dynamic allocation of infrastructure capacity, real-time and predictive information supply / demand management for public transport, for travel advice, for TM plan enforcement (e.g., by rewarding / punishing, etc.) are needed to be gradually introduced in the short term;
- Exchange of knowledge, experiences and best practices based on real-life cooperative mobility solutions and their costs / benefits are key elements for large scale up-take as well as to ensure interoperability, conformity and performance of technologies, systems and processes;
- The establishment of city-led business partnerships (Figure 13) is a key element for a coherent large scale deployment and a positive market roll-out, given the fact that policy goals and objectives will continue being an exclusive domain of public authorities; however, shaping these partnerships around EU-wide strategies and policy goals and MaaS principles is essential to avoid fragmentation;
- Innovation procurement is a key enabler to achieve faster yet sustainable market roll-out, and joint actions for procurement of pre-commercial R&D and/or innovative solutions[10] is a better way to achieve sounds results, while sharing in a fair way market risks between public and private stakeholders, also for innovative start-ups and SMEs.

The TM 2.0 platform will address the aspects above through others Task Forces with a more specific focus on deploying TM 2.0 in real traffic, assessing its benefits, and identify best practices.

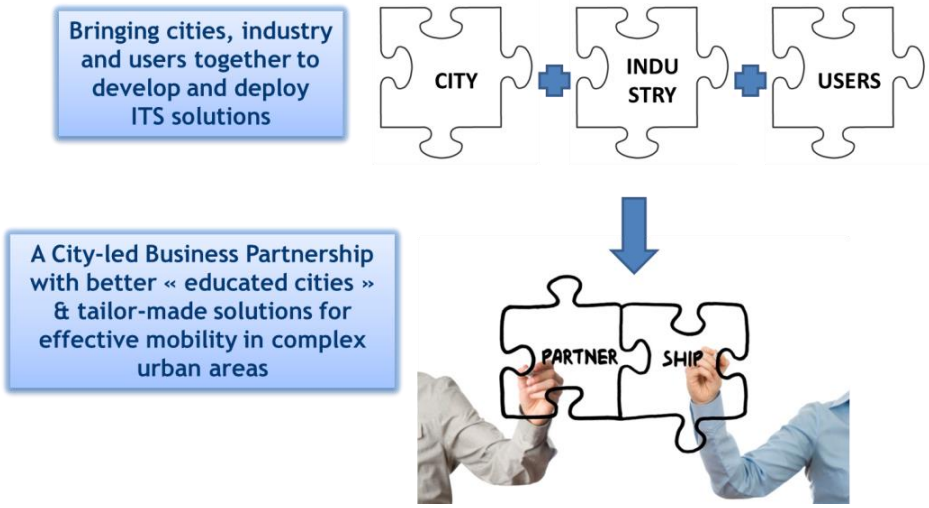

Figure 13: The need for city-led business partnerships

[10] See P4ITS final recommendations / guidelines at http://3mciz7425dl33nkqi32irbgu.wpengine.netdna-cdn.com/wp-content/uploads/sites/6/2014/02/P4ITS_DEL_D6.2-Final-recomdts-guidelines_v1.0.pdf.

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