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D2.2 Assessment of main barriers and KPIs for the implementation of ITS services

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Abbreviations

ANPR	Automatic Number Plate Recognition
APTS	Advanced Public Transportation System
ATIS	Advanced Traveller Information Systems
ATMS	Advanced Traffic Management System
ATPS	Advanced Transportation Payment System
CEN	European Committee for Standardisation
C-ITS	Cooperative Intelligent Transport Systems
CO_2	Carbon dioxide
CSF	Critical Success Factors
CVS	Cooperative Vehicle System
dB	Decibel
EC	European Commission
EETS	European Electronic Toll Service
ETSI	European Telecommunications Standards Institute
EU	European Union
FP7	Framework Program 7 of the European Commission
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPS	Global Positioning System
H2020	Horizon 2020 Program of the European Commission
I2V	Infrastructure to Vehicle
ICT	Information and Communication Technologies
ITS	Intelligent Transport Systems
KPI	Key Performance Indicator
MaaS	Mobility as a Service
MTA	Metropolitan Transportation Authorities
NO_x	Nitrogen Oxide
PM	Particulate Matter
PPP	Public Private Partnership
R&D	Research and development
RTTI	Real-Time Traffic and Travel Information
SMS	Short Message Service

TCP/IP	Transmission Control Protocol/Internet Protocol
TRL	Technology Readiness Level
US	United States
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Other transport participants
WP	Work Package

Abstract

To support the development of more robust business cases and more effective policy incentives for ITS services, a better understanding of the factors affecting the deployment of these services is required. The Horizon 2020 project NEWBITS (*NEW Business models for ITS)* aims to contribute to this improved understanding, among other things by assessing the barriers, enablers and key performance indicators (KPIs) for the deployment of ITS services. More specifically, in this deliverable we provide an overview of the barriers, enablers and KPIs for ITS services and identify the most relevant ones per market segment/service type. Furthermore, we explore the impact of external factors (macro-trends) on the future relevance of barriers and enablers. Finally, the barriers for applying KPIs are studied.

Various research methods are used in the assessment of barriers, enablers and KPIs. First a systematic review of the literature, supplemented with some interviews with key stakeholders, has been carried out in order to provide a complete overview of relevant barriers, enablers and KPIs. Subsequently, the main barriers, enablers and KPIs per market segment were determined based on the results of an on-line stakeholder survey (54 respondents). The results of this survey were supplemented by an assessment of the barriers, enablers and KPIs that were identified for 94 specific ITS services that are actually implemented/piloted.

Our study shows that the relevance of barriers and enablers for the deployment of ITS services differ significantly between market segments. However, some general patterns may be recognised. According to the stakeholders, lack of attractive business models, lack of political prioritisation, lack of cooperation between stakeholders and lack of interoperability between services are relevant barriers on all market segments. The opposites of these barriers (e.g. increasing political commitment) are often mentioned as relevant enablers, but also 'an increased popularity of *mobility as a service*' and 'enhanced public private partnerships' are often mentioned as enablers for the various market segments. The relevance of these barriers and enablers may be affected in the near future due to trends as urbanisation, ageing populations and technological developments (e.g. 5G and Internet of Things).

As for KPIs, we find that there are no universal deployment KPIs, but that their relevance depends on the market segment considered. For example, on market segments where services focused on end-users are offered, 'the number of end-users using the service' is indicated as the most relevant deployment KPI; however, for market segments focused on cooperative vehicle systems, the 'number of vehicles using the ITS service' was found to be the most relevant KPI. Benefit KPIs (indicators to measure the impact of the ITS service) were found to be best defined in line with the primary objective (i.e. safety, transport efficiency, environmental performance, comfort) of the service. Furthermore, benefit KPIs should preferably be direct measures of the intended impacts (e.g. emission level, number of accidents) instead of indirect measures (e.g. transport volumes). Finally, our study shows that for a significant share of the ITS services actually implemented/piloted no KPIs are defined/used. Important reasons for these low rates of KPI implementation are a lack of available/compatible data and of knowledge/skills

Executive summary

Intelligent Transport Systems (ITS) can significantly contribute to a cleaner, safer and more efficient transport system. A major role in this respect is expected for Cooperative Intelligent Transport Systems (C-ITS), as their cooperative element – enabled by digital connectivity between vehicles and between vehicles and transport infrastructure – is envisaged to contribute significantly to achieving the objectives mentioned above. However, the deployment of ITS services is slow and fragmented, among other things because robust and innovative business models are missing. Confidence of the key stakeholders in the long-term profitability of investments in these services are necessary and hence require these improved business models.

To support the development of more robust business models (and effective policy incentives) for ITS services, an improved understanding of the factors affecting the deployment of innovative ITS deployment is required. The Horizon 2020 project NEWBITS (*NEW Business models for ITS)* aims to contribute to this improved understanding. As part of the NEWBITS project, the barriers, enablers and key performance indicators (KPIs) for the deployment of ITS services are assessed. The results of this assessment are presented in this deliverable.

Objectives
The objectives of this report are:
- to provide an assessment of main barriers and enablers for the implementation of ITS services, distinguishing between different market segments / types of these services. The study will be focused on the current barriers and enablers, but will also explore the impact of external factors (macro-trends) on their future relevance.
- to provide an assessment of the main KPIs used for ITS services, again distinguishing between different market segments / types of these services. The main barriers for applying these KPIs will be studied as well.

Methodology
Several research methodologies have been used to assess the barriers, enablers and KPIs for the deployment of ITS services. First a systematic review of the literature, supplemented by 13 interviews with key stakeholders, has been conducted in order to provide a complete overview of the relevant barriers, enablers and KPIs.

One of the outputs of this activity were longlists of barriers, enablers and KPIs. From these longlists stakeholders were asked to choose the most relevant ones per market segment in an on-line stakeholder survey (54 respondents). The following market segments (identified in NEWBITS D2.1) were distinguished for this purpose: advanced travel information systems (ATIS), advanced traffic management system (ATMS), advanced transportation pricing systems (ATPS), advanced public transportation system (APTS) and cooperative vehicle system (CVS). Based on the results of the stakeholder survey, the main barriers, enablers and KPIs per market segment were identified. The stakeholder survey was also used to collect input for the assessment of barriers to the appliance of KPIs.

In addition to the on-line stakeholder survey, the barriers, enablers and KPIs applied for 94 actually implemented/piloted ITS services in Europe, the US and Australia (identified in NEWBITS D2.1) were assessed. The assessment was implemented based on an analysis of publicly available documents and communication (e.g. websites) related to the services, if

necessary complemented by information requests to relevant stakeholders heavily involved in the implementation of the services. The results of this assessment were used to validate the results of the stakeholder survey. Additionally, results per service type were derived from these assessments.

Finally, a literature study was carried out to study the impact of some external factors (macro-trends) on the future relevance of the various barriers and enablers.

Results on the assessment of barriers and enablers

An overview of the main barriers and enablers for the deployment of ITS services is shown in Table 1. These are general barriers and enablers (and not context-specific ones) commonly encountered during the deployment of ITS services. Although this long list of barriers and enablers is not exhaustive, it does contain the most relevant ones.

Category	Barriers	Enablers
Institutional	• Lack of a sufficient legal framework • Lack of political prioritisation	• Supportive regulation and clear legal framework • Increasing political commitment • Enhanced public-private partnerships
Economic	• Lack of funding • Lack of attractive business models	• Innovative funding schemes • Attractive business models
Technical	• Current infrastructure not ready to integrate innovative ITS technologies • Lack of interoperability and incompatibility among ITS services • Technical weaknesses in ensuring data security • High or uncertain maintenance costs	• Upgrade of ITS infrastructure • Standardisation for interoperability of ITS services • Lesser costs of maintenance
Social and Attitudes	• Lack of user acceptance • Limited understanding of user needs	• Higher levels of end users involvement • Increased attention for sustainable transport
Organisational	• Lack of cooperation between stakeholders • Lack of skilled staff for ITS companies	• More cooperation between stakeholders
Impact	• Lack of demonstrated benefits of ITS services	• Development of clear KPIs • Proven benefits of ITS services • Increased public awareness on ITS benefits and perception
Other	• Existence of the last mover advantage	• Increased popularity 'Mobility as a Service'

Table 1 Overview of barriers and enablers for the deployment of ITS services

From the list of barriers presented in Table 1, economic (lack of attractive business models and lack of funding) and technical barriers (incompatible infrastructure and lack of interoperability between services) were often mentioned by stakeholders as important, general barriers to the deployment of ITS services, as were the lack of cooperation between stakeholders and the lack of political prioritisation Based on the assessment of actually implemented/piloted ITS services also the lack of sufficient legal framework and the lack of user acceptance were identified as important barriers.

However, significant differences in barriers do exist between different market segments, as is shown by Table 2. For example, lack of attractive business models is found to be an important barrier for the ATIS, APTS and CVS market segments, while political prioritisation is most often mentioned as an important barrier for the ATMS and ATPS segments.

Technical barriers are relevant for all market segments, although there are differences in the type of barriers. For the user-driven market segments (ATIS, ATPS and APTS) the lack of interoperability among ITS services is seen as the most relevant barrier, while for the ATMS and CVS market segments inadequate infrastructure is most often mentioned as a technical barrier to the deployment of ITS services.

Market segment	Three most often mentioned barriers
Advanced Traveller Information Systems (ATIS)	1. Lack of attractive business models 2. Lack of cooperation between stakeholders 3. Lack of interoperability and incompatibility among ITS services
Advanced Traffic Management System (ATMS)	1. Lack of political prioritisation 2. Lack of funding 3. Current infrastructure not ready to integrate innovative ITS technologies
Advanced Transportation Pricing System (ATPS)	1. Lack of political prioritisation 2. Lack of user acceptance 3. Lack of interoperability and incompatibility among ITS services
Advanced Public Transportation System (APTS)	1. Lack of interoperability and incompatibility among ITS services 2. Lack of cooperation between stakeholders 3. Lack of attractive business models
Cooperative Vehicle System (CVS)	1. Lack of attractive business models 2. Current infrastructure not ready to integrate innovative ITS technologies 3. Lack of cooperation between stakeholders

Table 2 Most frequently mentioned barriers per market segment

Opposites of main barriers are identified as relevant enablers, i.e. increasing political commitment, standardisation for interoperability of ITS services, more cooperation between stakeholders and attractive business models. Also 'increased popularity of *mobility as a service*' and 'enhanced public private partnerships' were identified as relevant enablers, while higher level of end-user involvement was found as an important enabler for more mature ITS services.

As for barriers, enablers do differ significantly between market segments, as is shown by Table 3. For example, increased popularity of "Mobility as a Service" is most often mentioned for the ATIS and APTS segment (segments focussing on stimulating intermodal transport), while for the ATMS and CVS segments it is only modestly mentioned by the stakeholders.

Market segment	Three most often mentioned enablers
Advanced Traveller Information Systems (ATIS)	1. Increased popularity of "Mobility as a Service" 2. Attractive business models 3. More cooperation between stakeholders
Advanced Traffic Management System (ATMS)	1. Increasing political commitment 2. Enhanced public-private partnerships 3. More cooperation between stakeholders
Advanced Transportation Pricing System (ATPS)	1. Increasing political commitment 2. Attractive business models 3. Standardisation for interoperability of ITS services
Advanced Public Transportation System (APTS)	1. Increased popularity of "Mobility as a Service" 2. Increased attention for sustainable transport 3. Increasing political commitment
Cooperative Vehicle System (CVS)	1. Standardisation for interoperability of ITS services 2. Increasing political commitment 3. Supportive regulation and clear legal framework

Table 3 Most frequently mentioned enablers per market segment

The relevance of barriers and enablers may change in the future due to trends like urbanisation, increased attention for sustainability, emerging technologies (e.g. 5G, Internet of Things), demographic changes (e.g. ageing) and increased demand for multimodal transport. It is expected that political commitment may increase (e.g. due to increased attention for sustainable transport), while more attractive business models will become available (e.g. due to urbanisation). Furthermore, emerging technologies like 5G may improve the infrastructure to implement innovative ITS services which require intense and fast communication between vehicles and between vehicles and infrastructure. .

Results on the assessment of KPIs

With respect to KPIs, a distinction has been made between deployment KPIs and benefit KPIs. The former refer to indicators related to the extent by which ITS services are implemented, while benefit KPIs are related to the (desired) impacts of ITS services.

With respect to deployment KPIs, the following indicators were identified:

- Length of the transport network covered by ITS service
- Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)
- Number of network elements (e.g. intersections) covered by ITS service
- Number of specific infrastructure hardware (e.g. traffic lights) used
- Frequency by which ITS service is used
- Number of end-users of ITS service
- Number of vehicles featuring ITS technology in application area of ITS service
- Number of vehicles in application area actually using the ITS service
- Number of hours ITS service has operated
- Number of visits to website and portals linked to the ITS service.

From this list of KPIs, the stakeholders have chosen the most relevant ones for each of the five market segments. From this assessment, no universal deployment KPIs can be derived, as the relevance of the KPIs depends on the market segments considered (see Table 4).

Market segment	Three most often mentioned deployment KPIs
Advanced Traveller Information Systems (ATIS)	1. Number of end-users 2. Length of transport network covered by ITS service 3. Number of vehicles actually using the ITS service
Advanced Traffic Management System (ATMS)	1. Number of network elements covered by ITS service 2. Length of transport network covered by ITS service 3. Number of specific infrastructure hardware used
Advanced Transportation Pricing System (ATPS)	1. Number of end-users 2. Length of transport network covered by ITS service 3. Number of vehicles actually using the ITS service
Advanced Public Transportation System (APTS)	1. Number of end-users 2. Length of transport network covered by ITS service 3. Frequency by which ITS service is used
Cooperative Vehicle System (CVS)	1. Number of vehicles actually using the ITS service 2. Number of vehicles featuring ITS technology 3. Number of end-users

Table 4 Most frequently mentioned deployment KPIs per market segment

Some general patterns on the barriers per market segment can be recognised, though. For the market segments where services are offered that are focussed on end-users (ATIS, ATPS, APTS) the 'number of end-users of the ITS service' was most often indicated by the stakeholders as a relevant deployment KPI. On the other hand, for market segments focussed on infrastructure manager related services (ATMS), KPIs related to the ITS infrastructure were mentioned most often. Finally, the length of the transport network covered by the ITS service is frequently mentioned for all of the market segments, showing the rather general nature of this KPI.

As for benefit KPIs, it was found that these should be best defined in line with the primary objective (i.e. safety, transport efficiency, environmental performance, and comfort) of the service. As these primary objectives are only indirectly linked to market segments, it is not recommended to define a set of benefit KPIs per market segment. The most frequently mentioned benefit KPIs per primary objective in the stakeholder survey are shown in Table 5.

Primary benefit	Three most often mentioned benefit KPIs
Transport efficiency	1. Average journey time 2. Predictability of travel times 3. Total travel volumes
Environmental performance	1. Level of emissions 2. Total fuel/energy consumption 3. Number of times thresholds are exceeded
Comfort	1. Reliability of journey time 2. Quality of travel information provided 3. Reliability of transport services
Safety	1. Number of reported accidents 2. Number of reported fatal accidents 3. Number of accidents requiring medical attention

Table 5 Most frequently mentioned benefit KPIs per primary benefit

As illustrated by Table 5, KPIs directly measuring the intended impact (e.g. level of emissions) are preferred over more indirect benefit KPIs (e.g. transport volume to measure environmental performance). However, the assessment of KPIs applied for actually implemented/piloted ITS services shows that indirect measures are used quite often, probably because they are easily measurable and/or cover several impacts.

Finally, our assessment of actually implemented/piloted ITS services reveals that KPIs are not always defined and used for ITS projects. And even if they are defined, these are not always the ones considered most appropriate by the respondents of the stakeholder survey. Lack of available/compatible data and of knowledge/skills were identified as main reasons for not applying these (most appropriate) KPIs.

1 Introduction

1.1 Background

Intelligent Transport Systems (ITS) can significantly contribute to a cleaner, safer and more efficient transport system. Improvements in these fields are necessary, as transport is (still) an important source of greenhouse gas (GHG) and air pollutant emissions[1], results in huge social costs due to congested roads[2], and is responsible for a large number of annual fatalities due to traffic accidents[3]. In its Action Plan for the deployment of ITS in Europe, the European Commission sees an important role for ITS in order to further greening transport, improving transport efficiency, transport safety and security (European Commission, 2008). Furthermore, the Commission expects ITS to significantly contribute to the improvement of the competitiveness of European industry (European Commission, 2016), resulting in the creation of additional jobs and turnover.

One specific type of ITS are Cooperative Intelligent Transport Systems (C-ITS), which allow transport users and traffic managers to share information and use it to coordinate their actions. This cooperative element – enabled by digital connectivity between vehicles and between vehicles and transport infrastructure – is expected to increase the contribution ITS can provide to the objectives mentioned above. The C-ITS platform (2016) finds that the appliance of technical ready C-ITS services will already produce a benefit-cost ratio of up to 3 to 1 in the period up to 2030. Due to network effects[4], rapid deployment of C-ITS services at a large scale may even result in higher benefits and break even points that are quicker reached.

Although the significant and proven added value ITS services can provide to the European transport system, their deployment is considered to be slow and fragmented (C-ITS Platform, 2016; Ricardo, 2016). Robust and innovative business models that would support a truly responsive approach to accelerating commoditisation and price-competition in the market for ITS services are often missing, inter alia due to the public-oriented nature of C-ITS users (Agelidou et al., 2015). Confidence of the core stakeholders on the (long-term) profitability of their investments in C-ITS services and technologies is necessary and requires sound and convincing business cases.

To support the development of more robust business cases (and more effective policy incentives), a better understanding of the factors affecting the deployment of innovative ITS deployment is required. The Horizon 2020 project NEWBITS (*NEW Business models for ITS*) aims to contribute to this improved understanding, among other things by assessing the barriers, enablers and key performance indicators (KPIs) for the deployment of ITS services.

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[1] The European transport sector was responsible for about 20% of the GHG emissions, 45% of the NO_x emissions and 13% of the $PM_{2.5}$ emissions in Europe in 2014 (EEA, 2016a; 2016b).

[2] For example, the costs of road congestion are estimated at € 140 billion a year, about 1% of European GDP (TRT, 2016)

[3] The number of fatalities due to transport accidents is roughly estimated at 26,000 in Europe in 2014 (European Commission, 2016b).

[4] The effectiveness of C-ITS applications often increases if more vehicles and/or a larger share of the transport infrastructure are able to participate.

1.2 Objectives

The objectives of this Deliverable are:

- to provide an assessment of main barriers and enablers for the implementation of ITS services, distinguishing between different types of these services. The study will be focused on the current barriers and enablers, but will also explore the impact of external factors (macro-trends) on their future relevance.
- to provide an assessment of the main Key Performance Indicators (KPIs) used for ITS services, again distinguishing between different types of these services. The main barriers for applying these KPIs will be studied as well.

In order to achieve these two separate objectives of this deliverable, the following research questions are addressed in this study.

Research questions

1. What are the main barriers and enablers for different types of ITS services?
   a. Which barriers and enablers with respect to ITS services do exist?
   b. What are the main barriers and enablers for different categories of ITS services?
   c. What are the expected impacts of relevant external factors (macro-trends) on the future relevance of the identified main barriers and enablers?
2. What are relevant KPIs for different types of ITS services and which barriers for applying them can be distinguished?
   a. Which KPIs with respect to ITS services can be applied?
   b. What are the relevant KPIs for different categories of ITS services?
   c. What are the main barriers for the implementation of these KPIs?

1.3 The role of this deliverable in NEWBITS

1.3.1 The NEWBITS project

The main goal of the NEWBITS project is to provide a deep understanding of the changing conditions and dynamics that affect and influence the deployment of ITS services. This improved understanding must contribute to minimizing the failures inherent to ITS innovation diffusion, evolve present business models, and identify effective (policy) incentives to accelerate ITS deployment.

To achieve the objectives of the NEWBITS project, assessment at both the macro-level and the meso-level (business ecosystems) are conducted. At the macro-level an exploratory analysis of ITS services is carried out, including the identification and mapping of current ITS services, the assessment of barriers, enablers and KPIs for these services and a benchmark analysis on the deployment of ITS services in both the EU and US. At the meso-level, ITS services are assessed at the business ecosystem level, focussing on the identification how value is created by ITS companies within the context of the networks in which they operate. This improves the understanding of the ecosystems in which ITS companies operate and which factors are crucial in the creation and management of these ecosystems.

The results of these assessments at both macro- and meso-level will be used to develop guidelines for innovative business models and effective policy incentives. Furthermore, a set of training materials and virtual training concepts are developed in order to disseminate the main results of the NEWBITS project to relevant stakeholders.

1.3.2 The role of this deliverable

The assessment of barriers, enablers and KPIs for ITS services, as performed in this deliverable, is part of the macro-level assessments carried out in NEWBITS in order to better understand the ITS deployment process. It builds on the results of NEWBITS D2.1, which provides an overview and mapping of ITS services currently applied in the EU, US and Australia. In total 94 ITS services were identified in NEWBITS D2.1, which were categorized according to market segment and service type. In this deliverable, the barriers, enablers and KPIs of these services were assessed in order to provide insight in their relevance for the different market segments and service types. Elaborating on the assessments carried out in NEWBITS D2.1 therefore provides us the opportunity to gain in-depth knowledge of the factors that affect the deployment process of specific ITS services.

The results of this deliverable are an important input for the selection and taxonomy of the NEWBITS case studies (see NEWBITS D2.3). These case studies are conducted to assess ITS deployment at the level of business ecosystems. The barriers, enablers and KPIs are important criteria to select and validate these case studies. By applying the results of this deliverable in this process, a selection of case studies can be made that provide a balanced overview of all the barriers, enablers and KPIs relevant for the deployment of ITS services.

By providing input to the selection of the NEWBITS case studies, this deliverable indirectly supports the meso-level assessments to be carried out in NEWBITS WP3 (Holistic Intelligence Process) and WP4 (Developing Innovative Business Models). In these work packages the stakeholders and their interrelationships in ITS business ecosystems will be studied in detail.

The results of the assessments on barriers, enablers and KPIs do provide direct input for the development of guidelines for innovative business models and effective policy incentives for ITS deployment, as is carried out in NEWBITS WP5. The improved understanding of barriers and enablers for different types of ITS services is important input for identifying opportunities for developing more robust business cases and more effective policies. Furthermore, knowledge on the relevance of existing KPIs provide input to the development of more effective KPIs that can support the implementation of ITS deployment business cases and policies.

1.4 Overview of the study

In Chapter 2 the assessment framework applied in this deliverable is presented, discussing the scope of the study and the methodological framework applied. Based on this assessment framework the barriers and enablers for ITS services are analysed in Chapter 3, providing answers to research question 1 of this study. The second research question of this study is addressed in Chapter 4, discussing the (barriers for applying) KPIs for ITS services. Finally, the main conclusions of the study are presented in Chapter 5.

2 Assessment framework

2.1 Introduction

In this chapter we present the framework used to assess the barriers, enablers and KPIs for ITS services. In section 2.2, we first discuss the concept of ITS services as defined in NEWBITS D2.1. Furthermore, the results of the categorization of ITS services performed in NEWBITS D2.1 are briefly discussed. Subsequently, the approaches to assess the barriers, enablers and KPIs for ITS services are presented in section 2.3. In this section also the research methods applied for these approaches are discussed.

2.2 ITS services

2.2.1 Definitions of ITS and C-ITS

In NEWBITS D2.1, Intelligent Transport Systems (ITS) are defined as the application of information and communication technologies (ICT) in transport. It is considered that the main function of ITS is to increase the efficiency in the transport system, with special focus on the service and information provision for the full spectrum of users (drivers, passengers, vehicle owners, network operators, etc.) which involves a diversity of stakeholders (network operators).

A specific subset of ITS are Cooperative Intelligent Transport Systems (C-ITS), that has been defined by the European Committee for standardization (CEN) and the European Telecommunications Standards Institute (ETSI) as '*a subset of the overall ITS that communicates and shares information between ITS stations to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems'.* What C-ITS distinguishes from other ITS is the communication between different systems (i.e. personal ITS stations (e.g. mobile phones), vehicles, transport infrastructure or traffic management centres), which increases the ability for applications to collect and deliver information, and hence increases the overall quality of ITS services. This communication involves communication between vehicles (vehicle-to-vehicle, V2V), between vehicles and infrastructure (vehicle-to-infrastructure, V2I; infrastructure to vehicle, I2V) and/or between vehicles and other transport participants (V2X), such as pedestrians and cyclists.

2.2.2 Defining ITS services

The aim of this Deliverable is to assess the barriers, enablers and KPIs for ITS *services*. In NEWBITS D2.1 ITS services are defined as the combined use of ITS technologies in order to fulfil user requirements related to a transport mode (or the integration of more than one transport mode) on a certain market (tTrans, 2013). A broad overview of ITS services has been given in NEWBITS D2.1, including green light optimal speed advisory, multi-modal route planners, smart mobility cards and platooning.

2.2.3 Categories of ITS services

In NEWBITS D2.1 categories of ITS services are defined at two different levels, both fitting to the overall NEWBITS objectives. First, five different market segments of ITS services are distinguished (see Table 6). Given the business ecosystem scope of NEWBITS WP3 and WP4 (see section 1.3), this market-oriented categorisation of ITS services is regarded very useful for the purposes of NEWBITS.

Market segment	Description	Examples of services
Advanced Traveller Information Systems (ATIS)	ITS services that provide travelers with real-time travel and traffic information	• In-vehicle route and navigation systems • In-vehicle motorist service information systems • In-vehicle signing information systems • In-vehicle safety and warning systems
Advanced Traffic Management System (ATMS)	ITS services that focus on traffic control devices, such as traffic signals, ramp metering, parking management systems and demand and access management systems.	• Signal control • Highway systems • Enforcement systems • Parking management • Traffic monitoring • Demand and access management
Advanced Transportation Pricing System (ATPS)	ITS-enabled transportation pricing systems, mainly used for electronic toll collection purposes	• Vehicle miles travelled systems • Fee-based express lanes • Congestion pricing • Electronic toll collection
Advanced Public Transportation System (APTS)	ITS services that enable transit vehicles, whether bus or rail, to optimize their operations, e.g. by real-time reporting on their current location or improved information on their usage patterns.	• Multimodal route planners • Multi & smart ticketing • Optimised fleet management • Real time system status information • Schedule optimisation • Passenger information systems
Cooperative Vehicle System (CVS)	ITS services that involves communication and information sharing between ITS stations in order to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems.	• Green light optimal speed advice (V2I) • Emergency brake systems (V2V) • Vehicle platooning systems (V2V)

Table 6 ITS market segments

In addition to ITS market segments, different types of ITS services were distinguished in NEWBITS D2.1 (see Table 7). This was based on an inventory of 94 specific ITS services applied in the EU, US and Australia. These services were clustered considering market segment, primary benefit, technology readiness level (TRL) and key enabling technology. This clustering exercise provides four bundles of ITS services (service types) that well reflect the variety in the ITS services piloted or applied in the EU, US and Australia.

Service type	Characteristics	Examples of services
Type 1	• Services are already on the market (TRL 9) • Belong to the market segments ATMS, APTS or ATPS • Comfort and efficiency are the most common primary benefits • Key technologies are identification, communication and hardware infrastructure	• Oyster card • Scott rail smartcard • Access control Rome • Congestion charge London • Madrid smart parking
Type 2	• Services are mostly in pilot phase (TRL 7) • Belong mainly to the market segments CVS and ATIS • Safety and environmental performance are the main primary benefits	• In-vehicle safety and warning systems • Smart pedestrians crossings • Warning systems traffic queues

Service type	Characteristics	Examples of services
	• Key technologies are communication and hardware infrastructure.	
Type 3	• Services can be both in pilot phase or already on the market (TRL 7–9) • Belong to the market segments ATIS, ATMS and APTS • Efficiency improvement is the main primary benefit; • Key technologies are software infrastructure, positioning and algorithms	• Piedmont regional traffic centre • Lange management USA • Automated passenger counting systems • Parking management systems • Multimodal journey planners
Type 4	• Services are mainly in pilot phase (TRL 7) • Belong mainly to the market segment CVS • Efficiency improvement is the main primary benefit • Key technology is communication.	• Heavy vehicle platooning • Connected cruise control • Smart truck parking

Table 7 ITS service types

In this deliverable, we assess the barriers, enablers and KPIs both at the level of market segments and at the level of service types. By considering both levels of categorisation, we gain a more detailed understanding on the diversity in barriers, enablers and KPIs, which will be useful for developing robust business models and effective policy incentives for all kinds of ITS services.

2.3 Methodological approach

In this section we present the methodological approach used in this study to assess the barriers/enablers and KPIs relevant for ITS services. Although the assessments of both issues are rather comparable, there are some clear differences. For that reason, we first discuss separately the various assessment steps applied for the analysis of barriers/enablers and KPIs. Secondly, we discuss the various research methods (literature review, interviews, surveys) applied in both types of assessments.

2.3.1 Assessment of barriers/enablers

The assessment of barriers and enablers for ITS services consists of four consecutive steps (see Figure 1):

- **Step 1: Conduct a systematic review:** we started the assessment of barriers and enablers by clearly defining the concepts of barriers and enablers. Next, an overview of all relevant barriers and enablers for ITS services was provided and the way they affect these services was discussed. The barriers and enablers were categorised in some broad categories (e.g. economic barriers/enablers, technological barriers/enablers) to structure the analysis. The systematic review has been based on a thorough review of relevant literature and interviews with some key stakeholders.

- **Step 2: Identification of main barriers and enablers by market segment**: in this step we determined the main barriers and enablers for the five market segments identified in NEWBITS D2.1 (see section 2.2). For this purpose, we asked relevant stakeholders to identify for each market segment the five main barriers/enablers from the long list produced in step 1. This was done by using an on-line survey, providing us the opportunity to identify whether different groups of stakeholders (policy makers, academics/researchers, ITS industry and transport industry) have different views on the barriers and enablers for ITS services.

- **Step 3: Identification of main barriers and enablers by service type**: for the specific ITS services identified in NEWBITS D2.1, an overview of relevant barriers and enablers is given based on information publicly available (from project documents, websites, direct communication with project managers, etc.). Based on the results of this assessment it was analysed which are the main barriers/enablers per service type and any differences and similarities between service types are discussed. This information was compared with the results of step 1 and 2, in order to assess to what extent the relevant barriers/enablers are reflected in the specific ITS services identified in NEWBITS D2.1.

- **Exploration of the impact of external factors on the future relevance of barriers**: based on a literature review relevant external factors (so-called macro-trends) were identified and their impact on the future relevance of barriers and enablers was studied. Based on this assessment, some first insights on which barriers and enablers will become more/less important in the future were defined.

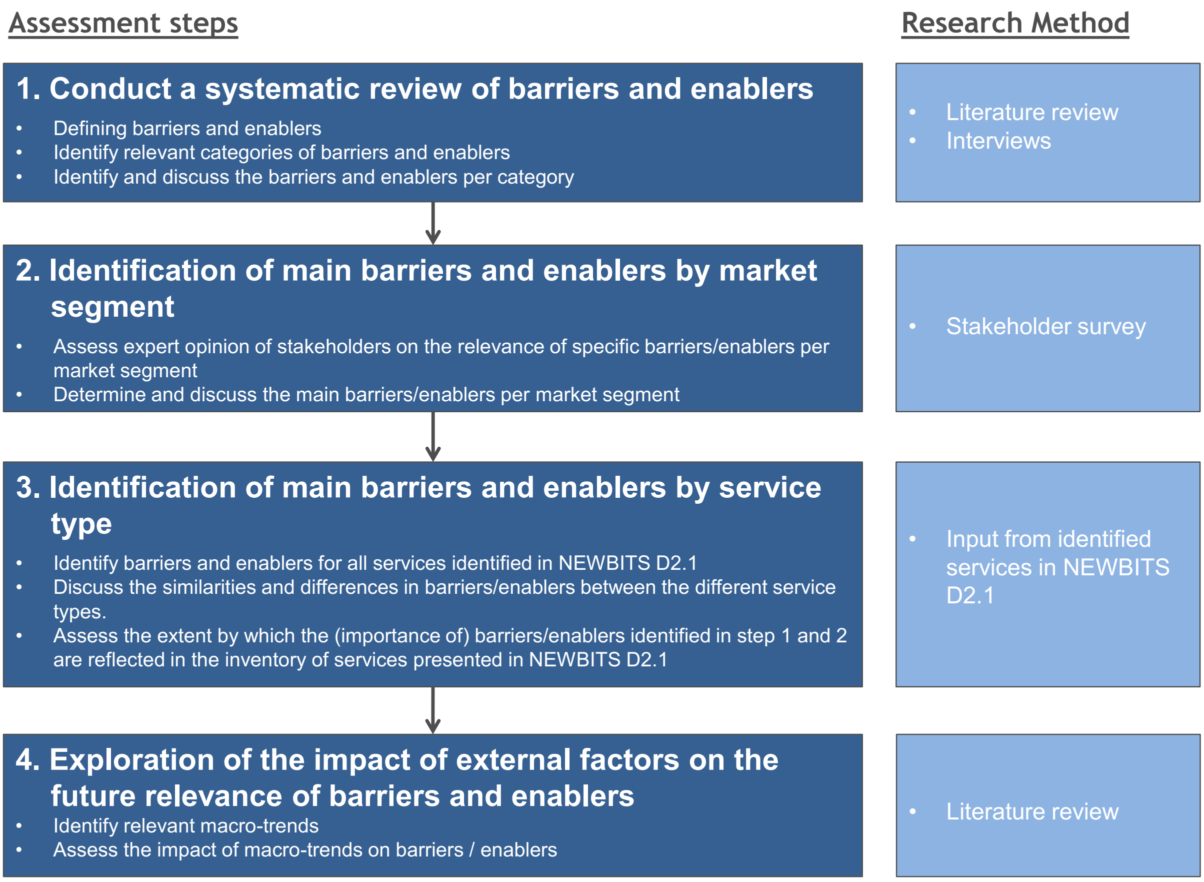

Figure 1 Methodological approach assessment barriers and enablers

2.3.2 Assessment of KPIs

The assessment of KPIs consist of four consecutive steps, presented in Figure 2. Particularly the first three steps are highly comparable to the steps followed for the assessment of barriers and enablers.

- **Step 1: Conduct a systematic review**: the analysis of KPIs was started by defining them and discuss the added value of applying KPIs. Based on a thorough literature review and some interviews with key stakeholders, a list of relevant KPIs was provided. These KPIs are categorised in some broad categories (e.g. deployment and benefit KPIs) in order to structure the analysis of KPIs.

- **Step 2: Mapping KPIs by market segment:** the relevant KPIs identified in step 1 were mapped on the five market segments (as defined in Section 2.2) based on the results of an on-line stakeholder survey. In this survey, stakeholders were asked to identify for each market segment the five most relevant KPIs from the selection of KPIs provided by step 1. Based on this mapping exercise the most relevant KPIs per market segment were identified.

- **Step 3: Assess utilisation of relevant KPIs per service type**: in this step, first the KPIs that are applied for the specific ITS services identified in NEWBITS D2.1 were identified. This was done by studying publicly available information (project documents, websites, direct communication with project managers, etc.). Based on this information it was analysed which are the relevant KPIs per service type and any differences and similarities between service types are discussed. Finally, it was analysed to what extent the different types / most relevant types of KPIs as identified in step 1 and 2 are actually utilised for the ITS services identified in NEWBITS D2.1.

- **Step 4: Assess barriers for the appliance of KPIs**: in the final step, the main barriers for the appliance of (some of) the KPIs were studied. Based on a review of the literature, a list of relevant barriers was identified. Next, the barriers were ranked based on their relevance (per market segment) based on the input provided by stakeholders in the on-line survey. These results were validated by results from the literature.

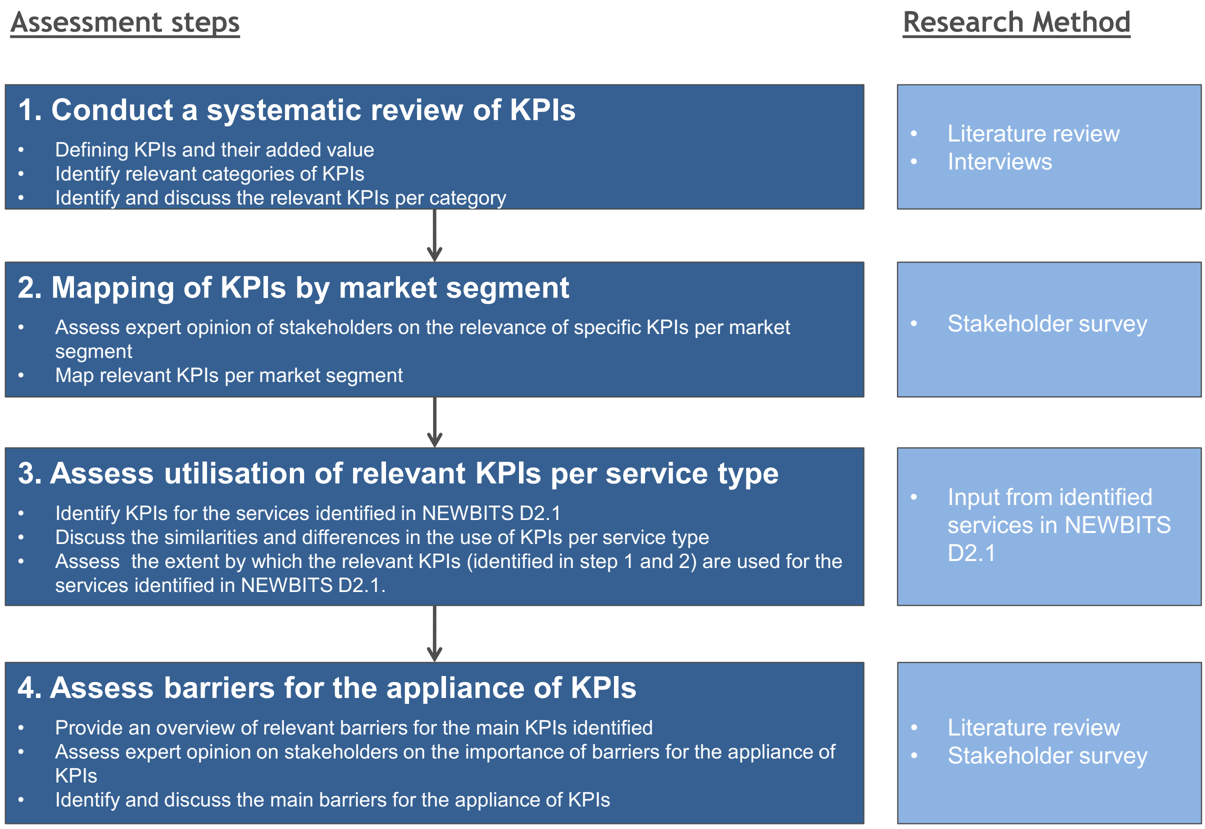

Figure 2 Methodological approach assessment KPIs

2.3.3 Research methods

As explained in the previous two subsections, various research methods are used in the assessment of barriers, enablers and KPIs. These methods are often complementary and therefore multiple methods are applied to study a specific research question. For example, for the systematic review of barriers, enablers and KPIs both a literature review and interviews are conducted.

The following methods are applied in this study:
1. Literature review
2. Stakeholder interviews (semi-structured)
3. Stakeholder survey
4. Input from identified services in D2.1

In the remainder of this section, we will discuss the various methods in more detail.

1. Literature review
An extensive literature review is carried out to systematically assess the existent evidence on barriers, enablers and key performance indicators. Therefore, relevant studies have been identified by searching relevant databases, searching of specialist ITS websites (e.g. EASYWAY) and using general search engines on the internet such as ‘Google’ and ‘Google scholar’. The following types of studies have been studied:
- Policy documents: officially released documents and national/EU policies.
- Academic literature

- Grey literature: all relevant studies not published via the traditional commercial or academic distribution channels.

The studies considered in this deliverable are presented in Chapter 3 and 4.

2. Stakeholder interviews
As input for the systematic review of barriers, enablers and KPIs, interviews with experts in the field of ITS were conducted. These interviews were used to collect information for both NEWBITS D2.1 and D2.2. For this deliverable, the interviews had the goal of collecting tacit knowledge on barriers, enablers and KPIs for ITS services, complementing the information found by the literature review.

The selection of the interviewees was based on a two-step approach:

1. *Development of a long list of relevant experts/stakeholders*; a long list of 108 possible interviewees has been composed, considering the fact that the interviewees should be representative of the NEWBITS target groups (ITS developers and providers, transport industry, policy makers and academia/researchers). Experts from the EU, US and Australia have been considered to provide coverage in all regions relevant for NEWBITS.
2. *Development of short list of relevant experts/stakeholders;* a short list of 17 experts in the field of ITS has been selected based on the following criteria:
   - Single-organisation representation: in cases where multiple representatives of the same organisations are on the list, the person with the most 'visible' expertise in the ITS field was selected (based on an internet search and LinkedIn® scan.
   - Variety of regions: experts from different regions/countries were selected.
   - Variety of types of organisations, covering as much as possible the range of NEWBITS target groups.
   - Involvement in projects: based on an internet search and LinkedIn® scan, it has been assessed whether the listed candidate has participated in relevant ITS projects and events.

From the short list of 17 interviewees, NEWBITS partners have finally interviewed in total 13 experts (see Table 8).

Interviewee	Country	Organisation
Alessandro Lue	Italy	Poliedra
Andre Perpey	France	Geoloc Systems
Avery Ash	United States	INRIX
Claus Doll	Germany	Fraunhofer ISI
Eric Koenders	The Netherlands	Dynniq
Evangelos Mitsakis	Greece	Hellenic Institute of Transport
Fabio Nusslo	Italy	Rome Mobility Agency
Jose Martinez	Spain	CTAG
Kerry Malone	Netherlands	TNO
Lluis Alegre	Spain	Metropolitan Transport Authority
Martin Bohm	Austria	Austriatech
Mohamad Talas	United States	NY Department of Transportation
Vladislav Maraš	Serbia	University of Belgrade

Table 8 List of interviewees

The interviews conducted had a semi-structured character, by using an interview schedule as guideline for the interviews (see Appendix 1). In essence, three blocks of questions have been included in this format, covering the following topics:

- General information about the role of their organisation in the ITS domain;
- ITS services: main services, future trends, primary benefits of ITS.
- KPIs, barriers and enablers.

Particularly the question in the third block were relevant for the assessments carried out in this deliverable. An assessment of the results of these interviews can be found in Appendix 3.

3. On-line stakeholder survey

An on-line stakeholder survey was conducted in order to collect input for:

- The identification of main barriers and enablers per market segment
- The mapping of KPIs per market segment
- The identification of the relevant barriers for applying KPIs related to the deployment of ITS services.

To collect input for these assessments, the on-line stakeholder consultation made use of the results of the systematic review of barriers/enablers and KPIs. From these reviews, a long list of barriers/enablers, KPIs and barriers for the appliance of KPIs were derived. In the survey, stakeholders were asked to choose from these long lists the five most important barriers/enablers/KPIs. Based on this input, the main barriers/enablers/KPIs were identified.

Conducting the on-line stakeholder survey required the following steps:

- *Establishing long list of potential respondents;* based on an assessment of the stakeholder networks of the NEWBITS partners complemented by an internet search, a long list of potential respondents was developed. This effort was supported by ITS UK, by disseminating the survey amongst their members.
- *Development of survey;* based on the results of the systematic review of barriers/enablers and KPIs a survey was developed, using the EU Survey platform. This platform was chosen because of its user-friendliness and as it is trusted/accepted by stakeholders. Draft versions of the survey were reviewed and commented twice by the other NEWBITS stakeholders. Based on the comments received, the final version of the survey was made.
- *Distribution of the survey;* the stakeholder survey has been on-line between April 12th and April 30th 2017 (about 2.5 weeks). All stakeholders on the long-list have been invited on a personal basis by one of the NEWBITS consortium partners to fill in the survey. A reminder has been sent in the final week the survey was on-line to increase the response rate.
- *Data cleaning and checking;* checks on completeness and consistency of the answers provided by the stakeholders was carried out, and open-ended questions were inspected and, where relevant, coded.
- *Analysing the results of the survey;* all answers to the surveys were documented and collated into a MS Excel sheet and were analysed by composing frequency tables and graphs.

A total of 54 completed surveys were received. Figure 3 shows that 52% of the respondents of the survey work in R&D (including universities and consultancy agencies), 22% in industry and 13% in public authorities. Another 13% of respondents work at an organisation that does not fall into these categories. A more detailed distribution of the types of organisation that respondents work for is illustrated by Figure 4.

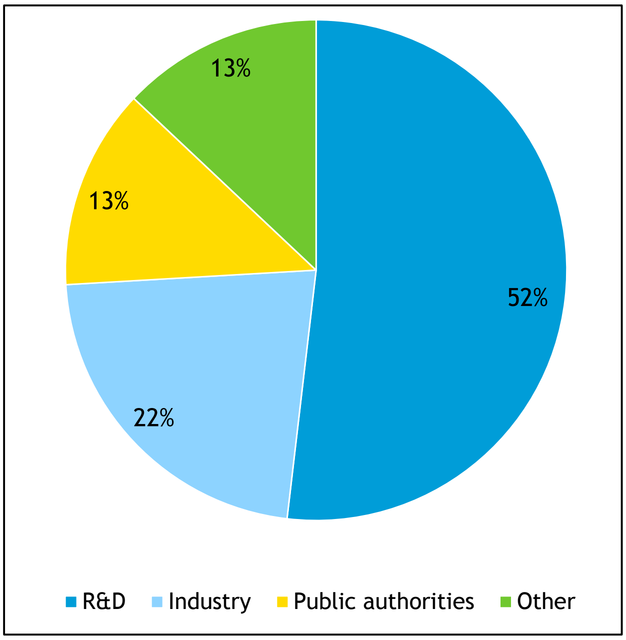

Figure 3 Type of respondents

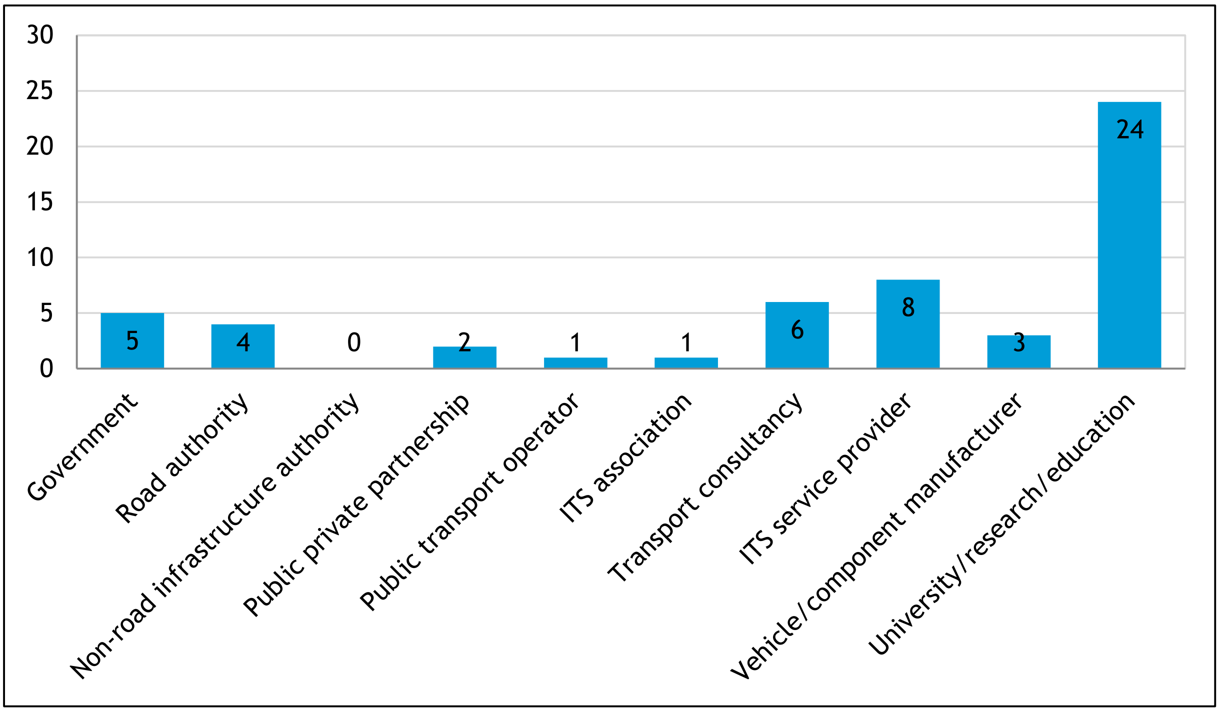

Figure 4 Detailed description of respondents

As shown in Figure 5, most respondents were active in more than one market segment, with the largest number prevalent in Advanced Traveller Information Systems (ATIS). All market segments are well covered by the sample of stakeholders, implying that the results of the survey are relevant for all market segments.

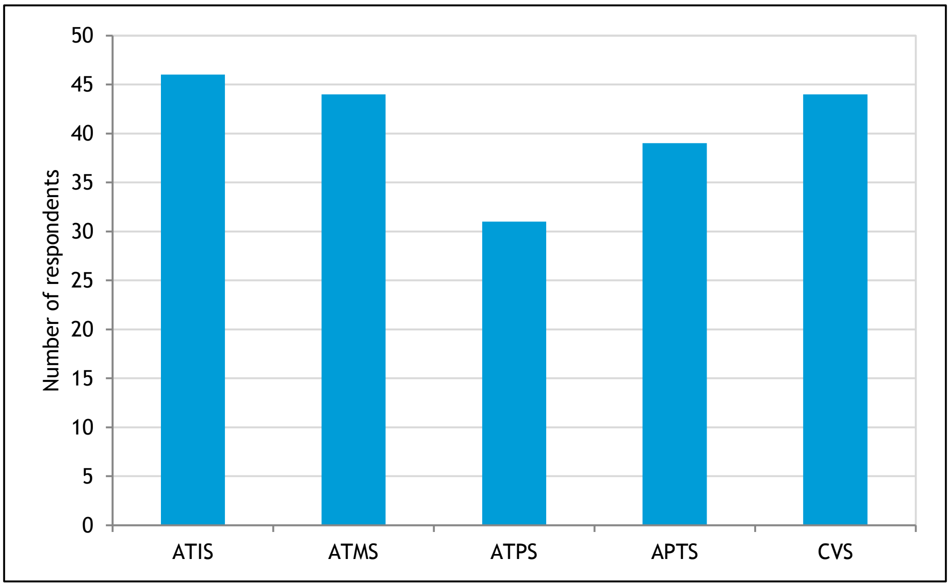

Figure 5 Number of respondents per market segment

Finally, the respondents are together active in a broad range of countries (see Figure 6), mainly in Europe but also in other countries like the US, Argentina, China and Australia.

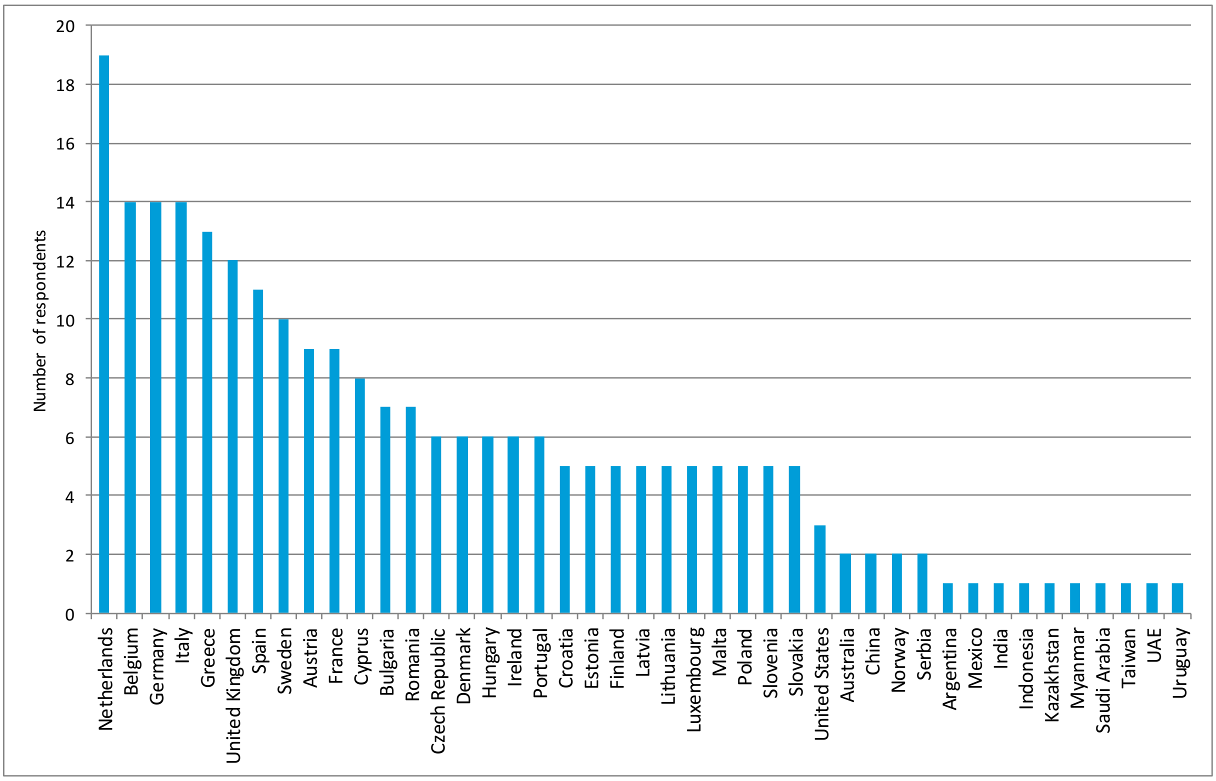

Figure 6 Number of respondents for each country

4. Input from identified services in NEWBITS D2.1

In NEWBITS D2.1 94 specific ITS services applied in the EU, US and Australia were identified, based on an extensive desk research supplemented with some stakeholder interviews. The approach applied to identify (and assess) these services is described in detail in NEWBITS D2.1.

By providing a fiche for each of the identified services, data has been collected in a structured way. For some of the services, this data gathering includes data on identified barriers, enablers and KPIs. However, these data were not yet complete and therefore additional assessments have been carried in preparation of this deliverable to complete these data as far as possible. Therefore, we have studied publicly available documents and communication (e.g. websites) which present relevant information on these services. For some of the services for which no written data was available, relevant stakeholders heavily involved in the implementation of the services were contacted (by email) to request for further information on barriers, enablers and KPIs. By conducting these additional assessments, for 77 of the 94 services information on barriers and enablers was collected. Additionally, for 53 of the 94 services some information on KPIs has been identified.

In a next step, the information on barriers, enablers and KPIs have been mapped to the ITS service types defined in NEWBITS D2.1. The results of this assessment have been used to identify the main barriers/enablers and KPIs per ITS service types.

3 Barriers and enablers

3.1 Introduction

This chapter provides an overview of the main barriers and enablers for the deployment of different types of ITS services. Furthermore, the impact of some external factors on these barriers and enablers is considered in order to assess their future relevance.

This chapter provides answers to research question 1 and underlying sub-questions (see the text box below).

Research question 1

What are the main barriers and enablers for different types of ITS services?

This question consists of three sub-questions:
1. *Which barriers and enablers with respect to ITS services do exist?*
2. *What are the main barriers and enablers for different categories of ITS services?*
3. *What are the expected impacts of relevant external factors (macro-trends) on the future relevance of the identified main barriers and enablers?*

In the remainder of this chapter we first provide a systematic review of the evidence available on barriers and enablers for ITS services. This review results in a clear definition and categorisation of barriers and enablers as well as in a complete overview of relevant barriers and enablers (Section 3.2). In Section 3.3, the main barriers and enablers per market segment are identified, while in Section 3.4 the main barriers and enablers per service type are discussed. Finally, in Section 3.5 some relevant external factors affecting the future relevance of barriers and enablers are discussed.

3.2 Systematic review of barriers and enablers

In order to provide a state-of-the-art overview of relevant barriers and enablers, a review of relevant literature sources is conducted, complemented by some interviews with relevant stakeholders (more information on these research methods applied can be found in Section 2.3.3). The systematic review starts with clearly defining and identifying relevant categories of barriers and enablers. This provides a clear framework that structures the broad inventory of barriers and enablers for ITS services.

3.2.1 Definition of barriers and enablers

Barriers are defined as any factor deterring, complicating and prohibiting the implementation or performance of ITS services. Conversely, any factor that supports the implementation or performance of these services can be identified as an enabler. Thus, barriers and enablers can be identified as opposites of one another (CIVITAS METEOR, 2006).

As indicated by the definitions presented above, barriers and enablers can be related to the implementation and/or performance of ITS services. For example, a lack of funding hampers the implementation of a service, while issues with interoperability of ITS services may hinder its actual performance. Given the overall NEWBITS objective (providing a deep understanding of the changing conditions and dynamics that affect and influence the deployment of ITS services), we focus on barriers and enablers affecting the implementation of ITS services in this study. However, both types of barriers/enablers are closely related: barriers that affect the performance of ITS services often (indirectly) affect the implementation of these services as well. For example, as actual performances of ITS services are poor, user acceptance will be poor as well and hence it will be difficult to implement the services on a large scale. Therefore, a broad range of barriers and enablers affecting the deployment of ITS services are relevant for the purpose of this study.

It is not the objective of this section to identify context-specific barriers and enablers related to particular services, but rather to gain insight into the general barriers and enablers commonly encountered during the implementation and operation of ITS services. At this level, we are able to study barriers and enablers for the whole spectrum of ITS services in general. Furthermore, the importance of the barriers and enablers for the various market segments and service types can be studied at this level as well.

3.2.2 Categorisation of barriers and enablers

To structure the barriers and enablers for the deployment of ITS services, some broad categories are defined based on a review of the literature, the results of the stakeholder interviews (see Appendix 3) and brainstorming sessions among the NEWBITS partners involved in this task. The definition of broad categories of barriers and enablers and the identification of specific barriers and enablers for each of the categories has been an integrated process with some iterative steps. In this way, it is guaranteed that the broad categories are in line with the actual barriers and enablers identified. In this report, we only present the final results of this approach.

An (non-exhaustive) overview of some relevant categorisations of barriers and enablers is given in Table 9. It is worth noting that these categories are applicable to both barriers and enablers since each identified category can be equally interpreted as barrier (lack, limitation, low) or enabler (presence, high level, improvement).

Source	Category
Albrecht & Al-Gazali (2016) – CIMEC	Technical / Economic / Legal / Political / Organisational
Toni (2014) – COMPASS4D	Technical / Legal and political / Economic / Interoperability / Others
CIVITAS METEOR (2006)	Technical / Public funds and subsidy / Politics and strategy / Planning / Institutions / Cooperation / Citizen participation / Information and public relations / Exchange and mutual learning / Cultural and life style / Problem pressure
Rietveld & Stough (2005)	Resource / institutional and policy, social and cultural / legal / side effects / other (physical) factors
Mulley et al. (2012)	Institutional / Economic / Operational / Attitudes, culture, perceptions and relationships between stakeholders / Information, education and promotion
NEWBITS	**Institutional / Economic / Technical / Social and attitudes / Organisational / Impact / Other**

Table 9 Broad categories of barriers and enablers

As shown in Table 9 different categories of barriers and enablers are distinguished by the various studies. The first three studies listed in the table have specifically considered barriers and enablers relevant for ITS services. Based on a survey for the suppliers' market aimed at gaining better understanding of the barriers and enablers for the use of C-ITS solutions in EU cities, Albrecht & Al-Gazali (2016) distinguish five categories of barriers: technical, economic, legal, political, and organisational. COMPASS4D (Toni 2014), a large ITS project classifies barriers into 5 main topics: technical, legal, economic, interoperability and 'other barriers'. For the 'other barriers', lack of awareness towards cooperative systems, road safety, privacy issues and security are examples of barriers covered in this category. The CIVITAS project (CIVITAS METEOR 2006) defines 11 categories of barriers and enablers (of which four are further divided into subcategories) where each identified category can be equally interpreted as barrier or enabler.

Rietveld & Stough (2005) and Mulley et al. (2012) present classifications for barriers/enablers in sustainable transport and flexible transport services. Although these classifications are not explicitly defined for ITS services, they may be relevant for this purpose and hence we have included them in our assessments. Rietveld & Stough 2005 group barriers into 6 categories for sustainable transport; resource, institutional and policy, social and cultural, legal, side effects, and other (physical) barriers. The categorisation proposed by Mulley et. al (2012) for flexible transport services provides a broader classification of 5 categories namely; Institutional, Economic, Operational, Attitudes, culture, perceptions and relationships between stakeholders, and Information, education and promotion.

After a detailed analysis of the categorisations applied in other studies (see Table 9), we noticed that some do not provide a clear distinction between categories. They are either too narrowly defined as in the case of CIVITAS METEOR 2006 or containing interdependencies. For example, the CIMEC project listed both legal and political issues as separate categories when they can actually be classified under the same category as institutional. Therefore, we decided to develop our own categorisation (based on the input from the literature review and the stakeholder interviews) in order to provide a clear-cut categorisation such that similar barriers/enablers are better interpreted to minimise as much as possible ambiguities and interdependencies. The resulting categories are found in the final row of Table 9. In the next section, these 7 categories are discussed in more detail.

3.2.3 Overview of barriers and enablers

Based on a review of the literature an overview of relevant barriers and enablers for the deployment of ITS services has been provided. This literature review has been complemented by the results of the stakeholder interviews conducted (see Appendix 3 for a detailed overview of the interview results).

As mentioned in Section 3.2.1, the objective of the systematic review is to identify the main general barriers and enablers (and hence not context-specific ones) commonly encountered during the deployment of ITS services. For that reason, we have rephrased some of the barriers and enablers found in the literature in more general terms. Furthermore, we have considered the similarities and differences between the identified barriers and enablers. Based on these assessments, 14 general barriers and 15 general enablers are defined (see Table 10). Although this long list of barriers and enablers is not exhaustive, it does contain the main ones (also in the light of the NEWBITS objectives). Therefore, this list is very useful as input for the assessments in the next sections (identifying the main barriers/enablers per market segment and service type). In the remainder of this section we discuss these enablers and barriers in more detail.

Category	Barriers	Enablers
Institutional	1. Lack of a sufficient legal framework 2. Lack of political prioritisation	1. Supportive regulation and clear legal framework 2. Increasing political commitment 3. Enhanced public-private partnerships
Economic	4. Lack of funding 5. Lack of attractive business models	4. Innovative funding schemes 5.Attractive business models
Technical	6. Current infrastructure not ready to integrate innovative ITS technologies 7. Lack of interoperability and incompatibility among ITS services 8. High or uncertain maintenance costs 9. Technical weaknesses in ensuring data security	6. Upgrade of ITS infrastructure 7. Standardisation for interoperability of ITS services 8. Lesser costs of maintenance
Social and Attitudes	10. Lack of user acceptance 11. Limited understanding of user needs	10. Higher levels of end users involvement 12. Increased attention for sustainable transport
Organisational	13. Lack of cooperation between stakeholders 14. Lack of skilled staff for ITS companies	13. More cooperation between stakeholders
Impact	15. Lack of demonstrated benefits of ITS services	15. Proven benefits of ITS services 16. Development of clear KPIs 17. Increased public awareness on ITS benefits and perception
Other	18. Existence of the last mover advantage	19. Increased popularity 'Mobility as a Service'

Table 10 Overview of barriers and enablers for the deployment of ITS services

Institutional barriers and enablers

This category comprises issues and drivers related to legal and regulation requirements, and the political framework. The influence of institutional barriers cannot be underestimated as these have been conceived as harder to overcome (Rietveld & Stough 2005) compared to technical or operational barriers that can be solved over short- to medium-term horizon. An example is given in Rietveld & Stough (2005) as to how a large project in the United States took over 20 years of negotiation, proposal and counter-proposal discussions to unplug institutional obstacles before implementation.

1. Legal framework

The *lack of a sufficient legal framework* is mentioned as an important barrier by a large number of sources (including the stakeholder interviews). For example, in the 2007 Action Plan for the use of ITS in freight transport logistics by the European Commission (Commission Communication 2007), the lack of standardisation and incompatible legal requirements are highlighted as one of the main obstacles for a delayed widespread deployment of ITS. Though the Action Plan was quite specific on freight transport, they are understood as generic barriers which are also affecting other road or transport types as already pinpointed in the Action Plan on ITS for road transport in 2008 (Commission Communication 2008).

In some countries, the law explicitly forbids the roll-out or adaptation of a particular technology. Innovative ITS services may also affect current legislations, as becomes clear from the recently concluded EU VRUITS project. The innovative services (Intelligent Pedestrian Traffic Signal and Intersection Safety systems) developed within this project challenges existing technical regulation about green time for pedestrians and regulation about signal timing. Liability risks that may arise from innovative services (e.g. who is responsible in case of malfunctioning or an accident?) is an important legal barrier as well (Cheon, 2003; KPMG, 2015). Differences in legal framework between countries (e.g. differences in transport policies) or national markets (e.g. national automobile markets) may impede the transferability of ITS services (Stough, 1997). Furthermore, one of the interviewees also attested, on the one hand, to the lack of legislation as a problem to test innovative ITS technologies but on the other hand, there is an important need of such test in order to promote the creation of the legislation.

A very important legal barrier is privacy. Vandezande & Janssen (2012) stated that ITS services can be pervasive and intrusive where they discussed the infringement of privacy concerned with monitoring and tracking of vehicles. The more services offered to the users and the more data flowing through the networks, the stronger the "being closely monitored" feeling is among the end users. It is hard to find a balance or the appropriate way to manage the data (or regulate the data privacy). While privacy is not much of an issue for ITS services in public transport (Llorca et al. 2010), it becomes a major challenge if the ITS deployed in this domain are to be transferred to other types of road vehicles, privacy issues may arise due to permanent traceability or possible liability in case of speed limit violations. According to the US Governors Highway Safety Association, privacy concerns have led 13 states to prohibit the use of automated speed cameras and 10 states to ban red light camera enforcement.

Given this large number of legal barriers, the *development of a clearer and supportive legal framework* is a key enabler to facilitate the deployment of innovative ITS services. One of the interviewees mentioned that the onus is on cities, involving the relevant authorities in order to unlock the current problem with legislation. It is also noticed by one of the interviewees that legal barriers are fading away in a more noticeable manner in some segments of the ITS markets (e.g. automated driving), where the legislation is being changed quickly, mainly because there is a lot of interest going on in this topic.

2. Political commitment

Political commitment (and knowledge) is not only key to implement the required legal changes, but also to realise other supportive measures for ITS deployment (e.g. financial support) (Albrecht & Gazali, 2016; Toni, 2014, some of the interviews). Therefore, political commitment has been adjudged by the interviewees as a way forward to speed up the successful implementation of advanced ITS solutions, as it provides certainty to investors and developers. A good example is the Nice Connected Boulevard initiative (Cisco IOE 2014) that received political backing from the mayor. This made the budgeting process to be relatively simple from the outset in which the initiative is paid for with public funds, utilizing allocations from the city's overall budget (Cisco IOE 2014). As consequence of a lack of political commitment, intergovernmental and inter-jurisdictional coordination is often underdeveloped, preventing the effective exchange of information across political or jurisdictional boundaries (Cheon, 2003; Declaration of Amsterdam, 2016).

3. Public-private partnerships

Finally, *enhanced public-private partnerships* are seen as an important enabler to incentivise the deployment of ITS services. Barfield & Dingus (2014) and Crainic et al. (2004) mention that the successful deployment of ITS cannot be achieved without the cooperation and understanding between both the public and private sector, and hence, this calls for a need for collaboration and public-private partnerships to promote the market uptake of ITS services (Shaheen et al., 2013). Also Toni (2014) emphasized that *real ITS deployment needs efficient cooperation between people of both public and private organisations.*

Economic barriers and enablers

Economic barriers include both the upfront costs of pilot projects execution, installation costs, the cost of transferring the initiative to market, and costs and fares to users.

4. Funding

Given the capital-intensive infrastructure requirements of ITS (Shaheen et al. 2013), *lack of funding* has become a major obstacle to its development and successful deployment (Albrecht & Al-Gazali, 2016; Toni, 2014; several interviewees). Moreover, ITS services often compete with conventional technologies (on project that are more urgent) for the same scare financial resources, limiting the funding opportunities for these innovative services (Cheon, 2003). In Rietveld & Stough 2005, lack of funding is said to be closely linked to institutional barriers when governments (national, state, and regional) are unwilling to make provision for initiatives that do not match their political priorities.

Although progress has recently been made regarding the financing of ITS development (European Commission, 2016c), additional steps are required. According to Shaheen et al. (2013), experts suggests that the *use of innovate funding schemes* and improved public outreach can be used to overcome the financial barriers. Schafer & Nilsson (2016) conducted an empirical study to investigate the effects of public and private funding schemes in ITS on freight flows and transportation performance on the highway system. The results emanating from this study reveals that the transportation performance of motor carriers would improve greatly with a collaboration of investments between businesses and governments to further develop ITS.

5. Business models

The lack of *attractive business models* is often mentioned as an important barrier to the deployment of ITS services (Albrecht & Al-Gazali, 2016). As transport operators are often driven by a profit motive (Giuliano and O'Brien, 2004), they will only participate in the deployment of these services as the financial benefits are clear. This in confirmed by one of the interviewees, who says that a ITS project may attract more investors if initiatives can demonstrate cost savings. The Optimod'Lyon was used as a good example of a project that proposed a potential generation of 83M€ from a 7M€ project. If the potential sales expected from this initiative become a reality, more and more private entities will join and exploit this market niche. The question of who is responsible for investment costs becomes less of an issue as stakeholders become aware of the benefits of ITS. The European Commission, in its ITS Action Plan points out that a critical mass of equipped users is necessary to attract investments and pull prices down for the user.

Technical barriers and enablers

An important group of barriers and enablers are the technical ones, including the adequacy of the existing infrastructural equipment, the presence of initial conditions for interoperability and standardization, the maintenance needs and issues related to data security.

6. ITS infrastucture

Technological infrastructure is a central topic in the implementation of a ITS service, both as a barrier and an enabler (CIVITAS METEOR, 2006; CIVITAS POINTER, 2011; Nordström et al., 2015). The initial inadequacy of the existing infrastructure to the purpose of introducing new ITS services is a very relevant barrier, which implies the necessity to invest money in hardware replacements or upgrades. For example, in a centralized traffic control application (UTC), a central computer with decision-intelligence manages the urban traffic through the regulation of road signals with their controllers located at junction level. These controllers need to be remotely controllable (i.e. connected to the centre). But this is not always the case, as in many cities there are still stand alone signal controllers. In the field of ITS and even more of C-ITS, telecommunications is the technology of utmost importance: links between field equipment and the centre, communications between vehicles and infrastructure (but also between vehicles) puts clear and tight requirements on the infrastructure. On the other hand, the availability of communication infrastructure represents an enabling key: when the ITS infrastructure grows due to the installation of a new service, the communication infrastructure (especially if adopting TCP/IP protocol – internet of things) allows additional extensions of the same service or for the introduction of new services, that will require lower costs and lower implementation problems.

7. Interoperability and compatibility

Interoperability and compatibility between different ITS services (both as a barrier, when missing, and as enabler when they are guaranteed and promoted) are aspects that can heavily affect the costs and implementation of new services (CIVITAS METEOR, 2006). A lack of standardisation of technologies is also often mentioned in the interviews as one of the main barriers to ITS deployment. Interoperability and compatibility issues may occur between different countries or cities by using different technologies and/or standards, affecting transport users travelling in both countries/cities. But also within countries/cities these issues may arise, e.g. as different transport operators use different, non-compatible electronic payment systems. These interoperability and compatibility issues affect transport users (discomfort), but also transport operators and authorities (increased costs) and ITS providers (less opportunities to apply a service on multiple markets). By developing clear industry design and performance standards, governments could promote the development, adoption and implementation of innovative ITS services, among other things by reducing the uncertainty in the return on investment (Cheon, 2003).

8. Maintenance costs

Another technical aspect that can play both a barrier role and an enabler role is the *maintenance needs* (Nordström et al, 2015; Mulley et al. 2012). In modern transport systems, maintenance costs are a major part of the operational costs and hence feared by transport operators and authorities. In particular, the extreme difficulty in containing and reducing this spending item has led to increased attention for all innovations that are capable in reducing maintenance need as well as to reject those innovations that require increased maintenance interventions. ITS technologies can affect maintenance needs by increasing the efficiency and productivity of the transport system. For example, ITS services for transit regularisation and prioritisation can reduce the number of public transport vehicles needed to provide the same level of service, thereby reducing spending for total maintenance. Moreover, the increased availability of data that is needed or produced during the operation of many ITS services (traffic data, operational data, vehicles' data and infrastructure data, etc.) may contribute to a switch from scheduled maintenance philosophies to ad-hoc predictive maintenance philosophies; improved knowledge on the efficiency and consumption status of the various components used in the transport system can allow more targeted and rational interventions, and therefore reduction in number and frequency of maintenance interventions.

9. Data security
Finally, *problems with respect to data security* is considered a relevant technical barrier for ITS services as well (US GAO, 2015; C-ITS Platform, 2016). For example, the widespread use of payments through contactless technologies (e.g. by smart mobility cards) exposes the users to greater risks of fraud, and to theft of personal data and money. With the progress in the integration of mobility services (e.g. as part of "Mobility as a Service" (MaaS) policies), this potential vulnerability becomes more and more relevant. Data security issues does not only concern the users' personal data or money, but also the data flow necessary for the interaction between various ITS components (vehicle and subsystems). This data flow is subject to illegal actions, e.g. by altering its content and hence the behaviour of some transportation components (e.g. autonomous vehicles). In this way, criminals or terrorists may deliberately cause malfunctions or incidents. Setting a standard defining the minimum security required in the hardware, as well as clear boundaries for software and connectivity could aid in overcoming these concerns (KPMG, 2015). Ideally, these standards should be harmonised across the globe. The European Commission is aiming to adopt acts laying down rules to ensure security of (C)-ITS communications by 2018.

Social and attitudes barriers and enablers
This category includes barriers/enablers related to user acceptance, (limited) understanding of user needs and increased attention for sustainable transport.

10. Understanding of users' needs
The *understanding of users' needs* is an operational factor that is often overlooked by most ITS projects, but its importance cannot be undermined as it plays a crucial role in the marketability of an innovation. It may not be perceived as a barrier per se, but can have significant influence either as a barrier or an enabler, On the one hand, the lack of users' needs analyses consequently brings about other barriers that include the lack of user acceptance and the use of new technologies, but an adequate user assessment on the other hand, is expected to encourage user acceptance, usability, and adoption. A ITS service understood to have a clear market vision, will incorporate in its pilot study a clear identification and assessment of the target users, user needs, demands, and preferences. The EC VRUITS project is an ITS initiative example which has a clearly defined target group from the outset, the vulnerable road users, and also thoroughly conducted user needs analysis to address the needs of these user groups during the execution of the project (VRUITS Consortium Deliverable 2013), Some needs are mostly driven by operators' requirements especially in the planning and operation of public transport. Key ITS solutions should deal with the capability to match users' needs at the best, in particular, new requirements in terms of flexibility and innovation approach as confirmed by emerging societal trends. One of the failings of these solutions is that most of the innovations have adopted an outside-in approach (Ramaswamy & Gouillart 2010), where end users are not engaged in participating in the co-creation process. Therefore, when brought to market, many innovations fail to reach the conventional users. To solve this, more *user-involvement* during the development and deployment process may be an important enabler for successfully implement innovative ITS services.

11. User acceptance

Acceptance of the ITS services by its users is key, as these innovative services can only be effectively implemented as users are willing to buy/use them (CIVITAS METEOR, 2006; several interviews). However, consumer inertia can harm user acceptance and hence ITS deployment. In general, consumers have difficulty accepting the risks associated with unproven technologies and tend to rely on familiar technologies they have used in the past (Cheon, 2003). Also privacy concerns may impede the users' acceptance of innovative ITS services. Lack of knowledge on the services may also deter acceptance by users. For example, FAMS Consortium (2004) reports that efforts in terms of service promotion and explanation may contribute significantly to user acceptance and hence the profitability of the service. User acceptance is influenced by cultural factors (values, norms, beliefs, customs and traditions) as well. These cultural factors are considered important conditioners to the acceptance of innovative technologies such as ITS services (Williamson, 1994; Sussman, 2008). However, these factors are relatively stable over time and their change tends to be slowly (Stough & Rietveld, 1997), such that measures intended to change them should be implemented over a long period. Finally, the user ability to pay for ITS services also plays a role in user acceptance. The different income levels and standards of living in countries must be taken into account. Though, this can be slightly overcome with promotions. A survey conducted in the I-5 Smart truck project (Martin & Shaheen 2012) reveals that majority of the respondents (truck drivers) are not willing to pay for the services or will pay very little as $3 for the access to parking availability data. The market uptake of ITS services must therefore strongly consider the price to quantify and the equivalent value being offered.

12. Increased attention for sustainable transport

The transport sector has been constantly confronted with different set of challenges in its transition to a more efficient and sustainable transportation systems. Most notably are safety, traffic congestion and the increasing levels of greenhouse gas emissions as a result of the rapidly changing demographics and urbanisation (European Commission, 2011). These are considered problems of paramount concern. As a consequence, various stakeholders in the public and private sectors have stepped up to tackle these challenges. The societal advantages (environmental, social, and economic) to be derived from ITS innovations point towards a more sustainable and environment-friendly transportation system. Therefore, *the increased attention for sustainable transport* may act as an enabler for ITS services. However, sustainability will not be achieved if the attitudes of transportation organisations towards sustainability are still been questioned. The more the key stakeholders begin to recognise the benefits of ITS, the better the quality of life of the citizens, and the environment if (C-ITS) innovations are fully exploited.

<u>Organisational barriers and enablers</u>

Organisational issues and drivers involves cooperation and the role of human resources.

13. Stakeholder cooperation

Increased stakeholder cooperation in the value chain is considered as an important driver to stimulating ITS deployment, both in the literature (e.g. Albrecht & Al-Gazali, 2016; CIVITAS METEOR, 2006, Shaheen et al., 2013) as in the interviews (see Appendix 3). For example, in a US case example from the interviews, a pilot project on the first initiative (Connected Vehicle) on Cooperative ITS for New York City involves a lot of stakeholders of the value chain: taxi fleets, MTA, fleets of UPS courier, private drivers, pedestrians for V2V safety, V2I/I2V safety and V2I/I2V pedestrian applications. The interviewee remarked that: *"An important enabler is the involvement of the all stakeholders of the value chain (Taxi fleets,* *MTA - Metropolitan Transportation Authorities, Freight fleets (UPS courier), private drivers/travellers/ passengers, emergency services, etc.) and an intensive* involvement of the local and national Government *(USDoT, NYCDoT, NYCDoS, Research Institutes, etc.)."*

The importance of stakeholder cooperation cannot be overemphasised. It becomes rather a necessity to deploy innovative solutions involving multiple stakeholders such as the ITS. Cooperation is considered an important drive measure towards implementation, where working together on common problems and shared goals has contributed to improve the solutions or opened new ways for financing (public-private partnership) (CIVITAS METEOR 2006). Initially, the Connected Boulevard initiative (Cisco IOE 2014) faced a cooperation challenge from lower-level city management personnel that showed unwillingness to participate in the smart city initiative. The administrators had to be convinced of the initiative validity, and then how they can play a very active role in solving the various issues surrounding implementation. This helped to eliminate departmental silos within city government which greatly enhanced the municipality's ability to operate effectively (Cisco IOE 2014). No doubt, the effectiveness of cooperation can help all the key stakeholders to maximise their potential and derive sufficient benefit, learn from each other and build a common pool of knowledge.

There may be different reasons for limited stakeholder cooperation. For example, the organisation structure of the industry can impede cooperation. Large companies often miss the (management) flexibility that is needed to efficiently contribute to the deployment process of ITS services (Paiva Fonseca, 2011). Sharing the ownership of potentially valuable intellectual property rights with entities with different objectives could also deter technology developers from participating in the research and implementation of ITS services (Cheon, 2003).

14. Availability of skilled staff

The *lack of skilled staff* can also constitute an important barrier to the deployment of ITS solutions. Competent human resources are often lacking to support ITS deployment due to the fact that innovative ITS services are relatively new and require a different set of skills. In some cases (Cisco IOE 2014), this may impede the cooperation of stakeholders especially in the public sector, to contribute to services operating outside their competent area. The lack can be also due to the reluctance of personnel to change or learn new technical skills (Button et al 2001), Additionally, organisational issues come into play in staff training when there is a lack of management support or the unwillingness of the companies' decision makers to change (Button et al 2001). Organisations must endeavour to establish continuing professional programs for human resource development. Participation in ITS dissemination activities should also be encouraged, while transportation programs in Universities should incorporate ITS-related courses so as to prepare highly skilled people for the industry. In transportation organizations that have continued to favour conventional infrastructure, a cultural change is considered a must for ITS deployment (Sussman 2008).

Impact barriers and enablers

With the growing interest in ITS deployment, the stock of services identified in NEWBITS D2.1 reveals the shortcomings of many European and National R&D projects in proving their impacts and benefits despite the technical demonstrations.

15. Demonstrated benefits

In several interviews, *the lack of demonstrated benefits* of ITS services is mentioned as an important barrier to their deployment (see Appendix 3). Increasing the number of pilot projects and the evidence on their impacts is therefore considered an important driver to accelerate the implementation/replicability of ITS on a large scale.

16. Key performance indicators

Assessing the impacts and benefits of ITS solutions in relation to the objectives can be considered an important step towards demonstrating their benefits with quantified parameters. However, the *lack of a common framework/methodology for examining key performance indicators* has hindered the adoption of ITS solutions (Schafer & Nilsson 2016). The 2DECIDE project (ITS Toolkit, 2017; Bohm, 2016) emphasised that the lack can be linked to the large variety of KPIs employed, where more than 250 KPIs have been identified for evaluating ITS solutions. This, they say, can become difficult in the process of interpretation and combination of evaluation results. Martin Bohm (Bohm, 2016) further calls for methodological consistency aside the harmonisation of KPIs to ensure an informed decision making needed for transferability of know-how. As highlighted by Bošnjak et al (2009), in the evaluation process of any (post-pilot) ITS solution it must be clear to all stakeholders how the system meets its predefined objectives with measurable indicators. If the KPIs are clearly defined from inception, it will be pretty straightforward to evaluate the impact/improvement of an ITS solution before and after implementation (requiring that the data collection to measure the indicators must have been performed the same way using the same methodology). The benefits and values to the citizens and environment must be identified and assessed accordingly.

17. User awareness on benefits of ITS

Not only should the benefits of ITS services be measured, the results of these measurements should be disseminated to the potential users of these services as well. *Increased public awareness on the benefits of ITS* is seen as an important driver of increased deployment of ITS services (interviews, Mulley et al 2012). End users should be able to identify themselves with ITS services, as they are not informed enough to trust and understand, innovative ITS technologies. Therefore, it is important that users see the additional benefits of using ITS services. This is essential to increase the penetration rate of the services, especially since the effect of the application often depends on the number of users.

Public perception plays a crucial role in defining government priorities as well (Shaheen et al. 2013). From the political perspective, it is not just enough to put an initiative to work. The successful deployment of ITS services requires political backing, which is predominantly dependent on quantifiable benefits; improvements and benefits to the populace and environment. For example, in the Connected Boulevard initiative, the city major warned of the stakeholders' inability to document/demonstrate quantifiable benefits in some aspects like environmental monitoring and waste management and that this lack of evidence may become a major setback to the initiative. Therefore, it is highly important to clearly measure and disseminate the benefits of the tested ITS services.

Other barriers and enablers

Finally, one barrier and one enabler is identified by the systematic review that cannot be easily allocated to one of the main categories defined in Section 3.2.2. Therefore, these two factors are separately discussed in this section.

18. Last mover advantage

First, a general barrier that may impede the implementation of ITS services is the existence of the *last mover advantage*. This concept, and the opposite concept 'first mover advantage'[5] are marketing conditions which are very recurrent in the field of technological goods and services, including ITS services. The last mover advantage refers to the fact that parties entering the market after the pioneering and exploration phase (Golder and Tellis, 2001) can exploit the knowledge gained from the pioneers in order to avoid failures that those pioneers have committed (e.g. see Kerin et al., 1992) or can optimise the service's cost structure based on data that was not available in the pioneering phase of the market. In addition, marketing costs may be lower for last movers as they can take advantage of the efforts done by pioneers to improve user knowledge and gain user acceptance. The case of imitating an existing product and hence exploiting the knowledge created by pioneers is the extreme example of the last mover advantage (Mansfield et al., 1981).

The existence of the last mover advantage incentivise pioneers to apply several measures, ranging from the protection of know-how to the strategic choice of ways and times of entering the market (Makadok, 1998). These kinds of developments generally slows down the deployment process of ITS services. In this sense, the existence of the last mover advantage and the resulting countermeasures taken by pioneering suppliers can result in a barrier to the rapid development of the (specific) ITS technology and the start-up of its market. In other words, it may be that the competition between first and last movers for their respective market positions results in a reduction of overall benefits for the entire production sector and, in the end, for the society as a whole. It should also be stressed that the delay with which any incumbent enters the market results in markets that remain longer oligopolistic. In these conditions both the constructive competition between players and the possibility of cooperation are obviously lacking which, though with opposite dynamics, can both hamper the development of further innovation and the growth of the overall market.

19. Mobility as a Service

A potential enabler of ITS services is the concept of '*Mobility as a Service' (MaaS*). This concept describes the shift from personally owned modes of transport towards mobility services that are consumed as a service. The MaaS concept is based on a model of combining different transport services, including business, organizational, design, marketing and communication aspects and, above all, business innovation, technological and regulatory aspects. According to this model *(Finger et al., 2015)*, the mobility needs of the user (in a certain geographic area or, in the future, globally) are met in a unified way, irrespective of the specificity of each mode of transport, operator or services linked to mobility. Ultimately the MaaS concept (*Li & Voege, 2017*) foresees that citizens can

[5] The first mover advantage refers to the situation in which the pioneer succeeds in gaining success quickly and without big failures, such that initial profits can be adequately reinvested in order to maintain their large market shares (Lieberman and Montgomery, 1988). Furthermore, these pioneers should be able to adopt a cost-structure sufficiently slim, scalable and dynamic such that it can be quickly adapted (even temporarily) once new parties enter the market.

purchase customized mobility packages that allow them to use whatever means of transport to reach a particular destination. This is only possible with the maximum integration of the different modes and services of transport (e.g. buses, subway, bike and car sharing, taxi, car pooling etc.) whose operators must ensure total access to data.

ITS represent the guiding element of this perspective change. In fact, the rapid evolution and the increasingly significant application of ICT in the transport sector creates an intermediate level between transport operators and users, essentially consisting of data and IT services useful to support the decisions of the user and the commercial use of the service. Thanks to this intermediate level, customer transport needs are summarized and translated into travel options through a single interface, providing integrated service provides the opportunity to offer transport users a tailored door-to-door solution.

However, although all the technologies necessary for the full realization of MaaS platforms already exist, the challenges for really achieving the MaaS objective are mainly of a regulatory nature. In fact, at the central political level, a regulatory framework is needed to take intermodality as a starting point, putting the user (citizens and businesses) at the heart of the new mobility system and seeing the role of the public as an enhancer of mobility solutions rather than as a direct provider of transport services. At the periphery level, regulatory requirements refer to issues like fare integration and hardware/procedure standardization for the commercial use of mobility services. Furthermore, a broadly shared view of the way fully integrated transport services should be achieved is not yet available at both the national and international level (Holmberg et al., 2016). Finally, transport operators are not always willing to share their data with third parties, as it is often not clear how they benefit from this sharing activity. It requires that the various actors in the transport chain become willing to pay for the information service provided (Bangsgaard, 2017).

To conclude, it can be stated that in general there are still several institutional barriers to the realisation of fully integrated transport (i.e. the operative concept of MaaS) and the removal of these barriers takes time and investments as well as increased trust between transport companies and platform operators. Overcoming, even partial, some of these barriers may be seen as an important enabler of ITS services in general, as this concept is able to multiply the expected benefits from the deployment of ITS services.

3.3 Main barriers and enablers per market segment

This section presents the main barriers and enablers for ITS deployment per market segment (see section 2.2). To assess this, an on-line stakeholder survey have been conducted (see Section 2.3.3). The respondents were asked to identify the main barriers and enablers (up to a maximum of 5) from the overview of barriers and enablers presented in the previous section (see Table 10). The option 'Other (please specify)' was also available'.

In the remainder of this section we first discuss the main barriers for ITS deployment, followed by a discussion on the main enablers facilitating ITS deployment.

3.3.1 Barriers

The main barriers for the deployment of ITS services without market segmentation are shown in Figure 7. These overall scores per barrier are calculated by summing up the individual scores on the five market segments. Although this assessment may not provide a perfect reflection of the barriers on the total ITS market (as not all market segments have an equal share in the total market) it does give a good first impression of the relevance of the various barriers.

According to the input provided by the stakeholders, economic (lack of attractive business models and lack of funding) and technical barriers (incompatible infrastructure and lack of interoperability between services) are important with respect to the deployment of ITS services. Also the lack of cooperation between stakeholders and the lack of political prioritisation are often mentioned as important barriers. Conversely, the existence of the last mover advantage and the lack of skilled staff for ITS companies are only mentioned by a few stakeholders as a relevant barrier.

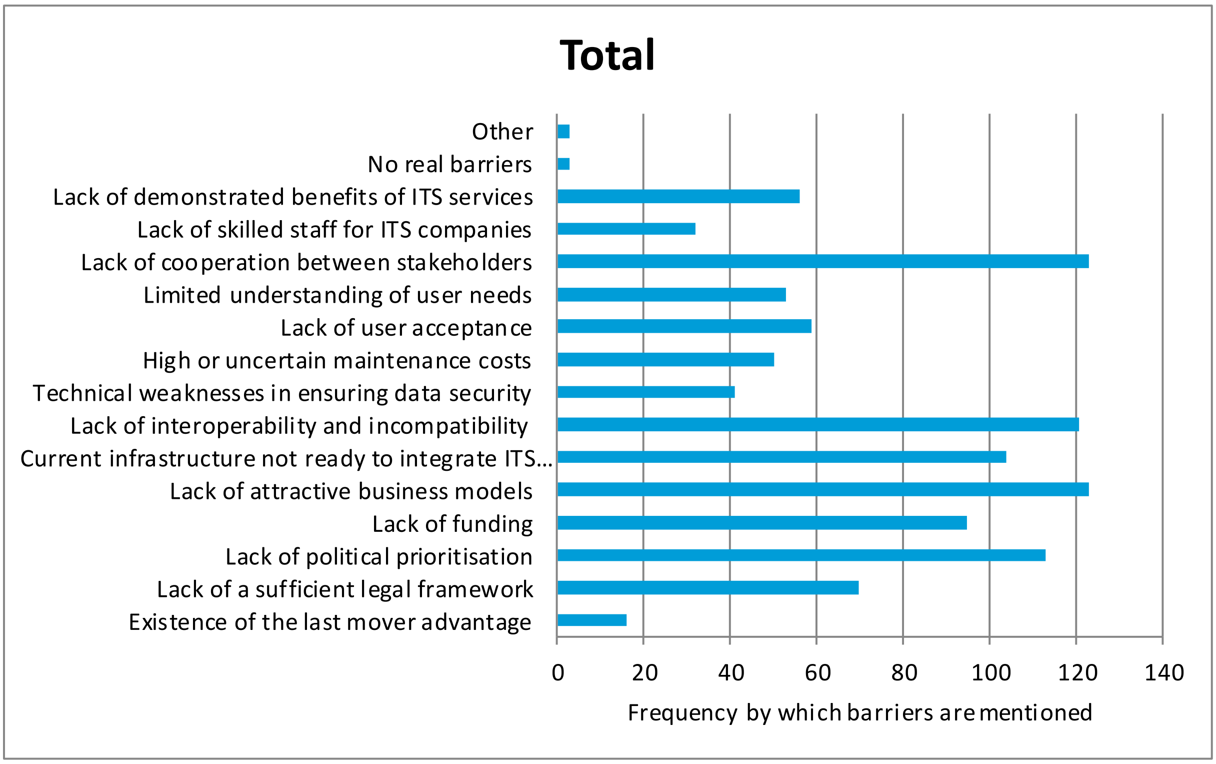

Figure 7 Main barriers to the deployment of ITS services

Different types of stakeholders (public authorities, industry, R&D, others) have participated in the on-line survey and it is interesting to assess whether their opinions differ with respect to the relevance of the different barriers. Therefore, we have calculated for three stakeholder groups[6] and for all stakeholders together how often an individual barrier is mentioned as share of all barriers that are mentioned by that stakeholder group (in %). In a next step, we have calculated for each stakeholder group the deviation (in percentage point) from the overall scores. The results are shown in Figure 8.

[6] The category 'Other' is not considered, as this encompasses a wide range of different types of stakeholders.

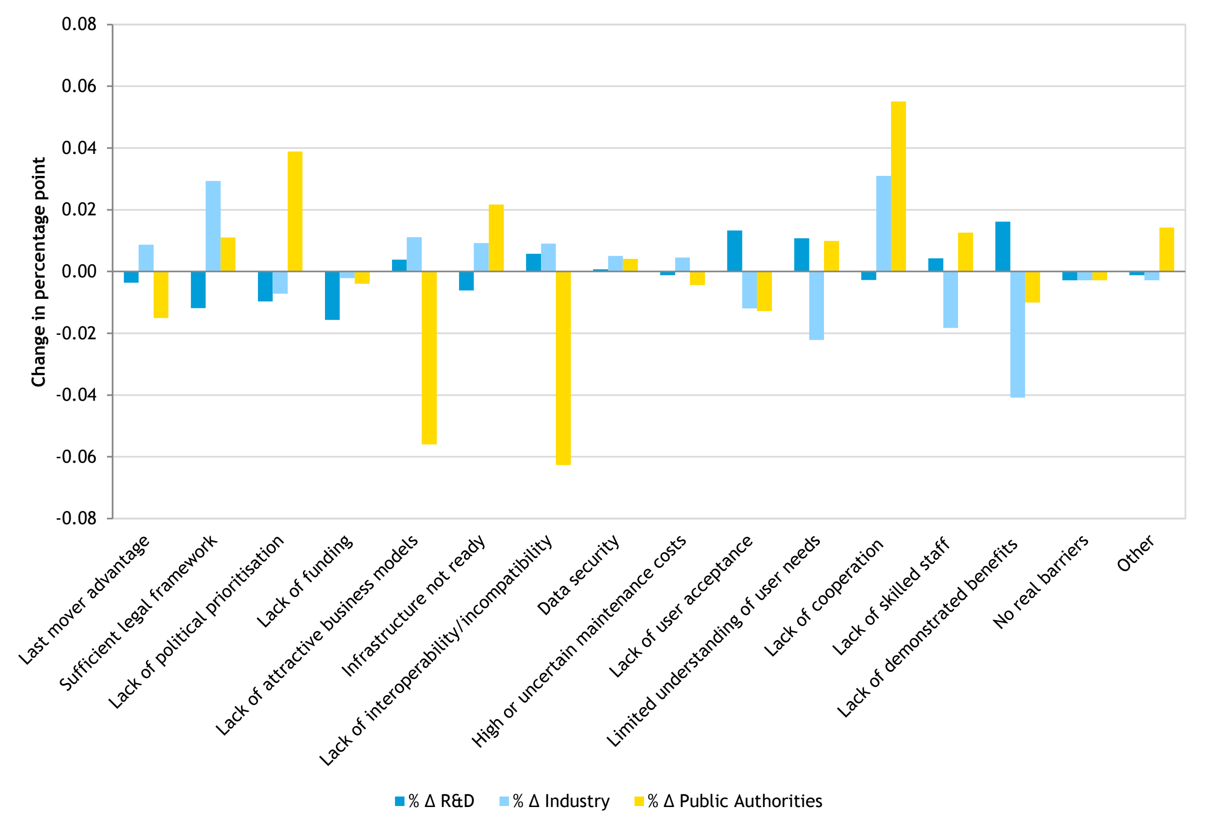

Figure 8 Differences in stakeholders' opinions on the relevance of the barriers

As becomes clear from Figure 8, there are significant differences between the various groups of stakeholders with respect to their opinions on relevant barriers. Both public authorities and industry consider 'lack of cooperation between stakeholders' a significantly more relevant barrier than R&D stakeholders. Furthermore, public authorities also think that 'lack of political prioritisation and 'inadequate ITS infrastructure' are more relevant barriers than indicated by all stakeholders together. On the other hand, they consider 'lack of attractive business models' and 'lack of interoperability/incompatibility' less relevant than the other stakeholders. As for the stakeholders from the industry, they consider a 'lack of sufficient legal framework' as a more important barrier than the other stakeholders. Finally, R&D stakeholders consider the 'lack of demonstrated benefits', 'lack of user acceptance' and 'the limited understanding of user needs' as more important barriers as the other stakeholders.

The detailed results on the relevance of barriers per market segment are given in Figure 9 to Figure 13. These results confirm the hypothesis that the barriers vary depending on the market segment. For ATIS respondents were relatively unanimous in identifying "lack of attractive business models" and "lack of cooperation between stakeholders" as two of the major barriers to ITS implementation. Additionally, lack of interoperability and incompatibility among ITS services was mentioned relatively often by stakeholders. The existence of the last mover advantage, on the other hand, was not considered an important barrier for ITS deployment by any of the respondents.

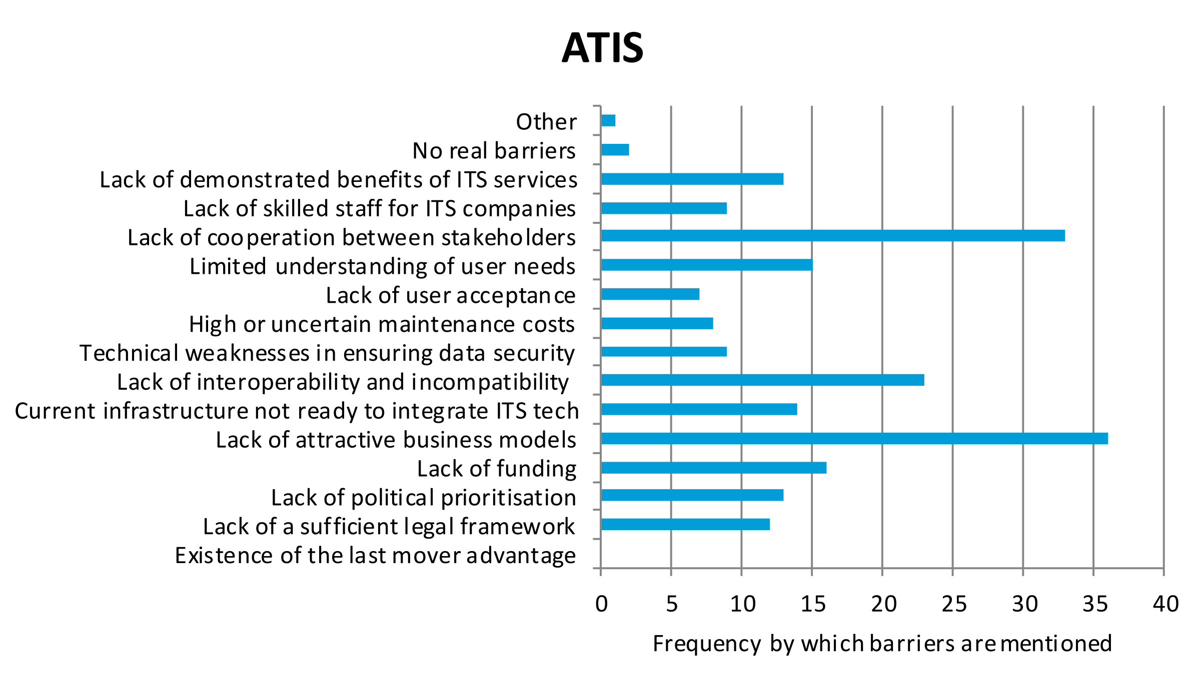

Figure 9 Main barriers to the deployment of ITS services in the ATIS segment

The lack of political prioritisation was signalled to be the most important barrier for the ATMS market segment, although lack of funding, lack of cooperation between stakeholders and some technical issues (lack of interoperability, inadequate infrastructure) are often mentioned as well. Compared to most other market segments, the lack of attractive business models is less often mentioned as an important barrier.

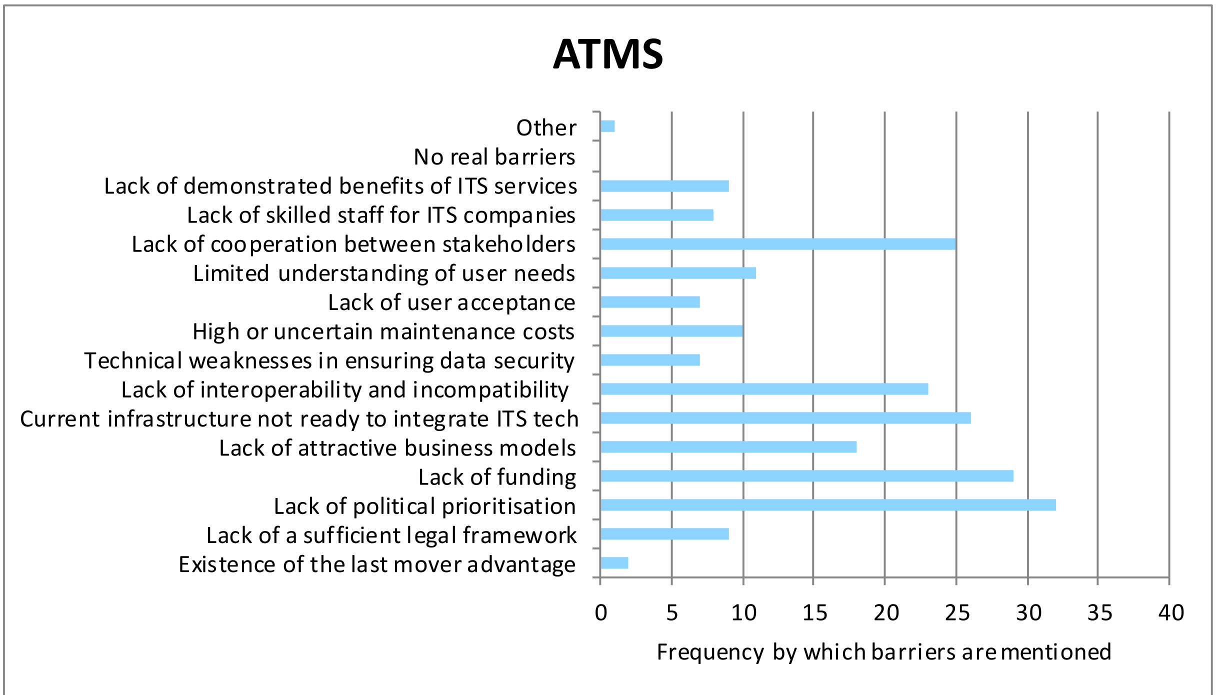

Figure 10 Main barriers to the deployment of ITS services in the ATMS segment

The stakeholders' opinions on the important barriers for the deployment of ITS services in the ATPS market segment is less homogenous as for the first two market segments. The lack of political prioritisation is most often mentioned by the respondents, followed by lack of user acceptance and lack of interoperability. Compared to the other market segments, particularly the lack of user acceptance is mentioned significantly more often, probably related to (the perceived) privacy and data security issues related to the services in this market segment. Lack of funding is, on the other hand, mentioned relatively little by the respondents as a main barrier for ITS deployment in this market segment.

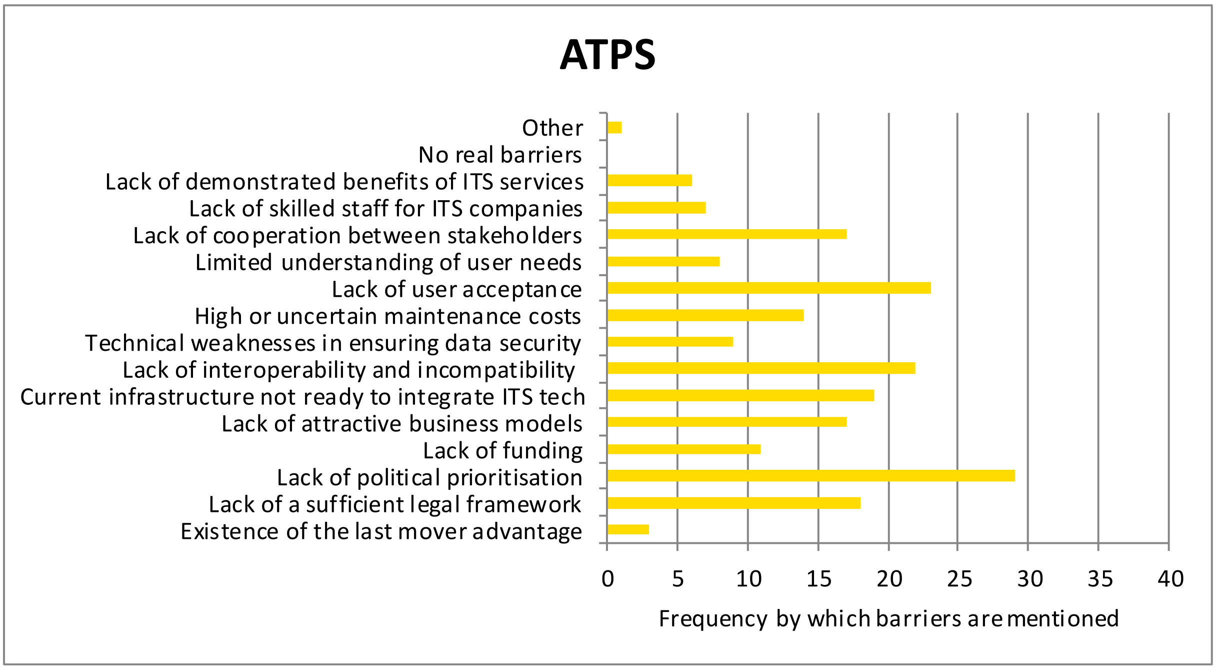

Figure 11 Main barriers to the deployment of ITS services in the ATPS segment

The APTS market segment was most hampered by “lack of interoperability and incompatibility among ITS services” (e.g. mobility smartcards that are not compatible for all different providers of public transportation), followed by lack of cooperation between stakeholders and lack of attractive business models.

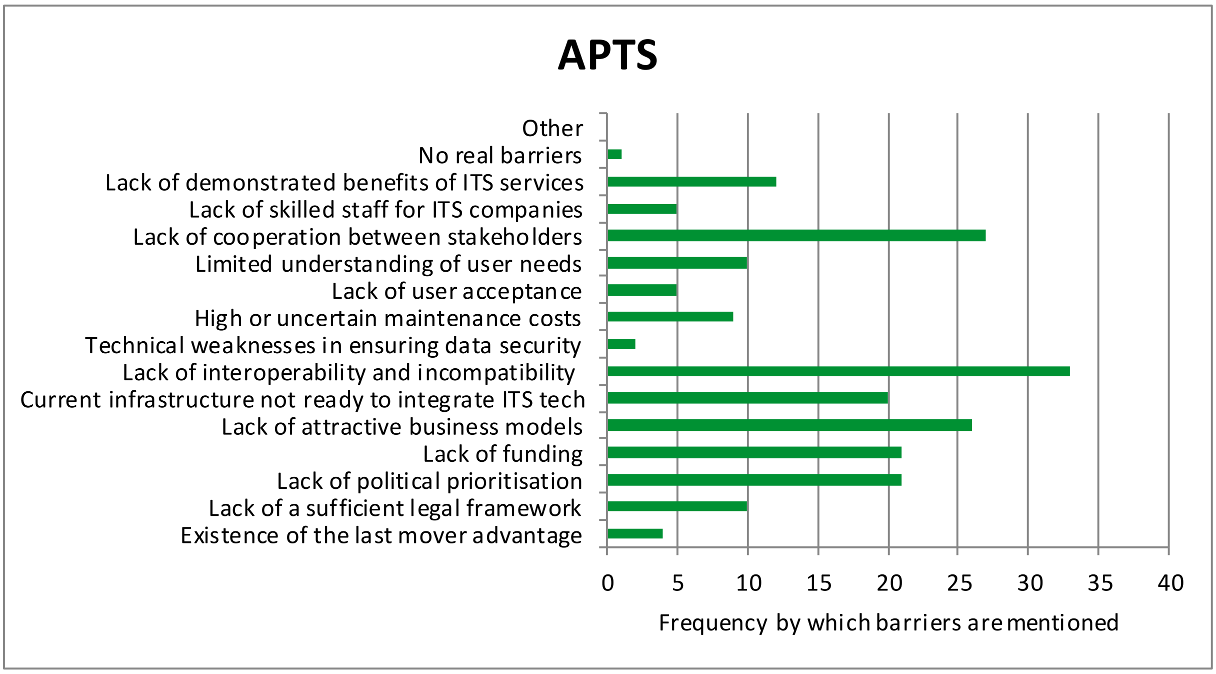

Figure 12 Main barriers to the deployment of ITS services in the APTS segment

Finally, the stakeholders' opinion on the relevant barriers for the CVS market segment is rather heterogeneous, which may (partly) be explained by the very innovative character of this market segment. The barriers most often mentioned is the lack of attractive business models, followed by lack of adequate infrastructure. Compared to the other market segments, the lack of a sufficient legal framework is relatively often mentioned, probably as this market segment covers innovative services that may heavily affect the current transport market (e.g. autonomous driving) and hence may require important changes to the current legal framework. As for the ATPS segment, user acceptance is relatively often indicated by respondents as an important barrier; this may be because of expected privacy issues or as the role of transport users may change drastically by implementing some of the CVS services (e.g. platooning).

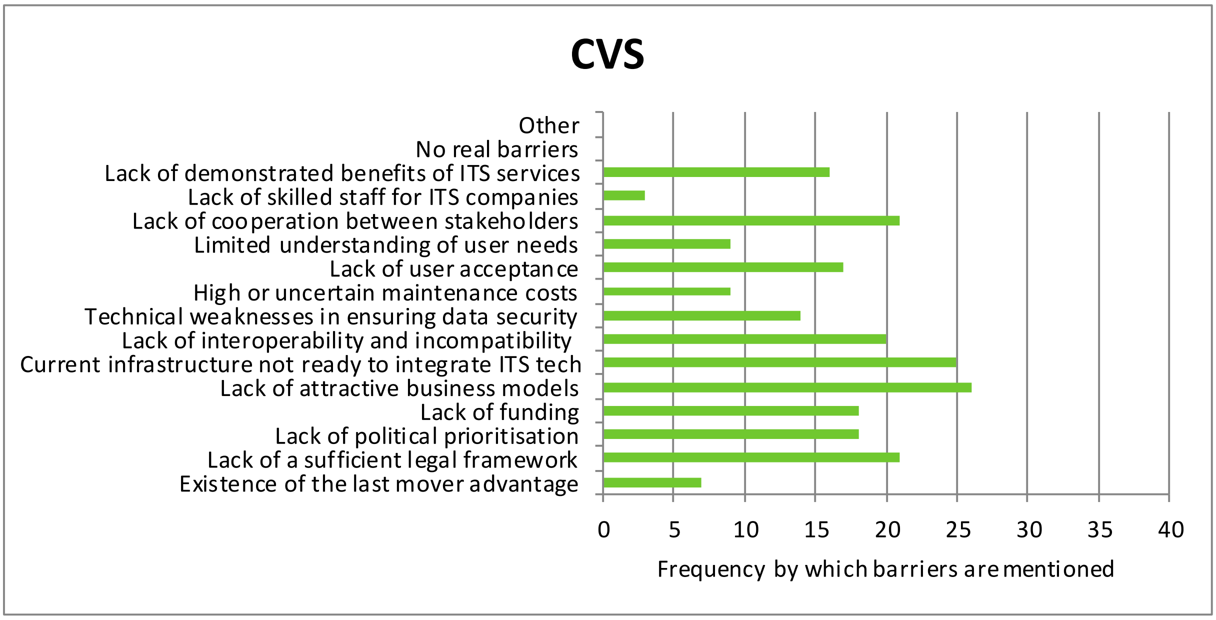

Figure 13 Main barriers to the deployment of ITS services in the CVS segment

3.3.2 Enablers

The following section presents the main enablers that facilitate the deployment of ITS services according to the respondents to the online survey. The main enablers for all five market segments together are shown in Figure 14. In general, the results are more heterogeneous as for barriers, complicating the task to identify the main enablers (both for all market segments together as for the individual segments).

Enablers often mentioned are increasing political commitment, standardisation for interoperability of ITS services, more cooperation between stakeholders and attractive business models. All these enablers are the opposites of barriers that were considered important by the stakeholders (see Section 3.3.1). In this light, it is surprising that innovative funding schemes and the upgrade of ITS infrastructure are only modestly scored by the stakeholders, as these two enablers are the opposites of two important barriers. No direct explanation for these inconsistent results is found. From the other enablers, an increased popularity of 'mobility as a service' and 'enhanced public private ships' are considered relevant factors that may support the deployment of ITS services as well.

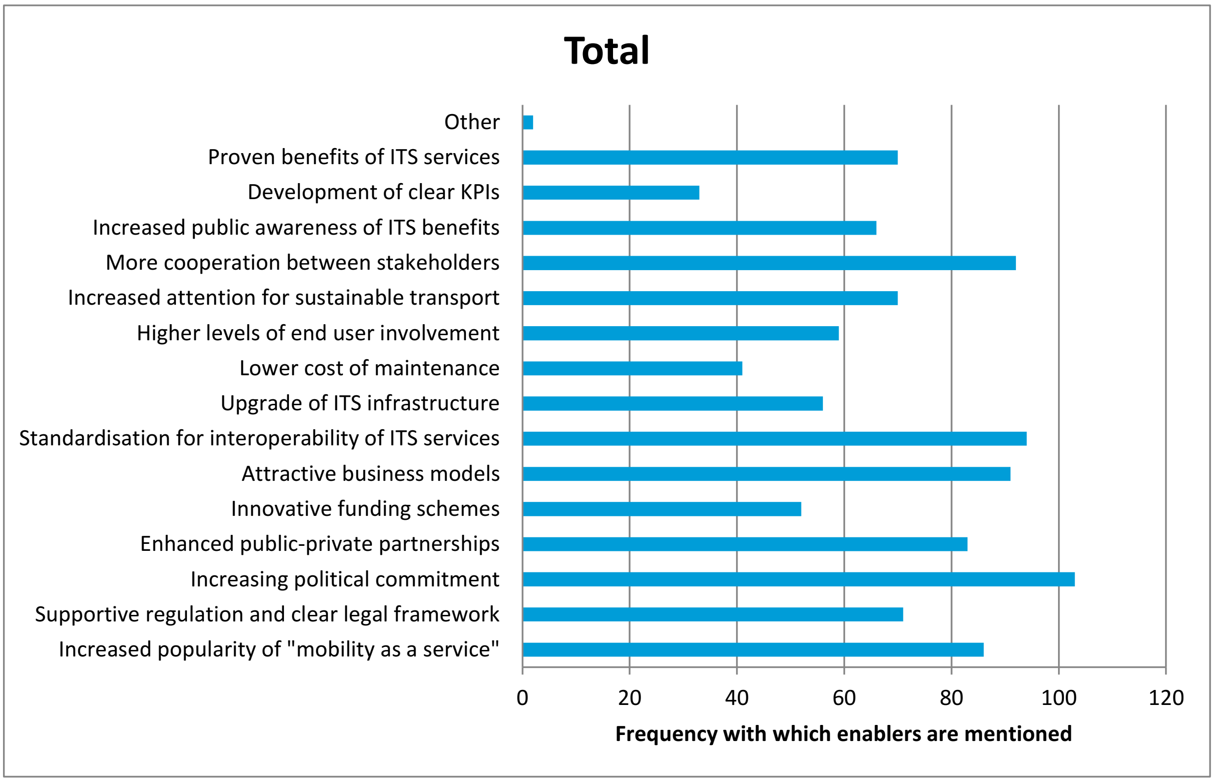

Figure 14 Main enablers to the deployment of ITS services

As shown in Figure 15, the opinions of the various groups of stakeholders with respect to the relevance of the enablers differ widely. The industry considers ‘the development of a clear legal framework’ and more intense ‘cooperation between stakeholders’ more important factors to facilitate ITS deployment than the other stakeholders, while ‘increased attention for sustainable transport’ and ‘proven benefits of ITS services’ are less relevant from their point of view. Public authorities, on the other hand, consider the implementation of ‘innovative funding schemes’ as a more important enabler, while ‘enhancing PPP’ and ‘upgrading of the ITS infrastructure’ are less important according to them. Finally, the R&D stakeholders think that the MaaS concept will become an important facilitating factor, while they do not expect less added value of a clearer legal framework.

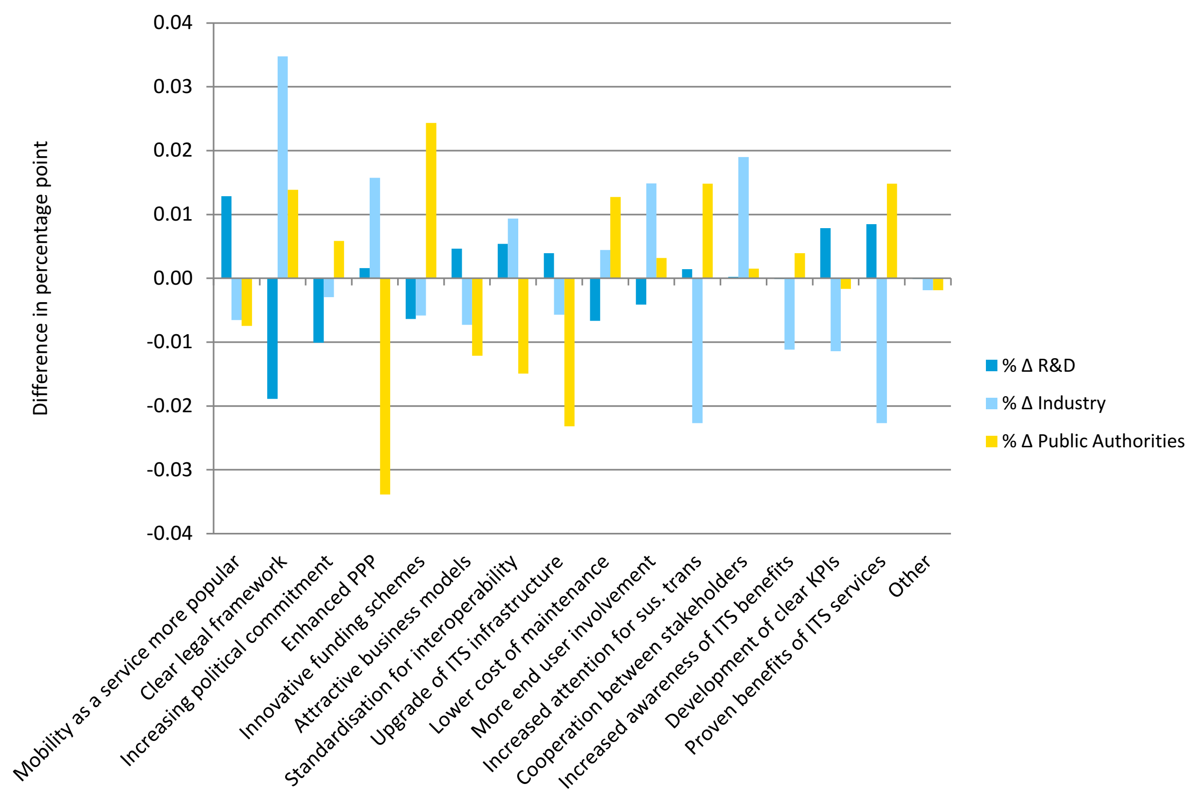

Figure 15 Differences in stakeholders' opinions on the relevance of the barriers

The main findings per market segment are found in Figure 16 to Figure 20. As for the barriers, significant differences in the importance of enablers per market segments exist. For the ATIS market segment, 'increased popularity of mobility as a service" was identified most frequently as an enabling factor, followed by the availability of attractive business models and more cooperation between stakeholders. Compared to the other market segments, higher levels of end user involvement and increased public awareness of ITS benefits are found to be relatively important (maybe due to the more mature character of this market segment).

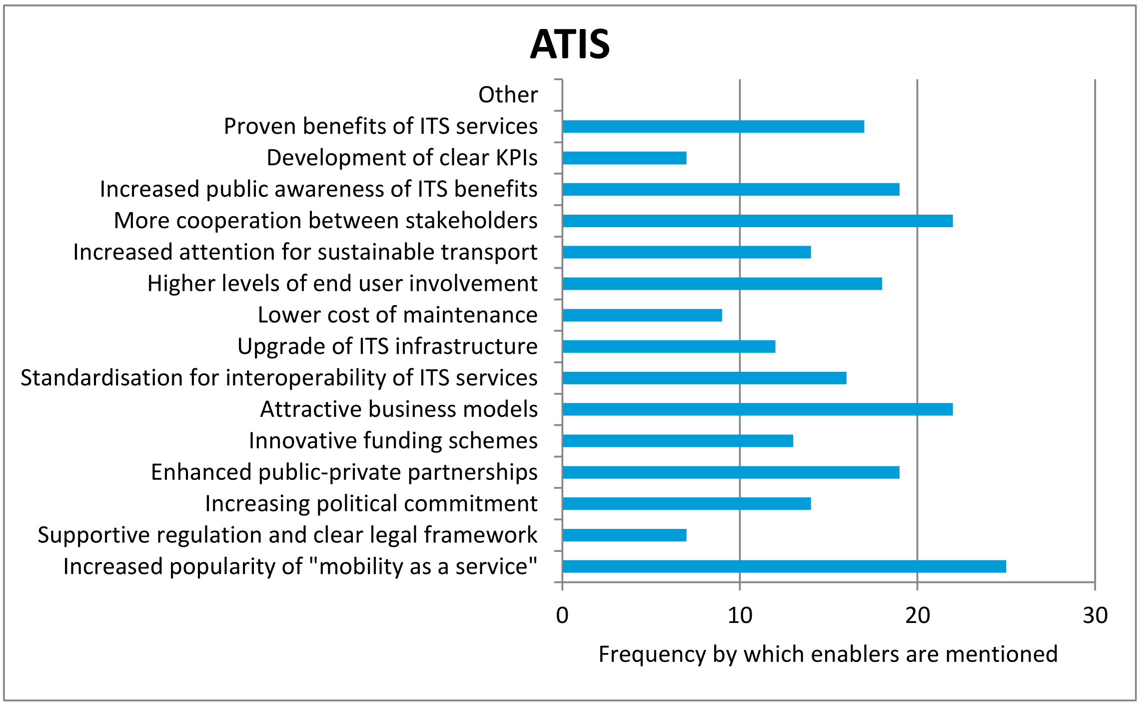

Figure 16 Main factors facilitating the deployment of ITS services in the ATIS segment

"Increasing political commitment" was named most frequently for the ATMS segment as relevant enabler, followed by enhanced public-private partnerships and more cooperation between stakeholders. Compared to other market segments, 'lowering the costs of maintenance' is more frequently mentioned as potential enabling factor, while 'higher levels of end-user involvement' and 'attractive business models' are less mentioned. These results can (at least partly) be explained by the fact that the ITS services on this market segment are mainly used by transport infrastructure managers, which are often public entities which are more cost than profit driven.

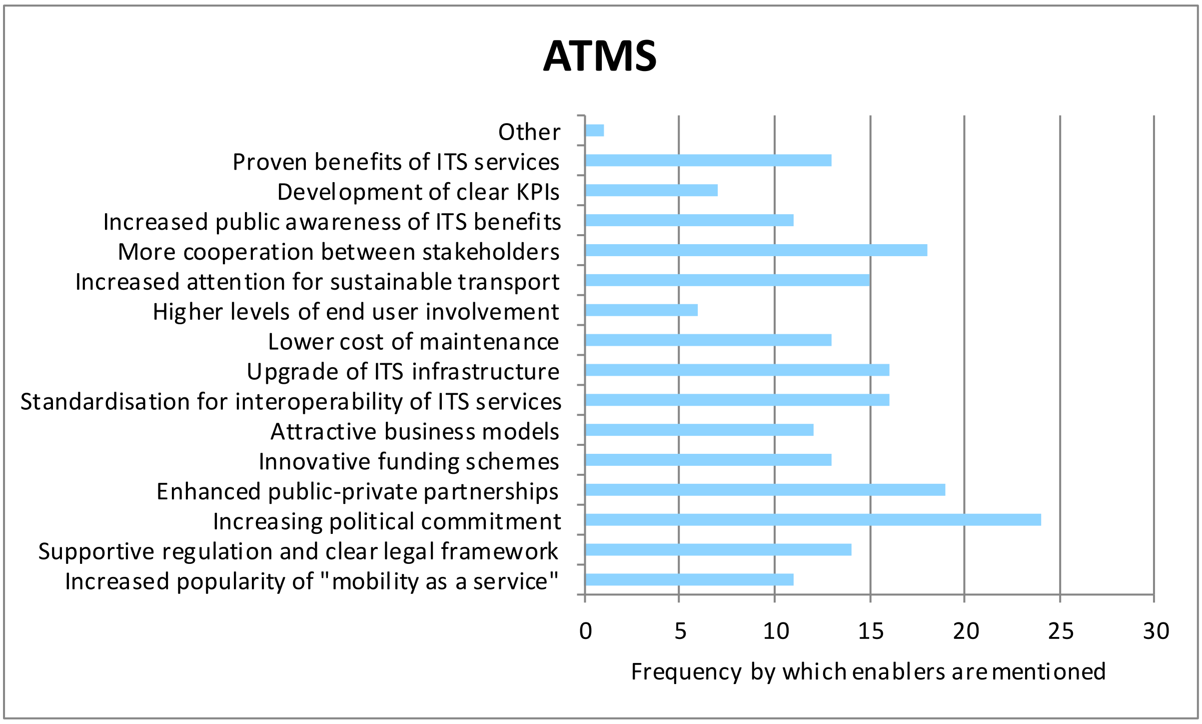

Figure 17 Main factors facilitating the deployment of ITS services in the ATMS segment

As for the ATMS segment, ‘increasing political commitment’ is mentioned most often as relevant enabler in the ATPS segment, followed by ‘the availability of more attractive business models’. ‘Standardisation for interoperability of ITS services’ is also considered to be an important enabler, particularly as this market segment covers several ITS services that can be rolled out widely once clear standards are set.

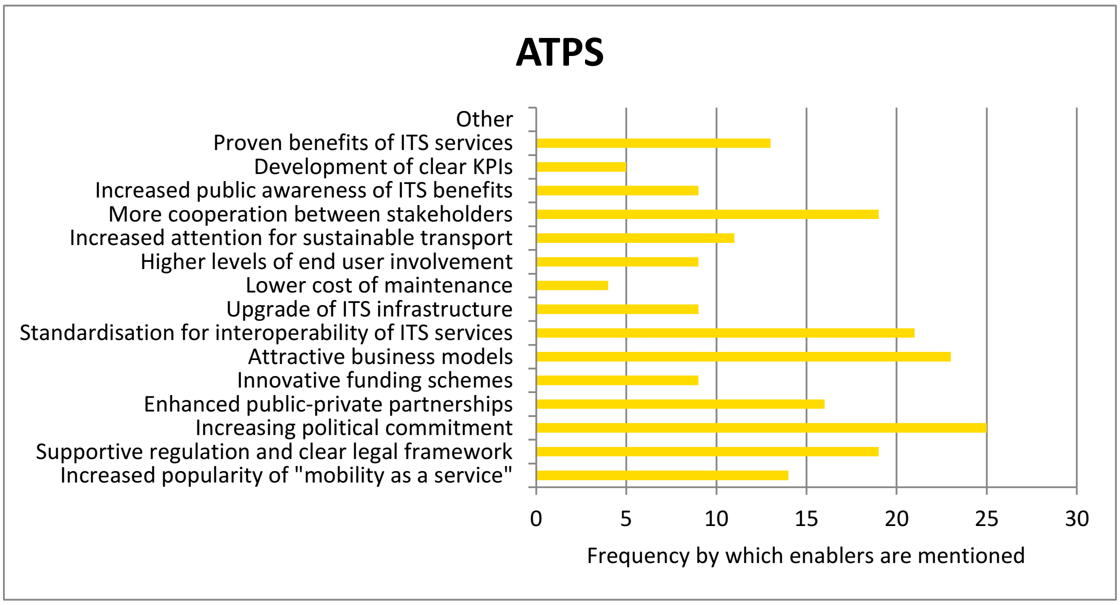

Figure 18 Main factors facilitating the deployment of ITS services in the ATPS segment

For the APTS market segment, ‘increased popularity of MaaS’ is most often mentioned as a relevant factor to support the deployment of ITS services. This market segments provides several ITS services focussed on facilitating multimodal transport, which is the core of the MaaS concept. Closely related to this, ‘increased attention for sustainable transport’ is also frequently mentioned as facilitating factor for this market segment. Compared to other market segments, ‘upgrade of the ITS infrastructure’ is only mentioned little as an important enabler.

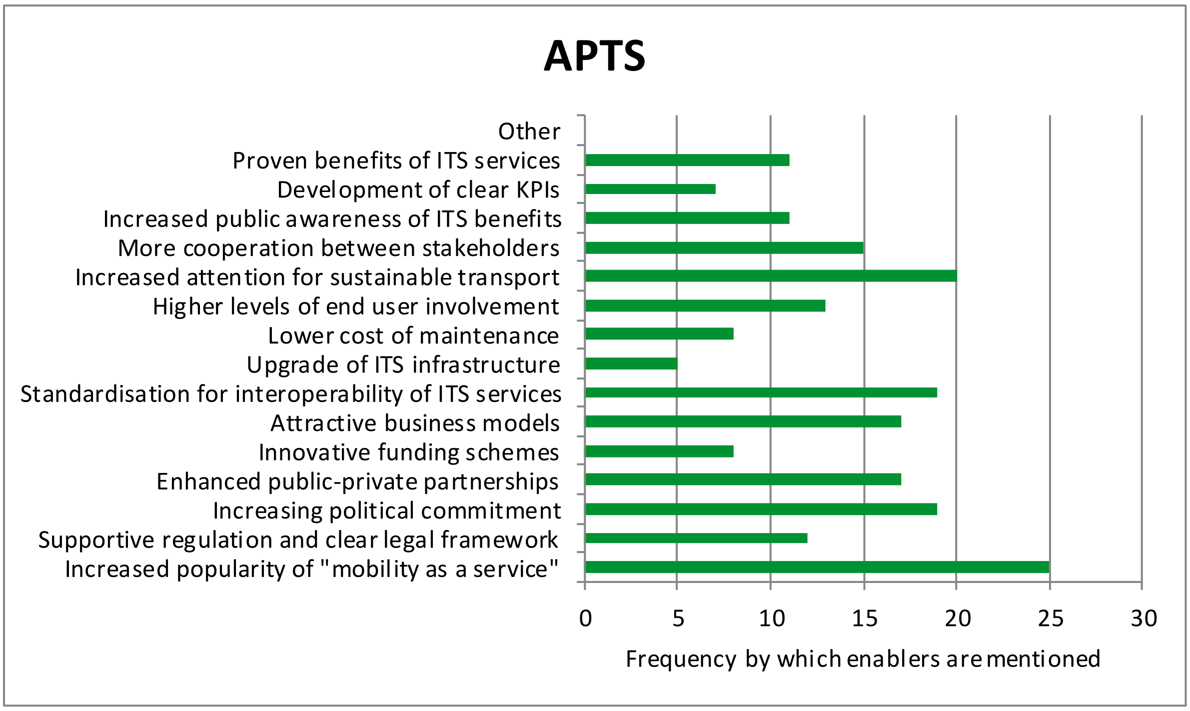

Figure 19 Main factors facilitating the deployment of ITS services in the ATPS segment

Finally, 'standardisation' and 'increasing political commitment' are most frequently mentioned as enabling factors for the CVS market segment. But also the development of a clear legal framework is often mentioned as a relevant enabler, reflecting the impact these innovative services may have on the transport landscape.

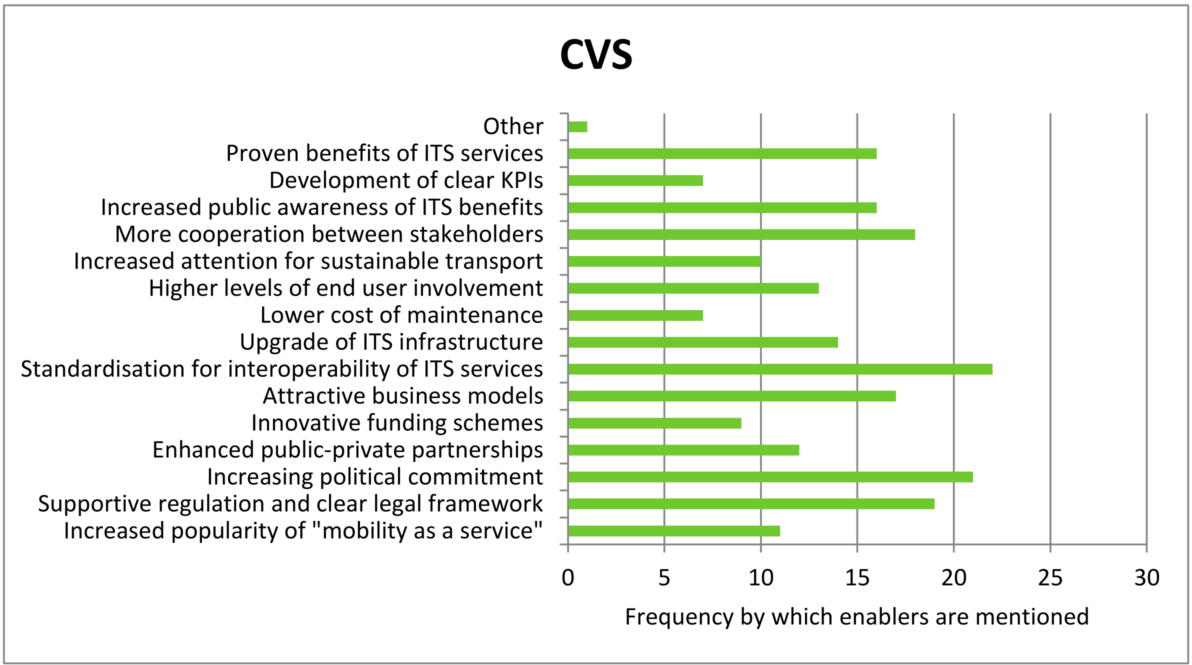

Figure 20 Main factors facilitating the deployment of ITS services in the CVS segment

3.4 Main barriers and enablers per service type

In NEWBITS D2.1 94 relevant ITS services deployed globally were identified. As explained in Section 2.2.3, these services were categorised in four different classes representing different types of services. The goal of this section is to investigate whether the barriers and enablers differ between these four types of services. Therefore, data was collected on the barriers and enablers related to the 94 services (for more details on the data gathering approach, see Section 2.3.3), documented in service specific fiches (see Appendix 6). Next, these service specific barriers and enablers were allocated to the more general types of barriers/enablers identified in Section 3.2.3. (see Appendix 4 for more details), in order to make comparisons with the results from Section 3.3 possible.

It is important to note that all of the ITS services are deployed in practice, as pilot or as operational service. This means that the identified barriers and enablers refer to services that are actually implemented/piloted and hence that (certain) deployment barriers/enables may be reflected to a lesser extent.

3.4.1 Barriers

In Table 11, it is shown how often the various types of barriers are identified for the 94 ITS services. In total 162 barriers are identified, of which the inadequate infrastructure and lack of user acceptance are most often found. On the other hand, the existence of last mover advantage is not mentioned at all for the identified services.

Category	Barrier	Occurrences
Technical	Current infrastructure not ready for service	32
Attitudes	Lack of user acceptance	32
Institutional	Lack of sufficient legal framework	21
Technical	Lack of interoperability and incompatibility	15
Technical	Technical weaknesses in ensuring data security	14
Impact	Lack of demonstrated benefits for ITS services	13
Economic	Lack of attractive business model	8
Institutional	Lack of political prioritization	8
Attitudes	Limited understanding of user needs	6
Organisational	Lack of cooperation between stakeholders	5
Economic	High or uncertain maintenance costs	4
Economic	Lack of funding	2
Organisational	Lack of skilled staff for ITS companies	2
Other	Existence of last mover advantage	0

Table 11 Occurrences of individual barriers

Compared to the results of the on-line survey, economic (particularly lack of funding) and organisational (lack of cooperation between stakeholders) barriers are relatively little indicated as relevant barriers, while lack of user acceptance, lack of sufficient legal framework and technical weaknesses in ensuring data security are more often found for the specific ITS services. These differences are (at least partly) explained by the fact that all ITS services considered are actually implemented/piloted, such that some barriers (e.g. lack of funding) are less relevant. Furthermore, the TRL level of most of the identified services is relatively high (at least 7 and often 9) and hence other types of barriers are found to be relevant.

In order to analyse differences in barriers per service type, we have allocated all identified ITS services and their barriers to the four different categories of service types (see Appendix 4). Table 12 shows the number of identified services and barriers per service type. Most barriers are identified for the services in type 2 and type 4.

Service type	Number of ITS services identified	Number of barriers identified
Type 1	20	22
Type 2	29	56
Type 3	22	25
Type 4	23	59

Table 12 Number of barriers per service type

Figure 21 shows the occurrence of barriers for the different service types. The figure shows that there are significant differences between the services. Type 1 services have barriers dominated by political prioritization and user acceptance, both related to acceptance. For Type 2 services, inadequate infrastructure, lack of user acceptance and lack of legal framework are the most frequent barriers. The latter two barriers are also most often found for Type 3 services. For Type 4 services, the same barriers as for Type 2 services are identified as relevant, except for the technical barriers (these are less relevant for these service types).

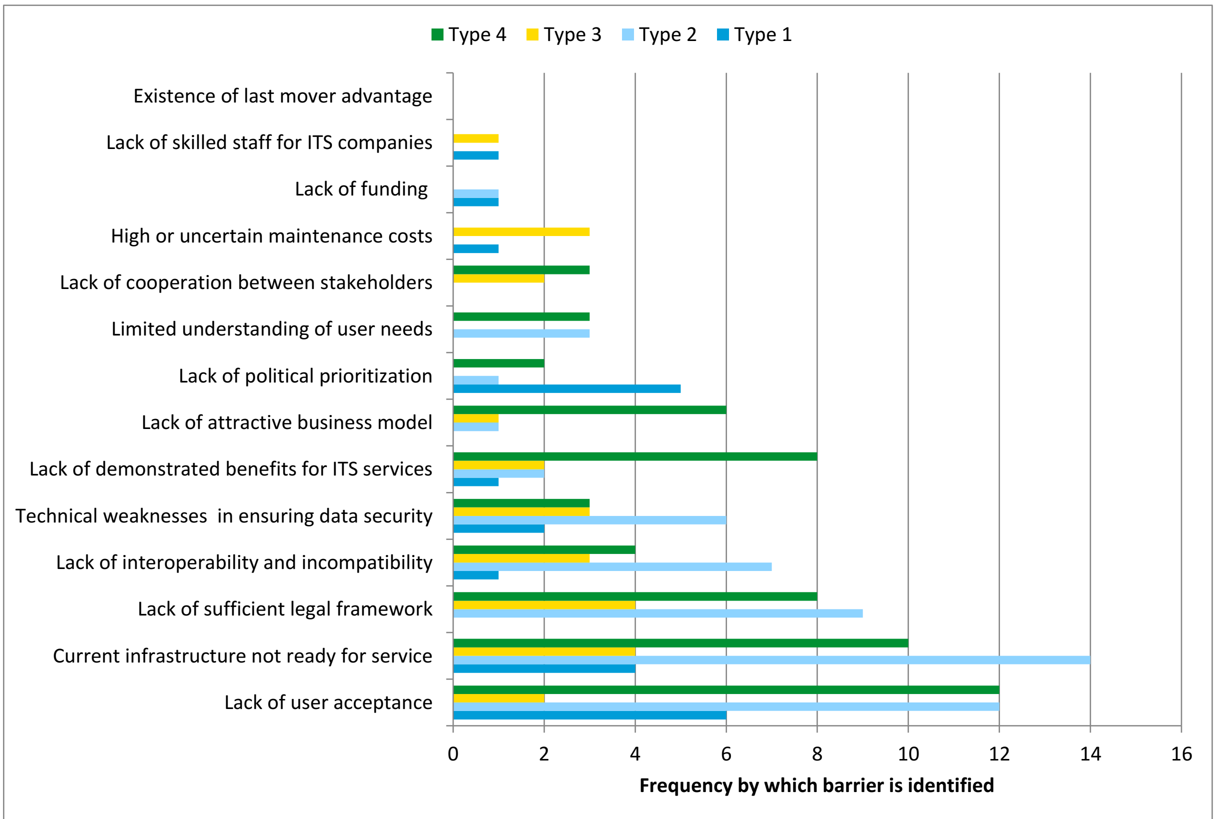

Figure 21 Barriers for type of services

When combining the characteristics of the type of services as shown in Section 2.2.3 (see Table 7) with the findings discussed above, some preliminary conclusions can be drawn:

- **Type 1** services are services with a technology readiness level of 9, which means that they are deployed on the market and are fully operational. As a consequence these services have to be able to convey end-users to use their products. The most important barriers are related to public acceptance of individual users and lack of political prioritisation. Barriers more related to the operational side of the service, for example the technical and organisational categories, are relatively less important for Type 1 services.

- **Type 2** services are mostly in the pilot phase and belong to the market segments of CVS an ATIS. These services are mostly aimed at improving safety and environmental performance. Since the services are not ready for market deployment yet, other barriers arise. Technical barriers are very important for this type of services, while lack of user acceptance is also important for this type of services. Furthermore, changes in the legal framework are necessary for this type of services, as they are often changing transport behaviour drastically (particularly the services on the CVS market).
- **Type 3** services are mainly aimed at efficiency and can be both in pilot phase or already on the market. Because of the broad scope of this category, a wide range of barriers may be relevant.
- **Type 4** services are mainly in the pilot phase and belong to the market type of C-ITS. The main primary benefit is efficiency. The largest barrier for this type of services is lack of user acceptance, which makes sense at cooperate vehicle solutions are relatively novel and unknown by the public. Furthermore many of these services are only effective with a high penetration rate which reduces the lack of demonstrated benefits, which is another important barrier. Lastly, the physical and legal infrastructure are two important barriers.

Not surprisingly, the barriers change as the service becomes more mature. Services with a low technology readiness level have more technological barriers and issues with the legal framework, while services with a higher technology readiness level have more barriers related to acceptance.

3.4.2 Enablers

The frequency by which the different types of enablers were identified for the specific ITS services is shown by Table 13. In total 101 enablers are identified, most of them related ‘more cooperation between stakeholders’ and ‘proven benefits of ITS services’. Mobility as a Service and clear KPIs have not been indicated as enablers for the selected services.

Category	Enablers	Occurrences
Organisational	More cooperation between stakeholders	17
Impact	Proven benefits of ITS services	17
Attitudes	Higher level of end user involvement	11
Economic	Attractive business scheme	10
Technical	Standardization for interoperability of ITS services	10
Institutional	Increasing political commitment	7
Attitudes	Increased public awareness of benefits of ITS	7
Institutional	Supportive regulation and clear legal framework	6
Institutional	Enhanced public-private partnership	4
Economic	Lower cost of maintenance	4
Attitudes	Increased attention for sustainable transport	4
Economic	Innovative funding scheme	2
Technical	Upgrade of ITS infrastructure	2
Impact	Development of clear KPIs	0
	Increased popularity “Mobility as a service”	0

Table 13 Occurrences of individual enablers

The results found are quite well in line with the results of the stakeholder survey. More cooperation between stakeholders, proven benefits of ITS services, attractive business schemes, standardisation and increased public awareness were also frequently mentioned by the stakeholders as important factors facilitating the deployment of ITS services. Higher level of end-user involvement is more frequently found for the identified services as would have been expected based on the survey results. But as for some of the barriers, this could be explained by the fact that only ITS services actually piloted/implemented are considered in this section.

As for the barriers, the enablers are allocated to the various services types (see Appendix 4) Table 14 shows the number of identified services and related enablers per service type.

Service type	Number of ITS services identified	Number of enablers identified
Type 1	20	24
Type 2	29	24
Type 3	22	19
Type 4	23	34

Table 14 Number of enablers per service type

Figure 22 shows the occurrence of the enablers. The most important enabler is cooperation between stakeholders; only for Type 1 services this enabler is almost not mentioned. For these services, 'proven benefits of ITS services', 'high level of user involvement' and 'attractive business models' are identified most frequently. For Type 2 services, high level of user involvement is also frequently identified as a relevant enabler, while for Type 3 services 'proven benefits of ITS services' are second most often identified enablers. For Type 4 services most enablers has been identified, with public awareness and standardization being relatively more important.

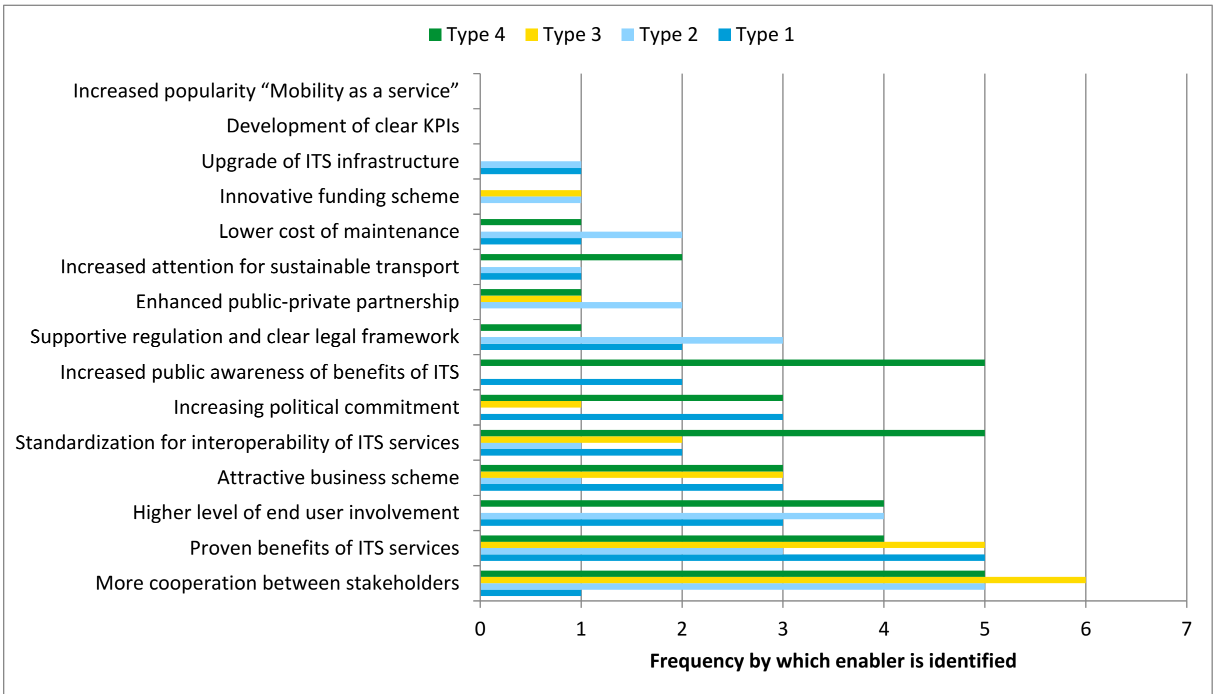

Figure 22 Enablers for type of services

Based on the findings above, the following preliminary conclusions can be drawn:

- **Type 1** services have TRL 9 and hence many enablers related to these services are focussed on (user) acceptance: demonstrated benefits of ITS services, higher level of user involvement, and increasing political commitment. Furthermore, more attractive business models to implement these services in a more profitable way is also considered an important supporting factor.

- **Type 2** services require more cooperation of stakeholders and higher end-user involvement. Particularly the former type of enabler is recognised as crucial for the development of innovative ITS services. Furthermore, a more sufficient legal framework is required, as these services often change transport behaviour significantly (particularly the services on the CVS market).
- **Type 3** services are rather diverse and this is reflected by the enablers identified for this type of services.
- **Type 4** services belong to the CVS market. Increased cooperation between stakeholders is required to support the development of this very innovative services. Furthermore, more public awareness is considered an important supportive factor, mainly as these services are relatively novel and unknown by the general public.

3.5 Impact of external factors on future relevance of barriers and enablers

This section takes a prospective outlook on megatrends that will impact ITS technologies and services in the medium term (2025), and their implications on the future relevance of barriers and enablers. According to Tinnilä & Kallio (2015), megatrends refer to the *focus on forecasting foreseeable future states with long spanning and significant impacts on society, environment, economy, as well as, more specific sectors*. A simpler definition of megatrends was given by Bernardino et al. (2015) as *stable trends driven by global forces that impact several societal areas*.

To achieve this task, we have performed the identification and impact of the megatrends in the area of transport (see Table 15) by desk research from past or ongoing European projects, scientific articles, and stakeholder interviews. This is not meant to be an exhaustive list, but it provides a guide to identifying the megatrends frequently mentioned and more relevant to ITS development. The megatrends are expected to have significant impact on the future development of ITS technologies and services.

Source	Category	Megatrends
Silva et al. (2014)		Population prospects, ageing, gross domestic product (GDP), income growth and distribution, urbanization patterns, changing lifestyles and mobility behaviours, environmental challenges, energy sources and technological innovations
L'Hostis et al. (2016)	Economic	Share of the European economy in world GDP declines, New business models
	Social	Restructuring working arrangements, Ageing population, Migration, Less car use by younger generations, Urbanisation, Growing concern over security threats
	Technological	Smart cities, Internet of Things and big data, Automation
	Political	Stricter regulations on environmental protection, Move away from fossil fuels towards energy efficiency and renewable energies
	Environmental	Climate change
	Legal	Diversifying approaches of governance, Legislative models adapts to new transport solutions and businesses
Bernardino et al. (2015)		Globalization, urbanization, ageing, knowledge society, individualism, migration, connectivity, immediate needs, slow movement, empowerment of women, awareness / consciousness, consumption, ever young, seeking for

Source	Category	Megatrends
		experiences, crowd sourcing
Harris et al. (2015)		Cloud computing, Wireless/mobile communication technologies and Internet of Things, Social networking, Advances in interface technologies, Big data
Forsblom (2013)		Growing emphasis on environmental issues, Ageing population, Urbanisation
Interviews		Community engagement and crowdsourcing, multimodality, 5G, smart cities, autonomous vehicles

Table 15 Overview of megatrends in transport

With the ITS global market expected to grow to be worth over $30bn by 2022 (Intelligent Transportation System Market by Roadway, 2017), we have selected 5 key megatrends that will shape the ITS industry in the medium term: urbanisation, sustainability (environmental challenges), emerging technologies (5G, Internet of Things), demography (global population growth with an emphasis on the "Generation Y" and ageing) and travel trends (multimodality). These have been agreed at the consortium level as the most relevant megatrends that can become major driving forces to influence barriers in ITS. In the remainder of this section we will discuss these five megatrends and their impacts on barriers and enablers for ITS services in more detail.

3.5.1 Urbanisation and growing investments in smart cities

During the last decade, technological advancements and economic growth in urban areas has led to the progressive desertion of rural areas towards the cities (Cocchia, 2014), hence, causing the densification of the cities. A UN study (United Nations, 2015) reveals that the world's urban population has been increasing during the last 60 years, and the trend is expected to continue with projections of additional 2.5 billion people by 2050 taking into account the overall growth of the world's population. This trend however, has been posing some major threats to the cities such as the increase in traffic congestion and air pollutant emissions, impacting negatively on the quality of life of citizens.

Possible solutions to urbanisation issues are now linked to smart city implementations. Smart cities have become a global trend conceived as a response to the increasing urbanisation challenges in cities for sustainability. The number of smart city implementations has increased significantly over the last years (Dameri, 2017a). An EU Parliament report in 2014 found out that over 268 out of the 468 cities in the EU28 have implemented one or more smart city initiatives. Amsterdam and Genoa are considered the leading cities in smart city initiative deployment in the EU (Dameri, 2017b). In this context, urban ITS is an integral part of the whole smart city initiative.

What this means for the roll-out of ITS solutions is that we will continue to see more commitments from cities (The Connected Boulevard, Optimod'Lyon, 2013). Cities are becoming more and more interested because of benefits related to reduction of traffic congestion and environmental footprint, as most relevant developments are services working in cities (Interview). Political barriers will be impacted as priority will be given to implementation of ITS initiatives (increasing political commitment). Additionally, urbanisation and smart city initiative trends will make it easier to make an economic argument for urban ITS implementations, that would otherwise have been difficult in rural areas. In other words, more attractive business cases for ITS services will probably arise.

3.5.2 Sustainability - Environmental challenges

The increasing concern for sustainability has grown in recent years, and in particular, sustainable transportation will be a major boost for ITS innovations as the transport sector continues to face challenges of safety, air pollution, and traffic congestion.

Silva et al. (2014) discuss the various trends in the demand for transportation systems up to 2030 and beyond. In their report, environmental challenges have been pinpointed as one of the most significant global trends of the 21st century. Specifically, the climate change phenomenon caused by excessive greenhouse gas emissions, which has a negative impact on the environment, economy and society. Transportation accounts for 20% of all CO_2 emissions with around 75% being caused by road transport (Kalmbach et al., 2011). Citizens, businesses and governments are becoming more aware of the consequences of greenhouse gas emissions. Buzz words like “Global warming”, “Climate change”, “Environment friendly” have been dominant in the media and even on off-the-shelf products in consumer markets.

The management of climate change consequences has been met by stricter regulations, such as the significant reduction in the emissions of sulphur dioxides. In the near future, ITS will play a major role in the reduction of CO_2 emissions.

Political commitment is expected to improve since they have the knowledge of the current problems and solutions to these are already available. As a result, all hands will be on deck to break down some of the hard institutional barriers (lack of political commitment, lack of a supportive and clear legal framework) as much as possible.

3.5.3 Emerging technologies

Connectivity remains the backbone of ITS technologies in providing information services, intelligent driver assistance, information sharing and cooperation between ITS-enabled devices (vehicles, users, and infrastructure). A new mobile wireless technology fifth generation (5G) is currently coming along by 2020 (ESPAS Report, 2015), which is set to provide ultra reliability with peak data rates, to break the barrier of connectivity. Reliability issues on information collection/delivery may become a thing of the past with the uptake of cellular 5G networks. The standards for 5G are yet to be set, but there are already huge consortiums of major global telecoms working to create worldwide standards around 5G (Qadir & Zaman, 2016).

There are some compelling benefits that will be derived from the uptake of 5G. For example, in C-ITS, 5G could allow V2V communications and support a co-existence of multi-tier heterogeneous wireless networks with diverse radio access technologies providing ubiquitous internet connectivity in vehicles (Interview). But it is not clear yet who will pay for the required infrastructure and use of frequency spectrum, whereas WiFi-P is an additional feature of your car and is free from then onwards. Furthermore, given the payment structure of mobile operators, it is not clear how clients of different mobile providers could communicate with each other (Interview). Also, the switch to 5G cellular technology will bring possibilities for hybrid C-ITS applications using both 5G as well as ETSI-G5.

Furthermore, the “Internet of Things” is expected to develop on a massive scale between now and 2030 (ESPAS Report, 2015). More and more devices will get connected to the ITS infrastructure, such that information collection and delivery will continue to scale to a large volume. More than 50 billion devices are expected to be connected to the internet by 2020 (Deloitte, 2014). More so, the speed at which the data is being collected/delivered will also increase at a high rate taking into account the diverse range of sources. The explosion of the Internet of Things will demand for a complete set of requirements and would require new decision support approaches such as the Big Data analytics to manage, store and make sense of the data.

These technological development may affect some of the technical barriers (particularly the current inadequacy of infrastructure to integrate innovate ITS technologies). However, it also requires efforts in terms of standardisation and an appropriate legal framework.

3.5.4 Demography (Global population growth): the “Generation Y” and ageing population

The world's population is expected to grow by another 1.1 billion people by 2030, reaching around a total of 8.3 billion people (ESPAS Report, 2015). One of the major trends leading to this population growth in the period to 2030 is the increase in life expectancy and decline in birth rates which have become the major driving forces behind the global ageing population. In the EU, the number of people over 65 is projected to account for roughly 23% compared with the 16% of today (Eurostat, 2013). As a consequence, there would be a significant increase in demand for healthcare services due to prevalence of chronic diseases in elderly population. According to the OECD Health Statistics 2015, there has been a rise in healthcare costs in the EU, in terms of the healthcare expenditure as a share of GDP. This has also been identified as a societal challenge in the H2020 Action Plan.

In economic terms, this would mean that governments will channel more funds into the healthcare system, and priorities of investments in other sectors such as transportation may well reduce. From a different viewpoint, this trend will be create opportunities for a new ITS market for senior citizens and vulnerable road users. As a result, it will generate business opportunities which will otherwise require new business models.

The Department of Economic and Social Affairs of the United Nations forecasts a projected increase of almost 0.4 billion population in the 15-34 age group of the world population by 2020. According to Frost and Sullivan (2010), this age group called “Generation Y” are the important customers of the future because they are techno savvy and connected 24/7, demanding and impatient, civic and environmental friendly. This would mean that ITS solutions will begin to experience an increase in user acceptance as the ageing population are less inclined to accept new technologies.

3.5.5 Travel Trend: Multimodality

Multimodality is another mega mobility trend, as the tendency of young adults to use multiple modes of transport has been on the rise in recent years (Kuhnimhof et al., 2012). This trend has been associated with reduced car ownership and decreasing workforce participation among the Generation Y (The World Bank, 2010). The Action Plan 1.1 of the ITS Directive 2010/40/EU recognised the increasing demand for European and multi-modal services to provide EU-wide Real-Time Traffic and Travel Information (RTTI) services. Some of the objectives outlined are: fair and transparent access to public data, promotion of public-private co-operation, increase in data quality, improvement in multi-modal co-operation, and encouraging (cross-border) data exchange. In this same Action Plan (1.5), actions were stated for the support of development of national, multi-modal travel planners and their EU-wide interconnection for multimodal journey planners. Some FP7 projects awarded under this Plan include WISEMODE and iTravel.

By the end of 2014, the EC adopted new rules to improve EU-wide traffic information services to road users (ITS News 2014) owed to the existence of a functioning market for RTTI services. The objectives were to make existing information services available to more users by increasing EU-wide interoperability and continuity of data and services, facilitate the sharing of digital data, and foster the availability of more and accurate data. This action has already translated into conception as new projects are being funded. Notably is the FP7 Co-Cities that aims to incorporate users and travellers' feedback to extend and validate existing mobility services to improve current traffic information management in cities and urban areas. With this trend, there is a need for cooperation between stakeholders in the private and public sectors in order to provide users with a seamless travel experience.

3.5.6 Conclusion

As discussed above, the five megatrends may significantly affect the current barriers and enablers for the deployment of ITS services. Urbanisation, more attention for sustainability and increased multimodality may result in more political commitment to implement ITS services. Furthermore, opportunities for more attractive business models are expected due to urbanisation (relatively compact application areas for ITS services with many potential users) and demographic trends (ageing populations may ask for other, more profitable mobility solutions). Emerging technologies (i.e. 5G and Internet of Things) may provide a more adequate infrastructure for innovative ITS technologies. Finally, user acceptance may increase as well due to the more prominent role of generation Y (who are more inclined to new technologies than older generations).

The megatrends identified may, however, also increase the relevance of some of the barriers. For example, the ageing population will require huge investments in health care and consequently less funds are available for other domains, including transport. Furthermore, the emerging technologies may ask for further standardisation efforts and a modified legal framework. Finally, the increased demand for multimodal transport requires even more cooperation between stakeholders, increasing the current challenge with respect to this issue.

4 Key performance indicators

4.1 Introduction

The use of clear and quantifiable key performance indicators (KPIs) may support the development of robust business models and effective policy incentives for the deployment of ITS services. For that reason, this chapter provides an overview of the existing KPIs for ITS services and identifies the most relevant ones for different types of services. Furthermore, the barriers for applying these KPIs are discussed.

This chapter provides answers to research question 2 and underlying sub-questions (see the text box below).

Research question 2

What are relevant KPIs for different types of ITS services and which barriers for applying them can be distinguished?

This question consists of three sub-questions:
1. *Which KPIs with respect to ITS services can be applied?*
2. *What are the relevant KPIs for different categories of ITS services?*
3. *What are the main barriers for the implementation of these KPIs?*

In the remainder of this chapter we first provide a systematic review of the evidence available on the KPIs for ITS services (Section 4.2), resulting in a clear definition of KPIs and an state-of-the-art overview of KPIs used for ITS services. Based on this overview, the main KPIs per market segment are identified in Section 4.3. Therefore, the KPIs identified are mapped on the market segments defined in Section 2.2.3 based on the results of the on-line stakeholder survey. In Section 4.4 the main KPIs per service type (see Section 2.2.3) are identified, based on data collected for 94 actual ITS services currently planned or implemented in Europe, the US and Australia. Finally, the barriers for applying the KPIs for ITS services are assessed in Section 4.5.

4.2 Systematic review of KPIs

In order to provide a state-of-the-art overview of relevant KPIs, a systematic review of relevant literature sources is conducted, complemented by some interviews with relevant stakeholders (more information on these research methods applied can be found in Section 2.3.3). This systematic review starts with clearly defining KPIs and identifying relevant categories of KPIs. This provides a clear framework that structures the broad inventory of KPIs for ITS services.

4.2.1 Definition of KPIs

Key performance indicators are used in many areas including sales, management and industry. The idea of KPIs to measure performance is originally introduced by Daniel and Rockart, both from McKinsey Company (Daniel, 1961; Rockart, 1979). They introduced the concepts of critical success factors (CSF) and key performance indicators (KPIs). Although both concepts are related, they are different: CSF are the key areas that are critical to the performance of a business, while KPIs are tools (indicators) to measure the performance of an organisation, system, product or service. For example, improving transport safety may be seen as a CSF with respect to ITS services, while the number of accidents reduced by the ITS service is a potential KPI of this service.

The idea of measuring performance through KPIs has evolved from business management towards other areas of application, including Intelligent Transport Systems. The definition of KPIs generally followed in European ITS deployment projects is the one from the FESTA Handbook *(FOT-Net 2016)*:

> *Performance indicators are quantitative or qualitative indicators, derived from one or several measures, agreed on beforehand, expressed as a percentage, index, rate or other value, which is monitored at regular or irregular intervals and can be compared to one or more criteria.*

As this definition is broadly applied in European ITS projects, we follow this definition proposed by FOT-Net in this deliverable as well. .

KPIs as elements of performance measurement
KPIs are crucial elements of performance measurement and monitoring of ITS services. As mentioned by Kaparis et al. (2011), performance measurement may significantly impact the development, implementation and management of ITS services (particularly for novel services where there is no existing evidence from similar cases), and may contribute to the identification and assessment of successful alternative services. Furthermore, it may provide the opportunity to objectively compare the performance of different types of ITS services. A performance-based implementation structure may therefore increase the success rate of ITS deployment, both in general and for specific ITS services.

According to Kaparis et al. (2011), a well-functioning performance measurement plan should constitute the following elements:

- Definition of general objective of the ITS service;
- Identification of specific performance objectives expressed in quantifiable and measurable form.
- Identification of specific performance measures (KPIs) to be used to measure the impacts or outcomes of the ITS services.
- Recognition of the factors that can be modified to positively affect the ITS service performance/deployment.
- Description of the resources required to achieve the objectives.

In order to adequately measure performance it is thus necessary to do more than define relevant KPIs. In this deliverable, however, we only focus on KPIs, among other things because most of the other elements of performance measurement are rather service specific. Furthermore, KPIs are crucial factors in performance measurement, as they allow for the comparison of the performance of different ITS services in future scenarios as well as the evaluation of the service performance over time.

Tailor-made vs. general KPIs
Effective KPIs are tailored to the needs of the service, recognising the specific objectives and characteristics of the individual services. Thus, instead of a one-for-all approach, tailor-made KPIs should preferably be applied (Kaparis et al., 2011). However, for the purpose of this study, we have studied KPIs particularly at a more general level, in order to be able to cover KPIs for the whole spectrum of ITS services. For example, instead of defining a KPI as '*the*

length of motorways covered by ITS service X', we define it as '*the length of transport infrastructure covered by an ITS service'.* At this level, assessing the importance of KPIs per market segment and type of service is feasible (what is not the case at the level of individual KPIs, as there will be a too large number of KPIs to be covered). For more information, see Section 4.2.3.

Although KPIs should preferable be defined at an individual level, some guidelines at a general level emerge from the literature as well:

- KPIs should be quantifiable measurements that reflect the critical factors needed for success and help in defining and measuring progress toward targeted objectives (Paiva Fonseca, 2011);
- KPIs should ideally be described as a single indicator and should be scalable (Kaparias et al. 2011);
- KPIs should be easy to understand, clearly defined and mutually understood (Keebler et al., 1999; Tangen, 2004);
- KPIs need to be aligned with the relevant business or technology deployment strategy (Neely et al., 2005);
- KPIs achieves a balance between delivering a minimum standard and supporting future investment and deployment (AECOM, 2015)
- KPIs encourage appropriate behaviour, makes use of economies of effort, and should be designed in consultation with those whose performance is measured (Keebler et al., 1999; Tangen, 2004).

4.2.2 Categories of KPIs

In order to structure the large amount of (possible) KPIs a variety of categorisation approaches is available. An overview of categorisations applied in several other studies is given in Table 16.

Source	Categories	Further categorisation
Kaparias et al. (2011)	Deployment	Efficiency (mobility, reliability, operational efficiency, system condition and performance)
		Safety (direct versus indirect effect; urban vs. interurban traffic)
		Environmental
		Social inclusion and land use
AECOM (2015)	Deployment	Road safety and security applications
		Optimal use of road traffic & travel data
		Continuity of traffic and freight management ITS services
		Linking the vehicle with the transport infrastructure
	Benefit	Network efficiency & congestion
		Improve environmental impacts
		Improve road safety
		Enhance modal iIntegration
Zhicai et al. (2006)	Benefit	Increased capacity and operational efficiency
		Improved safety
		Reduced environmental and energy impacts
		Increased productivity and for motor carriers and service providers (tax, couriers, etc.)
		Increased comfort and convenience of travel

Source	Categories	Further categorisation
		Improved cooperation between transportation systems operators
EIP + (2015)	Deployment	Coverage
		Integrated level of service enhancement
		Level of quality
	Benefit	Congestion
		Safety
		Environment

Table 16 Broad categories of ITS KPIs

A categorisation often used is between deployment and benefit KPIs. Deployment KPIs are those related to the extent by which ITS services are implemented. Examples include the percentage of road network using various types of ITS services and the percentage of vehicles with intelligent vehicle features (AECOM, 2015). Benefit KPIs, on the other hand, are related to the (desired) impacts of ITS services. Examples include the percentage change in journey times, accident rates or CO_2 emissions along routes once ITS have been implemented (AECOM, 2015). As both deployment and benefit KPIs are relevant for the effective deployment of ITS services, we consider both categories of KPIs in this study.

As for deployment KPIs, several subcategories are distinguished in the literature. AECOM (2015) differentiate deployment KPIs based on their intended impact (e.g. improved traffic safety). This differentiation is particularly useful for assessing KPIs at the level of individual ITS services. However, as this differentiation requires a rather detailed definition of the ITS service considered it is less useful for the purpose of this study, since we asses KPIs particularly at a more general level (see Section 4.2.1). EIP+ (2015) differentiates between coverage, integrated level of service enhancement and level of quality criteria. However, the latter two types of criteria are considered to be more operational criteria than deployment criteria, as they are measuring to what extent the ITS service functions well (e.g. number of downtimes). As for the purpose of the NEWBITS project operational KPIs are less relevant, we will not consider them in detail in this deliverable. To conclude, the subcategories used in the literature with respect to deployment KPIs are not relevant for this study. Therefore, the category 'deployment KPIs' has not been further broken down.

For benefit KPIs, a further breakdown has been applied, though. In line with NEWBITS D2.1, four primary benefits of ITS services are distinguished, along which line the benefit KPIs are categorised:

1. *Safety*: improved traffic safety
2. *Efficiency of the transport system*: more efficient use of the capacity of the transport network/system.
3. *Environmental performance*; less harmful environmental impacts due to transport
4. *Comfort*: improved travel experience of travellers.

This breakdown is well in line with the subcategories identified in the literature (see Table 16). Although slight differences exist between the various literature sources, most of them distinguish (most of) the categories mentioned above.

4.2.3 Overview of KPIs

Based on an extensive literature review, complemented by some interviews with relevant stakeholders, an overview of relevant deployment and benefit KPIs has been provided. Starting point of this assessment has been the study 'Key performance indicators for intelligent transport systems' (AECOM, 2015), which has performed a similar task. In addition to this study several other studies has been identified presenting other/additional KPIs.

The review of evidence from the literature sources and the interviews has been the first step in the approach to compose an overview of relevant KPIs. In a second step, it has been assessed whether there is overlap between the KPIs found in the various sources. Similar KPIs have been merged into a single KPI in order to avoid duplicate KPIs. Furthermore, the relevance of the KPIs has been assessed. AECOM (2015) has studied the relevance of the KPIs they present in their study, and the results of this assessment are used in this study as well. For the KPIs taken from other studies, a brief check on their relevance has been executed by the researchers based on the following criteria (Keebler et al., 1999):

- Is KPI quantitative?
- Easy to understand?
- Not too specific?

The third step has been rephrasing the KPIs such that they are in line with the general level at which KPIs are assessed in this study. For example, the original KPI '*Length and % of road network covered by incident detection and incident management*' has been rephrased to become '*Length (and %) of transport network covered by ITS service'.* Through rephrasing the KPIs has become more generic, such that they can be applied for different transport modes and ITS services.

Based on the results of the steps above, a final overview of KPIs has been composed.

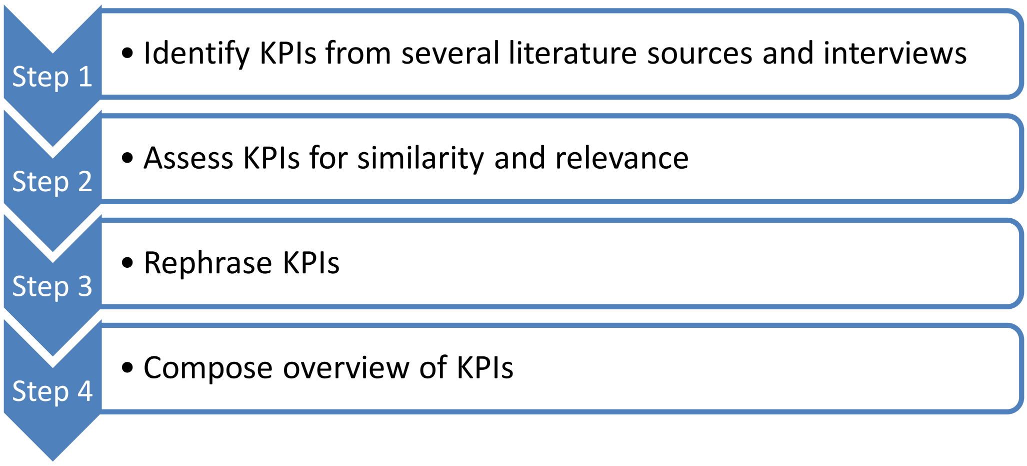

Figure 23 Detailed approach to provide overview of KPIs

Deployment KPIs
An overview of the deployment KPIs identified is given in Table 17. The detailed results on deployment KPIs (e.g. specific KPIs identified, sources from which they are taken) can be found in Appendix 2. Table 17 focuses on some examples of specific, tailor-made KPIs.

General KPIs	Examples of specific KPIs
Length of the transport network covered by ITS service	• Length of road network covered by automated speed detection • % of road network covered by traffic management systems • % of the road network compliant with the interoperability directive of the European Electronic Toll Service (EETS)
Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)	• % TEN-T network supporting cooperative systems (I2V, V2I)
Number of network elements (e.g. intersections; highway lanes) covered by ITS service	• Number and % of urban public transport stops for which dynamic traveller information is made available to the public • % expressway entry points equipped with ramp metering
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used	• Number of automatic number plate recognition (ANPR) systems in use • Number of automatic parking systems available
Frequency by which ITS service is used	• % public transport ticket transactions that utilise electronic payment technologies • Number of routing requests made to on-line travel information service
Number of end-users of ITS service	• % public transport ticket transactions that utilise electronic payment technologies
Number of vehicles featuring ITS technology in application area of ITS service	• % of vehicles equipped with dynamic navigation • Number of public buses and taxis equipped with Automatic Vehicle Location System (GPS)
Number of vehicles in application area actually using ITS service	• % demand responsive vehicles that operate under Computer Aided Dispatch • % taxis / taxi service providers providing a real-time and SMS-based booking service
Number of hours ITS service has operated	• Number of hours that dynamic traffic advice is displayed
Number of visits to website and portals linked to the ITS service	• Number of visits to websites offering traveller information

Table 17 Overview of deployment KPIs

As shown in Table 17, ten different types of deployment KPIs are distinguished. Three of them are related to the extent by which the transport infrastructure is equipped with an ITS service / technology, while two of them are measuring the extent by which vehicles are equipped/using ITS services/technologies. Additionally, two KPIs are related to the usage/users of the ITS services. Finally, KPIs are defined for the extent by which specific ITS technologies are applied, the time ITS services has been operated and the extent by which auxiliary portals to the ITS service are visited.

Benefit KPIs

An overview of the benefit KPIs is given in Table 18 to Table 21, differentiated to the four primary benefits of ITS services. More detailed results on specific KPIs identified (including the sources from which they are coming) can be found in Appendix 2.

With respect to safety, direct and indirect KPIs can be distinguished (see Table 18). The most direct KPI to measure traffic safety impacts is the reported perception of safety. Also the number of reported accidents, number of reported fatal accidents and number of reported accidents requiring medical attention are rather direct measurements of safety impacts. The other KPIs are more indirect (e.g. number of traffic violations), as they measure factors that may result in more unsafe traffic situations.

General KPIs	Examples of specific KPIs
Reported perception of safety	• Perception of road safety • Estimation of road safety performance
Number of reported accidents	• Absolute number of accidents • % change in number of reported accidents along routes where ITS service has been implemented
Number of reported fatal accidents	• Number of fatal accidents • Number of fatalities
Number of reported accidents requiring medical attention	• Severity of accidents per number of accidents reported • Number of fatalities / injuries
Costs of safety services	• Safety scheme costs
Incident response time	• Average incident response time • Average incident detection time
Number of traffic violations	• Reduction in number of violations (speeding, red light violations) • Change in crime reports relating to truck parking
Average driving speed	• Average driving speed • Driving speed variability
Average distance of vehicles driving behind each other (vehicle headways)	• Average headways

Table 18 Overview of KPIs related to traffic safety

The KPIs related to transport efficiency cover different aspects of the efficient use of the transport infrastructure/services. Some of the KPIs refer to the use made of the infrastructure (e.g. total traffic and transport volumes, average journey time), while others refer to the vehicles chosen (e.g. modal split of transport) or the travel time required (e.g. average journey time, average delay time). The twelve KPIs identified give, therefore, a good overview of the broad scope of this benefit category of ITS services.

General KPIs	Examples of specific KPIs
Total traffic and transport volumes	• Volume of transport to gross domestic product • Change in public transport average daily person flow between key points along a route
Modal split of transport	• % change in modal share on corridors where ITS service has been implemented • Reduction of private car use (in km/day)
Average journey time	• Change in total travel time • Average travel time to relevant points of interest (e.g. hospitals) on the road network.
Average variability of journey time	• % change in journey time variability on routes where ITS has been implemented • Change in journey time variability at key point of the road network
Predictability of travel times	• Change in predictability of travel times • Accuracy of measurement of speed and congestion
Average delay time	• Average time loss through waiting at cross-sections • Average delay time per vehicle
Average journey distance	• Average travel time and length on specific routes • Total vehicle kilometres travelled
Average traffic speed	See safety KPIs related to average traffic speed
Average peak hour traffic flow	• % change in peak hour traffic flow
Number of start & stops	• Number of stops and their delay time
Total capacity of the network	• Change in traffic capacity
Average occupancy level / load factor	• Change of vehicle occupancy

Table 19 Overview of KPIs related to transport efficiency

As for safety, direct and indirect KPIs can be distinguished for environmental performance (see Table 20). The level of emissions and number of times thresholds are exceeded are very direct KPIs, while number of start & stops and average traffic speed are KPIs that are only indirectly linked to the environmental performance of the transport system.

General KPIs	Examples of specific KPIs
Level of emissions (CO_2, air pollutants, noise)	• Change in PM10 emissions per vehicle km • Change in carbon footprint per transport mode and route
Number of times thresholds (e.g. dB thresholds for noise) are exceeded	• Change in number of hours where NO_x levels are above threshold • Number of peak noise events
Total external costs of transport	• Change in public costs for transport
Total traffic and transport volumes	See efficiency KPIs related to traffic an transport volumes
Modal split of transport	See efficiency KPIs related to modal split
Average fuel efficiency of vehicles	• Change in average fuel efficiency •
Total fuel / energy consumption	• Change in total fuel consumption • Carbon footprint per transport mode and route
Share of renewable fuels in total fuel consumption	• Change in share of renewables in total energy consumption
Number of start & stops	See efficiency KPIs related to start & stops
Average occupancy level / load factor	See efficiency KPIs related to average occupancy level / load factor
Average traffic speed	See efficiency KPIs related to average traffic speed

Table 20 Overview of KPIs related to environmental performance

Finally, the KPIs related to transport comfort are shown in Table 21. These KPIs cover the different aspects that make up transport comfort, such as the reliability of transport services, the quality of travel information provided and the average travel time.

General KPIs	Examples of specific KPIs
Reported level of comfort	• Reported confusion (e.g. on departure times) • Reported stress during travelling
Reported quality of transport services / infrastructure	• Consumer satisfaction with completed trips • Level of service with respect to walking and cycling facilities
Reliability of transport services	• Public transport journey time reliability – deviation from scheduled timetable • Likelihood that information about a severe event (e.g. accident) is distributed after < 5 minutes
Quality of travel information provided	• Quality (e.g. proper channel, right time, right place) of information received • Quality assessment of information provided
Average journey time	See efficiency KPIs related to average journey time
Reliability journey time	• Share of public transport trips leaving on-time
Average delay time	See efficiency KPIs related to average delay time
Average traffic speed	See efficiency KPIs related to average traffic speed
Perception of waiting time	• Average waiting time at bus stops • Average parking search time at public transport facilities

Table 21 Overview of KPIs related to transport comfort

4.3 Mapping of KPIs per market segment

In this section we assess the relevance of different types of KPIs per market segment. Therefore, we have mapped the KPIs identified in Section 4.2.3 on the five market segments based on the results of the on-line stakeholder survey. As in Section 4.2.3, a split between deployment and benefit KPIs is made.

4.3.1 Deployment KPIs

Although the online survey revealed that only few of the respondents believe developing clear KPIs will facilitate the deployment of ITS services, we asked the respondents which of the KPIs they believed would be most relevant to the deployment of ITS services. They were asked to identify a maximum of 5 from a list of 11 KPIs compiled from the literature.

Figure 24 to Figure 28 present the results to this question, showing clearly that there are no universal KPIs, but that they differ per market segment. However, some general patterns can be recognised. In the market segments where ITS services are provided that are focussed on the end-user (ATIS, ATPS, APTS and to a lesser extent CVS), the 'number of end-users of the ITS service' was most frequently mentioned as important KPI. On the other hand, market segments providing mainly ITS services focussed on transport operators / infrastructure managers (ATMS), KPIs related to the ITS infrastructure were mentioned most often. Furthermore, the length of the transport network covered by the ITS service is frequently mentioned for all of the market segments, showing the rather general nature of this KPI.

When we consider the various market segments into more detail, than we find for the ATIS market segment that the 'number of end-users of ITS service' was most frequently identified as an important KPI. Additionally, the length of the transport network covered by the ITS service and the number of vehicles using the ITS service were often mentioned by the respondents. Compared to the other market segments, the KPI 'number of visits to websites linked to the service' is mentioned relatively frequent, which is probably due to the fact that travel information is often provided (or detailed) on specific websites.

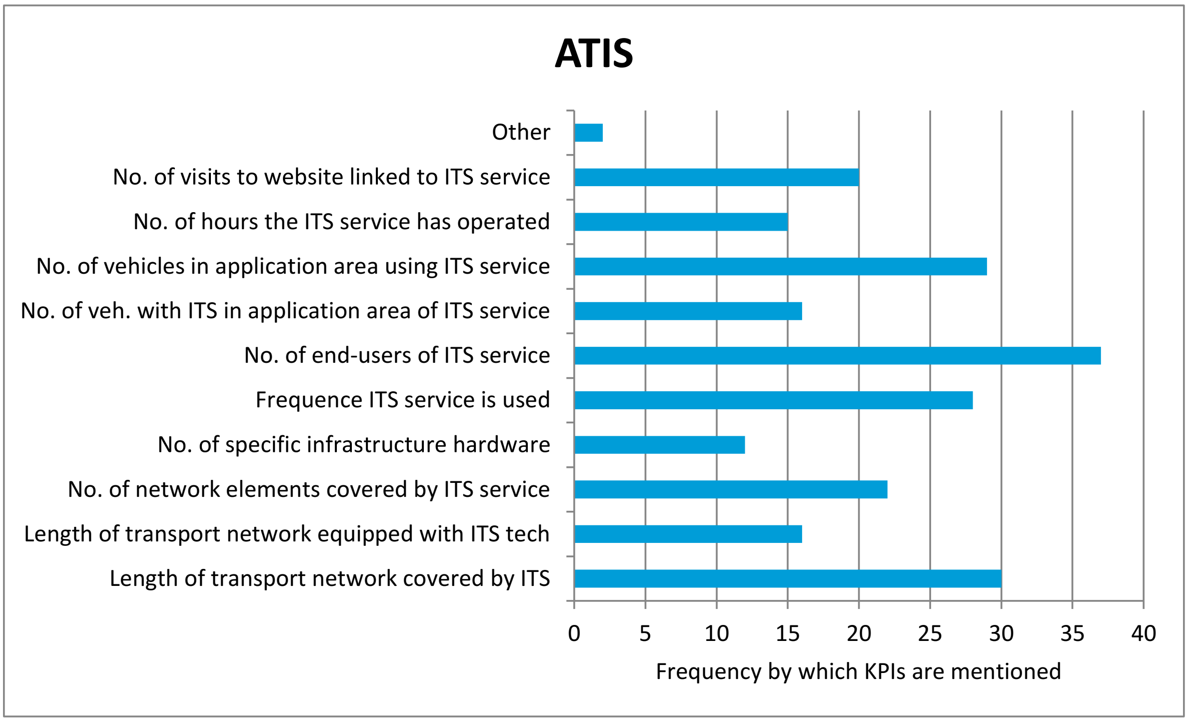

Figure 24 Main deployment KPIs in the ATIS segment

As many services in the ATMS market segment are focused on specific infrastructure elements (e.g. traffic lights, parking places), the KPI 'number of network elements covered by ITS service' is most frequently mentioned for this market segment. By the same reasoning also the relatively high score of 'number of specific infrastructure hardware' can be explained. The frequency by which the service is used is considered a less relevant KPI for this market segment, which may be explained that (compared to the other market segments) the number of direct users is relatively small.

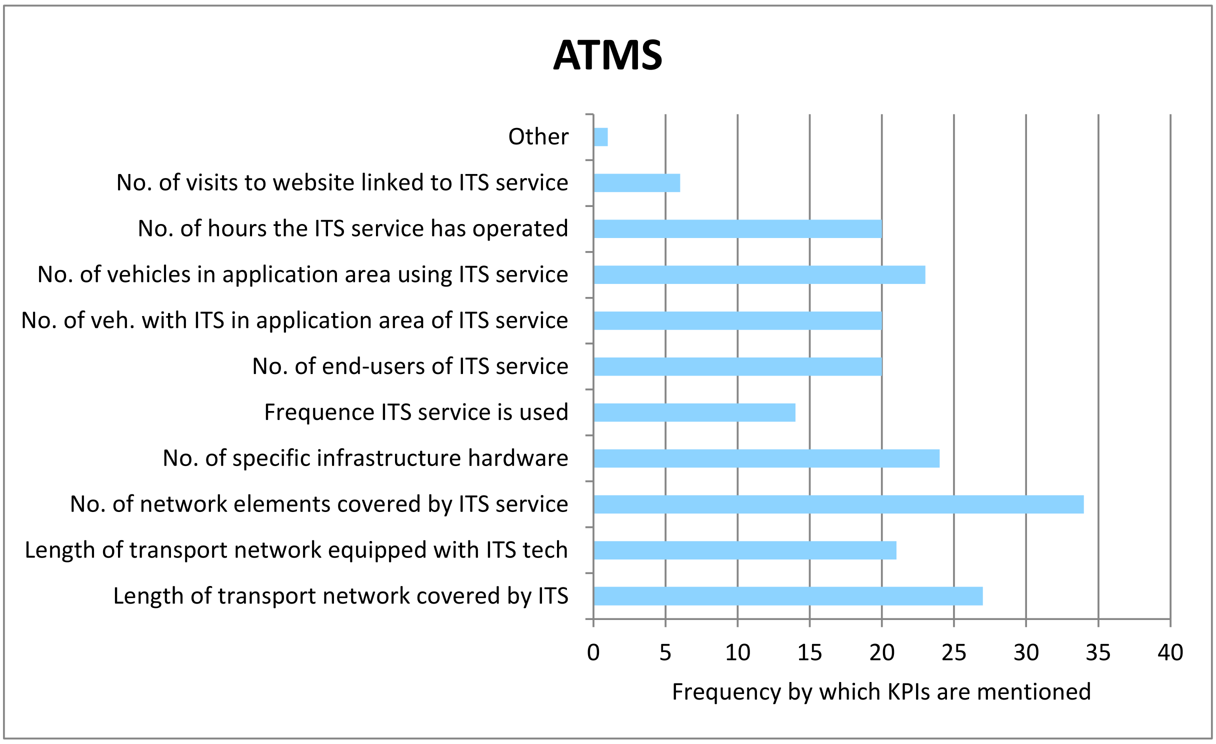

Figure 25 Main deployment KPIs in the ATMS segment

As for the ATIS market segment, the 'number of end-users of ITS service' was most frequently identified as an important KPI for the ATPS market segment, followed by the length of the transport network covered by the ITS service and the number of vehicles using the ITS service. The 'number of visits to websites linked to the service' is considered least important by the respondents.

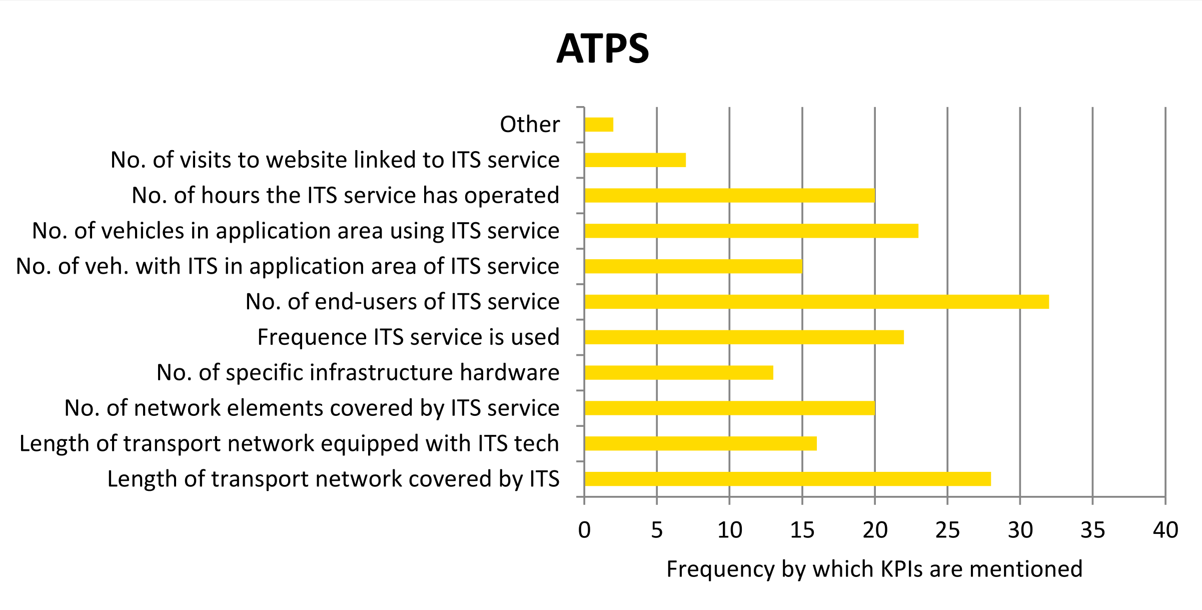

Figure 26 Main deployment KPIs in the ATPS segment

For the APTS market segment, the 'number of end-users of ITS service' and 'length of the transport network covered by the ITS service' were most frequently mentioned. The 'number of specific infrastructure hardware' was considered the least relevant deployment KPI for this market segment, probably because services in this segment are often not directly connected to the infrastructure (but to the vehicle instead).

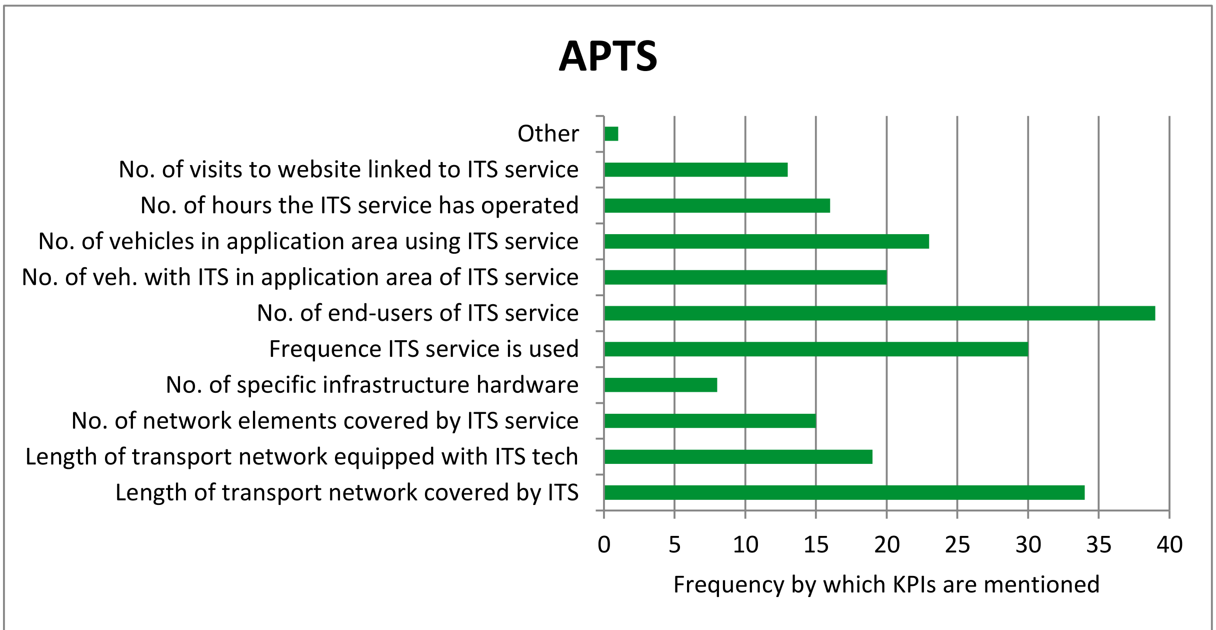

Figure 27 Main deployment KPIs in the ATPS segment

Finally, the 'number of vehicles in application area actually using ITS service' was (unsurprisingly) the most frequently mentioned KPI for the CVS segment. The nature of the services provided on this market, requiring vehicles containing specific communication technology, explains this result. By the same reasoning the high score of the KPI 'number of vehicles with ITS in application area' can be explained.

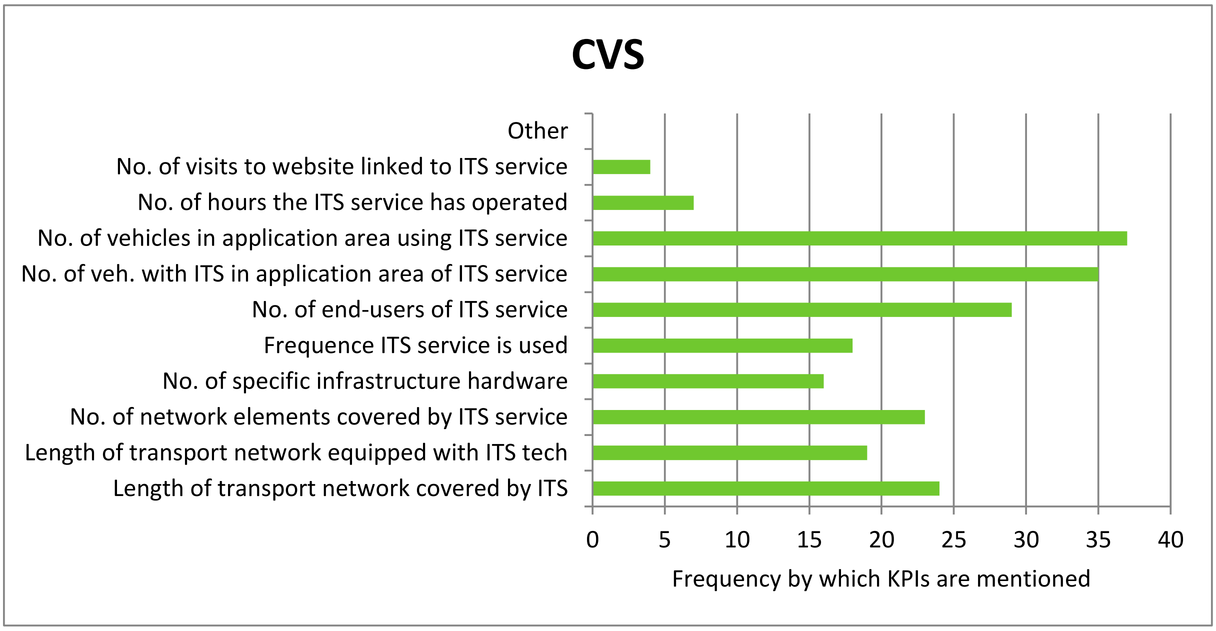

Figure 28 Main deployment KPIs in the CVS segment

4.3.2 Benefit KPIs

The relevance of benefit KPIs heavily depends on the objective of the ITS service considered. For services aimed at reducing congestion levels other KPIs should be used than for services meant to improve traffic safety. As these objectives are not directly connected to the various market segments, asking the respondents in the on-line survey to identify the main benefit KPIs per market segment is not very useful. Instead, we have applied a two-step approach. We first asked the respondents to identify the main benefit KPIs per primary benefit of ITS services, and secondly, we asked them to rank these primary benefits in order of importance for each of the market segments. By combining the results of these two questions, an indication of the relevance of benefit KPIs per market segment has been obtained.

Based on NEWBITS D2.1, we considered four different primary benefits of ITS services: safety, efficiency of the transport system, environmental performance and comfort. The most relevant KPIs for these primary benefits according to the stakeholders are shown in Figure 29 to Figure 32.

Average journey time was identified as the most important KPI when measuring the transport efficiency impact of ITS services, followed by predictability of travel times and total traffic volumes.

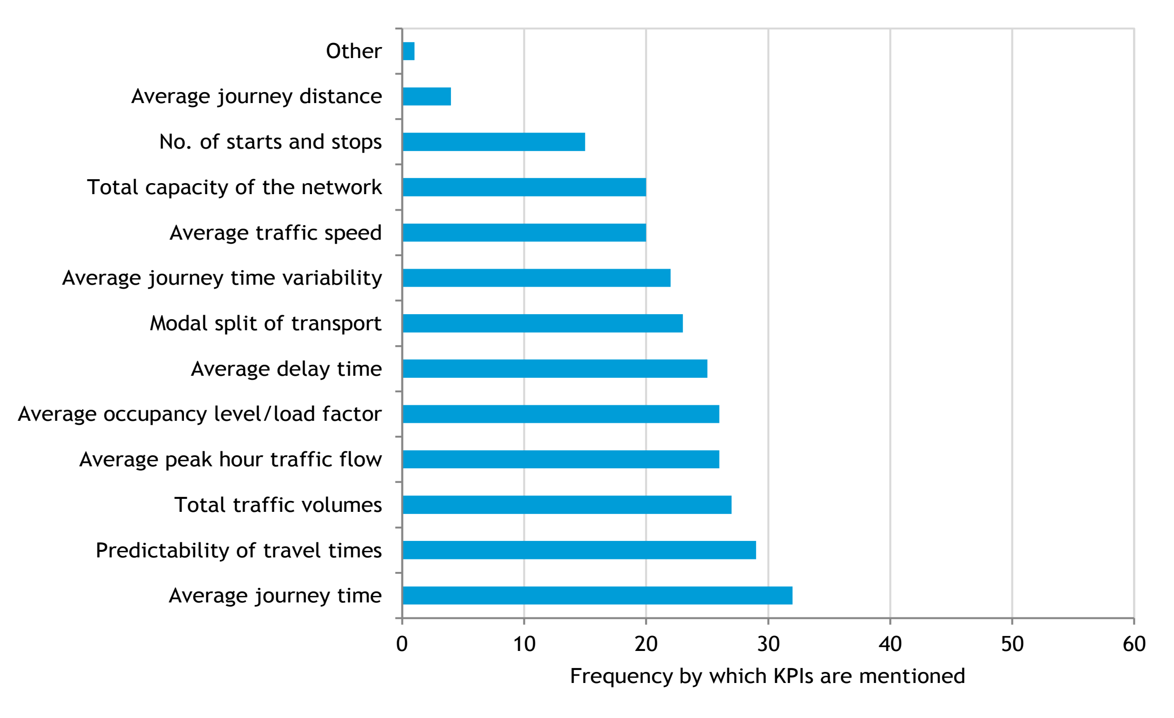

Figure 29 Main benefit KPIs for transport efficiency impacts of ITS services

Unsurprisingly the level of emissions was almost unanimously voted the most important KPI to measure the impact of the ITS service on environmental performance. Other direct measures of the environmental performance of traffic (such as total energy consumption and the number of times specific environmental thresholds are exceeded) are also frequently mentioned, while more indirect measures (e.g. average driving speeds and number of starts/stops) are deemed much less important.

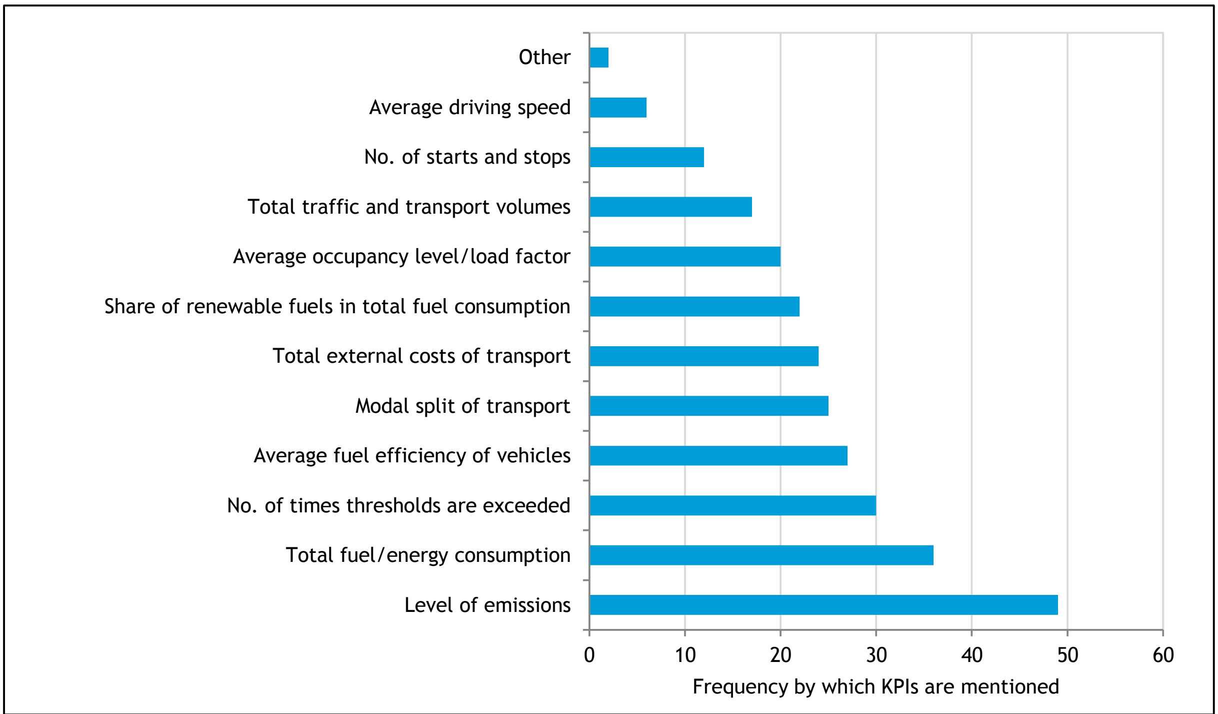

Figure 30 Main benefit KPIs for environmental impacts of ITS services

As for comfort, the reliability of journey time is mentioned most frequently, followed by the quality of travel information provided. The direct performance measure 'reported level of comfort' is only the fourth placed KPI, maybe because it is less easily measurable.

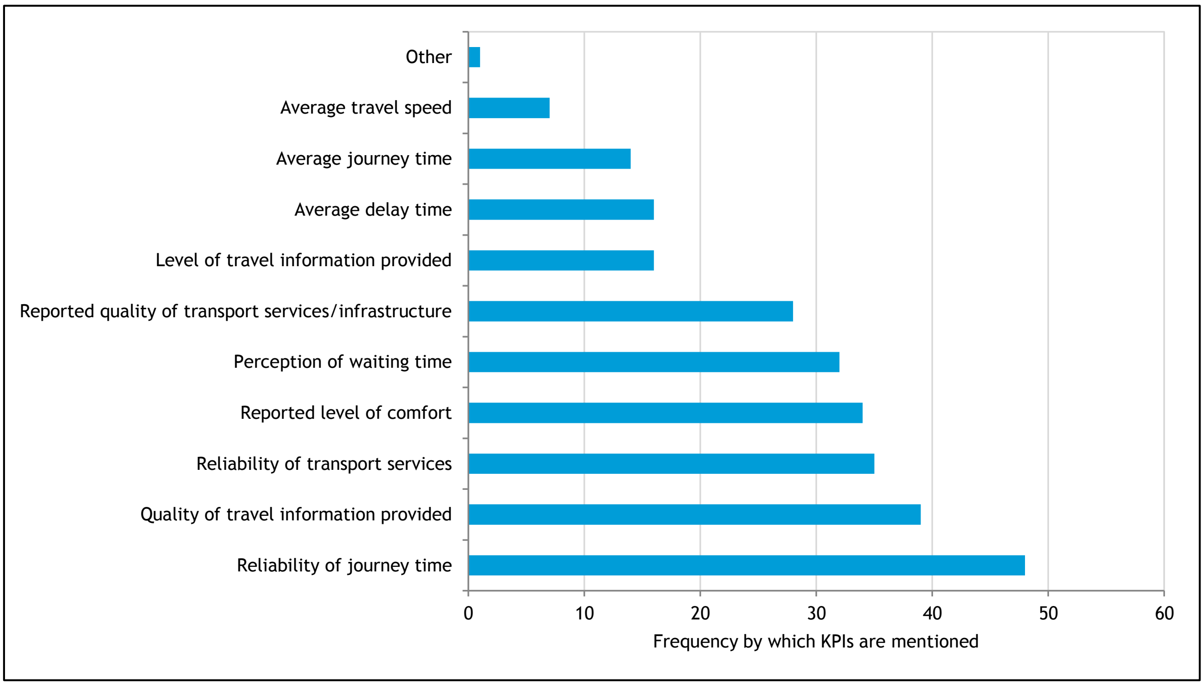

Figure 31 Main benefit KPIs for comfort impacts of ITS services

Similarly as for comfort impacts, the reported perception of safety is not considered an important KPI for the safety benefits of ITS services. More respondents voted for direct measurable facts, such as the reported number of (fatal) accidents, or accidents requiring medical attention. Indirect measures of traffic safety (e.g. vehicle headways and average driving speeds) are less frequently mentioned by the respondents.

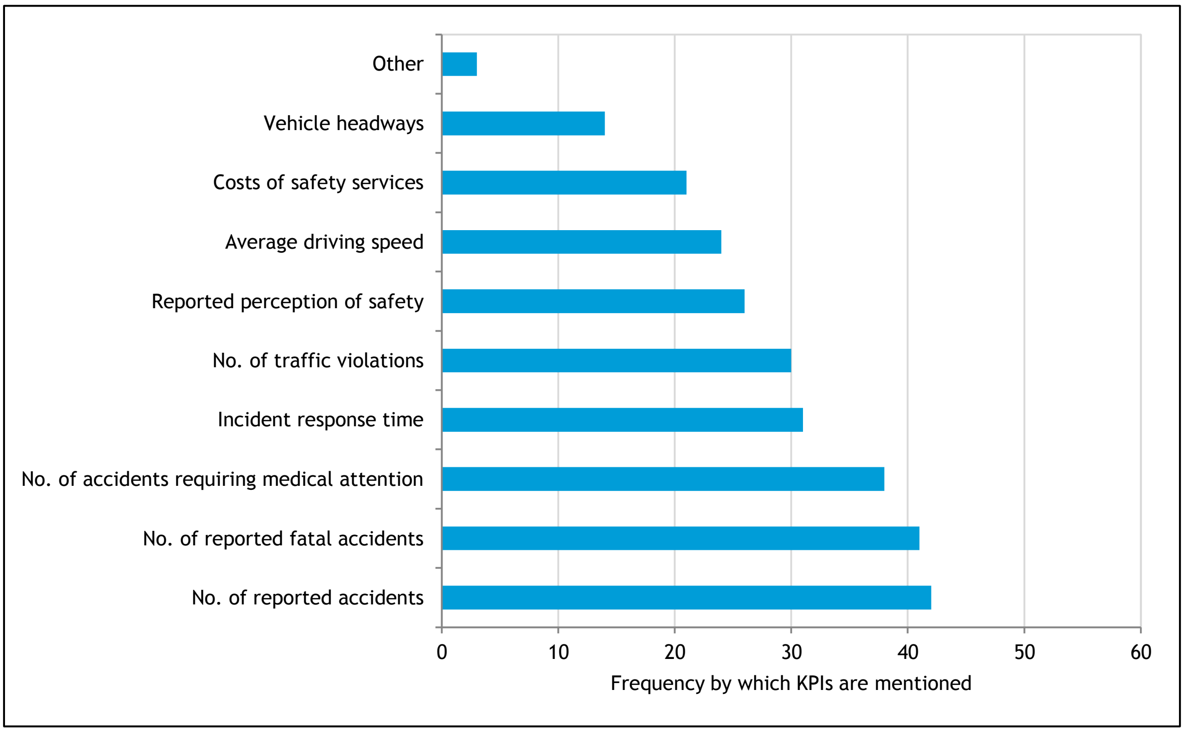

Figure 32 Main benefit KPIs for safety impacts of ITS services

As mentioned above, we have also asked the respondents of our online survey to rank the primary benefits in order of importance for each market segment. In order to present their answers in a clear way, the primary benefit that was ranked highest by a respondents was scored a ‘4’, while the primary benefit that was ranked lowest was scored a ‘1’. The average scores for the various market segments are shown in Figure 33.

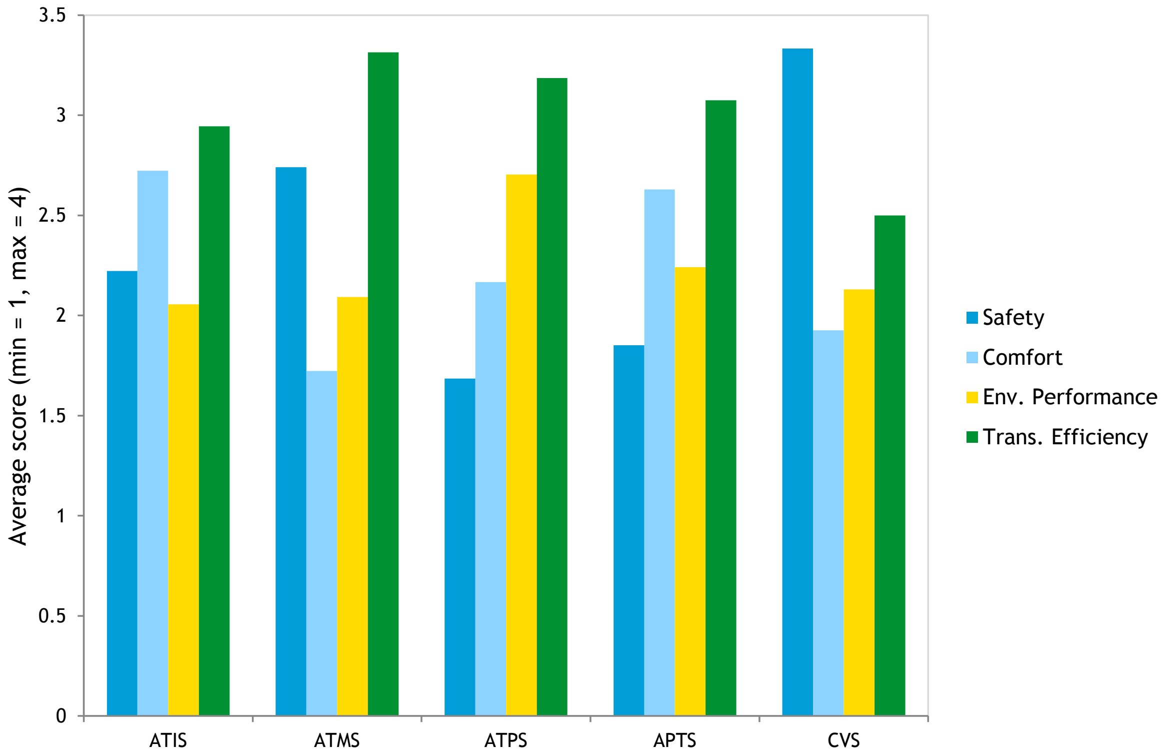

Figure 33 Relevance of primary benefits per market segment

Transport efficiency was identified as the most important primary benefit of ITS services for the ATIS, ATMS, ATPS and APTS market segments. The survey further revealed that the most important primary benefit of ITS services in the CVS market segment was safety. Traffic safety was also seen as an important primary benefit for the ATMS market segment, while for the more end-user focused market segments (particularly ATIS and APTS) comfort was ranked as second most important primary benefit.

Figure 33 shows that for most market segments a clear ranking of primary benefits is found. Based on this ranking the most relevant benefit KPIs per market segment could be determined. For example, for the CVS segment, the benefit KPIs with respect to transport safety are more often relevant than the KPIs with respect to comfort. However, it should be noticed that the relevance of benefit KPIs are only indirectly related to market segments and therefore it is not recommended to define a set of benefit KPIs per market segment. Instead, the set of benefit KPIs should be based on the primary objectives of the ITS service considered.

4.4 Utilisation of relevant KPIs per service type

In this section we investigate which KPIs are utilised in practice, differentiating between the four service types identified in Section 2.2.3. Therefore, we have collected data on the KPIs applied for the 94 ITS services identified in NEWBITS D2.1. These data has been documented in fiches, that can be found in Appendix 6. The service specific KPIs have been allocated to the more general types of KPIs defined in Section 4.2.3 (see Appendix 5 for more details). By applying this step, the results from this analysis are directly comparable to the results from Section 4.3.

4.4.1 Deployment KPIs

Deployment KPIs are not found often for the 94 selected ITS services; in total, only 35 KPIs are mentioned in the fiches. The number of end-users and the frequency of use are the two KPIs that are applied the most (see Figure 34). Particularly the number of end-users was also frequently mentioned in the stakeholder survey, indicating that this perceived effective KPI is also often applied in practice. However, other deployment KPIs considered important by the respondents of the survey (e.g. length of transport network covered by ITS service, number of network elements covered by ITS service) are not used for the selected ITS services. Although the evidence is poor, this provides some indication that the most effective KPIs are not always implemented in practice.

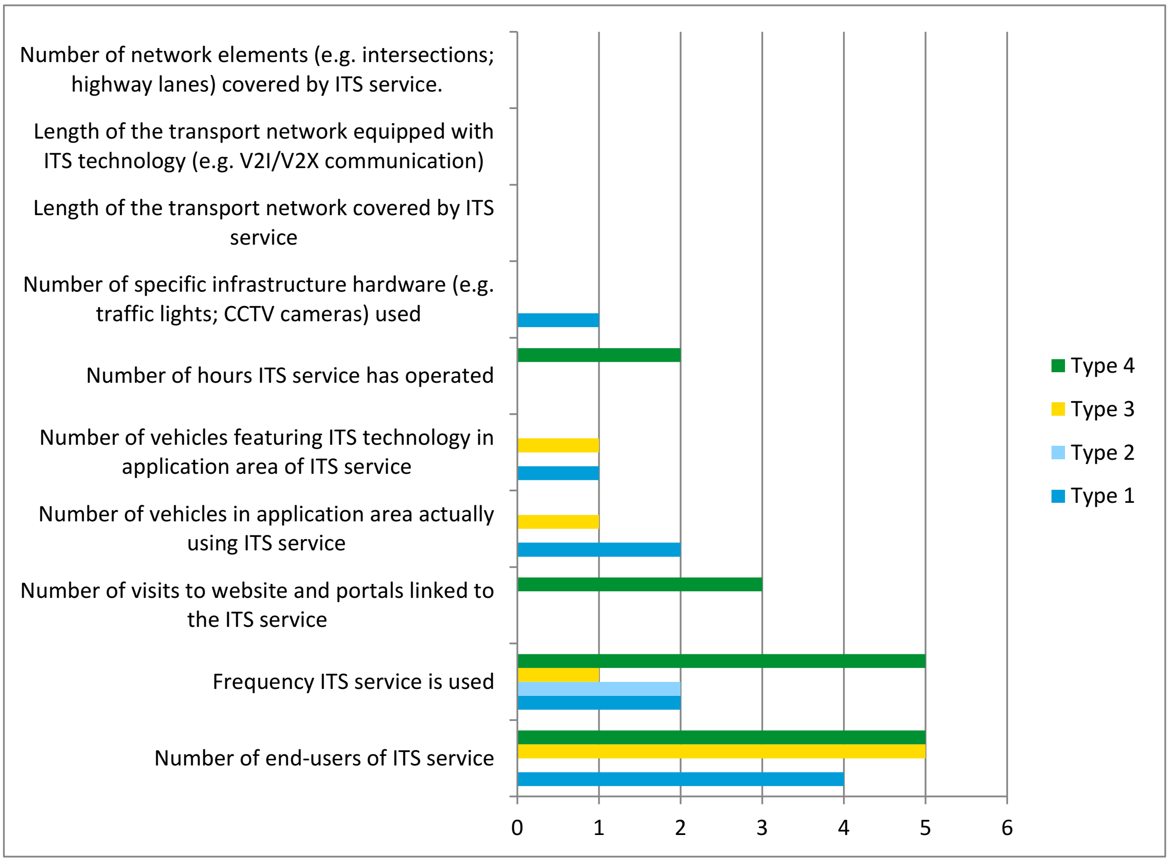

Figure 34 Deployment KPIs per type of services

The limited data found on deployment KPIs for the selected ITS services makes it very difficult to draw conclusions on differences in KPIs at a service type level. Therefore, we haven't carried out this assessment.

4.4.2 Benefit KPIs

Compared to deployment KPIs, more benefit KPIs have been identified for the selected services. In total 203 benefit KPIs are identified, relatively equally divided over the four service types. These KPIs have been allocated to the more general types of benefit KPIs defined in Section 4.2.3. As it was often not clear whether the KPIs for a specific ITS service refers to the primary objective/benefit of that service or to a secondary benefit, it was not possible to link all KPIs to one primary benefit (because some of the KPIs can be related to different objectives/benefits, e.g. average traffic speed may be related to all four primary benefits). These KPIs were considered for all primary benefits for which they may be relevant. As a consequence, the importance of these (more general) KPIs may be overestimated.

The benefit KPIs identified for services with a transport efficiency objective (primary or secondary) are shown in Figure 35. These KPIs are quite well in line with the results of the stakeholder survey. The survey identifies the 'average journey time' as the most relevant benefit KPI, while also 'total traffic volumes' was frequently mentioned in the survey. However, predictability of travel times was also identified as an important KPI by the survey, while it hasn't been applied for any of the ITS services considered in this section. A possible reason for this may be that this KPI is complex to measure and therefore is not often applied in real-world projects.

As shown in Figure 35, the types of benefit KPIs applied for services with a transport efficiency objective do not differ widely between the different service types. Only for Type 1 services 'modal split of transport' was identified as a benefit KPI. This can be explained by the fact that several ITS services aimed to reduce congestion levels belong the Service Type 1 (e.g. London congestion charge). Changing the modal split may significantly contribute to this objective and therefore 'modal split of transport' is used as a KPI for these services

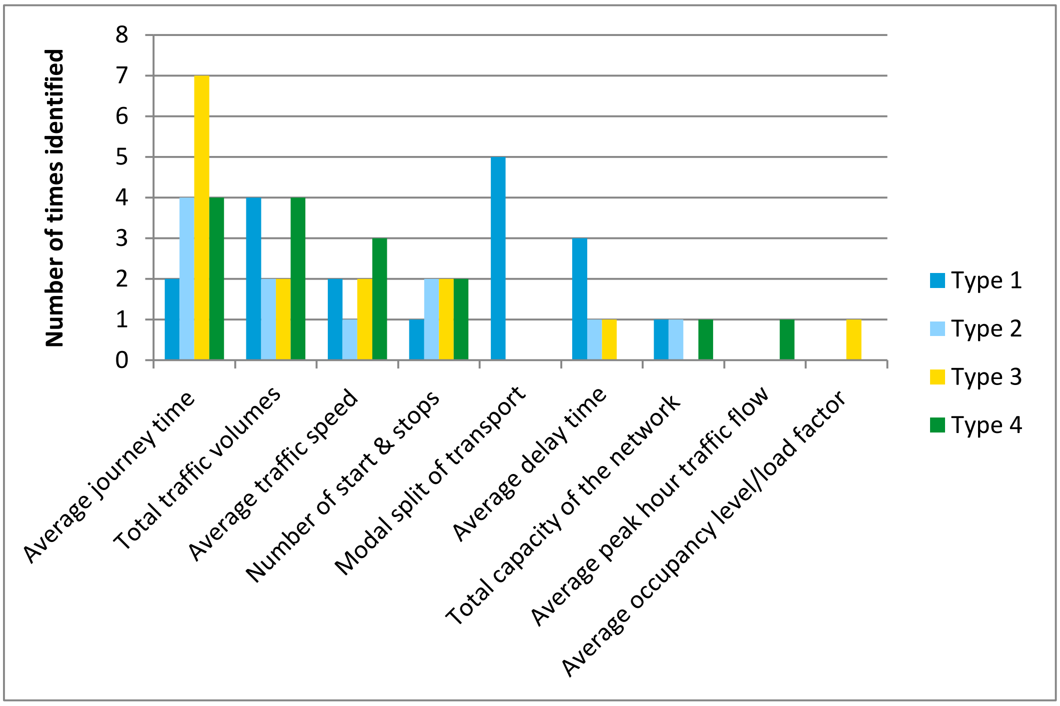

Figure 35 Benefit KPIs related to transport efficiency

The benefit KPIs identified for services with an environmental objective (primary or secondary) are shown in Figure 36. In line with the survey results, the level of emissions (and to a lesser extent 'total fuel/energy consumption) is often applied to measure the improvement of environmental performance. However, also more general KPIs (e.g. total traffic and transport volumes) are often applied, probably because these indicators can be used to measure several impacts of the ITS service. As we compare the different service types, we see that only for services from Type 2 ‘average fuel efficiency of vehicles’ is used as a KPI to measure environmental performance. As Type 2 services encompasses mainly services aiming at improving traffic safety and environmental performance, the use of such specific environmental KPI is not surprising.

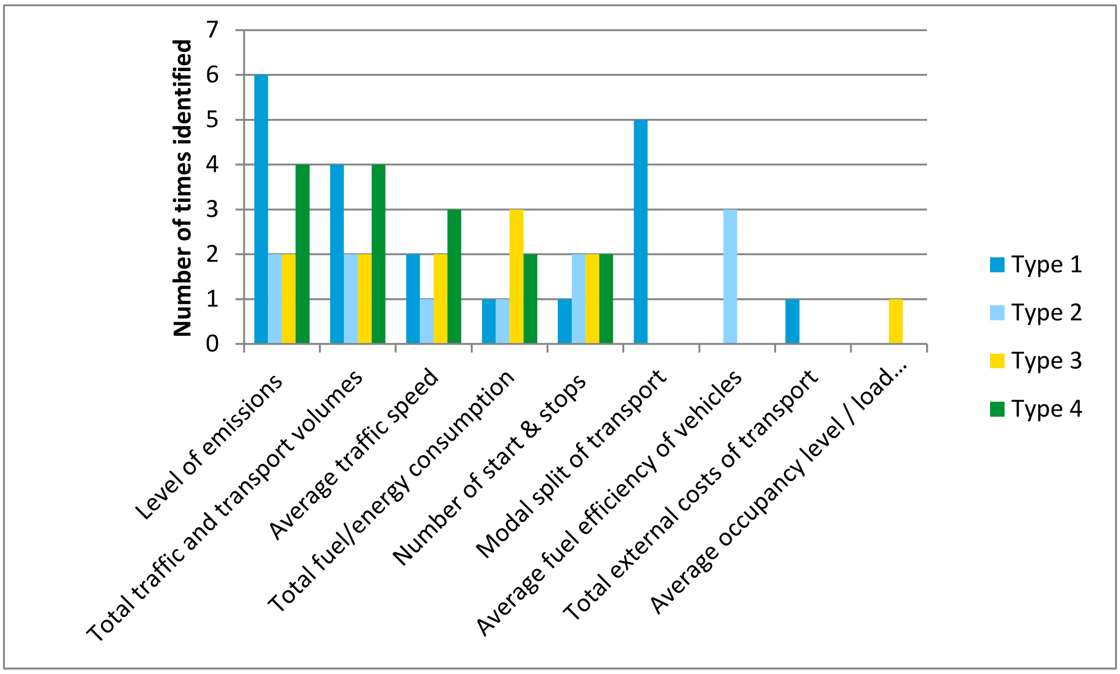

Figure 36 Benefit KPIs related to environmental performance

The benefit KPIs identified for services with a transport comfort objective (primary or secondary) are shown in Figure 37. Surprisingly, the main KPIs identified by the stakeholder survey (i.e. ‘reliability of journey time’, ‘quality of travel information’, ‘reliability of transport services’) are not/rarely applied in the selected services. A possible explanation may be that these KPIs are not easily measurable. Instead, ‘average journey time’ is most often applied for the selected services. No clear differences between type of services are found.

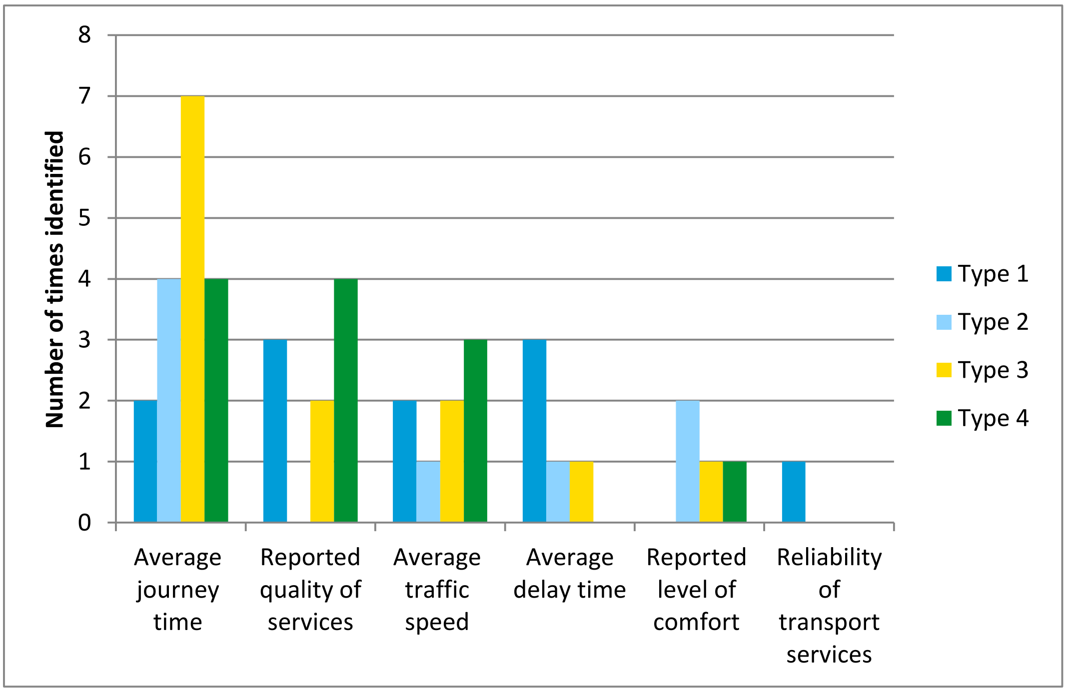

Figure 37 Benefit KPIs related to transport comfort

Finally, the benefit KPIs identified for services with a safety objective (primary or secondary) are shown in Figure 38. In line with the results of the stakeholder survey, number or reported accidents is most often applied. However, also more indirect KPIs (e.g. number of traffic violations and average driving speed) are regularly used, although they are considered less relevant by the respondents of the survey. Availability of data may be an important driver for applying these indirect KPIs. Particularly for services of Type 2 KPIs direct measuring impacts on traffic safety (e.g. number of accidents, incident response time) are applied. This is not surprising as the Type 2 services encompasses services which have improving traffic safety as primary objective.

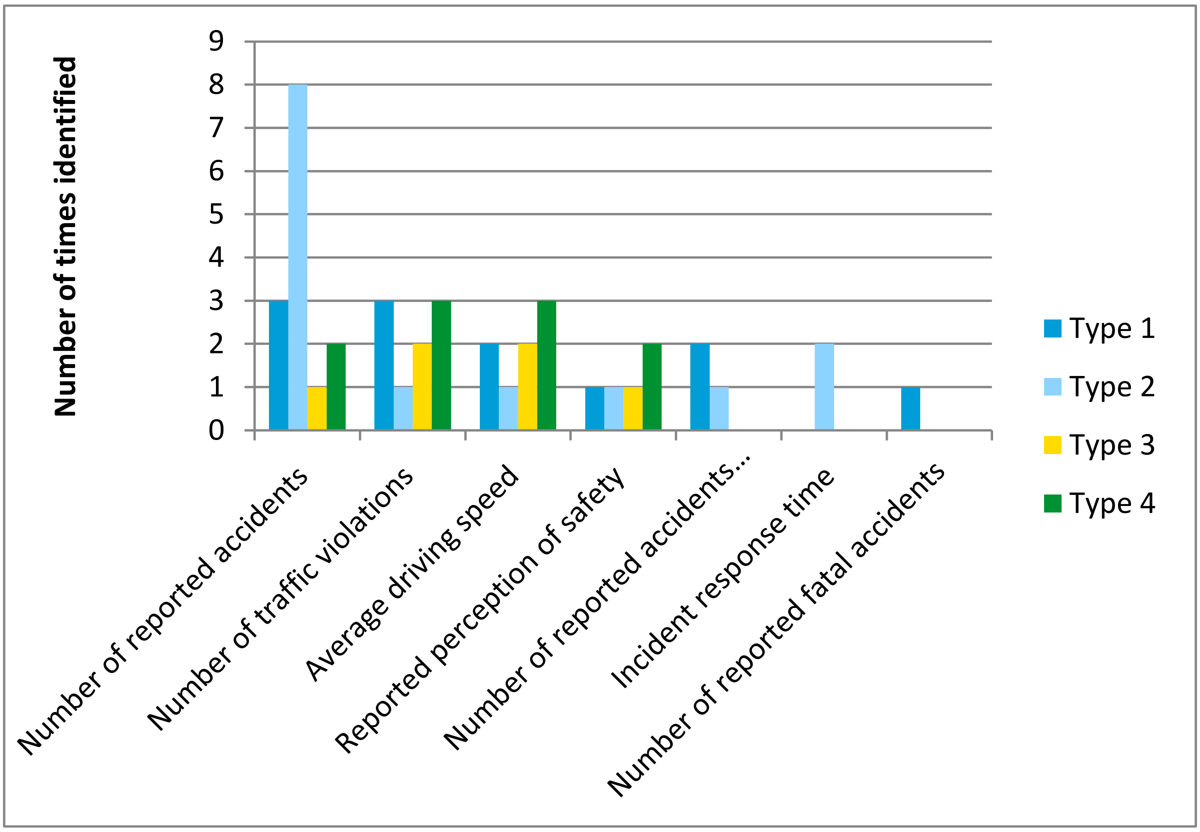

Figure 38 Benefit KPIs related to transport safety

To conclude, it has been shown that no clear distinction in benefit KPIs between the different types of services can be identified. As effective KPIs are designed based on the specific nature (and particularly objectives) of the ITS services, they will not be uniform per service type. Assessing and designing benefit KPIs based on the primary objective of the service considered makes therefore more sense.

4.5 Barriers for implementation of KPIs

Although effective KPIs for the deployment and performance of ITS services are (theoretically) available for the different market segments and service types, as was shown in Sections 4.3 and 4.4, they are often not applied in real-world projects. The barriers hampering the application of KPIs are studied in this section.

Based on an extensive literature review, AECOM (2015) provides a list of barriers that hinder the development and appliance of effective KPIs (see Table 22). Some of these barriers were confirmed by the stakeholders interviews conducted. As this list of barriers was considered complete by the NEWBITS partners, it has been used in the online stakeholder survey that was carried out to rank the barriers to their relevance.

KPI	Source
Lack of financing/funding	AECOM (2015)
Lack of staff resources	AECOM (2015)
Lack of knowledge/skills	AECOM (2015), interviews
Lack of guidance/best practices	AECOM (2015)
Lack of unified terminology for potential KPIs (lack of clearly defined KPIs)	AECOM (2015), interviews
Lack of co-operation between stakeholders	AECOM (2015)
Difficulties to realise co-operation between stakeholders due to different organisational and cultural backgrounds	AECOM (2015)
Lack of available /compatible data	AECOM (2015), interviews
Data ownership leading to difficulties in accessing information	AECOM (2015), interviews
Data privacy	AECOM (2015), interviews
Perceived limited added value of KPIs	AECOM (2015), interviews

Table 22 Barriers to the development and implementation of effective KPIs

The results of the online survey are shown in Figure 39. The respondents were asked to identify the three main barriers hampering the application of KPIs. Both lack of available/compatible data and a lack of knowledge/skills were identified as being the major barriers hampering the application of KPIs. Difficulties in accessing information due to data ownership was also frequently mentioned, as were lack of cooperation between stakeholders and funding shortages. A lack of staff resources was not frequently considered a major barrier to the application of KPIs, nor was data privacy.

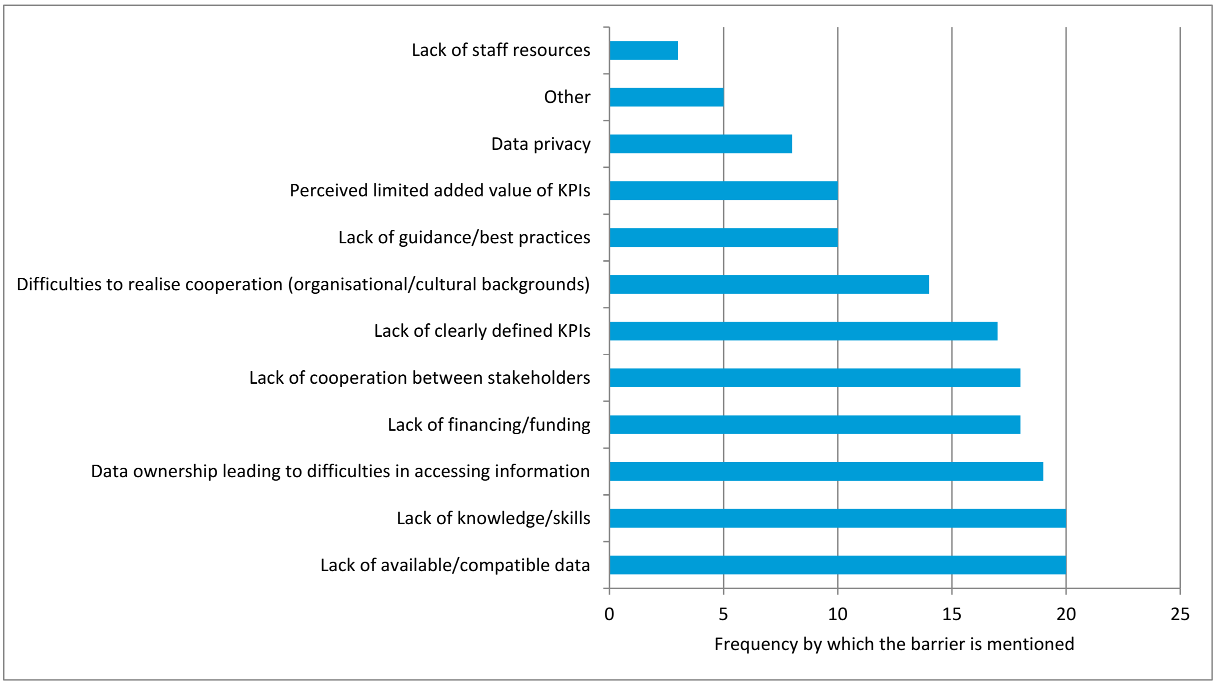

Figure 39 Main barriers to the development and implementation of KPIs

The results of the stakeholder survey are (partly) in line with the results found by AECOM (2015). They also found that lack of available/compatible data is one of the main barriers for applying KPIs, as well as funding shortages and a lack of cooperation between stakeholders. In contrast to our findings, lack of knowledge/skills were considered less important barriers by AECOM (2015).

5 Conclusions

In this final chapter we present the main conclusions with respect to barriers (Section 5.1), enablers (Section 5.2) and KPIs (Section 5.3) for the deployment of ITS services. Additionally, we present some recommendations for further research in Section 5.4.

5.1 Barriers

In this deliverable we have thoroughly studied the factors that deter, complicate and/or prohibit the implementation or performance of ITS services. Based on a systematic review of the literature, complemented with interviews with stakeholders a long list of potential barriers were identified. This list encompasses institutional, economic, technical, social and attitudes, organisational, impact and other barriers.

Based on the stakeholders survey and the assessment of barriers for a selection of ITS services actually implemented/piloted the importance of the various barriers has been studied. Economic (lack of attractive business models and lack of funding) and technical barriers (incompatible infrastructure and lack of interoperability between services) were often mentioned by stakeholders as important, general barriers to the deployment of ITS services. Also the lack of cooperation between stakeholders and the lack of political prioritisation are often mentioned by stakeholders as important barriers. Based on the assessment of actually implemented/piloted ITS services also the lack of sufficient legal framework and the lack of user acceptance were identified as important barriers.

However, significant differences in barriers do exist between different market segments. Lack of attractive business models is found to be an important barrier for the ATIS, APTS and CVS market segments, while political prioritisation is most often mentioned as an important barrier for the ATMS and ATPS segments. Technical barriers are relevant for all market segments, although there are differences in the type of barriers. For the user-driven market segments (ATIS, ATPS and APTS) the lack of interoperability among ITS services is seen as the most relevant barrier, while for the ATMS and CVS market segments inadequate infrastructure is most often mentioned as a technical barrier to the deployment of ITS services. Finally, lack of user acceptance is only often mentioned for the ATPS market segment, which is probably related to (the perceived) privacy and data security issues associates to the services in this market segment.

The assessment of barriers also shows that barriers heavily depend on the characteristics of the services considered. There are indication that the TRL of a service is related to the barriers associated to the service. For example, some technical barriers seems to be less relevant for higher TRLs, while more social barriers like user acceptance become just more relevant as technologies/services are more mature. The type of user may also affect the relevance of barriers. For example, the lack of attractive business models is found to be a less important barrier for the ATMS segment than for other market segments, which may be explained by the fact that traffic management is mostly a public task for which profitability is less important than for more commercial services.

Some external factors (megatrends) are identified that may affect the future relevance of some of the barriers to the deployment of ITS services. Particularly the lack of political commitment is expected to become a less important issue in the future, due to trends as urbanisation (ITS services are needed to fight the urban transport issues this causes), increased attention for sustainability and an increased demand for multimodal transport. Furthermore, emerging technologies (e.g. 5G and Internet of Things) may mitigate the inadequacy of the current infrastructure to implement innovative ITS services. Finally, the user acceptance is expected to grow in the near future, as new generations are less inclined to new technologies.

5.2 Enablers

In addition to barriers, enablers facilitating the deployment of ITS services have been studied. In general, the results found on enablers are more heterogeneous as for barriers.

Enablers often mentioned by stakeholders (in the survey) are increasing political commitment, standardisation for interoperability of ITS services, more cooperation between stakeholders and attractive business models. All these enablers are the opposites of barriers that were considered important by the stakeholders. Surprisingly, innovative funding schemes and the upgrade of ITS infrastructure are relatively modestly mentioned by stakeholders, although their opposites were found to be important barriers. No explanation for this result was found. From the other enablers, an increased popularity of ‘mobility as a service’ and ‘enhanced public private partnerships’ were identified as relevant enablers as well, while higher level of end-user involvement was found as an important enabler for more mature ITS services.

As for barriers, enablers do differ significantly between market segments. For example, increased popularity of “Mobility as a Service” is most often mentioned for the ATIS and APTS segment (segments focussing on stimulating intermodal transport), while for the ATMS and CVS segments it is only modestly mentioned by the stakeholders. A clear legal framework is seen as an important supporting factor for services in the CVS market (as these services challenge the current way of travelling and hence the current legal framework), while this factor is hardly mentioned for the ATIS segment (as providing and sharing of travel information is most of the times already possible within the current legal framework). This again shows that enablers (as was the case for barriers) heavily depend on the characteristics of the services and, more in general, the market segment considered.

5.3 KPIs

Although the development of clear Key Performance Indicators (KPIs) is mentioned by only a few respondents of the stakeholder survey as an important enabler facilitating the deployment of ITS services, much evidence is found in the literature on the important role KPIs (and more general performance measurement) may have in the development, implementation and management of ITS services. Furthermore, they may provide the opportunity to objectively compare the performance of different types of ITS services, although the lack of a common framework/methodology for defining KPIs may complicate this. Therefore, the results on the assessment of KPIs are relevant for improving the understanding of the deployment process of ITS services.

Our assessments show that there are no universal deployment KPIs, but that their relevance depends on the market segment considered. This should be taken into account in case a common framework for defining deployment KPIs will be developed. Some general patterns on the barriers per market segment can be recognised, though. For the market segments where services are offered that are focussed on end-users (ATIS, ATPS, APTS and to a lesser extent CVS) the 'number of end-users of the ITS service' was most often indicated by the stakeholders as a relevant deployment KPI. On the other hand, for market segments focussed on transport operator / infrastructure manager related services (ATMS), KPIs related to the ITS infrastructure were mentioned most often. Particularly for the CVS market segment, the 'number of vehicles using ITS service' was indicated as a relevant KPI (unsurprisingly, as services on this market require vehicles containing specific communication technology). Finally, the length of the transport network covered by the ITS service is frequently mentioned for all of the market segments, showing the rather general nature of this KPI.

As for the benefit KPIs, we found that these should be best defined in line with the primary objective (i.e. safety, transport efficiency, environmental performance, and comfort) of the service. As these objectives are only indirectly linked to market segments, it is not recommended to define a set of benefit KPIs per market segment. It was also found that KPIs direct measuring the intended impacts are preferred to more indirect measures. For example, for ITS services which aim at improving the environmental performance of transport, the 'level of emissions' was regarded the most relevant KPI, while 'change in transport volume' was only mentioned scarcely. However, the assessment of KPIs applied for actually implemented/piloted ITS services show that indirect measures are used quite often, probably because they are easily measurable and/or cover several impacts.

Our assessment of actually implemented/piloted ITS services reveals that KPIs are not always defined and used for ITS projects. And even if they are defined, these are not always the most appropriate ones. Lack of available/compatible data and of knowledge/skills were identified as main reasons for not applying (the most appropriate) KPIs. Other important barriers to implementing KPIs are difficulties in accessing information due to data ownership, lack of cooperation between stakeholders and funding shortages.

5.4 Recommendations for further research

Several options to elaborate on our assessments on barriers, enablers and KPIs for the deployment of ITS services can be distinguished. With respect to barriers and enablers, we briefly showed that their perceived relevance differ between different types of stakeholders (R&D, industry, public authorities). However, the number of respondents of the on-line stakeholder survey was limited and hence these findings are rather uncertain. A more extensive assessment of possible differences in the opinions of different types of stakeholders on the main barriers and enablers for the deployment of ITS services is therefore recommended. A better understanding of the opinions of the different stakeholders may be useful for developing innovative business models and more effective policy incentives. For the same purpose, further research on geographical differences in the relevance of barriers and enablers (e.g. is lack of funding a more important barrier in Eastern Europe than in other parts of Europe?) is recommended as well. Our study also provides some evidence that barriers and enablers may depend on the TRL of the ITS service considered. However this evidence is rather fragmentary and should be further studied, e.g. by conducting another stakeholder survey focussed on this topic.

As for KPIs, our study shows (based on the stakeholder survey) that the (perceived) relevance of deployment KPIs depends significantly on the market segment considered. Therefore, it would be interesting to assess to what extent different KPIs are applied in actually implemented services in the different market segments. This may provide insight in the deployment KPIs applied on the various market segment and to what extent they deviate from the preferred ones.

With respect to the barriers to implement KPIs, a differentiation to market segment and TRL may be a useful topic for further research as well, as this may improve our understanding of the measures that can be taken to increase the use of (effective) KPIs per market segment / type of ITS services.

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Appendices

Appendix 1 Interview format

Questionnaire on C-ITS applications

A. Background

For a European Commission funded research project, entitled NEWBITS (see Box 1 for more information), we aim, among other things, to identify and assess current initiatives in the field of cooperative intelligent transport systems (C-ITS). C-ITS applications refer to ITS technologies that allow vehicles to communicate with other vehicles (vehicle-to-vehicle systems) or with infrastructure (vehicle-to-infrastructure or infrastructure-to-vehicle systems). In this respect we apply a broad scope, including C-ITS applications for all types of transport modes and all types of transport (e.g. both long- en short-distance trips).

As input for our analyses we will use several assessment methods, one of which is interviewing some relevant experts/stakeholders from all over Europe and the US. The first objective of these interviews is to identify specific C-ITS applications that are currently implemented/tested in Europe and the US. Secondly, we would like to gather data on the key performance indicators used with respect to C-ITS applications as well as information on the main barriers and enablers for these applications.

In the remainder of this note you find the questions we would like to discuss with you face-to-face or by phone.

Box 1 NEWBITS – NEW business models for ITS

The main objective of the NEWBITS project is to improve the understanding of the changing conditions and dynamics that affect and/or influence the deployment and performance of innovative ITS innovations. This knowledge should minimize the failures inherent to ITS innovation diffusion, evolve present business models, and identify effective incentives to accelerate ITS deployment. To acquire this knowledge, an in-depth analysis of current/future ITS applications , their barriers and enablers, market conditions, user preferences, etc. will be carried out. Additionally, NEWBTIS acknowledge the fundamental importance of people in implementing complex innovations like ITS. The project will therefore thoroughly study the networks of ITS innovations, both internal and external to the organisations acting in the ITS fields, in order to provide insight in the different roles stakeholders have in these networks, their interactions and the added value of cooperation between these actors. Based on all knowledge acquired in this project, guidelines and strategies to foster ITS deployment and performance will be developed as well as a training program for specific stakeholders.

B. General information

Name of organisation:
Name of Interviewee(s):
Position of the interviewee:
Interviewer(s):
Date and Time:
Location:

1. In what way are you (or is your organisation) involved in the field of C-ITS solutions?
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………

C. C-ITS applications

2. What are/should be, in your opinion, the main objectives of implementing C-ITS applications (e.g. reducing traffic jams, improving traffic safety, reducing emissions, etc.)? Multiple answers possible.

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3. What are, to your knowledge, the main C-ITS applications that are currently applied/tested? For every application, please discuss (as far as possible) the following issues:
   - Brief description of the C-ITS application
   - Main objective(s)
   - Innovation phase (TRL)
   - Type of C-ITS (V2V, V2I, I2V)
   - Technologies used
   - Geographical scale (e.g. local, regional, national)
   - Type of transport: transport mode, transport type/motive (e.g. long-distance vs. short distance).
   - Type of stakeholders involved
   - Institutional arrangements (i.e. public, private, PPP)
   - Financing sources
   - Evidenced impacts
   - Costs: what are the main cost items (e.g. investment costs, operational costs) and what is their size.
   - Sources for additional information on this C-ITS application.

4. To your expectations, which developments will affect C-ITS most in the medium term (2025)? Please consider technological, financial/economic, social, and policy related developments.

   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………

D. Key performance indicators

5. What are in your opinion the preferred KPIs with respect to:
   a. the deployment of C-ITS applications?
   b. the performance of C-ITS applications?
   How do these preferred KPIs differ between various types of C-ITS applications?

   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………

6. What are the main barriers to apply these KPIs? And how could these barriers be overcome?

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   …………………………………………………………………………………………………..

7. What are the KPIs that are actually applied for the specific C-ITS applications identified in question 3? Please consider both KPIs for the deployment and performance of the specific C-ITS application.

   ……………………………………………………………………………………………………
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E. Barriers

8. What are, in general, the most important barriers currently for:
   a. the deployment of C-ITS applications;
   b. the performance of C-ITS applications.
   How do these barriers differ between various types of C-ITS applications?

   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………
   ……………………………………………………………………………………………………

9. What are the main barriers with respect to the specific C-ITS applications identified in question 3? Please consider both barriers for the deployment and performance of the specific C-ITS application.

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……

10. What do you foresee to be the largest barriers for the deployment and performance of C-ITS applications in the future?

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11. What are, in your opinion, the best options to tackle the barriers identified in questions 8-10?

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……
……

F. Enablers

12. What are, in general, the main enablers for:
    a. the deployment of C-ITS applications;
    b. the performance of C-ITS applications.
    How do these enablers differ between various types of C-ITS applications?

……
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……

13. What are the main enablers with respect to the specific C-ITS applications identified in question 3? Please consider both enablers for the deployment and performance of the specific C-ITS application.

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14. What are, in your opinion, the main options to strengthen the enablers identified by question 12 and 13?

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……………………………………………………………………………………………………
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G. Final questions

15. Is there anything else you would like to add to this interview?

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……………………………………………………………………………………………………
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16. Could you recommend two additional stakeholders who you feel it might be useful to speak to for this study?

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……………………………………………………………………………………………………

17. We would like to provide a summary of names of people interviewed in a NEWBITS deliverable. Is this fine by you?

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……………………………………………………………………………………………………

18. If there are any further questions/clarifications needed, do you mind if we get in touch with you again?

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Appendix 2 Stakeholder survey

In this Appendix we present the on-line stakeholder survey.

NEWBITS Survey

Introduction

The EU-funded project NEWBITS investigates the conditions and dynamics that affect the deployment of Intelligent Transport System (ITS) service. An improved understanding of these factors should contribute to more successful business models as well as more effective policy incentives for ITS series.

An important goal of NEWBITS is to provide an overview of the main barriers, enablers and Key Performance Indicators (KPIs) for the deployment of ITS services. More specifically, we would like to identify these for the market segments identified below.

- **Advanced Traveller Information Systems (ATIS):** ITS services that provide travellers with real-time travel and traffic information
- **Advances Traffic Management System (ATMS):** ITS services that focus on traffic control devices, such as traffic signals, ramp metering, parking management systems and demand & access management systems.
- **Advanced Transportation Pricing System (ATPS):** ITS-enabled transportation pricing systems, mainly used for electronic toll collection purposes.
- **Advanced Public Transportation System (APTS):** ITS services that enable transit vehicles, whether bus or rail, to optimise their operations, e.g. by real-time reporting on their current location or improved information on their usage patterns.
- **Cooperative Vehicle Systems (CVS):** ITS services that involve communication and information sharing between ITS stations in order to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems.

As an individual expert or organisation active within the field of ITS, we are seeking your input to this study through this survey which will ask you about your views on the most important barriers and enablers and most relevant KPIs for the deployment of ITS services in the different market segments.

This questionnaire has **9 questions** and will take approximately 10-15 minutes to answer.

All responses are strictly confidential. The NEWBITS consortium will not be able to personally identify you by the information you provide in your responses to this survey. We will not disclose your personal information to third parties.

General Information

1a. Which of the following best describes the type of organisation you represent?

- ○ Industry
- ○ Research & Development
- ○ Public authorities
- ○ End users
- ○ Other (please specify)

Industry: *service providers, automotive industry, private road infrastructure manger/operator, insurance companies, high-tech companies, geotechnical companies, engineering companies, communication experts*

Research & Development: *universities, research institutions, technology centres, regional cluster*

Public authorities: *policy makers, national regulatory authorities, transport ministries, regional authorities, cities and municipalities, traffic control centres, public road infrastructure manager/operator*

End users: *telecommunication providers, logistic/freight organisations, drivers, citizens, airlines/airport operator, cargo ports, transhipment stations, military/government.*

Please specify the type of organisation that represents you best

1b. What is the main purpose/activity of the organisation you represent? For example: government, road authority, non-road infrastructure authority, policy maker, public transport, intermediary, freight transport, ITS service provider, vehicle/component manufacturer, other (please specify).

2. In which of the following countries do you operate?
Multiple options are possible

- ☐ Australia
- ☐ Austria
- ☐ Belgium
- ☐ Bulgaria
- ☐ Croatia
- ☐ Cyprus
- ☐ Czech Republic
- ☐ Denmark
- ☐ Estonia
- ☐ Finland
- ☐ France
- ☐ Germany
- ☐ Greece
- ☐ Hungary
- ☐ Ireland

- ☐ Italy
- ☐ Latvia
- ☐ Lithuania
- ☐ Luxembourg
- ☐ Malta
- ☐ Netherlands
- ☐ Poland
- ☐ Portugal
- ☐ Romania
- ☐ Slovenia
- ☐ Slovakia
- ☐ Spain
- ☐ Sweden
- ☐ United Kingdom
- ☐ United States
- ☐ All of the above
- ☐ Other (please specify)

Please specify in which countries you operate

A. Market Segments

This section concerns the ITS market segments as described in the table below.

Market segment	Description	Examples of services
Advanced Traveller Information Systems (ATIS)	ITS services that provide travellers with real-time travel and traffic information	• Route and navigation systems • In-vehicle safety and warning systems • In-vehicle motorist services information services
Advanced Traffic Management System (ATMS)	ITS services that focus on traffic control devices, such as traffic signals, ramp metering, parking management systems and demand and access management systems	• Signal control • Parking management • Traffic monitoring • Demand and access management
Advanced Transportation Pricing System (ATPS)	ITS-enabled transportation pricing systems, mainly used for electronic toll collection purposes	• Electronic toll collection • Congestion pricing • Fee-based express lanes
Advanced Public Transportation System (APTS)	ITS services that enable transit vehicles, whether bus or rail, to optimize their operations, e.g. by real-time reporting on their current location or improved information on their usage patterns	• Multimodal journey planners • Multi & smart ticketing • Optimised fleet management • Real time system status information • Passenger information systems
Cooperative Vehicle System (CVS)	ITS services that involves communication and information sharing between ITS stations in order to give advice or facilitate actions with the objective of improving safety, sustainability, efficiency and comfort beyond the scope of stand-alone systems	• Green light optimal speed advice (V2I) • Emergency brake systems (V2V) • Vehicle platooning systems (V2V)

3. Which of the following ITS market segments are you or your organisation involved/interested in?
Multiple options are possible

- ☐ Advanced Traveller Information Systems (ATIS)
- ☐ Advanced Traffic Management System (ATMS)
- ☐ Advanced Transportation Pricing System (ATPS)
- ☐ Advanced Public Transportation System (APTS)
- ☐ Cooperative Vehicle System (CVS)
- ☐ All of the above

B. Barriers

In this section we will ask you about the most important barriers to ITS deployment for each of the market segments identified earlier. For a description of the market segments please see the bottom of the page.

4. From the list of fifteen barriers below, please choose the **five** most important barriers **per market segment** with respect to the deployment of ITS services.

The barriers can be categorised as follows:

General: 1
Institutional: 2-3
Economic: 4-5
Technical: 6-9
Attitudes: 10-11
Organisational:12-13
Impact: 14

	1. Existence of the last mover advantage	2. Lack of a sufficient legal framework (e.g. privacy protection)	3. Lack of political prioritisation	4. Lack of funding	5. Lack of attractive business models	6. Current infrastructure not ready to integrate innovative ITS technologies	7. Lack of interoperability and incompatibility among ITS services	8. Technical weaknesses in ensuring data security	9. High or uncertain maintenance costs	10. Lack of user acceptance	11. Limited understanding of user needs	12. Lack of cooperation between stakeholders	13. Lack of skilled staff for ITS companies	14. Lack of demonstrated benefits of ITS services	15. O (p sp
Advanced Traveller Information System (ATIS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Advanced Traffic Management System (ATMS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Advanced Transportation Pricing System (ATPS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Advanced Public Transportation System (APTS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Cooperative Vehicle System (CVS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Please specify the barrier(s) for Advanced Traveller Information Systems (ATIS)

Please specify the barrier(s) for Advanced Traffic Management System (ATMS)

Please specify the barrier(s) for Advanced Transport Pricing System (ATPS)

Please specify the barrier(s) for Advanced Public Transportation System (APTS)

Please specify the barrier(s) for Cooperative Vehicle System (CVS)

C. Enablers

In this section we will ask you about the most important enablers for ITS deployment for each of the market segments identified earlier. For a description of the market segments please see the bottom of the page.

5. From list of sixteen enablers below, please choose the **five** most important enablers **per market segment** that facilitate/support the deployment of ITS services.

The enablers can be categorised as follows:

General: 1
Institutional: 2-4
Economic: 5-6
Technical: 7-9
Attitudes: 10-11
Organisational: 12
Information: 13
Impact: 14-15

	1. Increased popularity "mobility as a service"	2. Supportive regulation and clear legal framework	3. Increasing political commitment	4. Enhanced public-private partnerships	5. Innovative funding schemes	6. Attractive business models	7. Standardisation for interoperability of ITS services	8. Upgrade of ITS infrastructure	9. Lower cost of maintenance	10. Higher levels of end users involvement	11. Increased attention for sustainable transport	12. More cooperation between stakeholders	13. Increased public awareness of benefits of ITS	14. Development of clear KPIs	15. Proven benefits of ITS services
Advanced Traveller Information System (ATIS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Advanced Traffic Management System (ATMS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Advanced Transportation Pricing System (ATPS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Advanced Public Transportation System (APTS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooperative Vehicle System (CVS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

"Mobility as a service" is the shift away from personally owned modes of transportation and towards mobility solutions that are consumed as a service. This enabler works by combining mobility services through a unified gateway, where users can pay for the services with a single account.

Please specify the enabler(s) for Advanced Traveller Information Systems (ATIS)

Please specify the enabler(s) for Advanced Traffic Management System (ATMS)

Please specify the enabler(s) for Advanced Transport Pricing System (ATPS)

Please specify the enabler(s) for Advanced Public Transportation System (APTS)

Please specify the enabler(s) for Cooperative Vehicle System (CVS)

D. Key Performance Indicators (KPIs) for deployment of ITS services

In this section we will ask you about the most important Key Performance Indicators (KPIs) with respect to ITS deployment for each of the market segments identified earlier. For a description of the market segments please see the bottom of the page.

Performance indicators are quantitative or qualitative indicators, derived from one of several measures, agreed on beforehand, expressed as a percentage, index, rate or other value, which is monitored at regular or irregular intervals and can be compared to one or more criteria – (FOT-Net 2016)

6. From the list of eleven KPIs below, please choose the **five** most relevant KPIs **per market segment** with respect to the deployment of ITS services

	1. Length of the transport network covered by the ITS service	2. Length of the transport network equipped with ITS technology	3. Number of network elements (e.g. intersections, infrastructure , parking spots, highway lanes) covered by ITS service	4. Number of specific infrastructure hardware (e.g. traffic lights, CCTV cameras)	5. Frequency ITS service is used	6. Number of end-users of ITS service	7. Number of vehicles featuring ITS technology in application are of ITS service	8. Number of vehicles in application area actually using ITS service	9. Number of hours the ITS service has operated	10. Number of visits to website / portals linked to ITS service	11. Other (please specify)
Advanced Traveller Information Systems (ATIS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Advanced Traffic Management System (ATMS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Advanced Transportation Pricing System (ATPS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Advanced Public Transport System (APTS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Cooperative Vehicle Systems (CVS)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please specify the KPI(s) for Advanced Traveller Information Systems (ATIS)

Please specify the KPI(s) for Advanced Traffic Management System (ATMS)

Please specify the KPI(s) for Advanced Transport Pricing System (ATPS)

Please specify the KPI(s) for Advanced Public Transportation System (APTS)

Please specify the KPI(s) for Cooperative Vehicle System (CVS)

E. Key Performance Indicators (KPIs) for impacts of ITS services

Four types of user benefits of applying ITS services are distinguished:

- *Safety*: improved traffic safety (e.g. less accidents)
- *Efficiency of the transport system*: more efficient use of the capacity of the transport network/system
- *Environmental performance*: less harmful environmental impacts due to transport
- *Comfort*: improved travel experience of travellers

7. Please rank the primary benefits of ITS services in order of importance **for each market segment**. Please rank on a scale of **1 – 4**, where 1 = the most important benefit and 4 = the least important benefit.

	Safety	Comfort	Environmental Performance	Transport Efficiency
Advanced Traveller Information System (ATIS)				
Advanced Traffic Management System (ATMS)				
Advanced Transportation Pricing System (ATPS)				
Advanced Public Transport System (APTS)				
Cooperative Vehicle System (CVS)				

8a. From the list of ten Key Performance Indicators (KPIs) below, please choose the **five** KPIs that are most relevant to the **safety** impacts of ITS services.

% change in

- ☐ Reported perception of safety
- ☐ Number of reported accidents
- ☐ Number of reported fatal accidents
- ☐ Number of reported accidents requiring medical attention
- ☐ Cost of safety services
- ☐ Incident response time
- ☐ Number of traffic violations
- ☐ Average driving speed
- ☐ Average distance between driving vehicles (vehicle headways)
- ☐ Other (please specify)

Please specify the most relevant KPI(s) related to the **safety** impacts of ITS services.

8b. From the list of thirteen Key Performance Indicators (KPIs) below, please choose the **five** KPIs that are most relevant to the **efficiency of the transport system.**

% change in

- ☐ Total traffic volumes
- ☐ Modal split of transport
- ☐ Average journey time
- ☐ Average journey time variability
- ☐ Predictability of travel times
- ☐ Average delay time
- ☐ Average journey distance
- ☐ Average traffic speed
- ☐ Average peak hour traffic flow
- ☐ Number of start & stops (e.g. at traffic lights)
- ☐ Total capacity of the network
- ☐ Average occupancy level/load factor
- ☐ Other (please specify)

Please specify the most relevant KPI(s) related to the **efficiency of the transport system** impacts of ITS services.

8c. From the list of twelve Key Performance Indicators (KPIs) below, please choose the **five** KPIs that are most relevant to the **environmental performance** impacts of ITS services.

% change in

- ☐ Level of emissions (CO2 / air pollutants / noise)
- ☐ Number of times thresholds (e.g. noise) are exceeded
- ☐ Total external costs of transport
- ☐ Total traffic and transport volumes
- ☐ Modal split of transport
- ☐ Average fuel efficiency of vehicles
- ☐ Total fuel/energy consumption
- ☐ Share of renewable fuels in total fuel consumption
- ☐ Number of starts & stops
- ☐ Average occupancy level/load factor
- ☐ Average driving speed
- ☐ Other (please specify)

Please specify the most relevant KPI(s) related to the **environmental performance** impacts of ITS services.

8d. From the list of eleven Key Performance Indicators (KPIs) below, please choose the **five** KPIs that are most relevant to the **comfort** impacts of ITS services

% change in

- ☐ Reported level of comfort
- ☐ Reported quality of transport services/infrastructure
- ☐ Reliability of transport services
- ☐ Quality of travel information provided
- ☐ Level of travel information provided
- ☐ Average journey time
- ☐ Reliability of journey time
- ☐ Perception of waiting time (e.g. at bus stop, in traffic jam)
- ☐ Average delay time
- ☐ Average travel speed
- ☐ Other (please specify)

Please specify the most relevant KPI(s) related to the **comfort** impacts of ITS services.

F. Barriers to KPI use

9. From the list of twelve barriers below, please choose the **three** main barriers that hamper the application of KPIs.

- ☐ Lack of financing/funding
- ☐ Lack of staff resources
- ☐ Lack of knowledge/skills
- ☐ Lack of guidance/best practices
- ☐ Lack of clearly defined KPIs
- ☐ Lack of cooperation between stakeholders
- ☐ Lack of available/compatible data
- ☐ Difficulties to realise cooperation between stakeholders due to different organisational and cultural backgrounds
- ☐ Data ownership leading to difficulties in accessing information
- ☐ Data privacy
- ☐ Perceived limited added value of KPIs
- ☐ Other (please specify)

Please specify what you believe to be the main barriers that hamper the application of KPIs.

End of survey

Thank you very much for your cooperation in this survey!

Are you willing to be contacted by the NEWBITS consortium in the future for information regarding participation in our events or community?

- ○ Yes
- ○ No

Please provide your email address.

This email address will only be used to keep you informed of the NEWBITS community and future events. Your email address will **not** be linked to your responses in the survey.

Appendix 3 Interview results

In this Appendix an overview of the main results of the stakeholder interviews relevant for this deliverable (sections D, E and F) is given. As discussed in Section 2.3.3, the interviewees (13 in total) are composed of relevant stakeholders and experts from different groups such as Transport authority (1), Government agencies (3), ITS solution providers (4), Research institutions (4), and Universities (1). They have been involved in important ITS projects locally, nationally, and at international level. All interviewees are asked the same questions (see Appendix 1).

It should be noted that the interview results provided in this Appendix represent the viewpoints of the different stakeholders involved in the interview and do not represent the general opinion of the majority of ITS stakeholders in practice. Thus, it does not given an overall conclusion on the importance of the barriers/enablers, but rather supports the identification of the different types of barriers/enablers relevant for the deployment of ITS services.

Barriers

A gross total of 56 barriers were collated from the interviews. A further analysis based on interpretation of similarities and synonyms in words resulted in a unique identification of 22 barriers, which are summarised in the text box below.

- Low level of policy makers' knowledge
- Lack of competencies in public administration
- ITS application proof-of-concept
- Lack of legal framework
- Enabling technology integration
- Political commitment
- User acceptance
- Data security
- Lack of standardisation for interoperability, compatibility
- Unequipped vehicles/users
- Low market penetration of ITS applications
- Lack of stakeholder cooperation
- Connectivity
- Installation and maintenance costs
- Lack of clear business models
- Privacy
- Lack of funding
- Lack of end users' awareness
- Lack of demonstrated benefits (to users, large scale deployments
- Reliability of technology and communication
- National protectionism
- Lack of scalability

Figure 40 shows the frequency by which the various barriers are mentioned by the stakeholders. The barriers most often mentioned are related to economic and technical issues, such as lack of funding and standardisation respectively. Also, there is a great concern for high installation costs and lack of legal framework. Other barriers often that have often come up are the low level of policy makers' knowledge, data security, privacy and lack of demonstrated benefits. This is not to downgrade the significance of other barriers such as end-users' awareness, lack of clear business models, and political commitment.

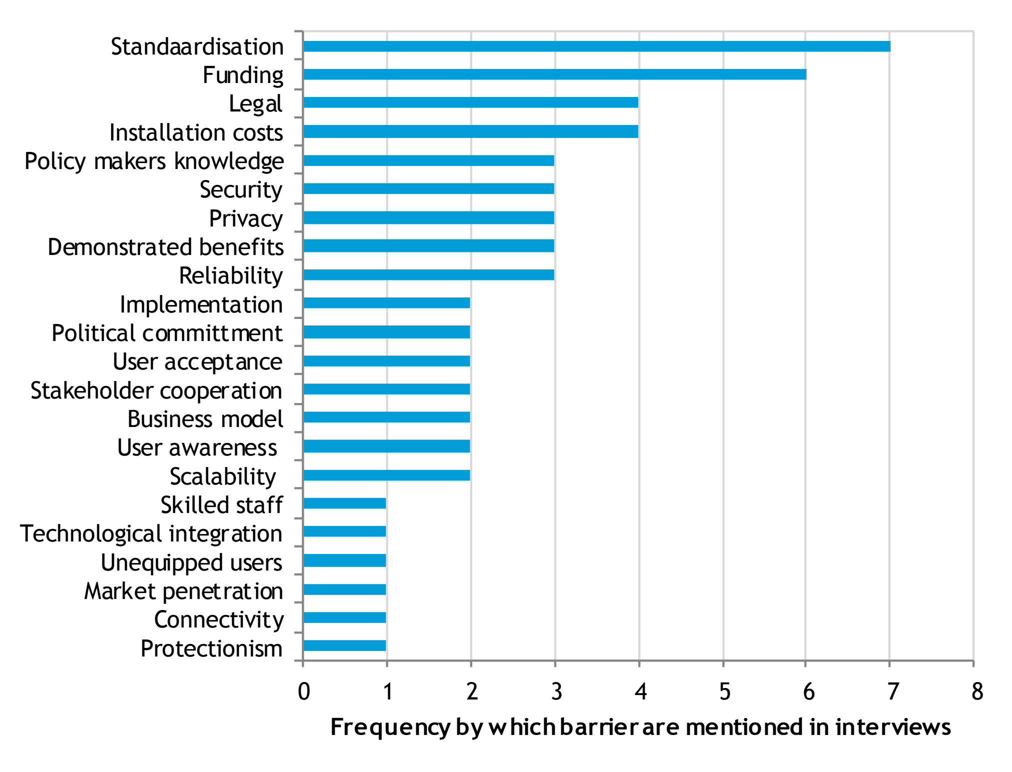


Figure 40 Frequency of barriers as listed by stakeholders in interviews

Enablers

In total 47 enablers were collated from the interviews, of which 18 unique ones. These are presented in the text box below.

- Availability of functional devices on the market
- Operational services
- Interest in autonomous driving
- Political commitment
- Ex-ante estimate studies
- 5G network for ubiquitous connectivity
- Low cost communication technologies
- Stakeholder involvement and cooperation (EU interest, mobile operator involvement, international cooperation
- Legal framework
- Funding schemes
- Environment for knowledge transfer
- Attractive business models
- Standardisation
- Look beyond proof of concept research projects (testing and demonstration)
- End users' awareness and acceptance
- Demonstrated benefits to users, policy makers
- Skilled staff
- Data security

Figure 41 illustrates the frequency of enablers indicated by stakeholders in the interviews. Regardless of the stakeholder type, most of the interviewees mention stakeholder involvement and cooperation in the value chain as an important driver to stimulating ITS deployment. It is mentioned that the EU has shown serious attention to ITS, and the creation of a good environment for knowledge transfer between the quadruple helix (Academia/Business/Society/Government) about the initiatives.

"The main enabler for the development and deployment of C-ITS applications is that the EU wants it and is pushing for it. This is a very strong factor at this time since the current status of some technologies could still be considered in early stages of maturity and the research &

innovation force provided by the EU is appreciated and welcome. No doubt private entities are also contributing a lot in the improvement of C-ITS initiatives but the EU should work (and is working) as an orchestrator for all these efforts."

Talking about innovative ITS initiatives, an interviewee commented that "*The dialogue between the Institutional bodies and all stakeholders can/have stimulate(d) the Research & Development of the industrial sector to provide advanced ITS solutions with high performances to avoid technical problems*". In the particular case of C-ITS, one of the respondents claimed that the automotive industry has showed a lot of interest for a long time and more recently, road operators have begun to show a lot of interest in C-ITS. This has increased investment and interest in the subject. An example is the Amsterdam group.

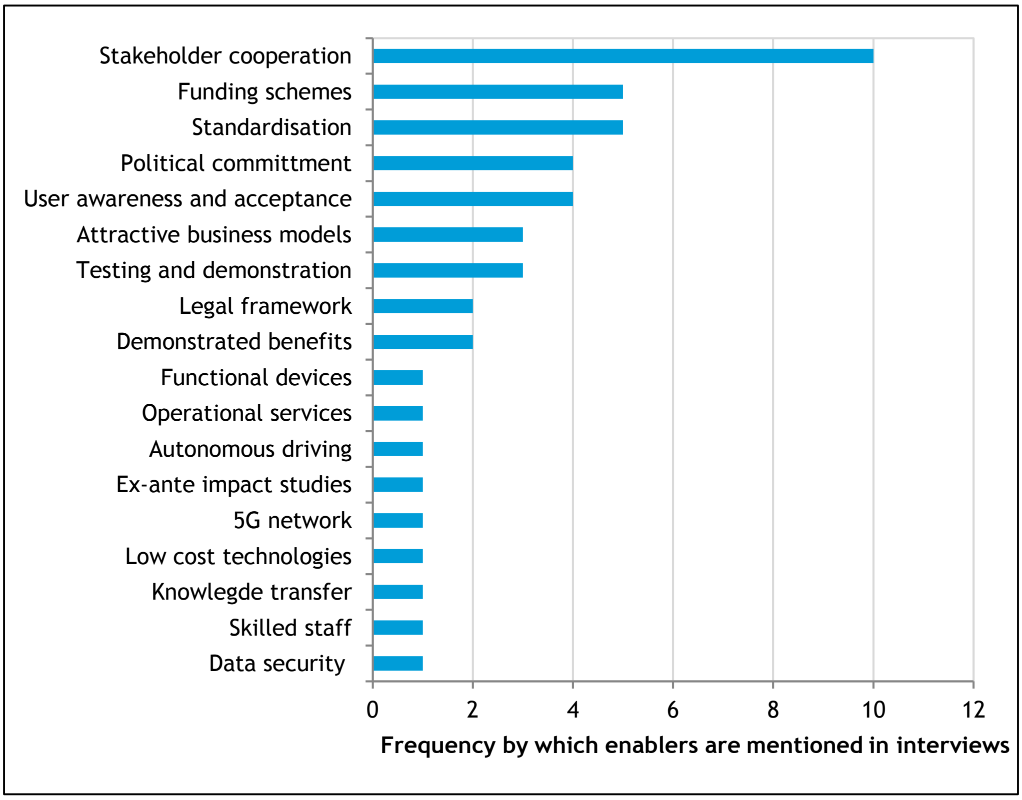


Figure 41 Frequency of enablers as listed by stakeholders in interviews

Also, as shown in the figure, emphasis is being laid on the need for standardisation and innovative funding schemes. Some of the measures for standardisation highlighted are finding a way to improve interoperability of technologies, and achieving a common set of standards, which are compatible with possible future technologies and keep track with rapid technology development. Other often mentioned enablers are raising awareness to end users and political commitment. One way to drive the rollout of ITS is to engage policy makers and end users by informing people (knowledge) about the use of ITS by raising awareness through demonstration projects.

One respondent hinted that business models and impact assessments are becoming more incorporated into ITS projects. Improved cost-benefit analysis must be performed taking into account the different stakeholders. To do this, it becomes necessary to better define the goal of pilots. In addition, some interviewees remarked that serious attention should be given to testing and demonstration to enhance ITS implementation; stakeholders should look beyond proof-of-concept and research projects requiring effective valuation systems to be put in place.

KPIs

Compared to barriers and enablers, the knowledge of the interviewees on KPIs seems to be poorer. Several of the interviewees explicitly indicate that they are not aware of the most relevant KPIs for ITS services. It is also argued that KPIs are not often applied for ITS services as most of them are in pilot phase. This may explain the lack of awareness of many stakeholders of relevant KPIs.

As for deployment KPIs, the following ones are mentioned in the interviews (all mentioned once):

- Number of equipped intersections / total number of intersections.
- Percentage of total traffic that receives and uses ITS services
- User penetration
- Number of vehicles equipped with ITS services
- Number of kilometres road equipped with ITS services
- Smartphone apps built and used
- Data traffic via smartphone apps
- Data traffic from C-ITS equipped cars or road sides.

An overview of the benefit KPIs mentioned in the interviews is given in Figure 42. In total 6 unique KPIs are mentioned, of which KPIs related to traffic safety and the environmental performance of transport are most often indicated by the stakeholders. Furthermore, KPIs related to travel times (reduction of travel time losses, average travel time, vehicle speeds) are often mentioned.

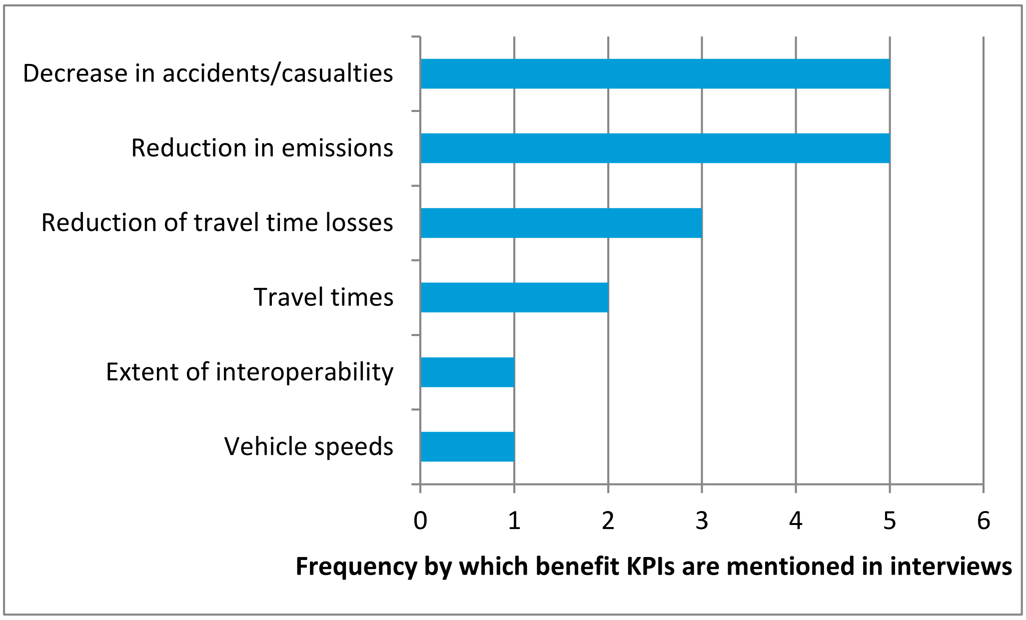


Figure 42 Frequency benefit KPIs as listed by stakeholders in interviews

Barriers to the implementation of KPIs

In total 7 unique barriers to the implementation of KPIs are mentioned by the interviewees:

- Lack of knowledge/skills to develop/measure KPIs (3)
- Lack of available data (2)
- Legal barriers to collect required data
- Data privacy
- Lack of standardised indicators / methodologies
- Perceived limited added value of KPIs

From these barriers, lack of available data and lack of knowledge/skills to develop/measure KPIs are mentioned multiple times (2 and 3 times, respectively), while all other barriers are only mentioned once. With respect to the lack of knowledge/skills, some of the interviewees refer to missing methodologies to accurately measure the impacts of ITS services (e.g. to isolate the impacts from the service from other (external) factors).

Appendix 4 Detailed results assessment of barriers and enablers

In this appendix, we present the detailed results of the assessment of barriers and enablers. More specifically, we present the barriers and enablers found for the ITS services identified in NEWBITS 2.1. These barriers and enablers are allocated to the general barriers and enablers identified in the systematic review of literature and interviews (see Section 3.2.3).

In the remainder of this Appendix, we first discuss the barriers (appendix 4.1), followed by the enablers (appendix 4.2).

4.1 Detailed results assessment of barriers

Table 23 to Table 26 present the barriers identified for the specific ITS services as investigated in NEWBITS D2.1. A distinction is made between Type 1 to Type 4 services, in order to make the data ready for the assessments carried out in Section 3.4. All specific barriers are allocated to one of the general barrier types defined in Section 3.2.3.

More detailed information on the specific barriers can be found in Appendix 6.

Category	General barrier	Service	Specific barriers
	Existence of last mover advantage		
Institutional	Lack of sufficient legal framework		
	Lack of political prioritization	Multi use lane Barcelona	Transport operators
		Milano Area C	Competitive with existing business/lack of political support
		TEXpress	Toll roads lack support of road users
		Rome access control	This was the first deploy in Italy ever of such kind of system: it required specific normative development at national level.
		Stockholm congestion pricing	The main barriers to congestion charging were public and political opposition.
Economic	Lack of funding	WAZE	Financing data handling
	Lack of attractive business model		
Technical	Current infrastructure not ready to integrate ITS technologies	Belfast rapid transit	Infrastructure issues
		Scot smart card	Adjusting infrastructure to smart card
		SENSIT Nedap	Sensoring during bad weather conditions is difficult.
		Telepass	Vehicles have to slow down for technical reasons
	Lack of interoperability and incompatibility among ITS services	RTPI	Software and communication issues
	Technical weaknesses in ensuring data security	FOTSIS 6	The quality and validity of the data is not guaranteed.
		Congestion Charge London	It requires sophisticated technology.
	High or uncertain maintenance costs	Congestion charge London	It might incur in higher administrative costs due to chasing up drivers who don't pay

Category	General barrier	Service	Specific barriers
			or try to avoid
Attitudes	Lack of user acceptance	Scot smart card	Moving existing passengers to a different type of ticket
		WAZE	Penetration rate needed for accurate functioning especially for generating the maps
		Ecomove improve traffic flow	Advices should be in line with the expectation of the driver to guarantee acceptance and compliance.
			Sufficient number of equipped vehicles
		Rome access control	Acceptance by people and commercial activities owners
		Stockholm congestion pricing	The main barriers to congestion charging were public and political opposition.
		Optibus	objection from operation people that were afraid to adopt a new technology
	Limited understanding of user needs		
Organisational	Lack of cooperation between stakeholders		
	Lack of skilled staff for ITS companies	FOTSIS 6	Training required for all stakeholders to get used to the system
Impact	Lack of demonstrated benefits for ITS services	RTPI	Operational issues due to traffic congestion or disruptions

Table 23 Identified barriers service type 1

Category	General barrier	Service	Specific barrier
	Existence of last mover advantage		
Institutional	Lack of sufficient legal framework	SATRE	liability after an accident
		CITI Australia	Current embargo on 5.9 GHz frequency
			No permanent licencing solution from Australian Communications and Media Authority
		C-ITS RWW	Judicial barriers
		Octo U	Privacy issues
			Use of personal data for marketing purposes
		HeERO	Policy level barriers
		EcoMove	Privacy preservation issue for drivers
		Wx-TINFO	Potential barriers can be find in the legal framework
	Lack of political prioritization	EcoMove sp3	EcoMove is competitive to existing institutions and public acceptance could be an issue

Category	General barrier	Service	Specific barrier
		Rome access control	This was the first deploy in Italy ever of such kind of system: it required specific normative development at national level.
Economic	Lack of funding	HeERO	Who finances?
	Lack of attractive business model	EcoGem	Cost of FEVs
Technical	Current infrastructure not ready to integrate ITS technologies	SATRE	Toll stations prove difficult for platoons
			Some Acceleration and deceleration lanes are too short
		INTELVIA	Technological challenge: New equipment is required to provide these services.
		eSEÑAL	Integration with existing infrastructure
		Dante	Detection under adverse weather conditions and during night-time hours
			Readiness of the road infrastructure to support the application
			Integration with existing infrastructure
		CITI Australia	Difficulty of installation of OBUs into heavy vehicles with regards to antennae, cable and screen placement
			GPS positioning inaccuracies
			Harsh terrain
		HeERO	How to integrate eCall into the current system
		FOTSIS 1 , 2	There are parts of EU highways without mobile network reception
			Infrastructure and vehicles equipped are insufficient
		EcoGem	Charging infrastructure and cost of technology and constraints on raw materials
	Lack of interoperability and incompatibility among ITS services	Safecross	Compatibility: The system used in the Spanish pilot is only SICE's controllers compatible
			Technical regulation about green time for pedestrians needs to be updated
		Dante	Visibility of the variable message panel if vehicle is not equipped with PDA
		C-ITS RWW	Standardization
		HeERO	Too many standards for safety answering points.
		EcoGem	Standardisation for interoperability – Interoperability of multiple components with different vendors

Category	General barrier	Service	Specific barrier
		EcoMove	Sub-systems interactions
	Technical weaknesses in ensuring data security	Safecross	The system could collect data on users
		INTELVIA	Security issues: transmitted signals may be altered.
		CACC	Communication system reliability (technical issues)
		C-ITS RWW	Technical barriers, mainly related to the presentation of the message
		C-ITS probe vehicle	Main barriers indicated are in the areas of security & privacy but have not further been discussed.
		EcoMove	Real time exchange is difficult technologically speaking
	High or uncertain maintenance costs		
Attitudes	Lack of user acceptance	SATRE	Lead vehicle has most responsibilities but only limited benefit in fuel reduction
			Trust in the lead driver and system necessary to automatically drive closely behind a truck without view
		Safecross	User acceptance to use phone and additional waiting time for cars
		Intelvia	Information shown to driver may interfere with driving - HMI - Driver distractions to be avoided.
		EcoMove 6.2	Advice should be in line with expectation driver
		eSEÑAL	Connectivity - Multiple signals' reception on OBU – Unimportant signals can overwhelm the driver.
		EcoMove 6.1	Advice should be within reasonable boundaries
			The overall benefits may not come at unacceptable costs for some individuals
		EcoMove support	Balancing traffic flows and so prioritizing traffic should be within acceptability thresholds and clear to drivers.
		CACC	Drivers willingness to give control to the system (user acceptance)
		EcoGem	User acceptability (predominantly depends on electrical energy management and the corresponding degree of autonomy that can be offered)
		EcoMove SP3	User acceptance and penetration
	Limited understanding of user needs	EcoMove 6.3	Advice should be in line with expectation driver
		CACC	Drivers comfort with regard to

Category	General barrier	Service	Specific barrier
			time-gaps between vehicles (user acceptance)
		C-ITS RWW	Human factor: what messages should be shown in-car and when does it get to much
Organisational	Lack of cooperation between stakeholders		
	Lack of skilled staff for ITS companies		
Impact	Lack of demonstrated benefits for ITS services	SATRE	High penetration is necessary to enjoy the benefits
		EcoMove 6.2	High penetration rate needed for effect

Table 24 Identified barriers service type 2

Category	General barrier	Service	Specific barrier
	Existence of last mover advantage		
Institutional	Lack of sufficient legal framework	In-Time	Need for certification either by EU, or dominant market player
		The connected boulevard, Nice	Security and privacy
		EcoMove parking	Driving and resting regulations truck drivers
		Fotsis 4	Permission to use road data
	Lack of political prioritization		
Economic	Lack of funding		
	Lack of attractive business model	CCTV	Cost associated with parts, and time investment of technology
Technical	Current infrastructure not ready to integrate ITS technologies	FAMS GPS	Poor mobile phone coverage
		EcoMove improve network	Insufficient information on the traffic state due to the lack of sensing possibilities
		Fotsis 4	Dynamic traffic conditions not integrated
			Alternative routes are not always equipped with measurement systems. Is the rerouting credible?
	Lack of interoperability and incompatibility among ITS services	In-Time	Current In-Time standard / data structure (trying to integrate a lot of existing formats and approaches) may be too complex, inflexible and slow (high overhead)
		ProbeIT	Different formats of all the sources
		Automatic passenger counter	Hardware failures and data processing, validation and analysis
	Technical weaknesses in ensuring data security	FAMS GPS	Poor technical documentation
		ProbeIT	The complex nature of the server setup and data integration

Category	General barrier	Service	Specific barrier
			algorithms
		CCTV	Security (Ensuring wireless networks are secure and safe to connect to company infrastructure)
	High or uncertain maintenance costs	Flitsmeister	Application programming interface turned out to be expensive as number of users grew
		Connected boulevard	Amount of the city budget available for future phases or expansion
		CCTV	Management of this sort of infrastructure and its health without introducing extra maintenance checks
Attitudes	Lack of user acceptance	FAMS GPS	Slow change in user transition from traditional interfaces
		Ecomove parking	User acceptance and compliance
	Limited understanding of user needs		
Organisational	Lack of cooperation between stakeholders	FAMS GPS	Stakeholder cooperation
		The connected boulevard, Nice	Garner cooperation from lower-level city management personnel
	Lack of skilled staff for ITS companies	Automatic passenger counter	Steep learning curve of implementation (regarding adjustments of software)
Impact	Lack of demonstrated benefits for ITS services	Automatic passenger counter	Less accurate than manual collection (80 -95 % compared to 90 and 95% for manual)
		The connected boulevard, Nice	Lack of demonstrated quantifiable benefits associated with environmental monitoring

Table 25 Identified barriers service type 3

Category	General barrier	Service	Specific barrier
	Existence of last mover advantage		
Institutional	Lack of sufficient legal framework	I-5 smart truck parking	Security and privacy
		Zoof	Regulation ensures that the advice of the app should be equal to the advice of the road side infrastructure.
		Fotsis 3,5	Getting access to data from national authorities.
		Guiade	privacy issues may arise due to permanent traceability or possible liability in case of speed limit violations
		Heavy vehicle platooning trial Australia	Lack of governmental approval for on-road trials

Category	General barrier	Service	Specific barrier
		Companion	Legislative action is necessary to allow the formation of platoons
		UK autodrive	Issues about insurance liability
			potential legal issues (including the aspects relating to privacy)
	Lack of political prioritization	Zoof	The in-car services conflict and compete with existing road side infrastructure (and its Industry)
		UK autodrive	Risk of disruptive effects on several industries and professions
Economic	Lack of funding		
	Lack of attractive business model	EcoMove Sp4 Freight	EcoMove is competitive to existing institutions and public acceptance could be an issue
		Parckr	No willingness to pay truck drivers
		I-5 smart truck parking	Unwillingness to pay (truck drivers)
		Zoof	The business model is not sustainable in its current form
		FOTsis 7	Hard to generate a positive business case
		Amsterdam Eva	Cost of Marketing do not outweigh the number of people who actively use the application -> low penetration leads to a limited effect. There is no positive business case
Technical	Current infrastructure not ready to integrate ITS technologies	FAMS GPS	Poor mobile phone coverage
		I-5 smart truck parking	Connectivity (signal interference)
		PPA Adam	Registration is necessary, which reduces the number of participants
			Availability of accurate congestion data for all roads.
		PPA superroute	Difficult to get suitable data from the application
		Fotsis 3, 5	Efficiently using existing road side equipment to generate accurate and matching traffic information
			Well-equipped infrastructure needed
		FOTsis 7	Stretch of road should be equipped with sensors and other systems for measurement
		Superroute –p	3g/4g network is often congested during events as many people are in the area
		Companion	Standardisation systems are required to form platoons
	Lack of interoperability and incompatibility among ITS services	IFM	Abundance of Proprietary Solutions that were not interoperable and required separate smartcards to run each scheme; aim has been to create

Category	General barrier	Service	Specific barrier
			Open Specifications (leading to CEN and ISO Specifications).
		EcoMove Sp4 Freight	Sub-systems interactions. An efficient truck planning could be influenced by C-ITS traffic lights who give priority to other vehicles.
		PPA Superroute	There is no coordination between services that offer real time travel advise. To offer spreading of traffic more coordination is needed. If more applications use real time traffic data overall efficiency is higher.
		Amsterdam Eva	No integration with door-to-door navigation
	Technical weaknesses in ensuring data security	FAMS GPS	Poor technical documentation
		I-5 smart truck parking	Security and privacy
		UK autodrive	Cyber-security issues
	High or uncertain maintenance costs		
Attitudes	Lack of user acceptance	FAMS VAMS	Slow change in user transition from traditional interfaces
		IFM	There was no clear linkage (or interfaces) between Journey Planning, Payment, Ticketing and Real Time Information.
		EcoMove Sp4 Freight	User acceptance and penetration
		I-5 smart truck parking	Educate truckers
			Illegally parked trucks (non-compliance)
		PPA Adam	Registration is necessary, which reduces the number of participants
			High expectations of mobile applications as mobile applications in general have reached a high quality
		PPA Superroute	50% ignores advice from the app
		FOtsis 7	Difficult to recruit drivers
			Usefulness perceived by users
		Flowpatrol	Users don't want to deviate the driving speed if there is a large difference between the observed and advised driving speed
		Freilot	Truck drivers do not believe the service works
	Limited understanding of user needs	EcoMove Sp4 Freight	Human reaction required → do people follow advice?
		PPA Adam	Many users use the App only in the beginning of the trip
			Accurate advice/location is key in a good user experience. No advice better than wrong advice.

Category	General barrier	Service	Specific barrier
Organisational	Lack of cooperation between stakeholders	FAMS VAMS	Stakeholder cooperation
		PPA Superroute	Time consuming coordination of stakeholders
		Mobility 2.0	In some case these bugs has direct and total dependency of third parties
	Lack of skilled staff for ITS companies		
Impact	Lack of demonstrated benefits for ITS services	Parckr	Service depends on the number of app users
		PPA Adam	Users do not 'appreciate' small benefits of the app -> normal congestion is anticipated and accepted
			Inability to show benefits due to low penetration rate -> no spreading of traffic possible
		PPA Superroute	Applications should be used structurally to have an impact on the traffic flow
		FOTsis 7	Measuring driving behaviour of recruited drivers
		Amsterdam EVA	Application has very limited effect after the event
		Flowpatrol	The number of users is to small to indicate an effect on a macro level
		Freilot	Hard to find significant effect

Table 26 Identified barriers service type 4

A summary of the findings on barriers is presented in Table 27. For the general barriers the number of occurrence is presented, distinguishing between the four different types of services. These results are discussed and interpreted in Section 3.4.1.

Macro category	Barriers	1	2	3	4	Total
Attitudes	Lack of user acceptance	6	12	2	12	32
Attitudes	Limited understanding of user needs	0	3	0	3	6
Economic	Lack of attractive business model	0	1	1	6	8
Economic	High or uncertain maintenance costs	1	0	3	0	4
Economic	Lack of funding	1	1	0	0	2
Impact	Lack of demonstrated benefits for ITS services	1	2	2	8	13
Institutional	Lack of sufficient legal framework	0	9	4	8	21
Institutional	Lack of political prioritization	5	1	0	2	8
Organisational	Lack of cooperation between stakeholders	0	0	2	3	5
Organisational	Lack of skilled staff for ITS companies	1	0	1	0	2
Technical	Current infrastructure not ready for service	4	14	4	10	32
Technical	Lack of interoperability and incompatibility	1	7	3	4	15

Technical	Technical weaknesses in ensuring data security	2	6	3	3	14
	Existence of last mover advantage	0	0	0	0	0
	Total	22	56	25	59	162

Table 27 Number of identified barriers per service type

4.2 Detailed results assessment of enablers

Table 28 to Table 31 present the enablers identified for the specific ITS services as investigated in NEWBITS D2.1. A distinction is made between Type 1 to Type 4 services, in order to make the data ready for the assessments carried out in Section 3.4. All specific enablers are allocated to one of the general barrier types defined in Section 3.2.3.

More detailed information on the specific enablers can be found in Appendix 6.

Category	General enabler	Service	Specific enabler
	Increased popularity “Mobility as a service”		
Institutional	Supportive regulation and clear legal framework	Congestion charge London	The fact that by law, net revenue from the Congestion Charge must be spent on further improvements to transport across London
		Milano Area C	Possibility to raise funds for soft mobility infrastructures (cycle lanes, pedestrian zones, 30kph zones).
	Increasing political commitment	Multi lane use Barcelona	Progress could only be reached thanks to the strong political will to continue and improve the urban transport situation.
		Madrid smart parking	adequate public funds
			full inclusion into planning agenda
		Rome access control	Increasing politic commitment
			Adequate public funding
	Enhanced public-private partnership		
Economic	Innovative funding scheme		
	Attractive business scheme	Waze	Free downloadable for smartphone
		Stockholm congestion pricing	New business scheme
		OPtibus	Efficiency and money saving
Technical	Standardization for interoperability of ITS services	FOTsis 6	Integration of different data sources and infrastructure
		VSC-A	Standardization for Interoperability
	Upgrade of ITS infrastructure	Stockholm congestion pricing	Upgrade of ITS infrastructure
	Lower cost of maintenance	Sensit Nedap	The system is wirelessly updateable
Attitudes	Higher level of end user	Waze	User based

Category	General enabler	Service	Specific enabler
	involvement	Opptibus	User friendly solutions
			Improvement of customer' service were the main enablers.
	Increased attention for sustainable transport	Stockholm congestion pricing	Increased attention for sustainable transport
Organisational	More cooperation between stakeholders	Scot rail smartcard	Cooperation between rail and subway operators
	Increased public awareness of benefits of ITS	Rome access control	Strong communication campaigns, involvement of people in the decision process
		Stockholm congestion pricing	Pre-operative trial. The Royal Institute of Technology conducted repeated surveys of public attitudes. Public support for the charges was lowest just before the trial, increased dramatically once the trial began and has remained consistently high at roughly 70% thereafter.
Impact	Development of clear KPIs		
	Proven benefits of ITS services	RTPI	That makes journey times more reliable and allow people to plan better their journeys.
		Scot rail smartcard	Reduction of travelling time and costs for both passengers and operators;
		Congestion charge London	General benefits for the population in the area due to reduced congestion, improvement of transport services, cleaner air, safer roads
		Milano area C	Improvement of the quality of life by reducing congestion, the number of accidents, uncontrolled parking, noise and air pollution
		Sanef	Proven benefits through easier toll payments

Table 28 Identified enablers service type 1

Category	General enabler	Service	Specific enabler
	Increased popularity "Mobility as a service"		
Institutional	Supportive regulation and clear legal framework	CITI Australia	Exception of embargo for test purposes (1st step to proof benefit)
			Yearly scientific licence granted by ACMA for CITI pilot deployment
		HeERO	Regulation about minimum

Category	General enabler	Service	Specific enabler
			requirements would increase reliability
	Increasing political commitment		
	Enhanced public-private partnership	C-ITS RWW	Leading role of government entity
		C-ITS Probe	Leading role of government entity
Economic	Innovative funding scheme	Safecross	Financing
	Attractive business scheme	Satre	There is a positive business case for long haul trucking to employ platooning systems
Technical	Standardization for interoperability of ITS services	Hogia	Relies on Tetra and Rankel platforms
	Upgrade of ITS infrastructure	C-ITS RWW	Availability of necessary infrastructure
	Lower cost of maintenance	eSenal	Physical installation of new road signs or modifications no longer needed
		HeERO	Tenders to select the best technology providers
Attitudes	Higher level of end user involvement	Satre	Trained drivers
		Intelvia	Participation of all the actors involved in the value chain including end users
		CACC	Incentives for drivers
		EcoGem	On-time application for the full market deployment of FEVs
	Increased attention for sustainable transport	EcoGem	Concern for fuel/energy efficiency, autonomy of FEVs and the reduction in $C0_2$ emissions
Organisational	More cooperation between stakeholders	Safecross	Cooperation among different stakeholders
		Intelvia	Participation of all the actors involved in the value chain including end users
		Dante	Stakeholder cooperation
		C-ITS RWW	International cooperation
		C-ITS Probe	International cooperation
	Increased public awareness of benefits of ITS		
Impact	Development of clear KPIs		
	Proven benefits of ITS services	eSenal	Visibility of road signs under adverse weather conditions.
		Dante	Advanced detection of possible occurrences of accidents
		OTCO U	Proven benefits

Table 29 Identified enablers service type 2

Category	General enabler	Service	Specific enabler
	Increased popularity "Mobility as a service"		
Institutional	Supportive regulation and clear legal framework		
	Increasing political commitment	Connected boulevard Nice	Political backing from city mayor
	Enhanced public-private partnership	ProbeIT	Leading role of the government in both funding the project and providing a view on potential benefits of such a system and how traffic regulation data can be integrated.
Economic	Innovative funding scheme	Connected boulevard Nice	Availability of funds - allocations from the city's overall budget
	Attractive business scheme	FAMS GPS	Reduction in total operating costs per revenue hour (Increase in revenue
		In - Time	Cost efficient approach for access and real-time use of third part data and services
		Connected boulevard Nice	Validation of collaborative multi-stakeholder alliance and business model
Technical	Standardization for interoperability of ITS services	FAMS GPS	Adaptation of existing DRT management tools for interoperability within an e-Business collaborative environment allowing co-operation amongst transport service suppliers and the operation of a new service value chain
		In - Time	Technical maturity - Demonstrated for wide scale of mobility services - Data models based on existing standards - International dimension (6 cities involved already in demo phase)
	Upgrade of ITS infrastructure		
	Lower cost of maintenance		
Attitudes	Higher level of end user involvement		
	Increased attention for sustainable transport		
Organisational	More cooperation between stakeholders	FAMS GPS	Development of innovative organizational platforms
		Flitsmeister	Partnerships with relevant parties (radio stations)
		ProbeIT	Cooperation between several stakeholders with different types of skills.
		Connected boulevard	Validation of collaborative

Category	General enabler	Service	Specific enabler
		Nice	multi-stakeholder alliance and business model
		DPI	cooperation with the European flight information network EuroControl and the National Air Traffic Control Centres
		FOtsis 4	Integration of different data sources.
	Increased public awareness of benefits of ITS		
Impact	Development of clear KPIs		
	Proven benefits of ITS services	FAMS GPS	Demonstrated end-user and personnel acceptance
		Flitsmeister	User experience
		Automatic t passenger counter	Proven benefits (cheaper, data availability and amount)
		CCTV	Safety and Comfort of Passengers and Staff
		Oyster card	General reduction of travelling time and costs for both passengers and operators

Table 30 Identified enablers service type 3

Category	General enabler	Service	Specific enabler
	Increased popularity "Mobility as a service"		
Institutional	Supportive regulation and clear legal framework	i-5 truck parking	Environmental and health legislation on the reduction of diesel exhaust emissions from truck idling
	Increasing political commitment	IFM	Collective agreements between the three main countries
		i-5 truck parking	Support from State government
		Uk Autodrive	Support of Coventry and Milton Keynes Councils (public sector) for the road demonstrations;
	Enhanced public-private partnership	Platooning Australia	Governmental funding & incentive package focusing on R&D, demonstration, deployment (similar to UK Intelligent Mobility Fund)
Economic	Innovative funding scheme		
	Attractive business scheme	FAMS GPS	Reduction in total operating costs per revenue hour (Increase in revenue
		i-5 truck parking	Scalability
		Parckr	One enabler was that no measurement systems have been used. This allowed the

Category	General enabler	Service	Specific enabler
			application to be affordable.
Technical	Standardization for interoperability of ITS services	FAMS GPS	Adaptation of existing DRT management tools for interoperability within an e-Business collaborative environment allowing co-operation amongst transport service suppliers and the operation of a new service value chain
		IFM	Common interface specifications between Journey Planning, Payment, Ticketing and Real Time Information are seen as critical.
		FOTsis 7	Integration of data and infrastructure
		Flowpatrol	Privacy standards of V2V communication have been validated
		Mobility 2.0	Integration of other trip related dynamic information data such as weather in order to enhance the prediction
	Upgrade of ITS infrastructure		
	Lower cost of maintenance	Guiade	Lesser costs of installation and maintenance
Attitudes	Higher level of end user involvement	i-5 truck parking	High acceptance by truck drivers and carriers
		Zoof	Rewarding of users works
			User approach in general important
		Amsterdam onderweg Super P-route	Free parking ticket in exchange
	Increased attention for sustainable transport	i-5 truck parking	Environmental and health legislation on the reduction of diesel exhaust emissions from truck idling
		UK Autodrive	Possibility to use to application to solve social (use of the cars from people who cannot drive), environmental and efficiency issues;
Organisational	More cooperation between stakeholders	FAMS GPS	Development of innovative organizational platforms
		i-5 truck parking	Stakeholder cooperation (Government, Universities, Private Sector)
		PPA Adam	Enthusiastic and cooperative stakeholders
		Amsterdam Eva	Positive cooperation between stakeholders
		Uk Autodrive	Cooperation between different types of stakeholders

Category	General enabler	Service	Specific enabler
			for both development/advancement of the application and utilisation (technology expert, public sector, etc.);
	Increased public awareness of benefits of ITS	IFM	Having a single spokesperson for Public Transport
		PPA Adam	Media attention results in curiosity with the public
		PPA superroute	Successful campaign to collect participants
		Amsterdam Eva	Google adworks successful marketing at affordable costs
		Amsterdam onderweg Super P-route	Not including one channel had significant consequences for the result of the marketing campaign
Impact	Development of clear KPIs		
	Proven benefits of ITS services	FAMS GPS	Demonstrated end-user and personnel acceptance
		IFM	The production and successful demonstration of a single smartcard with applications loaded for UK, France and Germany was a major Proof of Concept milestone.
			The Project was also able to publish common lists of Actors and Use Cases that have subsequently been validated by other administrations such as APTA (for the US) and Japan Railways and Codes of Practice. This agreement between operators has now extended to include performance criteria (such as operating distance between card and reader, transaction timings etc.).
		Platooning Australia	Successful On-road trials in for heavy vehicle platooning in Europe + North America

Table 31 Identified enablers service type 4

A summary of the findings on enablers is presented in Table 32. For the general barriers the number of occurrence is presented, distinguishing between the four different types of services. These results are discussed and interpreted in Section 3.4.2.

Macro category	Enablers	1	2	3	4	Total
Attitudes	Higher level of end user involvement	3	4	0	4	11
Attitudes	Increased public awareness of benefits of ITS	2	0	0	5	7
Attitudes	Increased attention for sustainable transport	1	1	0	2	4
Economic	Attractive business scheme	3	1	3	3	10
Economic	Lower cost of maintenance	1	2	0	1	4
Economic	Innovative funding scheme	0	1	1	0	2
impact	Proven benefits of ITS services	5	3	5	4	17
Impact	Development of clear KPIs	0	0	0	0	0
Institutional	Supportive regulation and clear legal framework	2	3	0	1	6
Institutional	Increasing political commitment	3	0	1	3	7
Institutional	Enhanced public-private partnership	0	2	1	1	4
Organisational	More cooperation between stakeholders	1	5	6	5	17
Technical	Standardization for interoperability of ITS services	2	1	2	5	10
Technical	Upgrade of ITS infrastructure	1	1	0	0	2
Other	Increased popularity “Mobility as a service”	0	0	0	0	0
	Total	24	24	19	34	101

Table 32 Number of identified enablers per service type

Appendix 5 Detailed results assessment of KPIs

In this appendix, we present the detailed results of the assessment of KPIs. In appendix 5.1 we first show the detailed results of the systematic review of the evidence from the literature (and interviews) on KPIs applied for ITS services. The detailed results of the assessment on the utilisation of relevant KPIs per service type are shown in appendix 5.2.

5.1 Detailed results systematic review

As explained in Section 4.2.3, we have applied a four step approach to provide an overview of KPIs:

1. Identify KPIs from several literature sources and interviews
2. Assess KPIs for similarity and relevance
3. Rephrase KPIs
4. Compose overview of KPIs

In this appendix the results of these four steps are discussed, both for deployment and benefit KPIs.

Deployment KPIs
An overview of the relevant deployment KPIs identified by the literature review and the interviews (including their sources) is given in Table 33. As it has become clear from this overview, similar KPIs are mentioned by the various sources. For example, Kaparias et al (2011), EIP+ (2015) and one of the interviewees mention the '*number of road network equipped with ITS'* as a relevant deployment KPIs. These KPIs can therefore be grouped under one header. By rephrasing KPIs, such that they meet the more general level relevant for this study, even more KPIs can be grouped together. For example, the KPIs '*Length and % of road network covered by incident detection and incident management'* and '*Length and % of road network covered by automated speed detection'* are rephrased to become '*Length of the transport network covered by ITS service'.* In this way, ten general deployment KPIs can be defined. These are shown in the first column of Table 33.

General KPIs	Specific KPIs identified	Source
Length of the transport network covered by ITS service	Length and % of road network covered by incident detection and incident management	AECOM (2015)
	Length and % of road network covered by automated speed detection.	AECOM (2015)
	% of TEN-T long-term work zone equipped with security applications and information (management) system	AECOM (2015)
	% national transport network covered by websites offering comprehensive traveler information (e.g. Journey planning, traffic information)	AECOM (2015)
	% TEN-T network covered by traffic advisory radio and/or mobile network reception and offering appropriate information services	AECOM (2015)
	% TEN-T network covered by a minimum level of information infrastructures (e.g. traffic, weather and environmental conditions monitoring, CCTV or traffic information and control centers)	AECOM (2015)
	% of TEN-T network covered by information about real-time delays	AECOM (2015)
	Road network covered by open app and TMC services (free to be use by travelers)	AECOM (2015)
	Road network covered by private app and TMC services (costs traveler)	AECOM (2015)
	% of the road network compliant with the interoperability directive of the European Electronic Toll Service (EETS)	AECOM (2015)
	% TEN-T network with a minimum level of traffic management and control(e.g. Dynamic lane management, ramp metering, VMS)	AECOM (2015)
	% bus routes equipped with Automatic Vehicle Location	AECOM (2015)

General KPIs	Specific KPIs identified	Source
	% of Network covered by traffic management plans	AECOM (2015)
	% of network covered by real-time services providing information in accordance to Delegated Regulation on Road Safety Information Service	AECOM (2015)
	% of network where data in accordance to Delegated Regulation on Road Safety Information Services are collected and provided	AECOM (2015)
	Number of kilometres road network equipped with ITS	Kaparias et al. (2011)
	Number of kilometres of non-motorised facilities equipped with ITS	Kaparias et al. (2011)
	% roads that has variable speed limit displays	Zhang et al. (1993)
	Number of lane kilometres designated for capacity upgrade contracts	Kaparias et al. (2011)
	Real-time transit arrival information is available on mobile platform (% bus stops/train stations/transit services covered under this service)	Zhang et al. (1993)
	Km and / or % road network covered or impacted by an ITS service	EIP+ (2015)
	Km road network equipped with ITS service	Interview
Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)	% TEN-T network supporting cooperative systems (I2V, V2I)	AECOM (2015)
Number of network elements (e.g. intersections; highway lanes) covered by ITS service.	% urban intersections providing safety enhancements for pedestrians and disabled or other vulnerable road users	AECOM (2015)
	Number of intelligent truck parking facilities per km of TEN-T network	AECOM (2015)
	% urban intersections providing priority signals for emergency blue light forces	AECOM (2015)
	% of long (to be defined) tunnels/bridges, equipped with complex incident det./res. System	AECOM (2015)
	Number and % of urban public transport stops for which dynamic traveler information is made available to the public. Report separately by public transport mode where possible.	AECOM (2015)
	Number and % of signal controlled road intersections using adaptive traffic control or prioritisation. Report separately by road type or area where possible.	AECOM (2015)
	% urban public transport network interchanges that are equipped with PT priority signals	AECOM (2015)
	% expressway entry points equipped with ramp metering	Zhang et al. (1993)
	% intersections having automated emergency vehicle signal priority system	Zhang et al. (1993)
	% intersections having automated transit signal priority system	Zhang et al. (1993)
	% intersections covered under network-coordinated signal system.	Zhang et al. (1993)
	The number of traffic centres equipped with certain minimum level of service	EIP+ (2015)
	Number of intersections equipped with ITS service as share of total number of intersections	Interview
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used.	Length and % of road network covered by automated speed detection. Report separately by road type where possible.	AECOM (2015)
	Number of gantries with dynamic traffic management functions per 100000 car kilometres per day	AECOM (2015)
	Number of applications based on open data/open services	AECOM (2015)
	Number of automatic number plate recognition (ANPR) systems, able to detect individual vehicles with ID	Zhang et al. (1993),
	Availability of automated parking system (human less) (Yes/NO)	Zhang et al.

General KPIs	Specific KPIs identified	Source
		(1993),
	Electronic (instant) transaction system available? • Mixed (both paper-based and e-transaction), • Toll/parking charge payment by e-transaction • only • Enforcement fines payment by e-transaction only	Zhang et al. (1993),
Frequency ITS service is used	% emergency vehicle dispatches facilitated by computer aided dispatch	AECOM (2015)
	% hazardous load movements for which information is logged or monitored using ITS	AECOM (2015)
	% public transport ticket transactions that utilise electronic payment technologies	AECOM (2015)
	No of routing requests	AECOM (2015)
	% hazardous/abnormal load movements for which ITS has been utilised to facilitate the sharing of information between relevant organisations	AECOM (2015)
	% road toll revenue collected by electronic toll collection systems	AECOM (2015)
	Number of automatically initiated eCalls	AECOM (2015)
	Number of cooperative services in use	AECOM (2015)
	Frequency of public transport	Kaparias et al. (2011)
	Number of trips	Kaparias et al. (2011)
	Number of public transport trips	Kaparias et al. (2011)
	Public transport rides per capita	Kaparias et al. (2011)
Number of end-users of ITS service	% public transport ticket transactions that utilise electronic payment technologies	AECOM (2015)
	% of passengers served by dynamic information at stops or on internet	AECOM (2015)
	User penetration rate	Interview
Number of vehicles featuring ITS technology in application area of ITS service	% of national fleet fitted with e-Call	AECOM (2015)
	% vehicle models currently offered for sale featuring intelligent vehicle services (vision enhancement, safety readiness, automated operation, cooperative systems	AECOM (2015)
	% vehicles sold featuring intelligent vehicle services (vision enhancement, safety readiness, automated operation, cooperative systems)	AECOM (2015)
	% vehicles equipped with dynamic navigation	AECOM (2015)
	Number of public buses and taxis equipped with Automatic Vehicle Location System (GPS). Similar for trains (continuous tracking/point tracking).	Zhang et al. (1993)
	% public transit vehicles having driverless control system	Zhang et al. (1993)
	Number of vehicles equipped with ITS service	Interview
	Number of vehicles entering some area (e.g. congestion charge area for which enforcement is done by ITS technology)	Interview
Number of vehicles in application area actually using ITS service	Status (yes/no/ how many) of TPS inclusion in national E-Call platform	AECOM (2015)
	% emergency vehicle dispatch systems linked to traffic management interventions	AECOM (2015)
	% demand responsive vehicles that operate under Computer Aided Dispatch	AECOM (2015)
	% taxis/taxi service providers provide real-time and SMS-based taxi booking service	Zhang et al. (1993)
	Percentage of total number of vehicles that receives and uses C-ITS services	Interview
Number of hours ITS service has	Number of hours when dynamic traffic advice is displayed (or on time of gantries)	AECOM (2015)

General KPIs	Specific KPIs identified	Source
operated	Access times to transport facilities, calculated at a basic level with field data collection, and at an intermediate level by means of surveys conducted among public transport users.	Kaparias et al. (2011)
Number of visits to website and portals linked to the ITS service	No of visits to websites and portals offering traveller information (e.g. journey planning, traffic information)	AECOM (2015)

Table 33 Detailed overview of deployment KPIs

Not all deployment KPIs identified in the literature and by the interviews are relevant for this study, because:

- They are not measurable
- They are unclear
- They are too specific
- They are operational KPIs instead of deployment KPIs.

Please find an overview of these KPIs in Table 34.

KPIs	Source	Comments
Number of security constrains	AECOM (2015)	Unclear
Timelines incident – Info messages	AECOM (2015)	Unclear
Coverage of incidents	AECOM (2015)	Unclear
Coverage of networks	AECOM (2015)	Unclear
% of “Wrong” Messages + % of detection of incidents	AECOM (2015)	Unclear
Datex II implemented for traffic data exchange (yes/no)	AECOM (2015)	Too specific
Cross border agreements on cooperation between road operators in place for data exchange	AECOM (2015)	Too specific
Cross border agreements on cooperation between road operators in place for operating adjacent traffic management systems	AECOM (2015)	Too specific
% of “Wrong” Messages	AECOM (2015)	Unclear
Use of telematics to manage freight vehicles (ITS is key to Public Transport Promotion)	AECOM (2015)	Too specific

Table 34 Deployment KPIs identified in the literature but not considered in this study

Benefit KPIs

By the same approach as for deployment KPIs, benefit KPIs are identified and assessed. The results of these analyses are shown in Table 35 to Table 38.

General KPIs	Specific KPIs identified	Source
Reported perception of safety	Perception of road safety	AECOM (2015)
	Estimation of safety performance on road	Interview
Number of reported accidents	% change in number of reported accidents along routes where ITS have been implemented. Report by accident severity where possible.	AECOM (2015)
	Number of accidents	Zhicai et al (2006)
	Number of secondary accidents	Zhicai et al (2006)
	Number of traffic accidents	Jianwei et al. (2010)

General KPIs	Specific KPIs identified	Source
	Number or % change in fatalities / injuries	EIP+ (2015)
	Number of accidents	Interview
Number of reported fatal accidents	Change in severity of accidents (i.e. Numbers killed or serious injured) per number of accidents reported	AECOM (2015)
	Number or % change in fatalities / injuries	EIP+ (2015)
	Number of fatal accidents	Interview
Number of reported accidents requiring medical attention	Change in severity of accidents (i.e. Numbers killed or serious injured) per number of accidents reported	AECOM (2015)
	Change in severity of accidents in workzones	AECOM (2015)
	Number or % change in fatalities / injuries	EIP+ (2015)
Costs of safety services	Safety scheme costs	Kolosz (2014)
Incident response time	Incident response time	Zhicai et al (2006)
	Incident detection time	Zhicai et al (2006)
Number of traffic violations	Reduction in violations (speeding, red light violations…)	AECOM (2015)
	Change in crime reports relating to truck parking	AECOM (2015)
	Number of speed limit violations	Kaparias et al. (2011)
	Number of signal violations	Kaparias et al. (2011)
	Number of speed violations	Interview
Average driving speed	Travel speed	Kaparias et al. (2011)
	Network speed variability	AECOM (2015)
	Average driving speed	Kesten et al. (2015)
	Travel speed	Vanderschuren (2008)
	Travel speed	Zhicai et al. (2011)
	Change in speed	EIP+ (2015)
	Driving speed	Interview
	Instantaneous vehicle speeds	Interview
	Traffic speed	Interview
	Average/total speeds can be calculated directly through local point detection means	Kaparias et al. (2011)
Average distance of vehicles driving behind each other (vehicle headways)	Average Headways	Vanderschuren (2008)
	Spacing between vehicles	Kaparias et al. (2011)

Table 35 Detailed overview of benefit KPIs related to traffic safety

General KPIs	Specific KPIs identified	Source
Total traffic volumes	Volume of transport to gross domestic product	Casal et al. (2005)
	Balance of corridor volumes	Zhicai et al. (2011)
	Volume of goods moved over existing facilities	Zhicai et al. (2011)
	Change in public transport average daily person flow between key points along a route	AECOM (2015)
Modal split of transport	% change in mode share on corridors where ITS have been implemented. Report percentage mode share separately for each mode.	AECOM (2015)
	Rail and inland waterway mode share along key corridors (tonne km)	AECOM (2015)
	Public Transport mode share along key corridors (people)	AECOM (2015)
	Active travel mode share (people)	AECOM (2015)
	Share of walking for children on their way to school	AECOM (2015)
	Modal split of transport	Casal et al. (2005)
	Increase of low impact mobility where ITS services are implemented	Interview
	Reduction of private car use in km/day	Interview

General KPIs	Specific KPIs identified	Source
	Modal split	Kaparias et al. (2011)
	Percentage of non-motorised trips for commuting	Kaparias et al. (2011)
	Percent of transfers between modes to be under “X” metres and “N” minutes	Kaparias et al. (2011)
Average journey time	Change in travel times	AECOM (2015)
	Reducing searching time in an unfamiliar area	AECOM (2015)
	% change in peak hour journey time along routes where ITS have been implemented. Report by vehicle type where possible.	AECOM (2015)
	Average travel time index	Li et al (2014)
	Average travel time and length on routs	Tsakarestos et al. (2011)
	Travel time	Zhicai et al (2006)
	Total travel time	Kesten et al. (2015)
	Driving time (1000h/a)	Sauna-aho et al. (2004)
	Vehicle hours driven (change in %,vehicle-km and tonne-km)	EIP+ (2015)
	Travel time (average per traffic unit) (hour/traffic unit)	EIP+ (2015)
	Travel time	Interview
	Driving time	Interview
	Average travel time to relevant points of interest (e.g. hospitals, local government offices, key highway intersections) on the road network	Kaparias et al. (2011)
	Average travel time to relevant points of interest on the public transport network	Kaparias et al. (2011)
	Average commuting time by public and private transport	Kaparias et al. (2011)
	Origin-destination (OD) route travel time and total travel time	Kaparias et al. (2011)
	Average/total travel times,	Kaparias et al. (2011)
Average variability of journey time	% change in journey time variability on routes where ITS have been implemented -as measured by coefficient of variation. Report by vehicle type where possible.	AECOM (2015)
	Variation index	Li et al. (2014)
	Journey time variability at key points	EIP+ (2015)
Predictability of travel times	Predictability of travel times	Zhicai et al (2006)
	Accuracy of measurement of speed and congestion	Interview
Average delay time	Average time loss through waiting at cross-sections (cars, PT, cycles)	AECOM (2015)
	Number of congestion incidents and their duration	Tsakarestos et al. (2011)
	Number of stops and their delay time	Eden et al. (2012)
	Average delay time per vehicle	Kesten et al. (2015)
	Total delay time	Kesten et al. (2015)
	Delay time	Zhicai et al (2006)
	Delay at intermodal transfer point	Zhicai et al (2006)
	Vehicle hours lost due to congestion (change in %)	EIP+ (2015)
	Average delay per vehicle km (hour delay/vehicle)	EIP+ (2015)
	Additional travel time caused by incidents (hour)	EIP+ (2015)
	Delay time	Kaparias et al. (2011)
	Connection times at transport facilities	Kaparias et al. (2011)
	Average distance and duration of transfers between modes	Kaparias et al. (2011)
	Average delay of public transport at intersections	Kaparias et al. (2011)
	Pedestrian/cyclists red times in signalised junctions	Kaparias et al. (2011)
Average journey distance	Average travel time and length on routs	Tsakarestos et al. (2011)
	Difference in vehicle kilometres driven	EIP+ (2015)
	Public transport supply in route-kilometres	Kaparias et al. (2011)
	Average distance and duration of transfers between modes	Kaparias et al. (2011)

General KPIs	Specific KPIs identified	Source
	Average commuting distance	Kaparias et al. (2011)
	Total motorway lane-kilometres	Kaparias et al. (2011)
	Vehicle-kilometres-travelled,	Kaparias et al. (2011)
Average traffic speed	See Safety for KPIs related to average traffic speed	
Average peak hour traffic flow	% change in peak hour traffic flow along routes where ITS have been implemented. Report by vehicle type where possible.	AECOM (2015)
	Average speed reduction on the arterials on the peak periods	Li et al. (2014)
Number of start & stops (e.g. at traffic lights)	Number of congestion incidents and their duration	Tsakarestos et al. (2011)
	Number of stops and their delay time	Eden et al. (2012)
	Average number of stops	Kesten et al. (2015)
	Number of stops	Kesten et al. (2015)
	Number of stops	Zhicai et al (2006)
	Traffic jams	Interview
	Number of stops of public transport at intersections	Kaparias et al. (2011)
Total capacity of the network	Traffic capacity	Jianwei et al. (2010)
	Throughput	Zhicai et al. (2006)
	Network's throughput increase due to ITS as substitution of land use for road widening	AECOM (2015)
Average occupancy level/load factor	Vehicle occupancy	Zhicai et al (2006)
	The occupancy of the P+R parking place	AECOM (2015)

Table 36 Detailed overview of benefit KPIs related to transport efficiency

General KPIs	Specific KPIs identified	Source
Level of emissions (CO2 / air pollutants / noise)	% change in annual CO2 emissions (Tons) on routes where ITS have been implemented.	AECOM (2015)
	Change in PM10 emissions per vehicle km	AECOM (2015)
	Change in noise level on detection point	AECOM (2015)
	Carbon footprint per transport media and route	AECOM (2015)
	Greenhouse gas emissions	Casal et al (2005)
	Pollution Key Performance Indicators	Eden et al. (2012)
	Road-side infrastructure emissions	Kolosz et al. (2014)
	Road users emissions	Kolosz et al. (2014)
	Kg CO_2 equivalency covered by ITS certificates	Kolosz et al. (2014)
	Kg CO_2 equivalency covered by ITS task or resource	Kolosz et al. (2014)
	Noise pollution	Zhicai et al. (2011)
	Emissions (NOx, CO, HC, PM, CO_2)	Sauna-aho et al (2004)
	CO_2 emissions (change in %) ,similar for NOx and PM10	EIP+ (2015)
	CO_2 emissions	Interview
	Emissions reduction (% of)	Interview
Number of times thresholds (e.g. dB thresholds for noise) are exceeded	Change in number of hours where NOx levels are above threshold	AECOM (2015)
	Change in number of hours where transport noise is above dB threshold	AECOM (2015)
	Number of peak noise events	AECOM (2015)
Total external costs of transport	Scheme Costs	Kolosz (2014)
	Costs of ITS services (euro)	EIP+ (2015)
	Public cost for transport	Kaparias et al. (2011)
	Value of fuel savings	Kaparias et al. (2011)

Total traffic and transport volumes	See Efficiency for KPIs related to traffic and transport volumes	
Modal split of transport	See Efficiency for KPIs relating to the modal split	
Average fuel efficiency of vehicles	Carbon footprint per transport media and route	AECOM (2015)
	Fuel efficiency	Zhicai et al. (2011)
Total fuel/energy consumption	Carbon footprint per transport media and route	AECOM (2015)
	Energy consumption and share of renewables	Casal et al. (2005)
	Energy used per task or resource	Kolosz et al. (2014)
	Road-side energy consumption	Kolosz et al. (2014)
	Fuel consumption	Zhicai et al. (2011)
	Fuel consumption (Ml/a)	Sauna-aho et al. (2004)
	Fuel consumption rate calculated based on the travel path data of individual vehicles	Interview
	Fuel consumption	Interview
Share of renewable fuels in total fuel consumption	Energy consumption and share of renewables	Casal et al (2005)
Number of start & stops (e.g. at traffic lights)	See Efficiency for an overview of KPIs related to start & stops	
Average occupancy level / load factor	See Efficiency for an overview of KPIs related to average occupancy level/load factor	
Average traffic speed	See Efficiency for an overview of KPIs related to average traffic speed	

Table 37 Detailed overview of benefit KPIs related to environmental performance

General KPIs	Specific KPIs identified	Source
Reported level of comfort	Opinion / qualitative research on availability / use of multimodal	AECOM (2015)
	Reported stress	Zhicai et al. (2011)
	Reported confusion	Zhicai et al. (2011)
Reported quality of transport services/infrastructure	Opinion / qualitative research on availability / use of multimodal	AECOM (2015)
	Customer satisfaction with completed projects	Kaparias et al. (2011)
	Customer perception of “kept promises” on project completion	Kaparias et al. (2011)
	Level of service of walking and cycling facilities,	Kaparias et al. (2011)
Reliability of transport services	Public Transport journey time reliability – deviation from scheduled timetable	AECOM (2015)
	Likelihood that information about a severe event (accident, congestion > 5Km) is distributed after < 5 Min.	AECOM (2015)
	Likelihood that information about a severe event (accident, congestion > 5Km) is received by a driver after < 5 Min.	AECOM (2015)
Quality of travel information provided	Quality (reaction time, pro per info. Distribution, proper channel, right time, right place) of info	AECOM (2015)
	Quality assessment of information provided.	AECOM (2015)
Level of travel information provided	Incident/congestion information	Zhicai et al. (2011)
Average journey time	See Efficiency for KPIs related to average journey time	
Reliability journey time	On-time performance of public transport	Kaparias et al. (2011)
	Punctuality of public transport	Li et al. (2014)
Average delay time	See Efficiency for KPIs related to average journey time	
Average traffic speed	See Safety for KPIs related to average journey time	
Perception of waiting time (e.g. at bus stop, in traffic jam)	Waiting time at bus stops	Interview
	Average parking search time at public transport facilities	Kaparias et al. (2011)

Table 38 Detailed overview of benefit KPIs related to transport comfort

An overview of the identified benefit KPIs not considered in this study is given in Table 39. For each of these KPIs it is indicated why they are not relevant for this study.

Benefit	KPIs	Source	Comments
Safety	Driver fatigue	Zhicai et al. (2011)	Unclear
	Safety objectives	Interview	Unclear
	Time to collision	Vanderschuren (2008)	Too specific
	Future KPI – Number of near misses recorded by ITS	AECOM (2015)	Not measurable
	Benefits from road safety messages during congestion / incidents etc	AECOM (2015)	Not measurable
	Road safety improvements from safe and secure parking	AECOM (2015)	Not measurable
	Number of misplaced vehicles on parking areas	AECOM (2015)	Too specific
	Journey time / reliability Safety traffic efficiency energy efficiency / (environment)	AECOM (2015)	Too many KPIs
Efficiency	case of congestion re-routing to alternative modes/routes (even to the secondary road	AECOM (2015)	Unclear

Benefit	KPIs	Source	Comments
	network) based on operator's recommendation		
	Operating costs	Zhicai et al. (2011)	Operational
	Just-in-time deliveries	Zhicai et al. (2011)	Too specific
	Sharing of information	Zhicai et al. (2011)	Unclear
	Information gathering costs	Zhicai et al. (2011)	Operational
	Consultation on implementation of control strategies	Zhicai et al. (2011)	Operational
	Variable vehicle operating costs at market price (MEUR/a)	Zhang et al. (1993)	Operational
	Variance of the time headway between consecutive vehicles of the same public transport line.	Kaparias et al. (2011)	Too specific
	Cost efficiency	Interview	Operational
	Public cost for transport,	Kaparias et al. (2011)	Operational
	Private cost for transport	Kaparias et al. (2011)	
	Average stopped delay time	Kesten et al. (2015)	Unclear
	Cost-benefit of existing facility versus new construction	Kaparias et al. (2011)	Operational
	Average cost per constructed lane-mile	Kaparias et al. (2011)	Operational
	Cost per passenger for urban public transport systems	Kaparias et al. (2011)	Operational
	Cost per vehicle miles of travel (VMT),	Kaparias et al. (2011)	Operational
	Number of missed connections at transfer points	Kaparias et al. (2011)	Too specific
Environmental	Municipal waste collected but not recycled	Casal et al. (2005)	Too specific
	Energy environment system	Zhelin (2012)	Unclear
	Right of way requirements	Zhicai et al. (2011)	Unclear
	External influence	Zhelin (2012)	Unclear
	Journey time / reliability Safety traffic efficiency energy efficiency / (environment)	AECOM (2015)	Too many KPIs
Comfort	Working conditions of drivers	Zhicai et al. (2011)	Not measurable

Table 39 Benefit KPIs identified in the literature but not considered in this study

5.2 Detailed results assessment of utilization of KPIs per service type

In this section we discuss in more detail the KPIs used for the ITS services identified in NEWBITS D2.1. These ITS services and their KPIs are categorized based on service type, such that the results of this analysis can be used as input for the assessment of the extent of utilization of KPIs per service type (see Section 4.4).

Deployment KPIs

An overview of the deployment KPIs used for the ITS services identified in NEWBITS D2.1 can be found in Table 40 to Table 43 (distinguished to service type). More detailed information on the KPIs applied for a specific ITS service can be found in Appendix 6.

Type of KPI	ITS service	Specific KPI
Length of the transport network covered by ITS service		
Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)		
Number of network elements (e.g. intersections; highway lanes) covered by ITS service.		
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used.	Oyster card	Number of cards in regular use
Frequency ITS service is used	Fotsis 6. Advanced enforcement	Use of the service
	Oyster card	Number of journeys
Number of end-users of ITS service	Fotsis 6. Advanced enforcement	Percentage of compliance/number of users/number of non-compliants
	Waze	Number of users
	Optibus	number of required drivers
	Oyster card	Reduction in the number of tickets sold
Number of vehicles featuring ITS technology in application area of ITS service	Milano area C	Number of vehicles outside Area
Number of vehicles in application area actually using ITS service	Milano area C	Number of vehicles entering the Area
	Optibus	number of required vehicles
Number of hours ITS service has operated		
Number of visits to website and portals linked to the ITS service		

Table 40 Deployment KPIs for Type 1 of ITS services

Type of KPI	ITS service	Specific KPI
Length of the transport network covered by ITS service		
Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)		
Number of network elements (e.g. intersections; highway lanes) covered by ITS service.		
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used.		

Type of KPI	ITS service	Specific KPI
Frequency ITS service is used	HeERO	Number of automatic/manual ecalls
	Fotsis 1 , 2	Use of the service
Number of end-users of ITS service		
Number of vehicles featuring ITS technology in application area of ITS service		
Number of vehicles in application area actually using ITS service		
Number of hours ITS service has operated		
Number of visits to website and portals linked to the ITS service		

Table 41 Deployment KPIs for Type 2 of ITS services

Type of KPI	ITS service	Specific KPI
Length of the transport network covered by ITS service		
Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)		
Number of network elements (e.g. intersections; highway lanes) covered by ITS service.		
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used.		
Frequency ITS service is used	Fotsis 4	Use of the service
Number of end-users of ITS service	FAMS GPS	Number of users
	Flitsmeister	Number of users
	Automatic passenger counter	Number of passengers
		Variation of passengers
	Fotsis 4	Percentage of compliance/number of users/number of non-compliant
Number of vehicles featuring ITS technology in application area of ITS	SMARTFREIGHT	- Proportion of equipped freight vehicles receiving incident warning within a specified time interval.

Type of KPI	ITS service	Specific KPI
service		
Number of vehicles in application area actually using ITS service	SMARTFREIGHT	- Proportion of equipped freight vehicles receiving incident warning within a specified time interval.
Number of hours ITS service has operated		
Number of visits to website and portals linked to the ITS service		

Table 42 Deployment KPIs for Type 3 of ITS services

Type of KPI	ITS service	Specific KPI
Length of the transport network covered by ITS service		
Length of the transport network equipped with ITS technology (e.g. V2I/V2X communication)		
Number of network elements (e.g. intersections; highway lanes) covered by ITS service.		
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used.		
Frequency ITS service is used	PPA superroute	Number of actual uses
	PPA superroute	Frequency of use
	ZOOF	Number of trips used
	Fotsis 4, 5	Use of service
	Flowpatrol	Number of trips
Number of end-users of ITS service	FAMS VAMS	Number of users
	PPA Adam	Number of applicants
	i-5 Smart Truck Parking	Number of users
	Amsterdam onderweg EVA	Number of downloads and conversion
	Fotsis 5	Percentage of compliance/number of users/number of non-compliants
Number of vehicles featuring ITS technology in application area of ITS service		
Number of vehicles in application area actually using ITS service		
Number of hours ITS	Flowpatrol	The service was available 99.5% of the time

service has operated		Uptime
Number of visits to website and portals linked to the ITS service	PPA superroute	Number of website registrations
	Flowpatrol	Number of downloads
	Amsterdam onderweg EVA	Number of downloads and conversion

Table 43 Deployment KPIs for Type 4 of ITS services

A summary of the findings on deployment KPIs is presented in Table 44. For the different types of general KPIs the number of occurrence is presented, distinguishing between the four different types of services. These results are discussed and interpreted in Section 4.4.1.

KPI Deployment	Type 1	Type 2	Type 3	Type 4	Total
Number of end-users of ITS service	4	0	5	5	**14**
Frequency ITS service is used	2	2	1	5	**10**
Number of visits to website and portals linked to the ITS service	0	0	0	3	**3**
Number of vehicles in application area actually using ITS service	2	0	1	0	**3**
Number of vehicles featuring ITS technology in application area of ITS service	1	0	1	0	**2**
Number of hours ITS service has operated	0	0	0	2	**2**
Number of specific infrastructure hardware (e.g. traffic lights; CCTV cameras) used	1	0	0	0	**1**
Length of the transport network covered by ITS service	0	0	0	0	**0**
Length of the transport network equipped with ITS technology	0	0	0	0	**0**
Number of network elements (e.g. intersections; highway lanes) covered by ITS service.	0	0	0	0	**0**
Total	**10**	**2**	**8**	**15**	**35**

Table 44 Deployment KPIs per type of services

For some of the ITS services other deployment KPIs are applied for the identified services, that cannot be allocated to the general KPIs defined for the purpose of this study (because they are too specific or more operational). An overview is given in Table 45. These KPIs are not considered in the assessments done in this study.

Type of KPI	Service type	Service	KPI
Deployment	Type 2	HeEro	Success rate of completed ecalls using 112
			Success rate of established voice transmissions
			Duration of voice channel blocking
			Duration until location is shown
			Success rate of correct locations
			Success rate of received locations (how many locations are actually shown)
			Success rate of heading information

Type of KPI	Service type	Service	KPI
			Number of cross-border/interoperability tests
	Type 4	FAMS	Acceptance of users
		Flowpatrol	Number of stakeholders
			Number of workers
			Number of fte

Table 45 Other deployment KPIs used for specific ITS services

Benefit KPIs

An overview of the benefit KPIs used for the ITS services identified in NEWBITS D2.1 can be found in Table 46 to Table 49 (distinguished to service type). More detailed information on the KPIs applied for a specific ITS service can be found in Appendix 6.

Benefit	Type of KPI	ITS service	Specific KPI
Safety	Reported perception of safety	Fotsis 6. Advanced enforcement	Change in perceived safety and attention of drivers
	Number of reported accidents	ASPI	Number of accidents
		Fotsis 6. Advanced enforcement	Number of incidents/accidents/severe accidents
		Milano Area C	Number of accidents
	Number of reported fatal accidents		
	Number of reported accidents requiring medical attention	Fotsis 6. Advanced enforcement	Number of incidents/accidents/severe accidents
		Fotsis 6. Advanced enforcement	Number of incidents/accidents/severe accidents
	Costs of safety services		
	Incident response time		
	Number of traffic violations	Fotsis 6. Advanced enforcement	Number/percentage of violations
		Rome Access control	Number of daily violations
		Oyster card	Reduction in fraud
	Average driving speed	Fotsis 6. Advanced enforcement	Change in speed (maximum, mean, deviation)
		Milano Area C	Speed of public transport vehicles
	Average distance of vehicles driving behind each other (vehicle headways)		
Efficiency	Total traffic volumes	Milano Area C	Volume of traffic reduced
			Traffic entering the zone reduced
		Rome Access control	Reduction of entrance flows
		Stockholm congestion pricing	Reduction ex ante/ex post traffic flows.
	Modal split of transport	Congestion charge London	Bus usage was increased by 38%, with 23% more public transport provided, due to there being more space on the roads

Benefit	Type of KPI	ITS service	Specific KPI
			Cycling levels in the Congestion Charging zone increased
		Milano Area C	Number and frequency of bus services
			Frequency of underground service
			Number of bike sharing stations and bikes
	Average journey time	Fotsis 6. Advanced enforcement	Decrease in travel time
			Decrease travel time service users
	Average variability of journey time		
	Predictability of travel times		
	Average delay time	Milano Area C	Congestion reduced
		Fotsis 6. Advanced enforcement	Change in congestion
		Oyster card	Reduction in queuing times at ticket offices
			Reduction in boarding times for buses
	Average journey distance		
	Average traffic speed	See Safety for KPIs related to average traffic speed	
	Average peak hour traffic flow		
	Number of start & stops (e.g. at traffic lights)	Congestion charge London	The proportion of time that drivers spend stationary or moving slowly
	Total capacity of the network	Oyster card	Improvement of the throughput at ticket gates
	Average occupancy level/load factor		
Environmental performance	Level of emissions (CO2 / air pollutants / noise)	ASPI	Reduction of emissions
		FOTSIS 6. Advanced enforcement	Change in fuel consumption/emissions/traffic noise
		Congestion charge London	Reduction of traffic emissions of nitrogen oxides (NOx) and Particulate Matter (PM10)
			CO2 emissions
		Milano Area C	CO2 emissions coming from traffic pollution
			Black Carbon emissions
	Number of times thresholds (e.g. dB thresholds for noise) are exceeded		
	Total external costs of transport	Optibus	efficiency of drivers and vehicles that influence on saving.
	Total traffic and transport volumes	See Efficiency for KPIs related to traffic and transport volumes	
	Modal split of transport	See Efficiency for KPIs relating to the modal split	
	Average fuel efficiency of vehicles		
	Total fuel/energy consumption	FOTSIS 6. Advanced enforcement	Change in fuel consumption/emissions/traffic noise
	Share of renewable fuels in total fuel consumption		

Benefit	Type of KPI	ITS service	Specific KPI
	Number of start & stops (e.g. at traffic lights)	See Efficiency for an overview of KPIs related to start & stops	
	Average occupancy level / load factor	See Efficiency for an overview of KPIs related to average occupancy level/load factor	
	Average traffic speed	See Efficiency for an overview of KPIs related to average traffic speed	
Comfort	Reported level of comfort		
	Reported quality of transport services/infrastructure	Fotsis 6. Advanced enforcement	Change in service level
			User experience (trust, comfort level, expectation, usefulness, desirability, comprehensible)
		Oyster card	Increase passenger level of satisfaction
	Reliability of transport services	Real time passenger information	Accuracy of services
	Quality of travel information provided		
	Level of travel information provided		
	Average journey time	See Efficiency for KPIs related to average journey time	
	Reliability journey time		
	Average delay time	See Efficiency for KPIs related to average journey time	
	Average traffic speed	See Safety for KPIs related to average journey time	
	Perception of waiting time (e.g. at bus stop, in traffic jam)		

Table 46 Benefit KPIs for Type 1 of ITS services

Benefit	Type of KPI	ITS service	Specific KPI
Safety	Reported perception of safety	Fotsis 2	Change in perceived safety and attention of drivers
	Number of reported accidents	SATRE	Reduction of highway related accidents
		SAFECROSS	Reduction of pedestrian accidents
		INTELVIA	% change in the number of reported accidents
		eSEÑAL	% change in the number of reported accidents
		DANTE	% reduction in the number of accidents and degree of seriousness
		C-ITS corridor RWW	Reduction in the number of accidents at road works locations.
		Fotsis 1;2	Number of incidents/accidents/severe accidents
	Number of reported fatal accidents		
	Number of reported accidents requiring medical attention	DANTE	% reduction in the number of accidents and degree of seriousness
	Costs of safety services		
	Incident response time	Fotsis 1; 2	Emergency response time

Benefit	Type of KPI	ITS service	Specific KPI
	Number of traffic violations	SAFECROSS	Reduction of red light violations by pedestrians
	Average driving speed	Fotsis 2	Change in speed (maximum, mean, deviation)
	Average distance of vehicles driving behind each other (vehicle headways)		
Efficiency	Total traffic volumes	Fotsis 2	Change in travel volume(volume, density, capacity
		Fotsis 2	Change in travel volume in bad weather conditions and incidents
	Modal split of transport		
	Average journey time	Fotsis 1, 2	Decrease in travel time
		Fotsis 1, 2	Decrease travel time service users
	Average variability of journey time		
	Predictability of travel times		
	Average delay time	SAFECROSS	Average waiting time of cars
	Average journey distance		
	Average traffic speed	See Safety for KPIs related to average traffic speed	
	Average peak hour traffic flow		
	Number of start & stops (e.g. at traffic lights)	Fotsis 1, 2	Change in congestion
	Total capacity of the network	Fotsis 2	Change in travel volume(volume, density, capacity)
	Average occupancy level/load factor		
Environmental performance	Level of emissions (CO2 / air pollutants / noise)	Fotsis 2	Change in fuel consumption/emissions/traffic noise
		EcoGem	% change in air and noise pollution
	Number of times thresholds (e.g. dB thresholds for noise) are exceeded		
	Total external costs of transport		
	Total traffic and transport volumes	See Efficiency for KPIs related to traffic and transport volumes	
	Modal split of transport	See Efficiency for KPIs relating to the modal split	
	Average fuel efficiency of vehicles	SATRE	fuel reduction for following vehicles at 8m distance
		EcoGem	Electrical energy consumption rate
			Prevention of battery depletion on the move
	Total fuel/energy consumption	EcoGem	% change in fuel consumption
	Share of renewable fuels in total fuel consumption		
	Number of start & stops (e.g. at traffic lights)	See Efficiency for an overview of KPIs related to start & stops	
	Average occupancy level / load factor	See Efficiency for an overview of KPIs related to average occupancy level/load factor	

Benefit	Type of KPI	ITS service	Specific KPI
	Average traffic speed	See Efficiency for an overview of KPIs related to average traffic speed	
Comfort	Reported level of comfort	Fotsis 1, 2	User experience (trust, comfort level, expectation, usefulness, desirability)
	Reported quality of transport services/infrastructure		
	Reliability of transport services		
	Quality of travel information provided		
	Level of travel information provided		
	Average journey time	See Efficiency for KPIs related to average journey time	
	Reliability journey time		
	Average delay time	See Efficiency for KPIs related to average journey time	
	Average traffic speed	See Safety for KPIs related to average journey time	
	Perception of waiting time (e.g. at bus stop, in traffic jam)		

Table 47 Benefit KPIs for Type 2 of ITS services

Benefit	Type of KPI	ITS service	Specific KPI
Safety	Reported perception of safety	Fotsis 4	Change in perceived safety and attention of drivers
	Number of reported accidents	Fotsis 4	Number of incidents/accidents/severe accidents
	Number of reported fatal accidents		
	Number of reported accidents requiring medical attention		
	Costs of safety services		
	Incident response time		
	Number of traffic violations	SMARTFREIGHT	Number of penalty charge notices incurred by freight operators for illegal parking or loading offences
		Fotsis 4	Number/percentage of violations
	Average driving speed	In-TIME	Average speed
		Fotsis 4	Change in speed (maximum, mean, deviation)
	Average distance of vehicles driving behind each other (vehicle headways)		
Efficiency	Total traffic volumes	SMARTFREIGHT	Classified vehicle counts by lorry type, goods type to be measured at locations of interest.
		Fotsis 4	Change in travel volume(volume, density, capacity)
	Modal split of transport		

Benefit	Type of KPI	ITS service	Specific KPI
	Average journey time	In-TIME	Change in travel time on selected routes for both, public transport and private vehicles
		SMARTFREIGHT	Trip journey times for individual lorries, particularly during peak times when traffic data may be of most benefit.
			Average link-specific journey times on key lorry routes, particularly during peak periods.
			Trip journey times for different categories of vehicle or goods. It is hoped that journey times are lower for priority groups.
		Fotsis 4	Decrease in travel time
			Decrease travel time service users
		NY MiM	Travel times
	Average variability of journey time		
	Predictability of travel times		
	Average delay time	In-TIME	Junction waiting time
	Average journey distance		
	Average traffic speed	See Safety for KPIs related to average traffic speed	
	Average peak hour traffic flow		
	Number of start & stops (e.g. at traffic lights)	The connected boulevard, Nice	% decrease in traffic congestion - Reduce traffic congestion
		Fotsis 4	Change in congestion
	Total capacity of the network		
	Average occupancy level/load factor	SMARTFREIGHT	Loading bay occupancy
Environmental performance	Level of emissions (CO_2 / air pollutants / noise)	The connected boulevard, Nice	% change in air pollution (noise, emissions)
			Change in fuel consumption/emissions/traffic noise
	Number of times thresholds (e.g. dB thresholds for noise) are exceeded		
	Total external costs of transport		
	Total traffic and transport volumes	See Efficiency for KPIs related to traffic and transport volumes	
	Modal split of transport	See Efficiency for KPIs relating to the modal split	
	Average fuel efficiency of vehicles		
	Total fuel/energy consumption	The connected boulevard, Nice	% change in power savings
			Reduce energy costs through a more efficient energy management.
		Fotsis 4	Change in fuel consumption/emissions/traffic noise
	Share of renewable fuels		

Benefit	Type of KPI	ITS service	Specific KPI
	in total fuel consumption		
	Number of start & stops (e.g. at traffic lights)	See Efficiency for an overview of KPIs related to start & stops	
	Average occupancy level / load factor	See Efficiency for an overview of KPIs related to average occupancy level/load factor	
	Average traffic speed	See Efficiency for an overview of KPIs related to average traffic speed	
Comfort	Reported level of comfort	FAMS GPS	Reported level of comfort and convenience
	Reported quality of transport services/infrastructure	FAMS GPS	% increase in the quality of service
		Fotsis 4	User experience (trust, comfort level, expectation, usefulness, desirability, comprehensible)
	Reliability of transport services		
	Quality of travel information provided		
	Level of travel information provided		
	Average journey time	See Efficiency for KPIs related to average journey time	
	Reliability journey time		
	Average delay time	See Efficiency for KPIs related to average journey time	
	Average traffic speed	See Safety for KPIs related to average journey time	
	Perception of waiting time (e.g. at bus stop, in traffic jam)		

Table 48 Benefit KPIs for Type 3 of ITS services

Benefit	Type of KPI	ITS service	Specific KPI
Safety	Reported perception of safety	Fotsis 3, 5	Change in perceived safety and attention of drivers
	Number of reported accidents	Fotsis 3, 5	Number of incidents/accidents/severe accidents
	Number of reported fatal accidents		
	Number of reported accidents requiring medical attention		
	Costs of safety services		
	Incident response time		
	Number of traffic violations	Fotsis 3, 5	Number/percentage of violations
		Fotsis 7	Location and number of violations
	Average driving speed	Fotsis 3,5	Change in speed (maximum, mean, deviation)
		GUIADE	Average road speed
	Average distance of vehicles driving behind each other (vehicle		

Benefit	Type of KPI	ITS service	Specific KPI
	headways)		
Efficiency	Total traffic volumes	Fotsis 3	Change in travel volume(volume, density, capacity)
		Fotsis 3, 5	Change in bad weather drives
		GUIADE	Average traffic load
	Modal split of transport		
	Average journey time	Fotsis 3,5	Decrease in travel time
		Fotsis 3, 5	Decrease travel time service users
	Average variability of journey time		
	Predictability of travel times		
	Average delay time		
	Average journey distance		
	Average traffic speed	See Safety for KPIs related to average traffic speed	
	Average peak hour traffic flow	Flowpatrol	Reduction shockwave jams
	Number of start & stops (e.g. at traffic lights)	Fotsis 3, 5	Change in congestion
	Total capacity of the network	Fotsis 3	Change in travel volume(volume, density, capacity)
	Average occupancy level/load factor		
Environmental performance	Level of emissions (CO2 / air pollutants / noise)	i-5 Smart Truck Parking	% change in C02 emissions
		Fotsis 3, 5	Change in fuel consumption/emissions/traffic noise
		Companion	CO_2 reduction
	Number of times thresholds (e.g. dB thresholds for noise) are exceeded		
	Total external costs of transport		
	Total traffic and transport volumes	See Efficiency for KPIs related to traffic and transport volumes	
	Modal split of transport	See Efficiency for KPIs relating to the modal split	
	Average fuel efficiency of vehicles		
	Total fuel/energy consumption	i-5 Smart Truck Parking	% change in fuel consumption
		Companion	Fuel reduction
	Share of renewable fuels in total fuel consumption		
	Number of start & stops (e.g. at traffic lights)	See Efficiency for an overview of KPIs related to start & stops	
	Average occupancy level / load factor	See Efficiency for an overview of KPIs related to average occupancy level/load factor	
	Average traffic speed	See Efficiency for an overview of KPIs related to average traffic speed	
Comfort	Reported level of comfort	FAMS VAMS	Reported level of comfort and convenience
	Reported quality of transport	FAMS VAMS	% increase in the quality of service
		Fotsis 3, 5	User experience (trust, comfort level,

Benefit	Type of KPI	ITS service	Specific KPI
	services/infrastructure		expectation, usefulness, desirability, comprehensible)
		Amsterdam mobile EVA	User experience
	Reliability of transport services		
	Quality of travel information provided		
	Level of travel information provided		
	Average journey time	See Efficiency for KPIs related to average journey time	
	Reliability journey time		
	Average delay time	See Efficiency for KPIs related to average journey time	
	Average traffic speed	See Safety for KPIs related to average journey time	
	Perception of waiting time (e.g. at bus stop, in traffic jam)		

Table 49 Benefit KPIs for Type 4 of ITS services

A summary of the findings on benefit KPIs is presented in Table 50. For the different types of general KPIs the number of occurrence is presented, distinguishing between the four different types of services. These results are discussed and interpreted in Section 4.4.2.

Primary Benefit	KPI	1	2	3	4	Total
Safety	Number of reported accidents	3	8	1	2	14
Safety	Number of traffic violations	3	1	2	3	9
Safety	Average driving speed	2	1	2	3	8
Safety	Reported perception of safety	1	1	1	2	5
Safety	Number of reported accidents requiring medical attention	2	1	0	0	3
Safety	Incident response time	0	2	0	0	2
Safety	Number of reported fatal accidents	1	0	0	0	1
Efficiency	Average journey time	2	4	7	4	17
Efficiency	Total traffic volumes	4	2	2	4	12
Efficiency	Average traffic speed	2	1	2	3	8
Efficiency	Number of start & stops (e.g. at traffic lights)	1	2	2	2	7
Efficiency	Modal split of transport	5	0	0	0	5
Efficiency	Average delay time	3	1	1	0	5
Efficiency	Total capacity of the network	1	1	0	1	3
Efficiency	Average peak hour traffic flow	0	0	0	1	1
Efficiency	Average occupancy level/load factor	0	0	1	0	1
Environmental performance	Level of emissions (CO2 / air pollutants / noise)	6	2	2	4	14
Environmental performance	Total traffic and transport volumes	4	2	2	4	12
Environmental performance	Average traffic speed	2	1	2	3	8
Environmental performance	Total fuel/energy consumption	1	1	3	2	7

Primary Benefit	KPI	1	2	3	4	Total
Environmental performance	Number of start & stops (e.g. at traffic lights)	1	2	2	2	7
Environmental performance	Modal split of transport	5	0	0	0	5
Environmental performance	Average fuel efficiency of vehicles	0	3	0	0	3
Environmental performance	Total external costs of transport	1	0	0	0	1
Environmental performance	Average occupancy level / load factor	0	0	1	0	1
Comfort	Average journey time	2	4	7	4	17
Comfort	Reported quality of transport services/infrastructure	3	0	2	4	9
Comfort	Average traffic speed	2	1	2	3	8
Comfort	Average delay time	3	1	1	0	5
Comfort	Reported level of comfort	0	2	1	1	4
Comfort	Reliability of transport services	1	0	0	0	1

Table 50 Occurrences of benefit KPIs per type of services

For some of the ITS services other benefit KPIs are applied for the identified services, that cannot be allocated to the general KPIs defined for the purpose of this study (because they are too specific or more operational). An overview is given in Table 51. These KPIs are not considered in the assessments done in this study.

Type of KPI	Service type	Service	KPI
Benefit	Type 1	Fotsis 6	Number of conflicting points/dangerous points
			Willingness to pay by service users
			Perceived usefulness of users/policy makers
		Optibus	Operational cost saving
	Type 2	Satre	User acceptance
		Fotsis 1, 2	Percentage of compliance
			Willingness to pay by service users
			Perceived usefulness of users/policy makers
			Reaction aware/unaware vehicles
	Type 3	FAMS GPS	User Acceptance
			% decrease in the amount of unanswered phone calls
			% decrease in booking and dispatch costs
			% increase in service accessibility to users
		SMARTFREIGHT	Percentage of delivery windows missed
			Percentage of illegal use of loading bay
		Connected boulevard Nice	% decrease in parking time.
			% change in parking income
		Ecomove parking	Detection rate (real occupancy/occupancy given by the system)
		Fotsis 4	Willingness to pay by service users
			Perceived usefulness of users/policy makers
			Percentage of compliance/number of users/number of non-compliant
	Type 4	FAMS VAMS	% decrease in the amount of unanswered phone calls
			% decrease in booking and dispatch costs
			% increase in service accessibility to users

Type of KPI	Service type	Service	KPI
		i-5 truck parking	decrease in parking time
		Zoof	Percentage of users following advice
		Fotsis 3.5	Number of conflicting points/dangerous points
			Willingness to pay by service users
			Perceived usefulness of users/policy makers
		Fotsis 7	User expectation perceived
			Usefulness perceived by users
		Amsterdam onderweg EVA	% the users follows advice
		Flowpatrol	Percentage of users following advice

Table 51 Other benefit KPIs used for ITS services

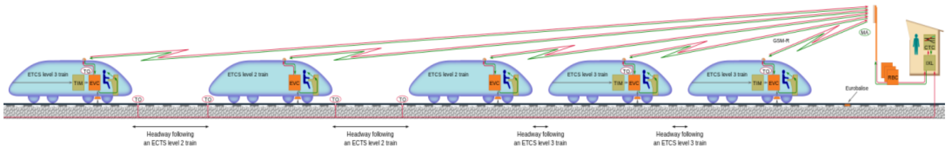
Appendix 6 ITS service fiches

In this appendix, fiches presenting the detailed information collected for the specific ITS services identified in NEWBITS D2.1 are given. The fiches in this deliverable mainly focus on the discussion of barriers, enablers and KPIs. Other information on the services can be found in NEWBITS D2.1.

6.1 Type 1 services

Belfast rapid transit	
Description	
Country	Northern Ireland, UK
Description	Belfast Rapid Transit (BRT) is an innovative and ambitious project that will create a new and dynamic public transport system for Belfast. The system will use high quality rapid transit vehicles which will provide a modern, comfortable environment for passengers in terms of space, security and on-board information. The BRT vehicles will have on-board information screens providing real time journey information and audio visual next halt and destination announcements. Free onboard Wi-Fi will also be provided. The BRT vehicles will be equipped with CCTV for both passenger and driver safety. Also, the halts will provide travel information.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No evidence yet, the system will be operational in September 2018.
Barriers	• Infrastructure issues • Technological issues
Enablers	Availability of people to use the vehicles for their journeys.

Communications based train control	
Description	
Country	Globally. Paris, New York, London
Description	Urban Metro communicates their location directly to the traffic management centre. This allows them to continuously broadcast their location, allowing a more efficient use of the system. Train have safety barriers (blocks) before and after their occupancy. In older systems, this was fixed depending on points that the train passed. CBTC allows these safety blocks to move along with the train. Even controlling metros automatically and thus removing the driver. An example of the system is Bombardier CityFlo
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs have been indicated
Barriers	No barriers have been indicated
Enablers	No enablers have been indicated

European rail traffic management system	
Description	
Country	Global, EU initiative
Description	Standardisation of train management systems. Cooperative system that should allow trains to operate cross border (if track gauges are same) as the communication language is the same. The ERTMS provides standardized rail messages to trains. Using (wireless) communication trains could transmit location, speed, direction and more route information to the traffic centre and other trains. This allows automatically calculations of routes and available track. 
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs have been indicated
Barriers	No barriers have been indicated
Enablers	No enablers have been indicated

Optibus: Ontime & Onschedule	
Description	
Country	Israel
Description	Optimization application, based on new patent pending algorithms. OnSchedule™, powered by Optibize™, plans crew and vehicle assignments using Interactive Schedule Optimization (ISO) methodology. Schedulers compare and evaluate different alternatives, immediately choosing the one that is most efficient and appropriate. Optibus OnTime™, also powered by Optibize™, lets control room operators respond in real time to unplanned incidents or changes, preventing negative implications on passenger service and cost.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	According to the person responsible of this, several KPIs are used to evaluate the solutions. The main performance indicator is operational cost saving - the difference between operational costs of the OnSchedule solution and operational costs of the baseline solution (the baseline solution refers to the schedule used by the customer prior to the use of our solution). There are other few indicators such as: • number of required vehicles and • number of required drivers (that can be compared with the baseline numbers), and • efficiency of drivers and vehicles that influence on saving.
Barriers	The main barrier was the objection from operation people that were afraid to adopt a new technology. The reason for that was not only techno-phobia, but also the concerns that Optibus solutions will eliminate operational jobs or will show that the operation people are doing a bad job.
Enablers	• Efficiency • money saving • user friendly solution • improvement of customer' service were the main enablers.

Oyster card	
Description	
Country	UK (London)
Description	Oyster is a smartcard which can hold pay as you go credit, Travelcard and Bus & Tram Pass season tickets. Use it to travel on bus, Tube, tram, DLR, London Overground, TfL Rail, Emirates Air Line, River Bus services and most National Rail services in London.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	The main performance indicators are: • Reduction in the number of tickets sold (66% reduction between 2003 – 2009) • Reduction in queuing times at ticket offices (40% reduction) • Improvement of the throughput at ticket gates (about 20 people more can pass at a sustained rate through an individual ticket fate at peak times) • Reduction in boarding times for buses (2-3 seconds per boarding reduction) • Reduction in fraud (the percentage of journeys made up by irregular travel has fallen by approximately 2.5% to 1.5% of total journeys made) • Increase passenger level of satisfaction (97-98% of passengers rated it as “like” or “strongly like” in monthly passenger surveys for 12 consecutive months) • Number of cards in regular use (in November 2008, these were over 6 million) • Number of journeys (in November 2008, thirty-eight million journeys were made each week using Oyster cards).
Barriers	No barriers indicated
Enablers	The main enablers are: • general reduction of travelling time and costs for both passengers and operators • automatic protection against loss or theft to any Oyster cards in your account reduction of queuing times and speed up journey times.

Real Time Passenger Information	
Description	
Country	Ireland
Description	Real Time Passenger Information (RTPI) shows when the bus is due to arrive at the bus stop so the journey can be planned more accurately. RTPI is displayed on signs at bus stops and shelters.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	One performance indicator has been explicitly mentioned: this is the level of accuracy of the services. Surveys in June 2013 in Dublin show the system has an average accuracy of 96% of services arriving within 60 seconds of the 'due' prediction. Continued development will further increase the accuracy.
Barriers	Main barriers in terms of effectiveness of the application are: • Operational issues due to traffic congestion or disruptions, accidents, road closure, mechanical problems, etc. that can affect the accuracy of the prediction; • Software and communication issues (faults in the communication between the central server and the on-bus equipment, need of software updates, etc.).

Enablers	An important enabler for the effectiveness of the application is the accuracy of the information provided. That makes journey times more reliable and allow people to plan better their journeys. The experience of real time bus arrival systems in other countries has shown that they can contribute to an increase in the number of people choosing to use the bus.

Scot Rail Smartcard	
Description	
Country	United Kingdom
Description	This is a smartcard that can be used on Scottish Rail services and on the SPT Subway. With a Smartcard there isn't any need for paper tickets as they are all loaded onto a single, reusable card. Several types of tickets are available, depending on the type of travelling. The price is the same than the paper tickets, but some benefits are available only on Smartcard. It's also faster and easier as the tickets can be bought online and there's no need to queue at the ticket office.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs have been indicated
Barriers	The main barriers are: • Moving existing passengers to a different public transport ticket type; Adapt the whole system to the new type of ticket (for example gates, inspector's machine to check the tickets, etc.).
Enablers	The main enablers are: • Reduction of travelling time and costs for both passengers and operators; • Cooperation between rail and subway operators.

VSC-A	
Description	
Country	USA
Description	Determine if DSRC (Dedicated Short Range Communications) @5.9 GHz & Vehicle Positioning can improve upon autonomous vehicle-based safety systems and/or enable new communication-based safety applications. Strong emphasis on resolving current communication and vehicle positioning issues so that the interoperable future deployments of DSRC+Positioning based safety systems will be enabled
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs have been indicated
Barriers	No barriers have been indicated
Enablers	Standardization for Interoperability

Waze	
Description	
Country	Israel origin, globally available and used service.
Description	Community based mapping and navigation service that connects drivers with each other to offer real time information. Available for smartphones it allows users to communicate with each other to form a 'waze community'. This community has its own 'map developers' to generate their maps. Users contribute due to passively reporting floating car data as well as actively by reporting accidents, speed traps, dangerous situations. Due to the accurate navigation and real time traffic information Waze has become a very large player in navigation, especially in countries where not many cars are equipped with navigation systems (Brazil) but the owners do have smartphones. Has total maps in 13 countries, ranging from western (USA, Germany) to developing (Chile, South-Africa)
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of users
Barriers	• Financing for data handling (servers, etc.) • Penetration rate needed for accurate functioning especially for generating the maps
Enablers	• Free downloadable for smartphone • Location based advertising brings in revenue • User based

Access Control in Rome	
Description	
Country	Italy
Description	In Rome the structure of the city and the limited resources in term of mass transit supply requires to limit congestion and traffic environmental impacts as well as the strong need to preserve the historical and archaeological city: Rome decided to implement a series of clean zones with a complex series of actions, according to the guideline provided by the Urban General Traffic Plan (PGTU), now reinforced and enlarged by the Strategic Sustainable Mobility Plan (SSMP), approved in 2010. The turning point was the implementation of the LTZ system with "electronic gates" in October 2001. The system is based on a ANPR procedure as well as the use of OBU connected via DSRL with the entrance gantries. The general idea is to forbid access to cars, increase the supply of Public Transport and increase the number of parking pricing slots along the LTZ cordons. A "White List" of authorized users is defined and constantly updated, so that non-authorized vehicles acceding the zones during the enforcement times are detected by the ANPR system and automatically fined
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Indicators: • reduction of entrance flows, • number of daily violations
Barriers	• Acceptance by people and commercial activities owners • This was the first deploy in Italy ever of such kind of system: it required specific normative development at national level.
Enablers	• Strong communication campaigns, involvement of people in the decision process • Increasing politic commitment

	• Adequate public fundings

Highway network traffic management Autostrade per l'Italia (ASPI)	
Description	
Country	Italy
Description	Autostrade per l'Italia (ASPI) is a motorway operator directly responsible for a network of 2,854 km and it provides systems and services to its sister companies managing approximately further 600 km. Everyday over 4 million drivers use the 3,400 km network managed by ASPI and by the other concessionaires of the Atlantia Group. The system features are such that: Allow operators to manage traffic in the event of incidents, road works and normal day to day activities of motorway operation; Contribute to reducing congestion on the motorway; Improve safety for motorway users and people working on the motorway; Provide accuracy and reliability of the system; Increase comfort and reduce stress for motorway users; Guarantee efficient interoperability with existent systems and flexibility to future upgrades and changes;
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of accidents Emissions reduction
Barriers	No barriers identified but costly fares
Enablers	• Effective operation • Focus on safety

EcoMove Improve traffic flow stability	
Description	
Country	Infrastructure systems gather information about speeds and headways of vehicles in the traffic flow. Based on this information the stability of the traffic flow is judged. Advice on speed and headway is given to drivers in order to improve the stability of the traffic flow and smooth out the speed profiles of the vehicles.
Description	• Avoid frequent heavy braking and acceleration from vehicles driving too close to each other, and thus reduce fuel consumption. • Prevention of shock waves by ensuring that disturbances in traffic flow do not grow in magnitude as they propagate upstream. Indirectly, improve road safety and comfort
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPI's indicated
Barriers	• Advices should be in line with the expectation of the driver to guarantee acceptance and compliance. • Sufficient number of equipped vehicles.
Enablers	No enablers indicated

<table>
<tr><th colspan="2">FOTsis 6 – Advanced Enforcement</th></tr>
<tr><th colspan="2">Description</th></tr>
<tr><td>Country</td><td>1 highway in Greece and 1 highway in Portugal</td></tr>
<tr><td>Description</td><td>This service uses different means and technologies besides the ones currently used to carry out traffic law enforcement. An example is the use of an On Board Unit that measures the maximum speed. Drivers get a warning when they exceed limits and enforcement actions when these warnings are violated. The basis of service is to see how notifications shown to drivers can be enforced. And how these data are managed and stored in the on board unit. Three elements are covered:
• Speed enforcement
• Lane enforcement
• Minimum distance between vehicles

The on board unit sends information towards the traffic centre. The road side infrastructure does the same. It is visible if the vehicle (on board unit) informs the same speed as is currently possible at the stretch of the road. It is than possible to see if the vehicle drives an acceptable speed. Non-compliance could trigger enforcement actions in real time and afterwards. This not only holds for going too fast, also slow drivers have the possibility to impose a lot of danger.</td></tr>
<tr><td>Type of ITS service</td><td>Type 1</td></tr>
<tr><th colspan="2">Assessment of barriers, enablers and key performance indicators</th></tr>
<tr><td>Key performance indicators</td><td>• Number of incidents/accidents/severe accidents
• Change in speed (maximum, mean, deviation)
• Decrease in travel time
• Decrease travel time service users
• Change in service level
• Change in fuel consumption/emissions/traffic noise
• Change in congestion
• Percentage of compliance/number of users/number of non-compliants
• Use of the service
• Change in perceived safety and attention of drivers
• User experience (trust, comfort level, expectation, usefulness, desirability, comprehensible)
• Number/percentage of violations
• Number of conflicting points/dangerous points
• Willingness to pay by service users
• Perceived usefulness of users/policy makers</td></tr>
<tr><td>Barriers</td><td>Main barriers with respect to the deployment of the application:
Deployment
• Very difficult to stimulate under drivers
• Training required for all stakeholders to get used to the system
• The quality and validity of the data is not guaranteed.
Benefit
• The data from the on board unit should match with the other data due to an unique timestamp</td></tr>
<tr><td>Enablers</td><td>Some important enablers are:
• Integration of different data sources
• Integration of infrastructure detection among each other</td></tr>
</table>

Madrid smart parking	
Description	
Country	Madrid (Spain)
Description	The city of Madrid has developed a Sustainable Urban Mobility Plan (SUMP) to promote more sustainable transport in the city and to reduce the use of private cars in favour of more sustainable modes. In the frame of the SUMP, thanks to the parking policy, Madrid is the first city in the world to implement a variable parking rate based on vehicle emissions Those who park on-street pay according to the level of environmental friendliness of the technology of the vehicles (in Euro-class): when a car is parked the driver is asked to submit its licence plate number. This is checked against a reference database that includes the eco-performance of the vehicle. This determines the cost of parking. Madrid shows that a coherent parking strategy can serve different policy goals: air quality, traffic management, energy use and clean vehicle deployment.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated
Barriers	No barriers indicated
Enablers	• adequate public funds • full inclusion into planning agenda

Multi-use lane in Barcelona	
Description	
Country	Spain
Description	In order to develop measures against the uncontrolled growth of private vehicles operating in the City– making goods deliveries more and more difficult – the municipality initiated a project analysing the effects of urban commercial transport on the traffic situation. The most advanced measure is the installation of so called multi-use lanes. Within Barcelona three lanes are used as multi-use lanes installed with VMS technology (variable message signs) which clarifies who is allowed to use the street (residents, clear-way, deliveries) according to the time of the day. Some roads in inner city area are equipped with (VMS). During the day time one lane of the street is reserved for activities of different user groups (parking, loading unloading, traffic flow). The variable message signs show the actual access rights per user group to use the lane. Technically, the approach is realised in such a way that a first VMS shows whether the lane can be used for floating traffic or whether it is dedicated to parking and loading activities. In case the lane is dedicated to parking and loading activities, a second VMS shows the actual allowance for a particular user group.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated
Barriers	Transport operators
Enablers	Progress could only be reached thanks to the strong political will to continue and improve the urban transport situation.

Sensit Nedap parking	
Description	
Country	Netherlands
Description	Wireless ground sensors that measure if parking spots are available. This is communicated towards a central station. This information is then communicated towards drivers. The sensors also measure times, which is used to inform authorities if parking times are exceeded. This product is developed by a private company NEDAP and the service is called Sensit.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators indicated
Barriers	Sensoring during bad weather conditions is difficult.
Enablers	The system is wirelessly updateable

Congestion Charge London	
Description	
Country	United Kingdom
Description	The Congestion Charge is an £11.50 daily charge for driving a vehicle within a specified area of central London during the week (between 07:00 and 18:00 from Monday to Friday). It was introduced by Transport for London (TfL) in February 2003 after an extensive public and stakeholder consultation. It was extended westward in February 2007, but the extension was then removed in December 2010. Paying the Congestion Charge enables motorists to drive in the charging area, leave and re-enter it as many times as required during the day. The drivers have to pay to register their Vehicle Registration Number (VRN) on a database. Cameras read the vehicle's number plates in the charging zone and check these against the database. Once a VRN has been matched, the photographic images of the vehicle are automatically deleted from the database. The daily charge can be paid before or on the day of travel by telephone, text message, online and by post. The payment can also be made via Congestion Charging Auto Pay, an automated payment system that gives a discounted daily charge rate. The drivers who have not paid the charge by midnight on the next charging day after they travel in the zone are issued with a Penalty Charge Notice. Exemptions and discounts are also available to certain categories of vehicles and individuals. By law, net revenue from the Congestion Charge must be spent on further improvements to transport across London.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	The main performance indicators used are: • Congestion reduced by 30%, and the volume of traffic reduced by 15%. • The proportion of time that drivers spend stationary or moving slowly in queues reduced by up to one-third. • Traffic entering the zone reduced by 18%, traffic circulating the zone was reduced by 15%. • Bus usage was increased by 38%, with 23% more public transport provided, due to there being more space on the roads. • Reduction of traffic emissions of nitrogen oxides (NOx) and Particulate Matter (PM10) by 12% in the zone. The impact on the ring road were less than plus/minus 2%. • CO_2 emissions were reduced by 19%, fuel by 20%.

	• Traffic on the ring road surrounding the charging area (where traffic is not charged) showed small reductions in congestion, reflecting better operational management, despite slightly higher traffic flows caused by the charging scheme. • No significant negative impact was identified on business and economy. Cycling levels in the Congestion Charging zone increased by 66%.
Barriers	The main barriers are: • It requires sophisticated technology. • It might incur in higher administrative costs due to chasing up drivers who don't pay or try to avoid.
Enablers	Some important enablers are: • The fact that by law, net revenue from the Congestion Charge must be spent on further improvements to transport across London; • General benefits for the population in the area due to reduced congestion, improvement of transport services, cleaner air, safer roads.

Maut	
Description	
Country	Germany and Austria
Description	Toll system for heavy duty vehicles on German and Austrian Highways and main national roads. The amount of the toll depends on the total distance that is driven by the trucks. On-board registration units capture the total distance driven and the amount of toll. This is collected automatically. Toll amount depends on: • Axles • Euro emission class The plan is to extend the toll for all road vehicles in 2018.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated
Barriers	Not indicated
Enablers	Not indicated

Milano Area C: Low Emission Zone & Charging Scheme	
Description	
Country	Italy
Description	This is a combined Low Emission Zone and urban road charging scheme. The "Area C" is the historical Centre of Milan bounded by the Cerchia dei Bastioni and it is a restricted traffic zone from Monday to Friday from 7.30 to 19.30 (18 on Thursday). This is the only scheme of its kind in Italy. The access points to the area are 43, including 7 for exclusive use of public transport, and are monitored by cameras. The surveillance cameras detect the entering vehicle and transmit the data collected to a computer which recognizes it and the corresponding due charge. To access the area is necessary to buy a ticket (the standard price is €5, but several types of tickets, discounts and exemptions are available); this can be purchased at parking meters, newsagents, tobacconists, ATM points (Milan Transport Company), Intesa Sanpaolo ATMs, online or by phone. In case of non-payment, a penalty is issued.
Type of ITS	Type 1

service	
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Performance indicators used are: • Number of vehicles entering the Area C • Number of vehicles outside Area C • Speed of public transport vehicles • Number of accidents • CO2 emissions coming from traffic pollution • Black Carbon emissions • Number and frequency of bus services • Frequency of underground service Number of bike sharing stations and bikes
Barriers	A barrier to the deployment of the application is political. Area C got a lot of criticism, especially from the right-wing politicians and many protests from the parking owners in the centres.
Enablers	Important enablers are: • Improvement of the quality of life by reducing the number of accidents, uncontrolled parking, noise and air pollution • Decrease of road traffic in the designated area • Improvement of public transport networks • Possibility to raise funds for soft mobility infrastructures (cycle lanes, pedestrian zones, 30kph zones).

Sanef UK Liber-t Automated Toll Payment Service	
Description	
Country	France
Description	Sanef, the French motorway operator, has extended its Liber-t automatic toll payment service to UK motorists. Liber-t is the French national télépéage scheme for light vehicles operated by the members of ASFA, the association of French motorway operators on behalf of the French government. It works on the entire French toll road network and can also be used to pay for parking in some car parks. To use the service, drivers have to register on the dedicated UK website and will receive a small electronic transponder (tag) to attach to the windscreen of the car, just behind the rear-view mirror. When approaching the barriers, a device by the barrier will read the transponder (tag), extract the unique reference of that user and then automatically open the barrier. The barrier has to be approached at walking pace and, when the transaction has been completed, the tag will “beep”, the traffic light changes to green and the barrier opens (on certain lanes it is possible to drive through at up to 30 km/h). Therefore, the user will not need to stop and manually pay the toll. They will receive an invoice and about 15 days later, the payment (in GBP) will be automatically collected from their bank account in the UK via Direct Debit.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No information available.
Barriers	No barriers indicated
Enablers	The main enablers are: • Travelling times are shorter for UK drivers due to avoiding queuing • There is no need to have Euro cash handy to pay tolls • Motorists with right hand drive cars don’t need to lean over or get out the car to pay the

	French autoroute tolls.

Stockholm Congestion Pricing	
Description	
Country	Sweden
Description	In 2006, the county of Stockholm had nearly 2,000,000 residents, of which almost half a million lived in the inner city. Of the approximately 320,000 people employed in the inner city, more than 210,000 of them commuted from outside the inner city. Prior to the congestion charges, the cordon around the inner city (see below picture)was crossed by 530,000 vehicles and 800,000 transit passengers each day. Between March 2003 and February 2004, the Swedish Road Administration, researched, designed and planned an access management system based upon the concept of charging. They tested multiple traffic forecasting models to determine how such charges would impact, among other things, public transit, traffic congestion and air quality. Most models predicted a traffic decrease of about 16%. There was no room on any of the city's bridges to build toll booths, so the idea of individual vehicle transponders linked directly to bank accounts was proposed. Eighteen unmanned electronic control points were established at all entrances into the cordon and the tax was applied on both the entry and exit of the area. For vehicles without a transponder, license plates were photographed using automatic number plate recognition (ANPR) technology and cross-referenced with Sweden's National Vehicle Registry to record the charge.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Operational indicator: reduction ex ante/ex post traffic flows.
Barriers	The main barriers to congestion charging were public and political opposition. The Mayor of Stockholm, for example, made a campaign promise not to introduce congestion charges; one political leader said at the time that congestion charging was "the most expensive way ever devised to commit political suicide." Many feared that: • License plate numbers would be misidentified • People would not know of the need to pay or how to pay the charge, resulting in court appeals or refusals to pay. • The system would favor wealthier, inner city residents and punish lower income people living outside the city. Despite these objections, a trial period was demanded by Sweden's Green Party during the 2002 federal election in exchange for its support for a national social-democratic government.
Enablers	• Large and diffused information campaigning. Large survey of citizens attitude. • Pre operative trial. The Royal Institute of Technology conducted repeated surveys of public attitudes. Public support for the charges was lowest just before the trial, increased dramatically once the trial began and has remained consistently high at roughly 70% thereafter. • New business scheme • Upgrade of ITS infrastructure • Increased attention for sustainable transport

TELEPASS	
Description	
Country	Italy, interoperability with specific motorway networks in France, Spain, Portugal and Belgium (Liefkenshoek Tunnel)
Description	Automatically road tolls at motorway toll gates through a device called Telepass. The automatic toll collection system Telepass uses DSRC technologies which consists of the microwave transmission of data between an in-vehicle device and roadside tolling infrastructure, mainly comprising DSRC gantries installed along the tolled road. The technology can be applied on motorways with open and closed toll systems. Each Telepass gate, whether entering or exiting, is equipped with DSRC technologies that automatically manage transits, maintain the dialogue with the on-board unit device and the connection with the information systems to charge for the transit, according to the logical steps illustrated in the following picture.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Performance indicators not explicitly defined
Barriers	Main barriers with respect to the deployment of the application: • In case of no dialogue between the two components of the Telepass application (OBU and roadside equipment), a special camera takes photograph of the vehicle registration number, in order to trace the author of the transit unauthorized or failed. • In general, the entire transaction takes place in a few tenths of a second, avoiding having to stop. The only constraint is the need to proceed slowly enough to give time to the apparatus to receive the signal and execute the transaction, for which there is a speed limit of 30 km / h during the transit in the Telepass lane.
Enablers	Some important enablers are: The overall operation is simple: when the vehicle equipped with Telepass transits along the special lane at the toll booth, an optical system (CTV) recognizes the type of vehicle and activates the signal through the relative transmitter apparatus. The on-board system responds to the "call" of the device on the ground, retransmitting a unique identification code. The ground unit records the passage of the vehicle identified and gave the order to raise the beam.

TEXpress	
Description	
Country	Texas, USA
Description	TEXpress Lanes are unique toll lanes built within an existing highway. They add additional capacity to the highway to relieve congestion and allow traffic to flow freely. They are adjacent to the general highway lanes, but they have independent entrances and exits. The driver can choose to use the TEXpress lanes and pay the tolls or to drive in the adjacent non-tolled general highway lanes. The price of the TEXepress lanes changes depending on the level of traffic in the corridor to maintain a minimum 50 mph speed of travel. This is different from the traditional toll roads that instead charge the same rate at all times and do not aim to ensure predictable travel times. Roadside equipment monitors real-time traffic conditions and calculates real-time traffic-based rates every 5 minutes throughout the day based upon the average speed and number of drivers who want to use the TEXpress Lanes. Prices may increase or decrease depending on the amount of traffic and the time of the day (prices are lower during non-peak times); the customers are notified of the price they would pay on the toll pricing signs prior to entering any segment of the lanes. The variable pricing aims to ensure a predictable, higher-speed commute. The TEXpress Lanes are all-electronic and cashless. For customers with a Texas tag, toll

	fees are automatically deducted from their pre-paid account. For those who don't have a tag, the video cameras will photograph the vehicle license plate and the North Texas Tollway Authority will send the bill to the registered vehicle owner.
Type of ITS service	Type 1
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No information found.
Barriers	A barrier to the deployment of the application is the fact that revenue-raising measures are never popular, especially in a time of economic stress. However, numerous toll facilities have been approved in the anti-tax environment of recent decades, and opinion polls consistently show that motorists prefer tolls over taxes and support the expansion of toll roads to improve driver options and travel times.
Enablers	The main enablers are: • The whole system is electronic and cashless. TEXpress Lanes automatically charges your Tag account or, if you don't have one, the tolling cameras will photograph the vehicle license plate and then a bill is then sent to the vehicle's owner. As there are no tollbooths, the traffic keeps moving; • The TEXpress Lanes make travelling more reliable and predictable; • Toll roads are generally safer than non-tolled roads due to better maintenance, pavement, and technology. They employ state-of-the-art technology to monitor road conditions and have a financial incentive to keep their roads running as safely and smoothly as possible.

6.2 Type 2 services

Satre (safe road trains) project	
Description	
Country	Intra-European. Consortium with partners from UK, Germany, Sweden and Spain
Description	Road train with truck as leading vehicle, followed by 1 truck and 3 different types of cars. Goal: develop strategies and technologies to allow vehicle platoons. The lead vehicle is driven by a professional driver; several vehicles follow are driven fully automatically by the system with little distance between the vehicles in the road train. An off-board system allowed Sartre drivers to locate a suitable platoon and navigate towards it. The project has analysed the following aspects: safety, fuel consumption, demonstration on different roads, commercial viability and policy advice.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	

Key performance indicators	• Level of deployment
	• Level of effectiveness (close related to the objectives of the application).
	    o 60% of the test drivers accepted the system
	    o 7-15% fuel reduction for following vehicles at 8m distance
	Trained drivers reduce the number of highway related accidents with 50%

Barriers	Discuss the main barriers for the C-ITS application, distinguishing barriers related to:
	• Level of deployment of the C-ITS application
	    o Legislation-> liability after an accident
	    o Toll stations prove difficult for platoons
	    o Some Acceleration and deceleration lanes are too short
	    o Practiced drivers needed to drive the leading vehicle

	○ Lead vehicle has most responsibilities but only limited benefit in fuel reduction -> solution: ▪ Pay fee towards lead vehicle ▪ Taking turns ▪ Other benefits. E.g. using the carpool lane • Effectiveness of the C-ITS application ○ High penetration is necessary to enjoy the benefits ○ Limited practicality for passenger cars ○ Trust in the lead driver and system necessary to automatically drive closely behind a truck without view
Enablers	Discuss the main enablers for the C-ITS application, distinguishing enablers related to • Level of deployment of the C-ITS application ○ There is a positive business case for long haul trucking to employ platooning systems • Effectiveness of the C-ITS application ○ Trained drivers • Benefits to encourage road trains are possible • Carpool lanes

SAFECROSS - Smart Pedestrian Crossing for People with Reduced Mobility	
Description	
Country	Spain (Madrid, Alcalá de Henares)
Description	SAFECROSS aims to develop an intelligent crossing designed for people with reduced mobility, as it provides real-time monitoring of pedestrians' movement. If the traffic controller detects anyone still using the crossing when it is reaching the end of the pedestrians' green phase, the 'green' time is extended until the pedestrian has crossed to the other side. If the crossing is empty when the time is running out, vehicle traffic can proceed, thereby contributing towards streamlining traffic flow. Also, it incorporates the activation of green light demand from the pedestrians' smartphones (Bluetooth) via two Android Apps allowing pedestrians and drivers interact through the deployment of cooperative services I2VRU and I2V. A C-ITS station provides the communication channel WiFi Mobile (802.11p) to vehicles, alerting vehicle drivers of the presence of pedestrians on the crosswalk.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Reduction of pedestrian accidents • Reduction of red light violations by pedestrians Average waiting time of cars
Barriers	the major potential barriers include: • Technical barrier ○ Compatibility: The system used in the Spanish pilot is only SICE's controllers compatible. Differences in traffic culture and traffic management (controller operating algorithms may be different). ○ Technical regulation about green time for pedestrians needs to be updated • Safety and Human factor ○ Users' behaviour/Potential of increasing journey times for car drivers - users' awareness of the application can lead to long waiting times of cars due to non-activation of green light, resulting in slight annoyance of drivers ○ People might be reluctant to use the mobile application to avoid running out of battery ○ Need to have the mobile phone in hand • Acceptance ○ Elderly users could not be familiar with smart phones and this lead to low

	acceptance.
	• Implementation
	  ○ The IPT system using Bluetooth beacons is not compatible with intersections working in pre-fixed mode or without push buttons.
	• Legal barriers
	  ○ Regulation about signal timing changes needs to be updated
	• Privacy
	  ○ The system could collect data on users

Enablers	• Financing • Cooperation among different stakeholders • Implementation across different environments • time horizon for implementation

INTELVIA	
Description	
Country	Spain
Description	INTELVIA is a system of control, signalling and communication to intelligently manage road traffic through C-ITS systems and computer vision. The computer vision solution increases intelligence in traffic management and in decision making from the control centre, allowing the automatic analysis of information and a faster detection of incidents and the management of the road network. Signalling information is stored in electronic road side units (RSU) distributed along the road network. Vehicles interact with these nodes deployed along the roadside. The electronic devices will transmit the signpost information to the nearby vehicles via wireless, to be displayed on the OBU. Different types of information could be transmitted: information about traffic parameters (speed limit and other road signs), route tracking, incidents, tolls, and weather alerts or warnings of approaching emergency vehicles.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	% change in the number of reported accidents
Barriers	• Equipment failure: Failure of communication nodes. • Technological challenge: New equipment is required to provide these services. • Information shown to driver may interfere with driving - HMI - Driver distractions to be avoided. • Security issues: transmitted signals may be altered. • Privacy
Enablers	• Participation of all the actors involved in the value chain including end users • Alternative for replacing ILDs, other technologies such as tags installed in vehicles, or laser scanners that reconstruct the 3D shape of the vehicles, whose installation and maintenance is more cumbersome than using only cameras.

eSEÑAL - Smart System for Traffic Signposting and Information	
Description	
Country	Spain
Description	eSEÑAL is a subproject of CABINTEC that aims to prevent accidents through the development of an intelligent signalling system. The OBU collects both static and dynamic data from the infrastructure Intelligently processes the data. Gives drivers information in advance about traffic signals, traffic congestion, road conditions as well as possible accidents, road work or delays via the OBU installed in the vehicle. The service has been tested in a lorry cab using a simulator.

Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	% change in the number of reported accidents
Barriers	• Connectivity - Multiple signals' reception on OBU – Unimportant signals can overwhelm the driver. • Integration with existing infrastructure
Enablers	• Visibility of road signs under adverse weather conditions. • Physical installation of new road signs or modifications no longer needed.

DANTE - Development and Application of New Technologies for integrated improvement of road safety and intersection design	
Description	
Country	Spain
Description	DANTE aims to develop an innovative system to improve road safety at T-junctions and crossroads on conventional two-lane motorways, where most fatal accidents occur (e.g. the risks of front/side collisions, running into cars pulling out slowly in front for the vehicle on the main road, and the vehicle on the secondary road approaching the intersection too fast and failing to comply with the STOP sign). Stereoscopic cameras detect the trajectory and speed of the vehicle on the main road when it is 80–250 m. from the intersection. A Lidar system detects any other vehicles within 80 m of the intersection, while a Stop-control system detects the speed and trajectory of the vehicle on the secondary road, determining whether it is going to stop. These integrated systems detect what is happening at the intersection by means of a centralized system that analyses data and, if a possible conflict is detected, triggers an alarm to warn the drivers involved. There are two ways of communicating with road users: with variable messages and beacons of different types on the road itself, plus an I2V system on the vehicle, presenting the information on a PDA device.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	% reduction in the number of accidents and degree of seriousness
Barriers	• Readiness of the road infrastructure to support the application • Detection under adverse weather conditions and during night-time hours • Visibility of the variable message panel if vehicle is not equipped with PDA • Integration with existing infrastructure
Enablers	• Advanced detection of possible occurrences of accidents • Stakeholder cooperation

EcoMove 6.3 Improve Lane Usage	
Description	
Country	European project
Description	Vehicles broadcast information about their position, speed, heading, etc. while they approach an (controlled) intersection, ramp metering installation or toll gate. Based on the actual queues, the control scheme and the approaching vehicles, the best distribution of vehicles over the available lanes is calculated. Next, individual vehicles are allocated to specific lanes and vehicle drivers are informed whether they should continue the same lane or not.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Vehicles undergo less braking and accelerating manoeuvres. The green waves are much better tuned with respect to both driving directions.
Barriers	• Advice should be in line with expectation drivers • Traffic safety must be preserved
Enablers	No enablers evidenced

EcoMove 6.2 Coordinate traffic controllers	
Description	
Country	European project
Description	While approaching a sequence of traffic light, vehicles periodically broadcast information about their position and speed. Together with detector and traffic light data from traffic light controllers a roadside unit processes the information and forwards it to a traffic control centre. The traffic control centre computes green wave control parameters and distributes them to traffic light controllers to enable coordination between controllers. Next, the road side unit computes speed advices based on the current traffic light control and sends the advices to the drivers. When following the speed advice, the vehicle drives smoothly through the green wave section.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Vehicles undergo less braking and accelerating manoeuvres. The green waves are much better tuned with respect to both driving directions.
Barriers	• Road users might not be willing to drive in line with the speed recommendations, especially if the recommended speed is too low. • An ecoGreenWave that is too dynamic might cause significant loss of capacity through unduly frequent switching of local control programs. • If there are no dynamic information signs at the road side, optimal instruction of the drivers can only be achieved with a sufficiently high percentage of equipped vehicles.
Enablers	No enablers indicated

EcoMove 6.3.1 Improve intersection control	
Description	
Country	European project
Description	Vehicles report to the intersection how they approach the intersection such that the intersection can determine when they enter or exit conflict zones on the intersection, when they pass the stop line, etc. Based on these the controller determines an optimal distribution of green times and tighter, less conservative green, yellow and red times. Information with respect to the estimated time at which vehicles will be able to pass the stop line is sent to the vehicles.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Considering CO2 optimisation, green allocation should be fair and within acceptability boundaries. • Green times should be reasonable given local guidelines and customs. Time related information should not change too often to prevent negative side-effects
Barriers	No barriers indicated
Enablers	No enablers indicated

EcoMove 6.3 Balance intersection control objectives	
Description	
Country	European project
Description	Vehicles report to the intersection controller about their approach of the intersection such that the intersection can build a detailed representation of demand. Starting from a basic intersection control plan (see use cases Improve intersection control), the controller now integrates priority schemes for specific vehicles and platoons and allows flexible sequences for traffic light control to find a best balance between changing demands. As suggested by other use cases, vehicles approaching the controlled intersection will be informed with speed and time related information.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated
Barriers	• The overall benefits may not come at unacceptable costs for some individuals • The safety of the intersection must not deteriorate
Enablers	No enablers indicated

EcoMove 6.3 Improve Ramp control	
Description	
Country	European project
Description	Vehicle report to the ramp controller about their approach of the ramp metering installation such that the ramp controller can build a detailed representation of the traffic demand on the on-ramp. The conditions on the mainstream (i.e. motorway) and upstream urban controlled intersections are monitored through infrastructure sensors and other roadside units. Near saturation on the mainstream and based on the mainstream, onramp and upstream conditions, the ramp controller determines a strategy that best fits the design of the on-ramp and balances the current demands and overall objectives. This may affect the control scheme, the queuing process as well as the driving behaviour of approaching vehicles. The latter is strongly related to information provisioning to drivers as discussed in other use cases.
Type of ITS	Type 2

service	
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Vehicles undergo less braking and accelerating manoeuvres. • Green waves are much better tuned with respect to both driving directions.
Barriers	• The overall benefits may not come at unacceptable costs for some individuals. • The safety of the intersection must not deteriorate
Enablers	No enablers indicated

eCoMove Support merging	
Description	
Country	European project
Description	By using roadside sensors and collecting ecoFVD (floating vehicle data) an infrastructure system monitors traffic flows at merging points on their traffic volumes, density, relative speeds of vehicles and following distances. Using vehicle trajectory data the number of lane changes at merging sections is estimated. First the overall traffic flow performance in terms of flow, speed and density is optimised which results in general speed and headway advices while approaching the merging point. In this process, the importance of the different traffic flows is carefully weighted. Next, near the merging point advices will be adapted to the number of mergers at that time, while the mergers themselves receive individualised recommendations for their speed and merging instant. Right after the merging point drivers will receive an advice that stimulates them to accelerate in order to best use the available road capacity
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators indicated
Barriers	• Safety, best represented by following distance (headway), should be guaranteed at all times. • Merge advices should be in line with gap acceptance. • Balancing traffic flows and so prioritizing traffic should be within acceptability thresholds and clear to drivers. • Negative side effects affecting other performance indicators should not exceed the benefits of obtained from better merging.
Enablers	No enablers indicated

EcoMove 6.3.5 Improve approach velocity	
Description	
Country	European project
Description	Vehicles broadcast information about their position, speed, heading, etc. while they approach an (controlled) intersection, ramp metering installation or toll gate. Based on the actual queues, the control scheme and the approaching vehicles, the best distribution of vehicles over the available lanes is calculated. Next, individual vehicles are allocated to specific lanes and vehicle drivers are informed whether they should continue on the same lane or not. In the figure below this use case is illustrated for a vehicle that approaches an intersection. The green vehicle is directed to the best lane for it to follow, given its destination, the queue length and the expected speed of outflow for each lane
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated

Barriers	No barriers indicated
Enablers	No enablers indicated

CACC - Cooperative Adaptive Cruise Control in Real Traffic Situations	
Description	
Country	USA
Description	Adaptive cruise control (ACC) systems can gain enhanced performance by adding vehicle-vehicle wireless communication to provide additional information to augment range sensor data, leading to cooperative ACC (CACC). CACC was designed, developed, implemented in production cars and tested in real-traffic scenarios (to compare to existing ACC systems).
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Implementation of the CACC system in 4 vehicles - Validation of the (i) performance of the controller, (ii) its improvements vs. the commercially available ACC systems
Barriers	• Communication system reliability (technical issues) • Response delays destabilizing following vehicles (traffic instability) • Drivers comfort with regards to time-gaps between vehicles (user acceptance) • Drivers willingness to give control to the system (user acceptance[7]) Low-level controllers (throttle, brake pedals) could not be modified (interoperability and compatibility with new systems)
Enablers	• Incentives for drivers (increased safety, reduced congestions, reduced travelling time, enhanced comfort driving) associated with additional information available from vehicles ahead of immediately preceding vehicle Good acceptability of commercially available ACC (basis for CACC)

CITI Australia	
Description	
Country	Australia
Description	Collision warning system test which aims to learn more about the challenges of deploying CITS and to better understand the implications for road infrastructure and all road users.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• This service is transferable • Vehicles are able to transmit and receive successfully • Collision alerts are successfully generated Drivers report collision warnings are accurate
Barriers	• Current embargo on 5.9 GHz frequency • No permanent licencing solution from Australian Communications and Media Authority • Difficulty of installation of OBUs into heavy vehicles with regards to antennae, cable and screen placement • GPS positioning inaccuracies • Harsh terrain

[7] Further reading on CACC – Human Factor Analysis: https://www.fhwa.dot.gov/publications/research/safety/13045/13045.pdf

Enablers	• Exception of embargo for test purposes (1st step to proof benefit) • Yearly scientific licence granted by ACMA for CITI pilot deployment

C-ITS Corridor: Road Works Warning	
Description	
Country	The Netherlands
Description	The Road Works Warning service aims to inform drivers about road works ahead. The warnings are transmitted using a secure short-range ETSI G5 (WiFi-p) connection and the 3G/4G mobile telephone network. Roadside beacons send a warning message to the traffic information centre. This information is made available to service providers who offer related services to drivers over the mobile network (3G/4G). Road users using these services receive a message about 3 kilometres before they reach the road works, containing information about the exact location of the road works. With help of WiFi-P technology information on the road works is sent directly to vehicles equipped with WiFi receivers and shown on their navigation screens. This may include information on the (adjusted) speed limits, lane availability, etc. The service has been tested on a small scale (two test locations with a very limited number of passenger cars) on the national highway (A16 and A58) in the Netherlands.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Only one performance indicator has been explicitly defined: Reduction in the number of accidents at road works locations.

Barriers	Main barriers with respect to the deployment of the application:
	• Judicial barriers:
	  o Is it allowed to share car location data?
	  o How to ask for permission from car drivers?
	  o Who is responsible if an accident happens due to incorrect information provided by this supplication?
	Main barriers with respect to the effectiveness of the application
	• Technical barriers, mainly related to the presentation of the message:
	  o Message shown differently by different systems
	  o Arrows and emergency/'plus lane' incorrectly shown
	  o DENM insufficient and limiting
	• Standardization
	  o Counting of lanes (inside out vs outside in)
	• Human factor: what messages should be shown in-car and when does it get to much
	How to measure the effect with Low penetration level

Enablers	Some important enablers are: • International cooperation: the pilot is part of the Cooperative ITS Corridor project, in which road managers and industrial partners in the Netherlands, Austria and Germany are testing C-ITS applications. This cooperation provides access to much relevant knowledge and technical support. • Leading role of government entity: as there is no business case for this application yet, an initiating role of government entities is necessary. • Availability of necessary infrastructure: road infrastructure with beacons and wifi-sensors was available, providing the opportunity to apply this pilot.

C-ITS Corridor: Probe Vehicle Data	
Description	
Country	Netherlands
Description	The probe vehicle data service aims to collect anonymous data from vehicles about road conditions and journey details at the stretch of road on the Dutch part of the 'C-ITS Corridor'. Examples of data being measured are speed, position on the road, braking power and the current weather conditions. The goal of this information is to allow road operators to create a more accurate image of the road. This information than can be used for multiple purposes, a.o. providing real time traffic warnings, performing adequate road maintenance and better analysing traffic flows. This service has been tested on a small scale on two national highways with a limited number of passenger cars (2) in the Netherlands.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicator has been explicitly defined
Barriers	Main barriers indicated are in the areas of security & privacy but have not further been discussed.
Enablers	Two enablers indicated are • International cooperation: the pilot is part of the Cooperative ITS Corridor project, in which road managers and industrial partners in the Netherlands, Austria and Germany are testing C-ITS applications. This cooperation provides access to much relevant knowledge and technical support. • Leading role of government entity: as there is no business case for this application yet, an initiating role of government entities is necessary.

Automatic dependent surveillance- broadcast	
Description	
Country	Global
Description	Technology to allow airplanes to broadcast their position, flight information and weather conditions. This information is sent to flight control centres as well as other airplanes. Mandatory in portions of Australian airspace, Required in US in 2020 for some planes. Mandatory in Europe from 2017 onwards. New satellite will allow full coverage and prevent planes 'getting lost'. Technique shows: Traffic: altitude, heading, speed and distance to other aircrafts. Weather Flight Information (restrictions for example)
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No barriers indicated
Barriers	No enablers indicated
Enablers	No barriers indicated

Secure Transport Communication based on TETRA (HOGIA)	
Description	
Country	Sweden, UK
Description	HOGIA system helps bus companies to improve the efficiency of communication between traffic management and bus drivers. Based on TETRA technology, Hogia can link up traffic

	management systems to national radio communication systems. This provides buses with a stable, user-friendly radio system and creates a safer, less stressful working environment for staff. Traffic managers can create communication groups based on bus routes or departure times, without the need to track down call numbers for individual buses or drivers. Traffic controllers can also call individual buses directly. Bus drivers can also use the same features in order to contact each other.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	As this is a newly launched project (December 2016), there is little information available
Barriers	As this is a newly launched project (December 2016), there is little information available
Enablers	• Implemented on TETRA platform (an EU standard for trunked radio system) which allows interoperability and deployment across EU countries • Service relies on tested and demonstrated traffic management system (Rakel) already deployed in public services, for example, groups based on specific police units or ambulances within a particular geographical area

Vx-TINFO	
Description	
Country	USA
Description	Weather Response Traffic Information System (Wx-TINFO) project's purpose is to design a system that brings together near- time environmental/weather-related data collected from both fixed and mobile data sources. Fixed: • Road Weather Information Systems (RWIS) Stations. • National Weather Service (NWS) Stations. • NWS Radar. • NWS Warnings (text) Mobile: • Integrated Mobile Observations (IMO) Project Fleet Safety Pilot Model Deployment Project Fleet.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs identified
Barriers	Potential barriers can be find into legal framework
Enablers	No enablers identified

Queue Warning (Q-WARN)	
Description	
Country	USA
Description	The application concept aims to minimize or prevent impacts of rear-end or secondary collisions by utilizing I2V and V2V communication to detect existing queues and/or predict impending queues; and communicate advisory queue warning messages to drivers in advance of roadway segments with existing or developing vehicle queues. The Q-WARN concept reflects an operational environment in which two essential tasks are performed: queue determination (detection and/or prediction) and queue information dissemination. In

	such an environment, the Q-WARN application may reside in the vehicle or within an infrastructure-based entity, or utilize a combination of both. The queue warning messages may either be communicated by the infrastructure-based entity using I2V communication or broadcast by vehicles that are in a queued state to nearby vehicles and infrastructure based entities. It is important to note that the Q-WARN application concept is not intended to operate as a crash avoidance system (e.g., like the forward collision warning safety application). In contrast to such systems, Q-WARN will engage well in advance of any potential crash situation, providing messages and information to the driver in order to minimize the likelihood of a crash avoidance or mitigation actions later. As such, Q-WARN-related driver communication will always give priority to crash avoidance/mitigation safety applications when such applications determine that a safety-related alert is necessary.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs identified
Barriers	No barriers identified
Enablers	No enablers identified

OCTO U	
Description	
Country	Italy, UK, Spain, France, US
Description	Octo Telematics is an Italian company, whose headquarter has been recently shifted to London, with offices in US, France and Spain. The company was founded in 2002, pioneering the use of telematics in the car insurance sector. Octo applies proprietary algorithms to this market to deliver information into driver risk, informing solutions that benefit both auto insurance companies and drivers. In 2015, a new Octo U app was launched. The app Octo U uses telematics technology to monitor and score driver behaviour, measuring speed, braking intensity and acceleration. Drivers who obtain the satisfactory score of 7.5 and above are then rewarded with the service of submitting their score to a panel of insurers for a quote discount of up to 10%, which they can choose to accept at their discretion. The app key algorithm is based on GPS point-retrieving technology to gather journey information and ranking each trip based on factors such as speed, breaking and acceleration, OCTO U also takes into account outside variables often directly affected by weather, such as road and traffic conditions, to determine driver scoring. For example, in the UK, drivers with good scores are rewarded with the service of a discounted insurance. The Octo company is in advanced discussions with insurance partners to launch this model in a growing number of international markets.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Performance indicators not explicitly defined
Barriers	Main barriers with respect to the deployment of the application: • Privacy issues • Use of personal data for marketing purposes
Enablers	Some important enablers are: • Octo U is available as a free download for iPhones and Android devices on Google Play, Apple app store and Amazon Kindle store • Auto stop and start function requires no driver interaction and makes it easy to record trips • Insights into driving behaviour • Practical hints and tips on how to improve • Discounted insurance premiums for good drivers

	• Benefits of telematics in a smartphone format

HeERO	
Description	
Country	Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Finland Germany, Greece, Luxembourg, Italy, Spain, The Netherlands, Turkey, Romania, Sweden
Description	The project will prepare, carry-out and coordinate 112 eCall pre-deployment pilots at EU level considering common EU standards. As soon as the eCall device in your car senses a severe impact in an accident, it automatically initiates a 112 emergency call to the nearest emergency center and transmits it the exact geographic location of the accident scene and other data. With the same effect, eCalls can also be made manually, at the push of a button. This is convenient if, for instance, you become witness of an accident. Whether the call is made manually or automatically, there will always be a voice connection between the vehicle and the emergency call center in addition to the automatic data link. This way, any car occupant capable of answering questions can provide the call center with additional details of the accident.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	The study has indicated 30 performance indicators, of which several are recommended: • Number of automatic/manual e-calls • Success rate of completed e-calls using 112 • Success rate of established voice transmissions • Duration of voice channel blocking • Duration until location is shown • Success rate of correct locations • Success rate of received locations (how many locations are actually shown) • Success rate of heading information • Number of cross-border/interoperability tests

Barriers	A deliverable focusses on the enablers and barriers. This are the summarised main barriers.
	• Policy level barriers
	  ○ EU regulation covers only radio communication
	  ○ No regulation on the implementation by mobile network operators
	  ○ Liability for OEM not clear if system doesn’t function
	  ○ Procurement is too complex for safety answering points.
	• Barriers at business and economic level
	  ○ Who finances mobile network expansion
	  ○ eCall imposes extra costs for OEMs while the service is free
	  ○ Who finances extra costs for Safety answering points.
	• Barriers at technology level
	  ○ Mobile network has some capability issues
	  ○ There is no minimum set of requirements about the in car system yet
	  ○ How to integrate eCall into the current system
	• Standardisation
	  ○ Too many standards for safety answering points.
	  ○ A centralised approach is necessary to get devices that work among each other

Enablers	The enablers have been documented extensively. The main enablers are:
	• Policy level
	  ○ Regulation about minimum requirements would increase reliability
	  ○ Mobile Network operators should be forced to implement, or minimum network coverage (main roads)
	  ○ Responsibilities for OEM if eCall system fails
	  ○ Tenders to select the best technology providers

	• Business and economics o Clarification funding for network aspects o OEMs could offer functions that combine with eCall o Procurements are too complex for safety answering points: difficult to get good partners o Standardisation is necessary to necessary to guarantee fair competition ▪ Enablers at technology level o Call routing should be tested and accurate. Especially at border areas. o LTE/4G uses a different technology as eCall (2g/3g) o New technologies are necessary to combine eCall with existing emergency systems ▪ Standardisation o Sms could back up eCall but is less time efficient o An overview that summarises existing standards

FOTsis 1 emergency management service/extended eCall	
Description	
Country	Tested in Spain and Greece on stretches of highways
Description	An extended emergency call (eCall) system that bring fast assistance to motorist through: An emergency message send via the smartphone of the driver towards the public safety answering point (PSAP) Existing road side infrastructure detects an accident (loops, CCTV). The road side managers than informs the public safety answering point. Both measures aim to reduce the notification times necessary for accidents. After an incident, the road operator and emergency vehicles will be notified if necessary. Furthermore, other road users will be informed after an accident occurs. Emergency vehicles are equipped with a tablet pc that informs, recommends and communicates with the PSAP. Furthermore, vehicles could be equipped with a mobile router to manage communication with the On Board Unit of a car and the traffic control centre. This project, as well as FOTsis in general is aimed towards a well-functioning infrastructure/i.e. the. Backoffice.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of incidents/accidents/severe accidents • Decrease in travel time • Decrease travel time service users • Change in congestion • Percentage of compliance • Use of the service • User experience (trust, comfort level, expectation, usefulness, desirability) • Emergency response time • Reaction aware/unaware vehicles • Willingness to pay by service users • Perceived usefulness of users/policy makers
Barriers	**Deployment** • Low number of vehicles with eCall equipment installed • There are parts of EU highways without mobile network reception • Large number of different Public Safety Answering Points (PSAP) among different nations **Benefit** • Low number of vehicles with ecall equipment installed • Only well-equipped highways can provide information about accidents via eCall • Limited length eCall messages
Enablers	No enablers have been specifically mentioned

FOTsis 2- Safety incident management	
Description	
Country	Spain, two stretches of highway
Description	F-SIMS provides real time information to drivers in order to warn them against risks or critical situations that have been detected by the road infrastructure. Warnings include Congestion and other incidents Recommended travel speed Difficult driving conditions due to observed or forecasted weather Information is gathered by the Highway Control Centre operator through roadside equipment.: Automatically detected via infrastructure systems Congestion via loop detection Bad weather via meteorological sensors HCC operator will assign the alert back through road side infrastructure or via smartphone.
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of incidents/accidents/severe accidents • Change in speed (maximum, mean, deviation) • Decrease in travel time • Decrease travel time service users • Change in travel volume(volume, density, capacity) • Change in fuel consumption/emissions/traffic noise • Change in travel volume in bad weather conditions and incidents • Change in congestion • Percentage of compliance • Use of the service • Change in perceived safety and attention of drivers • User experience (trust, comfort level, expectation, usefulness, desirability) • Emergency response time • Reaction aware/unaware vehicles • Willingness to pay by service users • Perceived usefulness of users/policy makers
Barriers	Main barriers with respect to the deployment of the application: **Deployment** • There are parts of EU highways without mobile network reception **Benefit** • Only well equipped highways can provide relevant information
Enablers	No enablers have been specifically mentioned

EcoGem - Cooperative Advanced Driver Assistance System for Green Cars	
Description	
Country	Italy, Turkey, Germany
Description	Taking into account the limited energy storage capabilities and recharging time of fully-electric vehicles (FEVs), EcoGem aims to design and develop an FEV-oriented Advanced Driver Assistance System (ADAS) equipped with suitable monitoring, learning, reasoning and management capabilities to automatically manage battery charging, energy saving, and route planning (that will help increase the FEV's autonomy and energy efficiency)
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	

Key performance indicators	• Electrical energy consumption rate • Degree of autonomy • Prevention of battery depletion on the move • % change in fuel consumption • % change in air and noise pollution
Barriers	• Standardisation for interoperability – Interoperability of multiple components with different vendors • Readiness of charging infrastructure • Cost of technology and constraints on raw materials • User acceptability (predominantly depends on electrical energy management and the corresponding degree of autonomy that can be offered) • Cost of FEVs
Enablers	• Concern for fuel/energy efficiency, autonomy of FEVs and the reduction in $C0_2$ emissions • On-time application for the full market deployment of FEVs

EcoMove SP3 – ecoSmartDriving	
Description	
Country	European project
Description	Ecosmartdriving exist out of a combination of several services that reduce inefficiencies for passenger cars that influence fuel consumption. Several-ITS services to reduce emissions are introduced, For instance: • Control vehicle condition (tyre pressure) • EcoUse of vehicle (no airco, seat heating) • Support EcoDriving In & off board feedback on Economic driving behaviour
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators indicated
Barriers	• EcoMove is competitive to existing institutions and public acceptance could be an issue • Human reaction required → do people follow advice? • Sub-systems interactions. An efficient truck planning could be influenced by C-ITS traffic lights who give priority to other vehicles. • User acceptance and penetration • Privacy preservation issue for drivers • Real time exchange is difficult technologically speaking
Enablers	No enablers indicated

EcoMove SP3 – dynamic navigation	
Description	
Country	European project
Description	Ecosmartdriving exist out of a combination of several services that reduce inefficiencies for passenger cars that influence fuel consumption. • Planning ecoTrip • Dynamic ecoNavigation • Dynamic ecoGuidance
Type of ITS service	Type 2
Assessment of barriers, enablers and key performance indicators	
Key performance	No KPIs have been indicated

indicators	
Barriers	• EcoMove is competitive to existing institutions and public acceptance could be an issue • Human reaction required → do people follow advice? • Sub-systems interactions. An efficient truck planning could be influenced by C-ITS traffic lights who give priority to other vehicles. • User acceptance and penetration
Enablers	No enablers have been indicated

6.3 Type 3 services

European Real Time Traffic Information (Co-Cities)	
Description	
Country	UK, Spain, Czech Republic, Austria, Belgium, Germany, Italy
Description	Co-Cities focused on providing one standardized interface between city traffic information and the Traffic Information Service Providers, the In-Time common interface. The availability of the full "feedback loop" enables an end-to-end testing and validation process for the single traffic information service in the cities and elaborates the future expansion steps for cities and service providers. The core service provided by Co-Cities being Interoperable and multimodal RTTI services to end-users, offered by Traffic Information Service Providers (TISPs).
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No barriers indicated
Barriers	No enablers indicated
Enablers	No barriers indicated

eBrio+ (VIX)	
Description	
Country	Australia
Description	Vix Technology has been designing, delivering, operating and maintaining some of the world's leading transit ticketing systems for the past 30 years. The VIX portfolio includes innovative smart booking, ticketing and secure payment systems. eBrio+ is an integrated, multi-modal, multi-operator and multi-media closed-loop ticketing solution. This ticketing solution can manage multiple transport operators and a variety of fare payment media including contactless magnetic cards, paper tickets and smartphone apps. Vix eBrio+ is implemented as a complete end-to-end fare collection system including devices and back office systems.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs have been indicated
Barriers	No barriers have been indicated
Enablers	No enablers have been indicated

Multi Modal International Journey Planning system (Enhanced Wisetrip)	
Description	
Country	UK, Netherlands, Finland, Italy, Spain, Greece, China, Brazil.
Description	Building on the knowledge developed in the **WISETRIP** project, **Enhanced WISETRIP** aimed to improve the possibilities for individual planning, booking and making multimodal journeys. The system is designed to take into consideration all user needs, multiple trip criteria, environmental impact and personal preferences using ITS services in real time covering: Bus, Coach, Rail, Ferry, Flights etc. In real time.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs have been indicated
Barriers	No barriers have been indicated
Enablers	No enablers have been indicated

Testing GPs, GPRS to assist the development of Demand Responsive Transport services in real time (FAMS)	
Description	
Country	UK (Scotland) and Denmark
Description	Testing how GPS, GPRS, could assist development of Multi Modal Transport Solutions using Travel Dispatch Centre to broker solutions between users and multi modal supply chain. Contact centre takes bookings from individuals and stakeholders to provide multi modal solutions using ITS platform to send information to/from vehicle to allow real time services to operate in the most cost effective manner. GPS, GPRS was used to track vehicles and allocate trips in real time to vehicles within pilot area. Reduction in duplication of resources, maximising use of resources to meet known demands.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of users • Acceptance of users • % increase in the quality of service • % decrease in the amount of unanswered phone calls • Reported level of comfort and convenience • % decrease in booking and dispatch costs • % increase in service accessibility to users
Barriers	• Stakeholder cooperation • Slow change in user transition from traditional interfaces • Poor technical documentation • Poor mobile phone coverage • Service promotion and explanation
Enablers	• Demonstrated end-user and personnel acceptance • Development of innovative organizational platforms • Adaptation of existing DRT management tools for interoperability within an e-Business collaborative environment allowing co-operation amongst transport service suppliers and the operation of a new service value chain • A centralised operational model where all the B2B services are managed by a single agency control room. • Reduction in total operating costs per revenue hour (Increase in revenue)

On Vehicle CCTV Systems	
Description	
Country	Global solutions
Description	Passenger security and driving surveillance using UMTS / WLAN. Video cameras installed inside and outside bus to monitor passenger behaviour and other road users.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	NO KPIs are identified
Barriers	Possible barriers are: • Management of this sort of infrastructure and its health without introducing extra maintenance checks • Reliability (knowing if the vehicle CCTV is operational on a day-to-day basis) • Costs associated with the recovery of DVR hard drives • Time burning and distributing CD's / DVD's for Police or solicitors • Spares (Investment in stock for replacement / spare hard drives) • Technology (cost, time and complexity of setting up multiple wireless networks) • Security (Ensuring wireless networks are secure and safe to connect to company infrastructure) • Complexity (Multiple software applications to manage different CCTV systems)
Enablers	The main enablers are: • Safety and Comfort of Passengers and Staff • Possibility of monitoring vehicle

Enhanced Real Time Traffic API (TIMON project)	
Description	
Country	Germany, Spain, Italy, UK, Hungary, Slovenia, Belgium, Netherlands
Description	TIMON aims to deliver a framework of services to all users of the transport ecosystem – drivers, vulnerable road users, and businesses. Enhanced Real Time Traffic API is on service offered. An amount of services will be gathered in an API that can be used to improve functionalities of other smartphone applications focused on enhancing road transport efficiency, such as car sharing applications, Electro Mobility services. The application will be capable of providing highly accurate predictions on traffic congestion based on ITS and open data. This service is also intended for business-oriented applications, such as fleet management companies (logistics companies, postal services, etc.), requiring a reliable estimation of the time delay on the selected route.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Not indicated yet as project is starting
Barriers	Not indicated yet as project is starting
Enablers	Not indicated yet as project is starting

Flitsmeister	
Description	
Country	Netherlands origin. Services (partly) available in all EU countries.
Description	Real time traffic information application with over 1 million users in the Netherlands. Originally aimed at providing location of speed traps via user reports. Currently more functions have been used and the service is integrated with other service operators. The main functions are (mobile) Speed traps and traffic jam. Secondary functions included are

	reports of: • Accident • Stationary vehicle on the road • Object on the road • Congestion • Road works • Slippery roads • Bad road conditions • Wrong-way driver • Mist/ bad visibility Users can report these situations, and this will be displayed to other app users. Services are expanding The Netherlands, providing real time information for 7 other European countries. The app is currently available inside Tesla vehicles. The app uses voice messages and audio to alarm drivers. This allows the app to run in the background which reduces battery dependency and reduces the change to distract drivers.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Number of users
Barriers	Application programming interface turned out to be expensive as number of users grew
Enablers	Deployment • User experience • Application should be an addition • Partnerships with relevant parties (radio stations) • Free basic service Benefit • User experience

In-TIME	
Description	
Country	Austria
Description	Multimodal Real Time Traffic and Travel Information (RTTI) services are seen as strategic measures for drastically reducing energy consumption in urban areas across the different modes of transport, by changing the mobility behaviour (modal shift) of the individual traveller from car to more sustainable means of collective transport. This change of traveller behaviour will result in less pollution and CO2emissions, less particle emissions, and less noise. In-Time aims to address these challenges by implementing and piloting an ICT infrastructure to facilitate the deployment and delivery of Multimodal RTTI services for drivers and travellers in European cities. In-Time aims to deploy and validate and innovative pan-European approach to Real Time Traffic and Travel Information (RTTI) services, largely based on ICT and ITS European standards, enabling the interoperability of information and services between local data/service providers, end-user Travel/Traffic Information Service Providers (TISPs) and across European cities.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Change in travel time on selected routes for both, public transport and private vehicles. A specific test-route has been selected in Bucharest. Change in travel time is one indicator that has been monitored, before and after the implementation of the system, on the selected ODs.

	• Junction waiting time (the reduction in delay for public transport vehicles or private vehicles at a junction expressed as a percentage of the normal delay at the junction). • Average speed
Barriers	• Still in pilot phase / no commercial validation yet • Business rules not yet clarified • Need for certification either by EU, or dominant market player • Current In-Time standard / data structure (trying to integrate a lot of existing formats and approaches) may be too complex, inflexible and slow (high overhead) • Formal standardisation of third party data aggregation may hamper further innovation and flexibility • Major promotion required towards local data owners to adopt preferred standards Incremental growth of local adopters, city per city, player per player – requires a driving force. • Decentralised approach induces risk of performance • No connection between cities yet available
Enablers	• Cost efficient approach for access and real-time use of third part data and services • Technical maturity - Demonstrated for wide scale of mobility services - Data models based on existing standards - International dimension (6 cities involved already in demo phase) • Results feeding into EU and EU ITS action plan realisation - Well known and accepted approach, maybe subject to further EU incentives / regulations - Fully supports intermodal transports - Aim for European standard of data and service delivery • Open back-office platform • Decentralised and scalable: European wide service market • Potential for distributed industry answer to Google mobility services

PROBEIT Foresight Vehicle	
Description	
Country	United Kingdom
Description	The ProbeIT project aims to build and demonstrate a system that will both allow dynamically changing information from traffic authority databases to be transmitted to vehicles, and for sensor data from vehicles to be received back and processed. The work was undertaken in 3 phases of integration: Non-dynamic data flow phase involved the collection of underlying map data to be used in the digital maps for navigation; The dynamic data flow phase involved production of data concerning speed limits, parking, dynamic navigation, real-time speed/traffic information; The final floating vehicle application phase concerned advanced probe vehicle information such as road works or air bag alert
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Indicator tables have been created to record the results of the evaluation of each component in the ProbeIT data chain and the overall ProbeIT system. The tables are further subdivided by the type of assessment: • Technical: where the indicator relates to a capability or functionality of the system. • Driver: where the indicator relates to the perceptions of the end-user. • Network Manager: where the indicator relates to the opinions of the information provider and transport network manager.
Barriers	The main barriers are: • The complex nature of the server setup and data integration algorithms • Different formats of all the sources • Need of further development by manufacturers, commercial service providers and traffic authorities in particular, in order to attain a sustainable system data collection,

	processing and delivery process for ITS applications.
Enablers	The main enablers are: • Cooperation between several stakeholders with different types of skills. • Leading role of the government in both funding the project and providing a view on potential benefits of such a system and how traffic regulation data can be integrated.

Smartfreight	
Description	
Country	Norway
Description	This project aimed to make urban freight transport more efficient, environmentally friendly and safe through smarter use of the distribution networks and improved delivery and return-load systems. The basic idea was to integrate urban traffic management systems with freight management and on board systems.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	- Trip journey times for individual lorries, particularly during peak times when traffic data may be of most benefit. - Average link-specific journey times on key lorry routes, particularly during peak periods. - Classified vehicle counts by lorry type, goods type to be measured at locations of interest. - Trip journey times for different categories of vehicle or goods. It is hoped that journey times are lower for priority groups. - Proportion of equipped freight vehicles receiving incident warning within a specified time interval. - a. Percentage of delivery windows missed b. Loading bay occupancy c. Percentage of illegal use of loading bay d. Number of penalty charge notices incurred by freight operators for illegal parking or loading offences
Barriers	• Less accurate than manual collection (80 -95 % compared to 90 and 95% for manual) • Hardware malfunction • Data processing and analysis • Steep learning curve of implementation (regarding adjustments of software) • Data validation
Enablers	• Cheaper than manual collection • Collect on every trip • Higher level of data with better quality

SmarTrAC	
Description	
Country	USA
Description	SmarTrAC is an innovative smart phone application that collects highly-detailed activity and travel behaviour data with minimal user burden, providing a compelling alternative to the traditional diary-based method typically used to collect individual travel and activity information. Key features: It automatically detects and classifies daily activity and travel episodes using smartphone GPS and accelerometer data. It allows users to view, correct, and augments the automatically detected and classified information. It provides annotated and aggregated activity/trip details.

Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Not indicated
Barriers	Not indicated
Enablers	Not indicated

Automatic Passenger Counting Systems	
Description	
Country	Global
Description	Counting passengers on/off bus allows operators to manage resources to meet demands. APC systems are electronic machines that count the number of passengers that board and disembark at every bus stop. Together with AVL systems, they form the two most important technologies that every transit system should have. In systems that have them, they replace the schedule checkers that previously collected ridership information manually. APC allows informed decisions about where people are riding, and when they are doing it. This is critical information for making service changes, establishing budgets, securing funding, and responding to changing ridership patterns.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of passengers • Variation of passengers
Barriers	• Less accurate than manual collection (80 -95 % compared to 90 and 95% for manual) • Hardware malfunction • Data processing and analysis • Steep learning curve of implementation (regarding adjustments of software) • Data validation
Enablers	• Cheaper than manual collection • Collect on every trip • Higher level of data with better quality

The connected boulevard, Nice	
Description	
Country	France.
Description	Manage and optimize all aspects of city management, including parking and traffic, street lighting, waste disposal and environment quality.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• % decrease in traffic congestion - Reduce traffic congestion • Reduce energy costs through a more efficient energy management. • % decrease in parking time. • % change in parking income • % change in air pollution (noise, emissions) • % change in power savings
Barriers	• Garner cooperation from lower-level city management personnel • Infrastructure (hardware, software, equipment) ownership and management by the city • Amount of the city budget available for future phases or expansion

	• Lack of demonstrated quantifiable benefits associated with environmental monitoring • Efficient use of captured data to provide real time information to end users • Security and privacy
Enablers	• Employs open architecture (computing and network platforms) system that allows addition of new technologies and projects in the future • Political backing from city mayor • Availability of funds - allocations from the city's overall budget • Elimination of departmental silos (silo management) within city government through (i) Coordination across governing bodies required to implement the projects, and (ii) a common architecture and systems framework across departments • Validation of collaborative multi-stakeholder alliance and business model • Cost savings

Departure Planning Information	
Description	
Country	United Kingdom
Description	The Transport Systems Catapult's Departure Planning Information (DPI) Programme is carried out in cooperation with the Civil Aviation Authority (CAA) and the National Air Traffic Services (NATS). The programme is rolling out real-time flight departure technology at airports across the UK. Fully integrated with the European flight information network EuroControl, DPI allows air traffic controllers to provide real-time information about the departure of aircraft, which in turn enables EuroControl and National Air Traffic Control Centres to make much better assessments regarding the arrival times of those aircraft.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	The information found does not explicitly mention performance indicators. However, it indicates that the DPI software enables more efficient management of any flight due to the real-time accuracy of the data. The software has: - Introduced huge improvements in take-off time accuracy - Increased safety and efficiency - Make the aircraft be where they need to go on time. Moreover, airline and airport professionals have noticed that DPI has made a considerable difference to the efficiencies of their systems: - Less time spent absorbing delays in the air - Increased on-time performance - Reduction in runway occupancy times - Major decrease in aircraft holding times. All this lead to the following benefits assessed at around £40 million: - Reduced passenger delays - Reduced fuel consumption - Reduced noise pollution - Reduced carbon emissions Improved air space efficiency.
Barriers	The main barrier is the lack of the software in some airports: the whole system should work better if the software is installed in as many airports as possible, especially in airports which are connected with flights.
Enablers	The main enabler to the deployment of the application is the cooperation with the European flight information network EuroControl and the National Air Traffic Control Centres: DPI allows air traffic controllers to provide real-time information about the departure of aircraft, which in turn enables EuroControl and National Air Traffic Control Centres to make much better assessments regarding the arrival times of those aircraft. Sharing the information between the relevant stakeholders involved is crucial for the whole system to work.

EcoMove Improve Network Usage	
Description	
Country	European project
Description	When driving in a road network, vehicles share information on their origin and destination to road side systems. By including data on green ratios and cycles times from local traffic controls, traffic state and fuel consumption data from the EnergyMap, and emission data from emission models, an optimal route distribution is computed for all origin-destination relations using specific cost and objective functions.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators indicated
Barriers	• Possible trade off between the objective functions • Origin-destination relations need to be known • Insufficient information on the traffic state due to the lack of sensing possibilities • For integration in a simulation model, the model must be able to simulate the local traffic control of eCoMove, features of cooperative systems, and must be able to reroute vehicles dynamically. • For integration on a test sites, data sources have to be accessible online and data from non-eCoMove entities must be comprehensive to uarantee sensible test results.
Enablers	No enablers have been mentioned

EcoMove Parking	
Description	
Country	European project. Tested at three France highways
Description	Improve parking guidance by providing real time information on the location of available parking spaces and dynamic routing to available parking facilities considering network state, events and current levels of pollutants. This should make finding a parking spot more efficient for road users, which reduces the stain on the traffic system. Which benefits the road operator. Road operators are aware of free parking spaces and want to advise vehicles about parking opportunities.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Detection rate (real occupancy/occupancy given by the system)
Barriers	• User acceptance and compliance • Quality of parking data from facilities • System should take into account that trucks are limited in their routing options. • Driving and resting regulations truck drivers
Enablers	No enablers mentioned specifically

Fotsis 4 - Dynamic Route Planning	
Description	
Country	Germany 3 highways and 1 highway in Spain

Description	The goal of this service is to manage traffic via dynamic route recommendations for predefined network meshes. Infrastructures generate information that provides a detailed overview of the traffic and weather situation. Based on current and forecasted traffic an optimal route is generated/altered to give a best service. The service provides a route recommendation. This improves road safety, comfort and reduces emissions. Reroutes have the costs that traffic at alternative roads is increasing. Data is collected from road side sensors and other equipment. Furthermore, data is collected from passing vehicles (position/speed). Historic data about input traffic, capacity of network, turning rates, and more is used to estimate the optimal routes given current traffic and weather conditions.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of incidents/accidents/severe accidents • Change in speed (maximum, mean, deviation) • Decrease in travel time • Decrease travel time service users • Change in travel volume(volume, density, capacity) • Change in fuel consumption/emissions/traffic noise • Change in congestion • Percentage of compliance/number of users/number of non-compliance • Use of the service • Change in perceived safety and attention of drivers • User experience (trust, comfort level, expectation, usefulness, desirability, comprehensible) • Number/percentage of violations • Willingness to pay by service users • Perceived usefulness of users/policy makers
Barriers	Main barriers with respect to the deployment of the application: **Deployment** • GPS guidance systems can not deal with route guidance through dynamic traffic information. (regular navigation does not account a football game that is scheduled to start in two hours, which is increasing the amount of traffic) • Permission to use road side data **Benefit** • Highway control centres have additional information regarding traffic and congestion compared to private companies (Google, Waze, ..). Therefore this service should be able to provide better advise. • Alternative routes are not always equipped with measurement systems. Is the rerouting credible? • Weather conditions on alternative routes is often unclear. How does the traffic react there.
Enablers	Some important enablers are: • Integration of different data sources. • Integration of infrastructure detection methods to a single data stream.

Lanes management in USA	
Description	
Country	USA
Description	In USA, by using lane management the following strategies can be implemented • regulate demand • separate traffic streams to reduce turbulence, and • utilize available and unused capacity. Examples of operating managed lane projects include high-occupancy vehicle (HOV) lanes, value priced lanes, high-occupancy toll (HOT) lanes, or exclusive or special use lanes. Each of these concepts offers unique benefits; therefore, careful consideration is given to project

	goals and objectives in choosing an appropriate lane management strategy or combination of strategies. Project goals may include increasing transit use, providing choices to the traveller, or generating revenue. The following figure is a diagram that captures the potential lane management applications that fall into this broad definition of "managed lanes." On the left of the diagram are the applications of a single operational strategy—pricing, vehicle eligibility, or access control:
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Not indicated
Barriers	Not indicated
Enablers	Not indicated

New York's Midtown in Motion (MiM) adaptive traffic signal control system	
Description	
Country	New York City (USA)
Description	Midtown in Motion is the congestion management system implemented in July 2011 for improving mobility and reducing delays due to traffic congestion in Midtown (New York). The program was completed in September 2013 and it included 210 microwave sensors, 56 traffic video cameras and 48 E-ZPass RFID readers at about 10.000 intersections to measure traffic speeds. The database of traffic demand was used to generate a two-level strategy: at one level, an 'algorithm of adaptive control' would respond to real-time traffic flow data, adjusting green-time signal phasing to anticipate build-ups of congestion; at a second level, TMC operators would respond to discrete incidents with appropriate action such as activation of pre-determined signal phasing, or requesting response from New York's Police Department. Midtown in Motion, the TMC, and ASTCs are some of the results of the nearly $300 million DOT has invested in traffic management tools and advanced technology across the city.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Barriers	Travel times
Enablers	NA
Key performance indicators	Potential enablers can be stated due to generic literature regarding the kind of technology deployed in NY: • Presence of adequate funding. Usually various cities cites "a lack of funding" as the principal reason why they were not more effective in traffic management applications. • Presence of adequate resource: lack of experts and HR resource can be a fact that hampers the achievement of good results • Presence of senior understanding: many Traffic Managers around the world stated that they felt that traffic management was not a significant enough priority for their city authority, thus producing insufficient outcomes. These enablers are the same of other similar ITS services.

Piedmont Regional Traffic Operation Centre: Traffic Supervisor
Description

Country	Piedmont Region (Italy): the system covers all the region (36.000 Km)
Description	The traffic supervisor centre is the heart and the head of the Regional traffic operation centre of Piedmont Region; it gathers real time information (provided by traffic sensors, floating car data and road operators) to feed its traffic model and forecast traffic for the next hour. The Supervisor is based on a traffic model that using origin and destination matrix and a graph describing the road network is able to estimate traffic conditions. The model is feed with real time measurement (traffic flows, speeds) in order to increase the reliability of traffic estimation and forecast.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Not indicated
Barriers	Not indicated
Enablers	Not indicated

Traffic Information System Romania	
Description	
Country	Romania: all national routes, motorways and Bucharest's main thoroughfares
Description	TrafficGuide - Real-time Traffic Information System for Romania has been a project developed by Electronic Solutions SRL and co-funded by European Union with European Fund for Regional Development. The project aim has been to develop a real-time traffic information system for Romanian Motorways, National Roads and Bucharest Area, monitoring a total of around 80,000 kilometres of road. The data gathered is compared, validated, harmonised and merged. The data sources are dynamically weighted during the harmonisation process to facilitate adaptation to local circumstances. Thanks to these solutions, it is possible to provide traffic managers with a comprehensive picture of speed, traffic densities and congestion across their traffic network.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Not indicated
Barriers	Not indicated
Enablers	Not indicated

Urban Traffic Control (UTC) London	
Description	
Country	England
Description	London has one of the largest integrated traffic signal systems in the world. There are 4.800 sets of traffic signals and all are owned and operated by Transport for London. Of these, 2,800 are controlled centrally directly by the UTC system, allowing the signal phasing timings to be controlled directly by the London Traffic Control Center and by Transport for London traffic signal engineers. Some 1300 sets of traffic signals are controlled by central computers systems that use a dynamic, real time demand responsive management systems. This adjust the operation of the traffic signals on a second by second basis. Vehicles detectors buried under the road surface, monitor the volume of traffic and levels of congestion and change the signal timings to optimise the road capacity. The systems use the SCOOT algorithm developed by the

	Transport Research Laboratory. The dynamic SCOOT approach provides significant improvement over the alternative “Fixed Time” approach and there is a continuing programme to extend SCOOT use. 500 sets of traffic signals are on fixed time and the relevant timing plans can be implemented remotely using computer control systems. These plans are derived7 through traffic modelling techniques. They vary according to the time of day and day of week and are designed to take in account of “expected” traffic conditions. Plans can be altered by the London Traffic Control Center operation staff, usually drawing on a growing library of pre-defined plans developed to meet a range of operational scenario. When significant incidents take place, or there are preparations for major events, traffic signal control engineers will develop new plans to meet the specific circumstances.
Type of ITS service	Type 3
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	NA
Barriers	NA
Enablers	Potential enablers can be stated due to generic literature regarding the kind of technology deployed in London: • Presence of adequate funding. Usually various cities cites “a lack of funding” as the principal reason why they were not more effective in traffic management applications. • Presence of adequate resource: lack of experts and HR resource can be a fact that hampers the achievement of good results • Presence of senior understanding: many Traffic Managers around the world stated that they felt that traffic management was not a significant enough priority for their city authority, thus producing insufficient outcomes. These enablers are the same of other similar ITS services.

6.4 Type 4 services

Virtual Agency Model Service (FAMS)	
Description	
Country	Scotland, Italy
Description	The objective of the FAMS (Flexible Agency for Collective Demand Responsive Mobility Services) Trial Project was to scale up technology, services and business models currently adopted in DRT and to support the evolution from single DRT applications towards the concept of a Flexible Agency for Collective Demand Responsive Mobility Services. FAMS has innovated solutions for DRT planning and operation by the implementation and trial of the Flexible Agency. Existing DRT management tools have been adapted and made interoperable within an e-Business collaborative environment allowing cooperation amongst transport service suppliers.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of users • Acceptance of users • % increase in the quality of service

	• % decrease in the amount of unanswered phone calls • Reported level of comfort and convenience • % decrease in booking and dispatch costs • % increase in service accessibility to users
Barriers	• Stakeholder cooperation • Slow change in user transition from traditional interfaces • Poor technical documentation • Poor mobile phone coverage • Service promotion and explanation
Enablers	• Demonstrated end-user and personnel acceptance • Development of innovative organizational platforms • Adaptation of existing DRT management tools for interoperability within an e-Business collaborative environment allowing co-operation amongst transport service suppliers and the operation of a new service value chain • A centralised operational model where all the B2B services are managed by a single agency control room. • Reduction in total operating costs per revenue hour (Increase in revenue)

Interoperable Fare Management Project – IFM	
Description	
Country	The partners involved in the project were based in United Kingdom, Germany, Belgium and France.
Description	In 2006, the French, German and UK based national interoperable transport organisations, who with many others across the world had been working together to write the International Standard on IFM (ISO EN 20014), came together to propose a project to the European Commission relating to IFM. Its main objective was to provide travellers with common styles of contactless media throughout Europe which can be used for multiple transport products in different geographic areas and for sustainable modal switching, such as the use of 'Park and Ride', unlike existing smart cards which are restricted to specific city or regional geographies. The project expected to significantly lower the barriers to mobility and encourage the use of public transport, contributing to a reduction of carbon emissions and a reduction or elimination of paper tickets, thus further enhancing the impact of smart media on environment and on the efficiency of public transport.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	According to the Project Coordinator, no formal performance indicators were used other than numbers of PT schemes attending IFM Forum meetings.
Barriers	According to the Project Coordinator, the main barriers were: • Abundance of Proprietary Solutions that were not interoperable and required separate smartcards to run each scheme; aim has been to create Open Specifications (leading to CEN and ISO Specifications). • Differences between Payment and Ticketing were not clear. There was no clear linkage (or interfaces) between Journey Planning, Payment, Ticketing and Real Time Information.
Enablers	According to the Project Coordinator, the main enablers were: • Collective agreements between the three main countries (France, Germany and UK) to adopt open and common Specifications allowing media issued in one country to be accepted in another and to phase out proprietary elements. • Common interface specifications between Journey Planning, Payment, Ticketing and Real Time Information are seen as critical. • The production and successful demonstration of a single smartcard with applications loaded for UK, France and Germany was a major Proof of Concept milestone. • The Project was also able to publish common lists of Actors and Use Cases that have subsequently been validated by other administrations such as APTA (for the US) and Japan Railways and Codes of Practice. This agreement between operators has now extended to include performance criteria (such as operating distance between card and

	reader, transaction timings etc.). • Having a single spokesperson for Public Transport (the Smart Ticketing Alliance, the on-going outcome of the EU-IFM Project) rather than many individual PT schemes has been a major success factor and has allowed formal Liaison Agreements to be forged with bodies such as GSMA (representing the Mobile Networks), NFC Forum (representing handset manufacturers), Global Platform (representing the standards body for smartcard operating systems and application management). The outputs of the EU-IFM Project have been used to create a number of CEN and ISO Standards (e.g. ISO 24014-3) and Technical Specifications (e.g. CEN TS 16794).

EcoMove Sp4 Freight - EcoTRIP	
Description	
Country	European project
Description	SP4 of EcoMove aims to reduce fuel use of trucks by several cooperative and non-cooperative solutions. Cooperative solution are included in EcoTrip, an environmental based trip planner using: • Efficient planning based on emissions with use of real time information • Active guidance of drivers based on navigation that combines fuel use and travel time and providing fuel efficient advise by a coaching system. • Driver evaluation based on post trip analysis on defined performance criteria • Truck authorization based on quality of trucks (zoning)
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators indicated
Barriers	• EcoMove is competitive to existing institutions and public acceptance could be an issue • Human reaction required → do people follow advice? • Sub-systems interactions. An efficient truck planning could be influenced by C-ITS traffic lights who give priority to other vehicles. • User acceptance and penetration
Enablers	No enablers indicated

I-5 Smart Truck Parking	
Description	
Country	USA
Description	Truck drivers are faced with a critical shortage in truck parking due to a dramatic growth in commercial vehicle truck travel on US nation's roads. A fatigued driver that must drive to search for a parking place can become not only a roadway hazard but an environmental hazard because they generate unnecessary diesel emissions. In this project, sponsored by FHWA (Federal Highway Administration), TSRC (Transportation Sustainability Research Center) is partnering with Caltrans to explore possible roles for Intelligent Transportation Systems (ITS) in alleviating the truck parking problem. The I-5 corridor in California will serve as a test bed for the use of ITS technologies to determine parking availability at participating truck stops. This information, as well as truck stop amenities and the opportunity to make a reservation, will be transmitted to commercial vehicle drivers. This suite of information may allow truckers to better plan and to operate more efficiently when they can by-pass a full truck stop and go directly to one that has space available. ParkingCarma and NAVTEQ are assisting TSRC with the parking availability, reservations, truck stop amenities, and routing. The information may be collected and disseminated through a variety of means including sensors, the Internet, mobile phones, changeable message signs, and radio.
Type of ITS service	Type 4

Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of users • % change in C02 emissions • % decrease in parking time • % change in fuel consumption
Barriers	• Working with privatized infrastructure on experimental ideas • Unwillingness to pay (truck drivers) • Security and privacy • Connectivity (signal interference) • Educate truckers • Illegally parked trucks
Enablers	• Stakeholder cooperation (Government, Universities, Private Sector) • High acceptance by truck drivers and carriers • Support from State government • Environmental and health legislation on the reduction of diesel exhaust emissions from truck idling • Scalability

Mobility 2.0	
Description	
Country	11 partners from 7 countries: Slovakia, France, The Netherlands, UK, Italy, Spain, Greece
Description	The project developed an integrated approach to enhance the catch up of the use of fully electric vehicles (FEV). The integrated approach has implied that the application developed by Mobility2.0 has utilised co-operative systems to simultaneously consider the bottlenecks undermining the FEV use, so that an overall optimisation in the use of FEV has been achieved. Mobility2.0 has focused on assisting the daily urban commute, which represents the bulk of urban mobility in order to compensate for the limited autonomy range
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators have been explicitly defined
Barriers	Some bugs had been detected during the testing phase of M2.0. In some case these bugs has direct and total dependency of third parties. Mainly these third parties can´t provide the information (e.g. dynamic information for Barcelona and Reggio Emilia).
Enablers	• Integration of other trip related dynamic information data such as weather in order to enhance the prediction • to increase performance and responsiveness of component, some improvements in Charging Planner functionality, based on advanced caching mechanisms

Parckr Cooperative truck parking	
Description	
Country	Informing Truck users about actual (via cooperative system in app) and predicted/future availability of parking spots. This allows drivers to better adjust driving times and reduces the necessity of dangerous parking. It uses historical data, real time traffic data and reported availability by other truck drivers. The service uses a mobile application called Parckr. About 2000 Benelux parking places are included. Available in France, Dutch, German, English and Polish.
Description	• Increasing efficiency as drivers can find the best suitable parking place on their route • Increases safety as there will be less dangerous parking as drivers are better informed. Furthermore, they do not have to park on parking places considered dangerous.

	Increase comfort of drivers. Less stress about finding a suitable parking place, less worries about driving times.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators indicated
Barriers	Two barriers have been indicated • No willingness to pay truck drivers • Service depends on the number of app users
Enablers	One enabler was that no measurement systems have been used. This allowed the application to be affordable.

Praktijkproef Amsterdam ADAM application: cooperative travel app	
Description	
Country	Netherlands
Description	Mobile application like superroute app but designed by a different consortium and in a different year. The application provided real time information about people who are entering/ exiting Amsterdam during rush hour especially. Information is gathered using floating car data (FCD) from app users and other sources available for road managers. App provides following advice: • Pre tip information • Optimal route/ alternative routes • Travel times • Parking information • Congestion • Real time information and push up messages in the case of relevant changes. App users can send voicetweet to traffic centres about relevant conditions. The app enables users to make the best choices before and during their trip. It is aimed at commuters who are familiar with the possible routes.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Two indicators that measure the deployment are indicated: • 20.000 downloads • 10.000 applicants
Barriers	Deployment • Registration is necessary, which reduces the number of participants • Instability of data from Traffic centres (NDW) which reduces the reliability of the service • Approaching companies for possible applicants is not successful. Personal approach is more successful. Benefit • High expectations of mobile applications as mobile applications in general have reached a high quality • Users do not 'appreciate' small benefits of the app -> normal congestion is anticipated and accepted • Availability of accurate congestion data for all roads. • Inability to show benefits due to low penetration rate -> no spreading of traffic possible • Many users use the App only in the beginning of the trip • Accurate advice/location is key in a good user experience. No advice better than

	wrong advice. • Penetration to low for effective database/portal
Enablers	Deployment • Enthusiastic and cooperative stakeholders • Media attention results in curiosity with the public

Praktijproef Amsterdam (PPA) –Superroute app: Real time travel advice	
Description	
Country	The Netherlands
Description	Supperroute is a mobile application for smartphones that provides real time information for people who are entering Amsterdam. Information is gathered using floating car data (FCD) from app users and other sources available to road managers. The mobile application provides following advice: • Departure time • Optimal route • Travel times • Navigation • Speed limit • Congestion • Real time information and push up messages in the case of relevant changes Before the first use users have filled in a questionnaire which determines a type of traveller: comfort, speed, reliability and adventure. Based on this types different routes are advised. Furthermore, in the case of a change in route due to for example a closed route, different users get different advises. This reduces the change of a congested secondary/alternative road.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	

Key performance indicators	Several indicators that measure the deployment are indicated:
	• 28.000 registration on website
	• 21.428 actual downloads
	• 19.865 actual uses
	• 956.832 trips of which 16.000 could be analysed
	  ○ 15% of the users uses the application weekly
	  ○ 30% every two weeks
	  ○ 55% sometimes
	
	A survey has measured the score

Barriers	**Deployment**
	• Difficult to get suitable data from the application
	  ○ The telephones have an inaccurate location
	  ○ People use broad locations e.g. city center and it is not clear when the trip has ended
	  ○ People close the app during operation
	  ○ People do not close the application after trip
	• Long preparation time until the app was running
	  ○ App functionality required time
	  ○ Time consuming coordination of stakeholders
	Benefit
	• 50% ignores advice from the app
	• Application has mixed user reviews
	• Precision of location is inadequate
	  ○ Especially at parking facilities
	• There is no coordination between services that offer real time travel advise. To offer spreading of traffic more coordination is needed. If more applications use real time traffic data overall efficiency is higher.

	• Applications should be used structurally to have an impact on the traffic flow
Enablers	• Participants informed/recruited via (physical) mailing. Addresses where collected based on license plate registration from road surveillance in Amsterdam. Addresses have been provided from the Dutch road authority based on the license plate registration. • Participants have been recruited via third party navigation/traffic application Flistmeister. This turned out to be successful in attracting participants. • Participants look for services that are integrated into a single mobile app. Thus offering a combination of different functions (navigation, congestion warning, speed limits, etc.)

ZooF : cooperative traffic information mobile app	
Description	
Country	Netherlands
Description	Zoof is a mobile application that provides smart advice to reduce traffic jams. It is intended to be used as a secondary screen next to navigation. The purpose of Zoof is to provide real time information about the road that is used. Zoof uses the 3g/4g network to receive information. The information includes: optimal speed, merging advice and distance in traffic jams.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	

Key performance indicators	Several performance indicators that measure the success of the deployment have been indicated:
	• Number of App Downloads
	• Number of trips used
	• Number of collected reward “Zoof” points
	    o Number of partners
	    o Places to spend points
	Deployment
	• Percentage of users following advice (80+%)

Barriers	• The business model is on barrier. Currently transport management is paid via general budgets. Individual users are not used to paying for their traffic advice. However as advice is becoming more personalised there is more need for ‘user pays’ principle. However there is no user acceptance for this. • The in-car services conflict and compete with existing road side infrastructure (and its Industry) • Regulation ensures that the advice of the app should be equal to the advice of the road side infrastructure. This results in conflicts and not optimized benefits of the application as the advice of the matrix has to be followed but is not optimal. • Road managers are responsible for maintaining of the roads. But these parties might not be the most optimal for management of traffic.
Enablers	• Rewarding of user works. This is done in two ways: complements via the application and reward points. The places where these points can be exchanged (fueling stations, parking areas) are responsible for paying the users. In stead of paying directly for the service, cooperating partners (fuelling stations, parking areas) pay for the users. This business model is not sustainable though. • User driven approach in general is important. Users are open for help (navigation etc.) but do not want to be overflown with information (traffic radio) and this should be specified according to their needs.

FOTsis 3 - Intelligent Congestion Control

Description	
Country	Spain 1 highway. Germany 3 highways
Description	• Improve the traffic load balancing in the road networks by introducing new algorithms to integrate dynamic data from diverse traffic information sources. • Provide and integrate different data sources and deploy a suitable communication network • Integrate infrastructure based detection of the traffic and weather conditions, incidents and the interaction between those • Manage traffic flow by controlling maximum speed and real time communication with drivers Service based mostly on existing infrastructure
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Number of incidents/accidents/severe accidents • Change in speed (maximum, mean, deviation) • Decrease in travel time • Decrease travel time service users • Change in travel volume(volume, density, capacity) • Change in fuel consumption/emissions/traffic noise • Change in bad weather drives • Change in congestion • Percentage of compliance/number of users/number of non-compliants • Use of the service • Change in perceived safety and attention of drivers • User experience (trust, comfort level, expectation, usefulness, desirability, comprehensible) • Number/percentage of violations • Number of conflicting points/dangerous points • Willingness to pay by service users • Perceived usefulness of users/policy makers
Barriers	Main barriers with respect to the deployment of the application: **Deployment** • Efficiently using existing road side equipment to generate accurate and matching traffic information • Getting access to data from national authorities. **Benefit** • Only well equipped highways can provide relevant information • There are parts of EU highways without mobile network reception
Enablers	No Enablers have been mentioned specifically

FOTsis 7 – Infrastructure safety assessment	
Description	
Country	2 highways in Portugal
Description	This service addresses the benefits of the exploitation of the information coming from the infrastructure i4 combination with information recorded by the on board unit. This will be used to identify and reconstruct specific related ‘situations’ that may occur in the road infrastructure. The performance of a road will be assessed post-process with use of the data measured by the on board unit. Three categories are defined: • Normal driving conditions • Degraded driving conditions due to weather, condition of driver, etc. • Imminent crash situations The data is very useful for feedback towards highway operators, emergency vehicles but

	also third parties, for instance insurance companies. This service is purely aimed about generating the data.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	several performance indicators have been set up. • User expectation perceived • Usefulness perceived by users • Willingness to pay by service users • Location and number of violations • Number of dangerous/conflicting points identified • Perceived usefulness policy makers/third parties
Barriers	Main barriers with respect to the deployment of the application: **Deployment** • Difficult to recruit drivers • Measuring driving behaviour of recruited drivers • On board units necessary that collects and records in-vehicle information related to the status of the vehicle • Combing OBU data with Road side Infrastructure data • Detailed information about the highway and weather conditions • Stretch of road should be equipped with sensors and other systems for measurement • Hard to generate a positive business case
Enablers	Some important enablers are: • Integration of different data sources • Integration of infrastructure detection among each other.

Guiade	
Description	
Country	Spain
Description	GUIADE aims to achieve automation in the positioning and guidance of public transport vehicles based on the multimodal perception of the environment, using the information collected by the vehicles as well as those supplied from the ITS infrastructure. Equipped public transport vehicles obtain information about their local environments using vision-based vehicle detection system (cameras etc.) and floating car data (FCD) technology. The cameras capture relevant information such as weather and daytime conditions, the number of vehicles in the local range of the bus as well as their relative position and velocity, while the FCD system captures information like global location, speed, and direction. The vehicles transmit this information to a central control unit wireless technology via GPRS/UMTS cellular protocols. The central unit then integrates the data collected by the fleet in order to generate updated traffic status and weather maps which will be used for fleet management tasks as well as to estimate the time of arrival. To minimize failure points of cellular networks, a backup V2V communication system based on WiFi is used so that in-range vehicles will exchange the most updated information available. Warnings of possible incidents detected by the ITS infrastructure are issued in advanced to the drivers through the ADAS systems of equipped vehicles.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	

Key performance indicators	• Average traffic load • Average road speed
Barriers	• Adverse weather conditions (e.g., wet or snowy roads) • Use of vision-based detection in dark areas (e.g. tunnels) For transfer to other types of road vehicles, privacy issues may arise due to permanent traceability or possible liability in case of speed limit violations.
Enablers	• No need to deal with privacy issues since the floating vehicles correspond to a fleet of public transport buses. • The advantage of using floating car data technology instead of fixed traffic monitoring technologies (lack of flexibility, static nature of the information, etc.) • Lesser costs of installation and maintenance

Amsterdam Mobile EVA : cooperative travel parking app	
Description	
Country	Netherlands
Description	This mobile application is similar to Super route-P but was made by a different consortium and active one year earlier. The mobile application was used to inform visitors of 10 events in Amsterdam to the optimal route as well as the best parking place. A portal behind this app and ADAM monitors the movement of participants and advices them based on their location. The application was adjusted and personalised for each event, and therefore also not available in the app stores when no event was scheduled. Go with Eva to Bruce Springsteen is one example of personalisation. Application is 'active' hours before the event, from this time onwards it is possible to plan your trip. App will provide optimal route as well as recommended departure time. If participants come close to the destinations the application will provide active and actual directions towards a parking place. Proximity is measured if the mobile phone passes a measurement point (pick-up point). The application switched from general advice (eg. Route shown on map) towards a more specified advice -> take a4, leave highway … and park at P2. Participants can use the app on departure as well. Portal receives information from parking garages, road management and uses this to send push messages to participants.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• User experience indicator • Number of downloads and conversion
Barriers	Deployment • Cost of Marketing do not outweigh the number of people who actively use the application -> low penetration leads to a limited effect. There is no positive business case Barriers • Sometimes participants are not picked up by the application -> do not get advice • No private business case possible. Costs do not outweigh direct benefits. • Only a need for the service in the case of large events in combination with actual traffic issues (road works, extranormal congestion, train strike) • Visitors often visit a single event. (not lenny kravitz and Katty perry). Therefore the app is not used again: low followup • Control time for applications used by iStory from Apple: app not ready on time for next event • No integration with door-to-door navigation • Application has very limited effect after the event
Enablers	• Technologically stable and operationally • Positive cooperation between stakeholders • Google adworks successful marketing at affordable costs

	• Spoken messages would improve safety

Amsterdam onderweg Super P-route : cooperative travel/parking app	
Description	
Country	Netherlands
Description	Mobile application that advices participants about parking opportunities and optimal routes during large events in Amsterdam and its surroundings. Gives advice on departure time and the ability to reserve a parking spot. Smart Routing algorithm uses real time information to give multiple route alternatives during travel. App uses load balancing (different users from the same location are advised different routes). Back office system is like the function of Super-Route Highlights: • Open platform • Advice for participants • Receives floating car data from participants Uses information of road authorities
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Deployment • The service was available 99.5% of the time Benefit • 50% of the users follows advice
Barriers	Service needs to have highly rated user experience as people have high expectations. 3g/4g network is often congested during events as many people are in the area
Enablers	• Marketing was done via multiple channels. Not including one channel had significant consequences for the result of the marketing campaign. o Direct mailing o Facebook of event/location o Google adds o Marktplaats adds o Adds on fansites o Radio commercials Free parking ticket in exchange

Heavy vehicle platooning trial Australia	
Description	
Country	Australia
Description	Heavy vehicle platooning, a group of 2 or more wirelessly-connected heavy vehicles that travel at highway speed in close proximity, nose-to-tail. A lead vehicle is followed by a number of other vehicles that precisely match the lead vehicle's speed and manoeuvres (synchronization of speed, braking and positioning) Under the technology, a lead truck assumes control of the convoy or platoon through V2V communication and the trailing vehicles fall into lock-step. Other vehicles can wirelessly connect and seamlessly join or leave the platoon at any time
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	General road management KPIs: % community satisfaction (target: 90)

	% road network permitted for use by heavy vehicles B Double – 27.5 m (target: 96) % network configuration bridges strength (target: 89) KPIs for Heavy vehicle platooning: Use telematics technology to enhance heavy vehicle access to the Kwinana Industrial Area Roll out Road Safety Management System (ROSMA) operator training workshops Identify and develop solutions to improve capacity of current assets through the Western Australian Road Research and Innovation Program. Facilitate demonstrations of autonomous technology for heavy vehicle platooning. Implement actions from the Restricted Access Vehicle Network Access Strategy.
Barriers	• Lack of governmental approval for on-road trials • Pending formal agreements between transport companies and technology providers/vehicle manufacturers participating in the trial
Enablers	Successful On-road trials in for heavy vehicle platooning in Europe + North America Transformational innovation within the Transport Sector Governmental funding & incentive package focusing on R&D, demonstration, deployment (similar to UK Intelligent Mobility Fund) AV Accelerator Program (to ensure truck platooning and other market technologies (high speed highway assist, remote car parking) to come to market

Companion truck platooning	
Description	
Country	Sweden, Spain
Description	An on-board unit was installed inside Scania trucks. This ensured that trucks could communicate between each other and this allowed the forming of platoons. These platoons allow trucks to drive in close proximity which indulges a slipstream effect which reduces the fuel consumption of the follower truck. Furthermore, several aspects of the system have been tested: • Merging • Splitting • Platoon formation • Double lane change • Varying speed • Gap modification • Emergency braking • Cutting vehicles On board drivers get information about main manoeuvres to secure the anxiety of driving in close proximity. Platoons not only have to cooperate with each other but also must react to other (not) connected forms of transport, for example by allowing them to merge inside the platoon at a highway.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	• Fuel reduction C02 reduction
Barriers	Two barriers regarding the deployment have been indicated • Standardisation systems are required to form platoons

	• Legislative action is necessary to allow the formation of platoons Two barriers regarding the benefit of platoons have been indicated • Weather conditions • Changing road network
Enablers	No specific enablers regarding the deployment are indicated Two enablers of the benefit have been indicated. • Calculation of fuel efficient routes allowed platoons to be formed in the most efficient way • Using real time traffic information allowed trucks to find each other

Connected cruise control	
Description	
Country	Netherlands
Description	A built-in route indicator that efficiently guides drivers through busy traffic, reducing congestion problems. Advised: • Driving speed which takes congestion ahead into account Warnings for problems/incidents ahead
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No performance indicators discussed
Barriers	No main barriers discussed
Enablers	No main enablers are discussed

FlowPatrol : cooperative traffic information mobile app	
Description	
Country	Netherlands
Description	FlowPatrol is a mobile application installed on smartphones that advices users about speed and traffic warnings. Data is collected from (existing) road infrastructure (loops), and through the application itself speed and location of the vehicle are detected. This collecting is done either through 3g/4g or through FlowRadar: an on board installed ITS station that sends and receives data through WiFi-P. Flowradar is installed with a sucker inside the car, and uses one 12v hole. It then connects with mobile phones via Bluetooth to send messages. Data collection is thus possible via two methods: 3g/4g via mobile phone Via the on-board unit and WiFi-p The service offered to app users is the same. The on-board unit might have better location services, and thus more accurate travel advice.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	

Key performance indicators	Deployment
	• Number of stakeholders
	• Uptime
	• Number of workers
	• Number of fte
	  • Number of downloads.
	  • Number of trips. → App users receive tickets to win prices through a lottery
	Benefit
	• Reducing “shockwave Jams” ,which are 40% currently of the Jams on this stretch

	of highway • Percentage of users following advice
Barriers	• Latency is a benefit barrier restricting timely communication to the users. • The deployment area restricted large scale adoption of the application. • The number of users is to small to indicate an effect on a macro level. • Users don't want to deviate the driving speed if there is a large difference between the observed and advised driving speed
Enablers	• Technically the application is ready for implementation. • Privacy standards of V2V communication have been validated

FOTsis 5 - Special Vehicle Tracking	
Description	
Country	1 highway in Portugal, 1 highway in Spain
Description	Monitoring and detecting vehicle considered special: Dangerous goods, heavy vehicle for example. How effective the combination of in-vehicle information and information provided by the infrastructure (pre-trip, traffic and weather conditions) can be at minimizing the impact of special vehicles. Instead of continuously locating these vehicles, the goal is to combine this with historical and real time data. The service thus: • Detects the entering/leaving of special vehicles on highway • Monitors special vehicles on highway • Warning informing other vehicles/infrastructure Process: Transport operator asks for permission to use a road providing details about its vehicle and route. This is taken into account and access to a certain route is granted. Than other actions are taken to ensure a successful trip. Special vehicles are equipped with an on-board unit to inform traffic centres about its position. Road side beacons are used to receive and send information towards the special vehicle.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	Several hypothetical performance indicators have been defined • Number of incidents/accidents/severe accidents • Change in speed (maximum, mean, deviation) • Decrease in travel time • Decrease travel time service users • Change in fuel consumption/emissions/traffic noise • Change in bad weather drives • Change in congestion • Percentage of compliance/number of users/number of non-compliants • Use of the service • Change in perceived safety and attention of drivers • User experience (trust, comfort level, expectation, usefulness, desirability, comprehensible) • Number/percentage of violations • Number of conflicting points/dangerous points • Willingness to pay by service users • Perceived usefulness of users/policy makers
Barriers	Main barriers with respect to the deployment of the application: **Deployment** • GPS guidance systems can not deal with route guidance through dynamic traffic information. (a football game in two hours is not accounted for) • Permission to use road side data • Beacons on highway required, which are currently not among standard highway

	infrastructure • On board units using 3G are necessary **Benefit** • Highway control centres have additional information regarding traffic and congestion compared to private companies (google, waze, ..). Therefore they can provide better advise hypothetically. • Alternative routes are not always equipped with measurement systems. Is the rerouting credible? • Weather conditions on alternative routes is often unclear. How does the traffic react there.
Enablers	No enablers are specifically mentioned

Freilot. Truck priority at intersections	
Description	
Country	EU FP 7 project tested in: France, Netherlands, Poland, Spain
Description	Freilot aims to reduce congestion and emissions in cities. Four measures have been designed and implemented. Traffic light priority is highlighted here: Energy efficiency optimised intersections (trucks and emergency vehicles get priority from traffic controllers at intersections to increase fuel efficiency) In total 177 vehicles have been equipped divided over 4 cities.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated
Barriers	• Truck drivers do not believe the service works • Hard to find significant effect of service
Enablers	No enablers indicated

Roadart (Research On Alternative Diversity Aspects foR Trucks)	
Description	
Country	4 partners from 3 countries: Germany, The Netherlands, Greece
Description	The ROADART project aims to demonstrate especially the road safety applications for T2T and T2I systems under critical conditions in a real environment, like tunnels and platooning of several trucks driving close behind each other.
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No KPIs indicated
Barriers	No barriers indicated
Enablers	No enablers indicated

UK Autodrive	
Description	
Country	Automated driving project with special focus on cooperative driving. Platooning test
Description	• Integrate autonomous and connected vehicles into real-world urban environments; • Show how autonomous and connected vehicles could solve everyday challenges such

	as congestion; • Demonstrate the commercial operation of electric-powered self-driving "pods" at a city scale; • Provide insight for key stakeholders and decision-makers, including legislators, insurers and investors; Examine the potential benefits (in terms of safety, traffic flow and the environment) of having cars that can "talk to each other
Type of ITS service	Type 4
Assessment of barriers, enablers and key performance indicators	
Key performance indicators	No information about performance indicators (the project is in progress).
Barriers	The man barriers to the application are: • Reliability • Potential legal issues (including the aspects relating to privacy) • Issues about insurance liability • Cyber-security issues • Public acceptance issues • Risk of unlawful access to essential controls (hacking into the control systems) • Risk of disruptive effects on several industries and professions (including car manufacturers and professional drivers).
Enablers	Important enablers are: • Cooperation between different types of stakeholders for both development/advancement of the application and utilisation (technology expert, public sector, etc.); • Possibility to use to application to solve social (use of the cars from people who cannot drive), environmental and efficiency issues; • Support of Coventry and Milton Keynes Councils (public sector) for the road demonstrations; • Increased safety levels than conventional cars (due to their much faster reaction times and by removing the human errors that currently play a part in the vast majority of road traffic accidents). • Possible development of jobs in several sectors either directly or indirectly related to this new technology.