CIVITAS
Cleaner and better transport in cities

POLICY NOTE

Intelligent Transport Systems and traffic management in urban areas

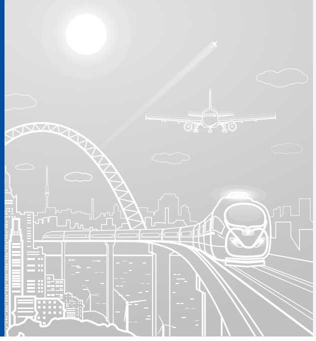


Table of Contents

Preface

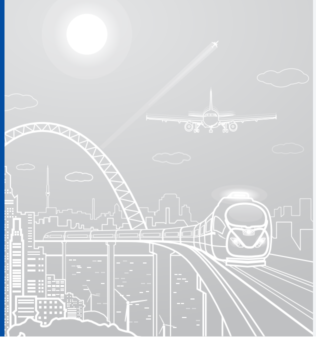
This is the fourth policy note in the CIVITAS Policy Analysis series developed by CIVITAS WIKI. CIVITAS WIKI policy notes are intended to inform decision makers and urban professionals on relevant topics that currently play an important role in urban mobility planning and operations.

This policy note addresses the topic of urban Intelligent Transport Systems (ITS) and traffic management. ITS and traffic management applications help cities to achieve policy goals with regard to accessibility, livability and safety. Accelerated by technology and ICT developments, the possibilities of using ITS and traffic management in urban environments have increased substantially in the past decade. This document provides information about recent developments in ITS and traffic management. In doing so, the document is intended to provide support to urban professionals in an initial selection of measure types suitable for their situation. The authors of this policy note are aware of the fact that this is a very broad topic and that this note will not answer all questions that readers might have when it comes to the selection and implementation of ITS and traffic management measures in cities. However, we hope that this note offers help, guidance, insights and information to make that easier.

We hope you enjoy reading this note.

The CIVITAS WIKI team

This publication was produced by the CIVITAS WIKI consortium. The policy note was compiled by Eline Jonkers and Teije Gorris (TNO, the Netherlands). The authors of this policy note would like to thank Mary Panagopoulou for her research, Ivo Cré, Leon Deckers, Suzanne Hoadley, Ben Immers, Jeroen Kosters, Emile Oostenbrink, Julie Raffaillac, Arjen Reijneveld, Henk Schuurman and Henk Taale for discussing with us their work and the content of this note, and Mike McDonald and Isabel Wilmink for doing all that as well as reviewing the manuscript.



Introduction

Background

European cities are facing a number of challenges that are related to transportation. Economic costs of traffic congestion are estimated to be 80 billion Euros annually (European Commission, 2013-1). Urban areas account for 23% of all CO_2 emissions from transport (European Commission, 2013-1). Urban areas account for 38% of Europe's road fatalities, with vulnerable users such as pedestrians being particularly exposed (European Commission, 2013-1). Other transportation challenges are related to the robustness and reliability of the public transportation system and increasing parking demands. With high population densities and a high share of short-distance trips, there is a great potential for cities to contribute to reducing greenhouse gas emissions from transport by 60% by 2050 and halving the use of "conventionally fuelled" cars in urban transport by 2030 (European Commission, 2011).

Managing urban traffic requires finding a balance between throughput, livability, safety and sustainability. As cities are expected to grow in the coming decades (leading to increased traffic demand), the challenge of managing traffic will increase, as space to develop road networks is often limited or non-existing. That urban traffic is characterized by a mix of different modes of transport (pedestrians, bicycles, public transport, motorized vehicles) makes the challenge even more complex.

Intelligent Transport Systems (ITS) and traffic management are instruments that enable operators of urban transport networks to manage traffic and transport to meet policy goals. ITS and traffic management approaches can lead to positive effects on throughput, pollution, and safety. For example, (real-time) information on eco-friendly modes of transport such as walking, cycling and public transport can influence change to more sustainable modes, whilst optimizing control settings of traffic signals can reduce fuel consumption and emission of pollutants.

Goal of the policy note

This policy note aims to provide information and support for professionals working in or for European municipalities (decision makers, urban/transport planners). This note can be used to help in the initial selection of ITS and traffic management measures to meet local conditions of mobility characteristics, challenges and policy goals.

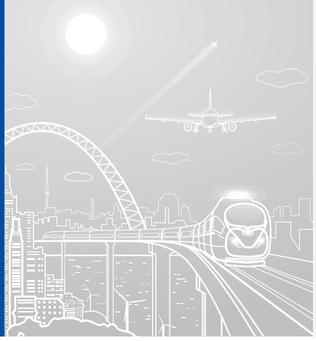
Step by step guidance

The first part of the policy note describes an approach to translate urban (mobility) policy goals into a logical and structured set of ITS and traffic management solutions. The second part of the note provides background information and practical examples.

The approach presented builds upon the Handbook Sustainable Traffic Management (in Dutch 'Gebiedsgericht Benutten') (Rijkswaterstaat, 2004), which has been applied extensively since 2004 mainly to interurban traffic situations. The approach has been adapted for this note to make it relevant for cities. A five step guide is provided to help develop a business case for ITS and traffic management measures. The process starts with the positioning of ITS and traffic management in the urban mobility context and a structured approach to selection of services and measures is provided. It concludes with guidance on 'selling the story'. See the figure on the next page for an overview of the steps.

The approach has specific advantages. Firstly, it works from an integrated viewpoint for the city's traffic and transport system. It is not focused on one specific area or one specific problem but on a coherent set of measures and solutions. As such it is in line with the guidelines for sustainable urban mobility planning. Secondly, the approach starts with a comprehensive analysis of the current state of the city, instead of jumping immediately to possible solutions. Finally the approach ensures building commitment from the city stakeholders, from the operational to the strategic level.

Gebiedsgericht Benutten, (Rijkswaterstaat, 2004) has been used in the description of the steps.



Background information and examples

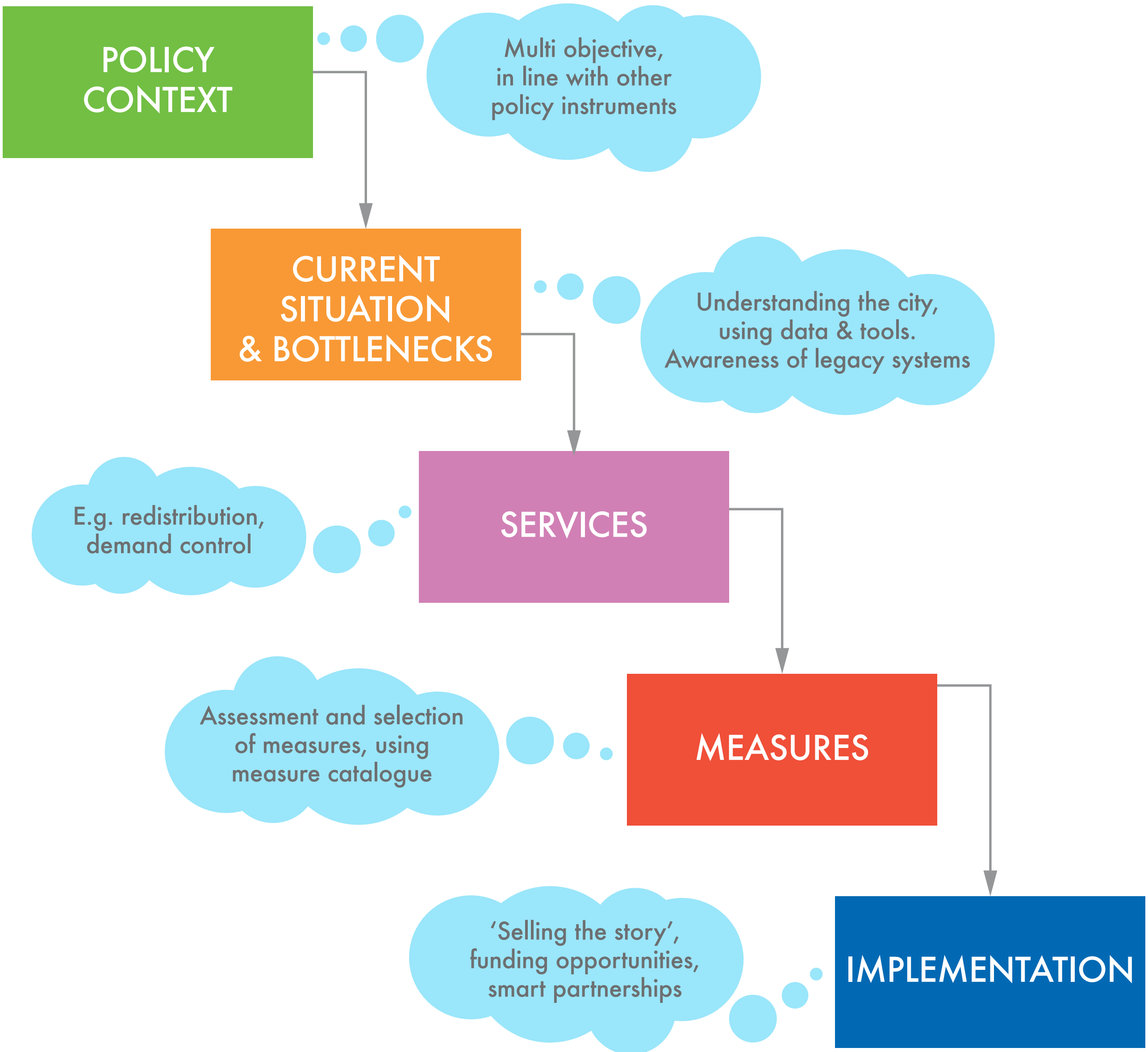
As well as step-by-step guidance this policy note provides practical background information. There is a measure catalogue offering measure descriptions, benefits and possible barriers, insights on expected future developments and relevant EU policies, and practical city cases.

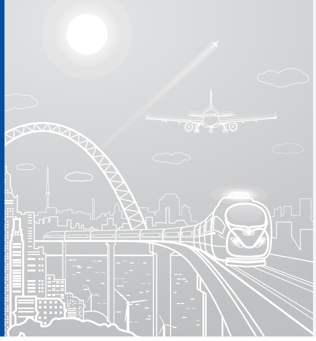
The contents of this policy note are based on evaluations of measures demonstrated in European cities as part of the CIVITAS Initiative, as well as from other application sources.

Characteristics of urban traffic

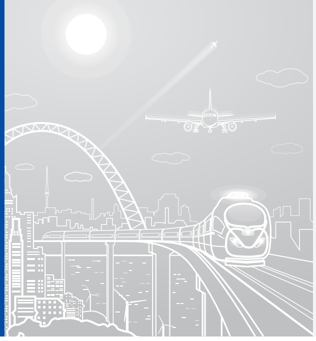
The characteristics of an urban mobility system (TrafficQuest, 2014) can be seen in the infographic on the next page. These characteristics are key factors when selecting measures.

Overview of the steps for setting a strategy and defining and implementing measures





Infographic with important characteristics of urban traffic



Introduction on Intelligent Transport Systems and traffic management

This section serves as an introduction to Intelligent Transport Systems and traffic management. Definitions and explanations of both terms and their relationship are given. Further information is provided specifically related to the use of Intelligent Transport Systems and traffic management in urban environments.

Definitions

Intelligent transport systems (ITS) are applications of advanced sensor, computer electronics and communication technologies which, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks. ITS applications include telematics and all types of communications in vehicles, between vehicles (e.g. vehicle-to-vehicle), and between vehicles and fixed locations (e.g. vehicle-to-infrastructure).

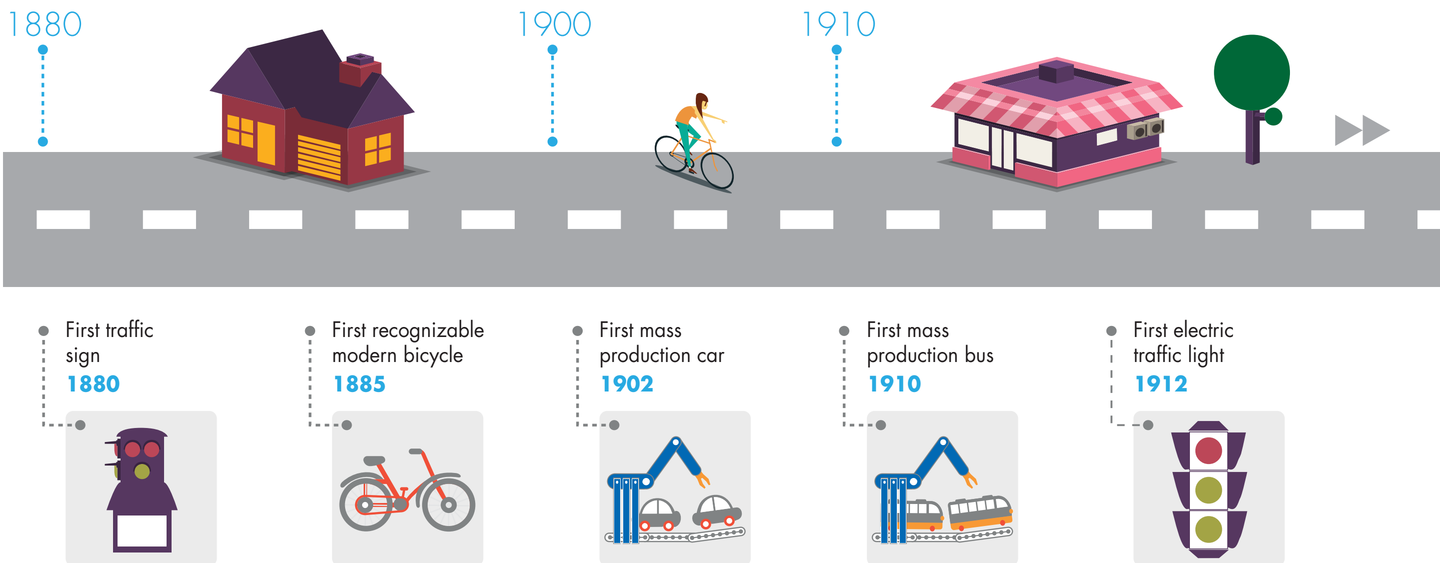
Traffic management applies measures to adjust the demand and capacity of the traffic network in time and space, to better 'match' the traffic demand and supply (capacity) (TrafficQuest, 2012). Examples of traffic management measures are variable settings for traffic lights, variable speed limits, parking guidance, dynamic lane management and dynamic route information.

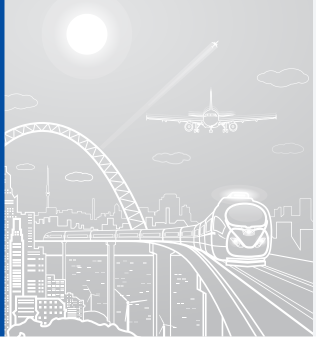
ITS is the application of ICT in traffic and transport, and traffic management is an instrument to achieve (policy) goals of a city. Many traffic management measures use ICT and can therefore be called ITS, but there are exceptions (e.g. one-way streets, static access management). Just as there are ITS systems that are not (primarily) used for traffic management, such as electric toll collection. This policy note concentrates on traffic management measures that use ITS and ITS systems that are relevant for cities. This is further explained in the rest of this section.

Categorization

ITS applications can be categorized in different ways, see for example (Ecostand, 2011), (ICT for Clean and Efficient Mobility), (Amitran, 2014) and (Spyropoulou, 2004). For this note a categorization of ITS applications is chosen that is based on their expected use:

1. Demand and access management (including pricing);
2. Traffic management and control;
3. Travel and traffic information;
4. Driver assistance and cooperative systems;
5. Logistics and fleet management;
6. Safety and emergency systems.

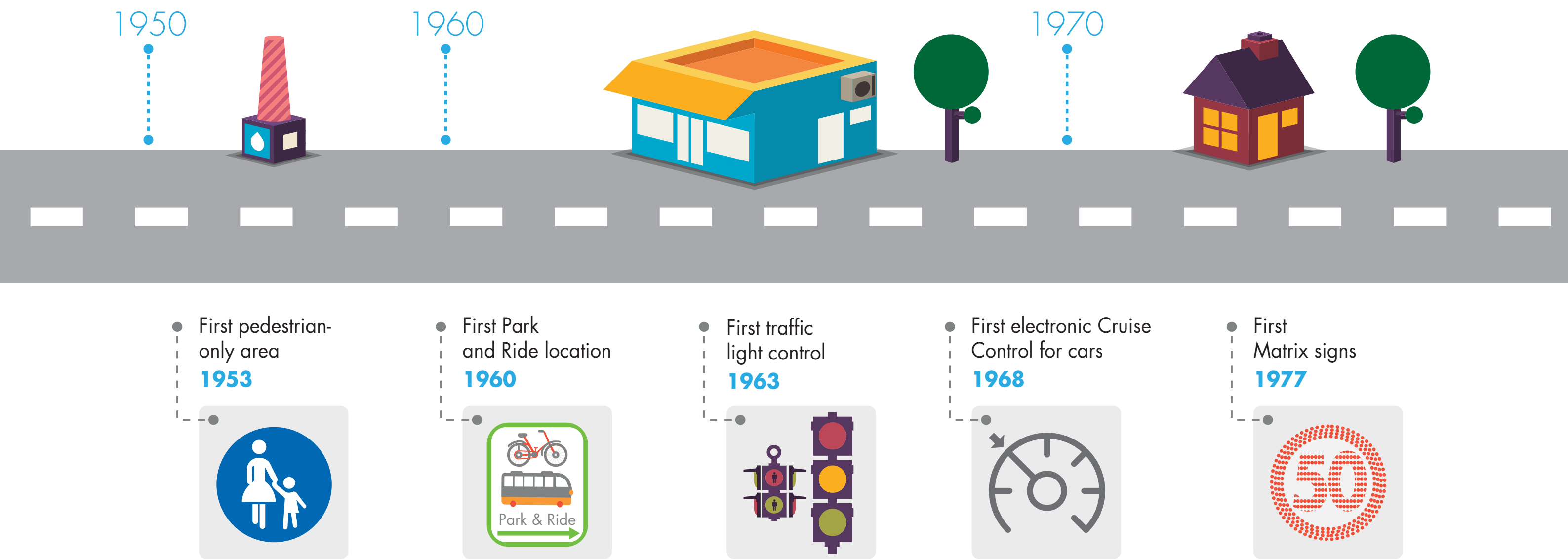


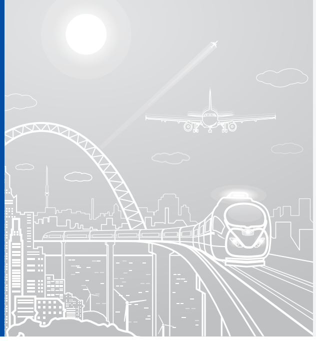


The focus of this note lies on three fields of interest which comprise the most relevant ITS applications for cities: *demand and access management*, *traffic management and control*, and *travel and traffic information*. *Demand and access management* measures are usually applied with additional enforcement strategies and the use of static and variable messages signs. They aim at handling flows in cities, especially in city centers where high levels of congestion and air pollution occur. *Traffic management and control* measures aim at reducing transportation problems by either controlling the circulation of all transport modes or focusing on specific modes such as public transport. *Travel and traffic information* measures provide (real-time) data to e.g. drivers and users of public transport in order to enable better informed decision making and reduce transportation problems. Both demand and access management measures and traffic management and control measures depend on the use of travel and traffic information in order to increase their efficiency. Measures in one of the three focus categories can be selected by city decision makers and be applied in the urban area in order to fulfill the desired goals.

Categories of ITS applications that are not included in this policy note are *driver assistance and cooperative systems*, *logistics and fleet management*, and *safety and emergency systems*. *Driver assistance and cooperative systems* are usually related to on-board vehicle systems and the decision to use them is made by the individual driver (although in case of cooperative vehicle-to-infrastructure systems infrastructure equipment is also needed). The same holds for *safety and emergency systems*. Innovative cooperative systems relevant to cities, such as cooperative intersections and ITS Spots as they have in Japan, have not been included in this policy note, since they are experimental at the moment. *Logistics and fleet management systems* are usually implemented by logistics companies on a level broader than just the city. Also, urban freight logistics are dealt with in a separate CIVITAS policy note.

The three focus categories of ITS applications can be specified one step further. The specification we use is based on Ecostand (2011) and Amitran (2014) and is shown in the figure on the next page (encircled the categories that are included in this policy note). Only sub categories relevant for cities are included. Navigation systems are not included, because it is not likely that the deployment of such systems is in the circle of influence of city administrations. Cities can facilitate navigation and parking apps by making certain data accessible (open data), but in the end it is a decision of individual drivers to use those systems. The subcategories as shown on the right-hand side of the figure are not yet on the level of concrete systems.





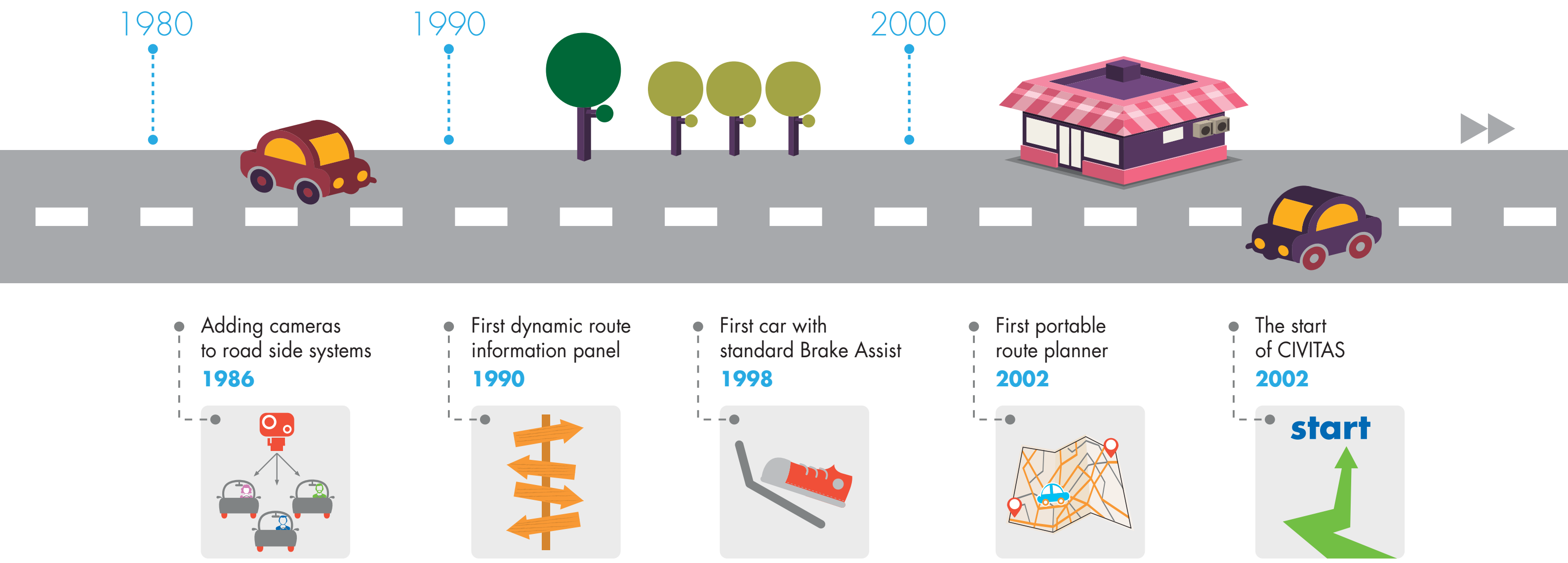
Main categories of ITS applications	Subcategories relevant for cities
Demand and access management	Restricted access; Road pricing
Traffic management and control	Lane Management; Public transport priority; Signal control
Travel and traffic information	Parking guidance; Travel and traffic information
Driver assistance and cooperative systems	
Logistics and fleet management	
Safety and emergency systems	

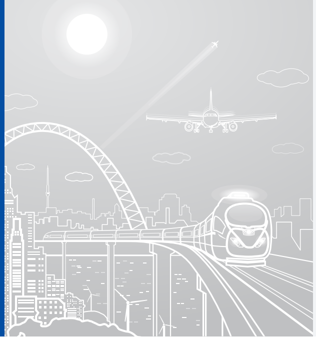
[dashed box] = what is covered in this policy note.

ITS categories and subcategories

Traffic management centre

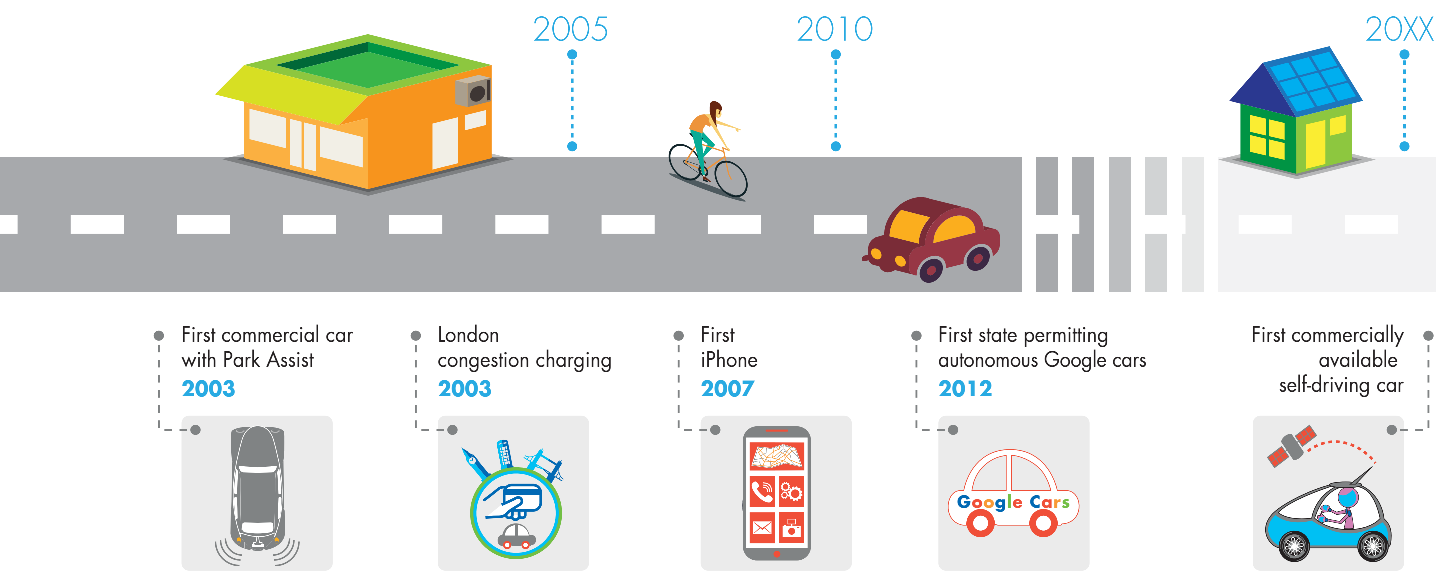
A special enabler for traffic management and ITS is the traffic management centre (also called traffic control centre). When the number of operational tasks increases, or the size and complexity of instruments and scenarios increases, a traffic management centre could become necessary. A traffic management center can support the management of traffic flows in an integrated way during 'normal' conditions as well as during unforeseen circumstances (e.g. accidents). In a traffic management centre traffic is monitored with for example cameras and data from traffic detectors (e.g. induction loops), control systems are operated, and responses can be coordinated with other crews (e.g. police). The size and span of control of a traffic centre differ per city and can be from very simple to very large and/or innovative.





Traffic management centre in the Netherlands
Source https://beeldbank.rws.nl, Rijkswaterstaat / Tinelou van der Elsken

Infographic timeline with important traffic, traffic management and ITS moments



Step 1: Policy context

The first step is to position ITS and traffic management in the relevant urban mobility policy context. The writing down of this in a document is what we call an *(ITS and) traffic management strategy*. This strategy defines what policy ambitions will be achieved through ITS and traffic management. It comprises the rationale and guiding principles to deploy a set of effective and efficient ITS and traffic management measures.

Policy objectives

The purpose of traffic management is to inform, guide and if necessary direct road users. It is a management process that contributes to achieving policy objectives. Policy objectives in the urban context that ITS and traffic management can contribute to are for example:

- Accessibility of the city
- A clean environment
- Low energy use
- A safe city
- Attractiveness of the city for tourists

'Traditional' transportation goals include more efficient and effective traffic (less congestion, shorter travel times, larger network capacity), higher service quality (higher public transport punctuality and reliability, more parking places, shorter waiting times), improved travel patterns (volume of travel or movement of goods by modes, modal split, modal integration) and improved transport safety (less casualties and incidents) (Hall and Van de Lindt, 2009). Environmental goals that could be achieved through means of traffic management comprise improvement of the environment (CO_2), air quality (NO_2, PM_{10}, $PM_{2,5}$, EC) and noise. Whether traffic management is aimed at traditional or sustainable goals, to make it successful measures should be clearly embedded in the relevant policy framework.

Policy ambitions are normally set down in local mobility plans, for example in a Sustainable Urban Mobility Plan (SUMP). The development of a traffic management strategy could be initiated in the context of the development of a SUMP (top-down), but it could also be initiated bottom-up. For example when certain traffic management or control systems reach the end of their life time and there is a need for upgrading and replacement. Updating the traffic management strategy might then be necessary and should be the starting point for this process.

In the traffic management strategy, specify the contribution ITS and traffic management could have in achieving the policy goals. In order to do this, make the policy goals as concrete as possible. For example, identify targets, indicators and criteria (value of the indicator that is strived for or that should not be exceeded). These are, in the end, political choices and can be part of the policy plan or SUMP. If such choices have not been made yet, the planners and analysts could determine values based on legislation or values they think are acceptable, and these values should be discussed and agreed upon by decision makers and/or politicians. Examples of indicators, targets and criteria are:

- Public transport should have a modal share of at least 30% for all trips within the city
- The minimum average speed at city transit links should be 40 km/h
- Average waiting time for pedestrians at urban shopping areas should not exceed 70 seconds
- PM10 levels should be below 40 µg/m³ in housing areas in the city
- Transport related CO_2 production should be reduced by 25%

Traffic management is (just) one of the tools (policy instruments) in a broader mobility toolkit policy makers have at hand. Other instruments that could contribute to the same objectives are urban planning, infrastructure planning, public transport policies and cycling policies. In order to be effective, instruments and measures should be properly aligned. Having insight into the landscape of policy ambitions and related instruments helps to identify and scope specific traffic management measures in the next steps.

Guiding principles

Second part of the first step is the definition of guiding principles. Guiding principles are used as a common set of rules to rely upon in making decisions in next steps and putting measures into practice (deployment). Guiding principles can be established on several aspects. Some examples:

- *Prioritization of modes.* For example to prioritize sustainable transport modes. In this way, when developing measures, measures will be oriented to such modes first. A more varied approach is also possible, where mode oriented priority could be established depending on the area in the city.

- *Prioritization of segments.* Priorities can be put on trip purposes or destinations of traffic. In that way accessibility to jobs, leisure locations and tourist attractions can be secured.

- *Strategy type.* When it comes to behaviour of travellers, one can try to change this on different levels. The most relevant choices in the urban context are:

    1. Prevent people from travelling (too far)

    2. Mode shift: traffic that cannot be avoided should be as sustainable as possible

    3. Change departure time

    4. Change in route choice / Change in driving behaviour

- *ITS/ICT.* Developments in ITS and related topics (ICT, big/open data, mobile applications) have progressed rapidly over the past decade, and developments will continue. Cities should think about their position when it comes to the level of market involvement in development and deployment, data accessibility (open data), data standards, and dealing with in-house advisors and prevention of vendor lock-ins.

- *Legacy systems.* Often cities have systems in place. Choosing between upgrading or replacement of systems is a difficult decision. At this stage 'rules' could be established on how the city in general wants to deal with legacy systems. Systems that need replacement could actually be a driver to speed up developments.

Step 2: Current situation and bottlenecks

In step 1 traffic management has been framed in the urban mobility policy context. As such the ambition (or desired situation) has been defined. Step 2 is about understanding the mobility characteristics in your city. In step 2 a structured problem analysis has to be carried out to define the situation as it is now and identify the bottlenecks. These bottlenecks can be for example traffic performance related (delays, safety, performance of the public transport system) or related to air quality and noise. This will form the path for later steps that elaborate on ways to go from the current situation (step 2) to the desired situation (step 1): based on the type and location of bottlenecks, ITS and traffic management services can be explored that are most suitable to tackle the problems.

It is possible that an analysis as described below is already (partly) performed in setting up the urban mobility plan. It is worthwhile to explore this and use the work already done.

Current situation

First, make a structured inventory of the current network or supply side of the system. This could be organized in structured way by using a GIS tool or traffic model suite, and/or by using local knowledge combined with data that are available or can be collected. It is relevant to have insight in the following characteristics (this is not an exhaustive list):

- Road network
    1. Road capacities
    2. Speed limits
    3. Intersection characteristics
    4. Important parking locations (including capacity)

- Public transport
    1. Routes
    2. Important transfer points/stops
    3. Frequency
    4. Intersection priorities

- Cycling
    1. Cycling lanes and their characteristics
    2. Intersection priorities

- Legacy systems
    1. Traffic lights and type of control
    2. Information panels
    3. Parking information systems

4. Static and dynamic signs (e.g. for environmental zones)

Second, acquire insight in the demand side (mobility patterns). In other words, how is the urban transport system being used. Relevant indicators include:

- Identification of areas of trip generation (residential areas) and trip attraction (jobs, retail, leisure, hospital, parking)
- Origin-destination relations, if possible differentiated by time of day (morning peak, evening peak, weekend, rest of the day)
- Modal split figures
- Traffic volumes on important routes, if possible differentiated by time of day

These figures can be compiled using statistical data, monitoring systems (e.g. from cameras or detectors at traffic lights), and traffic models. It is recommended that cities monitor and generate numbers. Sources of information that can be added to this are data from Google Maps ('typical traffic'), service providers, social media and local knowledge.

Identification and prioritization of bottlenecks

There are various ways to identify bottlenecks and it is recommended to use different sources. Throughput bottlenecks can be identified by confronting supply and demand, for example by using a (multimodal) traffic model. If this is combined with environmental models to get insight into air quality and noise levels, also environmental bottlenecks/hot spots can be identified. Identify bottlenecks for all modes (cars, public transport, cycling, walking) and also for parking, and see where these overlap (in time and space). When extensive data sets are available the actual situation in the city can be visualized based on the most recent data.

When using a model, bottlenecks can be derived by comparing the results of the traffic model assignment to a reference situation, using indicators and criteria for classification of the current situation into e.g. 'acceptable' and 'problematic'. Identification of indicators and criteria was part of the first step.

When bottlenecks are identified priorities need to be assigned. This can help to identify the order by which bottlenecks should be tackled (short term and long term). There are different inputs for making the prioritization such as the political situation.

Step 3: Services

The previous steps explained how traffic management and ITS can contribute to realizing the policy goals for the city and how to acquire insights in the current situation in the city (problem analysis). This step, *Services*, is about selecting approaches to resolving the bottlenecks and achieving the policy goals. The suitable *type* of solution – called 'service' – is selected (the selection of detailed measures takes place in the next step). The selection of services is done in order to concentrate on the desired outcome and the method of achieving the outcome instead of getting lost in technical and physical (in)possibilities that come with concrete measures. It is recommended to have a map of the city with a visualization of bottlenecks at hand. This makes it easier to come to a selection of services.

First, for each bottleneck, identify the location (if there is one) as specifically as possible and specify when this bottleneck occurs (e.g. morning peak, weekend, etc.). Note that a distinction can be made between technical/operational bottlenecks (e.g. an intersection not functioning properly) and bottlenecks related to traveller behaviour (e.g. too many people using a short cut through a residential area). When it comes to behaviour of travellers, one can try to intervene on different levels:

- Encourage people to avoid travelling (e.g. by working from home instead of going to work).
- Achieve a mode shift. Trips that cannot be avoided should be as sustainable as possible. For example through promoting preferred modes such as public transport and cycling. A precondition for such a strategy is that infrastructures for alternative modes are in place, so that there is a minimum resistance for mode change.
- Change in departure time (e.g. from peak hour to non-peak hour).
- Change in route choice.
- Change in driving behaviour.

Next, the general approach how to tackle each bottleneck and how to reach each policy goal in terms of services needs to be discussed. Five types of services can be distinguished (Rijkswaterstaat, 2004):

1. **Flow control:** this is an option for relatively minor (throughput) bottlenecks, for which you want to achieve a calmer traffic situation by smoothening the traffic flow.
2. **Traffic flow redistribution:** this is an option when there are throughput bottlenecks, and there are alternative roads and routes available.
3. **Traffic and travel demand control:** this goes a step further than the previous two services in that you want to control traffic and travel directly, e.g. by discouraging people to travel, encouraging them to use another mode of transport or choose another departure time.
4. **Road capacity control:** this service goes furthest. Extra capacity is offered to (part of) the road users. Usually the local effect on traffic flow will be considerable, but there may also be effects on other parts of the network.
5. **Information:** this category comprises services (not falling under one of the other service groups) that provide information to travellers.

The services can be connected to the behaviour levels. Service 1 (*flow control*) contributes to achieving a calmer traffic situation. As a consequence this part of the network or city could become more attractive for other modes. Service 2 (*traffic flow redistribution*) is aimed at influencing route choice of road users. Service 3 (*traffic and travel demand control*) is about motivating people to avoid travelling (working at home), choose other modes and/or departure times. Service 4 (*road capacity control*) could influence all levels, but is expected to have the largest impact on route choice, and on the longer term on mode choice as well. Service 5 (*information*) could have an effect on all levels. A change in driving behaviour is more difficult to achieve with services that cities can provide (although it is tried with speed bumps and traffic cameras). Cities can deploy promotion and awareness campaigns to influence the behaviour of travellers, and they can use enforcement instruments (e.g. cameras).

Step 4: Measures

Since there is not such a thing as 'the most effective service', consider a broad range of services when exploring services to tackle bottlenecks. Try to combine conventional and new services. It is helpful to indicate the intended services on a map, and when the 'picture' is complete, check with all people involved whether as a group you are satisfied with the services chosen. Describe the selected set of services and include the following information:

- Location
- Type of service and effect aimed at
- The type of bottleneck(s) and/or policy goal the service refers to
- Time period (e.g. peak, off-peak, recreational)
- Time horizon (now, in five years' time, etc.)
- Interaction with other services
- Stakeholders involved

In addition, check the overall set of services for logic and consistency, and keep the following things in mind when selecting the services:

- Is the effect of the service proportional to the severity of the bottleneck? For example, a service such as calming traffic will probably have a relatively small contribution when there is a large amount of congestion due to overload of the network. In that case other – more effective – services might be preferable.
- Is the service a realistic option? This depends on the available physical space, legal aspects, costs, etc. For example, offering extra lanes is not always possible in an urban environment.
- Are negative side effects to be expected? For example traffic starting to use residential streets. In this case it can be wise to implement additional services to counter the negative side effects. In some cases it might even be better to not resolve the bottleneck.

In the previous step, services have been selected as a general indication of the intended measures to tackle the identified bottlenecks and achieve policy goals. This step is about translating the services into measures and listing specific properties of the measures such as feasibility, expected costs and expected effects (if possible). This will result in a comprehensive overview of the total set of measures that is required to achieve the policy goals and solve the bottlenecks. In many cases available budgets and resources will define if and to what extent the package of measures can be implemented. This is why measures have to be prioritized.

This section of the policy note provides further *guidance* for selecting measures. It does not prescribe detailed, specific measures that have to be chosen, since there are too many of them and it is impossible to do this without knowing the local situation. Guidance is given on the type of measure, and the steps in detailing this further. Later in this note a so called 'measure catalogue' is provided that can help in exploring measures. The CIVITAS knowledge base[1] contains a more extensive set of measures that has been implemented in European cities.

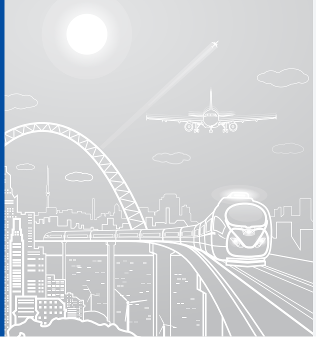
In the first part of this step information is provided on the relation between the measure types and the services and policy goals, so that the right measure types can be selected. The second part gives guidance on how to make a list of more specific measures.

Relation between measure types, services and policy goals

In step 3 of this policy note five types of services were introduced. These services have to be further specified into measure types. These are not yet concrete measures in the sense that the exact implementation is specified; this is very dependent on the circumstances and cannot be advised on in this policy note.

In the table on the next page an overview can be found of services and measure types and the relation (strong in dark green, weaker in light green) between them. This overview was made based on expert judgement of the authors of this note.

1 http://civitas.eu/search-the-kb



Overview of services and measure types and the connection between them

ITS category	Measure type	Service				
		Flow control	Traffic flow redistribution	Traffic and travel demand control	Road capacity control	Information
Demand and access management	Restricted access					
	Road pricing					
Traffic management and control	Lane management					
	Public transport priority					
	Signal control					
Travel and traffic information	Parking guidance					
	Travel and traffic information					

No or weak relation	Average relation	Strong relation

To give some examples, for the service *traffic flow redistribution* traffic has to be spread over the network in a better way. This could be achieved by providing information (about routes or parking) to drivers either via Variable Message Signs or smartphone applications. For *traffic demand control* people could be encouraged to travel during off-peak hours (by road pricing or rewards) or not to travel at all (e.g. teleworking). *Road capacity control* could be effectuated by offering extra lanes or distribute them differently (e.g. shared lanes, priority lanes).

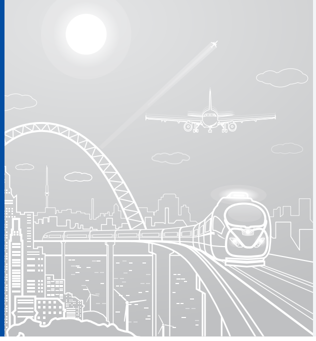
The expected effect sizes of the different measure types are compared regarding the main city policy objectives (transportation and environment) as considered for this note. The comparison is shown in the table on the next page. Some findings that are shown in the table: from the selected measures, *road pricing* has the largest expected impact on transportation problems. It has been proved to reduce congestion significantly, but the measure could also be deployed to contribute to road safety and modal shift policies. More intelligent settings of *signal control* have shown improvements in congestion and travel times and at the same time contribute to road safety and reduction of pollutant emissions. *Travel and traffic information* measures could reduce congestion as well as encourage people to use public transport instead of the car. Measures that are expected to have a large contribution to environmental policy objectives are *road pricing*, *restricted access* and *lane management*.

The measure types discussed in this note have also been compared on parameters such as costs, public acceptance, stakeholder issues and proof of functioning. Measure specific issues are described in the measure catalogue.

Selecting measures

There are a number of intermediate steps to be taken. First, for each service identified in step 3 select one or more measure types to effectuate that particular service. The table given in the previous section can serve as a starting point. Then specify the measure types to actual measures, using the information in the measure catalogue in this note, the CIVITAS knowledge base, and other sources you have available as point of reference. Several measures may be required for a single service. In this case make sure that the measures can actually be combined, both from a physical and from a traffic control point of view. On the other hand, it is possible that one single measure can serve a number of different services (e.g. restricted access can achieve traffic flow redistribution and traffic and travel demand control). If relevant, determine the exact location in the network where the measure is to be deployed.

Second, indicate the effect you intend to achieve with the measure. You can grade the effectiveness for example on a scale from 1 (minimal effect) to 3 (highly effective). Estimate whether the measure offers the 'desired strength' that is



Comparison of measure types for the policy goals transportation and environment

Urban policy goals		Restricted access	Road pricing	Lane management	Public transport priority	Signal control	Parking guidance	Travel & traffic information
Transportation	Congestion	Average	Large			Average	Small	Average
	Travel time			Small	Average	Average	Small	
	Accessibility						Average	
	Road safety		Average	Small		Average	Small	Small
	Waiting times				Average			Small
	Modal split	Average	Average		Small			Average
	Reliability of PT			Average	Average	Small		
Environment	Air quality	Average	Average	Small	Small	Small	Small	Average
	Fuel savings		Average	Small	Small	Small		
	Noise reduction	Average	Average	Small				

No effect	+ Small	+ Average	+ Large

needed for the service. If this strength cannot be achieved, additional measures or enforcement may help. Find out if there are (unwanted) side-effects the measure could bring about. If this is the case explore alternatives or compensatory services and measures. Consider a broad range of measures looking at all modes and assess their impact on mobility patterns as well as on related economic, social and environmental concerns.

Third, check whether the measure is already available, and whether it can be used immediately for the intended purpose. Also check whether minor modifications to an existing measure will suffice, or whether a completely new measure has to be provided. Using an existing measure generally saves time and money.

Fourth, assess the feasibility of the measure. This will provide insight into the amount of effort that will be needed to realize the measure. The following aspects (aspects of the measure as well as aspects that characterize the city) should be looked at (this is not an exhaustive list):

- Technical aspects
- Geographical, environmental, demographic, socio-economic and cultural backgrounds
- Legal feasibility (e.g. procedures, noise and air quality limits)
- Institutional framework
- Support from stakeholders such as executive bodies, road users, residents (public acceptability)
- Monitoring systems requirements
- Enforcement issues

In addition to the factors mentioned above , it would be good to consider current urban trends such as urbanization (the population of Europe's cities continues to grow and further increases demand for urban transport), the e-society (new ways of organizing work, e-shopping) and technological progress (connectivity, e-mobility, in-car systems). If the measure appears to be partially or completely unfeasible, an alternative has to be found. If a measure, though feasible, involves large risks or requires additional effort, this should be included in the description of the measure.

Finally, describe the properties of the measure that are required for setting the priorities, such as:

- Completion time
- Costs estimation, including investments for civil engineering and electrical work, maintenance and running costs, wages, management costs, research costs and enforcement costs.
- Estimation of the effects to be achieved through the measure. Indicators can be used for this, see for example (Conduits, 2011). Keep in mind that estimated effects usually apply for average conditions that may differ from the actual conditions in your specific situation.
- Relevant service(s). To which service(s) does the measure contribute?

The result of all these steps is a basic list of realistic measures, with properties of those measures. It is important to estimate which criteria will be considered relevant by the executive body involved whenever a choice has to be made between different measures. These criteria can be used when giving priorities to the measures. For achieving a balance in the set of measures it is important to have both 'push' measures (e.g. road pricing) and 'pull' measures (e.g. increased access to and incentives for public transport). Below is a (simplified) example of such a list.

Prioritizing measures

The first step in prioritizing the measures is to find out whether any arrangements have already been made regarding any of the measures. When such arrangements have already been made (or even obligations have been entered into), this will probably mean that the realization of those measures will no longer be a point of discussion. Such measures can be put at the top of the programme of measures.

Second, prioritize the remaining measures per bottleneck. Use the prioritization of the bottlenecks as a starting point. The measures intended for the bottleneck(s) with the highest priority will come at the top of the programme of measures (but after the measures for which arrangements have already been made). They are followed by the measures related to the bottleneck(s) with the next highest priority, and so on.

Further prioritization, fine tuning and detailing can be done by looking at the most important goals you want to reach, limitations (e.g. with regard to budget), timing of measures (starting and completion date of implementation), expected effectiveness, costs, etc. It is hard to prescribe this precisely, since it depends on the city. It is also worth investigating whether measures that are later in the programme can be realized earlier by 'riding along' with major measures earlier in the programme.

A general estimate of the overall effectiveness of all measures regarding traffic flow, safety, and quality of the living environment can usually be derived from the effects of the separate measures. Estimating effectiveness regarding accessibility is more difficult since it involves network effects. Possibly a traffic model can be used.

Bottleneck	Service	Measure	Expected impact	Costs	Risks
A	Flow control	Dynamic speed limit	high	high	Technological complexity
B	Traffic and travel demand control	Access restriction	medium	low	Acceptance

Step 5: Implementation

The previous steps have resulted in a prioritized set of measures. Now it is time to prepare for implementation. The following elements are relevant:

- Stakeholder management
- Building the business case or "storytelling": getting commitment and funding
- Specifications and procurement

Stakeholder management

It is important to gain commitment from all stakeholders, who should be involved as early in the process as possible, and to build ownership. Different types of stakeholders can be approached in different ways. For example, making room for experiments and innovation can be an opportunity to stimulate innovative business concepts and start ups and as such can improve the attractiveness of the city for entrepreneurs. Cooperation with the (local) market can also be beneficial in the sense that it stimulates the local economy.

The general public and in particular the citizens of the city are end users; they are the ones confronted with the measures. In case of big changes it can be considered to actively involve them in the development process, to facilitate acceptability.

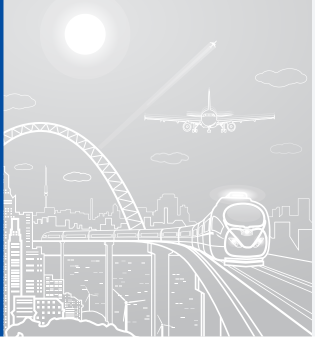
On the next page an infographic is shown with relevant stakeholders for deploying ITS in a city. Stakeholders most directly involved with and influencing deployment are shown in the inner circle, other stakeholders are shown outside the circle.

Building the business case or "storytelling"

Relevant stakeholders (e.g. aldermen, mayor, user groups, etc.) need to be involved and convinced of the necessity to implement the measures that have been selected. Generally a combination of actions is carried out to achieve this. The following activities are important:

- Estimate effects of "do nothing" scenarios. If possible quantify and then monetize what happens if no measures will be implemented. In essence this is an extrapolation of step 2 (problem analysis). Applying a traffic model can help. Standard valuation methods are available to monetize delay costs, accidents, etc. (Ricardo-AEA, 2014). Use examples of other cities (where they did nothing) as a warning.
- Estimate the costs of measures. If the previous steps are carried out in a proper way, this is already available. If not, make the estimation now or hire an expert to make the calculation. If necessary work out one or two alternative solutions. Include investment, operation and maintenance costs.
- Estimate benefits. All possible benefits have to be included, e.g. societal, economic. Think also of the fact that new systems could make it possible to reduce maintenance and/or management costs. Provide examples from other cities where these measures were a success.
- Show benefit-cost ratios.
- Use storytelling. For example, develop cause and effect chains: measure X leads to Y, and Y leads to Z. Benefit Z is important because a recent household survey has provided insight into the fact that citizens find this benefit important.
- Clarify what is meaningful for the person you are talking to. For example, is it something a mayor could 'open' or 'celebrate' (e.g. a new station)? Or is it something a councilor can use to gain media attention? The fact that a project is "opened" or a measure is implemented could already be a benefit for a politician in the sense that he or she has made an achievement and gains publicity.
- Produce examples of traffic management and ITS in your own city. Visualize the success of the measures in an attractive poster or factsheet. Include facts, figures and photos (produce them yourself or use examples from other cities).
- Find additional or other potential financing sources. There might be some local, national or European opportunities to acquire subsidies for implementation of measures. Or explore private investments, and involve knowledge institutes for research and development.

Infographic with stakeholders for ITS deployment in a city



Specifications and procurement

The definition of specifications and preparing for procurement is usually an iterative process. First specifications are defined on a high level. Then a procurement method is chosen. After that, more detailed specifications can be defined. The procurement method that is chosen should fit the ambition of the measures and the size of the business case. Examples of procurement methods are public private partnerships (PPP), dialogue, and competition. The specifications should fit the choice of procurement and vice versa. Consider defining specifications at the functional level instead of specifying the technical solution in detail. This opens the path to challenging the creativity of the industry which may lead to better solutions in the long term. Choose open data formats and/or European standards, and try to avoid vendor lock-in.

Measure catalogue

For seven categories of urban ITS measures (as specified in 'Introduction on ITS and traffic management') more information is presented in this section. The following topics are discussed:

- Description and general characteristics of the measure
- Benefits and possible negative impacts
- Possible barriers for implementation
- Examples

The information about the measures is mostly collected from CIVITAS evaluations of measures implemented in cities. If figures are available for specific examples these figures are provided, otherwise qualitative information is given about the effect types. Furthermore, some sources outside CIVITAS have been studied in order to have a more objective, global view of the impacts of the measures. This measure catalogue discusses measures that are proven technology and can be implemented in other cities as well. More information about future technologies is presented later in this note. Indications of costs have not been included, since numbers are only available for specific examples and they are not representative for all measures. The costs of a specific measure are highly related to implementation choices, city characteristics, area where the measure is applied, etc.

It is impossible to present in this measure catalogue all possible information about the measure types. For more information the reader is referred to the CIVITAS website, where comprehensive information about measures implemented in CIVITAS is presented, and research reports have been made available. The reader is also referred to the CIVITAS Thematic Group on Transport Telematics[2]. This group brings together people working on and interested in ITS and traffic management in urban areas to network and learn, and tries to respond to questions on this topic. Another useful source is the iMobility Working Group for Clean and Efficient Mobility (Antonissen et al., 2013).

2 http://www.civitas.eu/TG/transport-telematics

Restricted access

Restricted access is the prohibition of certain vehicles (usually motorized vehicles) in certain roads or areas. The prohibition can also be addressed to certain modes or time periods. Examples of specific restricted access measures are:

- Restricted access to a city center. Can be restricted in time (e.g. no vehicles in the city center during peak hours) or area (no vehicles in specific zones or on specific roads).
- Restricted access for freight vehicles (weight, time or road restrictions).
- Low emission zones (where only environment-friendly vehicles are allowed).

Benefits

Transportation	Reduced traffic volumes during the controlled hours or in the controlled area
	Modal shift, increase in the use of public transport and cycling
	Increase in public transport speed
	Decrease in the number of delivery vans and trucks with a simultaneous increase in the average weight per delivery/vehicle load factor
Environment	Improvement in air quality
	Decrease in noise
Economy	Revenues from permits and fines
Society	Better preservation and access to cultural heritage sites
	High acceptance (> 80%) by citizens (not the same for all citizens, see barriers below)
	Considerable improvement in pedestrian comfort
Safety	Considerable improvement in pedestrian safety

Possible barriers for implementation

- Lack of proper justification could delay the process
- Strong political and legal barriers if the monitoring is done through cameras and number plate recognition
- Residents and shopkeepers tend to have a negative attitude towards such measures
- Relocating the problem, i.e. traffic will redistribute to other parts of the network

Examples

Brescia (Italy) applied a Limited Time Zone (LTZ) with different time bands to allow freight distribution in the city center, where about five hundred commercial businesses are located. The results showed that the number of delivery vans decreased by 18%, trucks by 14.5% and lorries by 2.5%, while the average weight per delivery increased by 12%.

In the historical city center in *Iasi (Romania)* there was an urgent need to reduce traffic to increase the attractiveness and make the area more pedestrian-friendly. Strong restriction measures led to 92% fewer cars crossing the center at peak hours and 91% at off peak hours. Levels of CO, NO_2 and noise decreased both during daytime and nighttime.

Source: Mobiliteitsbedrijf Stad Gent

Road pricing

In principle road pricing schemes could be applied everywhere, but it is usually applied in cities with 500,000 inhabitants or more. Four general types of road pricing in cities are in use (Klunder et al., 2009):

- Cordon area around the city center, with charges for passing the cordon line
- Wide area road pricing, which charges for being inside an area
- City center toll ring, with toll collection surrounding the city
- Corridor or single facility road pricing, where access to a lane or a facility is priced
- Some applications may also have the following features:
- Different tariffs according to the time of day, with higher charges during peak periods
- Exception of congestion charging for vehicles using alternative fuels

The implementation and functioning of this measure does not require the use of ITS. However, ITS are needed for monitoring and enforcement to ensure that vehicles have paid the requested charging. Hence, this measure is included in the proposed solutions as ITS are an important part of its application.

Benefits

Transportation	Reduction of number of kilometres driven
	Reduction of traffic congestion (20-30%)
	Modal shift to public transport and bicycle
Environment	Reduction in CO_2 and PM emissions (> 10%)
	Reduction of fuel consumption
	Noise reduction
Economy	Revenues
Safety	Reduction in car crashes and in pedestrian crash injuries

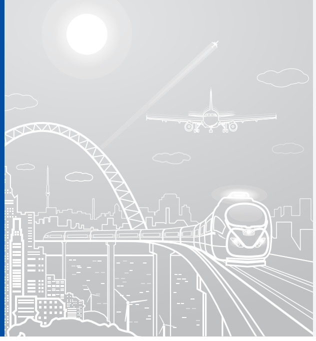
Possible barriers for implementation

- Disagreements on how to set tolls, what to do with any excess revenues, whether and how certain drivers (e.g. people living/working in an area where pricing is implemented) should be compensated or exempted
- Risk to transfer the congestion problem to another area of the city
- Relatively difficult to implement, both technically and politically
- Relatively small acceptance; users do not want to pay, even if this may decrease urban congestion

Examples

In *Oslo (Norway)* a toll ring was introduced and this resulted in a reduction of fuel consumption of 35%.

In *London (United Kingdom)* congestion charging resulted in a 10% reduction in traffic levels from baseline conditions (2013 compared to 2003) and contributed to an overall reduction of 11% in vehicle kilometres in London between 2002 and 2012. It also resulted in a 28% reduction in car crashes and 6% in pedestrian injuries. In 2007, the congestion charge measure in London had operational and administrative costs of 90 million Euros and revenues of 213 million Euros. The net revenues were estimated at 123 million Euros.



Lane management

Lane management is the flexible use of lanes in certain situations. Lane management can be applied in order to:

- Indicate/safeguard dedicated and controlled lanes for public transport
- Achieve a temporary closing of lanes in case of accidents, incidents, maintenance work and construction measures (safeguarding of lanes)
- Increase road capacity in peak hours (e.g. hard shoulder used as extra lane)

Lane management can vary from being static to more dynamic. An example of dynamic lane management is a lane reserved to be used either by certain modes or at certain times depending on the traffic situation. Another example is to use lanes for public transport in the morning and for delivery vehicles in the evening.

Benefits

Transportation	Improvement in the reliability and the punctuality of public transport
	Reduction in the number of vehicle hours lost
	Positive effect on traffic flow (not necessarily for all modes)
Environment	Fuel savings as a result of the increase in public transport passengers (indirect effect)
	Small reduction in noise and pollutant emissions by means of traffic smoothing
Economy	Sometimes infrastructure is needed but also it can be a solution to avoid having to build more infrastructure
Society	Acceptance by users (this can differ per mode)
Safety	Reduced accident risk. Positive effect on the traffic safety.

Possible barriers for implementation

- Large investment costs when additional infrastructure needs to be built.
- Complaints from users experiencing disbenefits because other modes have prioritization/extra lanes

Examples

The problem of the unauthorized use of bus lanes by private cars was addressed in *Genova (Italy)* via a control system, including monitoring devices and relevant warning signs. As a result of the monitoring devices, the illegal use of bus lanes decreased by 71% during 2007. This in turn resulted in increased bus lane efficiency and improved image of public transportation in the city. The acceptance by users was 64%.

Public transport priority

Public transport priority means that the traffic control settings are programmed in such way that stops for buses or trams are minimized. The complexity of such a measure increases when the complexity of the design of the intersection increases. For example when traffic lights also need to consider other road users (pedestrians, cyclists) and impacts on upstream/downstream intersections. Signal priority must be carefully implemented so that it does not create relatively large (negative) impacts on other traffic flows. There are two main approaches for providing public transport priority (Improve Public Transport, 2015):

- In a passive system the control cycle (the repeating pattern of green, yellow, red signals) is set to enable public transport vehicles to progress through the system without stopping (based on the average public transport speed)
- In an active system the traffic signal timing is adjusted in real-time based on the expected arrival of the public transport vehicle at the intersection

Benefits

Transportation	Reduction of travel times for public transport users (3-16%)
	Increase in public transport travel speed
	Reduction of average public transport waiting times at traffic lights
	Improvement in punctuality of public transport
Environment	Reduced bus fuel consumption
	Reduced emissions
Economy	Revenues due to increase in the number of passengers of public transport (long-term)
	Possible reduction of public transport rolling stock
Society	High acceptance by users (>70%)

Possible barriers for implementation

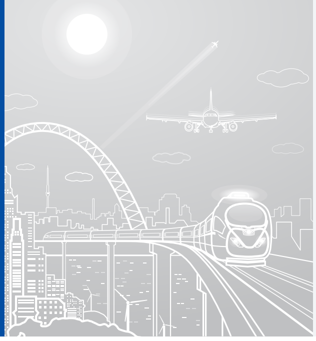
- Other traffic needs to wait longer so there might be longer travel times for them (and they might oppose the measure)
- Necessity of dedicated infrastructure for targeted modes (e.g. a separate bus lane at an intersection) and associated enforcement

Examples

Bus priority systems were tested in *Toulouse (France)* on a small scale with the aim of fully integrating them at operational level throughout the city. The result was a 52% reduction of average public transport waiting times at traffic lights.

In *Malmö (Sweden)* bus priority systems were introduced at 42 sets of traffic lights, improving the bus service by increasing the frequency from one bus every 10 minutes to one bus every 7.5 minutes without having to introduce additional vehicles. Improvement in punctuality was noticed: 2% towards city center and 4% away from the city center.

In *Tallinn (Estonia)* reduced emissions were observed after the installation of a priority system for buses (PM: -33.3%, NO_x: -20%, CO: -26%, CO_2: -4.1 %).



Signal control

Signal control aims to process traffic at intersections in an efficient and safe manner. The objective is to allow a smooth flow of all traffic at intersections. ITS applications for traffic signals (communication systems, adaptive control systems, real-time data collection and analysis, and traffic lights coordination) enable signal control systems to anticipate on expected traffic flows and operate with greater efficiency.

Benefits

Transportation	Decrease in travel times (up to 10% in peak hours)
	Reduced congestion (smoother flows)
	Improvement 5-20% in the travel mean speed in different EU cities
	More efficient engine use and smoother driving (due to minimization of stop and go conditions)
Environment	Reduction in CO_2 emissions (2-10%) and reduction in other emissions
	Small decrease in fuel consumption
Economy	Improved operational efficiency of the network
	Postponement or elimination of the need to construct additional road capacity

Possible barriers for implementation

- The state-of-the-art differs greatly across Europe and different technological standards exist within cities and countries.
- If the measure is not implemented correctly or fully (as was sometimes the case in the testing phases of CIVITAS) negative impacts might occur, such as higher travel times, reduced travel speed and increased fuel consumption and emissions.

Examples

An adaptive traffic signal control system was implemented in *Aalborg (Denmark)* on the most congested part of the main ring road outside the center of Aalborg. With the measure transportation time decreased by 8.5% per trip in the peak periods. Due to smoother driving patterns, the estimated fuel consumption decreased by 2.5% on the section of the ring road.

Parking guidance

Parking guidance systems present dynamic information to drivers for parking in controlled areas. They are designed to aid in the search for vacant parking spaces by directing drivers to parking garages (e.g. by indicating the number of places available in different garages). The systems combine traffic monitoring, communication, processing and variable message sign technologies to provide the service. Parking guidance systems consist of management software and an electronic map of the parking space embedded in the software, which can directly reflect the occupancy of the parking garage in real time.

Benefits

Transportation	Locally, small reduction in traffic volumes and delay and increase in average speed
	Reduction of kilometers travelled
	Better accessibility of the city center and other locations that draw large numbers of visitors coming by car (e.g. sport stadium)
	Optimisation of the parking capacity usage
	Minimization of time necessary to locate vacant spaces
	Reduced (long-stay) parking in inappropriate locations (such as central and residential areas)
	Change in the parking behavior of citizens (long-term)
Environment	Small improvement in air quality (locally)
Economy	Easy to implement
Society	Easy for people to understand, high acceptability

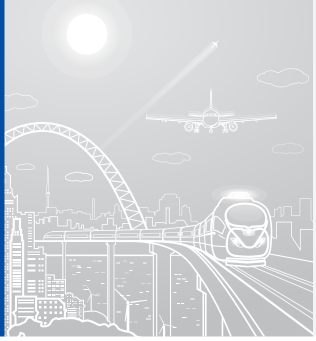
Possible barriers for implementation

No major barriers have been observed. It is sometimes difficult to involve all relevant private parking garage owners, but given the number of parking guidance systems in Europe, this is not a big problem.

Examples

Every September *Monza (Italy)* hosts the Formula 1 Grand-Prix and more than one hundred thousand people arrive in the city. Parking information is imperative during these periods. Before the implementation of the parking guidance measure in 2009, occupancy rate of parking garages was unknown because garage owners did not provide data. With the parking information system, data are much more reliable and can be used to better understand the distribution of cars in the different parking garages of the city.

Source: Mobiliteitsbedrijf Stad Gent



Travel and traffic information

Travel and traffic information is a very broad measure that can have various shapes and forms, in the type of information that is provided (static, dynamic), the mode that it provides information about (car, public transport, walking, cycling, multimodal), the way it is provided (mobile phone, road signs, etc.), etc. Below are some examples for a number of recipients:

- To drivers through mobile phones (mobile applications, Bluetooth, SMS). For example information about incidents, routes, and parking.
- For public transport passengers the information can be on-board for upcoming stops, destination, weather forecast, advertisement, news. Also, electronic signs on the stops can inform the passengers and/or mobile and website applications can provide useful information (delays, incidents, timetables, etc.).
- Information to freight operators through signs, website and mobile platforms about preferred routes.
- Multimodal journey planning services (via applications or websites) can inform travelers about a range of transport options tailored to their specific requirements. These services can be linked together to facilitate cross-border and interregional multimodal journey planning.

Benefits

Transportation	Reduction of congestion
	Modal shift in favor of sustainable modes of transport, e.g. public transport, cycling
	Improved traffic management
	Time saving in public transport (e.g. shorter waiting times because of real time information on departure times)
	Support of inter-modality
Environment	Better air quality (through transportation benefits)
Economy	If the service is reliable people might be willing to pay a small fee to use a service (e.g. download mobile application)
Society	High awareness and acceptance
	Increased public transport passengers' satisfaction and comfort

Possible barriers for implementation

In many European cities information is provided to travellers; major barriers that might have been there in the past were overcome. However, the level of service differs. A difficulty might lie in the fact that for some measures information from different sources needs to be combined, so different providers have to be involved. However, this is not a problem of the city.

Examples

In *Monza (Italy)* improved traveller information was provided to passengers at ten key stops in the city. The electronic bus stops cost 217,800 Euros and there was an increase in public transport of 4.1% after the implementation of the measure.

Future developments

This section briefly describes some future developments that are foreseen in the field of ITS and traffic management. The text below is adapted from (TrafficQuest, 2012) and (TrafficQuest, 2014-2).

In the coming years many changes in the field of traffic and transport are expected, on a technical level as well as on a societal, demographic and economic level. All changes will impact the development and application of traffic management and ITS solutions in cities.

An important technological development is cooperative systems (using vehicle-to-vehicle and vehicle-to-infrastructure communication). For instance, data can be acquired from vehicles and transmitted to a server for central data fusion and processing. These data can be used to detect events such as rain and congestion. The server can process an advice dedicated to a single or a specific group of drivers and transmit it wirelessly to vehicles. Or information is passed on between vehicles. Day-one applications of cooperative systems are often aimed at increasing road safety. However, communication between in-vehicle and roadside systems offers various opportunities. New cooperative systems can be platforms for all kinds of services – such as individual guidance, routing, hazard warnings and crash avoidance. New traffic management systems are possible due to the presence of increasing penetration rates of probe vehicles with more accurate positioning data. The figure on the next page shows characteristics of in-car and roadside ITS in an infographic.

A parallel development to cooperative systems is the introduction of automated vehicles. A lot of benefits are expected from automation. Some parties promise self-driving cars by around 2020. However, it is not expected that we will have fully self-driving cars (where you can sit behind the steering wheel and do something else) in the next few years. However, vehicles that are 'connected' and that have systems on board that automate part of the driving task are already on the market. Connected and automated vehicles will have an influence on traffic management. Cooperative systems may also influence the number of roadside systems that are needed. However, the transition from road-side to in-vehicle systems will take time. Also, automated vehicles are likely to first be introduced on motorways; automated driving in cities is more difficult because of the mix of traffic.

In addition to technology for motorized vehicles, ITS solutions are being developed for vulnerable road users (e.g. cyclists, pedestrians). This is of course highly relevant for cities. The VRUITS project[3] gives an overview of systems we can expect in the future.

With technology developing, data becomes more and more important. 'Open data' is a term that is used increasingly. More and more public transport operators and road authorities are sharing their traffic and transport data so that these data can be used by service providers. This open approach to data exchange contributes to better traffic predictions and more efficient traffic management. On the other hand it calls for higher harmonization of data formats and interfaces.

Another trend is that road users have increasing access to accurate, real-time and intelligent traffic and travel information, so that they can manage their individual objectives. A side effect of personal traffic information and the role that the private sector plays, is that road users have more information and are less dependent on information coming from road operators. This means that in the future it is even more important that the government and the private sector work together in informing, managing and controlling traffic flows. With the growth in the use of in-vehicle technologies (e.g. navigation systems, cooperative systems) the private sector could take on more traffic management tasks than just providing information. Individual interests represented by the private sector and societal interests (as laid down in policy documents) must be balanced with a view to safeguard a global optimum. If not, the government will need to introduce countermeasures in order to prevent unwanted behavior of well-informed users – for example: travel through a town center full of vulnerable road users because it is just a little faster.

3 www.vruits.eu

Trends for the future other than technological trends are that future trip purposes and travel patterns will change because of demographic shifts, the aging population and social media. Flexible work environments will be more common and this has implications for residential locations, departure times, and commuting distances. This could call for a more flexible deployment of the infrastructure and services and a proactive influence on the traffic demand. This leads almost automatically to an extension of the role of traffic management.

With more flexible management of supply and demand, there will be greater opportunities for coordination and thus for combating congestion, enabling seamless journeys and fostering co-modality. This will require a higher degree of instrumentation and/or service provision across modes and networks, within cities and in interface with their surrounding environment.

Infographic showing characteristics of in-car and roadside ITS

References

- (Amitran, 2014). D3.1: Methodology for classification of ITS, http://www.amitran.eu/assets/02-March-2015/AmitranD31Methodology-for-classification-of-ITS.pdf.
- (Antonissen et al., 2013). Antonissen T., Dijkstra A., Dreher S., de Haan R., Heiber I., van der Kroon P., Ludeking M., van Muiswinkel K., Pandazis J.-C., Pascotto L., Riederer M., Trommer S., Vreeswijk J., Wilmink I., Johansson H. (2013), *Identifying the most promising ITS solutions for clean and efficient mobility*, iMobility Working group for Clean and Efficient Mobility (WG4CEM).
- (Conduits, 2011). Conduits consortium, *Key Performance Indicators for traffic management and Intelligent Transport Systems*, Deliverable No. 3.5.
- (Ecostand, 2011). Benz T., Andre M., Boulter P., Castermans J., Driever H., de Kievit M., El Faouzi N.-E., Spence A., Turksma S., Voge T. (2011). *Inception report and state-of-the-art review*. (European Commission, 2011). *Roadmap to a single European transport area – Towards a competitive and resource efficient transport system*, White paper, COM(2011)144, Brussels.
- (European Commission, 2013-1) *Communication from the commissions to the European parliament, the council, the European economic and social committee and the committee of the regions*, COM(2013)913, Brussels.
- (European Commission, 2013-2) *Mobilising Intelligent Transport Systems for EU cities*. Accompanying the document: Communication from the commissions to the European parliament, the council, the European economic and social committee and the committee of the regions, SWD(2013)527, Brussels.
- (Hall and Van de Lindt, 2009). Hall R., van de Lindt M., Emmert S. (2009). Framework for evaluation in CIVITAS Pointer.
- (ICT for Clean and Efficient Mobility). iMobility Working Group ICT for Clean and Efficient Mobility, http://www.imobilitysupport.eu/imobility-forum/working-groups/ict-for-clean-and-efficient-mobility.
- (Improve Public Transport, 2015). http://improve-public-transport.wikispaces.com/intro_TSP, on 10/6/2015.
- (Klunder et al., 2009). Klunder G.A., Malone K., Mak J., Wilmink I., Schirokoff A., Sihvola N., Holmen C., Berger A., de Lange R., Roeterdink W., Kosmatopoulos E. (2009). *Impact of information and communication technologies on energy efficiency in road transport*, TNO report for European Commission.
- (Ricardo-AEA, 2014). *Update of the Handbook on External Costs of Transport*, 2014. http://ec.europa.eu/transport/themes/sustainable/studies/doc/2014-handbook-external-costs-transport.pdf
- (Rijkswaterstaat, 2004). *Werkboek Gebiedsgericht Benutten* or (Rijkswaterstaat 2003). *Handbook Sustainable Traffic Management*. Dutch version available here: http://www.rijkswaterstaat.nl/images/Werkboek%20GGB%20A4_tcm174-329114.pdf.
- (Spyropoulou, 2004). Spyropoulou I., *Available Intelligent Transport Systems : An in-depth overview*, http://www.noehumanist.org/documents/DesignGuidelines-useracceptance-and-Impact-of-ITS/Available-ITS-and-designguidelines/I1_ispyropoulou.pdf
- (TrafficQuest, 2012). *The future of traffic management. State of the Art, Current Trends and Perspectives for the Future.*
- (TrafficQuest, 2014). *TrafficQuest report 'Stedelijk verkeersmanagent'* (urban traffic management, in Dutch), Problemen van nu en oplossingsrichtingen voor de toekomst, Workshop report, Utrecht, 2 July 2014.
- (TrafficQuest, 2014-2). *Coöperatieve systemen en automatisch rijden* (in Dutch), 2014

NOTES

Intelligent Transport Systems and traffic management in urban areas

CIVITAS

CIVITAS
Cleaner and better transport in cities

POLICY NOTE