European Platform on Sustainable Urban Mobility Plans

THE ROLE OF INTELLIGENT TRANSPORT SYSTEMS (ITS) IN SUSTAINABLE URBAN MOBILITY PLANNING

MAKE SMARTER INTEGRATED MOBILITY PLANS AND POLICIES

Imprint

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Author(s):
Prof. Eric Sampson, Lidia Signor, Manuela Flachi, Emily Hemmings, Giacomo Somma (ERTICO – ITS Europe); Dr. Georgia Aifadopoulou, Dr. Evangelos Mitsakis (HIT – CERTH), Dr. Vasilis Sourlas (ICCS NTUA)

Contributors:
City of Antwerp, Transport for Greater Manchester, City of Eindhoven, City of Trikala.

Reviewer(s):
Isabelle Vandoorne (EC - DG MOVE), Peter Staelens (EUROCITIES)

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Contacts:
ERTICO – ITS Europe, Blue Tower – 2nd Floor, Avenue Louise 326, 1050 Brussels, Belgium,
www.ertico.com, Tel. +32 (0)2 400 0700, info@mail.ertico.com

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Guide to the reader

This document provides guidance on a specific topic related to Sustainable Urban Mobility Planning (SUMP). It is based on the concept of SUMP as outlined by the European Commission's Urban Mobility Package and described in detail in the European SUMP Guidelines (second edition).

Sustainable Urban Mobility Planning is a strategic and integrated approach for dealing with the complexity of urban transport. Its core goal is to improve accessibility and quality of life by achieving a shift towards sustainable mobility. SUMP advocates evidence-based decision making guided by a long-term vision for sustainable mobility. This in turn requires a thorough assessment of the current situation and future trends, a widely supported common vision with strategic objectives, and an integrated set of regulatory, promotional, financial, technical and infrastructure measures to deliver the objectives. Implementation of a SUMP needs to be accompanied by reliable monitoring and evaluation processes. In contrast to traditional planning SUMP places particular emphasis on the involvement of citizens and stakeholders, the coordination of policies between sectors (transport, land use, environment, economic development, social policy, health, safety, energy, etc.), and a broad cooperation with private sector actors across different layers of government.

This document is part of a compendium of guides and briefings that complement the newly updated second edition of the SUMP Guidelines. They elaborate difficult planning aspects in more detail, provide guidance for specific contexts, or focus on important policy fields.

There are two types of document – 'Topic Guides' provide comprehensive planning recommendations on established topics, 'Practitioner Briefings' are less elaborate documents addressing emerging topics with a higher level of uncertainty.

Guides and briefings on how to address the following topics in a SUMP process are published together with the second edition of the SUMP Guidelines in 2019:

- **Planning process:**
Participation; Monitoring and evaluation; Institutional cooperation; Measure selection; Action planning; Funding and financing; Procurement.

- **Contexts:**
Metropolitan regions; Polycentric regions; Smaller cities; National support.

- **Policy fields:**
Safety; Health; Energy (SECAPs); Logistics; Walking; Cycling; Parking; Shared mobility; Mobility as a Service; Intelligent Transport Systems; Electrification; Access regulation; Automation.

They are part of a growing knowledge base that will be regularly updated with new guidance. All the latest documents can always be found in the 'Mobility Plans' section of the European Commission's urban mobility portal Eltis (www.eltis.org).

[1] Annex 1 of COM(2013) 91

[2] Rupprecht Consult - Forschung & Beratung GmbH (editor), 2019 Guidelines for Developing and Implementing a Sustainable Urban Mobility Plan, Second Edition.

Summary

Mobility issues are increasingly important all over the world in today's fast-growing urban areas and particularly in Europe where in 2015 almost 75% of inhabitants lived in urban areas according to Eurostat.[3] At the same time the supply of mobility services, especially in densely populated areas, is continuously increasing as well as citizens demand a more reliable, flexible, easily accessible, multimodal and finally more personalised travel experience. Although European investments in new transport infrastructures over the past decades have been massive the benefits for urban mobility and liveability in cities are still limited, while the challenges are growing in magnitude and complexity. An observed yet marginal change is that in the last 10 years the modal share of private car usage in most European cities has slowly decreased. Today, urban areas require solutions based on new instruments that address user behaviour, connect different networks and optimise transport systems as a whole, and complement new infrastructure which is increasingly costly and complex to implement.

Intelligent Transport Systems and Services are not new for cities as the Urban Mobility Package (UMP2013[4]) already focussed on the "Coordinated deployment of urban ITS[5]", as one of the five key focus areas[6] together with the "Development and implementation of SUMPs[7]".

ITS solutions already adopted for mobility management in urban areas include: interactive traffic management, integrated multimodal traveller services (multimodal information services and smart ticketing and booking), Cooperative Intelligent Transport Systems (C-ITS) services, access control to road infrastructure, user mobility behaviour monitoring and demand management for supporting sustainable mobility choices. More recently, a range of ITS services is providing the underpinning systems for Mobility as a Service – the concept that a single mobility service accessible on demand delivers an integrated range of transport services as an alternative to owning a vehicle and accessing transport modes separately. There is a Practitioner Briefing on MaaS in parallel with this one.

The present document provides planners and decision-makers with an integrated overview of the essential measures and considerations regarding the use of ITS in the SUMP process. In this framework, ITS should be considered to have three roles related to mobility planning:

1. Tools to implement transport measures and achieve policy goals
2. City infrastructure to enable innovation in transport and beyond
3. Data provider for supporting, developing, monitoring, assessing and evaluating SUMPs

Therefore, ITS roles may be associated with the SUMP steps in order to define:

• The relevance of ITS (existing and future) to sustainable urban mobility planning.
• How ITS should be approached in the SUMP process, i.e. what is needed to be done during the planning phases to have ITS taken into account and unlock its potential

Public Authorities should be aware that ITS imply both policy and technical elements that go beyond the SUMP process and/or local competencies.
In the first chapter an introduction on ITS for sustainable urban mobility is provided for mobility professionals who are not familiar with this. In chapters two and three the 8 SUMP principles and the main steps of the new SUMP cycle are discussed in detail. Finally, chapter four presents the conclusions of this guidance document regarding considering ITS in SUMP implementation.

[3] Official statistics of EUROSTAT explained here: *https://ec.europa.eu/eurostat/statistics-explained/index.php/Urban_Europe_-_statistics_on_cities,_towns_and_suburbs_-_executive_summary*

[4] For more information: *https://ec.europa.eu/transport/sites/transport/files/themes/urban/doc/ump/com%282013%29913_en.pdf*

[5] Coordinated deployment of urban ITS, to realise the full potential of ITS. Urban ITS deployment is expected to deliver benefits in all UMP2013 areas of intervention, ranging from demand and traffic management, to urban logistics, access restrictions, casualty reduction and improved mobility with public transport (PT) modes.

[6] The 5 issues areas are: Development and implementation of SUMPs, Focused action on urban logistics, Smarter and clearer urban access regulations, Coordinated deployment of urban ITS and Targeted action on urban road safety.

[7] Development and implementation of SUMPs, to improve accessibility of urban areas and provide high- quality and sustainable mobility and transport to, through and within the urban area. Impact assessment of SUMPs revealed a marked shift towards integrated urban mobility planning, while instances of a lack of coordination and the inability of some new Member States cities to keep up with the momentum were also observed.

1. Introduction

1.1 What is ITS and C-ITS?

ITS is short for Intelligent Transport Systems (once known as Telematics) and refers to the use of electronics, information processing and communications technologies to deliver transport improvements instead of extending physical infrastructure, thereby saving money (typically over 20%), time, and reducing environmental impact. A first definition given by the 2010 ITS Directive[8] is:

"'Intelligent Transport Systems' or 'ITS' means systems in which information and communication technologi.e.s are appli.e.d in the fi.e.ld of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport".

More specifically ITS services and products are based on combining a wide variety of information about transport networks, travellers and vehicles. They can be deployed on infrastructure to improve network management and increase productivity; on vehicles to improve safety, reduce journey times and polluting emissions; by travellers to simplify ticketing and payment and deliver better information; and can connect all three of these sectors to improve mobility and accessibility across the board. ITS can be mode-specific as well as multimodal and cover all the key components of transport systems: vehicles, infrastructure, passengers in and drivers of vehicles.

ITS imply the cooperation of a variety of stakeholders, often private and public, and may require innovative procurement processes, public-private partnerships and regulatory mechanisms as well as open architectures and data that can involve the participation of end-users. It is important to stress the fact that ITS are a component of many innovative concepts in transport and beyond, such as Smart Cities, Mobility as a Service (MaaS), Connected and Automated Mobility (CAM) and integrated transport systems.

ITS use a variety of telematics type technologies including mobile, wireless and satellite communication technologies but also sensors and detectors, digital cameras and image processing software, real-time information collection and management as well as high power computing linked to extensive databases to supply the 'intelligence'. According to the Horizon 2020 funded project CAPITAL and its first introductory ITS[9] course at Newcastle University example typologies of ITS include:

- Infrastructure-based systems, using short-range and long-range communication technologies which can improve sustainability and network management, e.g. road user charging, variable message signs and managed motorways

- Vehicle-based systems, using telematics and in-vehicle technologies which can provide safety-based services to drivers, e.g. blind spot monitoring, navigation systems and eco-driving

- Systems based on nomadic devices eg smartphones, tablets) using communication technologies to improve public transport information services for both passengers and operators such as through journey planning, smart ticketing and smart cards.

A simple and early example of an ITS service is the control of traffic signals. The signals at a junction – north-south and east-west crossroads for example – are often changed by fixed timing. There may be extra time for the south-north traffic in the morning as it reflects people travelling to work; in the middle of the day there is equal rationing; and in the evening there is extra time north-south as travellers go back home. A much more efficient and responsive control strategy is to fit detectors into the road surface (pressure pads) that count the actual flow volumes and assign signal priority to reflect what is actually happening. Sets of equipped signals can then be connected so that groups of vehicles are handed from one intersection to the next, thereby creating an Urban Traffic Management Service.

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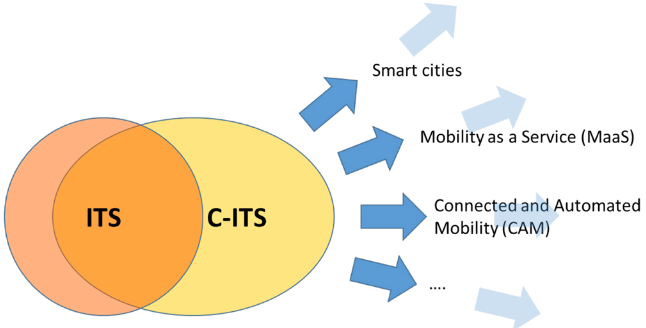
[8] DIRECTIVE 2010/40/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7 July 201 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport, available here: https://eur-lex.europa.eu/legal- content/EN/TXT/?uri=CELEX:32010L0040

[9] Lecture 1 of the introductory course to ITS and C-ITS of the CAPITAL project available here: https://www.its-elearning.eu/courses/course-v1:Capital+ITS1+test/about For more information, enrol for free in the courses offered on ITS in the CAPITAL online training platform, at https://www.its- elearning.eu/courses.

ITS implementation in Europe has accelerated following the introduction of the ITS Directive[10] in 2010 with the first implementation concerning traffic management, emergency call or eCall, and secure truck parking. ITS are currently undergoing a significant expansion in terms of both actual deployment and application areas with a shift towards user-centric and multimodal services. New solutions are also being used to persuade users to change their travelling or driving behaviour. For example the focus might be travellers changing to other modes or on drivers making a more efficient use of existing infrastructures and networks.



Among recent ITS developments C-ITS (standing for Cooperative Intelligent Transport Systems) enable data exchange through wireless technology[11] so that vehicles can connect and interact with other vehicles (Vehicle-to-Vehicle or V2V), the road infrastructure (Vehicle-to-Infrastructure or V2I and Infrastructure-to-Vehicle or I2V) and other road users, such as pedestrians, cyclists and motorcyclists (Vehicle-to-anything or V2X). The Delegated Act (legislation made using powers contained in the ITS Directive) with regard to the deployment and operational use of cooperative intelligent transport systems[12] of the European Commission defines C-ITS as follows:
'Cooperative intelligent transport systems' or 'C-ITS' means intelligent transport systems that enable ITS users to cooperate by exchanging secured and trusted messages through the EU C-ITS security credential management system.

Examples of technologically mature C-ITS services, so called "Day 1" services, include applications providing notifications for hazardous location (e.g. road works warnings, weather conditions, emergency brake light, slow/ stationary vehicles and traffic jam ahead warning), signage information (e.g. in-vehicle signage and speed limits, signal violation / intersection safety, green light optimal speed advisory, traffic signal priority requested by designated vehicles). Less mature "Day 1.5" services include notifications related to protection of vulnerable road users', on / off street parking management and information, park & ride information, cooperative automated cruise control, dynamic traffic information and smart routing services.

Benefits of C-ITS include reduced environmental impacts, enhanced safety and operational efficiency, e.g. for public transport operators or fleet managers, and improved road network efficiency. Recent deployments are showing that benefits can be significantly increased by the combined use of C-ITS services ("bundling"). C-ITS stakeholders include public authorities (local, regional and national), passenger / freight transport operators and service providers (public and private), fleet operators (e.g. emergency vehicles or commercial vehicle operators), and other road users (including vulnerable road users such as pedestrians or cyclists).

ITS and C-ITS have often been developed and implemented in pilot projects, such as R&D&I projects co-funded by the European Commission (e.g. FP7, H2020, CEF projects), but also in ad hoc strategies, e.g. smart cities and digital transition. In this document ITS solutions are taken into account as fully implemented measures, beyond the piloting or "gadget" experience. Where there are references to services still at a pilot stage they are measures to be integrated in a more comprehensive vision and strategy in order to unlock their potential for more sustainable urban mobility. For further information on the recent evolutions in C-ITS in Europe see the box below.

[10] For more information on the EU legal framework for ITS implementation please see the Annexes.

[11] Communication standards that underpin C-ITS are known as ITS-G5 (802.11p or dedicated short range communication – DSRC) and use a wireless networking technology on a different frequency from conventional Wi-Fi.

[12] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=pi_com:C(2019)1789

Where to find more information on recent evolutions in C-ITS in Europe

There are a number of parallel activities and initiatives fostering C-ITS development, with members of the various projects and fora representing a broad spectrum of C-ITS stakeholders:

- C-Roads1 platform and implementing projects (funded by the Connecting Europe Facility - CEF programme). This platform is a cooperation of EU Member States and road operators working on the harmonised and holistic deployment of interoperable C-ITS services in Europe, forming the basis for a later Pan-European C-ITS implementation (interoperability across borders and along the whole value chain, suitable deployment scenarios etc).

- CIMEC project (Cooperative ITS for Mobility in European Cities, funded under H2020), focused on the urban C-ITS context, aiming to identify cities' main transport challenges and assist/guide the choices and priorities towards the adoption of C-ITS solutions.

- C-MobILE project (Accelerating C-ITS Mobility Innovation and deployment in Europe, funded under H2020) focusing on large scale deployment of interoperable, bundled Day 1 / Day 1.5 services in real- life settings and in complex urban areas for various mobility challenges and users, including vulnerable road user safety, traffic lights operations, eco-driving, routing and parking, etc.

- Amsterdam Group, an early strategic alliance of committed key stakeholders with the objective to facilitate joint deployment of C-ITS in Europe.

- Single Platform for open road testing and pre-deployment of Connected, Cooperative and Automated Mobility (CCAM), established by the European Commission (DG MOVE, DG CNECT, DG GROW, DG RTD) and composed by the EU Member States (28) and key stakeholders (30) with the mission to provide advice and support, to coordinate CCAM development and pre-deployment and to create synergies.

1.2 Why to integrate an ITS approach in SUMP?

ITS can be considered to have three roles related to sustainable urban mobility planning:

1. Tools to implement transport measures and achieve policy goals:
ITS enable measures such as access restrictions, users' behaviour change, environmentally friendly traffic management, parking management, priority schemes for green modes, and safety monitoring all of which feature prominently in the SUMPS.

2. City infrastructure:
ITS enable cities to build on existing infrastructure to deliver innovative mobility schemes and leverage measures to accomplish more sustainable and cost-effective visions and to tackle urban transport challenges for passengers and freight efficiently and effectively. Depending on the ITS level of readiness and maturity in a city ITS offer tailored support reflecting the city needs and objectives, readiness and implementation plans. For example, through (cooperative) ITS cities can play an important role in aggregating and making available open data for re-use through smart city/urban mobility data portals, by creating an open ITS architecture, and by introducing public-private contractual arrangements that promote the exchange of data.

3. Data provider for supporting, developing, monitoring, assessing and evaluating SUMPs:
ITS can aggregate the major data sources that support SUMPs development, monitoring and implementation. For example ITS enable collecting and storing, exchanging and elaborating digital information and data, e.g. real-time data on traffic and people flows. Therefore, ITS can be used as a tool in the different steps of the SUMP development process (e.g. baseline-analysis, modelling, scenario-development, monitoring, user/stakeholder involvement, etc.).

1.3 Opportunities and Challenges

1.3.1 Opportunities

As many cities in Europe are deploying ITS and C-ITS services in real-world projects many benefits are recognised from their use for a more sustainable urban mobility. Since ITS and C-ITS solutions are tailored to cities as well as to the needs and priorities of the different stakeholders involved the ultimate precise benefits depend on the specific field implementation.

An example of a service delivering environmental benefits is the Green Light Optimum Speed Advisory (GLOSA), which allows drivers to have in-vehicle information on the best speed to adopt while approaching a signalised intersection in order to avoid having to stop due to a red light, or even to slow down and then accelerate back to cruise speed, thus reducing fuel consumption and increasing comfort. More generally ITS and C-ITS can increase the transport system efficiency and operational efficiency. Examples are the Green Priority at signalised intersections for emergency services or public transport vehicles, or real-time information about off-street and on-street parking, which can reduce congestion and pollution as a result of less time spent in a vehicle looking for parking spot. More recently, with Mobility-as-a-Service, thanks to the evolution of (mobile) technology and the digitisation of the public domain, it is now easier than ever to collect detailed user behaviour data. This in turn can be used to optimise policies and nudge travellers towards more sustainable modes of transport, while giving users a seamless journey experience.

Chapter 4 provides a simplified view on how this variety of ITS and C-ITS solutions can support cities' mobility policy objectives through a short description of each typology, followed by references to some examples successfully implemented in cities.

(C)-ITS represent for cities a means to facilitate the implementation of SUMP measures in an integrated and more cost-effective manner, in line with the city's vision and ambition. They also help to create the preconditions for a fully integrated smarter mobility by investing in the ITS architecture that will allow innovation on the desired scale. Both C-ITS and conventional ITS give cities an opportunity to raise awareness of the impact of new technologies on the mobility behaviour of citizens while addressing risks linked to privacy and cybersecurity as well as the need for data policies.

1.3.2 Challenges

Because each city is unique, (C-)ITS solutions must be adapted to the local context and be in line with the city's vision and ambition to serve wider policy goals. Expertise from various fields is required to address the social, economic and environmental challenges that characterise urban mobility as well as the technical expertise to understand the impacts and implications of (C-)ITS solutions. This raises an important need for building local knowledge bases but also for sharing information and cooperating across professions, such as ITS officers in cities and their SUMP colleagues, and across governance levels, but also across cities, regions and national borders. In other words, national, regional and local authorities need to move away from a 'silo approach' to envision the bigger picture and embrace the user perspective and participation also in relation to technology. Assistance and guidance must be available, as in the example in the box below.

(C-)ITS often have agglomeration coverage and their adoption mobilises multi-stakeholder planning processes. The identification and effective involvement of such stakeholders is often a challenge in relation to organisational aspects (roles and responsibilities of each stakeholder), business models, taking into account the levels of subsidy in place, and funding mechanisms, often available at national and European levels.

Another important aspect is to understand the legal framework and ensure, for example, that data protection legislation is correctly applied. Similarly open and interoperable architectures are essential to ensure service availability to all users. To meet this requirement procurement actions by public authorities must be based on clear functional requirements defining outputs – what the final product has to do and not any specific ways in which the solution has to be designed, thereby giving suppliers maximum flexibility for innovation. It is also important that all items supplied must match open standards and operate on open platforms, so that the risk of vendor lock-in is minimised and future procurements are not constrained in any way. As the number of products deployed grows it becomes increasingly important to ensure that key data items are used in as many different ways as possible and each new system does not include the cost of acquiring data that is already available. To make deployment more flexible and more cost effective the use of "service bundling" is recommended, which makes it is easy to 'plug in' a new service to a (C-)ITS platform because of similar infrastructure requirements.

In the Netherlands local, regional and national authorities learn together

In the Dutch programme Krachtenbundeling Smart Mobility, national, regional and local authorities work together on:

• bringing mass to ITS solutions and making an impact with ITS/Smart Mobility. This is particularly important since ITS is still very scattered implemented, with trials and pilots;
• developing a human capital agenda for skilled experts and expertise that are currently hard to find;
• implementing the right ITS solutions in the right place;
• ensuring collective learning from the pilots with ad-hoc learning mechanisms;
• developing a national ITS/Smart Mobility dataprogramme to ensure data availability and make sure that all authorities share the same data in the same way (otherwise service providers/developers have no business case).

1.4 Cross-Referencing to the other SUMP Guidelines

This document does not focus specifically on Connected and Automated Vehicles, Shared Mobility, Mobility as a Service, electrification or Urban Vehicle Access Regulations (UVAR) because they are already covered by other specific guidelines, as noted below.

Other guides treating more specifically with SUMP measures:

- **Road vehicle automation in sustainable urban mobility planning**

Further guidance on Road vehicle automation can be found in the **Practitioner Briefing Road vehicle automation in sustainable urban mobility planning**

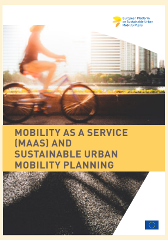
(https://www.eltis.org).

- **Integration of shared mobility approaches in sustainable urban mobility planning**

Further guidance on shared mobility can be found in the **Practitioner Briefing Integration of shared mobility approaches in sustainable urban mobility planning**

((https://www.eltis.org).

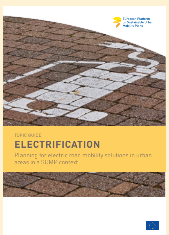
- **Mobility as a Service (MaaS) and sustainable urban mobility planning**



Further guidance on Mobility as a Service can be found in the **Practitioner Briefing Mobility as a Service (MaaS) and sustainable urban mobility planning**

(https://www.eltis.org).

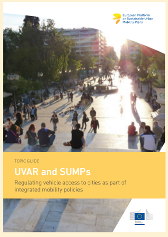
- **Electrification in sustainable urban mobility planning**



Further guidance on Electrification can be found in the **Topic Guide Electrification in sustainable urban mobility planning**

(https://www.eltis.org).

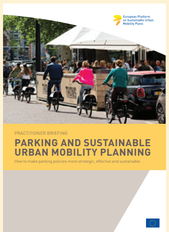
- **Urban Vehicle Access Regulations and sustainable urban mobility planning**



Further guidance on road pricing, congestion charges and related UVAR measures can be found in the **Topic Guide UVAR and SUMPs**

(https://www.eltis.org).

- **Parking and sustainable urban mobility planning**



Further guidance on parking can be found in the **Practitioner Briefing Parking and sustainable urban mobility planning**

(https://www.eltis.org).

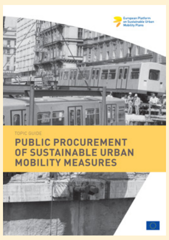
More info on specific steps in other guides:

- **Funding and financing options for Sustainable Urban Mobility**

Further guidance on funding and financing can be found in the **Topic Guide Funding and financing options for Sustainable Urban Mobility**

(https://www.eltis.org).

- **Public procurement of sustainable urban mobility measures**



Further guidance on procurement can be found in the **Topic Guide Public procurement of sustainable urban mobility measures**

(https://www.eltis.org).

2 The 8 SUMP principles and the relevance of ITS

Building on existing practices and regulatory frameworks, the basic characteristics of a Sustainable Urban Mobility planning can be summarised in the following 8 principles according to the 2013 Urban Mobility Package.

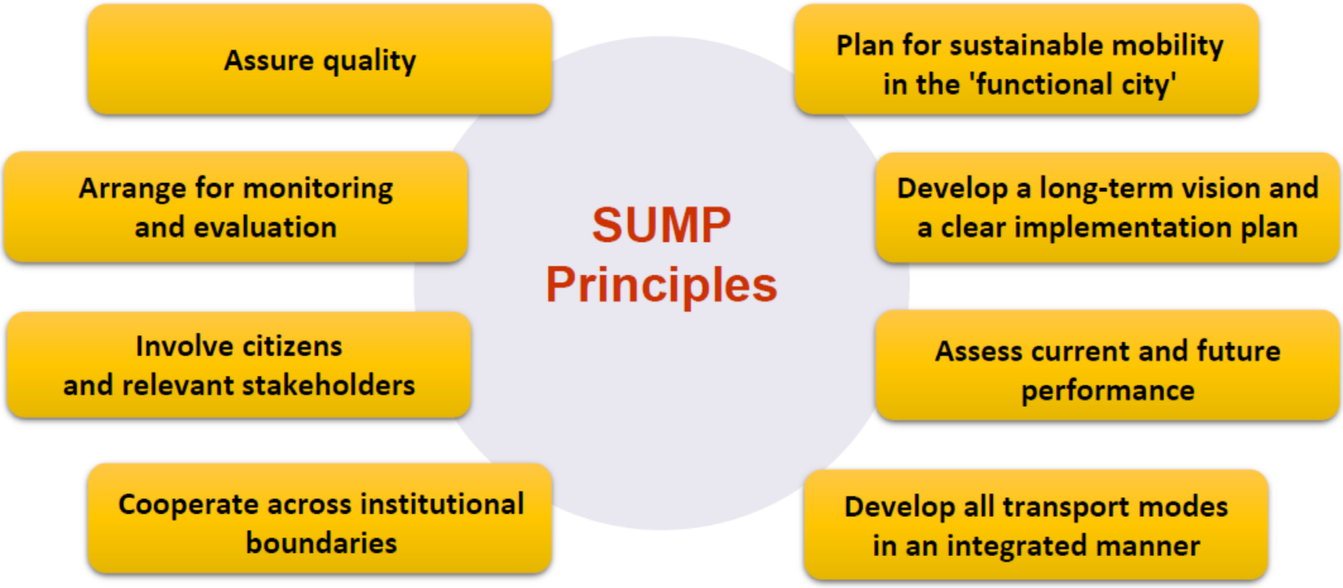


Figure 1. SUMP principles.

The 8 SUMP principles will be addressed through an introduction of the specific key challenges posed by the deployment of ITS. The reader will find the recommendations in Chapter 3.

2.1 Plan of sustainable mobility for the 'functional urban area'

From the user perspective the whole transport network is one entity with trips not stopping at historically defined city or administrative boundaries. Urban ITS implementation has to plan beyond municipal borders and can thus be recognised as major enabler for sustainable mobility in metropolitan areas. The development of new information communication technologies, enabling simulation, real-time control, systems integration and data exchange, offers the opportunity to address complex problems such as urban congestion at their metropolitan scale, and this despite the supply fragmentation among different operators.

As an example, multimodal information systems provide information on all modes of transport (car including the associated parking, public transport, railway timetables and related information, bike, bike or car sharing services, car-pooling etc..) allowing the users any combination of modes to go from A to B. In that perspective multimodal traveller information has an important role to play and is an incentive for users to change their mobility routines from exclusive use of car to non-exclusive use. Some studies have estimated the potential of multimodal information on modal shift at approximately 5%.

2.2 Develop a long-term vision and a clear implementation plan

ITS solutions should be goal-oriented where the technology serves the goals. However, there might be a need to harmonise the existing specific strategies, such as smart cities, MaaS and ad-hoc ITS strategies. The harmonisation of all plans including ITS implementations within the SUMP approach will provide a more robust implementation plan tackling both the transport supply side, including infrastructure, as well as the demand side, better feasibility of systems and will finally result in defining a smarter coordinated mobility vision for the city.

Cities should first become aware of technology trends (e.g. autonomous automated vehicles, monorails and cable rails, promotion of 'slow transport' and micromobility solutions, drones for city logistics etc.) and then define the level and the process of penetration of these technologies relevant for the city's future vision. A city's readiness level for adopting these technologies is likely to be related to the maturity and degree of integration of its urban ITS infrastructure and services. It is much simpler to introduce a new service (e.g. micromobility) if the city has an open data architecture and other ITS and C-ITS use a common open platform.

2.3 Assess current and future performance

ITS can offer significant added value to urban authorities in helping the assessment of the current and future transport systems performance and quantifying the impact of the mobility policies and measures that have been implemented. ITS can provide digital information on efficiency and sustainability of the urban mobility system and in particular can:

a) Collect real-time information through continuous monitoring and produce data through analysis and simulation techniques.

b) Implement policies at different levels of the urban area.

c) Offer tools and methods that help to reach policy goals within a limited amount of time and in a dynamic way.

d) Directly feed information regarding the SUMP performance indicators, as defined by the city with the impact assessment KPIs already defined and calculated. They allow common performance indicator content, also valid for verification, assessment and comparison across Europe.

2.4 Develop all transport modes in an integrated manner

Smart technologies and ITS should be considered as a tool and basic infrastructure to achieve integrated development of transport modes with an important role in the management of infrastructure and transport subsystems operations in a city. They offer demand management techniques directly (through pricing or flow management) and indirectly (by the impact of traveller on modal choice and user behaviour).

Key application of urban ITS like traffic and travel Information, smart ticketing, traffic management etc. are supporting in practice the development of transport modes and their use in an integrated matter. For example, with the arrival of ITS the ticketing system gains an important statistical function that allows public transport operators and authorities to better know the transport network usage by tracking its user (whilst respecting their privacy rights) and get significant inputs to the strategic analysis process of decision makers. Thus, data can be used to adapt the transport supply according to the customer needs and to manage the network more efficiently. For operators it also means enhanced security and lower fraud and operating costs.

At the same time, for users smart ticketing means:

a. complementary services and a wider multiservice offer, encouraging intermodality/multimodality and simplifying the use of all modes;

b. a different relationship between the mobility service provider, the user and the ticket/access provider;

c. improved quality, efficiency and image of all modes in the network as well as easy integration with other green modes;

d. a common communication/design language throughout the whole user experience.

ITS has the potential to provide the user with a seamless experience and take away all the barriers during the whole customer journey. This means:

a) it is important to have a common design language in both the digital space as the physical world

b) the product offerings of mobility providers have to be easy to understand and both machine- and human-readable.

c) the digital solution is never a replacement for the offline experience but something to help to augment this experience.

2.5 Cooperate across institutional boundaries

Many ITS systems (like traffic management and control, or network access restrictions, PT passenger information systems, etc.) require coordination across institutional boundaries: at city and regional levels as well as among municipalities.

Usually the national ITS architecture defines the typology of systems and services, the high-level specifications and the technical interoperability requirements of urban ITS. At regional level the detailed ITS systems design and operation is made by private and public stakeholders on a transport network that includes multiple municipalities and service providers. At local level operational requirements for fulfilling users' needs or sustainability objectives are formulated demanding customised operations (i.e. C-ITS services for priority of buses at signal intersections) or radical changes (i.e. reduce traffic in city centre or support Low Traffic Zone implementation).

SUMP processes can take advantage of the existence of integrated ITS in urban areas as they often create the basis for multi-stakeholders common understanding and cooperation.

2.6. Involve citizens and relevant stakeholders

ITS can be a great help for active stakeholder engagement as they provide public authorities with objective data and simulations that can be useful for engaging with stakeholders, formulating a shared vision and pursuing sustainable solutions. In addition, ITS platforms can be used to involve citizens already using ITS solutions such as smart ticketing systems, multimodal route planners, micro-mobility services etc. directly in the planning process. These users are active commuters and are aware of what the technology can bring to sustainable mobility.

In order to be efficient and reach its goals a SUMP requires good identification of the relevant stakeholders. However not all stakeholders have the knowledge and the capacity for considering smart mobility options and ITS related solutions for the future. It is therefore important to have a multidisciplinary approach and introduce technology providers and ITS related operators active in the area as part of the SUMP multi-stakeholder platforms.

2.7 Arrange for monitoring and evaluation

The success of a SUMP development and implementation very much depends on both a solid methodology for evaluation; and reliable monitoring techniques and technologies, that can collect the data required for SUMP implementation monitoring and evaluation. The measurable targets that the SUMP wants to achieve should be based on a realistic assessment of the current scenario. In reflecting on the current situation, the most reliable source of information on European cities is the data collected or produced by ITS (data from the traffic control centres and the PT fleet management systems and services etc.).

The ITS already applied in a city can therefore assist in the monitoring and assessment of SUMPs by providing information related to the conditions of the mobility network and services. Public authorities can be in charge of setting up a multimodal dataset for their urban area, utilising the data produced and/or collected from ITS implementations in their cities. In so doing they can gather the various sources of data of the transport operators, including real-time information, when available. This multimodal data set should then be made available, through the National Access Point, in accordance with European regulation, especially Commission Delegated Regulation of the ITS Directive setting out specifications for the provision of EU-wide multimodal travel information services (EU 2017/1926[13] of 31 May 2017 - short MMTIS NAP).

[13] The delegated act aims to encourage Member states to look for cost-effective ways to digitise existing static and dynamic data of different transport modes and addresses for example the establishment of national access points, the accessibility, exchange and re-use of static and dynamic travel data, the linking of travel information services, the requirements for proper re-use and the assessment of compliance. See regulation's text here: *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R1926*

2.8 Assure quality

The quality of the process and the compliance of SUMPs with the set target needs to be examined regularly. Assuring quality of the SUMP development process is usually implemented by external reviewers or higher levels of government, however, a set of process compliance criteria could and should be applied in the SUMP process in order to guarantee a minimum level of quality. The standards for the quality assurance process (i.e. in terms of number of participating stakeholders, documents, accompanying decision, level of feedback expected or required from the citizens etc.) should be set by the stakeholders. The quality assurance process should be governed by the municipality. wise, The quality of the SUMP content could be assured by checking the compliance of the priorities and individual measures with existing technical guidelines. This can in particular be the case for the ITS and smart mobility related components of the SUMP, where openness and interoperability must be assured.

3 Considering ITS in SUMP implementation

This chapter introduces the essential actions and considerations that urban planners and decision-makers should take into account for an ITS integrated approach during each one of the four phases of the SUMP process presented in the figure below.

Figure 2 The planning process for SUMPs

3.1 PHASE I: Preparation and analysis of mobility situation

Figure 3. Phase I of a SUMP process

This first phase is very important for the SUMP elaboration and the success of its over-arching planning approach. The cities should develop and put in place the capacities needed for SUMP development in the context of the smart mobility era of the future. Authorities should rely on the good mapping of existing initiatives related to ITS infrastructure and services development as well as their stakeholder's knowledge about technological solutions related to the efficient transport and mobility management. In doing so they can develop an understanding of: a) what systems and technologies are available; b) what is the maturity of the city in adopting ITS and smart mobility solutions; and c) what are the roles of the actors in the ecosystem and which of them could undertake responsibility for systems development and implementation.
In this context it is important when planning stakeholders and citizens' involvement in SUMPs to secure participation of the ITS (development and operation) related actors' ecosystem in the area. As shown in Figure 2 these actors might be: a) Network Managers such as highway operators or traffic management authorities, PT operators, on and off-street parking or commercial fleet (taxi, bike, freight distribution fleets etc.) management actors, who use Information and communications technology (ICT) or ITS for their daily operations. b) ITS vendors, which include technology providers or ITS service and platform operators. c) the users of the ITS services and citizens, like in the example of e-governance in Trikala in the box below. Another interesting actor to engage with in dialogue can be ITS associations, as explained in the case of Antwerp and Belgium in the box at the end of this section.

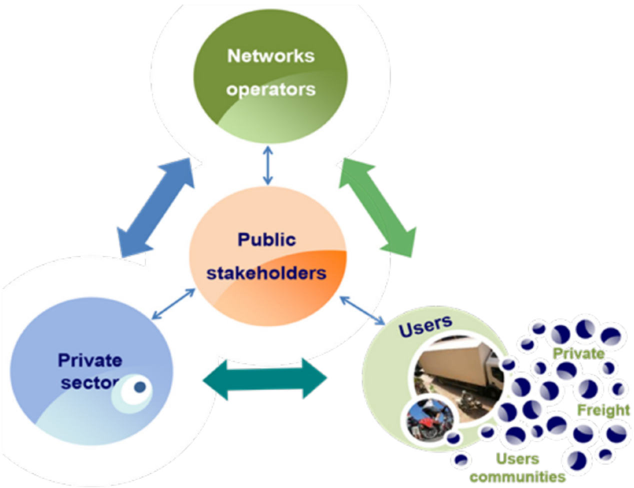


Figure 4. Interactions of ITS related actors

Depending on the business model applied in each urban area for the development and operation of ITS, the typology and possible interactions of the ITS related stakeholders are shown in figure 2. Cities should consider these interactions for defining and mobilising the appropriate actors. In addition to public funding there is also a strong private investment in developing ITS and Public-Private-Partnerships are also happening around Europe for advanced ITS implementations. The ITS developers and operators community involves (public and private) stakeholders who could provide important contributions to the SUMP process.
As already been discussed, ITS planning is not happening just at local level: ITS implementation in urban areas usually concerns the management of transport and mobility systems that extend beyond the municipal level. Few ITS are owned or operated by the municipal authorities. It is therefore recommended during the Planning Framework Assessment step to look beyond municipality boundaries and learn about the ITS planning framework. This is usually depicted in the national or regional ITS architecture, which applies to the municipality. This architecture usually defines the typology of ITS foreseen for urban areas and the different systems' interoperability and standardisation requirements. It also identifies or solves legal issues related to the ITS implementation.

It is necessary to check the level of national ITS architecture already implemented, list the ITS systems and services currently available in the area and check for ITS planned for future implementation. The rationale and objectives of both ITS implementations and future plans should be tested for sustainability requirements. At this same step of the planning framework assessment, it is important to check if a smart mobility development plan exists or is being pursued for or by the city. Such plans are usually developed in the context of a smart city strategy and plan. The SUMP process could be the "terrain" for integrating these plans. Therefore, identifying who is involved or leading the process (i.e. smart city cluster or other division of the municipality, innovation agency etc.) and assessing the content of the current or future smart city planning framework for mobility at this step of the SUMP process, is crucial for achieving a holistic policy approaches for sustainable mobility.

Data is important all around the SUMP process for clearly describing the existing situation, supporting the selection of measures, justifying policy scenario choices among alternatives and for quantifying the impact of a SUMP implementation. ITS are based on real time information and similar data collection and from their operation new data sets can be generated formulating a rich digital content for the mobility in the urban area they concern. In SUMP municipalities need to secure availability of datasets for analysis, for planning and for evaluation of SUMPs. However, they face the situation on the one hand of not knowing what data are needed and on the other hand of not being aware were this data can be found in a reliable and consistent way.

In the context of the Data Sources Identification process, it is worth mentioning ongoing and upcoming progress thanks to European Regulation, before getting into local practices and recommendations. In the frame of the Commission Delegated Regulation of the ITS Directive setting out specifications for the provision of EU-wide multimodal travel information services (EU 2017/1926[14] of 31 May 2017 - short MMTIS NAP), Member States are setting up National Access Points[15] (NAPs) to facilitate access, easy exchange and reuse of travel and traffic data from all modalities available in a country. This could be a valuable data source worth consulting as it could reduce the time and cost of data research and acquisition since, as a single digital interface, NAPs

[14] See regulation's text here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R1926 For more information on the European legal framework for ITS implementation see the Annexes.

[15] The National Access Points can take various forms, such as a database, data warehouse, data marketplace, repository, and register, web portal or similar depending on the type of data concerned and provide discovery services, making it easier to fuse, crunch or analyse the requested data sets. For more info on the NAPs see here: https://ec.europa.eu/transport/themes/its/road/action_plan/nap_en As an example of NAP for delegated regulation MMTIS, you can see: https://transport.data.gouv.fr

Figure 5. Roles and interactions related to data *(source: Industrial Data Space)*

provide access to open mobility data either directly or through reference to the data sources. As all transport actors are required to as a minimum to make static travel and traffic data available as open data, it also means that the local public authority as data producer, e.g. traffic management, has also the obligation to make data available in specific set of standards. In fact, local public authorities are included in a bigger picture within an evolving European ITS framework that aims, for example, at enabling multimodal travel suggestions to end-users (also as part of MaaS) within or across national borders in the EU zone as well as preparing the arrival to the roads of vehicles with increasing levels of automation. Already end 2019 all scheduled modes of modalities in the EU-zone must deliver travel and traffic data in the NeTEx format. The implementation of the NAPs is expected to be a major revolution for the public and private actors involved in delivering mobility services throughout the whole EU.

Meanwhile, at a local level from the practices observed it is helpful to involve ITS operators and secure their support and cooperation. They are able to provide datasets as well as methods and tools for extraction of knowledge from the data and for quantification of indices that describe the mobility situation in the city and help to monitor its evolution. Valuable data might be available from other sources such as floating vehicle data from commercial fleet management systems, traffic management centres' sensor networks, traveller information systems and multimodal trip planners. These and similar ITS systems can provide operational characteristics (speeds, delays, travel times, traffic levels, transport demand estimation etc.) of the multimodal transport network. It is important to try to get a good view on the various roles and responsibilities of the players in the data ecosystem while mapping the various data-roles (owner, provider, user, broker...), as in the diagram below. Digital content (data and metadata) collected and produced by each existing ITS in the city should be listed while quality and terms of provisioning of historical or real time data should be checked with the data owner.

Once sources are identified data from them needs to be made available to the municipality for the SUMP planning process. This is a more challenging task since it requires trust among stakeholders and guaranteed neutrality by the municipality (or region or National body) in the role of SUMP Data Aggregator.Public authorities also need to deal with the cost of acquiring data and there might be specific organisations facilitating data provision, e.g. in the UK the OneTransport platform provides access to data sets in a common format under a variety of licensing and commercial arrangements. Best practices around Europe show that when a trusted environment for urban mobility data sharing has been achieved it has been based on the set up of dedicated working structures, inside and outside the local administration e.g. at Transport for West Midlands a Policy, Strategy and Innovation Directorate was created to get the required skills and disciplines together in one place. These structures enabled long-term cooperation among the actors on a "value return" scheme. The ITS operators and the smart mobility solutions providers are main contributors of data (and particularly big data) together with academia and consultants who usually maintain transport models for supporting strategic planning and decision making. Typical examples are smart mobility Living Labs or smart city clusters around Europe were actors exchange and provide data for better planning and management of urban mobility, but also cooperate for defining priorities for sustainable and smart mobility development.

The following are good examples: Copenhagen Big Data Solution Lab[16], Barcelona open Living Lab[17], Thessaloniki Smart mobility Living Lab[18], Antwerp Smartzone[19].

On this important aspect of data availability for SUMP (development and implementation monitoring) the advice to the municipalities or Regions is to follow a four-step approach:

a) Identify if dedicated working structure(s) for data sharing (in accordance with the above, including National Access Points) exist.

b) If YES then ask for the list of data that can be provided, involve the owners in the SUMP process and sign a memorandum of understanding (MoU) for data provisioning.

c) If NOT define inside the SUMP multi stakeholder platform a "data provisioning subgroup or task force" which will involve competent actors in the subject and which will undertake the task of listing the available data and mapping data provisioning scheme for SUMP in a short period.

d) Pursue the setup and operation of a longer-term structure for smart mobility data sharing in any of the various forms presented above which is most suitable for the actors' ecosystem. This working structure (e.g. Living Lab) will aim to become a data aggregator and a stakeholder's collaborative platform for smart and sustainable mobility knowledge generation. It might be coordinated by the municipality or other neutral party (usually academia) and could involve ITS stakeholders from beyond the city jurisdiction. Use this structure for: a) defining new and maintaining provision of datasets already available by ITS sources and facilitating availability of this data for SUMP; b) create a repository of these data for current mobility situation assessment, SUMP planning and impact monitoring; c) stimulate local stakeholders' knowledge on what ITS solutions can contribute to the resolution of their local problems; and d) assess city readiness in adopting ITS and smart mobility options and support decision making for promoting ITS and technology enabled smart mobility.

When analysing mobility situations, it is important to do so by quantifying mobility indices that describe sufficiently the current situation, are commonly understood by all stakeholders and are able to be quantified in the future by using the same methodology and dataset. This is to secure compatibility of analysis results between current and future time horizons (i.e. after SUMP measure implementation). The municipalities should apply the sustainable mobility indices proposed by the European Local Transport Information Service (ELTIS) and specified through the Sustainable Urban Mobility Indicators (SUMI) KPIs methodology.

The quantification of an important part of these KPIs may be supported by ITS systems data such as: access to mobility services, commuting travel time, congestion and delays, opportunity for active mobility, multimodal integration, satisfaction with PT and modal split.

In this same step of the SUMP process (i.e. the analysis of mobility situations) the municipalities are requested to understand opportunities for quickly advancing in sustainability. In this context, the level of readiness of the municipality transport and mobility network in

[16] More information is available at: Western Digital, April 25th 2017, Copenhagen: A Smart City is a Better City, url: https://datamakespossible.westerndigital.com/copenhagen-smart-city-better-city/

[17] More information is available at: Serra, Artur, March 10th 2014, The city as a living lab: Barcelona's initiative, url: https://www.slideshare.net/openlivinglabs/barcelona-laboratori-a-bcn-innovation- ecosystem-2

[18] More information is available at: Aifandopoulou, Georgia, 2017, Thessaloniki: a Living Lab Intelligent Mobility, url: https://docplayer.gr/47558141-Thessaloniki-ena-living-lab-eyfyoys-kinitikotitas.html

[19] More information is available at: https://antwerpsmartzone.be/en/

adopting integrated ITS, smart sustainable mobility options or disruptive technologies should also be assessed. In reality ITS or smart mobility deployment have different results and rhythms of adoption in different urban environments. Outcomes also vary by region and are influenced by parameters including quality of communication infrastructure, socio-economics and demographics, overall trip patterns, the quality and coverage of existing public transit systems and green modes, and the presence and strength of the innovative transport and mobility business community. Municipalities could use the smart mobility interaction working structure presented above or the SUMP multi-stakeholders platform for conducting a dedicated "Delphi" survey among competent actors to define opportunities and potential for ITS and smart sustainable mobility development.

Example: ITS.be & "Coalition of the Willing"

Moving innovation forward in a complex institutionalized country as Belgium is hard and requires many stakeholders. To promote communication between the various stakeholders within ITS, ITS.be – a public private partnership- organizes regular meetups with all stakeholders across topics. Through these various meetings, a "coalition of the willing" has grown with players from both government as private industry. This coalition functions as a sounding board for new ideas or bottlenecks.

Example of public participation, e-governance and ITS tools

ITS tools can be used also for stakeholders and citizens' involvement in SUMPs. For example, the city of Trikala has built ITS tools in order to foster e-governance and participation for all citizens, which could also be used in the SUMP devopment process. The local community can send any possible claim, complaint and request directly to the Municipal Authority through an online application accessible also through a mobile phone, available for free on Google Play and the App Store. Its basic function is the capacity to log and monitor the progress of resident petitions. The application is linked with a residents' service platform and directs the received claims straight to the competent Municipal Department. Furthermore, it covers basic information needs, by displaying announcements and events posted on the Municipality's website. It also functions as a tourist guide, highlighting points of interest on a map and displaying handy information such as useful telephone numbers, pharmacies open late, and gas stations.

More info: *https://trikalacity.gr/en/smart-trikala/*

3.2 PHASE II: Strategy Development

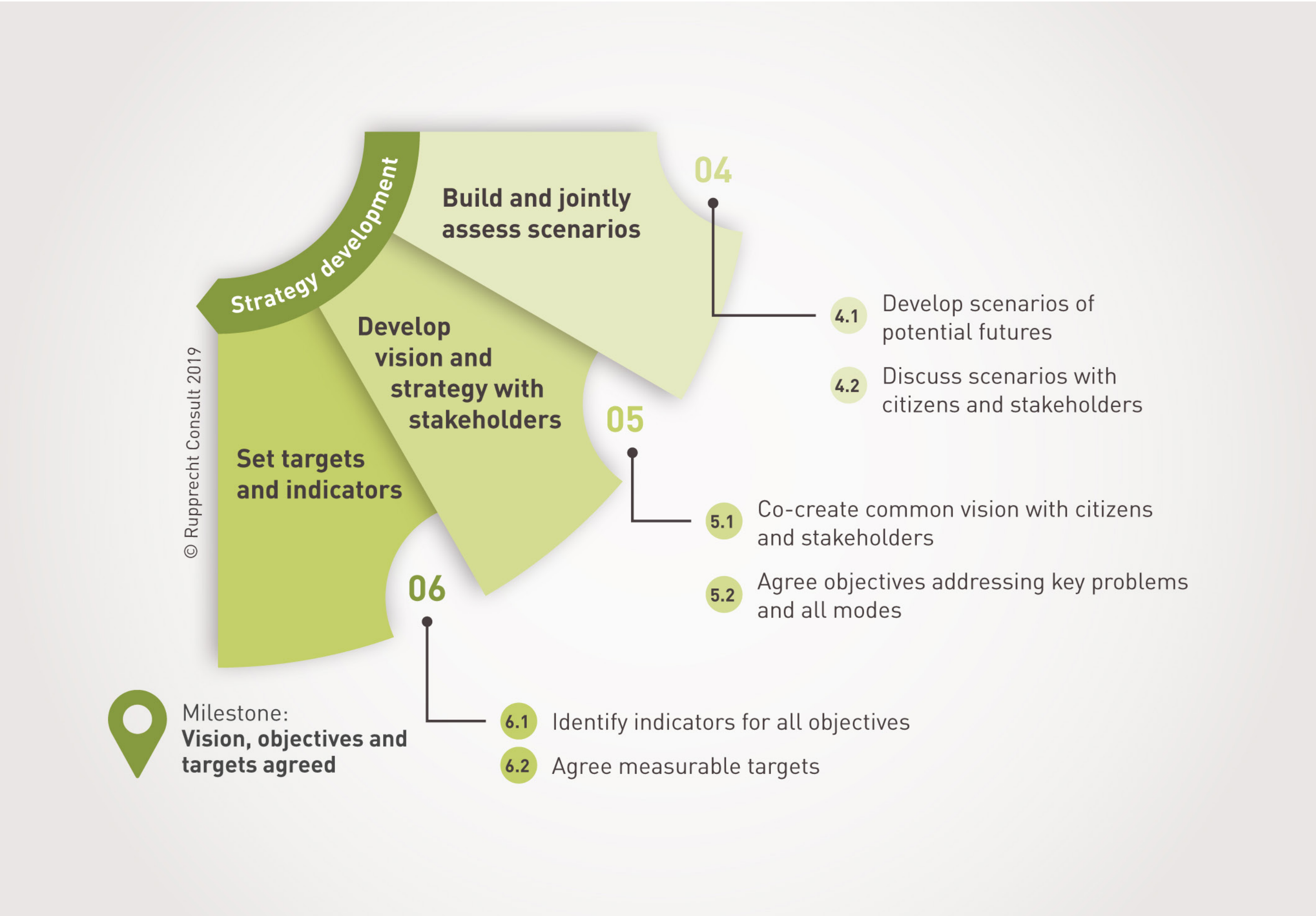


Figure 7. Phase II of a SUMP process

Fundamental new technological developments like ITS and disruptive technologies can be part of efforts to provide future-oriented answers to the various challenges of designing urban and regional sustainable mobility. A joint strategy, considering, at multiple levels of reasoning the city's future and a good combination of measures justified under different perspectives, is the way to move forward in this step. Highly technology-based transport management approaches should be jointly considered with procedures for a fundamental reduction of selected modes of transport and introduction of new modes and means of transport.

Cities choose smart mobility as an important pillar of their strategy for sustainable mobility when they realise that there are opportunities for innovative growth and increased competitiveness of public and private bodies in the green and smart mobility industry. At this step of the long-term strategy for SUMP creation it is worth including visions of large-scale ITS deployment and smart city mobility developments that are in line with innovative growth priorities of the local and national mobility industry.

In the context of the above, when developing scenarios for potential futures the definition of smart and green mobility scenarios as one of the alternative scenarios of the SUMP should be considered. In creating such a scenario the starting point could be the list of future ITS implementations collected and the smart mobility opportunities identified during Phase I of assessment process. Then the identification of the relation between the policy goals and the contribution of ITS or smart mobility solution implementation to goal achievement is required. Also, considerations should be given to the way these implementations will happen. For instance should a public authority build a real-time PT information app or should it open such data to enable third parties to take the lead?

At this step of the process city authorities can choose all or some of the following activities for enriching and successfully completing the scenarios of the potential future:

• It is important to Communicate to stakeholders the ITS solutions and the impact these solutions can achieve on sustainable mobility. CAPITAL project tutorials may be used for supporting this process.[20]

• Application of market intelligence techniques can be considered in joint meetings of private companies (technology operators etc.) and institutions for identifying innovative solutions that the local and national industry can provide for fulfilling the sustainable mobility needs of the city. Through this process scenarios content will be enriched and will make maximum use of the opportunities identified in Phase I. The best practices from the Green Mind Project in implementing market intelligent techniques for supporting smart and green mobility can be used in implementing this process.[21]

• At this stage it is recommended to mobilise existing and related business and technological clusters for enriching and validating future scenarios for large-scale ITS and smart mobility deployment. Best practices in this regards may be found from Andalusia Smart City Cluster. [22]

The co-create common vision and objectives in practice implies that the SUMP process at this step will integrate intelligent transport development visions and smart city and innovative growth visions in one smart and sustainable mobility vision for the city. This is a challenging process that requires intensive interaction between stakeholders with different priorities, but a common understanding of trends and overall goals. For an objective analysis and evaluation of possible trends (when defining the long-term vision) the foresight method seems to be a meaningful approach for strategic transport infrastructure and ITS planning. If followed it allows for realistic implementation planning for the different time horizons in later steps of the SUMP process. The municipalities are advised to use external support for managing stakeholders' interactions during integrated vision formulation. The use of learning networks, such as the ITS associations mentioned in 3.1 in relation to Phase I, can be useful for public authorities.

Definition of measurable targets and indicators for all targets, related to ITS and smart mobility adoption should be performed in line with smart mobility targets and indicators from the smart cities plan. These should be adapted as appropriate for expressing the level of infrastructure and services it is desired to reach for achieving the specific goals of the SUMP. The ITS related targets should also reflect organisational targets like the creation of a cross-agency ITS strategy and actions taken to ensure an efficient use of resources. Other ITS and smart mobility adoption targets can be considered at this stage and may be expressed in terms of big data availability, integrated ITS infrastructure management, efficiency of operations, innovation adoption, and improved maturity of the city in adoption of the smart sustainable mobility scenario vs. ITS readiness level.

There is a variety of measures contributing to sustainable mobility enabled or supported by ITS. For example the application and surveillance of access restrictions to categories of vehicles for designated areas, users' behaviour changes through multimodal real time information provision, environmentally friendly traffic and intersection or corridor management, parking management, multimodal integrated payment and booking, priority schemes to green modes, safety monitoring etc.

In principle when looking to identify measures packages, the selection of the ITS infrastructure and services should be made that can support problem alleviation and SUMP goals achievement.

ITS and smart mobility measures should not be selected for implementation by analogy of problems and system characteristics in other cities, since cities are unique and a package of measures should be tailor-made to the cities needs and the its stakeholders' priorities and goals. However, the cities can consult the table presented in chapter 4 to help the first identification of ITS measures according to the major sustainability objectives. In Chapter 4 each of the ITS solutions is briefly described and examples are given, drawn from across Europe, of real world deployment. Many of the examples are drawn from the Horizon 2020 project CAPITAL[23].

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[20] See: Collaborative cApacity Programme on ITS Training-educAtion and Liaison (CAPITAL), EU Funded Project, url: http://capital-project.its-elearning.eu/

[21] See: The Green Mind Project, url: https://greenmind.interreg-med.eu/

[22] Andalusia Smart City Cluster, url: https://www.clustercollaboration.eu/cluster-organisations/cluster-andalucia-smart-city

[23] Collaborative cApacity Programme on ITS Training-educAtion and Liaison (CAPITAL), EU Funded Project, url: http://capital-project.its-elearning.eu/

3.3 PHASE III: Measures Planning

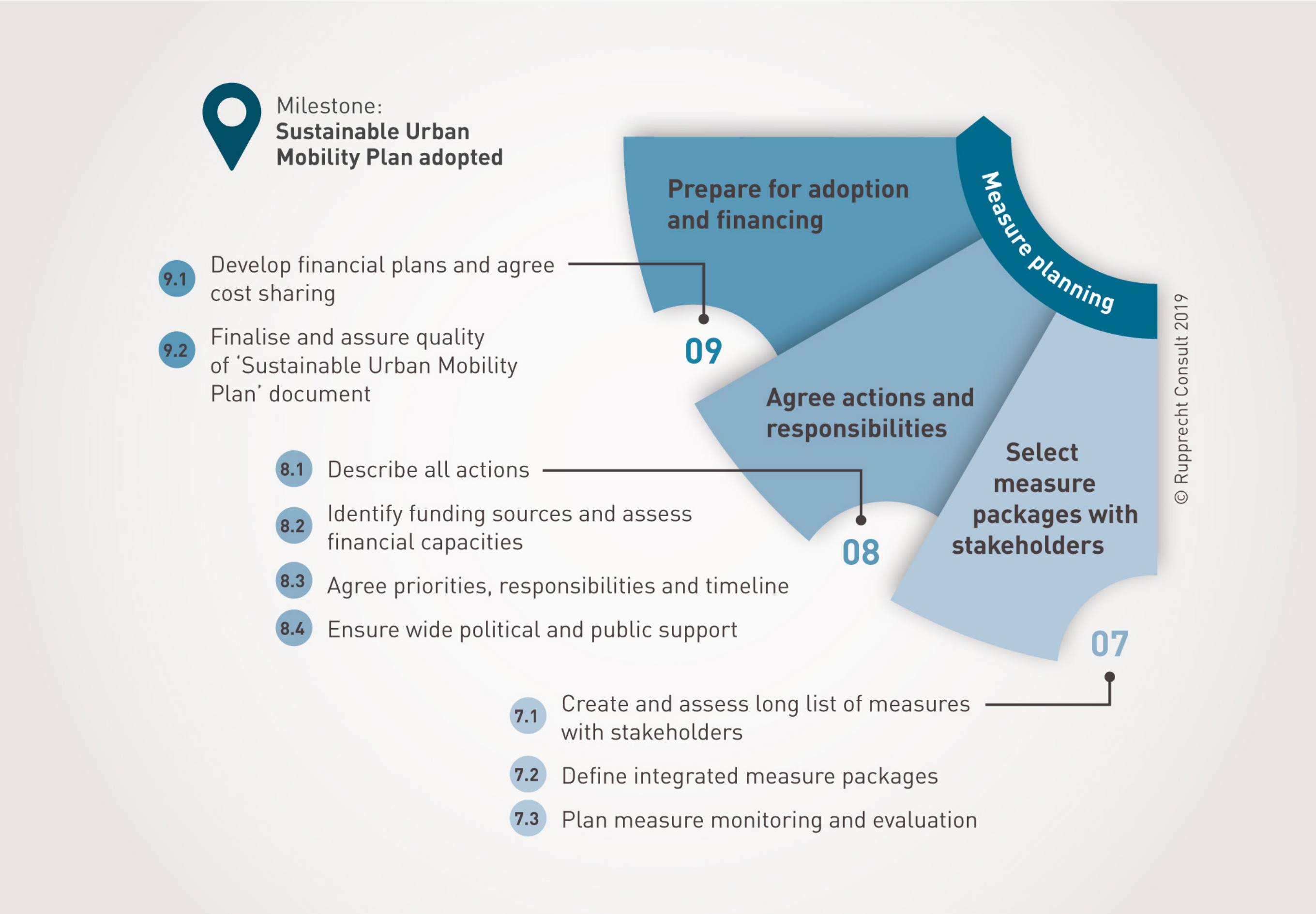


Figure 8. Phase III of a SUMP process

In this phase the selection of the appropriate mix of measures should be performed and their implementation process should be put in place. ITS can be a measure by itself (e.g. environmentally friendly traffic management) or the enabling technology for a measure implementation (e.g. electronic monitoring of access restrictions of categories of vehicles to designated areas or Low Traffic Zones implementation). There is a variety of measures contributing to sustainable mobility that are enabled or implemented through ITS. For example the application user's behaviour changes through multimodal real time information provision, environmentally friendly traffic and intersection control or corridor management, parking management, multimodal integrated payment and booking, priority schemes to green modes, safety monitoring etc.
At this same Phase III municipalities should take into account that for the identification of the funding and the budget for ITS measures it will usually require securing combined investments by public and private stakeholders. As a successfully tested process in many cities for a variety of ITS developments, public authorities could perform public funding screening and organise business to business meetings among technology providers and other stakeholders to define appropriate PPPs or new business models.

Consider EU funding instruments for ITS and C-ITS related activities

Most research and innovation projects have been executed under the EU Framework Programme for Research and Innovation "Horizon 2020". Next steps in the field of connected and automated mobility (follow-up domains of C-ITS) are expected to be addressed by the upcoming "Horizon Europe". More info: *https://ec.europa.eu/programmes/horizon2020/en*

Other key funding instruments:

- Connecting Europe Facility (CEF), which focuses on harmonized C-ITS deployment projects, as well as on horizontal priorities such as traffic management systems. More info: *https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport*
- INTERREG or interregional cooperation with projects funded through the European Regional Development Fund. More info: *https://interreg.eu/*

3.4 PHASE IV: Implementation and monitoring

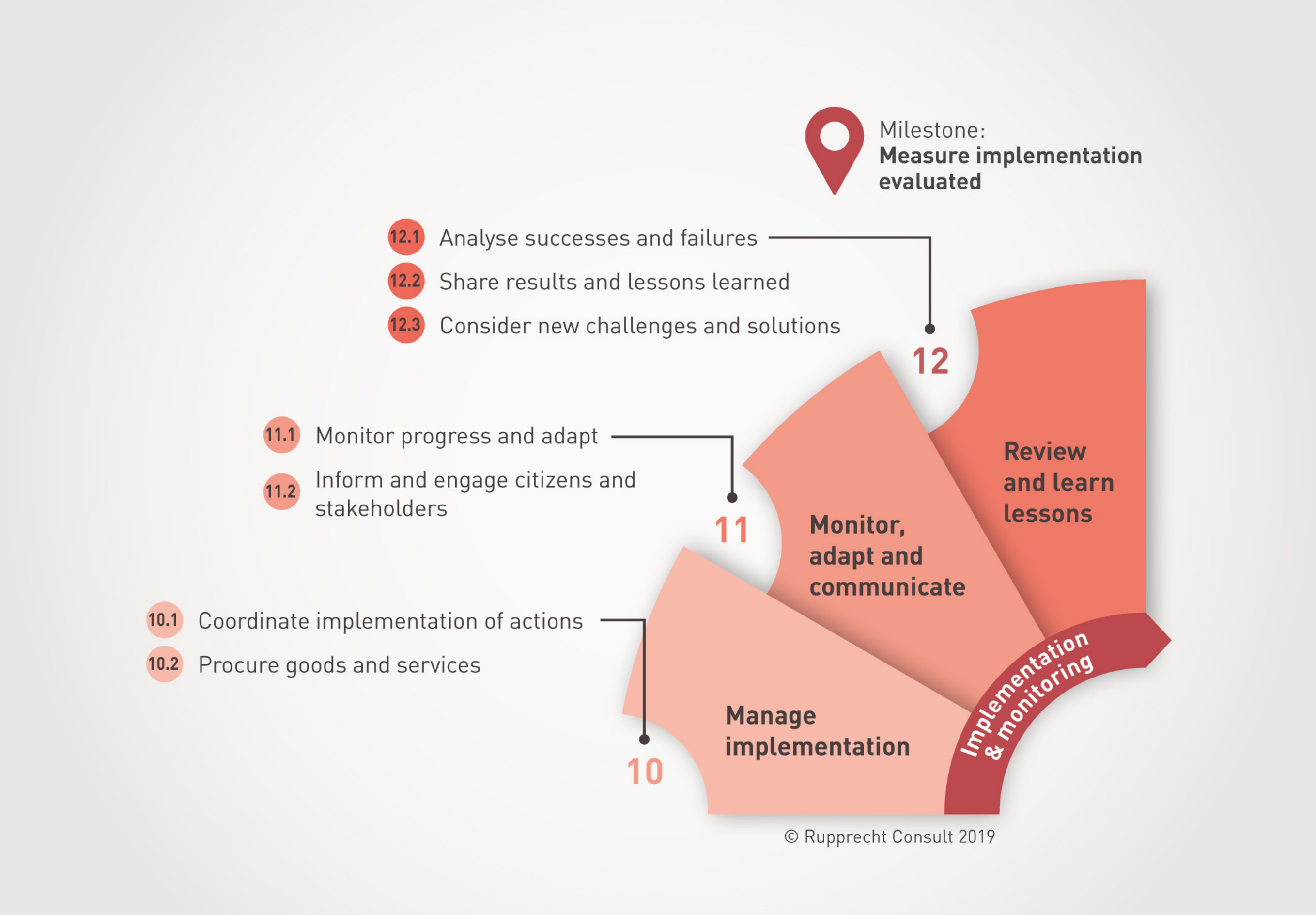


Figure 9. Phase IV of a SUMP process

This last phase of the SUMP process aims at achieving procurement of systems and services related to the SUMP implementation and at securing continuous monitoring of the impact the selected measures have on achieving the SUMP goals.

When procurement of ITS for sustainable mobility is considered in the context of the SUMP more dialogue between procurers, developers and producers is necessary. The most important aspect of ITS is the interconnectivity of equipment and solutions. In the past information systems, signalling, street lighting, and on-board equipment have been treated as separate systems with no interaction. ITS ties these systems together and adds new functionalities. For this reason an ITS purchase is dependent on existing systems and needs, which often require individual tailor-made solutions. New procurement techniques should be implemented in order to allow open dialogue and secure those innovative solutions will be adopted. This way procurers can get an understanding of the solutions available on the market, the producers and developers can get an understanding of the existing systems, needs and challenges of the procurer. Through this dialogue new solutions can be created.
In the context of the above it is recommended to the city authorities to follow ITS procurement recommendations developed by the SPICE project which include among others:
• Thorough understanding of the existing systems implemented on site;
• Introduction of a competitive dialogue or clarification phase into the procurement process;
• Cooperation between existing and new suppliers with

the purpose of innovation and new learnings;
• Focusing on the life-cycle costs of different options (including power consumption, service and maintenance costs of equipment, software and back-end);
• Identification of open standards and protocols to avoid vendor lock-in.
A best practice of innovative procurement for ITS for sustainable mobility was developed in the SPICE Project.[24] The working structures proposed in Phase I of the SUMP process may be used for hosting and implementing procurement dialogue. Similarly to Phase I, it may also be beneficial for the open innovating procurement process to use business intelligence techniques to assess local and national industry potential for solutions provision.

Monitoring SUMP Implementation at this Phase requires efficient, responsive data collection and straightforward impact assessment to guide decision making towards policy and measures adaptation. Based on the mapping of available data from the ITS systems and services performed at Phase I and the data repository for SUMP that could possibly be created at that moment, at this stage cities should consider developing a smart and sustainable mobility monitoring observatory for their urban area. The system should collect data from different ITS sources and smart mobility systems and should quantify KPIs and impact assessment indices based on these data. There are several methodologies for assessing impact of sustainable urban mobility measures. Some of the SUMI KPIs presented in Phase I could be also used for this purpose as well as a variety of indices dedicated to measures' categories. What is crucial for the cities at this stage is to apply an Open Services and Open Data policy on information provision for ITS and other smart mobility service providers thereby allowing fair competition between service providers and stimulating data availability for SUMP impact assessment.

Cities are invited to check the availability of "smart city dashboards" that could be further enhanced to cover the need for sustainable mobility monitoring. Applying dashboard functionality over the sustainability Observatory data sets could provide the decision makers with a clear view regarding SUMP goals achievement. The "Smart City Control Centre" of the city of Trikala in the box below provides an inspiring example.

When considering ITS as one of the measures applied for sustainable mobility in the context of the SUMP, it is obvious that ITS efficiency should be also assessed. At this point it should be mentioned that there is not an evaluation culture in ITS. Cities implement systems, e.g. real-time information to users, bus priority at traffic lights, etc. but rarely is the effect of this investment measured. This should change and cities should take easy ITS and smart mobility solutions evaluation approaches like those presented previously.

Smart Trikala – Smart City Control Center

A control centre for all "Smart City" services was established in the city of Trikala located in the Municipality. Terminals were installed to monitor the following systems:
• GIS displays spatial – urban planning data and points of interest in the Municipality of Trikala
• The Cisco Smart+Connected Digital Platformis designed to display the data it collects on one admin screen
• Traffic light operation monitoring system. It offers online monitoring of malfunctions and blown light bulbs in the city's intersections that are regulated by traffic lights.
• Municipal vehicle traffic recording system
• Terminal for monitoring the operation of wireless network hubs for free Wi-Fi access
• Solenoid valves monitoring and regulating system – Municipal Water and Sanitation Utility
• Recording and monitoring of the progress of residents' petitions
• Posting of Municipality of Trikala open data

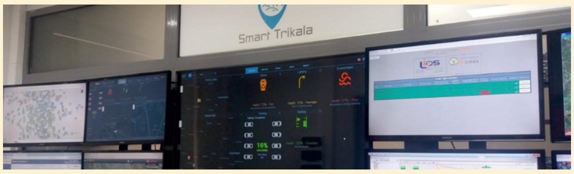


Figure 10. Smart Trikala Control Centre
More info on the Intelligent Urban Mobility Management System of Trikala: *https://trikalacity.gr/en/smart-trikala/*

[24] The SPICE Project, *url: https://spice-project.eu/best-practices/*

4 What ITS solutions can serve your SUMP goals?

The section presents a description of key ITS services that can in principle contribute to the achievement of urban sustainable mobility goals.

The tables in the following page are intended to be a first tool for planners and decision-makers to choose their measures according to the goals and priorities they pursuit. In the rows, there are 13 objectives that are common in SUMP, from the general such as improving liveability to the more specific such as gathering better data.

- Improve city liveability
- Reduce CO2 and improve air quality
- Reduce noise emissions
- Improve transport accessibility
- Improve safety
- Reduce congestion
- Boost economic growth
- Unlock spatial opportunities
- Enable smoother, seamless journeys
- Boost public transport
- Boost active travel
- Boost electromobility
- Better transport data

In the columns, 15 types of ITS measures, being products or more elaborate services, are listed from the most common in cities such as Reactive traffic management and control to the newest and more complex solutions, such as Mobility as a Service.

- Reactive traffic management and control
- Predictive Traffic management and control
- Public Transport and emergency vehicle priority
- Traveller information
- Parking management and information
- Red light & parking enforcement
- Maps and location referencing
- Dynamic route guidance
- Floating vehicle data
- Road user charging
- Fleet Management Systems
- Demand-responsive transport
- E-ticketing
- E-payment
- Mobility as a Service

For each intersection an appreciation of the correlation between the goal and the corresponding ITS measure is given, in 4 growing levels, from very little or non-existent (-) to XXX, as the highest correlation estimated. Please note that this is a first general appreciation and the impact of every specific measure should be carefully studied during the Measure planning phase (Phase III of the SUMP cycle – see chapter 3).

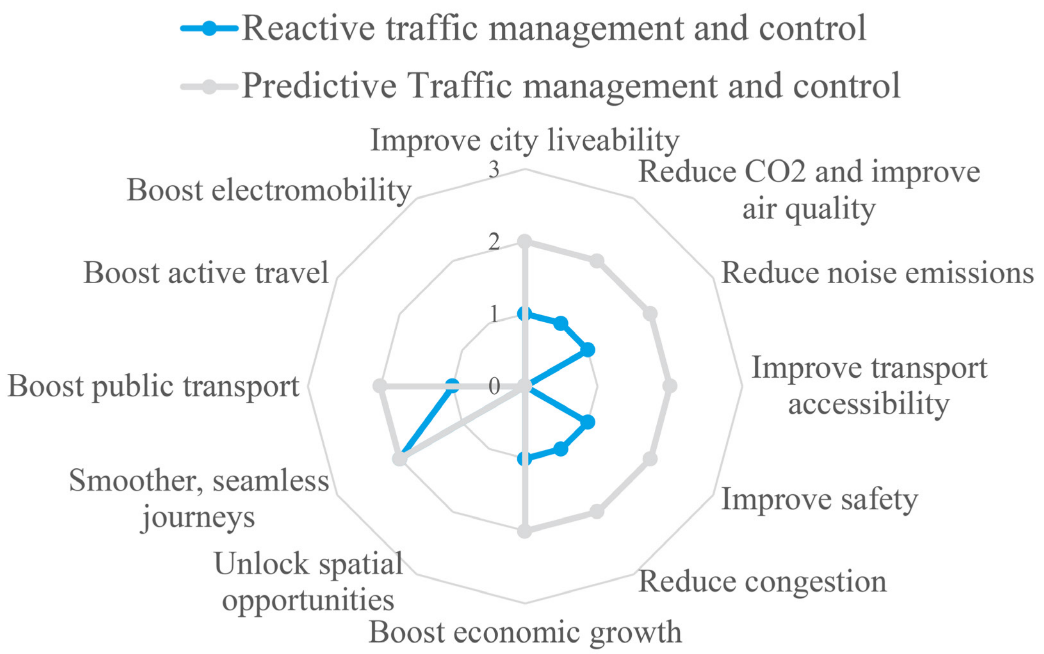
In the following paragraphs each of the ITS services of the tables is briefly described and examples of real world deployment given, drawn from across Europe and the world. Many of the examples are drawn from the Horizon 2020 projects CAPITAL[25] and C-MobILE[26]. A chart will remind the goals that the specific measure can pursuit and give a first possible "goal fingerprint" of it.

[25] Collaborative cApacity Programme on ITS Training-educAtion and Liaison (CAPITAL), EU Funded Project, url: *http://capital-project.its-elearning.eu/*

[26] Accelerating C-ITS Mobility Innovation and Deployment in Europe (C-MobILE), EU funded Project, url: h*ttps://c-mobile-project.eu/*

SUMP GOALS / ITS MEASURES	Reactive traffic management and control	Predictive Traffic management and control	Public Transport and emergency vehicle priority	Traveller information	Parking management and information	Red light & parking enforcement	Maps and location referencing	Dynamic route guidance	Floating vehicle data	Road user charging	Fleet Management Systems	Demand-responsive transport	E-ticketing	E-payment	Mobility as a Service
Improve city liveability	x	xx	xx	xx	xx	x	xx	xx	-	x	x	x	xxx	xxx	xxx
Reduce CO2 and improve air quality	x	xx	-	xx	x	x	-	x	-	xxx	xx	x	-	xxx	x
Reduce noise emissions	x	xx	-	xx	x	-	-	-	-	xxx	xx	x	-	-	xx
Improve transport accessibility	-	xx	x	x	x	-	xxx	-	x	x	-	xxx	xx	xx	xxx
Improve safety	x	xx	xx	xx	-	xxx	-	x	-	xx	-	-	xx	xxx	-
Reduce congestion	x	xx	xx	xx	x	xx	x	xx	x	xxx	xx	xx	x	xx	xx
Boost economic growth	x	xx	x	x	xx	xx	-	-	-	xx	x	x	xx	xx	xx
Unlock spatial opportunities	-	-	xxx	xx	xxx	xx	x	-	-	xxx	-	x	-	xx	xxx
Smoother, seamless journeys	xx	xx	xx	xxx	x	x	xx	xx	x	x	-	xx	xxx	xxx	x
Boost public transport	x	xx	xxx	xx	x	-	xx	-	x	x	xxx	xxx	xx	xx	x
Boost active travel	-	-	-	xx	-	xx	xx	-	-	x	-	-	xxx	-	x
Boost electromobility	-	-	-	xx	x	x	xx	x	x	xx	x	-	-	-	xx
Better transport data	x	xx	x	xxx	x	x	xx	xx	xxx	xx	xx	x	x	x	xx

4.1 Reactive and predictive traffic management and control



These two services are taken together. Reactive management is as described above (section 2.1) for the simple cross roads: the system measures what is happening and then reacts to it. Even the most basic systems are still capable of supporting different mobility policies and so local authorities intending to install services also need to think about pedestrians, cyclists, buses and trams, and consider the policy decisions regarding the priority to be given to these different road users. Linking general traffic control with other systems such as access control, parking and bus or tram priority also comes under this general heading of traffic management. Local authorities need to identify their requirements for the whole traffic management system and then think about how different components of the system should be procured, upgraded and managed.

Predictive systems bring added efficiency and flexibility. The central control software holds historic data on traffic flows across the network and looks for patterns in the current movement of vehicles that in the past had led to congestion. Traffic signals can then be adjusted before the flows start to decrease to provide a smoother path for everyone, and companies providing dynamic route guidance can be alerted to changing circumstances to enable them to send revised directions to users to complement the revised traffic signal timings.

One vital element when designing systems is avoiding supplier lock-in when integrating components. Procurement needs to be done on the basis of standard "platforms" running open source software rather than single-function bespoke purchases so that future developments are not constrained. The Traffic Management 2.0 (TM2.0)[27]

Innovation platform was launched in 2014 by stakeholders in this area to focus on new solutions for advanced interactive traffic management.

Examples:
http://www.opticities.com/pilot-cities/lyon/

https://www.aimsun.com/real-time-traffic-management-tti-2018/

[27] TM2.0 Innovation platform, url: https://tm20.org/

Grand Lyon Multimodal Traffic Management System

CRITER is the multimodal traffic management centre of Lyon, which enables real-time management of traffic, through the management of green waves and the provision of traffic light intersection priority to PT. The monitoring of the road network is achieved through cameras and sensors. CRITER links together certain traffic light intersections. This allows the prompt detection, through sensors, of even the smallest breakdown and its prompt repair. Traffic lights are being coordinated based on the actual automobile traffic. Furthermore, the system informs (in real time) drivers and travellers on the traffic status and events, weather forecast, parking places, bike road network, free bike service (places and bikes free in real time), car sharing and carpooling. The system also contributed to truck prioritised traffic management within the FREILOT European project.

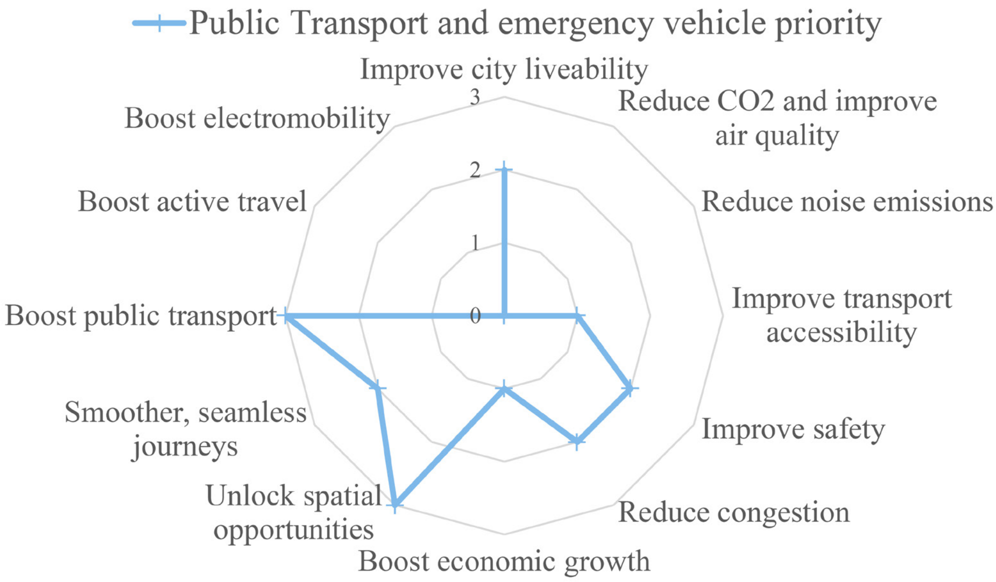
CRITER manages traffic on a 2400 km road network of Lyon. 1096 traffic lights are connected together to the central system, 209 video cameras on the main road axes of Lyon, 477 measuring stations for real time traffic detection and 42 Variable Message Signs are installed (including 22 assigned to bicycles).

Intelligent Urban Mobility Management System of Thessaloniki

The Intelligent Urban Mobility Management System of Thessaloniki1 provides, through its Urban Mobility Centre, e-services to travellers. The system facilitates user mobility and raises their environmental awareness, as well as improving traffic management and control in the central area of Thessaloniki through its Traffic Control Centre.
The operations of the Traffic Control Centre include:
• Dynamic estimation of traffic conditions for future periods within a day;
• Dynamic management of traffic lights based on the estimated traffic conditions; and
• Incident Detection and Management using real-time information.
Overall, the results of the project for the city, the travellers in the city and the city's related entities can be summarised as follows:
• Cooperation and interfaces between involved stakeholders;
• State of the art intelligent urban mobility management system;
• State of the art advanced traveller information services;
• Infrastructures/Equipment;
• Traffic data – Times series databases;
• Updated traffic models and decision support systems;
• Know-how in the field of urban mobility management; and
• Possibilities for continuous further development.

Thessaloniki's Urban Mobility Center, Thessaloniki's Intelligent Urban Mobility Management System, *url: http://www.mobithess.gr/*

4.2 Public transport and emergency vehicle priority



If a traffic management service is aware of the location and intended destination of a particular vehicle then it can give that vehicle priority, e.g. setting signals to green as the vehicle approaches and changing the timings of signals along the vehicle's intended route to accelerate flows and generally clear the path. The interaction can be delivered in a number of ways. Buses in cities are often part of a fleet management system (see below) which can "talk to" the traffic management software to exchange data. Similarly emergency vehicles such as ambulances, fire appliances etc. will have a control centre able to supply the required origin and destination data. The rapidly development of C-ITS provides a highly effective way of alerting traffic management systems to the needs of prioritised vehicles.

Examples:
https://civitas.eu/measure/public-transport-priority-system
https://www.tmr.qld.gov.au/Safety/Road-safety/Emergency-Vehicle-Priority

https://www.galileo-masters.eu/winner/hali-always-green-traffic-signals-emergency-vehicles/

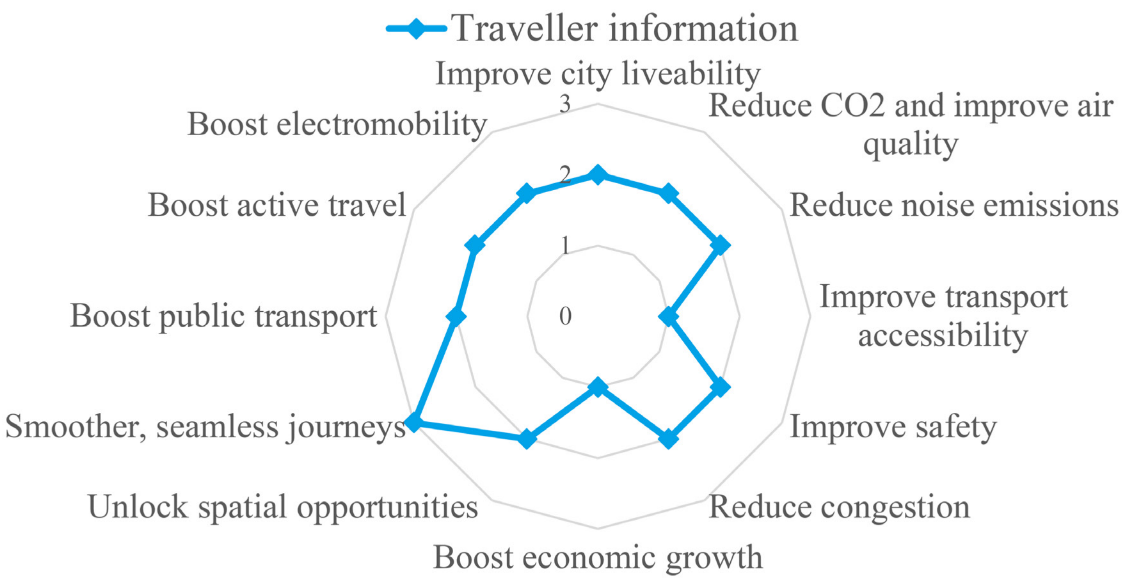
Hali Traffic signal pre-emption system in Finland

HALI is an open traffic signal preemption product for authorities and an open ecosystem to companies. The system is widely used by the authorities in the provinces of Northern Ostrobothnia, Kainuu, Pirkanmaa and Eastern part of Finland. HALI preemption system is based on satellite navigation and wireless communications. The vehicle equipment consists of a programmable 3G/4G modem which has a built-in GPS-chip, external antenna and a control panel. The main software is in a low cost virtual server. Traffic signals are controlled through a programmable I/O controller at the moment but a newer version is going to be developed where there will be solution to send commands directly to traffic light controller´s using software interface from the HALI server using fast data network. Some of the software comes with the devices, but the very heart of the system is a fully customized central software on the server. All of the interfaces are open and the source code is owned and shared by the authorities which make further development possible. Emergency vehicles send data of their location and the usage of their controls when emergency lights are on. The main software tracks movement and different conditions to decide when a forced green is needed. The preemption is started early enough so that the vehicles queuing in traffic lights can move off before the emergency vehicle arrives. The preemption ends when the emergency vehicle crosses the stop line. A convoy gets as long of a green as needed. Traffic lights can work normally between vehicles if the distance is greater. The next version of the HALI-preemption system is planned to be introduced in 2019 and all cities of Finland will be able to adopt the system. A non-profit association is established to manage the open product so that any authority and company can be part of HALI in the future.

City of Vigo - Green Priority service combined with "Emergency Vehicle Warning"

Vigo city is currently providing Road Works Warning, Road Hazard Warning (Traffic Jam Ahead Warning and Stationary Vehicle Warning), Emergency Vehicle Warning, Signal Violation Warning (Red Light Negation Warning), Green Priority (for Emergency Vehicles) and GLOSA (Time to Green). This bundle of services where Green Priority is combined with "Emergency Vehicle Warning" aims to reduce the response times of the emergency vehicles, such as ambulances, fire trucks, and police cars. The combination of the two services can be implemented as follows. The green priority request including the identification information of the emergency vehicle can be published via on-board C-ITS applications in the vehicle. Consequently, traffic light controllers can pick up this information and determine in what way they can and will respond the request. The same information can also be picked up by road side units (RSUs) and/or other vehicles and cooperatively communicated to the traffic on the route of the emergency vehicle. This combination not only allows emergency vehicles to travel faster and safer but also allows other vehicles to react faster and in a safe manner. The traffic manager offers increased priority for the emergency vehicles operated by the emergency vehicle operator. By making use of this increased priority, emergency vehicle operator provides quicker response times for the cases of emergency. To compensate the increased operating costs, the emergency vehicle operator benefits from lessened driver stress in return. The technology infrastructure required for the services is installed and maintained by the technical service provider. In return for the operational costs related to its co-production activities, the technical service provider benefits from the subsidy support provided by the city municipality. Similarly, the traffic manager will benefit from potential market advantage and better market position in return for the operational costs resulting from the prioritization of the traffic lights.

4.3 Traveller information



Traveller information systems aim to deliver timely and accurate information to public transport passengers, drivers, travel planners and fleet managers so that route and mode choices can be adjusted in the light of the information. Services can be accessed from computer terminals, hand-held devices such as smartphones and in-vehicle equipment. These services are especially important as users can be informed in real-time about disruptions, alternative solutions based on their personal preferences/profile or conditions that might influence their behaviour (weather, dynamic pricing change, possible incentives…). For cities, traveller information systems should be seen as a key element of an overall mobility demand management strategy since these information systems can provide the users with direct and focused information, e.g. drivers can be advised of network congestion and be given guidance on where to go for Park-and-Ride of conventional parking. Information can be sent directly to vehicles or displayed on roadside infrastructure such as variable message signs (VMS).

Some cities are starting to use the systems to give warning of poor air quality when traffic signals will be deliberately changed to slow down the flow of vehicles into city centres. As with many other ITS services a key procurement point is purchasing open systems so that traveller information can receive data from other services and can communicate to road user charging and traffic management applications in various ways.

Providing correct travel information is also key in giving all users in the mobility system a seamless and 'care-free' experience. It is key to make sure the quality and amount of information per mode is of the same quality. Active modes of transportation like walking and cycling are often forgotten when it comes to providing and collecting data but have the greatest impact on a more sustainable mobility.

Relevant links:

https://ec.europa.eu/transport/themes/its/road/application_areas/traveller_information_en

"Smart ways to Antwerp" to give all accessibility information and smart alternatives to reach the city of Antwerp: *www.slimnaarantwerpen.be/en*

Smart Ways to Antwerp

The Smart Ways To Antwerp Route Planner is an intermodal route planner which uses real- time mobility data and information on all modes to give the user advice on how to travel from point A to point B. The parameters and logic used by the route planner are defined by the city to make sure route advice is inline with the goals of the city. Users can also create a user account and define personal preferences. This way, the users get route advice that suits them best while still supporting the cities goals.
The API of the route planner is also open for others (eg MaaS and mobility providers) to use

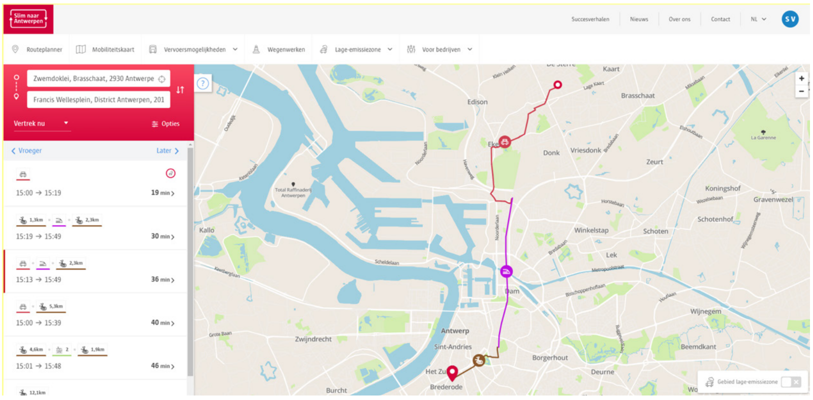


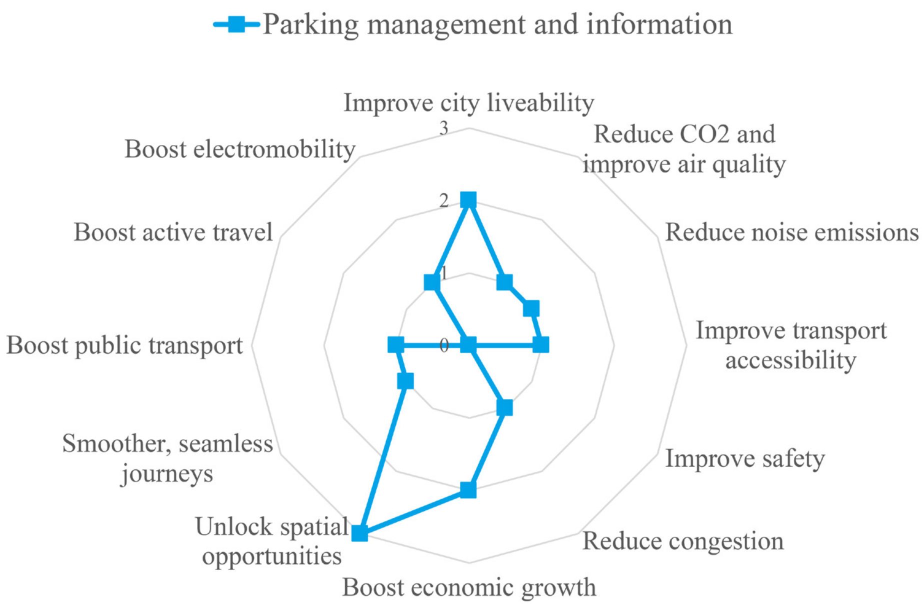
Figure 11 Smart Ways to Antwerp Intermodal Route Planner

'Smart Ways to Antwerp', a project from the City of Antwerp on promoting an ambitious modal split needed a way to inform all types of users on best ways to come to Antwerp and move around in Antwerp. To accomplish this goal, an intermodal route planner was developed to provide users with a combined mobility offer (eg. car to train to bikeshare to walking). Since most users come from outside the city regions, the route planner works for the whole BeNeLux area. The route planner also uses real-time and predictive data in the calculation of the various routes and takes into account various parameters defined by the city (max. walking distance, penalties for certain modes, attractiveness of P+R,...).

Real time traffic data in Newcastle

Newcastle currently implements Road Work Warning, Green Priority, GLOSA, Road Work/Hazard Warning and Blind Spot Detection/Vulnerable road User Warning. These traffic Information services such as road hazard, road works, and traffic jam warning aim to inform the driver in a timely manner, allowing the driver to be better prepared for upcoming obstacles, to improve his or her decision making while driving and to take action in advance. These services can either be offered through Roadside Units (RSUs) or combined with the service in-vehicle signage. RSUs can collect data on road hazards, road works and traffic jams, as well on real-time the behaviour of traffic users. Consequently, through either in-vehicle signage or RSUs, this data can be integrated and communicated to traffic users, allowing them to improve their decision making. The value of these services can be extended through mode and trip time advice in cases where traffic congestion increases or hazardous scenarios occur, allowing the driver to continue his or her journey. This may include dynamic re-routing or advising drivers to take a different mode of transport instead so that a more comfortable and safer trip experience is obtained.
More info on: *https://c-mobile-project.eu/*

4.4 Parking management and information



In many cities there is extensive wasted time – and the associated gaseous emissions – as vehicles roam the network looking for places to park. The location of the larger, managed, car parks is not always well signposted and drivers complain of a slow or difficult journey only to find on arrival that the car park is full. The solution, of benefit to both operators and users, is some form of parking management system that counts vehicles in and out of parks and so is able to indicate the current numbers of vacancies. This approach can be taken further if historic data on occupancy is available as it enables some predictions to be introduced thereby reducing the possibility that a vehicle is directed to an apparent vacancy that disappears at the last minute.

Los Angeles has experimented successfully with the management and dynamic pricing of on-street spaces. Roadside sensors detect the presence of vehicles so spaces can be notified to subscribers using the parking app. Under-utilised spaces can be offered at a reduced price and spaces in highly popular locations can be given a surcharge. This new approach has increased space usage by about 30% and income by about 15%; there is early evidence that parking times are reducing slightly as drivers feel more confident that a delayed arrival will not lead to a missed parking opportunity.

Examples:
https://link.springer.com/chapter/10.1007/978-3-319-07293-7_31

Smart Parking Management System in Trikala

This system allows the identification, imaging and monitoring of designated parking spaces in the city centre. Two major roads in the centre of the city (Othonos and Garibaldi streets) have specialized sensors, with each sensor corresponding to one discreet, delineated parking spot. Thus, each sensor provides feedback to the network's controllers by sending appropriate signals when the spot is occupied or unoccupied. Furthermore, local community and tourists can be informed in real time about the availability of parking spots in the selected area, both through the parking mobile app for smart phones and through signs that are installed in central points around the city. The application also offers the option for electronic payment for a parking spot. Through the city's ongoing SUMP, this service will be extended in a larger area in the city centre. More info: https://trikalacity.gr/en/smart-parking-system/

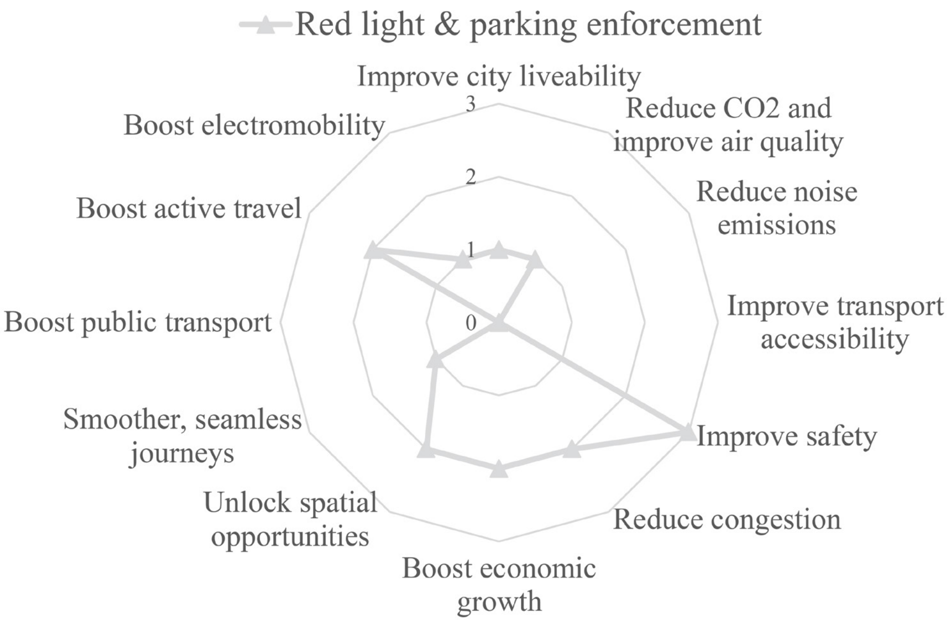
Urban Parking in Bordeaux

Bordeaux currently implements Urban parking, Road Work Warning, Road Hazard Warning, Emergency Vehicle Warning, Signal violation warning, GLOSA and In Vehicle Signage. The municipality, as representative of vehicle drivers in the city, is offered green and comfortable commuting in the city through offering a service bundle including urban parking availability, mode and trip time advice and in-vehicle signage. A service provider offers a software application (either as a smartphone application or as on-board unit) to commuters by vehicle which is financed by the municipality. The application allows car commuters to use the service bundle, which collects data on the location and desired destination of the user. This data is integrated with data on parking availability near the user. Consequently, advice and guidance is presented to the user on where to find the nearest suitable parking space, accompanied by mode and trip time advice to reach the desired destination from this parking space (if necessary). Preferably, parking spaces are selected outside the city centre to avoid congestion in the inner city. To stimulate this behaviour of the user public transport tickets are offered through the application for reduced tariffs or even free, depending on the current traffic situation and behaviour in the city. Commuters by car are therefore stimulated to avoid driving or cruising around the inner city to find a parking space which should reduce pollution and driving stress and create greener and more comfortable commuting experience for car commuters.
More info on: https://c-mobile-project.eu/

Freight delivery in urban area with parking availability spots in Bilbao

The service implemented in Bilbao provides information to help its users make informed decisions about available parking places. It aims to reduce congestion, time loss, pollution and stress caused by cruising for parking. Based on user data and parking availability data near the user which can be collected through roadside units (RSUs) and / or on-board applications, the service offers an optimal advice to the user (through in-vehicle signage) with regards to the nearest available parking space, in order to minimize the search for a suitable parking location. The value of the service can be further enhanced through accompanying urban parking availability by mode and trip time advice to facilitate travelling from the parking location to the desired destination. In this way parking outside congested areas or high traffic city sections can be made more comfortable. It addresses traffic disruption due to urban freight transport by bringing structure into the management of parking process and capacity during urban freight delivery through the use of parking availability service. Technically, the parking availability is enabled by an application where Parking Operator offers time and availability information about parking spots that are allocated for freight delivery and Truck Drivers of logistics companies (or of specific associations) indicate their urban delivery information (required time and duration) through reservation. However these schemes are effective only when all relevant stakeholders collaborate closely and the system is operated and monitored effectively. The key stakeholders include the City Municipality (that owns the parking spaces and is required to regulate this process for traffic efficiency and security), Retailers/Shops (that require delivery of goods for their operation), and Logistics Companies (or Truck Associations) that offer the delivery service. The City Municipality provides the parking space that is appropriate for freight delivery free to relevant parties, and pays the Parking Provider for operating the service. In return it benefits from the optimized use of parking space, and -more importantly from better traffic management leading to less traffic disruptions around these spots. The Parking Provider organizes the time availability of these parking spots, and operates the reservation system, and in turn benefits from the service fee it receives from the City Municipality. Although the Truck Drivers can be less flexible in the time-window for their delivery, they will spend less time (and fuel) for looking for appropriate parking spots and will benefit from securing a parking spot that can be more appropriate for loading/unloading. Trucks that stay longer than their reserved time-slot can be subject to increased parking rates or fines. As a remark, specific parking slots that are used for loading/unloading can be equipped with sensors that read licence plates to confirm the presence of the vehicles.
More info on: https://c-mobile-project.eu/

4.5 Red light and parking enforcement



Many cities have installed static cameras at junctions to detect red light running and have mobile cameras fitted to local authority vehicles, especially buses, to detect unlawful parking and in particular parking in restricted areas at junctions or in bus lanes. These installations can be easily linked to a back office that tracks vehicle owners from the licence plate number and automatically launches the enforcement process with the photographic evidence in support.

Examples:

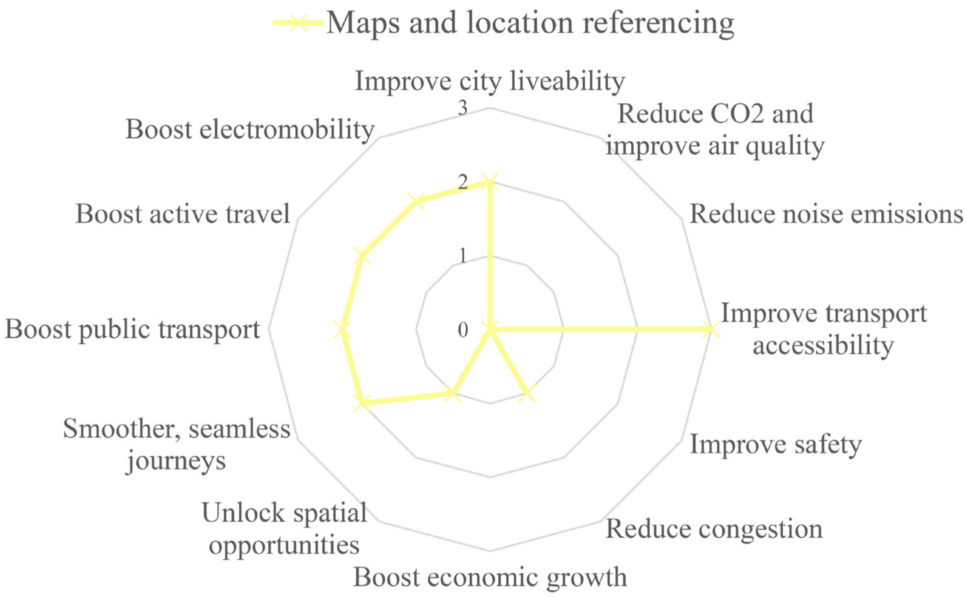
https://www.nidirect.gov.uk/articles/enforcement-bus-lanes-and-bus-only-streets

Smart Parking Management System in Trikala – with parking enforcement

In addition to the functions of the Smart Parking Management System explained in 4.4, traffic control authorities are provided with real-time information about illegal parking instances through static cameras.

More info: *https://trikalacity.gr/en/smart-parking-system/*

4.6 Maps and location referencing



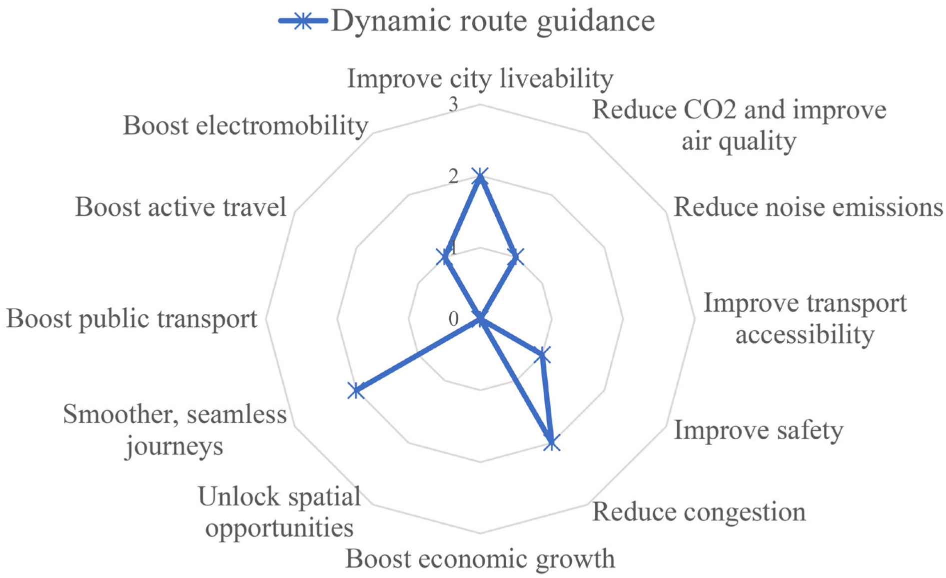
Maps are essential ingredients of most ITS services and there has been a steady move to convert traditional style 'analogue' maps to digital format for over 30 years. Current digital maps are very precise and are able to add layers of information on local features. There is still not a complete international standard on mapping, so it can be difficult to integrate the products from competing suppliers. In parallel with the development of digital maps and techniques for handling storage and updating there has been massive growth in the improvement of position determination using satellite signals.

In the early 1970s the US Government launched a number of satellites (Global Positioning System or GPS) designed to give military users position fixing accurate to around 10m. In 1983 the US government made GPS available to any user with reduced precision compared to the military version and in 2000 the deliberate degradation of the signals was stopped, improving the positioning from about 100m to around 10m. In addition to GPS there are a Chinese system BeiDou, a Russian system GLONASS and an EU system GALILEO. Positional accuracy to 5m or better is now very easy to achieve and the cost of portable or in-vehicle receivers is continuing to drop.

Examples:
https://www.sciencedirect.com/topics/earth-and-planetary-sciences/digital-mapping

https://unstats.un.org/unsd/geoinfo/UNGEGN/docs/_data_ICAcourses/_HtmlModules/_Documents/D06/documents/D06-04_KnippersPPTeaching.pdf

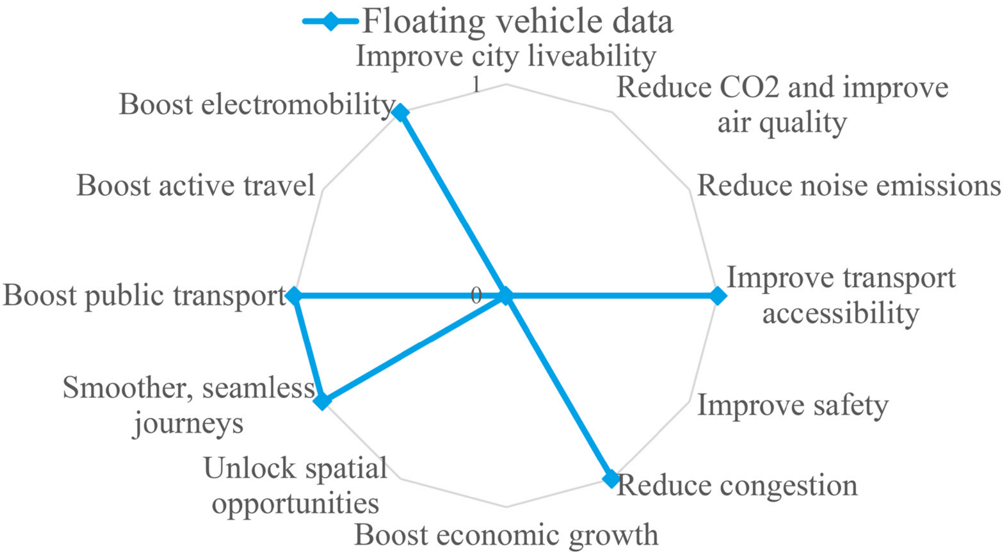
4.7 Dynamic route guidance



The earliest in-car navigation system was introduced around 1981 and was based on sensors measuring a car's acceleration and direction to generate changes to the known starting position. About 10 years later the first commercial product appeared that used GPS to determine position that could be shown on a digital map. A wireless telephony link enabled the system to be notified of traffic congestion, bad weather and incidents so that the calculated route to a destination could be amended. In common with many ITS products, the physical size and cost have dropped dramatically and route guidance services or "SatNav" are now available in smartphones for negligible extra cost.

Examples:
https://www.hindawi.com/journals/misy/2016/3727865/

4.8 Floating vehicle data



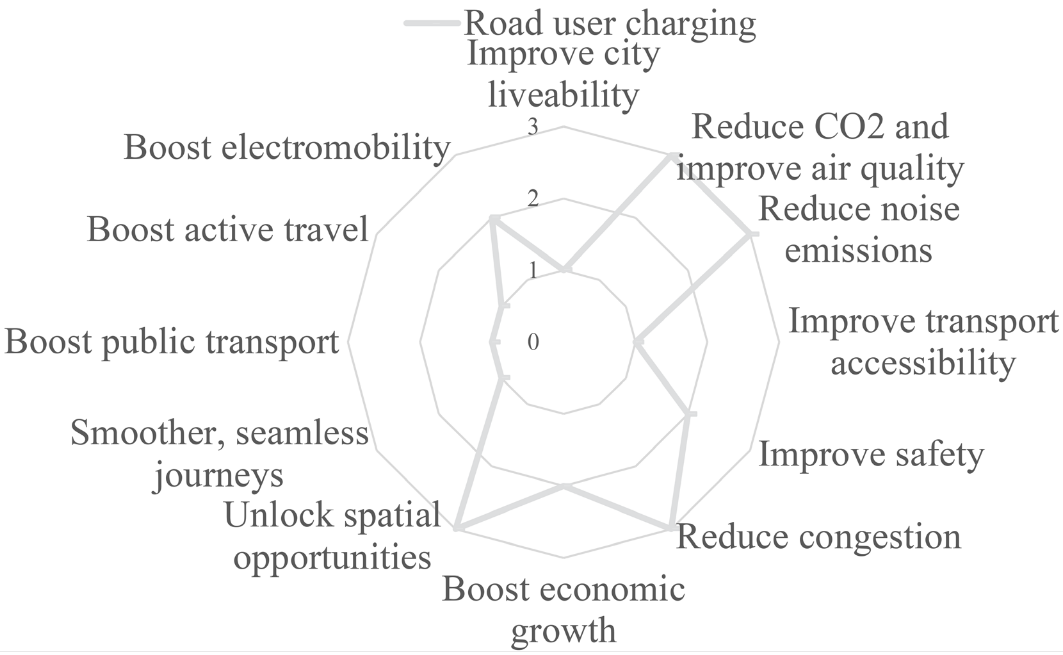
Floating vehicle data is often referred to as 'probe vehicle data'. It is a data service based on participating vehicles sharing their location on the road network so by comparing the time difference between multiple points the journey time between the points can be measured. Combining data from many individual vehicles gives network managers details of traffic speeds at different places in the network. A city authority could choose to install roadside beacons and collect the data directly from suitably equipped vehicles, for example its own buses. Singapore uses equipped taxis to measure the average traffic speeds and this information is used to drive changes to the prices in the Congestion Charge system. However private drivers would need to see a benefit from supplying the data and might require stringent measures to ensure that their privacy was maintained.
A number of suppliers of route guidance services (see link below) have incorporated anonymised location feedback into the on-board device that serves the double purpose of generating real-time data for the route guidance calculations and building probe data records that can be sold commercially.

Examples:
https://www.researchgate.net/post/What_is_floating_car_data_method_or_data

Antwerp FlowCheck (Be-Mobile)

The City of Antwerp uses FlowCheck by BeMobile to monitor key axis in the city center. In the past couple of years, major? roadworks on various arteries of the city have been performed. To keep an eye on the impact of these roadworks on congestion levels, FlowCheck was used to do periodic analysis of major? axis. When extreme build-up of congestion was detected overtime, measures were taken. Combined with the data from ANPR-cameras (counting vehicles in and out of the city), these analytics made it possible to limit the impact of the roadworks.

4.9 Road user charging



Road user charging, also known as 'road pricing' or 'congestion charging' is deployed around the world to combat congestion, reduce carbon and other polluting emissions, compensate for falling revenues from fuel taxes, improve the efficiency of the existing transport infrastructure, recover the costs of new infrastructure such as roads and bridges and to meet the 'economic theory' principle that "the user pays" or "the polluter pays". Road pricing is already in operational use in many countries but issues remain regarding user acceptance especially for new schemes. It is important when considering the introduction of pricing to establish how the acceptance problem has been addressed in existing operational scenarios. It has been demonstrated that if users understand the reasons for it – and above all if they have experienced it in use and understand how it will affect them personally – acceptance follows.

There are various systems for road user charging but they all require a method to detect that a vehicle is at the edge of a charge area, a way to identify the vehicle or the driver to link to a payment method, and a way to detect and enforce accidental violations or deliberate evasion. There are three widely adopted complete systems: i) using an on-board microwave transponder that records the passage of the vehicle at roadside transmitters and generates an off-line payment (much of France, Singapore, Florida etc.); ii) fitting an in-vehicle unit that uses GPS location and digital maps to plot the journey, match to charge rates and create an off-line account (German lorry charge scheme); iii) use of number plate recognition cameras to log the movement of a vehicle in and out of charge areas to generate an off-line account (London).

There are a number of policy principles for levying the use charge:

• Passing through a specific link [French Autoroutes, many river crossings]
• Passing through each one of many links [French Autoroutes]
• Being in an area [London, Stockholm]
• Causing congestion [Singapore]
• Being in each one of many areas [CityLink and EastLink Melbourne]
• Each km you travel on a link [German lorry scheme, Oregon Opt-in scheme]

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• Each km you travel varied by vehicle weight, time of day, class of road, degree of congestion etc. [Swiss and Austrian lorry schemes]

Road user charging is one of the oldest established ITS services able to meet a variety of specifications. However, the key point for procurement is setting requirements based on an open platform so that future changes to the initial system can be put to competitive tender and the key data items collected by any system can be used in the deployment of other services.

Relevant links:
https://www.intelligenttransport.com/transport-articles/1402/technological-trends-in-road-user- charging-and-congestion-charging-systems/

https://www.eta.co.uk/2012/04/26/what-is-road-user-charging-and-why-is-it-important/

https://www.racfoundation.org/wp-content/uploads/2017/11/acceptability_of_road_pricing- walker-2011.pdf

Antwerp UVAR and MaaS-incentive

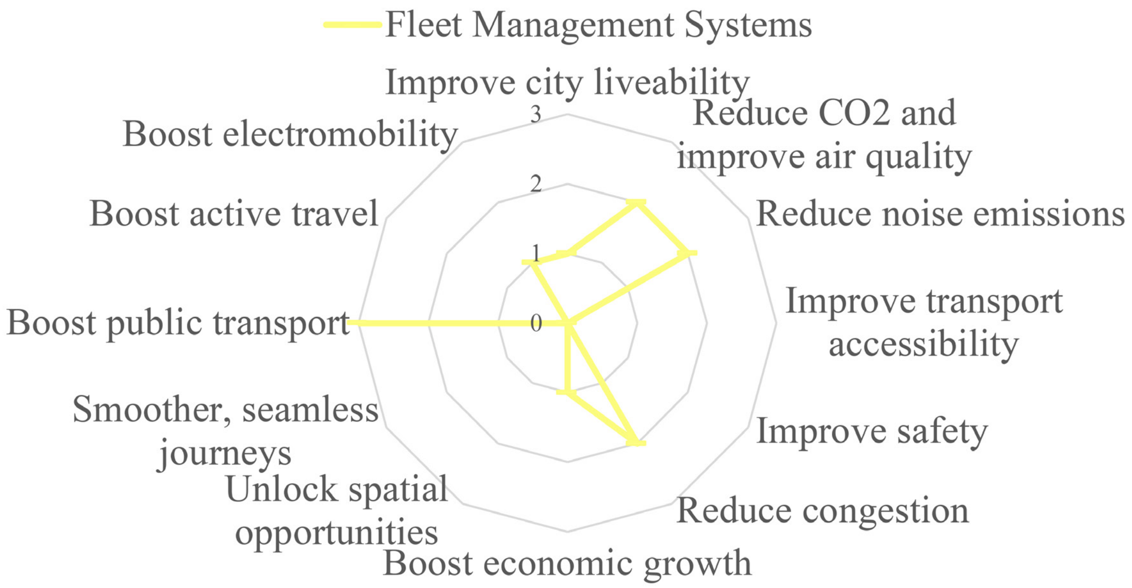
The norms for LEZ in Antwerp will become more stringent in 2020. Since this is a moment where people will consider if they still need to buy a new car or not an incentive was created where inhabitants of Antwerp can get a reduction on their MaaS-subscription if they hand-in their parking permit. By combining both measures, car use is decentives and shared mobility is promoted. The data collected through both schemes can be used for more insights and improve the MaaS-offering.

Congestion charge system in Stockholm

The implementation of the Congestion charging system in Stockholm has a main goal to reduce traffic congestion in the Stockholm inner city. The Stockholm Congestion charging system includes the following main parts:Tolling Stations; Data Service Centre; Toll Charger's Central System.Tolling stations is the road side system, where gantry mounted cameras takes images of passing vehicles license plates. Images are processed by an OCR engine, to get the license plate number in clear text. The Data Service Centre processes and stores the vehicle passage data collected from tolling stations and is responsible for data exchange with Toll Charger's Central System. The Central System identifies vehicle owners, does manual validation on images with poor OCR results and manages a helpdesk for the public. Once the owner of the vehicle has been identified, a tax is levied. The Central System also provide web based services, where vehicle owners can review their own passages.

https://www.transportstyrelsen.se/en/road/Congestion-taxes-in-Stockholm-and-Goteborg/

4.10 Fleet management systems



Fleet management is the organisation and coordination of working vehicles. Effective fleet management can help to reduce the cost and improve the efficiency of keeping business vehicles and commonly consists of tracking a vehicle's location and mechanical information, as well as monitoring driver behaviour, using a range of on-board sensors and data collection linked to the operating base by wireless. The vehicle location and potential range become important when matched with the business's orders so that, for example, arrangements can be made to allocate a 7.5 tonne truck for a load of only 5 tonnes and not a 12.5 tonne truck with its higher running costs.

The aims of managing a fleet and the operational principles remain largely the same regardless of fleet type, however the underpinning tasks will vary depending on the size of a business and the volume of business vehicles. For heavy vehicles the system can monitor the driver's hours at work to ensure compliance with international regulations and also check the axle weights and load distribution. For lighter vehicles the performance of similar vehicles can be assessed as well as measuring how economical drivers are with similar vehicles on similar routes. Vehicles carrying very valuable cargo can be equipped with a variety of security devices to deter theft.

Examples:
https://www.rac.co.uk/business/articles/your-business-matters/what-is-fleet-management

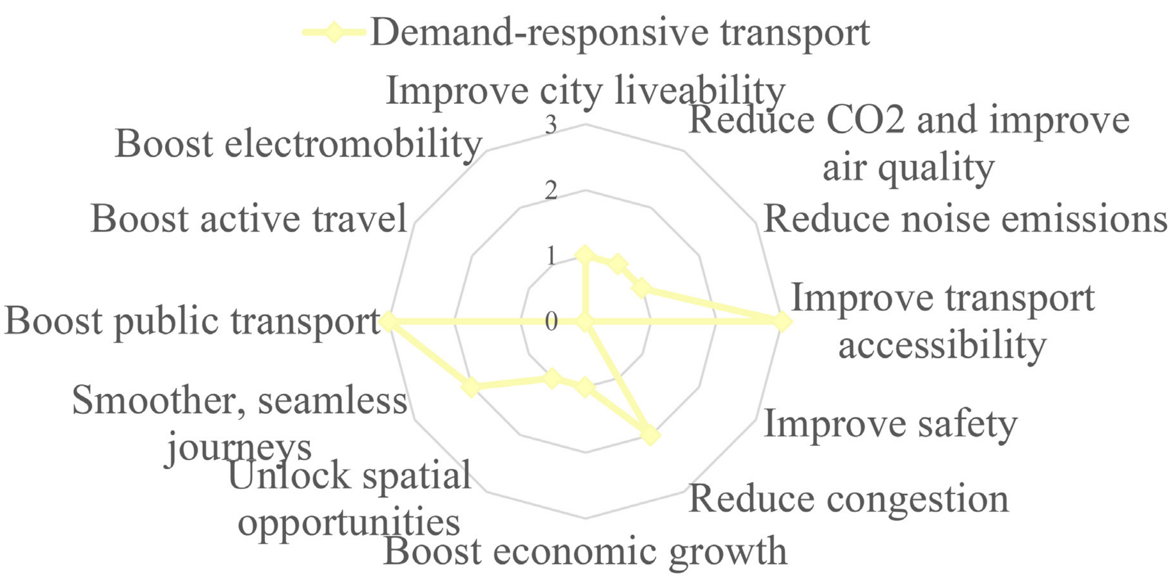
https://dtc.jrc.ec.europa.eu/dtc_smart_tachograph.php

Trucks traffic management in the urban area of Helmond

The City of Helmond has chosen to develop and upscale GLOSA and priority at intersections for trucks in order to mitigate the impact of freight traffic in the urban area. Thanks to Co-operative Intelligent Transport Systems (C-ITS) - in particular green priority and green light optimal speed advice (GLOSA) - trucks can anticipate their approach to identified intersections and avoids stopping at intersections. The C-ITS solutions that have been implemented in the city of Helmond to reduce the impact of truck traffic in the city have had benefits notably on what regards the fuel consumption of trucks emissions. The cooperation between the various public and private entities was fruitful and companies involved want to cooperate in further deployment. The feedback of the drivers and the logistics operators has been rather positive – notably on the perception of improved comfort, travel time and of reduction of fuel. The City has increased in-house knowledge and expertise of C-ITS and reinforce the links and partnerships with local stakeholders. The City of Helmond is very much focused on making the next steps towards large scale deployment of C-ITS solutions. Its mobility policy ("Helmond Mobiel 2015") focuses on a better use of existing infrastructure through the use of cooperative technology. Services for professional users like green priority, GLOSA are to be up scaled in a near future notably through EU projects like C-MOBILE.

More info on: *https://www.helmond.nl/BIS/2007/notities%20en%20kaarten/126,%20Helmond%20Mobiel%202015.pdf*

4.11 Demand-responsive transport



Demand-responsive transport (DRT) is a variant of public bus transport. Bus transport invariably operates to set timetables on fixed routes so has the potential benefit of a regular service enabling reliable transport planning. However, the negative aspect to this is that for some customers the fixed route does not go close enough to where they want to start a journey so for many reasons, for example limited personal mobility, accessibility is limited.

The essence of the demand-responsive service is flexibility: the customer makes contact with a central office (telephone call, on-line access or postal request) to seek a trip from place A to place B at around x O'clock on dates D or E. The central office then assembles the various proposals and uses the sort of software that delivery companies use to plan journeys to devise a route that minimises distance travelled and maximises the numbers of pick-ups. The individual travellers can then be given a price, or for socially provided travel approval can be sought.

To work efficiently and effectively DRT needs travellers to have a degree of flexibility in their requests, good communications between travellers, service operators and traffic managers, and fast reactive journey planners.

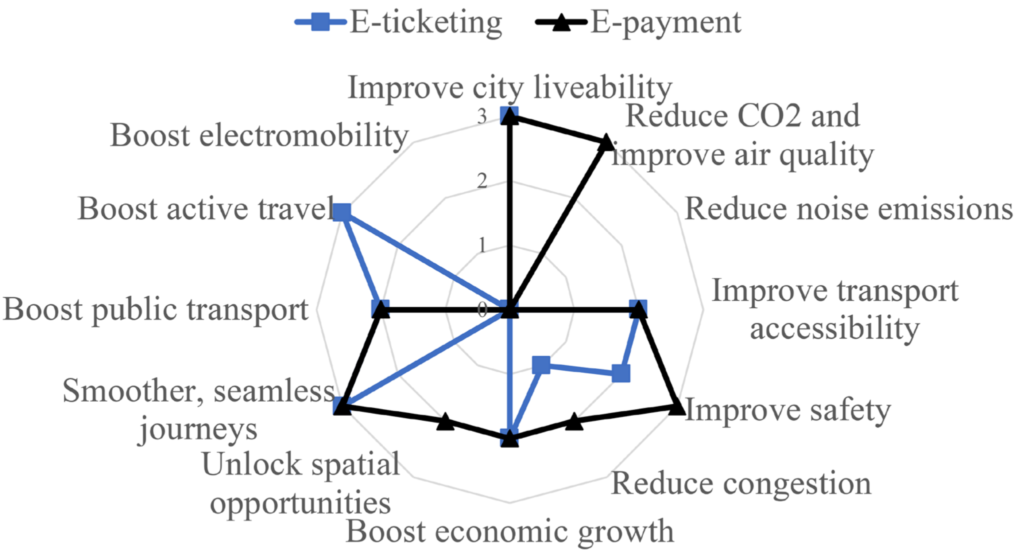
Examples:
https://ctauk.org/wp-content/uploads/2018/05/The-Future-of-Demand-Responsive-Transport-1.pdf

Bristol-based ride-to-work micro-transit service

Slide is branded as a 'ride to work' transport service, established in 2016, operating in Bristol until 2018. The service targets the heavily congested morning and evening peak hours along major commuter routes. Pick up and drop off locations can require a short walk for passengers, but are designed to make more optimal routes for drivers.

More info on: http://www.slidebristol.com

4.12 E-ticketing and E-payment



A traditional transport "ticket" is a piece of paper or cardboard giving the details of the origin and destination of the journey that has been paid for, any associated conditions such as flexibility, times of day when use is permitted etc. and the legal conditions under which the journey is made. In order to give increased flexibility to travellers, and reduce the requirement to have access to some sort of printer in order to collect a ticket, many PT providers now offer a range of ticket types including those based around QR codes that can be displayed on smartphone screens and scanned by entry gates and ticket inspectors.

Innovations in ticketing have also coincided with innovations in payment technologies. Numerous cities now issue some form of smart card, a credit-card-size device that has a small amount of processor power and storage and derives its electrical power by Near-Field Communication with infrastructure so that battery power is avoided. This type of city card can be issued as a "once-off" for a single journey, charged with money for pay-as-you-go trips, or used as the identification device for a weekly, monthly or longer travel pass. The traditional banks and credit card companies have also moved into the transport market with the use of contactless payment cards on city transport at 'swipe in' 'swipe out' terminals.

There are many advantages from the use of E-ticketing and E-Payment such as reduced costs of handling cash, reduced fraud and similar losses, increased business data available in real-time, greater flexibility in ticket pricing and implementing changes to fares. However the design of systems needs much care. Many commercial transport providers have launched their own E-schemes to encourage brand loyalty and linking these into one interoperable package, such as MaaS requires, is far from straightforward. Services need to be planned to ensure that card issuers and account management companies are not given near-monopolies and that future upgrade and change paths are guaranteed. And operators need to keep in mind that users want one "universal" card and not a wallet of many.

Relevant links:

https://searchsecurity.techtarget.com/definition/smart-card

http://www.stm.info/en/info/fares/opus-cards-and-other-fare-media/opus-card

https://www.stib-mivb.be/article.html?l=enand_guid=30af0085-2483-3410-5394-a71daf08acd1

Integrated mobile e-ticketing system in Rome

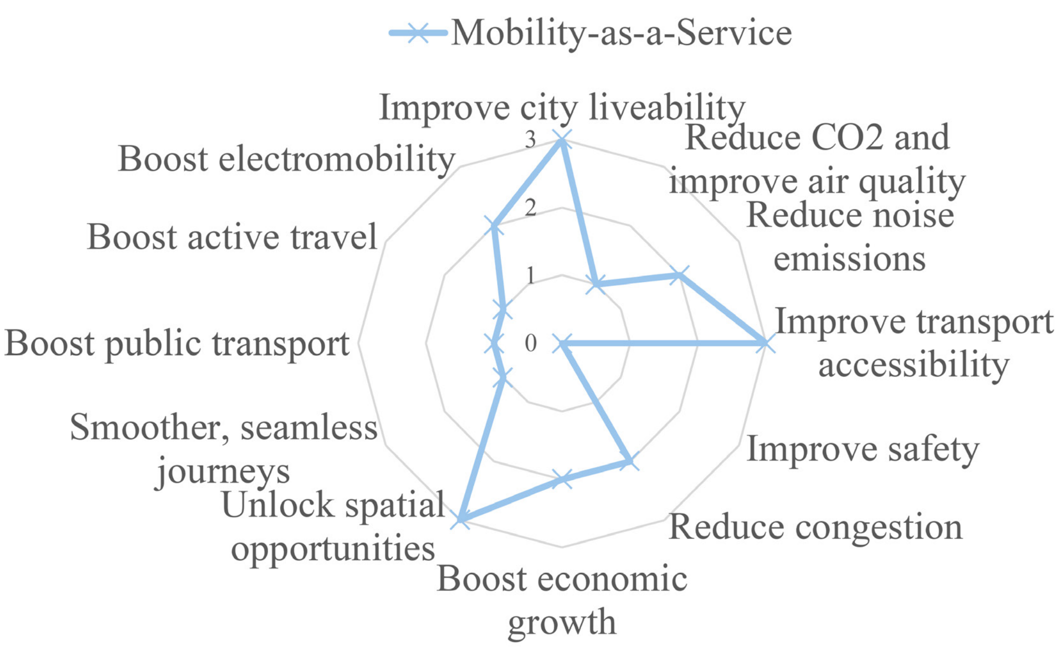
In the second half of 2015 a new service called BIPiù was launched in Rome . The new service allows the purchase of "dematerialised" bus and metro tickets via smartphones. The BiPiù service is available through myCicero®, a free application available in the App Store and Google Play. myCicero integrates in the same App all the information on local mobility, schedules and route calculation, purchasing tickets for bus and metro, and on-street parking payment. myCicero from 2015 provides in Rome a new service for contact-less & Mobile Ticketing responding, on one hand, to the needs of new customer segments through the dematerialization of the media and, on the other, the needs of virtualization of sales network through new distribution channels capable of ensuring time coverage of 24 hours a day and a specific offer, compared to changing customer needs. Basically, once the user is registered to myCicero service, s/he can buy a ticket via the App and get on the smartphone the equivalent of a paper ticket (Figure 11). The validation of the ticket will then happen nearing the smartphone to the QR-Code present on buses or the Metro gate, and by tapping a button on the App. With the new ticketing system (although the classic paper ticket still remains) also the control methods become technological: controllers are provided with a handheld device with a dedicated application to check if the ticket is actually validated.

More info on: https://viajeoplus.eu/best-solutions/

Antwerp P+R plus free PT-ticket

To promote the use of Park&Ride schemes in Antwerp a combined offer was launched. Users could get a free De Lijn (PTA) ticket if they parked on a P+R. Thanks to the Mobile-ticket of the PT operator, it was possible for 4411 (digital parking ticket reseller) to sell both tickets in a seamless way for the customer while validating if the P+R and PT were actually used.

4.13 Mobility as a Service



Mobility as a Service (MaaS) is a term used to describe a move away from personal ownership of a travel mode such as a car and towards purchasing a mix of mobility solutions that are provided in the same way as any other service. MaaS is enabled by combining transport services from public and private providers through a unified gateway that creates and manages the elements of the overall trip with users paying with a single account. Users can elect to pay per trip or via a monthly fee for a designated volume of 'mobility'. A key MaaS goal is that an end-user app should work in different cities, so that travellers can roam without needing to become familiar with a new app or to sign up to new services.

Two concepts are key to the success of MaaS: i) travellers need to move away from the assumption that they need to own their personal travel provision; and ii) providers need to move away from wanting a very high market share with a fairly fixed corpus of 'our customers' to a model where they are in effect a wholesale provider to a smaller retailer.

MaaS is supported by many innovative new mobility service providers such as ride-sharing and e-hailing services, bike-sharing programs, and car-sharing services as well as on-demand "pop-up" bus services. The expectation of self-driving cars within a few years is another strong driver as it will challenge the economic benefit of owning a personal car over using on-demand car services. MaaS relies on improvements in journey planners, in particular the ability to integrate multiple modes of transport into seamless trip chains, and the availability of open platforms so that bookings and payments can be managed collectively as one financial transaction covering all legs of the trip.

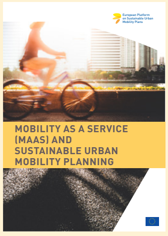
It is thought that the first real MaaS Service started running in Helsinki in Finland in 2017.

For more information on how to integrate MaaS in your SUMP, please consult the Practitioner Briefing on MaaS:

Relevant links:

https://maas.global/maas-as-a-concept/

https://maas-alliance.eu/



Further guidance on Mobility as a Service can be found in the **Practitioner Briefing Mobility as a Service (MaaS) and sustainable urban mobility planning**

(https://www.eltis.org).

MaaS in Antwerp
In the past couple of years, multiple private MaaS-players have become active and have been actively supported by the City of Antwerp. The various players have different approaches to the implementation of their services. Skipr and Whim are stand-alone apps with their own branding offering both B2B and B2C products. Olympus Mobility is more a platform provider whose services are integrated in banking apps (KBC & Belfius) but they also offer B2B-solutions.

The biggest challenge for all the players is the integration of the various mobility solutions and the financial model behind the reselling of these services. Since margins on many mobility services are already low (or even negative...), it is difficult for most MaaS-players to find a good business model themselves. It is key to stimulate PTO to create a product offer that is interesting for resellers/integrators/MaaS-players so that they in turn can create an integrated offer which is most interesting for the end-user and which provides them with a seamless travel experience. [Strange sentence. What does it mean exactly for PTOs?]

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6 Annexes

6.1 The EU legal framework for ITS implementation

In order to stimulate the use of ITS around Europe EU put in place a legal framework that aims to a) facilitate the use of data produced by ITS and b) support coordinated and interoperable deployment of ITS along the TEN-T corridors and in urban and interurban environments.

The milestones of efforts been undertaken for supporting implementation of ITS are the ITS Action Plan and the ITS Directive 2010/40/EC. Following these the Urban ITS Expert Group has been formed, to study the specific needs and potentials of ITS in urban areas.

The activities of the expert group have resulted to the publication of guidelines covering:
• Multimodal Information
• Smart Ticketing
• Traffic Management
• Standardisation needs
• Best Practice Collection

The reports are available at *http://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupDetail&groupID=2 520.*

The EC having acknowledged the importance of C-ITS formed the C-ITS Platform, a cooperative framework including national authorities, C-ITS stakeholders and the EC, to develop a shared vision on the interoperable deployment of C-ITS in the EU. The C-ITS Platform developed two reports in 2016 and 2017, available at *https://ec.europa.eu/transport/themes/its/c-its_en.*
The EC has adopted in 2016 the European Strategy on Cooperative Intelligent Transport Systems (COM 2016/766 *https://eurlex.europa.eu/legalcontent/EN/TXT/HTML/?uri=CELEX:52016DC0766&from=EN),* aiming to accelerate the deployment of C-ITS in Europe.
The strategy includes the adoption of the appropriate legal framework at EU level to ensure legal certainty for public and private investors, the availability of EU funding for projects, the continuation of the C-ITS Platform process as well as international cooperation with other main regions of the world on all aspects related to cooperative, connected and automated vehicles. It also involves continuous coordination, in a learning-by-doing approach, with the C-ROADS platform, which gathers real- life deployment activities in Member States. Security and certificate policies for the deployment of C-ITS technologies are also supported as a result of the C-ITS Strategy.

The role of Intelligent Transport Systems (ITS) in Sustainable Urban Mobility Planning:

Make smarter integrated mobility plans and policies