COMPASS

OPTIMISED CO-MODAL PASSENGER TRANSPORT FOR REDUCING CARBON EMISSIONS

DELIVERABLE D5.1

HANDBOOK OF ICT SOLUTIONS FOR IMPROVING CO-MODALITY IN PASSENGER TRANSPORT

Due Date: 31st October 2013
Submitted: November 2013
Main Editor: MCRIT
Main Author: All Partners
Dissemination: PUBLIC

SEVENTH FRAMEWORK PROGRAMME

Project co-funded by the European Commission within the Seventh Framework Programme, Theme 7 Transport
Contract number 284722
Project Start Date: 1 November 2011, Project Duration: 25 months

Document Control Sheet

Contract Number:	284722		
Project Acronym:	COMPASS		
Workpackage:	WP5		
Version:	V1.0		
Document History:	V0.1	7 December 2011	Task partners WP5 and WP6
	V0.2	21 October 2013	Peer review
	V0.3	25 October 2013	TTS Italia
	V0.4	31 October 2013	Project Coordinator
	V1.0	27 November 2013	Consortium Project Officer Public

Classification – This report is:									
Draft		Final	X	Confidential		Restricted		Public	X

Partners Owning:	All
Main Editor:	Oriol Biosca, Andreu Ulied (MCRIT), Gianni Caramanico (TTS)
Partners Contributed:	All Partners
Made Available To:	All COMPASS Partners
This document should be referenced as:	Biosca O., Ulied A., Caramanico G., Bielefeldt C., Calvet M., Carreras B., Rodrigo R., Cooper J., Fonzone A., Stewart K., Condie H., Schnell O., Mandel B., Bak M., Borkowski P., Pawlowska B., Matthews B., Chen H., Shibayama T., Lemmerer H., Emberger G., Enei R., de Stassio C., di Bartolo C, Maffi S., Franchi L.; "Handbook of ICT Solutions for Improving Co-Modality in Passenger Transport", Deliverable D5.1 of COMPASS, Co-funded by FP7. TRI, Edinburgh Napier University, Edinburgh, October 2013

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EXECUTIVE SUMMARY

The COMPASS Handbook of ICT Solutions puts together a set of 96 solutions applying to urban and metropolitan mobility, long distance passenger transport and also innovative ICT solutions aimed at increasing the quality of transport services in areas where demand levels are low, like rural or sparsely populated regions.

The COMPASS Handbook of ICT Solutions is available in a paper edition and in an online internet version accessible at http://www.fp7-compass.eu/.

The ICT solutions presented in the COMPASS Handbook are classified in the next five broad categories:

1. **Transportation management systems**, solutions aimed at helping to plan and running efficiently the transport system.

   This section includes solutions for urban transport management (e.g. smart signal management or signal priority for public transport), for road management (e.g. ramp metering or congestion monitoring based on smart phones), for improving air operation (e.g. air traffic control applications allowing planes to fly in direct paths point to point), rail operation (e.g. ETCS or GMS-R) and maritime operation (e.g. quicker and more complete vessel identification protocols via AIS).

2. **Traveller information systems**, in which the key characteristic is to assist the traveller with several parts of information (travel time, routes, traffic conditions, etc);

   This section includes solutions aimed at better guiding passengers through the transport network (e.g. airport interactive maps on tablets assisting passengers around large transport terminals, or augmented reality applications easily guiding public transport users to the closest bus station), travel planners (e.g. door-to-door multimodal travel planners considering congestion and transport service schedules), solutions aimed at delivering transport information to travellers on real-time (e.g. cooperative P2P applications based e.g. on twitter to monitor transport networksô status and alert on eventual service disruptions) and other smart phone apps designed to make journey planning easier for travellers (e.g. smart phone based travel assistants grouping travel tickets, hotel bookings, boarding passesé or smart seat allocation algorithms based on the traveller social network profile (e.g. facebook, linkdin)).

3. **Smart ticketing and tolling applications**, addressing new ways to get tickets and to pay for using transport services;

   This section includes upcoming solutions for road toll payment with low affectation on traffic flow (e.g. free-flow transponder-based toll payment compatible in multiple countries), automated access management (e.g. high occupancy vehicle identification at toll plazas based on automatic camera occupation detection), and on innovative formats for paying public transport tickets or parking charges (e.g. via SMS or smart cards).

4. **Smart vehicles and infrastructure**, including ICTs aimed at improving vehicle efficiency per se and vehicle intelligence as a result of increased vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communications;

   This section includes upcoming solutions enhancing vehicle safety and driving comfort and accuracy (e.g. traffic jam assistants or self-parking cars), and for increasing vehicle intelligence via communications between vehicles (e.g. vanet V2V networks, automatically driven car trains), and via vehicle to infrastructure communications (e.g. information transmission on weather and road surface condition from road infrastructure to rolling vehicles).

5. **Demand responsive transport (DRT) and shared mobility systems**, which includes transport solutions enabled by ICT solutions to set up innovative transport services adjusted to demand and allowing users to share vehicles.

   This section includes upcoming solutions aimed at addressing the more and more popular concept of shared mobility (e.g. car sharing, car pooling, sharing car parks), and other innovative solutions based on demand responsive systems, specially suited for delivering efficient transport solutions when transport demand is too low for conventional public transport services.

The handbook can be used in a number of different ways, but two main entry points are provided for easy navigation.

A. All ICT solutions have been synthesised in section 0.5.2 in abstracts of less than 10 lines each. This is intended for quick understanding of each of the solution's concept and problems that it addresses.

B. If the user has candidate solutions in mind, the synthesis of solutions by performance in section 0.5.1 allows to quickly compare solutions and identify which one applies better.

Each of the Handbook's solutions is identified with a unique numerical ID,

- Indicating the family and subfamiliy it belongs to;
- Indicating the chapter in the Handbook where the solution might be expected to be found in;
- Indicating the ID of the solution in the online Handbook accessible at http://www.fp7-compass.eu/

For each solution in the handbook, the following information may be expected in the systematically established factsheet structure:

- A synthesis of the fundamental characteristics of each solution: name, family, subfamily, domain of application (urban, rural, long-distance transport), technology behind, implementation status (existing, pilot, concept)
- Links to all reference documents behind the reporting of each solution, and any other relevant reference or interesting link.
- A brief description of the solution;
- A short description of the problems it seeks to address;
- A summary of its applicability described in terms of pre-requisites and barriers to implementation;
- The circumstances in which it would be particularly appropriate and the circumstances in which it would be inappropriate or difficult to implement;
- A commentary on the scores recorded in the matrix for this solution;
- Comments on any other impacts that are particularly relevant for this particular solution; and
- Multimedia contents better illustrating the nature of the solution.

The online handbook allows, in addition, visualising multimedia materials illustrating the insights of different ICT solutions. Users in the online handbook can also post comments to each of the factsheets providing additional insights or questions to a particular solution, and rate them in relation to its interest.

All solutions are documented in the COMPASS Handbook based on existing examples of their application.

Text in the reporting body of each solution factsheet may literally cite original sources. All references to original sources are included at the beginning of each solution factsheet.

In chapter 6 of the Handbook, four business models are discussed for the applications listed below. Business models are discussed on the basis of product, customer interface, infrastructure management and financial aspects.

- Shared Bike Systems
- Share Taxis
- Mobile Traveller Information Systems
- Car Park Management Systems

Each model is presented in a schematic and easily readable format, in four sections defined on the basis of the pillars mentioned above where the nine major elements of he business model are described. Each model has been discussed with industry and academic experts, after the investigation and design works.

A strategy overview is given by the SWOT analysis elaborated for each business domain, in order to provide a full view of both the money earning and the strategic logic.

0. INTRODUCTION TO THE HANDBOOK

0.1 AIM

One of the aims of the research to undertaken in the COMPASS project is recommending solutions that will allow improvements to the planning and operation of the passenger transport network to enhance co-modality in transport thus contributing to the reduction of carbon emissions.

The identified ICT solutions and technologies have shown significant potential in favouring co-modal seamless solutions. In particular, ICT technologies are deemed to represent the key instruments to convey the relevant information to the passengers for making a seamless trip possible: from the information on timetables, delays and interconnections to the availability of smart ticketing. More transport safety (through cooperative applications), a better environment (through transport management tools) and accessibility (in particular the development of Demand Responsive Transport services) will also benefit from the extensive implementation of ICT applications.

The COMPASS Handbook of ICT Solutions puts together a set of 96 solutions applying to urban and metropolitan mobility, long distance passenger transport and also innovative ICT solutions aimed at increasing the quality of transport services in areas where demand levels are low, like rural or sparsely populated regions.

The COMPASS Handbook of ICT Solutions is available on a paper edition and in an online internet version accessible at http://www.fp7-compass.eu/.

The ICT solutions are presented in the COMPASS Handbook classified in the next five broad categories:

1. **Transportation management systems**, solutions aimed at helping to plan and running efficiently the transport system;
2. **Traveller information systems**, in which the key characteristic is to assist the traveller with several parts of information (travel time, routes, traffic conditions, etc);
3. **Smart ticketing and tolling applications**, addressing new ways to get tickets and to pay for using transport services;
4. **Smart vehicles and infrastructure**, including ICTs aimed at improving vehicle efficiency per se and vehicle intelligense as a result of increased vehicle to infrastructure (V2I) and vehicle to vehicle (V2V) communications;
5. **Demand responsive transport (DRT) and shared mobility systems**, which includes transport solutions enabled by ICT solutions to set up innovative transport services adjusted to demand and allowing users to share vehicles.

0.2 HOW TO USE THE HANDBOOK

0.2.1 Paper handbook

The COMPASS Handbook of ICT Solutions comprises:

- A set of 96 ICT solutions for better passenger transport.
- An evaluation framework by which to judge the usefulness of different solutions (section 0 of the Handbook)
- Matrices summarising the usefulness of the 96 identified solutions (section 0.5.1).
- Abstracts of all 96 ICT solutions for quick apprehension of Handbook contents (section 0.5.2).
- Text descriptions of each of the 96 identified solutions, including examples of their application, references and links to more detailed case studies and sources of information (chapters 1 to 5).
- Four business models for representative ICT Solutions (chapter 6)

The handbook can be used in a number of different ways, but two main entry points are provided for easy naviagation of the Handbook.

A. All ICT solutions have been synthesised in section 0.5.2 in abstracts less than 10 lines each. This is intended for quick understanding of each of the solutionsôconcept and problems that it addresses.

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- Comments on any other impacts that are particularly relevant for this particular solution; and
- Multimedia contents better illustrating the nature of the solution.

All solutions are documented in the COMPASS Handbook based on existing examples of their application.

Text in the reporting body of each solution factsheet may in some cases literally cite original sources. All references to original sources are included at the beginning of each solution factsheet.

0.2.2 Online handbook

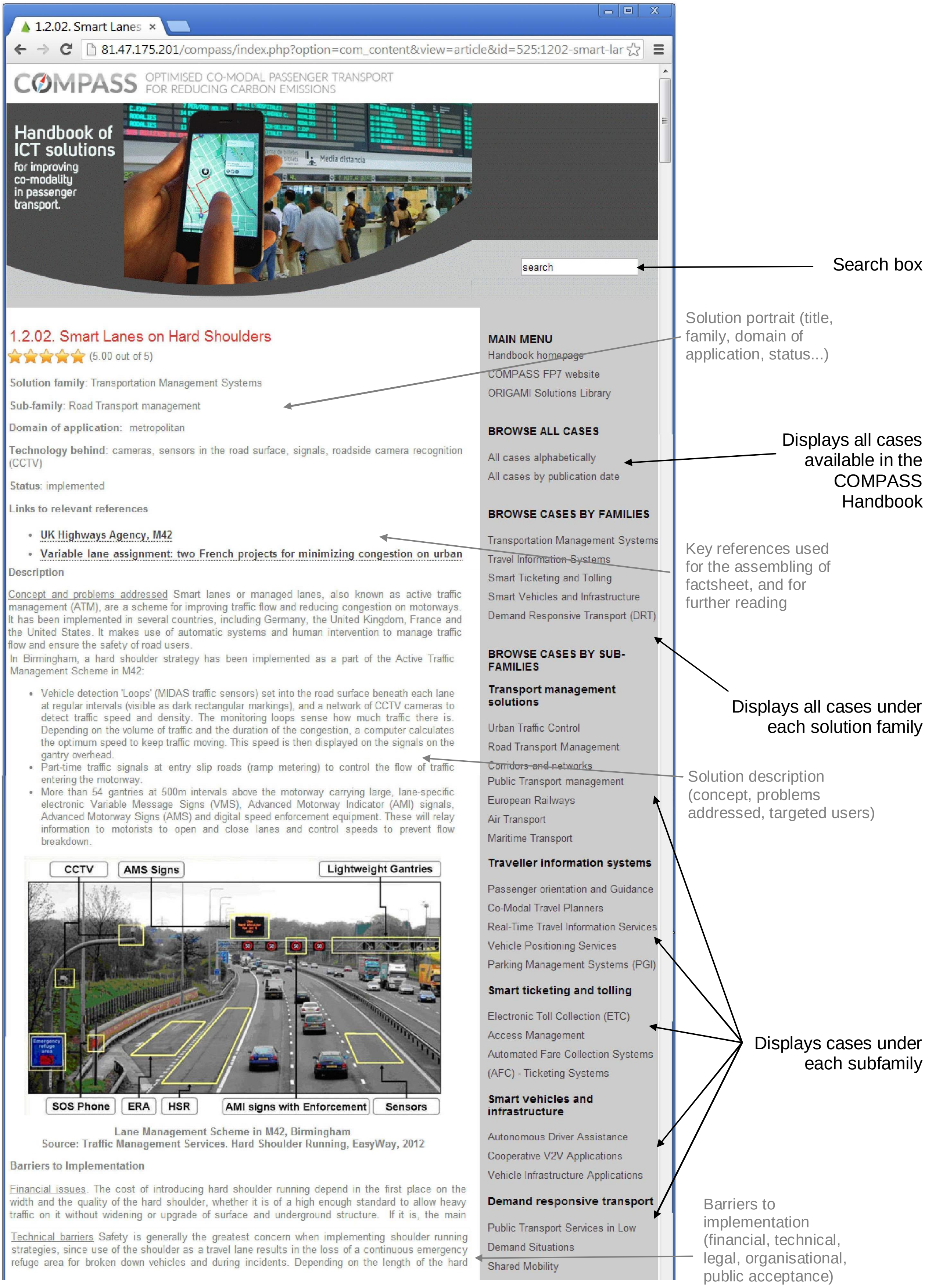
The COMPASS Handbook of ICT Solutions is available both in a paper copy and online accessible at http://www.fp7-compass.eu.

The contents of the online handbook and the paper handbook are both identified with unique IDs.

The structure of factsheets is the same both for the paper handbook and the online one. The online handbook allows, in addition, visualising multimedia materials illustrating the insides of different ICT solutions.

Users in the online handbook can also post comments to each of the factsheets providing additional insights or questions to a particular solution, and rate them in relation to its interest.

The navigation of the online COMPASS Handbook of ICT Solutions works as follows:


1.2.02. Smart Lanes
81.47.175.201/compass/index.php?option=com_content&view=article&id=525:1202-smart-lar
COMPASS OPTIMISED CO-MODAL PASSENGER TRANSPORT FOR REDUCING CARBON EMISSIONS
Handbook of ICT solutions for improving co-modality in passenger transport.
search
1.2.02. Smart Lanes on Hard Shoulders
(5.00 out of 5)
Solution family: Transportation Management Systems
Sub-family: Road Transport management
Domain of application: metropolitan
Technology behind: cameras, sensors in the road surface, signals, roadside camera recognition (CCTV)
Status: implemented
Links to relevant references
UK Highways Agency, M42
Variable lane assignment: two French projects for minimizing congestion on urban
Description
Concept and problems addressed Smart lanes or managed lanes, also known as active traffic management (ATM), are a scheme for improving traffic flow and reducing congestion on motorways. It has been implemented in several countries, including Germany, the United Kingdom, France and the United States. It makes use of automatic systems and human intervention to manage traffic flow and ensure the safety of road users.
In Birmingham, a hard shoulder strategy has been implemented as a part of the Active Traffic Management Scheme in M42:
Vehicle detection 'Loops' (MIDAS traffic sensors) set into the road surface beneath each lane at regular intervals (visible as dark rectangular markings), and a network of CCTV cameras to detect traffic speed and density. The monitoring loops sense how much traffic there is. Depending on the volume of traffic and the duration of the congestion, a computer calculates the optimum speed to keep traffic moving. This speed is then displayed on the signals on the gantry overhead.
Part-time traffic signals at entry slip roads (ramp metering) to control the flow of traffic entering the motorway.
More than 54 gantries at 500m intervals above the motorway carrying large, lane-specific electronic Variable Message Signs (VMS), Advanced Motorway Indicator (AMI) signals, Advanced Motorway Signs (AMS) and digital speed enforcement equipment. These will relay information to motorists to open and close lanes and control speeds to prevent flow breakdown.
CCTV
AMS Signs
Lightweight Gantries
SOS Phone
ERA
HSR
AMI signs with Enforcement
Sensors
Lane Management Scheme in M42, Birmingham
Source: Traffic Management Services. Hard Shoulder Running, EasyWay, 2012
Barriers to Implementation
Financial issues. The cost of introducing hard shoulder running depend in the first place on the width and the quality of the hard shoulder, whether it is of a high enough standard to allow heavy traffic on it without widening or upgrade of surface and underground structure. If it is, the main
Technical barriers Safety is generally the greatest concern when implementing shoulder running strategies, since use of the shoulder as a travel lane results in the loss of a continuous emergency refuge area for broken down vehicles and during incidents. Depending on the length of the hard
MAIN MENU
Handbook homepage
COMPASS FP7 website
ORIGAMI Solutions Library
BROWSE ALL CASES
All cases alphabetically
All cases by publication date
BROWSE CASES BY FAMILIES
Transportation Management Systems
Travel Information Systems
Smart Ticketing and Tolling
Smart Vehicles and Infrastructure
Demand Responsive Transport (DRT)
BROWSE CASES BY SUB-FAMILIES
Transport management solutions
Urban Traffic Control
Road Transport Management
Corridors and networks
Public Transport management
European Railways
Air Transport
Maritime Transport
Traveller information systems
Passenger orientation and Guidance
Co-Modal Travel Planners
Real-Time Travel Information Services
Vehicle Positioning Services
Parking Management Systems (PGI)
Smart ticketing and tolling
Electronic Toll Collection (ETC)
Access Management
Automated Fare Collection Systems (AFC) - Ticketing Systems
Smart vehicles and infrastructure
Autonomous Driver Assistance
Cooperative V2V Applications
Vehicle Infrastructure Applications
Demand responsive transport
Public Transport Services in Low Demand Situations
Shared Mobility
Search box
Solution portrait (title, family, domain of application, status...)
Displays all cases available in the COMPASS Handbook
Key references used for the assembling of factsheet, and for further reading
Displays all cases under each solution family
Solution description (concept, problems addressed, targeted users)
Displays cases under each subfamily
Barriers to implementation (financial, technical, legal, organisational, public acceptance)

Organisational complexity Coordination between road operators and Emergency Services. The UK approach requires a visual inspection of the hard shoulder before it is opened. This requires some intervention on the part of operators, which means that the system cannot be started automatically.

Legal issues. Legal frameworks may need to be adjusted to allow circulation of vehicles on hard shoulders of motorways.

User and public acceptance. User and public acceptance is very high, as it is an obvious way to alleviate congestion.

Interest for Travellers

Door to door travel time. In The Netherlands, it was found that implementing temporary shoulder use has increased overall capacity 7% to 22% (depending on usage levels) and decreased travel times by 1 to 3 minutes during congested periods.

Travel cost. The evaluation carried in Germany (A5 between the Frankfurt NW intersection and the Friedberg junction) revealed that temporary hard shoulder usage saved congestion related losses amounting to approx. 3,200 vehicles hours per day. Converted using the corresponding time cost rates; this means economic benefits from avoided time losses amounting to € 48,000 per day or € 10 million euro per year.

Comfort and convenience. Smart lanes and hard shoulder management increase the capacity of motorways and lower traffic congestion, resulting on increased comfort for car users from smoother driving conditions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€-€€€	D2D travel time	✓	Car usage	+	Mobility	✓
Operation and maintenance costs	€	D2D travel cost	✓	Bus and coach usage	0	Congestion	✓
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

VDOT: I-66 Active Traffic Management System in ...

Simulation of Active Traffic Management

Add your comment

Your name:

Your email:

Subject:

Comment:

ICT TECHNOLOGIES

Cloud Technologies

Global Positioning System (GPS)

DSRC / RFID

Wireless Technologies

Mobile Phone

Radiowave / Infrared Beacons

Roadside Camera Recognition (CCTV/ANPR)

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Source: COMPASS, 2013

Figure 0-1 Online COMPASS Handbook of ICT Solutions. http://www.fp7-compass.eu/)

0.3 COMPASS HANDBOOK IN FIGURES

The COMPASS Handbook of ICT Solutions comprises a set of 96 ICT solutions for improved passenger transport.

ICT solutions are classified in 5 families and 20 subfamilies, each one of them dealing with different topics. Although there is inevitably some overlap between these categories, they help to put some structure in what would otherwise have been a rather indigestible list. It is, however, important that toolkit users do not confine their search for solutions solely to those in a single category.

Solutions have also been characterised in relation to their domain of application (urban and metropolitan mobility, rural mobility, long-distance transport). Solutions may apply to one or more domains.

The following figures provide a quick overview of the coverage of the COMPASS Handbook of ICT Solutions by topics and domains.

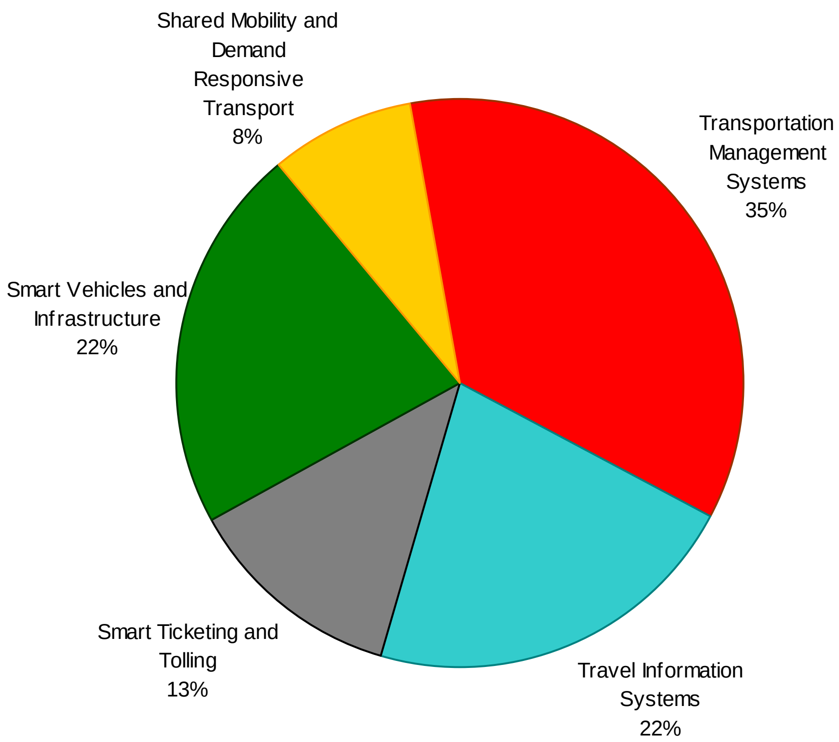
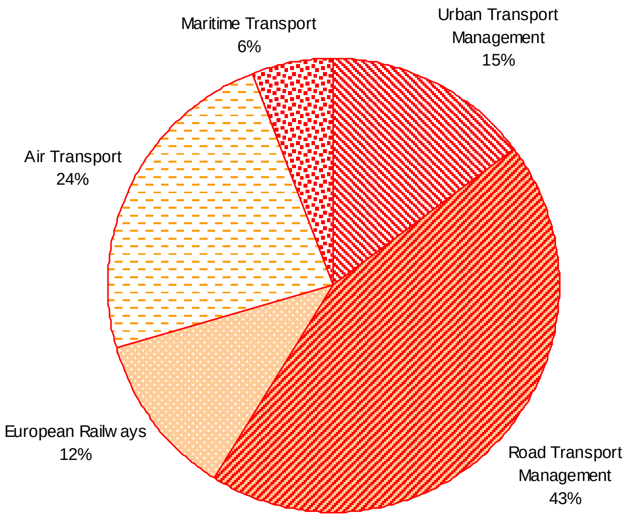
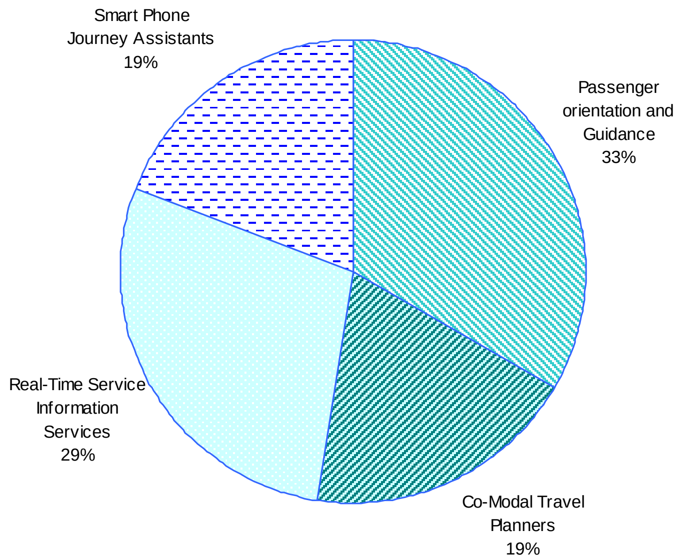


Figure 0-2 COMPASS ICT Solutions by families

Transportation Management Systems



Traveller Information Systems



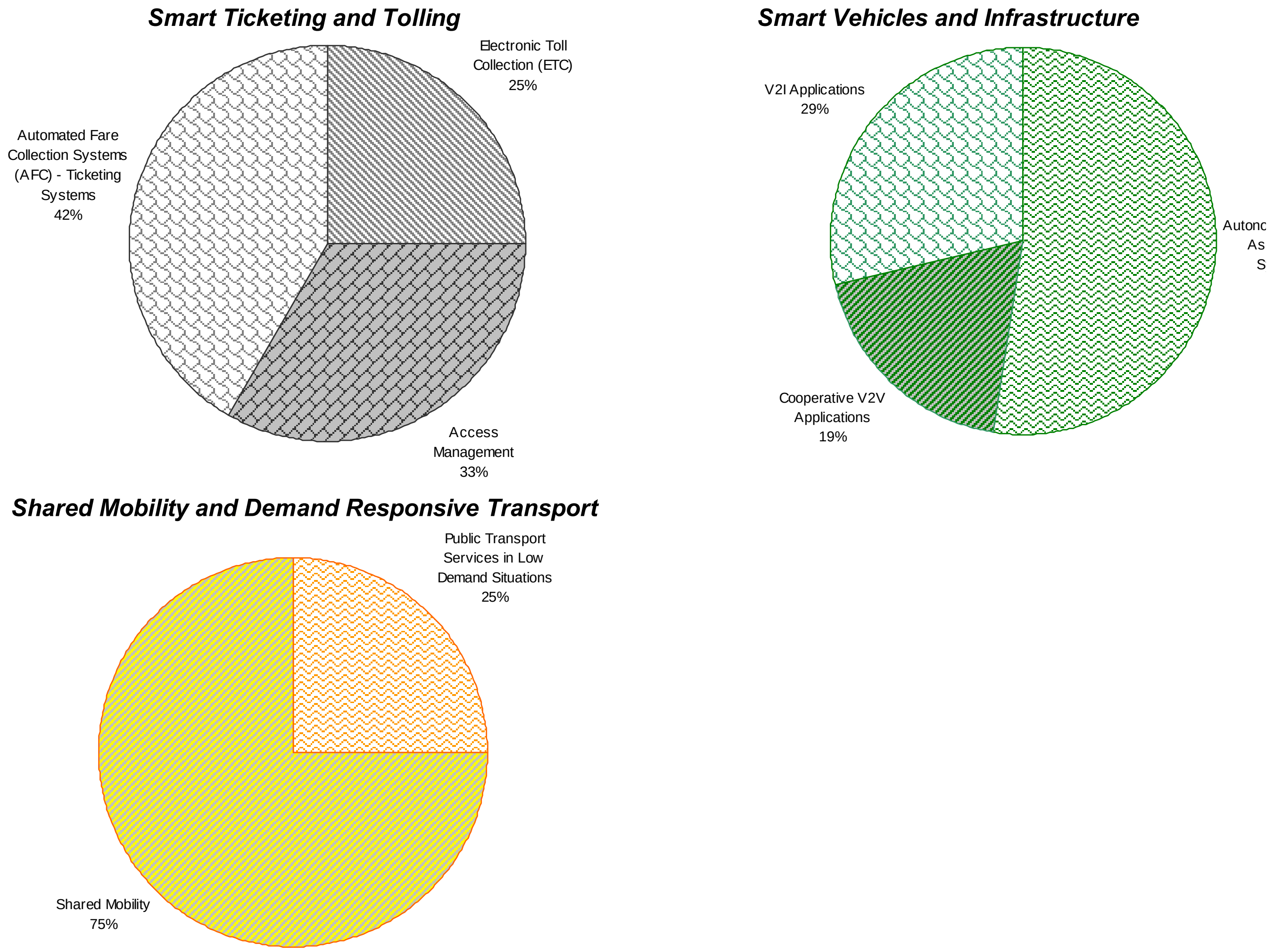


Figure 0-3 COMPASS ICT Solutions by sub-families

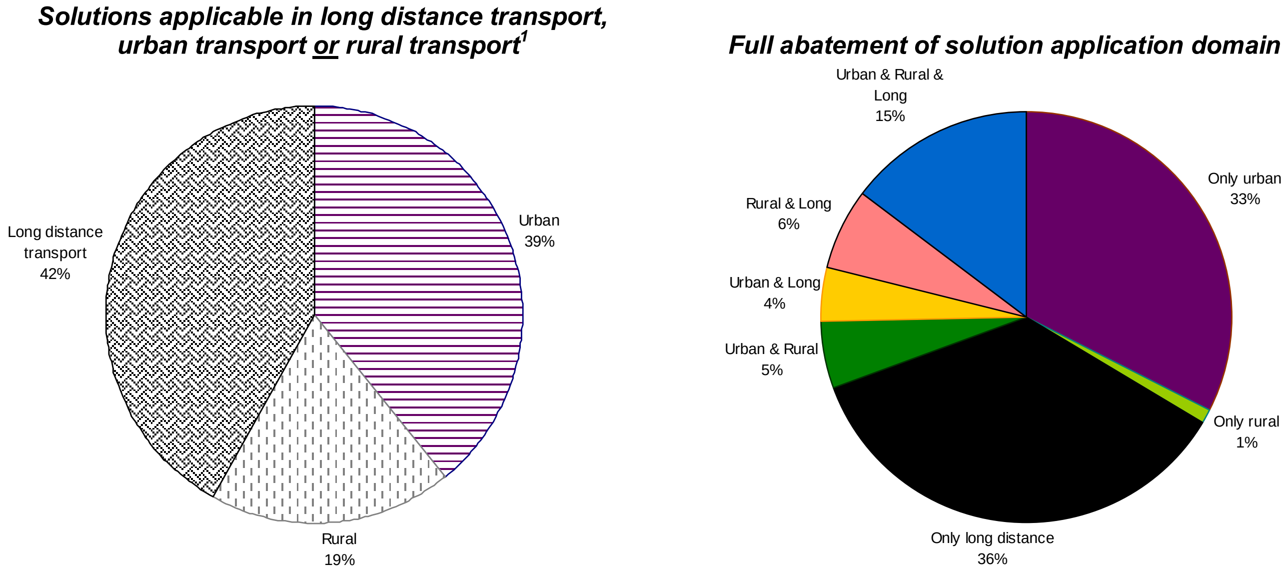


Figure 0-4 COMPASS ICT Solutions by domain of application

[1] Solutions may be applicable to more than one category (i.e. urban, rural or long-distance transport). For instance, car technology solutions in subfamily 4.1 apply to mostly all categories. In the left figure, solutions are distributed among categories, considering that if a solutions applies to more than one category it is then counted on both; in the right figure, solutions are classified on mutually exclusive classes (AND).

0.4 Assessment Framework

0.4.1 Background and Approach

The evaluation framework of COMPASS was determined following the principles of evaluation of the INTERCONNECT toolkit[2] and taking account of the considerations made for the ORIGAMI[3] project.

INTERCONNECT listed a 12 assessment criteria, including costs of implementation, technical, financial, organisational-legal feasibilities, user and political acceptance, impact on travel time, travel cost, comfort and convenience, safety, security, and detectable increased accessibility for people with impairments. These 12 criteria were used in qualitative terms, although for project costs, travel time and travel costs quantitative thresholds were defined.

Additionally, ORIGAMI used this thematic approach in combination with a discussion on stakeholders involved, based on RailPAGõs[4] assessment framework by the European Investment Bank, to define a set of criteria to assess transferability of best practices. A solution was considered to have a high transferability potential when it had a manifested interest for a wide range of stakeholders (users, operators, government), and when conditions were such that there were no feasibility barriers to its transferability. The analysis of interest and feasibility for different stakeholders was based on the INTERCONNECT criteria.

In addition to these previously exposed, COMPASS incorporated also assessment criteria in line with criteria used by the European Comission in the transport White Paper[5], in the EU2020 strategy[6] and in the Cohesion Policy[7]. These additional criteria include modal shift, increased mobility, congestion, CO2 emissions, contribution to user-pays-principle, European economic progress and territorial cohesion.

Table 0-1 Assessment criteria in COMPASS

Feasibility	Interest for Travellers	Modal change	Other Impacts
Investment Costs	D2D travel time	Car usage	Increased Mobility
Operation and Maintenance Costs	D2D travel cost	Bus and Coach usage	Congestion
Financial Viability	Comfort and convenience	Rail usage	CO2 emissions
Technical Feasibility	Safety	Ferry usage	Contribution to User Pays Principle
Organisational Feasibility	Security	Aerplane usage	European Economic Progress
Administrative Burden	Access. for impaired pax.		Territorial Cohesion
Legal feasibility			
User Acceptance			
Public acceptance			

[2] INTERCONNECT FP7 project (www.interconnect-projet.eu).
Bonsall, P., Abrantes, P., Bak, M., Bielefeldt, C., Borkowski, P., Maffii, S., Mandel, B., Matthews, B., Shires, J., Pawlowska, B., Schnell, O., and de Stasio, C. ñDeliverable 3.1: An Analysis of Potential Solutions for Improving Interconnectivity of Passenger Networksò, WP3, INTERCONNECT, Co-funded by FP7. TRI, Edinburgh Napier University, Edinburgh, March 2011

[3] ORIGAMI FP7 project (www.origami-project.eu).
Ulied A, Biosca O, Bielefeldt C, Calvet M, Rodrigo R, Carreno M, Cullinane K, Condie H, Bak M, Borkowski P, Mandel B, Schnell O, Shepherd S, Matthews B, Bonsall P, Enei R, Lemmerer H, Emberger G, ñFinalised Collection of Best Practice Examplesò, Milestone MS6 of ORIGAMI, Co-funded by FP7. TRI, Edinburgh Napier University, Edinburgh, January 2013

[4] Turró et al.; ñRailway Project Appraisal Guidelines *RailPAG"*, European Investment Bank EIB, 2005

[5] WHITE PAPER ñRoadmap to a Single European Transport Area ï Towards a competitive and resource efficient transport systemò, EC 2011 (COM(2011) 144 final)

[6] COMMUNICATION FROM THE COMMISSION EUROPE 2020 ñA strategy for smart, sustainable and inclusive growthò, EC 2010 (COM(2010) 2020 final)

[7] Green Paper on Territorial Cohesion ñTurning territorial diversity into strengthò, EC 2008 (COM(2008) 616 final) and Territorial Agenda of the European Union 2020 ñTowards an Inclusive, Smart and Sustainable Europe of Diverse Regionsò agreed at the Informal Ministerial Meeting of Ministers responsible for Spatial Planning and Territorial Development at Hungary, 2011

Solutions identified both in the COMPASS Handbook of ICT Solutions and in the COMPASS Case Studies[8] are discussed qualitatively for each of the assessment criteria considered above, then synthesised using a set of scores which follow the rules exposed below. Scores are aimed at providing quick portraits of solutions and allowing for quick comparison between solutions.

0.4.2 General Rules for Assessment of Solutions in COMPASS

Feasibility

Investment costs

There are two aspects concerning investment costs considered in COMPASS: subsidies and the relative scale of the total cost of implementation of a solution.

If the development of a system is a) subsidised by the State of e.g. by the European Commission AND it is then b) made available to multiple users, as in the example of ADS-B that is meant to replace flight radar, then these development costs are not counted as investment costs. Investment costs are then the costs that are being actually paid by each of the bodies that are installing / implementing one of these systems. If only a) applies, for instance in the case where a tram system that is later to be operated by a private company, then the total cost of the system counts independent of which part of it was funded privately or publicly.

The only scores available for investment costs are ú, úú, and úúú, meaning in turn cheap, expensive, very expensive. Exact costs are not known in most cases, normally at best a possible range of costs, and only rarely precise costs, hence it is impossible to define precise borderlines between them. What is even more pertinent, is that costs are relative to the type of user and system: ú 1,000 for a mobile app is forbiddingly high, ú 1,000 for a system installed in a luxury car is not particularly notable for the buyer, and ú 1,000 for a roadside sign is regarded a cheap measure by a road authority. All scores given here have to be seen in this context.

Operation and maintenance costs

The same as has just been said about the relativity of investment costs is also true for operation and maintenance costs. Even an annual fee of ú1 may be regarded by many as expensive for a mobile app, while it is a non-issue in most other contexts.

But here is another aspect to be considered. If a new ramp metering system is installed, then all specific operational and maintenance costs count against the new system. These may depend to some extent on whether the ramp meter is a stand-alone system or part of a larger motorway control system, but the differences between these two circumstances are in most cases somewhat limited.

Where, as in the case of the improved weather information with a four-dimensional weather cube, one existing system is replaced by a better, the score is determined through the comparison of the operation and maintenance costs: if the new system is more expensive to run then the old one (even if it produces much better results), it gets úúú, if the costs are roughly the same úú, and if the new system is cheaper to run than the old one, then it gets ú, even if it might still be expensive in absolute terms.

Things become more difficult if the old systems cannot be phased out as the new one comes in, as in the case of ADS-B replacing flight radar. Until all planes are equipped with the new system, both systems have to operate in parallel and the running costs of both systems are incurred for a considerable time period. The general time horizon of COMPASS is 20 years, and in such a case the operation and maintenance costs have to be judged in total over the next 20 years and compared with the costs of the existing system, in this case radar, over the 20 years. If the new plus the old systems become cheaper in total over the 20 years, then it is ú, if it is the same in average úú, and more expensive then it is úúú.

[8] Deliverable D6.2 of COMPASS ñAn Assessment of the Potential Impact of ICT Solutions on a co-modal Transport Systemò

Financial viability

A √ for financial viability means that the system is not just socially beneficial, but actually raises income that is higher than the running costs and √√ means a significant surplus. It is judged as 0 if there is no direct return of investment or if the return is too low to pay back the investment, operational and maintenance costs within a reasonable time period. It also gets 0 for public investors, if the social overall social benefit is greater or at least in the same range as the systems costs. X or XX are only applied if a private investor is not expected to see a return for his investment in any shape or form. For instance a car driver, who invests in a safety system as an extra to his car, might not have had any accident in the future anyhow, but the system might save him from an accident that he would have had; so in this case the score would still be 0, because there is a real chance of a personal gain (which is the reason why the driver invested in the system in the first place) even if no guarantee for it.

Technical feasibility

If there are technical problems that have not yet been solved in relation to the exposed solution, then this gets a X. Whether there were no problems in the first place or whether the initial problems have already been overcome does not make a difference, in both cases it is considered a 0.

Organisational feasibility

If there are organisational problems that have not yet been solved in relation to the exposed solution, then this gets a X. Whether there were no problems in the first place or whether the initial problems have already been overcome does not make a difference, in both cases it is considered a 0.

Administrative burden

If the administrative burden increases through the introduction of the system, the solution is scored with an X; if the administrative burden decreases, it is a √; and otherwise it is a 0.

Legal feasibility

If there are legal problems that have not yet been solved, then this gets a X. Whether there were no problems in the first place or whether the initial problems have already been overcome does not make a difference, in both cases it is a 0.

User acceptance

The users for each of the solutions in COMPASS are not necessarily the travellers, but those who buy and install the system, i.e. those identified as targeted users. If they take it because somebody forces them to, but they have no objections against it either, user acceptance is granted a 0. If they object to the system and therefore either not agree to install it or have to be forced to install it, that will be X or even XX. If they welcome and embrace it, it will be a √.

Public acceptance

If the public is not even aware of the system, as for many of the aircraft related ones, then it is always a 0. If there can be positive comments expected in the press or it can be generally expected that the public will welcome the idea, it will be a √, and if the public do not like the idea, then it is a X or in case of a public outcry even a XX.

Synthesis of performance scores

Table 0-2 Performance criteria in relation Feasibility issues

Investment costs	Operation and maintenance costs	Financial Viability	Technical Feasibility	Organisation al Feasibility	Administrati ve burden	Legal feasibility	User acceptance	Public Acceptance
		XX	XX	XX		XX	XX	XX
		X / XX	X / XX	X / XX		X / XX	X / XX	X / XX
úúú	úúú	X	X	X	X	X	X	X
úú / úúú	úú / úúú	(X)	(X)	(X)	(X)	(X)	(X)	(X)
úú	úú	0	0	0	0	0	0	0
€ / úú	ú / úú	(√)		(√)	(√)		(√)	(√)
ú	ú	√		√	√		√	√
		√ / √√						
		√√						

Interest for travellers

D2D travel time

A significant change in travel time is a √ (travel time savings) or an X (travel time increases). If the changes in travel time are about a few minutes in rare situation, then it is left to 0. Frequent borderline cases of 10 minutes are identified with (X) or (√).

D2D travel costs

A significant change in door to door travel cost is a √ (travel cost savings) or an X (travel cost increases). Travel cost can increase or decrease due to e.g. a change in fuel and vehicle operating costs (for roads) and/or to fees and charges e.g. rail or flight tickets, or road toll. The installation cost of a new on-board system has already been taken into account under the investment costs, and does not come up here again the form of costs of depreciation. Similarly, savings due to the value of travel time savings are accounted for under travel time, and cost savings from the prevention of accidents are accounted for under safety, and neither are double counted here again.

Comfort and convenience

A typical example for an increase in comfort is the situation where a better weather forecasting system allows pilots to avoid areas of turbulence. Another is the seat choice via facebook, where the passenger has a better chance to sit next to somebody who wants to talk on a long flight, as he does, or be silent and read a book, as he does.

An increase in punctuality and reliability and a reduction in delays have already been scored under D2D travel time and eventually under congestion reduction, and do not score again here.

Safety

An increase in transport safety is given a √ and a reduction is a X.

Security

An increase in transport security is given a √ and a reduction is a X.

Accessibility for impaired passengers

An increase in accessibility for impaired passengers is given a √ and a reduction is a X.

Synthesis of performance scores

Table 0-3 Performance criteria in relation Interest for Travellers

D2D travel time	D2D travel cost	Comfort and convenience	Safety	Security	Accessibility for impaired
XX	XX				
X / XX	X / XX				
X	X	X	X	X	X
(X)	(X)	(X)	(X)	(X)	(X)
0	0	0	0	0	0
(√)	(√)	(√)	(√)	(√)	(√)
√	√	√	√	√	√
			√ / √√		
			√√		

Modal change

Car, bus and coach, rail, ferry, and aeroplane usage

Under this section, it is assessed if solutions have an impact on modal change. Therefore, for each mode, a **+** is given for an increase in the use of that mode, and a **-** for a decrease.

Synthesis of performance scores

Table 0-4 Performance criteria in relation to Modal Change

Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage
- -	- -	- -	- -	- -
- / - -	- / - -	- / - -	- / - -	- / - -
-	-	-	-	-
(-)	(-)	(-)	(-)	(-)
0	0	0	0	0
(+)	(+)	(+)	(+)	(+)
+	+	+	+	+
+ / ++	+ / ++	+ / ++	+ / ++	+ / ++
++	++	++	++	++

Other Impacts

Mobility

Increases in mobility get √ and decreases X.

Congestion in overcrowded corridors

A reduction in overall congestion gets √. When reduction of congestion is only very localised, it is given a (√). It should be borne in mind that congestion reduction also means decreases in D2D travel time.

CO2 emissions

A reduction in CO_2 emissions can come from two main sources: one is the reduction in congestion and concurrent reduction in fuel consumption and the other one is a shift towards more sustainable modes. CO_2 emissions are granted √ for reductions (or even √√ in cases where impacts are very wide ranging indeed), and X or even XX for increases (e.g. in solutions promoting an increased use of the road or air mode in relation to rail).

Contribution to user pays principle

This is a simple case of √ if there is a contribution, 0 if there is none, and X if the system is counterproductive to this target.

European economic progress

Improvements through a system must be very wide ranging and of large scale to allow the judgement that it is making any significant progress towards European economic progress. In this case, solutions get a √.

Territorial cohesion

The main aspect that allows a √ for this is an improvement in cross-border connections or increased accessibility of remote territories.

Synthesis of performance scores

Table 0-5 Performance criteria in relation to Other Impacts

Mobility	Congestion in overcrowded corridors	CO2 emissions	Contribution to User Pays principle	European economic progress	Territorial Cohesion
XX		XX			
X / XX		X / XX			
X	X	X	X	X	X
(X)	(X)	(X)	(X)	(X)	(X)
0	0	0	0	0	0
(√)	(√)	(√)	(√)	(√)	(√)
√	√	√	√	√	√
√ / √√		√ / √√			
√√		√√			

0.5 SYNTHESIS OF SOLUTIONS IN THE HANDBOOK

0.5.1 Handbook solutions by performance

		Feasibility									Interest for Travellers						Modal Change					Other Impacts					
		Investment costs	Operation and maintenance costs	Financial viability	Technical feasibility	Organisational feasibility	Administrative burden	Legal feasibility	User acceptance	Public acceptance	D2D travel time	D2D travel costs	Comfort and convenience	Safety	Security	Accessibility for mob. imp. Passengers	Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage	Mobility	Congestion	CO2 emissions	Contribution to user pays principle	European economic progress	Territorial cohesion
1	**TRANSPORT MANAGEMENT SYSTEMS**																										
1.1	**Urban Transport Management**																										
1.1.1	Traffic responsive signal management with distributed processing	€€	€€	V	0	0	0	0	V	V	V	V	V	0	0	0	-	+	0	0	0	0	V	V	0	0	0
1.1.2	Traffic responsive signal management with central processing	€€	€€	V	0	0	0	0	V	V	V	V	V	0	0	0	-	+	0	0	0	0	V	V	0	0	0
1.1.3	Signal priority for bus and tram	€	€	V	0	0	0	0	V	V	V	0	0	(V)	0	0	-	+	0	0	0	0	V	V	0	0	0
1.1.4	Delay / irregularity / disorder management system for public transport	€€	€	V	0	0	0	0	V	0	V	0	V	0	0	0	(-)	(+)	(+)	0	0	0	0	(V)	0	0	0
1.1.5	Vehicle and fleet management system	€	€	0	0	0	0	0	V	0	V	0	V	0	V	V	(-)	(+)	(+)	0	0	0	(V)	(V)	0	0	0
1.2	**Road Transport Management**																										
1.2.1	Variable Speed Limit (VSL) to improve traffic flow	€	€	0	0	0	0	0	V	V	V	V	V	0	0	0	+	0	0	0	0	0	V	V	0	0	0
1.2.2	Smart lanes on hard shoulders	€ / €€€	€	0	0	0	0	0	V	V	V	V	V	V	0	0	+	0	0	0	0	V	V	V	0	0	0
1.2.3	Ramp metering	€€	€	0	0	0	0	0	V	V	V	V	V	(V)	0	0	0	0	0	0	0	0	V	V	0	0	0
1.2.4	High Occupancy Toll (HOT) lane	€€€	€€	V	(X)	(X)	(X)	0	V	0	(V)	(X)	V	(V)	0	0	+	0	0	0	0	(V)	(V)	(V)	V	0	0
1.2.5	Variable congestion charging systems	€€€	€€	VV	0	0	X	0	(X)	(X)	V	X	0	V	0	0	- -	++	++	0	0	X	V	V	V	0	0
1.2.6	Adaptive routing applications based on real time congestion monitoring	€€€	€€	(X)	0	(X)	V	0	V	V	V	V	V	0	0	0	0	0	0	0	0	0	V	V	0	0	0
1.2.7	Congestion monitoring based on probe vehicles and smart phones	€€	€	V	0	0	0	0	V	V	V	V	0	0	0	0	0	0	0	0	0	0	V	V	0	0	0
1.2.8	Travel data collection based on twitter	€	€	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2.9	Average speed checks for speed limit enforcement	€€	€€	VV	0	0	X	0	X	X	0	V	0	V	0	0	0	0	0	0	0	0	(V)	V	0	0	0
1.2.10	Reduce speed for fun: speed camera lottery	€€	€	V	0	0	0	0	0	V	(X)	(V)	0	V	0	0	0	0	0	0	0	0	(V)	(V)	0	0	0
1.2.11	Automatic incident detection with CCTV images	€	€	V	0	0	V	0	V	V	V	0	V	V	0	0	0	0	0	0	0	0	V	V	0	0	0
1.2.12	Vehicles miles travelled pricing	€€€	€	V	0	0	0	0	V	(V)	0	X	V	0	0	0	0	0	+	0	0	0	(V)	V	V	0	0
1.2.13	Vehicles miles travelled insurances	€ / €€	€€	V	0	0	X	0	V	V	0	(V)	0	V	0	0	-	+	0	0	0	0	V	V	V	0	0
1.2.14	Conventional weather detection systems	€€	€	V	0	0	0	0	V	V	0	V	0	VV	0	0	(-)	(+)	(+)	0	0	0	V	V	0	0	0
1.2.15	Road maintenance data via crowd sourcing	€	€	V	0	(X)	0	V	0	V	0	0	V	V	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3	**Railway Traffic Management**																										
1.3.1	Programmed traffic control for railways	€	€	VV	(X)	V	0	0	0	0	V	0	0	0	0	0	0	0	+	0	0	0	0	0	0	0	0
1.3.2	Earthquake detection and alarm system for railway	€€	€€	V	0	0	0	0	V	V	0	(X)	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3.3	European Train Control System (ETCS)	€€	€	V	0	X	0	0	V	0	V	0	0	V	0	0	(-)	0	+	0	(-)	(V)	0	V	0	0	(V)
1.3.4	GSM-R (voice radio system)	€€	€	V	0	0	0	0	V	0	V	(X)	0	V	0	0	0	0	V	0	0	(V)	0	0	0	0	V
1.4	**Air Transport Management**																										
1.4.1	Single European Sky ATM Research (SESAR)	€€€	€€€	V	0	0	V	0	(X)	0	V	V	0	VV	0	0	(-)	0	(-)	0	(+)	(V)	V	V	0	V	0
1.4.2	Enable air routes as the crow flies	€€€	€€€	VV	0	(X)	0	0	V	0	V	V	0	(V)	0	0	0	0	0	0	(+)	0	V	V	0	(V)	0
1.4.3	Accurate weather information for air navigation	€€€	€€	V	0	0	0	0	V	0	(V)	0	(V)	V	0	0	0	0	0	0	0	0	(V)	(V)	0	0	0
1.4.4	ADS-B: satellite-based successor to radar	€€€	€€€	V	0	0	0	0	0	0	(V)	(X)	0	V	0	0	0	0	0	0	0	0	(V)	(V)	0	0	0
1.4.5	Airplane Surface Movement Guidance and Control System at Airports (A-SMGCS)	€€	€€	V	0	0	0	0	V	0	(V)	0	0	(V)	0	0	0	0	0	0	0	0	(V)	(V)	0	0	0
1.4.6	Radio frequency luggage identification at airports	€€€	€	(X)	0	0	V	0	V	0	V	0	V	0	0	V	0	0	0	0	0	0	0	0	0	0	0
1.4.7	Automated solutions for security and boarding control at airports	€€	€	0	0	0	V	0	V	(V)	V	(X)	V	0	V	0	0	0	-	0	+	0	0	(X)	0	0	0
1.4.8	Electronic luggage tags	€	€	V	0	0	0	0	V	V	V	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	**Maritime Transport Management**																										
1.5.1	River Inland Automatic identification system (AIS)	€€	€	V	0	0	0	0	V	0	V	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5.2	Sertica	€	€	V	0	0	V	0	V	0	0	(V)	0	(V)	0	0	0	0	0	0	0	0	0	(V)	0	0	0

Figure 0-5 Performance of "Transport Management Systems" solutions

		Feasibility									Interest for Travellers						Modal Change					Other Impacts					
		Investment costs	Operation and maintenance costs	Financial viability	Technical feasibility	Organisational feasibility	Administrative burden	Legal feasibility	User acceptance	Public acceptance	D2D travel time	D2D travel costs	Comfort and convenience	Safety	Security	Accessibility for mob. imp. Passengers	Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage	Mobility	Congestion	CO2 emissions	Contribution to user pays principle	European economic progress	Territorial cohesion
2	**TRAVELLER INFORMATION SYSTEMS**																										
2.1	**Passenger Orientation and Guidance**																										
2.1.1	Integrated passenger guidance through transport terminals on mobile devices	€€	€	V	0	0	0	0	V	0	0	0	V	0	0	V	0	0	0	0	0	0	0	0	0	0	0
2.1.2	Passenger guidance for visually impaired people	€	€	V	0	0	0	0	(V)	0	V	V	0	(V)	0	V	(-)	+	+	0	0	V	0	0	0	0	0
2.1.3	Bluetooth based queueing estimated time at transport terminals	€	€	0	0	0	0	0	V	V	(V)	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.1.4	Augmented reality smartphone apps to locate closest public transport station	€	€	V	0	0	0	0	V	V	V	0	0	0	V	V	-	0	+	0	0	0	(V)	(V)	0	0	0
2.1.5	On-street parking availability guidance application	€€€	€€	V	0	0	0	0	V	V	V	0	V	0	0	0	+	-	0	0	0	0	V	V	0	0	0
2.1.6	Park house smart guidance	€€	€	0	0	0	0	0	(V)	V	V	(X)	0	0	(V)	0	0	0	0	0	0	V	V	0	0	0	0
2.1.7	Parking guidance for bicycles	€€	€	0	0	0	0	0	V	V	(V)	0	V	0	0	0	-	0	(+)	0	0	0	0	0	0	0	0
2.2	**Co-Modal Travel Planners**																										
2.2.1	Point-to-point traveller information system on mobile devices	€	€	0	0	0	0	0	V	V	V	V	VV	V	0	V	-	+	+	0	0	0	V	V	0	0	0
2.2.2	Urban point-to-point traveller information system on personal computers (web based)	€€	€	0	0	0	0	0	V	V	V	V	V	V	0	V	-	+	+	0	0	0	V	V	0	0	0
2.2.3	Interurban traveller information system on personal computers (web based)	€€	€	(V)	0	(X)	0	0	V	V	V	V	V	0	0	0	-	+	+	+	+	0	V	V	0	0	0
2.2.4	Route planners for bikes	€ / €€	€	0	0	0	0	0	V	V	0	0	V	V	0	0	(-)	(-)	0	0	0	0	(V)	(V)	0	0	0
2.3	**Real-Time Service Information Services**																										
2.3.1	Live travel time information on mobile phone / internet	€ / €€€	€	X-V	0	0	0	0	V	V	V	0	V	0	(V)	(V)	-	+	0	0	0	0	V	V	0	0	0
2.3.2	Live travel time information at local public transport terminals	€€	€	0	0	0	0	0	V	V	(V)	0	V	0	0	0	(-)	(+)	0	0	0	0	(V)	(V)	0	0	0
2.3.3	Live public transport travel time information inside vehicles	€ / €€	€	0	0	0	V	0	V	V	(V)	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.3.4	Real-time public transport information based on social media	€	€	V	0	0	(X)	(X)	V	V	V	0	V	0	0	0	(-)	(+)	(+)	0	0	0	(V)	(V)	0	0	0
2.3.5	Bus location systems	€€	€€	(V)	0	0	0	0	V	V	V	0	V	0	0	V	-	+	0	0	0	(V)	V	V	0	0	0
2.3.6	Vehicle tracking applications	€	€	V	0	0	0	0	V	V	V	(V)	0	0	(X)	0	0	0	0	0	0	0	0	0	0	0	0
2.4	**Smart Phone Journey Assistants**																										
2.4.1	Travel organising assistants or passbook applications	€	€	0	0	0	0	0	V	V	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.4.2	Informed seat choice applications for airplanes	€	€	V	0	0	0	0	V	V	0	0	VV	0	0	V	0	0	0	0	0	0	0	0	0	0	0
2.4.3	Seat allocation based on travellers' social profile	€	€	V	0	0	0	0	V	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.4.4	Smartphone taxi apps	€€€	€	V	0	0	0	(X)	V	V	V	0	V	0	0	(V)	0	0	0	0	0	0	0	0	0	0	0

Figure 0-6 Performance of "Traveller Information Systems" solutions

	Feasibility									Interest for Travellers						Modal Change					Other Impacts					
	Investment costs	Operation and maintenance costs	Financial viability	Technical feasibility	Organisational feasibility	Administrative burden	Legal feasibility	User acceptance	Public acceptance	D2D travel time	D2D travel costs	Comfort and convenience	Safety	Security	Accessibility for mob. imp. Passengers	Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage	Mobility	Congestion	CO2 emissions	Contribution to user pays principle	European economic progress	Territorial cohesion
3 SMART TICKETING AND TOLLING																										
3.1 Electronic Toll Collection (ETC)																										
3.1.1 Integrated transnational highways toll payments	€€€	€€	V	(X)	(X)	(X)	0	V	V	V	(V)	V	0	0	0	(+)	0	0	(+)	0	0	V	V	0	0	V
3.1.2 National highways free-flow payment	€€€	€€	V	(X)	0	V	0	V	V	V	(V)	V	V	0	0	0	0	0	0	0	0	V	V	0	0	0
3.1.3 Semi-automated payment at highway toll plazas	€€	€	VV	0	(X)	V	0	V	V	V	0	V	(V)	0	0	(+)	(-)	0	0	0	0	V	V	0	0	0
3.2 Access Management																										
3.2.1 Camera-based vehicle access control	€€	€€	(V)	0	0	X	0	V	V	0	0	(V)	0	(V)	0	0	0	0	0	0	0	0	0	0	0	0
3.2.2 Transmission-based vehicle access control	€€€	€€	V	0	0	V	0	V	V	V	0	(V)	0	0	0	0	0	0	0	0	0	V	V	0	0	0
3.2.3 Smartcard-based personal access control	€€	€	V	0	0	V	0	V	V	0	V	VV	0	V	0	-	+	+	0	0	0	V	V	0	0	0
3.2.4 Biometric personal access control	€€	€	0	0	0	0	0	V	V	V	0	0	0	V	0	0	0	0	0	0	0	V	0	0	0	0
3.3 Automated Fare Collection Systems (AFC) - Ticketing Systems																										
3.3.1 Public transport smart cards	€€	€	V	0	V	V	0	V	V	V	(V)	V	0	V	0	-	+	+	0	0	0	V	V	0	0	0
3.3.2 SMS boarding passes	€	€	VV	(X)	0	0	0	V	V	0	0	0	V	V	0	0	0	0	0	0	0	0	0	0	0	0
3.3.3 SMS ticket purchase in public transport	€	€	V	(X)	0	V	0	V	V	V	0	0	0	V	V	-	+	+	0	0	0	V	V	0	0	0
3.3.4 SMS parking payment	€	€	V	0	0	V	0	V	V	0	0	V	0	0	V	0	0	0	0	0	0	0	0	0	0	0
3.3.5 Integration of rail ticketing into airline GDS	€	€	V	0	0	0	0	V	V	(V)	(V)	V	0	0	0	-	0	+	0	-	0	V	V	0	0	0

Figure 0-7 Performance of "Smart Ticketing and Tolling" solutions

		Feasibility									Interest for Travellers						Modal Change					Other Impacts					
		Investment costs	Operation and maintenance costs	Financial viability	Technical feasibility	Organisational feasibility	Administrative burden	Legal feasibility	User acceptance	Public acceptance	D2D travel time	D2D travel costs	Comfort and convenience	Safety	Security	Accessibility for mob. imp. Passengers	Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage	Mobility	Congestion	CO_2 emissions	Contribution to user pays principle	European economic progress	Territorial cohesion
4	**SMART VEHICLES AND INFRASTRUCTURE**																										
4.1	**Autonomous Driver Assistance Systems**																										
4.1.1	Head-up display	€	€	0	0	0	0	0	V	0	0	0	V	V	0	V	0	0	0	0	0	0	0	0	0	0	0
4.1.2	Night vision in cars	€	€	0	0	0	0	0	V	0	0	0	V	V	0	V	0	0	0	0	0	V	0	0	0	0	0
4.1.3	Driver drowsiness detection system for cars	€	€	0	0	0	0	0	V	0	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.4	Automatic car parking	€	€	0	0	0	0	0	V	0	(V)	0	VV	V	0	V	+	0	0	0	0	V	(V)	(V)	0	0	0
4.1.5	Blind spot detection for cars	€	€	0	0	0	0	0	V	0	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.6	Collision avoidance system for buses (pre-crash system)	€	€	0	0	0	0	0	V	0	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.7	Pedestrian and cycle scanning for cars	€€	€	0	0	0	0	0	V	(V)	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.8	Lane Departure Warning Systems (LDWS) for cars	€	€	0	0	0	0	0	V	0	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
4.1.9	Traffic jam assistant	€	€	0	(X)	0	0	0	V	0	V	(V)	V	V	0	0	0	0	0	0	0	0	V	(V)	0	0	0
4.1.10	Adaptive Cruise Control (ACC)	€	€	0	0	0	0	0	V	0	0	V	V	V	0	0	0	0	0	0	0	0	0	V	0	0	0
4.1.11	Autonomous vehicles	€€€	€	0	X	0	0	0	V	V	V	V	VV	V	0	V	+	-	-	0	0	VV	V	V	0	V	0
4.2	**Cooperative Vehicle to Vehicle (V2V) Applications**																										
4.2.1	Vehicular ad-hoc network	€	€	X	X	0	0	0	XX / V	0	(V)	(V)	V	V	(X)	0	0	0	0	0	0	0	(V)	(V)	0	0	0
4.2.2	Enhanced driver awareness system	€ / €€€	€	0	0	0	0	0	(V)	0	(V)	(V)	0	V	0	0	0	0	0	0	0	0	(V)	(V)	0	0	0
4.2.3	Cloud sourced safety map	€	€	0	0	0	0	0	V	V	0	0	0	V	0	0	0	0	0	0	0	0	0	0	0	0	0
4.2.4	Automatically driven car trains (SARTRE)	€€	€	X	(X)	(X)	0	(X)	XX / V	V	(X)	(X)	VV	V	(X)	0	+	0	0	0	0	0	V	V	0	0	0
4.3	**Vehicle to Infrastructure (V2I) Applications**																										
4.3.1	Personal Rapit Transit (PODCars)	€€€	€€€	V	0	0	0	0	V	(V)	V	(V)	VV	(X)	(X)	V	0	0	0	0	0	0	0	V	0	V	0
4.3.2	Passive Intelligent Speed Adaptation (ISA)	€	€	0	0	0	0	0	V	0	0	V	0	V	0	0	0	0	0	0	0	0	(V)	V	0	0	0
4.3.3	Active Intelligent Speed Adaptation (ISA)	€€	€	0	0	0	0	0	(V)	0	0	V	0	V	0	0	0	0	0	0	0	0	(V)	V	0	0	0
4.3.4	Weather detection by vehicles	€	€	V	0	0	0	0	V	V	0	V	0	VV	0	0	0	0	0	0	0	0	V	V	0	0	0
4.3.5	Emergency vehicle notification system (eCall)	€ / €€€	€ / €€	0	0	X	V	0	V	V	0	0	0	V	0	0	0	0	0	0	0	0	(V)	(V)	0	0	0
4.3.6	Cooperative traveller assistance	€ / €€€	€	0	0	0	0	0	(V)	0	V	V	0	0	0	0	0	0	0	0	0	0	V	V	0	0	0

Figure 0-8 Performance of "Smart Vehicles and Infrastructure" solutions

		Feasibility									Interest for Travellers						Modal Change					Other Impacts					
		Investment costs	Operation and maintenance costs	Financial viability	Technical feasibility	Organisational feasibility	Administrative burden	Legal feasibility	User acceptance	Public acceptance	D2D travel time	D2D travel costs	Comfort and convenience	Safety	Security	Accessibility for mob. imp. Passengers	Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage	Mobility	Congestion	CO2 emissions	Contribution to user pays principle	European economic progress	Territorial cohesion
5	SHARED MOBILITY AND DEMAND RESPONSIVE TRANSPORT																										
5.1	Public Transport Services in Low Demand Situations																										
5.1.1	DRT Planning and scheduling optimisation systems	€€	€	V	0	(X)	V	0	0	V	V	(V)	(V)	0	0	(V)	-	+	0	0	0	(V)	0	0	0	0	0
5.1.2	Computerised dispatch and positioning systems	€€	€	V	0	0	V	0	V	0	V	V	(V)	0	(V)	(V)	-	+	0	0	0	(V)	(V)	0	0	0	0
5.2	Shared Mobility																										
5.2.1	Commercial fixed point car sharing (Zipcar)	€	€	V	0	0	0	0	V	V	(V)	(V)	V	0	0	0	-	+	+	0	0	(V)	(V)	(V)	0	0	0
5.2.2	Free-floating car sharing systems (car2go)	€€€	€€	V	0	0	0	0	V	V	(V)	(V)	V	0	0	0	-	+	+	0	0	(V)	(V)	(V)	0	0	0
5.2.3	Grass-root cooperative car sharing systems (CARUSO)	€	€	V	0	0	0	0	V	V	(V)	V	V	(V)	0	0	(-)	(+)	(+)	0	0	V	0	V	0	0	0
5.2.4	Carpooling, Share-a-ride schemes, booking systems (Mitfahrzentrale)	€€	€	0	0	0	0	0	V	0	(V)	V	0	0	(X)	0	V	X	X	0	0	V	(V)	(V)	0	0	0
5.2.5	Shared bike scheme management system	€€	€	0	0	0	0	0	V	V	V	V	V	0	0	0	-	+	0	0	0	(V)	V	V	0	0	0
5.2.6	Shared car parking - WeSmartPark	€	€	V	0	(X)	0	0	V	V	V	V	V	0	0	0	+	-	0	0	0	0	0	0	0	0	0

Figure 0-9 Performance of "Shared Mobility and Demand Responsive Transport" solutions

0.5.2 Handbook solutions by abstracts

1- Transportation Management Systems

1.1- Urban Transport Management

1.1.1- Traffic responsive signal management with distributed processing

Traffic responsive centralised signal management with distributed systems are those in which, generally, the intersection controller is responsible for control decisions at intersection. There are several types of distribute systems, ranging from fully flexible, large-scale systems (UTOPIA), over fully flexible isolated systems (e.g. MOVA) and pre-planned systems with local modification (small closed-loop systems).

1.1.2- Traffic responsive signal management with central processing

In centralised signal control systems, a central computer makes control decisions and directs the actions of individual controllers. Each intersection requires only a standard controller and interfacing unit and does not perform any software functions. Central systems have the following characteristics.

1.1.3- Signal priority for bus and tram

This application is aimed at improving public transport by providing priority for buses and trams at signalized intersections through green lights. Transit Signal Priority (TSP) enables public transport to operate more service with the same resources, to reduce delays and unreliable services caused by sharing the right of way with other traffic and thus attracting more passengers. By reducing conflicts with private traffic, transit priority improvements also can reduce accidents and driver stress.

1.1.4- Delay / irregularity / disorder management system for public transport

Delay management has been very common in air transport, but it is becoming more and more important in public transport, where passengers have to decide in a shorter time whether to wait or to take an alternative route. If big disruptions occur in a public transport network, such disruptions lead to severe violations of the timetable. The three mayor tasks in disruption management are timetable adjustment, rolling stock rescheduling and crew rescheduling (e.g. allocation of drivers).

1.1.5- Vehicle and fleet management system

Fleet management focuses on the operation of public transport vehicles and technologies that can be applied to improve vehicle and fleet planning, scheduling and operations. The most basic function in a fleet management system is the automatic vehicle location (AVL) component, commonly GPS-based. The GPS systems will communicate to the depot and other offices the information on vehicle location to provide better urban transport control, vehicle priority and real-time information both pre-journey (at bus stop, web, via SMS) and during the journey (in the vehicle).

1.2- Road Transport Management

1.2.1- Variable Speed Limit (VSL) to improve traffic flow

Variable Speed Limits (VSL) are used to improve traffic conditions on congested motorways. On motorways, much of the variation in speed and headways between vehicles in the same lane and between lanes is characteristic of unstable traffic conditions. A minor incident may cause long traffic queues, congestion, and frustrated drivers, which in turn may lead to accidents and long travel times that entail a cost to society, the private sector, and individuals alike. By changing speed limits in congested motorways based on real-time traffic flow information, VSL systems aim at mitigating congestion waves.

1.2.2- Smart lanes on hard shoulders

Temporary shoulder use is a congestion management strategy typically deployed in conjunction with speed harmonization to address capacity bottlenecks on the freeway network. The strategy provides additional capacity during times of congestion and reduced travel speeds. In Hessen (Germany), the hard shoulder increases the capacity of the standard three lane motorway sections by 20%. This permits traffic volumes of over 7,000 vehicles per hour without traffic breakdown.

1.2.3- Ramp metering

Ramp metering consists in controlling the flow of traffic entering on the access ramps to a motorway. Ramps are used to stock vehicles temporarily, in order to optimise the flow on the motorway itself, and maintain it below the critical level, over which congestion is likely to appear. Ramp metering is used to solve a problem of congestion created by a bottleneck that originates by an excess of demand on one or more ramps of a motorway. Ramp metering aims at maintaining the full utilization of the motorwaysô capacity, even during rush hours and in case of incidents.

1.2.4- High Occupancy Toll (HOT) lane

In the face of growing urban congestion and the high cost of creating new capacity on motorways, roadway authorities are considering new High Occupancy Toll (HOT) lanes or the conversion of existing High Occupancy Vehicle (HOV) to HOT lanes to improve highway quality of service and to make maximum use of existing highway infrastructure. HOV lanes are reserved for vehicles with a driver and one or more passengers in order to expand the passenger throughput of the respective lane. HOT lanes are HOV lanes, where single-occupancy vehicles (SOVs) are allowed to drive when paying a toll.

1.2.5- Variable congestion charging systems

Road charging system can be defined as a special fee that is paid by vehicles for its entrance into the specific area of city. The high of the fee is usually dependent on number of entrances into the area or time spent there or according to vehicle mode. Electronic road pricing systems provide a targeted solution for congestion pricing by allowing the authorities to pin-point specific congested spots and vary the congestion charge according to prevailing traffic conditions. Therefore, the charges can either increase or decrease according to the demand of usage of the priced-road or expressway.

1.2.6- Adaptive routing applications based on real time congestion monitoring

Public authorities define strategies in order to regulate traffic in case of serious disruption (such as recurrent traffic congestion, long-term road works or special events), and the urban Strategic Routing Application (SRA) provides enhanced routing functionalities that take into account these pre-defined strategies. The new aspect of this application compared to existing approaches is that route suggestions take into consideration not only network strategies but also real-time traffic information and give individualised routing suggestions to each vehicle.

1.2.7- Congestion monitoring based on probe vehicles and smart phones

Due to the increased traffic congestion in heavily populated areas, there is a high demand for improvements in the efficiency of transportation systems. Acquisition of road traffic data is a crucial and necessary activity for a traffic management information system. Probe vehicle data can provide continuous, more detailed and more widespread information on the status of traffic at any one moment. Real-time views of congestion on the road network is being provided by Google Maps since 2013 based on live display of the number of Android phones travelling along the network.

1.2.8- Travel data collection based on twitter

Geolocated tweets have been used to find the most frequently travelled routes in selected US and European cities (Eric Fischer, 2011). This sort of data could be used to optimise transport systems. If the volume of geo-tagged tweets is used as a proxy for traffic levels, transport planners could use this data to fine-tune existing transport networks and establish where new routes are needed. Furthermore, by comparing the data with known traffic volumes, the information could also give an indication to traffic control operators of traffic levels on routes not equipped with traffic detectors.

1.2.09- Average speed checks for speed limit enforcement

In order to reduce the road accident rate, Italian Motorways infrastructure manager developed Tutor, a speed detector system based on a check ñon road sectionò rather than a check ñon timeò. Vehicles are detected on two separated sections of the road, where vehicles are recorded by cameras along with the date and the time of passage. The system calculates average speed between both sections and in case of maximum speed exceeded, enforcement procedures are activated.

1.2.10- Reduce speed for fun: speed camera lottery

This is an experimental system to enforce speed limits based on the belief that if motorists are given positive incentives to check their speed they will obey posted speed limits. Leveraging traffic camera and speed capture technologies, the Speed Camera Lottery device photographs all drivers passing beneath it. Part of the subsequent fines levied against speeders is pooled in a lottery with a random winner periodically drawn from the group of speed limit adherents.

1.2.11- Automatic incident detection with CCTV images

Systems for automatic incident detection (AID) are aimed at increasing safety and security levels for drivers and infrastructure managers. Events such as motionless vehicles, wrong way vehicles, presence of pedestrians are automatically detected through digital processing of video streams. Automatic Incident Detection System is capable to detect incidents happening around the coverage area and help to prevent them in favourable cases.

1.2.12- Vehicles miles travelled pricing

In pay-per-use road pricing program, a meter is placed on the dashboard of cars, showed the price of the trip: based on GPS technologies, the system tabulates a charge for each car trip by using a mileage-based formula that also takes into account of a car's fuel efficiency, the time of day and the route. This system is different from existing toll systems. While most toll systems aim at financing the costs of a specific roads, this pricing scheme is not linked to individual roads, but covers the entire network and is focussed on the behaviour of the road user. Pay-per-use taxation can replace fixed vehicle (ownership and gas) taxes.

1.2.13- Vehicles miles travelled insurances

Vehicles Miles Travelled Insurances is a mechanism by which the cost of insurance is directly related to the distance driven. When people drive less, they pay less. Those who drive more will pay more. The analogy eloquently used by Jason Bordoff and Pascal Noel in their Brookings Institute paper (Bordoff & Pascal 2008) is that of an All-You-Can-Eat-Buffet. Traditional motor insurance is like All-You-Can-Drive insurance. You pay for your insurance once, and then you can drive as much as you like without it costing any more. Given that you can only be involved in an accident if you are actually driving your car, this is about as absurd as paying a flat rate for petrol and filling up whenever you need to.

1.2.14- Conventional weather detection systems

Weather conditions affect the operation of the national transport system by changing the driving environment as well as the behaviour of drivers. To increase driver information, weather detection systems can measure a number of indicators by means of on-road detectors, like fog and wind, pavement condition (e.g., wet, snowy, icy, flooded), pavement chemical concentration or pavement freeze-point temperature, pavement temperature, visibility. It is expected that in the future, these weather detection systems will be able to directly inform vehicles (V2I), which will then be able to respond to road conditions for a safer drive.

1.5.15- Road maintenance data via crowd sourcing

This fact sheet focuses on the use of crowd-sourcing to collect road maintenance data, in particular potholes. Crowd sourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people. It has become an increasingly popular tool in the form of smart phone apps for reporting the real-time traffic conditions and road infrastructure status such as congestion, road-works, abandoned vehicles and potholes. Many local authorities have also developed smart-phone apps to allow citizens to report issues related to the conditions of their living environments including potholes, graffiti, street light outages directly to their local government organisation using their phones.

1.3- Railway Traffic Management

1.3.1- Programmed traffic control for railways

A robust railway timetable should be able to accommodate and recover from the occurrence of minor delays, but dealing with more serious unexpected events requires ongoing, real-time rail traffic management and control. New systems are being implemented providing automated traffic management tools that can control, in real-time, the trains in the network and at stations so as to optimise specific performance indicators, such as punctuality or regularity.

1.3.2- Earthquake detection and alarm system for railways

Whilst prediction of earthquake occurrences is still highly problematic, detection and early-warning is possible, and systems have been developed and implemented for this purpose. The Japanese Railway Technical Research Institute developed the úurgent earthquake detection and alarm systemö (UrEDAS) for use along Shinkansen lines. When an earthquake occurs, the railway systems are automated via the train protection systems so as to remove any source of human error or delay, enabling automatic shut-down of train power supplies when specified seismic thresholds are passed. This is thought to reduce the likelihood and extent of train derailments in the aftermath of the earthquake.

1.3.3- European train control system (ETCS)

The European Train Control System (ETCS) is a signalling, control and train protection system designed to replace the many incompatible safety systems currently used by European railways, especially on high-speed lines. The ETCS is a European technical standard for ún-cabö train signalling and speed control. Train Control Systems serve to automatically control the speed of trains so as to enhance safety. Information is transmitted from the ground to the train, where an on-board computer uses it to calculate the maximum authorised speed and then automatically slows down the train if necessary.

1.3.4- GSM-R (voice radio system)

GSM-R serves to provide secure voice and data communications between trains and ground based organisations and personnel. Specifically, it enables communications between various railway operations staff, including drivers, dispatchers, train engineers and station controllers. In turn, it facilitates various applications, such as cargo-tracking, video surveillance and passenger information services. GSM-R was developed with the aim of being an interoperable and cost-effective digital replacement for a range of incompatible cable and analogue systems previously in existence across Europe.

1.4- Air Transport Management

1.4.1- SESAR (Single European Sky ATM Research)

Contrary to the United States, Europe does not have a single sky, one in which air navigation is managed at the European level. The EU Single European Sky is an ambitious initiative launched by the European Commission in 2004 to reform the architecture of European air traffic management. It proposes a legislative approach to meet future capacity and safety needs at a European rather than a local level. The Single European Sky is the only way to provide a uniform and high level of safety and efficiency over Europeös skies.

1.4.2- Enable air routes as the crow flies

Recent studies have demonstrated that air routes in Europe are not optimally designed. In 2009 a flightös route was on average 47.6 km (or 5.4%) too long compared to its optimum flight trajectory. Deviations from the optimum flight trajectory generate additional flight and engine running time, fuel burn, gas emissions and high costs to the industry. Extended air routes are due to several factors, e.g. sub-optimal airspace design, inefficient city pairs, constraints related to the need for civil and military airspace users to share the airspace, inappropriate flight planning and route utilisation or route restrictions.

1.4.3- Accurate weather information for air navigation

Next Generation (NextGen) Network Enabled Weather (NNEW) is a project to develop a 4-dimension (all points, lateral, vertical and time dimensions) weather data cube (4-D Wx Data Cube) from disparate contributors and locations. Weather has a considerable impact on aviation operations. Providing the accurate and timely weather information required by aviation decision makers is an element of the Next Generation Air Transportation System. This will increase airspace capacity, improve efficiency, and improve air safety.

1.4.4- ADS-B: satellite-based successor to radar

Radar technology dates back to World War II. Radar occasionally has problems discriminating airplanes from migratory birds and rain õclutter.ö ADS-B, which receives data directly from transmitters rather than scanning for targets like radars, does not have a problem with clutter. ADS-B uses GPS signals along with aircraft avionics to transmit the aircraftõs location to ground receivers. The ground receivers then transmit that information to controller screens and cockpit displays on aircraft equipped with ADS-B avionics. The improved accuracy, integrity and reliability of satellite signals over radar means controllers will be able to safely reduce the mandatory separation between aircraft. This will increase capacity in the nationõs skies

1.4.5- Airplane Surface Movement Guidance and Control System at airports (A-SMGCS)

Proper management of existing airside infrastructure at airports is key to optimise airport capacity, particularly in adverse weather conditions. Operations on the airport airside are managed today õmanuallyö. A considerable amount of research effort is concentrated on the development of Advanced Surface Movement Guidance and Control Systems (A-SMGCS). Airports are considered as the main bottleneck of the Air Traffic Management (ATM) system, and airport delays are a growing proportion of the total ATM delay.

1.4.6- Radio frequency luggage identification at airports

This application is aimed at limiting delays associated with luggage check-in at the airport and locating luggage afterwards, increasing reliability of luggage handling processes, while ensuring a smooth luggage drop and pick up for passengers, be that to the luggage conveyer belt in baggage collection areas in airports or even in check-in areas outside airports (e.g. in rail stations). Radio Frequency Luggage Identification involves the use of chips embedded into luggage tags to ensure that luggage can be tracked much more effectively that the current system which uses labels with printed bar codes. RFID supplies a real time and accurate view of the baggage along the transportation, and enormously enhances the ability for baggage sorting, baggage matching and baggage tracking.

1.4.7- Electronic luggage tags

The development of the personalised electronic bag tag (a digital alternative to the traditional paper luggage tag) is targeted at improving the flow of customers, making it quicker, smoother and easier for travellers to check in and pass through airports. The tags can be used by passengers who have their booking details sent to their smart phone using the official airline app. Each tag carries a special computer chip and has two small screens on each side. Once checked in, customers just need to hold their smart phone over the electronic tag, and the app is then held over the electronic bag tag.

1.4.8- Automated Solutions for Security and Boarding Control at Airports

IATA presented a new integrated checkpoint concept aimed at improving security procedures at airports while minimising their impact on travellers. Passengers approaching this new concept of checkpoint will be directed to one of three lanes according to the results of a risk assessment of the passenger conducted by government before they arrive at the airport: óknown travellerô lane, ónormalô lane, and óenhanced securityô lane. On the way towards the IATA checkpoint concept, many innovations are being applied today to increase the speed and efficiency of airport formalities, i.e. check-in, security controls and boarding.

1.5- Maritime Transport Management

1.5.1- Inland Automatic Identification System (AIS)

AIS stands for ñAutomatic Identification Systemò and enables to identify the current position of the vessels using global positioning systems (GPS). It is a system in which ships continually transmit their ID, position course, speed and other data to all other nearby ships and shoreside authorities on a common VHF radio channel. This data transmission is based on a standard specified for ñTracking and Tracingò by, the so-called Inland-AIS standard. This standard guarantees 100% compatibility with the maritime AIS system and has the capacity to expand its applications to meet the needs of inland waterway transport. AIS transponders have proven their worth in maritime waterway transport in supporting navigation and were made part of the mandatory equipment for vessels with more than 300 gross registered tons in 2002.

1.5.2- SERTICA Maritime Fleet Management IT Solution

SERTICA is a widespread distributed computer system that supports shipõs maintenance, purchasing and fleet management. Its first and main function is to give computer alerts when any part of the ship is due for routine maintenance. It also reports all ñnear-missesò, as well as, as a warning, to all other ships of the fleet, as well as ñnon-conformitiesò.

2- Traveller Information Systems

2.1- Passenger Orientation and Guidance

2.1.1- Integrated passenger guidance through transport terminals on mobile devices

As 4G networks are implemented, the speed of connectivity and the ability to interact with large amounts of data over the wireless eco-system will result in new levels of customer information. The always connected traveller will expect to receive in the future not only information on schedules and departures/arrivals announcements, but a much larger range of services like guidance through transport terminals (e.g. instructions on how to reach boarding gates or train platforms), expected waiting time at security checkpoints, eventual incidences, or information on retailer options or airport services.

2.1.2- Passenger guidance for visually impaired people

Passenger guidance for visually impaired people seeks to make use of satellite navigation technologies in conjunction with screen magnification and speech synthesis technologies in order to provide route navigation and wayfinding information to people with a visual impairment. One of the key ways in which visual impairment impacts on people is identified to be the way it affects them getting about as a pedestrian.

2.1.3- Bluetooth based queuing estimated time at transport terminals

This system automatically measures and displays the wait time of queuing passengers in lines. Airplane passengers are passively tracked using their Bluetooth-enabled mobile devices, real-time queuing information is then generated, and accurate queuing times are displayed on the flight information display screens (FIDS). Though currently applied at airports, this technology can be applied to any other transport terminal in areas likely to generate queues, e.g. ticket sells at train stations.

2.1.4- Augmented reality smart phone apps to locate closest public transport station

Augmented Reality refers to the overlaying of geo-information data onto the óreal worldô view, utilising the camera and connectivity of a smart phone, tablet or similar device. A number of travel-related augmented reality applications have emerged onto the market. In most cases, these focus on the metro, tram or underground network of a particular city, overlaying guidance elements pointing closest stations and stops above the images of the streets taken from the smart phone camera.

2.1.5- On-street parking availability guidance application

This application is aimed at more effective parking management, both on supply side and on demand side. The two major issues affecting parking systems are: congestion caused by traffic looking for an available parking-bay and an effective enforcement. Thanks to this ITS application not only it is possible to get real-time availability of parking facilities, but also enforcement personnel is helped in checking irregularities and parking payment can also performed via SMS or apps. The network system is based on wireless sensors that are located under every parking bay, and on intelligent parking meters.

2.1.6- *Park house smart guidance*

Smart parking refers to the utilisation of various technologies to efficiently manage the use of a parking garage or park house. Underpinning the system are traffic sensors that count the number of vehicles entering and exiting the parking garage. The data collected by these sensors is then pushed out to drivers via a variety of channels, permitting an optimisation of existing parking spaces.

2.1.7- *Parking guidance for bicycles*

An Automatic Bicycle Parking Detection system consists in an electronic device that detects if and how long a bicycle is parked in a bicycle rack. To that purpose each individual parking rail has a toggle-switch and a small battery. The toggle-switch is activated as soon as a bicycle is positioned: thus, the device sends a wireless signal to the receiver (usually on a pole positioned in the parking facility). All receivers transmit information to a central computer stationed at the company managing the system. The data collected are returned via the internet to the parking facility manager in order to have a clear and instant picture of bicycle parking availability and to check which bicycles have been parking for more than the time allowed.

2.2- Co-Modal Travel Planners

2.2.1- *Point-to-point traveller information system on mobile devices*

Traveller information systems on mobile devices are electronic systems which offer assistance to travellers at all times and places, being multimodal and covering public transport, bicycles, walking, private cars, taxis, etc. These applications give access to internet-based information services such as public transport timetables, route guidance including maps, road and traffic events as well as real-time information on transport or road network conditions. Users may also able to access booking and reservation facilities and read the latest tourist and destination information (e.g. points of interest).

2.2.2- *Urban point-to-point traveller information system on personal computers (web based)*

Traveller information systems on personal computers are websites or desktop gadgets that offer assistance to travellers on their personal computer at home or on the way (laptops). These systems are multimodal, covering public transport, bicycles, walking, private cars, taxis, etc.

2.2.3- *Interurban traveller information system on personal computers (web based)*

City-to-city traveller information systems on personal computers are software solutions for long-distance travel planning. Examples for systems, which are providing travellers pre-trip with real-time travel information across borders, regions and different modes of transport, are ñrouteRANKò or ñEU-Spiritò. These two examples are representing different approaches: the former being an integrative system, the latter a compilation of already existing information systems.

2.2.4- *Route planners for bikes*

A number of online and mobile applications exist to assist cyclists in planning their cycle route. These vary in sophistication and the number of route selection criteria provided for, as well as in the type and number of additional facilities they offer. In general, they enable cyclists to set a series of selection criteria for their route choice, such as: route with highest proportion of cycle lanes; shortest route; least trafficked route; least undulating route; most scenic route.

2.3- Real-Time Service Information Systems

2.3.1- *Live travel time information on mobile phone / internet*

The real time travel information is aimed at offering correct and reliable real-time information for passengers before and during travelling to enable them to plan door-to-door journeys using the most appropriate departure time and route from the beginning to the end of their journey.

2.3.2- *Live travel time information at local public transport terminals*

A passenger information (display) system (PIS or PIDS) is an electronic information system which provides real-time passenger information. It may include both predictions about arrival and departure times, as well as information about the nature and causes of disruptions. It may be used both physically within a transportation hub and remotely using a web browser or mobile device.

2.3.3- *Live public transport travel time information inside vehicles*

The attractiveness and popularity of public transportation can be improved by providing passengers with reliable real-time information about services. Real time information about actual arrival times improves the comfort for passengers and increase user satisfaction. This information is very important especially when the passengers have any transfer during their trips. Sometimes passengers have only a transfer time of a couple of minutes. It is very positive that the timetable of the trains, buses, airplanes, are so dense but often the transfer times are too small.

2.3.4- *Real-Time public transport information based on social media*

Twitter usage among public transport travellers grows rapidly, with a flow of information that circulates between operators and passengers, and vice versa or between the passengers of public transport themselves. It is becoming indispensable because of the poor quality of other communications during disruptions. The system is organised through Twitterbots, programs used to spam Twitter feeds, posts, or other information. Twitter is shown as a valuable source of real time information.

2.3.5- *Bus location systems*

This application provides accurate real-time information about selected bus services. Using on-board GPS technology, BLSs would enable passengers to find out exactly when the next bus is due to arrive. This application requires buses to be equipped with an onboard computer, GPS navigation system and a communication media which sends the position of the buses to a central computer.

2.3.6- *Vehicle tracking applications*

Vehicle tracking systems are web or smart phone based applications which show live air, rail or maritime traffic information. They allow tracking airplanes, vessels or trains and learn more about the service they are developing, e.g. identification, information on their itinerary, expected time of arrival, eventual delays.

2.4- Real-Time Service Information Systems

2.4.1- *Travel organising assistants or passbook applications*

There are many "travel management" programs out there that help travellers keep track of things like flight confirmation numbers, hotel confirmation numbers and similar issues. One of them is TripIt. It stores the confirmation emails which the user gets from hotels and airlines. Another similar application is TripCase. Sabre's TripCase has more advanced functions than TripIt has. TripCase gives the user continually updated flight delay and gate status for flights, and suggests alternative flights if the user is about to miss his.

2.4.2- *Informed seat choice applications for airplanes*

SeatGuru is an application for smart phones aimed at increasing the air traveller journey comfort by assisting him in taking best informed seat choices. With this application, travellers are informed on which seats to book and which to avoid based on the characteristics of each airplane, even considering specific customisations performed by each carrier. The system is based on a wide database continuously updated with the comments provided by travellers.

2.4.3- Seat allocation based on travellers' social profiles

These are tools developed by air carriers to let passengers find out about interesting people who will be on board their flight, such as other passengers attending the same event as them at destination, and allowing them to book seats together. Technology is based on sharing Facebook or LinkedIn profiles, checking passengersô profile details and where there might be matches, allocating seats together.

2.4.4- Smart phone taxi apps

Smart phone taxi apps allow for the rapid booking of taxis and other similar vehicles, with the potential to allow for an easy method of taxi engagement. They may provide users with additional information such as taxi approximate time of arrival or driver profile, or allow for direct taxi payment via SMS.

3- Smart Ticketing and Tolling

3.1- Electronic Toll Collection (ETC)

3.1.1- Integrated transnational highways toll payments

EasyGo is a partnership between the barrier systems, toll roads, bridge companies and ferry operators. The project is the only single contract system in Europe offering a cross border payment service for toll collection. The purpose is to enable users to drive through all the toll facilities they might encounter on their way through Northern Europe ï quickly and easily. The intention is to have a unique payment system throughout Europe (whether it is a BroBizz, an AutoPASS or an AutoBizz).

3.1.2- National Highways free-flow payment

There are many types of free-flow systems ï ORT (Open Road Tolling) or Multi Lane Free Flow (MLFF), AET (All Electronic Tolling), HOT (High Occupancy Toll): they all aim at eliminating plazas and booths from tolled-roads. Vehicles are no more obliged to stop at plazas, nor even slow down and pass through reserved lanes for automatic electronic payment (RFID traditional systems by OBUs), but they simply continue their trip flowing on the road.

3.1.3- Semi-automated payment at highways toll plazas

Electronic toll collection (ETC) systems were introduced in order to tackle the issue of increasing ñtoll gate congestionò. Traditional manual systems for toll collection can only accommodate a maximum of 240 vehicles/hour, while with ETC systems this number has risen to 800 vehicles/hour. ETC is based on transmission-based vehicle access control technologies with vehicles being charged when passing toll stations without stopping. Vehicles are identified by means of DSRC communications between toll antennae and vehicle On Board Units. With the advent of ETC technologies, however, concessionaires have been confronted with the problem of billing non-registered users, e.g. from other states or other concessions. Manual payment option is still required.

3.2- Access Management

3.2.1- Camera-based vehicle access control

Vehicle access control applications very often rely on systems that are transmission-based, consisting of readers and tags or transponders. Over the past few years, a new type of technology which is camera-based is getting increasingly popular. Classically used as a mean of speed control, cameras are used today for vehicle access control systems. Camera-based vehicle access control systems are making use of Automatic Number Plate Recognition (ANPR) technology and dedicated camera systems to monitor and photograph vehicles entering and exiting the access boundaries.

3.2.2- Transmission-based vehicle access control

Vehicle access control applications vary in terms of technology: a simple system with a physical barrier controlled with a remote-controller is often enough where a very limited number of vehicles are to be allowed in, e.g. in a private parking; to implement a complex vehicle access control application that is used by thousands of private vehicles, a system relying on advanced transmission-based communications is often used nowadays, namely Dedicated Short Range Communication (DSRC) technology. The system allows for vehicle identification while vehicles move, and is built upon DSRC transponders installed in the vehicles and antennae on the controller side. This type of system is frequently used for road pricing in cities and tolled motorways, but simplified ones without payment function are employed for access control e.g. to a segregated busway or a parking on which only some vehicles are allowed in.

3.2.3- Smartcard-based personal access control

A smartcard, typically a type of chip card, is a plastic card that contains an embedded computer chip that stores and transmits data. This data is usually associated with either value, information or both and is stored and processed within the card's chip. Typically used in public transport access control, contactless smartcards are used for electronic ticketing in many cities today. Contactless smartcards require only the proximity to a reader (generally within 10 cm) for data exchange, using Radio Frequency Identification (RFID) or Near Field Communication (NFC) technology to establish a communication between the card and the validation device.

3.2.4- Biometric personal access control

Biometric personal access control means a method of identifying or verifying an individual's identity based on measurement of physical features or repeatable actions, which are unique to that individual. Biometrics can be used to "verify" or "identify" a specific individual: verification (also called authentication) refers to the problem of confirming or denying a person's claimed identity, whereas identification refers to the problem of establishing or authenticating a subject's specific identity.

3.3- Automated Fare Collection Systems (AFC) - Ticketing Systems

3.3.1- Public transport smart cards

Smart card solutions, in the form of electronic fare ticketing and payment, promise to deliver on the demands of convenient, affordable and efficient travel options for public transport users. A smart card contains an embedded integrated circuit chip capable of storing information for identification, authentication, data storage and application processing. Most modern smart cards, especially those used on public transport, employ the RFID (radio frequency identification) technology between card and reader without physical insertion of the card and hence are contact less. They allow rapid movement through stations and onto different modes of travel. Examples of widely used contactless smart cards are London's Oyster card or Paris' Navigo.

3.3.2- SMS boarding passes

A mobile boarding pass refers to the delivery of an airline boarding pass direct to the passenger's mobile device. The passenger can check-in to the flight online, and initiate the sending of their boarding pass directly to their mobile phone either via email or SMS, or within a specific smart phone app. The boarding pass will then be displayed on the mobile device's screen in the form of a two dimensional barcode. This barcode needs to include some very specific information, required by the IATA resolution no. 792 which specifies the mandatory fields and suggests optional fields to be included in the barcode.

3.3.3- SMS ticket purchase in public transport

The SMS public transport ticket aims to provide an attractive and flexible alternative to purchasing a public transport ticket from the driver on the vehicle. The aims are to increase the proportion of tickets purchased in advance, and to reduce the journey time delay associated with on-vehicle ticket purchases. To purchase a ticket public transport users send an SMS to a specified number prior to them boarding the bus or tram and in response they receive a unique confirmation SMS which serves as their ticket.

3.3.4- SMS parking payment

SMS parking saves time and effort by eliminating the need for inconvenient cash payments and offers many additional conveniences to the users, including high availability, parking time notifications, ability to easily extend parking time remotely, and more. SMS Payment parking system is usually implemented by municipalities in cooperation with the mobile operators, so that end-clients can simply pay for their parking time by sending one or more SMS messages, charged directly to their phone bill. As an additional convenience, drivers receive notification SMS messages, reminding them when their parking time is about to expire.

3.3.5- Integration of rail ticketing into airline GDS

Global Distribution Systems (GDS) are networks which enable automated transactions between vendors and booking agents providing travel related services, facilitating the linking, or consolidation, of service availability information, rates and bookings across different service providers. Initially developed for the airline industry as a means of networking their computer reservations systems, they were then expanded to include hotels and car-hire, and they are now being further expanded to include rail services. This is enabling booking agents to choose and book integrated air-rail tickets, through systems such as Syntigoôs AirRail system, Amadeusôs Global Rail Sales Platform and AccesRailôs Rail & Fly.

4- Smart Vehicles and Infrastructure

4.1- Autonomous Driver Assistance Systems

4.1.1- Head-up display

Head-up display is the term used to describe optical systems that project information from various vehicle systems into the extended field of vision of the driver. The head-up display enables the driver to register important vehicle information quickly and precisely. The list of information and vehicle parameters that can be shown by the head-up display is long, the most common being current vehicle speed and speed limits, as well as navigation information. Others possibilities are warnings for lane departure, settings for adaptive cruise control, night vision assistants, RPM levels to aid in manual gear changing and even pre-collision detection where the hud will flash warnings if the car is about to crash.

4.1.2- Night visions in cars

An automotive night vision system is a system to increase a vehicle driver's perception and seeing distance in darkness or poor weather beyond the reach of the vehicle's headlights. Currently two types of night vision technologies are on the market with complementary strengths: Far-Infrared (FIR) and Near-Infrared (NIR) systems. FIR systems are passive, detecting the thermal radiation at wavelengths in the interval 8-12 εm NIR systems use a light source with a wavelength of approximately 0.8 εm to illuminate the object and then detect the reflected light. The main advantages of NIR systems are the high resolution and driver acceptance of the naturally scene representation in the picture.

4.1.3- Driver drowsiness detection system for cars

The term Driver Drowsiness Detection (DDD) system refers to in-vehicle systems that monitor driver and/or vehicle behaviour. These systems monitor the performance of the driver, and provide alerts or stimulation if the driver seems to be impaired. It warns drivers when they are getting drowsy. The system evaluates variations in the lateral position of the vehicle, in the velocity, in the steering wheel angle and in other signals to identify drowsy behaviour. Other methods monitor driverôs sleepiness from the images taken by in-vehicle cameras, based on the fact that the occurrence of sleepiness is reflected through the driverôs face appearance and head/eyes activity.

4.1.4- Automatic car parking

Automatic parking uses computer processors which are tied to a number of sensors and image recognition technologies to enable the car to manoeuvre autonomously from a traffic lane into a parking place. The main procedures of automatic parking are to utilise ultrasonic sensors and cameras on the forward and rear bumpers to detect obstacles, the available parking space, and surrounding vehicles to calculate optimum steering angles, and interface with the Electric Power Steering systems of the vehicle to guide the car into the parking spot.

4.1.5- Blind spot detection for cars

Blind Spot Detection (BSM) systems use either radar or rear-looking video cameras to detect vehicles in the driver's blind spot. If a moving object is detected within the specified zone, a warning signal is issued. The systems only flag moving vehicles; they do not react to fixed objects such as traffic signs at the roadside that the subject vehicle is passing. Generally, the system will illuminate a warning light, often located on the appropriate side mirror, to advise the driver of the presence of the adjacent vehicle. Some systems vibrate the steering wheel if the driver attempts to initiate an unsafe passing manoeuvre.

4.1.6- Collision avoidance system for buses (pre-crash system)

The system is designed to help bus operators navigate tight manoeuvres at speeds below 15mph and with lane changes at speeds greater than 15mph. This system has a sensor location in buses; in other words what the sensors are able to "see". Nearly 46% of bus accidents across the United States each year occur on the left or right side of the bus. These collisions result in property damage, and they can negatively impact on revenue operations and public perception.

4.1.7- Pedestrian and cycle scanning for cars

The system consists of a radar scanner, on-board high-resolution cameras and an on-board computation unit. The radar scanner is set in the front grill of the car and scans the area ahead of the car continuously and measures the distances to any object that may be a cause of an accident. The camera is set in front of the rear-view mirror and it takes photographs of the object detected by the radar. The image is sent to the on-board computation unit and it compares the image with its large database to identify if the object is a pedestrian, a cyclist, a motorbike or anything else. Then, this system monitors the movement of such detected object.

4.1.8- Lane Departure Waning System (LDWS) for cars

Lane Departure Warning (LDW) systems monitor the position of the vehicle with respect to the lane boundary. They warn drivers when the vehicle is travelling above a certain speed threshold and the vehicle's turn signal is not used to indicate the intention of lane change or departure, but nevertheless the vehicle is about to leave its lane. Lane departure warning systems are a means of reducing the number of collisions and hence the number of people killed or injured.

4.1.9- Traffic jam assistant

The Traffic Jam Assistant is a system designed to relieve the driver from manoeuvring the car in slow moving traffic jams. The assistant allows the vehicle to autonomously follow the car in front, even in stop/start traffic. The system is designed to work at speeds between 0 and 60 km/h. Two radar sensors monitor fan-shaped fields some 250 metres in length. A wide-angle video camera monitors the lane markings, and it can also detect objects such as other vehicles, pedestrians and guardrails. If it is necessary to make room for emergency vehicles or manoeuvre around an obstacle, the system follows the car ahead. The radar sensors not only detect the vehicle ahead, but also other vehicles in front of it.

4.1.10- Adaptive Cruise Control (ACC)

Automatic cruise control is used to maintain the speed of a vehicle set by the driver through the automatic operation of the throttle of the vehicle. In steady traffic conditions, it is effective and improves driver comfort. When traffic is busy or congested or in urban areas, however, speeds vary widely and these systems are no longer effective. Adaptive systems allow adjusting pre-recorded speeds based on road traffic conditions, moderating car speed in case of detecting a slower car ahead. All cruise control systems must be capable of being turned off both explicitly and automatically when the driver presses the brake, and often also the clutch.

4.1.11- Autonomous vehicles

A step forward from car platooning (SARTRE), a driverless car is a vehicle that finally does not need human intervention to function. It is also called autonomous, autopilot or auto-drive car. In driverless cars, drivers now turn to be passengers. Autonomous vehicles aim at mimicking the decisions made by a human driver, mostly using artificial-intelligence software combined with a wide range of sensors to identify anything near the car.

4.2- Cooperative Vehicle to Vehicle (V2V) Applications

4.2.1- Vehicular ad-hoc network

Vehicular Ad-hoc Networks (VANET) are self organized communication networks providing services for intelligent vehicle-to-vehicle and vehicle-to-infrastructure communications and applications that try to improve active safety, traffic management, and performance. The information exchange in VANETs occurs at any time, while moving, and in many small fragments, conveyed by nearby vehicles and static Road Side Units (RSUs). VANETôs technology uses moving cars as nodes in a network to create a mobile network. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 metres of each other to connect and, in turn, create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created. It is estimated that the first systems to fully integrate this technology will be police and fire vehicles to communicate with each other for safety purposes.

4.2.2- Enhanced driver awareness system

Enhanced Driver Awareness (EDA) is a cooperative safety application designed to keep the driver aware about his/her nearby environment and keep the traffic manager informed about the dynamic situation regarding the road network. EDA can have a variety of applications depending on the levels and types of assistance that the system provides to the driver.

4.2.3- Cloud sourced safety map

The cloud-sourced safety map is an online application designated to visualise the accident risks of streets with different sources of data and thus to raise awareness of any traffic-related risks in the urban area. The prototype was launched in March 2013 and it is tested in a suburban area of Tokyo, namely in the prefecture of Saitama, Japan. The application is accessible via web browsers on PCs and smart phones.

4.2.4- Automatically driven car trains (SARTRE)

A car train consists of a manually driven lead truck, which is followed by vehicles that are driven autonomously at speeds of up to 90 km/h, in some cases with no more than a four-metre gap between the vehicles. Vehicles follow each other thanks to vehicle to vehicle communications, complemented by sensors and detectors. The lead vehicle is driven by a professional driver and has total control over different functions. The vehicle could be a taxi, truck or a bus. The joining vehicles will be equipped with collision mitigation, adaptive cruise control, lane departure warning and brake control systems to allow autonomous drive. The lead vehicle will control the vehicles in the platoon longitudinally and laterally through signals. The road platoon can include six to eight following vehicles which have both auto and self-driven modes. They can automatically join a platoon and act independently after reaching the destination.

4.3- Vehicle to Infrastructure (V2I) Applications

4.3.1- Personal Rapid Transit (PODCars)

Personal Rapid Transit (PRT) is a form of public transport that uses small automated electric ópodcarsô to provide a taxi-like DRT service for individuals or small groups of travellers. The ultimate goal of PRT is to provide a system of transportation which combines the sustainability of a light rail with the convenience of the private car, allowing trips to be customised to optimise how travellers reach their destinations. PRT is a system aimed at providing public transport solutions for relatively low demand levels. Only two running systems exist at Heathrow Airport and Masdar City (Emirates).

4.3.2- Passive Intelligent Speed Adaptation (ISA)

Intelligent Speed Adaptation (ISA) is an in-vehicle system that uses information about the speed of the vehicle in relation to the speed limit in force at a particular location, and hence supports drivers to adhere to the speed limit. There are fundamentally two types of speed adaptation systems, namely passive and active. The fundamental difference between passive and active ISA is that passive systems warn the driver when the speed limit has been exceeded whereas active counterparts intervene and automatically correct the vehicle's speed to conform to the speed limit.

4.3.3- Active Intelligent Speed Adaptation (ISA)

An active ISA system intervenes in the driving when the vehicle is travelling at a speed in excess of the speed limit, and actually reduces or limits the vehicle's speed automatically by manipulating the engine and/or braking systems. Most active ISA systems provide an override system so that the driver can disable the ISA, if necessary, on a temporary basis.

4.3.4- Weather detection by vehicles

Conventional weather monitoring with roadside and in-road sensors are limited through the fact that the information is only as dense as the density of the monitoring stations. If one station shows fog, or rain, or snow and the adjacent one not, then nobody knows where in between the adverse weather conditions starts. This could be overcome by information constantly collected in the car and then transmitted to roadside communication units together with the precise positions in which the data was collected.

4.3.5- Emergency vehicle notification system (eCall)

When a car fitted with eCall senses a major impact in an accident, the eCall device automatically calls the nearest emergency centre and transmits a set of data. The system provides the emergency services with instant information about the precise location of the accident, reducing response time up to about 50% in rural areas and 40% in urban areas. eCall is linked to another initiative of the Commission, 112, the single European emergency number. eCall can either be generated manually by the occupants of the vehicle, or automatically by sensors' activation situated inside the vehicle.

4.3.6- Cooperative traveller assistance

Cooperative Traveller Assistance (CTA) is concerned with balanced use of the road network (from a traffic manager perspective) and reliable travel time (form a driver perspective). On-board recorded vehicle data is transmitted on real-time to roadside monitoring units, providing information about vehicle location and performance which can be used for traffic management purposes. Live information on traffic characteristics can be useful for monitoring the efficiency of the network, such as delays, stops, emissions and so on. The CTA system is capable of offering better prediction of travel times based on planned routes from cars, real-time assistance for drivers in rerouting to evade accidents and travel delays.

5- Shared Mobility and Demand Responsive Transport

5.1- Public Transport Services in Low Demand Situations

5.1.1- DRT planning and scheduling optimisation systems

Demand Responsive Transport systems, often called dial-a-ride because of the initial need to book them by phone, has been known for some years and has generally emerged where the opportunity for large-scale bus services is limited by a lack of demand and/or a lack of available public funds to support these. Operations have typically emerged with very limited use of technologies, and may operate in some instances without any additional processing beyond that possible manually. In recent years, local government authorities are increasingly facing very strict budgetary pressures to deliver public passenger transport with reducing budgets, forcing the move towards route optimisation systems.

5.1.2- Computerised dispatch and positioning systems

The taxi market is in rapid flux, and has seen a variety of dispatch systems emerge affecting one or more of the vehicle types within the market. The computerised positioning and dispatch system is aimed at improving the supply of demand responsive services, improving operating efficiencies, and reducing support costs. Innovation in dispatch technology has split between the driver based system typically including app based limo services, and 'shore based' radio systems, more typical of taxi companies. The dispatch system reported in this factsheet relates to shore based, company oriented, systems as opposed to driver-oriented apps.

5.2- Shared Mobility

5.2.1- Commercial Fixed Point Car sharing (Zipcar)

Commercial Fixed Point Car Sharing schemes address the need to access a vehicle for short term exclusive use, for a fee. Fixed systems imply that cars are picked at a fixed location for return to the same location, or an alternative fixed point maintained by the same scheme. Schemes themselves may vary between small cooperatives, often based on a specific community, and a number of larger branded schemes, including Zipcars being an example of a fixed point branded operation.

5.2.2- Free-floating car sharing systems (car2go)

Free floating (dynamic) car sharing e.g. car2go, differs in the working principle from classic fixed point car sharing systems on the fact that pick up / drop off of a car is possible freely in a defined zone of a city, as cars have no fixed positioning. Booking is just possible on the spot, preferably by smart phone app showing the position of the next available cars, and the renting duration is fully flexible and does not need to be indicated when booking.

5.2.3- Grass-root cooperative car-sharing systems (CARUSO)

Grass-root cooperative car-sharing CARUSO is an application aiming at facilitating private car-sharing for a closed group through offering an easily accessible online platform. It enables bookings for people who need a car and for people who want to share their own car with others. The platform CARUSO is currently available as a combination of web-based user interface and a smart phone or CARUSO-Box installed in the shared car for logging. The system only provides the platform and it does not provide the car. The system can be easily implemented even in remote rural areas where no other car-sharing offers exist. The platform can be used by companies, communities and private individuals for free at the moment.

5.2.4- Carpooling, share-a ride schemes, booking systems (Mitfahrzentrale)

Car pooling provides an opportunity to share a trip with passengers travelling from similar origins to similar destinations, and will include a planning function in which drivers and potential passengers are brought together. It is mainly different from car sharing in the fact that the later typically provide access to vehicles alone, while in car pooling the driver and passengers share the ride.

5.2.5- Shared bike scheme management system

Bicycle sharing schemes comprise short-term urban rental schemes that enable bicycles to be picked up at any self-service bicycle station and returned to any other station after use. Bicycle sharing schemes are aiming at integrating, expanding and promoting cycling in transport systems.

2.5.4- Shared Car Parking - We Smart Park

WeSmartPark is a start-up business where people owning car parking spaces that are not being used over important periods of time can enrol to share them with other drivers. City drivers can register this system to be allowed to use car parking spaces in the pool, at a cheaper fare than parking at conventional park houses. Income raised from using pooled car parking is shared at equal parts between the company and the owner of the car park.

0.6 COMPASS BUSINESS MODELS

In chapter 6 of the Handbook, four business models are discussed for the applications listed below. Business models are discussed on the basis of product, customer interface, infrastructure management and financial aspects.

- Shared Bike Systems
- Share Taxis
- Mobile Traveller Information Systems

- Car Park Management Systems

Each model is presented in a schematic and easily readable format, in four sections defined on the basis of the pillars mentioned above where the nine major elements of he business model are described. Each model has been discussed with industry and academic experts, after the investigation and design works.

A strategy overview is given by the SWOT analysis elaborated for each business domain, in order to provide a full view of both the money earning and the strategic logic.

1 TRANSPORTATION MANAGEMENT SYSTEMS

1.1 Urban Transport Management

1.1.1 Traffic responsive signal management with distributed processing

Solution family: Transportation Management Systems

Sub-family: Urban Transport Management

Domain of application: Urban

Technology behind: Traffic control signals, detectors, local controllers, central computers

Status: implemented

Links to relevant references

- UTOPIA/SPOT applications
- FHWA, OTA, 1997 ñAdvanced Transportation Management Technologiesò
- UTOPIA UTC application
- UTOPIA UTC application 2
- MOVA UTC application

Description

Concept and problems addressed. Traffic responsive centralised signal management with distributed systems are those in which, generally, the intersection controller is responsible for control decisions at intersection. There are several types of distribute systems, ranging from fully flexible, large-scale systems (UTOPIA), over fully flexible isolated systems (e.g. MOVA) and pre-planned systems with local modification (small closed-loop systems).

Distributed systems have the following characteristics:

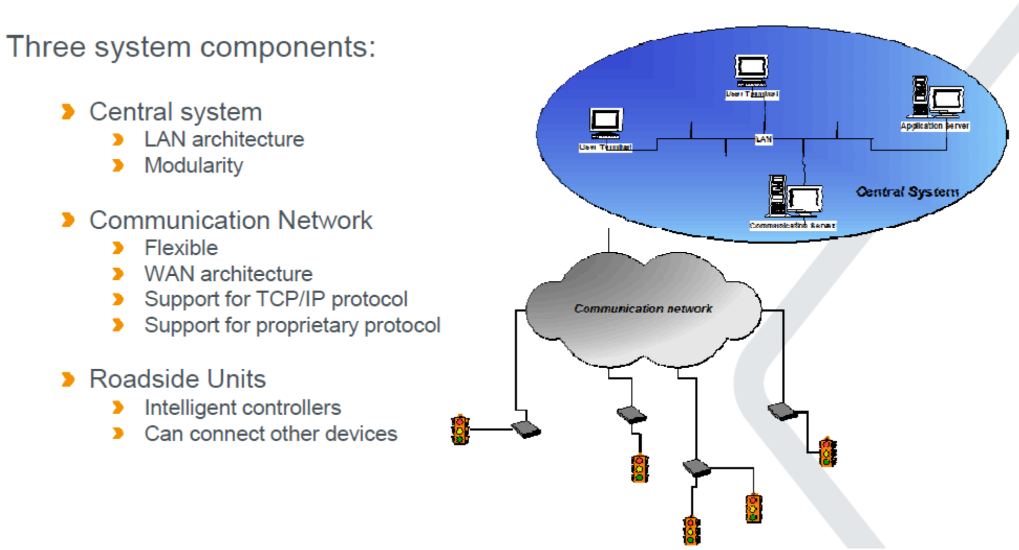
- They rely on intelligent local intersection controllers. Because the power of the system is inherent in the local controller, these controllers must have all the features desired for signal control at the intersection.
- They are inherently robust. Distributed systems do not transmit mandatory real-time control commands over the communications network. Consequently, the intended operation of the system can be maintained even during communications and central computer downtime. True distributed systems incorporate this characteristic more effectively than centralised systems with a time-base backup. They are always operating in time-base coordination, with the central computer and communications network used only to maintain the accuracy of the internal clock.
- There are options to reduce system costs. The communications network need not be reliable enough to carry mandatory real-time communications. Consequently, inexpensive communications alternatives, including wireless alternatives, are viable options that can significantly reduce the cost of a new system.

Therefore, distributed systems may be preferred when:

- Powerful local intersection control is desired.
- Project budgets limit the installation of new linear infrastructure and fault-tolerant central computer networks.
- Improved reliability is required through the use of microprocessors and multiple levels of fall-back control.
- Existing infrastructures must be used.
- The signal system has few existing facilities (e.g., computers, interconnect).

- Wireless communications technologies must be used.
- Absolute real-time surveillance is not needed.
- Centrally optimised adaptive control is not needed.

An example of the large-scale applications of distributed systems is UTOPIA (Urban Traffic Optimisation by Integrated Automation) / SPOT (System for Priority and Optimisation of Traffic), designed and developed by FIAT Research Centre, ITAL TEL and MIZAR Automazione in Turin, Italy. UTOPIA can be considered as the most sophisticated decentralised system. The objective of the system is to improve both private and public transport efficiency. The system has been fully operational since 1985 on a network of about forty signalised junctions in the central area of Turin. The area also contains a tram line and control of the trams is integrated within UTOPIA/SPOT. UTOPIA/SPOT is now used in several cities in Italy and also in the Netherlands, USA, Norway, Finland and Denmark.



Source: UTOPIA UTC application
UTOPIA architecture (Urban Traffic Optimisation by Integrated Automation)

An example of isolated flexible system that can be modified locally, on the based on detector data, is MOVA, applied all over Britain and worldwide. MOVA, which stands for Microprocessor Optimised Vehicle Actuation, was originally created in 1980 and it is now an established strategy for the control of traffic light signals at isolated junctions ï i.e. junctions that are uncoordinated with any neighbouring signals. MOVA has been designed to operate at different ranges of traffic conditions, from low flows through to a junction that is overloaded. For the major part of the range - before congestion occurs, MOVA operates in a delay minimising mode; if any approach becomes overloaded, the system switches to a capacity maximising procedure. MOVA is also able to operate at a wide range of junctions, from the very simple ôshuttle-workingö to large, multi-phase multi-lane sites.

The closed-loop system applications are distributed processors traffic-control system with control logic distributed among three levels: the local controller, the on-street master, and the office computer. Three control modes are typically found with most closed-loop systems: time of day, manual, and traffic responsive. With the time-of-day mode, the controller unit can automatically select and implement a pre-planned traffic-signal timing plan and sequence (cycle/offset/split) based on the time of day, day of week, and/or time of year. With the manual mode, the operator specifies the pattern number of the desired traffic-signal timing plan and sequence via the computer console. With the traffic-responsive mode, the computer automatically selects the predefined traffic-signal timing plan best suited to accommodate the current traffic flow conditions in the signal network.

Targeted users. Traffic control operators are the target users of the applications.

Barriers to Implementation

Financial issues. The savings in communications infrastructure usually compensates for the potential higher cost of local controllers. Installation and maintenance costs would be significant. On average, installation and maintenance costs for UTOPIA are approximately ú 80,000 per intersection, but costs for MOVA are around ú 20,000 for one junction, and costs for other less sophisticated systems are still lower. The other components of costs for maintaining the system operation include consulting costs in the case of UTOPIA and, in all cases, the costs of maintaining hardware and software. But the return of investment in terms of social benefits is high.

Technical barriers. There are no real technical barriers. However, all systems require adequate fine-tuning and there will always be some system down times, mainly when detectors are damaged.

Organisational complexity. There are no organisational issues.

Legal issues. There are no legal issues.

User and public acceptance. User and public acceptance is high. Acceptance is highest where drivers and pedestrians can see that the signals respond quickly to actual demand.

Interest for Travellers

Door to door travel time. Benefits of implementing UTOPIA were shown to give an increase in private traffic speed of 9.5% in 1985 and 15.9% in 1986, following system tuning. In peak times the speed increases were 35%. Public transport vehicles, which were given absolute priority, showed a speed increase of 19.9% in 1985 (Wood, 1993).

Travel cost. The reduction in travel times goes hand in hand with a reduction of Vehicle Operating Costs including fuel costs.

Comfort and convenience. The likely reduction of queues improves the travel comfort and convenience.

Safety. No significant changes in traffic safety compared with fixed-time system have been observed.

Security. No particular impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

Where the control systems are used to visibly favour public transport, that may encourage car drivers to switch to buses and trams.

Other notable impacts

At times of high traffic demand, even the most sophisticated UTC systems will not be able to avoid congestion, but they will certainly reduce it and thereby reduce fuel consumption and emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment Costs	€€	D2D travel time	✓	Car usage	-	Increased Mobility	0
Operation and Maintenance Costs	€€	D2D travel cost	✓	Bus and Coach usage	+	Congestion	✓
Financial Viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical Feasibility	0	Safety	0	Ferry usage	0	Contribution to User Pays Principle	0
Organisational Feasibility	0	Security	0	Aerplane usage	0	European Economic Progress	0
Administrative Burden	0	Accessibility for mob. Imp. Passengers	0			Territorial Cohesion	0
Legal feasibility	0						
User Acceptance	✓						
Public acceptance	✓						

1.1.2 Traffic responsive signal management with central processing

Solution family: Transportation Management Systems

Sub-family: Urban Transport Management

Domain of application: Urban

Technology behind: Traffic control signals, detectors, local controllers, central computers and operator displays

Status: implemented

Links to relevant references

- SCOOT application
- SCATS UTC application
- BALANCE UTC application
- FHWA, OTA, 1997 ñAdvanced Transportation Management Technologiesò
- FHWA, 20056, ñTraffic Control System Handbookò

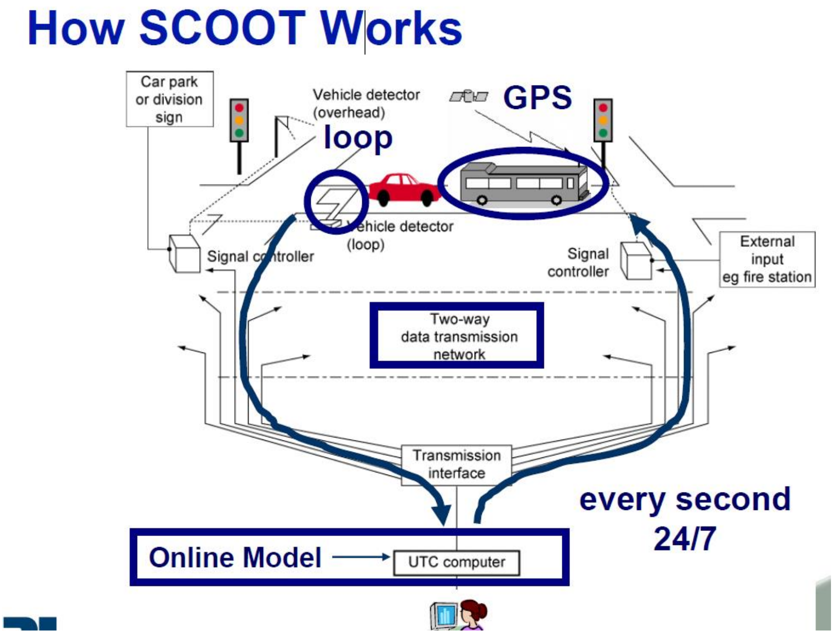
Description

Concept and problems addressed. In centralised signal control systems, a central computer makes control decisions and directs the actions of individual controllers. Each intersection requires only a standard controller and interfacing unit and does not perform any software functions. Central systems have the following characteristics:

- They depend on reliable communications networks. Because real-time control commands are transmitted from the central computer to the local intersection, any interruption in the communications network forces the local controller to operate without that real-time control and revert to its back-up plan.
- They depend on reliable central computers.
- They are often not easily expanded. Many traditional centralised systems are designed around a maximum network size. Increasing the size of the network requires a significant investment in central computer upgrades and, often, upgrades in the software as well.
- They are expensive. Communication networks typically consume at least two-thirds of the cost of a system. Centralised systems require communications networks with high throughput reliability, which typically precludes the successful use of wireless communications.
- They provide excellent surveillance response time. The systemœs communication network is reliable enough to allow mandatory real-time control communications.

There are many variants of tailor made control systems around the world, but three of the most widely used systems based on a standard software, where only the parameters need to be adapted to the individual local situation are SCOOT, SCATS and BALANCE.

The world leaders is SCOOT, which was developed by the then Transport and Road Research Laboratory (TRRL) in the UK, originally designed to control dense urban networks, such as large towns and cities. However, it is now also used in small networks, especially for areas where traffic patterns are unpredictable. It controls the cycle time, green splits and offsets for intersections and pedestrian crossings. It now includes facilities for public transport priority, traffic gating and incident detection. Applications have been developed worldwide, i.e. in Canada, USA, South America, South Africa, China, Thailand and India, and within Europe in Madrid and more than 130 cities in the UK.



Source: *SCOOT* *"Traffic control and signal modelling in the Capital"*
How SCOOT Works?

SCATS, which is an area wide traffic management system that operates under the Windows environment, was developed in Australia. Like SCOOT, it controls the cycle time, green splits and offsets for intersections and pedestrian crossings. It can adaptively modify these values to optimise the operation to suit the prevailing traffic. Alternatively, it can manage intersections in fixed-time mode where it can change plans by time of day and day of week. It is designed to coordinate traffic signals for networks or for arterial roads. As of June 2012, SCATS applications were licensed to operate in more than 35,531 intersections worldwide, including installations in Australia, Bangladesh, Brazil, Brunei, Chile, China, Ecuador, Fiji, Indonesia, Iran, Ireland, Israel, Jordan, Laos, Malaysia, Mexico, New Zealand, Philippines, Poland, Qatar, Singapore, South Africa, Thailand, USA and Vietnam.

BALANCE, equally, allows flexible reactions of cycle time, offset and green split to changing levels of traffic and with a comprehensive view on the traffic situation over the whole network. It was developed in particular with a view to balancing the needs of public transport and private cars. The application is currently used in Hamburg, Ingolstadt and other cities in Germany with a total of more than 100 traffic signals.

Targeted users. Urban traffic control operators are the key users.

Barriers to Implementation

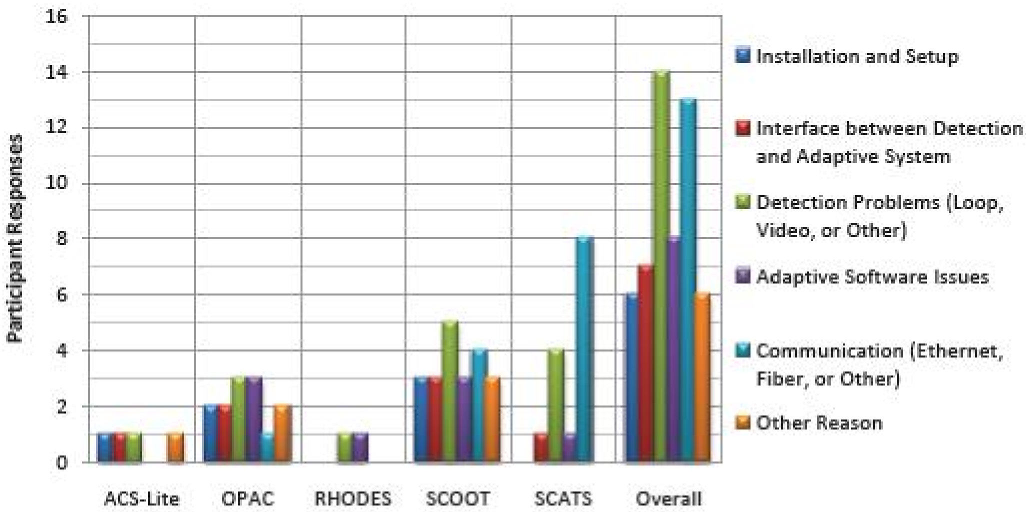
Financial issues. Installing SCOOT costs ú 20,000 - 30,000 per junction. Overall user benefits are predicted amount to about ú 90,000 per junction (considering the value of time at 2009 and excluding vehicle operating costs (wear and tear, fuel, etc) and social cost of carbon reductions.

SCATS costs on average $ 60,000 per intersection (estimate based on the USA study ñAdaptive Traffic Control Systems in USAò, HDR, 2009).

Upgrading costs in both cases (SCATS and SCOOT) were reported to be about $20,000 per intersection.

Operating costs depend on the level of manual supervision in the control centre, but in principal, all the systems mentioned can operate without any regular supervision. However, the systems require regular maintenance, most notably the detection system.

Technical barriers. There are no real technical barriers. However, all systems require adequate fine-tuning and operators need appropriate training. Furthermore, the survey carried out in the USA (ñAdaptive Traffic Control Systems in USAò, HDR, 2009) among local traffic engineers employed in some USA municipalities indicates that on average the SCATS and SCOOT were out of service by 5% of total operating time, due to software problems, communication failures, detection problems, etc, as shown in the next picture.



Source: "Adaptive Traffic Control Systems in USA", HDR, 2009
Reliability Issues with Urban Traffic Control Systems

Organisational complexity. There are no organisational issues.

Legal issues. There are no legal issues.

User and public acceptance. User and public acceptance is high. It is generally acknowledged that urban traffic needs to be controlled by traffic signals, and where drivers can see that they respond to actual demand, acceptance is highest.

Interest for Travellers

Door to door travel time. Many field tests have shown that all three of the above systems lead to significant travel time savings compared with fixed-time control. Comparisons of the benefits of SCOOT, against fixed time plans, showed reductions in delays to vehicles of average 27% at Foleshill Road in Coventry - a radial network in Coventry with long link lengths. In Worcester the use of SCOOT rather than fixed time UTC showed considerable saving which was estimated to be 83,000 vehicle hours or £357,000 per annum at 1985 prices. The replacement of isolated signal control in Worcester by SCOOT was also estimated to save 180,000 vehicle hours per annum or £750,000 per annum. In Southampton, economic benefit, excluding accident and fire damage savings, amounted to approximately £140,000 per annum at 1984 prices for the Portswood/St. Denys area alone.

In Sao Paulo in 1997 a survey showed that SCOOT reduced vehicle delays by an average of 20% in one area tested and 38% in another over the existing TRANSYT fixed time plans. It was estimated that financial benefits to Sao Paulo as a result of these delay reductions would amount to approximately $1.5 US million per year. (Mazzamatti et al, 1998).

Travel cost. The reduction in travel times goes hand in hand with a reduction of Vehicle Operating Costs including fuel costs.

Comfort and convenience. The likely reduction of queues improves the travel comfort and convenience.

Safety. No significant changes in traffic safety compared with fixed-time system have been observed.

Security. No particular impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

Where the control systems are used to visibly favour public transport, that may encourage car drivers to switch to buses and trams.

Other notable impacts

At times of high traffic demand, even the most sophisticated UTC systems will not be able to avoid congestion, but they will certainly reduce it and thereby reduce fuel consumption and emissions.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment Costs	€€	D2D travel time	✓	Car usage	-	Increased Mobility	0
Operation and Maintenance Costs	€€	D2D travel cost	✓	Bus and Coach usage	+	Congestion	✓
Financial Viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical Feasibility	0	Safety	0	Ferry usage	0	Contribution to User Pays Principle	0
Organisational Feasibility	0	Security	0	Aeroplane usage	0	European Economic Progress	0
Administrative Burden	0	Accessibility for mob. Imp. Passengers	0			Territorial Cohesion	0
Legal Feasibility	0						
User Acceptance	✓						
Public acceptance	✓						

1.1.3 Signal priority for bus and tram

Solution family: Transportation Management Systems

Sub-family: Urban Transport Management

Domain of application: Urban

Technology behind: GPS; Beacon; Radio frequency systems; Loop based/optical vehicle detection systems.

Status: Implemented

Links to relevant references

- Implementation of Zurich's Transit Priority Program by Andrew Nash, Research Associate, Mineta Transportation Institute, 2002.
- Transit Signal Priority
- Transit Signal Priority (TSP): A Planning and Implementation Handbook by ITS America, 2005.
- SCOOT
- SCATS
- BALANCE – intelligent signal control for sustainable road traffic, GEVAS SOFTWARE, 2009
- SWARCO Worldwide

Description

Concept and problems addressed. This application is aimed at improving public transport by providing priority for buses and trams at signalised intersections. Signal priority modifies the normal signal operation process to better accommodate public transport vehicles. Public Transport Signal Priority (PTSP) enables public transport to operate more services with the same resources, to reduce delays and unreliable services caused by sharing the right of way with other traffic and thus attracting more passengers. By reducing conflicts with private traffic, public transport priority improvements also can reduce accidents and driver stress. PTSP is a cost effective way to make public transport more competitive with the car. There are two main approaches for providing PTSP – a passive and an active PTSP system. In the passive PTSP system signals are set to turn green based on average public transport vehicle speed without any interaction between the public transport vehicle and traffic signal system. The more complex and better option is an active PTSP system, with which the bus sends a signal to the traffic signal controller (a computer) located near the traffic signal or in a central headquarter, and the controller then decides how the traffic signal should react to this information. For the active PTSP system, various types of strategies can be used (early green, green extension, special public transport phases). A third possibility for priority treatments are Adaptive/Real-time Controls, where priority is provided and simultaneously given performance criteria (e.g. person/transit/vehicle delay) are optimised.

The use of PTSP systems is common in Europe (e.g. Zurich) and rapidly growing across North America. All of the major UTC systems (see separate sheets) in Europe (SCOOT, SCATS, BALANCE, UTOPIA/SPOT) have special features for providing public transport priority.

With PTSP systems data concerning the punctuality measures on specific public transport lines can be gathered. The original schedules can be compared with the actual schedules and improvements related to the implemented PTSP system (e.g. increased punctuality) can be illustrated. In Toronto for example, average public transport delay reductions of up to 46% could be achieved. In Turin, with UTOPIA, public transport vehicles, which were given absolute priority, showed a speed increase of 19.9% in 1985 (Wood, 1993).

Targeted users. The targeted users for this application are public transport operators and traffic authorities.

Barriers to implementation

Financial issues. The costs of PTSP systems are dependent on the configuration of the system, with somewhat higher costs associated with signal upgrades, equipment/software for the intersection, vehicles, or the central management system. Many PTSP systems have been implemented without costly upgrades. Due to many different factors affecting the costs and to the desired functionality of the system, a comparison of cost is very difficult and only a limited amount of information regarding PTSP costs exists. According to the report of ITS America (based on a very limited amount of reported data) costs have ranged between ú 6,000 ú and ú 12,000 per intersection. If existing software and controller equipment can be used, which is the case in most situations, costs can be under ú 4,000 ú per intersection. Maintenance and operational costs are generally more or less absorbed by the general operation and maintenance of the UTC system. Return of investment in terms of social benefit is high.

Technical barriers. No technical barriers.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no legal obstacles.

User and public acceptance. Public transport operators welcome the system and the general public readily accepts them.

Interest for Travellers

Door to door travel time. Reduced delay ï even if not always elimination of delay ï to public transport vehicles enhances transport efficiency as well as improve schedule adherence. Even if private cars may have to wait longer, due to their lower occupancy, this will generally not outweigh the advantages for public transport users.

Travel cost. Savings in operating costs for buses will be counterbalanced by small cost increases for cars. On balance there should not be any significant change.

Comfort and convenience. No particular impact.

Safety. Through the reduction of conflicts with private traffic, public transport priority improvements may also reduce driver stress and accidents.

Security. No impact is expected.

Accessibility for impaired. No impact is expected.

Modal change

Public transport priority improvements are a way for increasing the punctuality and the efficiency of the public transport system. Faster and more reliable services are very attractive for passengers, and therefore priority systems are a good way for making public transport more competitive against cars.

Other notable impacts

Congestion and CO2 emissions. To some extent the priority for public transport will increase congestion for private cars in the first place. However, if the priority measures are visible enough for car drivers, this will convince many of them that using public transport is the better option, and that will then reduce overall traffic volumes and resulting congestion in the long run. This in turn will also reduce CO2 emissions. Zurichȁs system is a very impressive example for high priority of public transport, where private cars have to wait twice the time at traffic signs than public transport, but the use of buses and trams is much higher than in most European cities.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	+	Congestion	✓
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

A comprehensive overview about Signal Priority for Bus and Tram exists on Youtube, but containing advertisement:

http://www.youtube.com/watch?v=oT80Y18oAH8

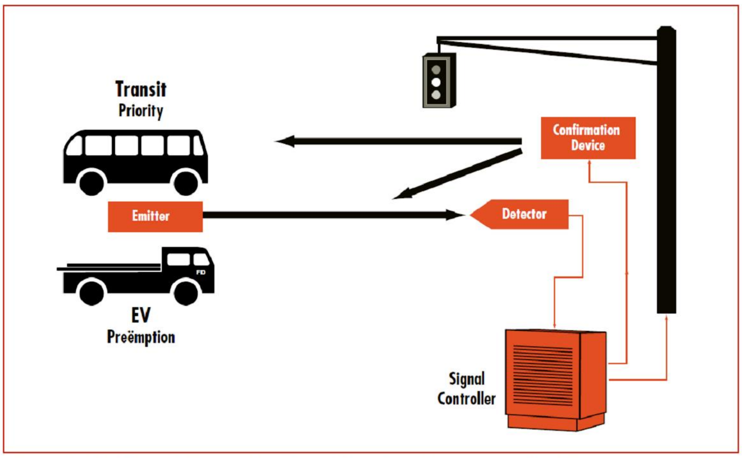


Figure 1: Priority and Preemption Example at Local Intersection Level[2]

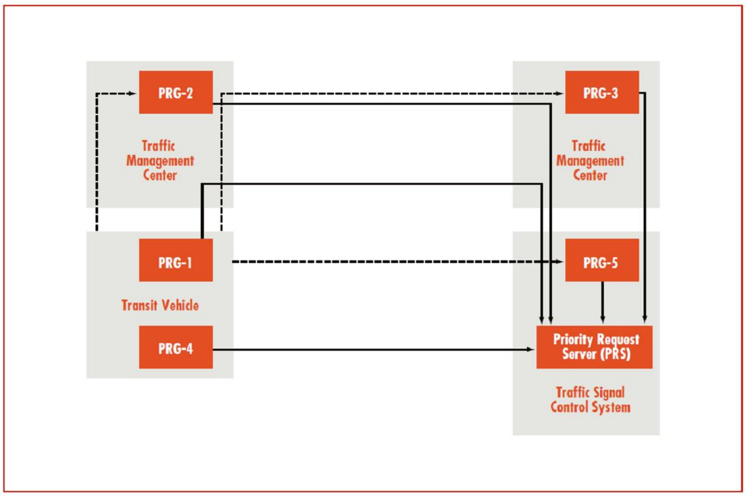


Figure 2: TSP Main Systems and Component

Note: The PRG can be located in either the transit vehicle, the transit management center, the traffic management center, or in the traffic signal control system equipped with wayside transit vehicle detection.

1.1.4 Delay / irregularity / disorder management system for public transport

Solution family: Transportation Management Systems

Sub-family: Urban Transport Management

Domain of application: Urban

Technology behind: GPS; Beacon; Train/tram/bus scheduling algorithm; I2V communication;

Status: Implemented

Links to relevant references

- Enhanced transport quality and tramway energy efficiency by multi-modal traffic management systems, by Christian Gassl
- Tramway Management and Control, Thales Group
- Fleet management with IVU.fleet, IVU Traffic Technologies AG
- Automatic Vehicle Location Fact Sheet: Fixed Route Bus Transit, DoT, 2007
- Automatic Vehicle Location Fact Sheet: Transit Overview, DoT, 2007

Description

Concept and problems addressed. Possible disruption of operations in public transport systems will always remain unavoidable. In the urban context, delay can be caused by various reasons such as sudden appearance of a number of passengers that calls for a longer time at stops, congestion of private traffic, accumulation of delays at the traffic lights, etc. This typically leads to irregular intervals: the interval before the delayed service becomes longer while the intervals between the delayed one and the following ones become shorter. As a result, the delayed one gets overcrowded, and this causes further delay. Larger disruptions can be caused by technical breaks, street blockage such as wrongly parked cars on the path, accidents (not only on the street but along the street such as fire), etc. Some of these disruptions may only lead to small delays, which can be absorbed by the buffer times integrated into the timetable. If a larger disruption occurs, this can cause a temporary shutdown of a path. Such disruptions lead to severe violations of the timetable, which have to be resolved by the dispatchers.

Delay management is becoming more important in public transport, where passengers have to decide quickly whether to wait or to take an alternative route.

The major tasks in disruption management are:

- Timetable adjustment;
- Organisation of connecting services;
- Communication between control centre and individual drivers;
- Providing real-time information for the passengers and the public.

Classically, these tasks had been, in the best case, undertaken manually. For example, timetable adjustment had been often relying on experiences of dispatchers. Another example is that the transmission of operational changes (e.g. the new schedule) was mostly based on the direct conversation between the dispatchers and the drivers using a vehicle wireless radio system or mobile phones.

Recent advanced public transport management system enables many of the aforementioned tasks to be partly automated and gives a decision-making support to dispatchers. For example, suggestion for optimal timetable alternation is made for dispatchers automatically based on real-time locations of vehicles, available paths, and so on. Connection assurance is also automated. In case of larger disruption, it is likely that the path reallocation and rolling stock rescheduling is needed while these can be similarly automated. Communication with drivers with on-board devices and real-time information provision for passengers can be made automatically with such advanced systems. Communication with drivers is fairly simplified with automatically generated text messages to inform the drivers about new departure time, etc., via dedicated radio network or cellular network. Passengers are benefited with the real-time information at the station, which could also be provided via other channels such as smartphone apps and/or social media such as Twitter. They are also benefited with guaranteed connection to other lines.

Further sophisticated systems for trams and potentially buses that consider road traffic conditions are being developed rapidly. A system developed in Dresden, Germany, for example, incorporates data on punctuality, headway regularity and connection services, which are held by a tramway operator, with the traffic conditions of the private vehicles that is held by an urban traffic control, so that the signal control for the tram is optimised in case of delay. For example, when the tram has a delay while the road traffic condition is good, higher priority for the tram is given by controlling traffic lights (e.g. longer green phase), while connecting bus receives a signal to wait for the delayed tram.

The delay, irregularity and disorder management system is not realised with single equipment; rather, the system is realised partly using common components to other systems and partly employing its own component. Common components include AVL (automatic vehicle location system, for buses and tram) and dynamic passenger information system. Components that are specific to this system include rescheduling/reallocation system, and automated communication system between the control centre.

Targeted users. The targeted users of delay or disruption management systems are public transport operators and infrastructure managers.

Barriers to implementation

Financial issues. The cost is unknown, while the cost for some components is estimable. For example, Automatic vehicle location (AVL) systemsô total implementation costs per vehicle is estimated to be approximately ú 6,000, while it can reach to ú 12,000, with an annual maintenance costs around 2% of the equipment cost. The pay-back comes from the increased efficiency of the fleet management.

Technical barriers. There is no significant technical barrier.

Organisational complexity. When the road traffic information is incorporated, cooperation between the public transport control centre and the road traffic control is essential.

Legal issues. There should not be any insurmountable legal obstacles to this application.

User and public acceptance. The public will not even be aware of the system, while the public transport operators will readily accept it.

Interest for Travellers

Door to door travel time. Delays will still occur, but the optimal management can provide a quicker recovery from delays. Guaranteed connection minimises the waiting time that would be much longer without it during the irregularity.

Travel cost. In principle, travellers should perceive no additional travel costs, but the price for implementing such systems could be included in ticket fees and/or taxes.

Comfort and convenience. Delay remains uncomfortable and inconvenient for passengers, while such aspects are minimised with proper management with this system.

Safety. There are no specific safety issues addressed by this system.

Security. No significant impact expected.

Accessibility for impaired. No particular impact is expected.

Modal change

With delay management systems the passengers can be kept satisfied in the case of delays and increased reliability of public transport attracts more passengers, who may shift from private cars.

Other notable impacts

CO2 emissions. There is no clear impact on congestion, while aforementioned modal change could contribute to the reduction of CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	(-)	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	(+)	Congestion	0
Financial viability	✓	Comfort and convenience	✓	Rail usage	(+)	CO2 emissions	(✓)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

1.1.5 Vehicle and fleet management system

Solution family: Transportation Management Systems

Sub-family: Urban Transport Management

Domain of application: Urban, rural

Technology behind: GPS; Beacon.

Status: Implemented

Links to relevant references

- Bus Fleet Management Systems
- INITRANS
- Automatic Vehicle Location Fact Sheet: Transit Overview. September 2007

Description

Concept and problems addressed. Fleet management focuses on the operation of public transport vehicles and technologies that can be applied to improve vehicle and fleet planning, scheduling and operations. Fleet management can improve the efficiency and safety of the vehicles, which results in a reliable system that could attract new users and help the operation become more cost-effective. The most basic function in a fleet management system is the automatic vehicle location (AVL) component, commonly GPS-based. This AVL system consists of two components, the location technology (hardware and software to determine the vehicle location, GPS receivers and computer on-board) and the data transmission methodology (data exchange between vehicle and management center). The GPS systems will communicate with the depot and other offices using a wireless system such as GPRS (General Packet Radio Service) and mobile networks. The information on the vehicle location is fed to various other systems to provide better urban transport control, vehicle priority and real-time information both pre-journey (at bus stop, web, via SMS) and during the journey (in the vehicle).

Fleet management systems have two functions: they allow the management during operations (e.g. location of vehicles) and the rolling stock management including a maintenance data base (e.g. maintenance history). Fleet management is used in public transport, for emergency vehicles, taxis, car sharing businesses but also for smaller businesses controlling their vehicles (e.g. delivery services). The collected data comprises vehicle location at specific intervals or upon request, vehicle and driver identification, distance driven, average speed, fuel consumption, driving hours, engine performance, etc. Both functions of fleet management systems ï the management during operations and the rolling stock management ï are important for scheduling. With fleet management systems data about the history of a vehicle (e.g. the last maintenance, repair) is accessible, but also future schedules for maintenance can be generated. Regular and controlled fleet vehicle maintenance contributes to comprehensive scheduling, more efficient and lower cost repairs, fewer technical problems and a more efficient management and budgeting of the fleet.

Targeted users. The target users for fleet management systems are public transport operators, taxi operators, emergency vehicle services (e.g. police, ambulance), car sharing businesses or delivery services.

Barriers to implementation

Financial issues. For vehicle and fleet management systems, the automatic vehicle location (AVL) systems are probably the most expensive part, which are available at a wide range of costs and levels of sophistication. In general, AVL is a core technology for larger agencies, especially bus and multimodal agencies, as they can spread the cost of the system over a larger fleet size. Costs for on-board GPS equipment ranges from ú 400 to ú 1,500 per vehicle, but total implementation costs per vehicle can reach ú 12,000, with median per vehicle cost estimated at ú 6,000. The annual maintenance costs are about ú 800 per vehicle.

Technical barriers. There are no technical barriers although the GPS signal cannot penetrate to tunnels, between tall buildings or under dense tree canopies, and complementary technologies such as dead-reckoning, signpost and odometer technology may be necessary.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no legal obstacles.

User and public acceptance. The public will not even be aware of the system, while the public transport operators will readily accept it.

Interest for Travellers

Door to door travel time. Fleet management systems can help increasing the reliability of timetables and transfers through schedule adherence monitoring and the protection of transfers at risk. Through the fleet management, waiting time at stations can be reduced and passengers are accurately informed and provided with real-time data.

Travel cost. There should not be any impact on travel costs, if the investment costs are counterbalanced by efficiency gains.

Comfort and convenience. Fleet management systems can be applied for delay management, which allows a faster recovery in the case of disruptions or delays. The inconvenience of the passengers due to delays can be minimised.

Safety. There are no expected impacts on safety.

Security. Security can be increased through alert features and social control features like video cameras at stations or on-board.

Accessibility for impaired. In combination with passenger information systems, fleet management systems can provide vehicle information for impaired persons via displays at stations (e.g. low-floor vehicles arriving).

Modal change

Fleet management systems can create a higher awareness and attractiveness of public transport due to more reliable services and improved passenger information and services at home, at stations and on board. Informed passengers are satisfied passengers, even in the case of delays, and there are no reasons for changing the mode of transport.

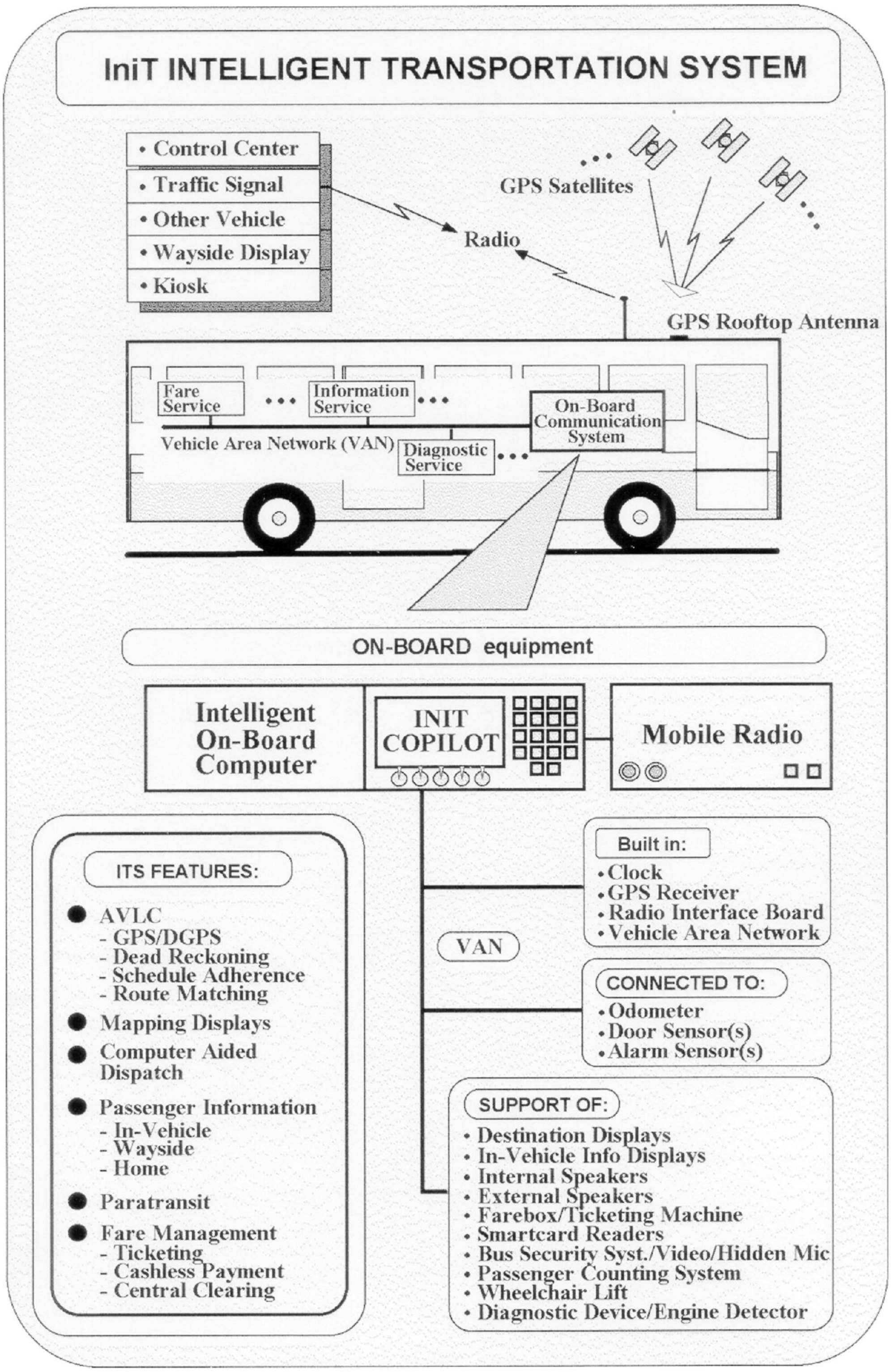
Other notable impacts

Congestion and CO2 emissions. If public transport customers are prevented from taking their cars instead for future trips this will avoid an increase in congestion and CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	(-)	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	(+)	Congestion	(✓)
Financial viability	0	Comfort and convenience	✓	Rail usage	(+)	CO2 emissions	(✓)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	✓	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials



Source: INITRANS
Intelligent Transport System

1.2 ROAD TRANSPORT MANAGEMENT

1.2.1 Variable Speed Limit (VSL) to improve traffic flow

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: metropolitan, long-distance

Technology behind: Variable Message Signs, detectors (inductive loops, microwave detectors, CCTV cameras)

Status: implemented

Links to relevant references

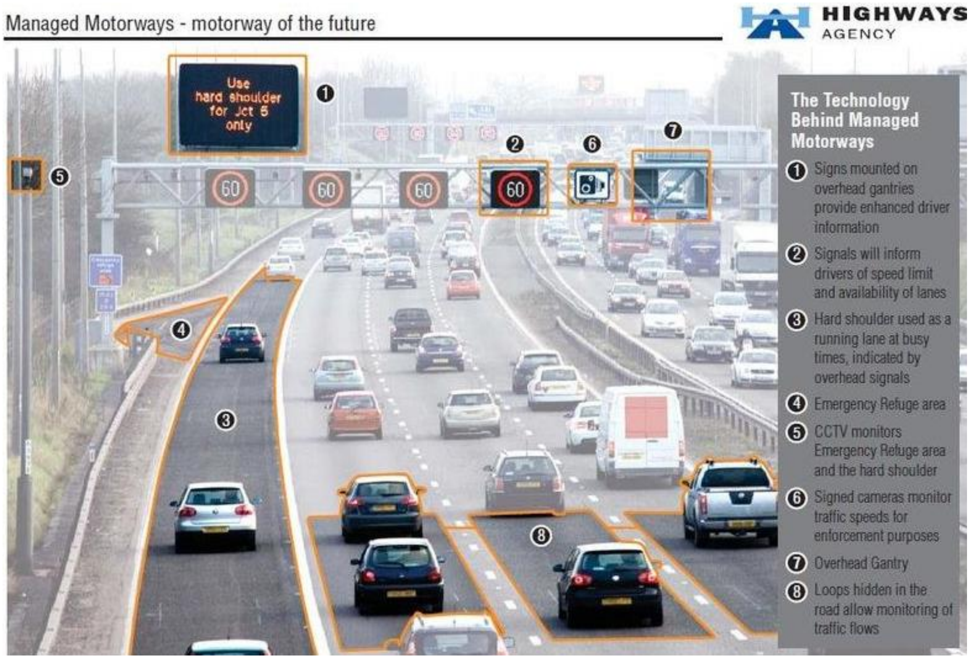
- Nissan, Albania. *Evaluation of Variable Speed Limits: Empirical Evidence and Simulation Analysis of Stockholm's Motorway Control System* (KTH, School of Architecture and the Built Environment (ABE), Transport and Economics, Traffic and Logistics), 2010
- Markos Papageorgiou, *Optimal Mainstream Traffic Flow Control of Large-Scale Motorway Networks*
- Markos Papageorgiou, Elias Kosmatopoulos, and Ioannis Papamichail *Effects of Variable Speed Limits on Motorway Traffic Flow*
- Carlson, R.C., Papamichail, I., Papageorgiou, M.: Local feedback-based mainstream traffic flow control on motorways using variable speed limits. *IEEE Trans. on Intelligent Transportation Systems* 12 (2011), pp. 1261-1276.
- Rodrigo C. Carlson, Ioannis Papamichail, Markos Papageorgiou, and Albert Messmer *Optimal Motorway Traffic Flow Control Involving Variable Speed Limits and Ramp Metering* Transportation Science 2010 44:238-253
- A guide to Variable Message Signs and their use, UK Highways Agency
- Examples of Variable Speed Limit Applications, TRB Annual Meeting 2000.
- Inter Urban
- RITA

Description

Concept and problems addressed. Variable Speed Limits (VSL) are used to improve traffic conditions on busy motorways. On motorways, the variation in speed and headways between vehicles in the same lane and between lanes is often the cause of unstable traffic conditions under high traffic volumes. A minor incident may cause long traffic queues, congestion, and frustrated drivers, which in turn may lead to accidents and long travel times that entail a cost to individuals and society alike.

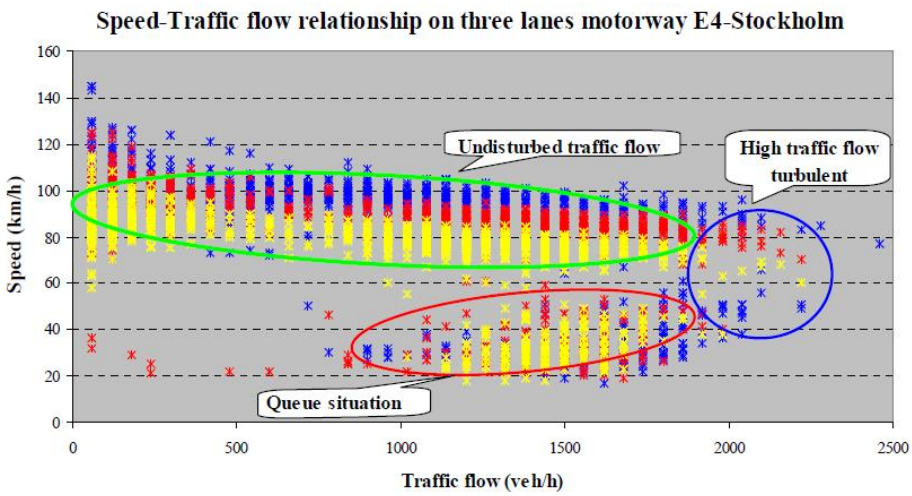
Considerable efforts have made to develop strategies and systems for dynamic traffic management aimed at increasing the intelligence of motorways to improve their performance suffering from recurrent congestion. Many strategies are being developed to increase the capacity of the existing infrastructure through improved operating efficiency and fewer occurrences of congestion, either focused on managing flows at entrances and exists of the motorway (ramp metering), on the main motorway (mainline control), or specifically for hard shoulders which are temporarily given over to traffic (sometimes referred to as managed motorways).

Amongst several applications in mainline control, dynamic variable speed limits, displayed on Variable Message Signs (VMS) are aimed at harmonising heavy flow. This may generally be done for two purposes: first of all to avoid the breakdown of the traffic flow as already mentioned above or, in cases where traffic has already broken down downstream due to a known bottleneck or an incident, to slow down traffic approaching the critical stretch of road systematically and in a controlled manner to avoid secondary accidents. A third application is hard shoulder running, where the additional lane and the lack of a hard shoulder as a refuge for cars breaking down, necessitate a speed reduction for safety reasons during the opening times of the hard shoulder.



Source: UK Highways Agency
Managed Motorway Functioning in the UK (MIDAS system)

Typically, a motorway traffic management system includes detection of average speed, traffic volume, density, and environmental factors. This information, combined with a simple algorithm or even a simple threshold for traffic volume and / or density is sufficient to operate a system that is intended to prevent or delay traffic breakdown at high traffic volumes and density as illustrated in the figure below.



Source: A. Nissan 2010
Speed-Traffic Flow relationship on the E4 Stockholm motorway. VSL is mostly effective under ῆigh traffic flow turbulentὸconditions

Where the aim is to slow down traffic in front of a known bottleneck the same information as for the case above is sufficient.

However, there are also concepts (that have not been tried in practice though) to use the VSLs to optimise the traffic flow not only locally, but over a whole motorway network in the form of Mainstream Traffic Flow Control (MTFC) in which case the control algorithms become very sophisticated ï see Papageorgiou reference above for more detail.

Where traffic is to be controlled by VSLs in order to slow traffic down ahead of a random incident or accident, this has to be detected in the first place and Automatic Incident Detection systems (AIDs) are needed to trigger the VSLs. The AID algorithm processes the collected data to analyse whether an incident has taken place or not. High detection rate in conjunction with low false alarms rates are desirable for good performance of a motorway network. AID algorithms detect incidents using data (flow speed, flow density) collected from, for example, inductive loops, CCTV cameras or microwave detectors. The AID algorithms are considered to be key components of a successful motorway traffic management system. The performance of the algorithm is dependent on the quality of the data collected.

Several examples of VSL applications exist in Europe. VSL systems are implemented as advisory in Stockholm or mandatory on German motorways (A5 Karlsruhe, A8 Munich, A3 Köln) or in the UK on the M25 and M42 Managed Motorways around London and Birmingham. Studies indicate that enforcement is necessary to achieve and maintain a sufficient level of acceptance. The results from simulation studies performed by the KTH in Stockholm also indicate that driver compliance is an important factor and VSL performance quickly deteriorates as compliance rate drops.

The success of VSL depends to a large extent on how drivers respond to the displayed speed limits, and interact with other drivers. Studies on the M25 motorway round London, in the UK (UK Highway Agency, 2004) show that safety benefits of VSL systems arose as a result of adjustments in driving behaviour. Drivers kept more uniform headways, which resulted in reduced braking. Accidents with injuries were reduced by 10%. Furthermore, traffic noise was reduced by 0.7 decibels, and fuel consumption, and thereby emissions, were reduced by 2-8% overall.

Targeted users. Motorway operators, especially in urban and metropolitan surroundings.

Barriers to Implementation

Financial issues. Considerable infrastructure investment is necessary to implement a full motorway control system. It requires installing loop detectors, microwave radars or video detection to read flow and speeds in a motorway stretch, ideally every 500m, speed signalling gantries, a central processing unit, the implementation of Automatic Incident Detection algorithms and software and the related communication system. The equipment can be then used not just for VSL, but also for issues like hard shoulder management, ramp metering, or general traffic monitoring. A full system was estimated to cost in the UKọs Webtag (CBA) Analysis between £4 and £6.9 per mile, including initial investment, maintenance and renewal after 15 years, in a 2 year period, in contrast to 10 years and £30 million per mile (investment renewal and maintenance) for motorway widening (Webster, 2007).

A pure VSL system is much less expensive. In 1997, a system consisting of radar detection, six weather stations, nine variable message signs (VMS), and radio and microwave transmission systems, covering 40 miles, was installed in Washington State for just $ 5 million. In 2011 a contract worth £ 12.9 million was let in Scotland for installing a VSL system on a 14 mile stretch in the approaches to the Forth Road Bridge. These are of course only the investment costs, and maintenance and eventual replacement will add considerably to these figures, but the total will still be much lower than the cost for a full motor control system.

However, in most cases a general motorway control and monitoring system will be already in place when the introduction of VSLs is considered, and then the marginal costs for the VSL is much lower: a VMS gantry for the VSL signs costs just around ú 100,000. The marginal operational and maintenance costs are also low. Added to that may be the costs for speed cameras for the enforcement of the speed limit that should ideally be installed at least in one or two places in the controlled stretch of the motorway, but these are also very low. Moreover, most effective for the speed enforcement are anyhow mobile speed cameras, which are hidden and which drivers may expected anywhere in the controlled area, if such hidden speed-checks are made often enough.

The only income created from the VSL system may come from the fines for detected speed violations, but since they normally go into different accounts than those of the motorway operator, they are not relevant for the financial viability of the VSL, which is generally given.

Technical barriers. A full motorway control system that includes sophisticated infrastructure and algorithms can be a very complex system, because it covers a large area consisting of different kinds of traffic installations and traffic conditions. However, in the typical case where the VSL is an add-on to the existing motorway control system, the added complexity of the VSL is in most cases very low even if intelligent algorithms are used to control the VSL.

Organisational complexity. Organisational complexity is very low. It usually involves the motorway operator and/or the public road administration, which for most motorways in Europe are the same body. Equally the administrative burden is very low for the system itself, although the speed enforcement will add some.

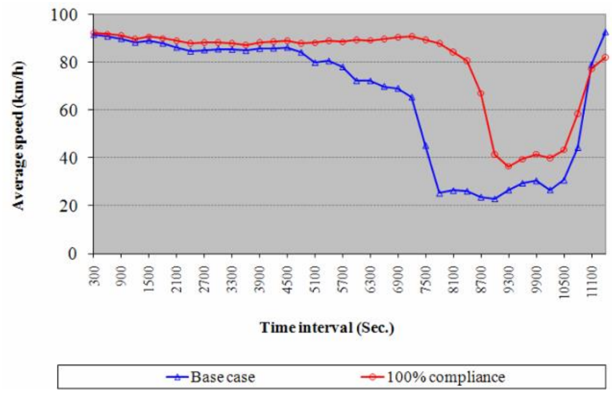
Legal issues. There should not be any legal obstacles to such systems.

User and public acceptance. Public acceptance of VSLs is generally very high, even if some segments of the public oppose the use of speed cameras to enforce speed limits. Driversô acceptance of VSLs is generally high where they see that the speed limits are applied judiciously and traffic volumes are indeed very high. Nevertheless speed enforcement will be necessary for full compliance.

Interest for Travellers

Door to door travel time. Webtag appraisal for M25 MIDAS system indicated increased journey times for users as average flow speed decreased, although economic losses from increased travel times were outweighed by increase in fuel efficiency due to smoother traffic flows. However, this suggests that the VSL had been applied too often and too early, when flow without the speed limit would have stayed stable.

The simulation in Stockholm VSL for the E4 Motorways suggested overall speed increase due the delayed onset of the traffic breakdown. It is this effect that is the main purpose of VSLs, and where these traffic conditions are given, VSLs will reduce overall travel time considerably.



Source: A. Nissan 2010
Simulation of average car speed in a section of E4 Stockholm along morning peak hour, with VLS (100% compliance) and without (base case)

Also where VSLs are applied to slow down traffic smoothly ahead of bottlenecks or incidents, travel time will increase slightly on most days. However, without them, the risk of secondary accidents increases strongly and the benefits are then very large due to the prevention of a very significant slowing down of traffic due to the secondary accident.

Travel cost. A more regular and stable flow pattern is likely to produce savings in fuel consumption and vehicle operating costs. For Londonô M25, it was estimated that VSL could be reducing stop-start driving by 6%, leading to a fuel consumption reduced by 2 to 8%, leading in turn to a similar emissions decrease.

Comfort and convenience. VLS may improve driving comfort under heavy traffic conditions. Decrease of congestion events increases also comfort and convenience for users.

Safety. VSL strategies aim to reduce primary accidents due to large speed variations between cars and/or to reduce secondary accidents upstream from bottlenecks and primary incidents. VSL can produce a safer traffic environment, especially in corridors with very mixed traffic. In the Rhone Valley motorway managed by ASF, it was estimated that the system was able to reduce accidents by 25%. In the M25 London motorway, injury accident drops were estimated on a 10%. Analyses of VSLs in Germany point towards a 20% to 30% accident reduction.

Security. No particular impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

As VSL tends to improve driving conditions on motorways, especially under congestion conditions, typically on commuting peak-hours, it may lead towards increase of the share of road transport in urban environments. However, the magnitude of this increase may be discussable.

Other notable impacts

Congestion. A VSL can be effective in reducing travel time and improving traffic conditions on the motorway, when it prevents congestion. In France, a VSL system implemented in the Rhone Valley motorway was estimated to have increased capacity by 5% and reduced congestion events by 20%. For the M25 in London, a business case developed in 2004 by the Highway Agency estimated that stop-start driving was reduced by 6%.

Environmental Impact. VSL contributes to lower fuel consumption and emission reductions resulting from the lower frequency and severity of acceleration/deceleration manoeuvres. In London M25, it was estimated that noise was reduced by 0.7 decibels, and that fuel consumption, and thereby CO_2 emissions, were reduced by 2-8% overall. Webtag assessment estimated an NO_x drop of 1.5%, a CO drop of 3.9% and a PMx drop of 7.9%.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	+	Mobility	0
Operation and maintenance costs	€	D2D travel cost	✓	Bus and coach usage	0	Congestion	✓
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Simulation of Active Traffic Management

http://www.youtube.com/watch?v=W7ZUqDNWoYs&feature=related

Building Smarter Highways- Active Traffic Management

http://www.youtube.com/watch?NR=1&v=cd0doR0Ga-I&feature=endscreen

1.2.2 Smart lanes on hard shoulders

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: metropolitan

Technology behind: cameras, sensors in the road surface, signals, roadside camera recognition (CCTV)

Status: implemented

Links to relevant references

- UK Highways Agency, M42
- *Variable lane assignment: two French projects for minimizing congestion on urban motorways* by Desnouailles, C; Boillon, P; Cohen, S; Nouvier, J;
- *Active Traffic Management: the next step in Congestion Management*. US Department of Transportation. Federal Highway Administration, 2007
- *Traffic Management Services. Hard shoulder running*. Deployment guideline, EasyWay, 2012
- Managed Motorways Monitoring/Evaluation of Through Junction Running (TJR), Highways Agency, 2012
- *Managed Motorways - Experience from the UK* by David Kamnitzer, Adam Simpson, IBI Group, 2012.
- *Active Traffic Management Concept of Operations* by Parsons Brinckerhoff, Telvent Farradyne and Jacobs Carter Burgess, Washington State Department of Transportation, 2008
- *Temporary Hard Shoulder Use in Hessen – Experiences and Strategic Planning*
- *Operational Experience with Temporary Hard Shoulder Running in Germany*
- *Synthesis of Active Traffic Management Experiences in Europe and the United States* by FHWA, 2010
- M42 Active Traffic Management Scheme, Birmingham, United Kingdom

Description

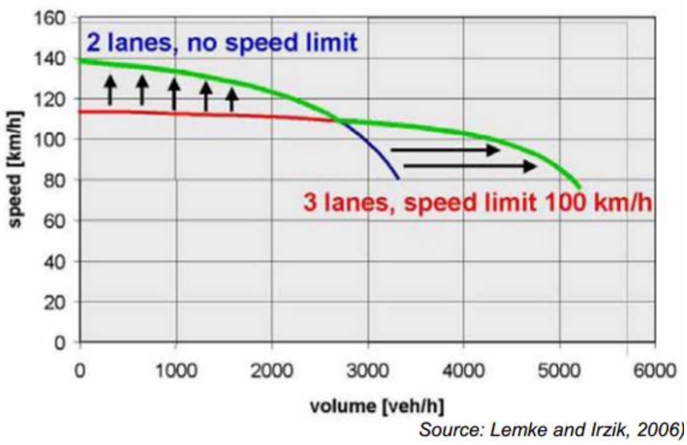
Concept and problems addressed. Smart lanes or managed lanes, also known as active traffic management (ATM), are a scheme for improving traffic flow and reducing congestion on motorways. It has been implemented in several countries, including Germany, the United Kingdom, France and the United States. It makes use of automatic systems and human intervention to manage traffic flow and ensure the safety of road users.

Techniques of ATM are listed below:

- Speed Harmonisation: to dynamically and automatically reduce speed limits approaching areas of congestion, collisions, or special events. Benefit: to maintain flow and reduce risk of collisions. (see separate factsheet on Variable Speed Limits)
- Queue Warning: to warn motorists of downstream queues (or backups) and direct through-traffic to alternative lanes. Benefit: to effectively utilise available roadway capacity and reduce the likelihood of speed differentials and collisions related to queuing.
- Junction Control: to use variable traffic signs, dynamic pavement markings, and lane use control to direct traffic to specific lanes (mainline or ramp) based on varying traffic demand. Benefit: to effectively utilise available road capacity and manage traffic flows to reduce congestion.
- Hard Shoulder Running: to use the hard shoulder as a travel lane during congested periods or to allow traffic to move around an incident. Benefit: to minimise recurrent congestion and manage traffic during incidents.

- Dynamic Rerouting: to change destination signs to account for current traffic conditions. Benefit: to effectively utilise available road capacity by redirecting traffic to less congested roads.
- Travel Time Signs: to provide estimated travel time and communicate travel and traffic conditions. Benefit: to allow for better en-route decisions by travellers.

Temporary shoulder use is a congestion management strategy typically deployed in conjunction with speed harmonisation to address capacity bottlenecks on the motorway network. The strategy provides additional capacity during times of congestion and reduced travel speeds. In Hessen (Germany), the hard shoulder increases the capacity of the standard three lane motorway sections by 20%. This permits traffic volumes of over 7,000 vehicles per hour without traffic breakdown.



Source: Synthesis of Active Traffic Management Experiences in Europe and the United States by FHWA, 2010
Speed-volume relationship of temporary shoulder use in Germany

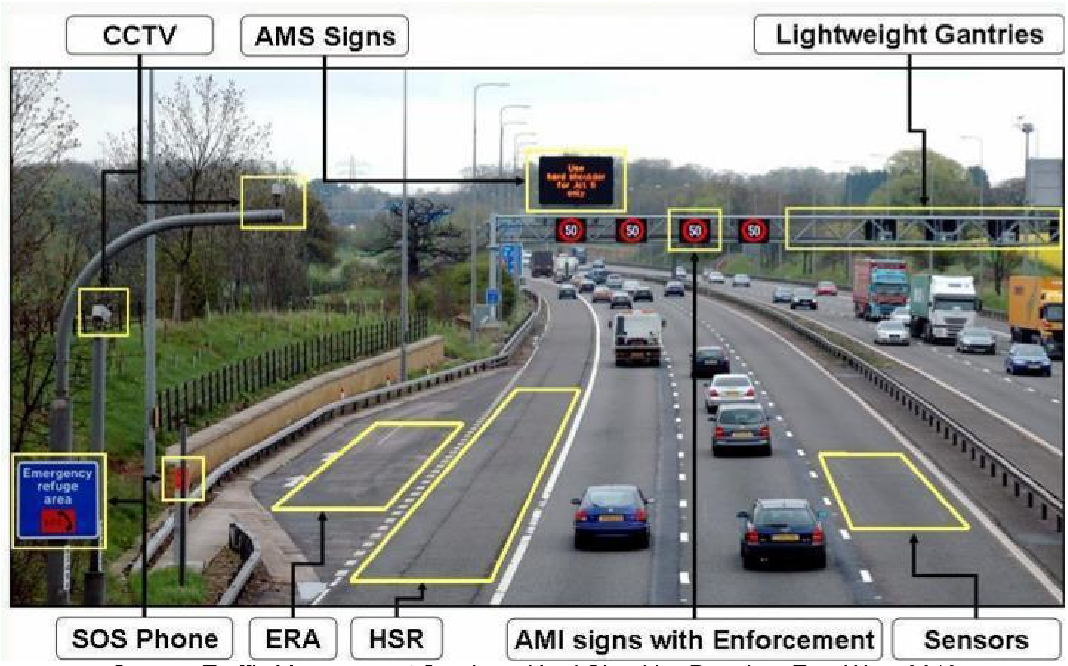
Hard shoulder running is carried out via the following functions:

- Monitoring - Collect real time information on the traffic situation of the network
- Safeguarding - Check if the hard shoulder is free of debris, obstructing the safe use of the hard shoulder and free of vehicles within a certain time frame.
- Dynamic information - Inform the road user if the hard shoulder is open or closed
  - Open: Signing above the hard shoulder indicates either the allowed speed limit or a symbol like a green arrow pointed downwards. In addition dynamic or static signing alongside to the road can provide the road user with reassurance that the hard shoulder can be used.
  - Close/clearing: To start the clearing process, a yellow (flashing) arrow pointing diagonally downward should be used as transition signal. The clearing process can take place by means of lane change that can be done for the whole section simultaneously or forward by means of discharging.

In Birmingham, a hard shoulder strategy has been implemented as a part of the Active Traffic Management Scheme in M42:

- Vehicle detection 'Loops' (MIDAS traffic sensors) set into the road surface beneath each lane at regular intervals (visible as dark rectangular markings), and a network of CCTV cameras to detect traffic speed and density. The monitoring loops sense how much traffic there is. Depending on the volume of traffic and the duration of the congestion, a computer calculates the optimum speed to keep traffic moving. This speed is then displayed on the signals on the gantry overhead.
- Part-time traffic signals at entry slip roads (ramp metering) to control the flow of traffic entering the motorway.
- More than 54 gantries at 500m intervals above the motorway carrying large, lane-specific electronic Variable Message Signs (VMS), Advanced Motorway Indicator (AMI) signals, Advanced Motorway Signs (AMS) and digital speed enforcement equipment. These will

relay information to motorists to open and close lanes and control speeds to prevent flow breakdown.



Source: Traffic Management Services. Hard Shoulder Running, EasyWay, 2012
Lane Management Scheme in M42, Birmingham

Targeted users. The targeted users for this application are motorway operators, especially in urban and metropolitan surroundings suffering from heavy congestion.

Barriers to Implementation

Financial issues. The cost of introducing hard shoulder running depend in the first place on the width and the quality of the hard shoulder, whether it is of a high enough standard to allow heavy traffic on it without widening or upgrade of surface and underground structure. If it is, the main costs are those for installing Variable Message signs on gantries and / or on the side of the motorway. With a typical gantry costing around ú100,000, these investments are relatively low compared to widening the motorway or, even more so, building new motorways. If, however, the hard shoulders need to be widened and/or reinforced to allow regular heavy traffic on it, then the costs are much higher depending on the level of improvements needed. After that, operation and maintenance cost are comparatively low.

Technical barriers. Safety is generally the greatest concern when implementing shoulder running strategies, since use of the shoulder as a travel lane results in the loss of a continuous emergency refuge area for broken down vehicles and during incidents. Depending on the length of the hard shoulder running section, the provision of infrequent paved emergency refuge areas or pull-outs may be advisable for the affected segment. Alternative refuge areas would be outside of the shoulder area and would provide a designated place for stalled or disabled vehicles while allowing use of the hard shoulder as a travel lane. In England, the alternative refuge areas are spaced every one-third or one-fourth mile. In contrast, Germany does not generally include refuge areas. Very short segments may not require a refuge area anyhow.

Another safety issue relates to impediments in the shoulder (i.e. stalled vehicles or debris) that needs to be cleared before opening the lane to use.

Organisational complexity. Coordination between road operators and Emergency Services. The UK approach requires a visual inspection of the hard shoulder before it is opened. This requires some intervention on the part of operators, which means that the system cannot be started automatically.

Legal issues. Legal frameworks may need to be adjusted to allow circulation of vehicles on hard shoulders of motorways.

User and public acceptance. User and public acceptance is very high, as it is an obvious way to alleviate congestion.

Interest for Travellers

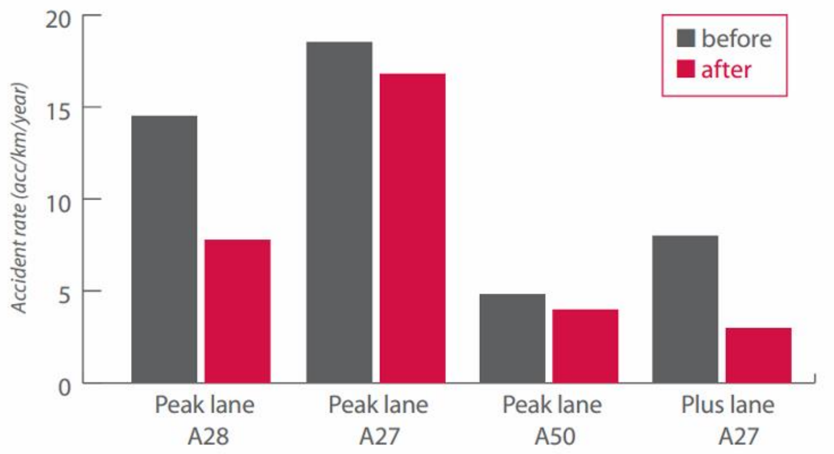
Door to door travel time. In The Netherlands, it was found that implementing temporary shoulder use has increased overall capacity 7% to 22% (depending on usage levels) and decreased travel times by 1 to 3 minutes during congested periods.

Travel cost. The evaluation carried in Germany (A5 between the Frankfurt NW intersection and the Friedberg junction) revealed that temporary hard shoulder usage saved congestion related losses amounting to approx. 3,200 vehicles hours per day. Converted using the corresponding time cost rates; this means economic benefits from avoided time losses amounting to ú 48,000 per day or ú 10 million euro per year.

Comfort and convenience. Smart lanes and hard shoulder management increase the capacity of motorways and lower traffic congestion, resulting on increased comfort for car users from smoother driving conditions.

Safety. The Dutch have seen a reduction in incidents on facilities with hard shoulder running. Additional safety benefits may include fewer queues and shock waves, lower travel speeds with harmonisation, better monitoring, and swifter incident response. As in Germany, temporary shoulder use is allowed only when speed harmonisation is in effect. Also, additional facilities help mitigate any adverse safety consequences the operational strategy may create, including the following:

- Overhead lane signs;
- Emergency refuge areas with automatic vehicle detection;
- Speed reduction during times of temporary shoulder use;
- Variable route signs at junctions;
- Advanced incident detection;
- CCTV surveillance;
- Incident management;
- Street lighting.



Source: Active Traffic Management: the next step in Congestion Management. US Department of Transportation. Federal Highway Administration, 2007

Incident reductions for Dutch temporary hard shoulder use

Security. No impact is expected.

Accessibility for impaired. No impact is expected.

Modal change

Smart lanes and hard shoulder management are expected to improve of travel times due to decreased congestion in motorways. As a result, road alternatives may become more attractive and modal shift from other transportation modes may be observed.

Other notable impacts

Mobility. Further to an impact on mode change, the creation of additional capacity on motorways has, at least in the past, regularly led to an induction of traffic, and this may also be expected from the introduction of hard shoulder running, although no related research results are known.

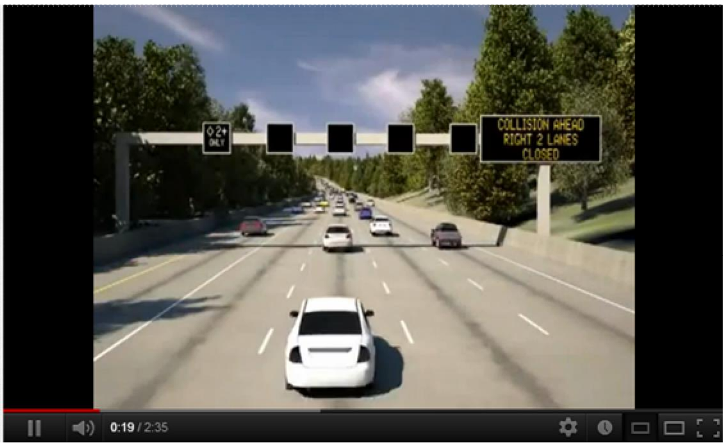
Congestion and emissions. Systems for Active Traffic Management (ATM) have positive effects on the traffic flow and reduce traffic-related congestion and accidents (which would be followed by further congestion). By means of traffic smoothing, noise and pollutant emissions are reduced. In France (A4-A86), the principal emission of pollutants and gases with greenhouse effect decreased by 4.25% and the energy consumption by 15%.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€-€€€	D2D travel time	✓	Car usage	+	Mobility	✓
Operation and maintenance costs	€	D2D travel cost	✓	Bus and coach usage	0	Congestion	✓
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

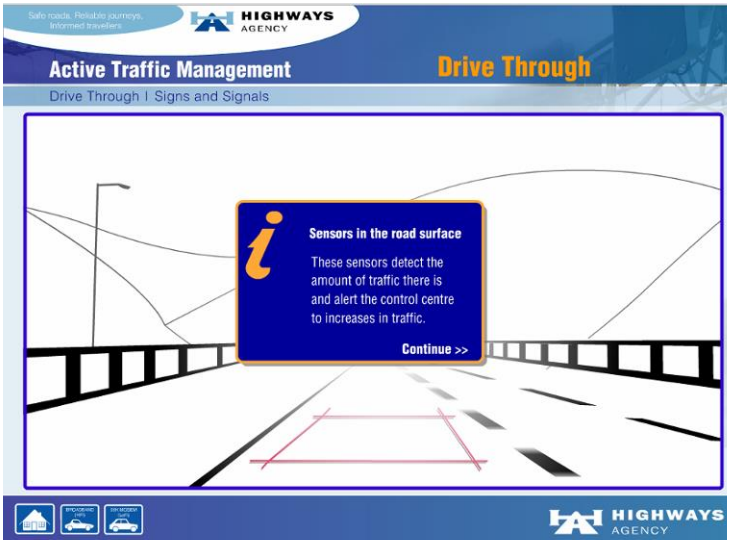
Illustrative materials

VDOT: I-66 Active Traffic Management System in Northern Virginia



http://www.youtube.com/watch?v=x-ZZKhaLRzI

Active traffic management ï UK Highway traffic Management



VISSIM Traffic Simulation featuring Active Traffic Management (ATM)

http://www.youtube.com/watch?v=W7ZUqDNWoYs

1.2.3 Ramp metering

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: urban

Technology behind: detectors, traffic lights, red light cameras

Status: implemented

Links to relevant references

- European Ramp Metering Project (EURAMP), 2007.
- EURAMP Evaluation Results, 2007.
- EURAMP Handbook of Ramp Metering, 2007
- Highway Agency
- Swarco Solutions
- Ramp Metering in the Netherlands: an overview by Frans Middelham and Henk Taale, 2006
- Ramp Metering with an objective to reduce fuel consumption by Jaap Vreeswijk, Zeremariam Woldeab , Zeremariam Woldeab and Jing Bie, 2011.
- Traffic management services. Ramp Metering. Deployment guidelines by EasyWay, 2012.
- Synthesis of Active Traffic Management Experiences in Europe and the United States

Description

Concept and problems addressed. Ramp metering controls the flow of traffic entering on the access ramps to a motorway. Ramps are used to store vehicles temporarily, in order to optimise the flow on the motorway itself, and maintain it below the critical level, over which congestion is likely to appear. Ramp metering is used to solve a problem of congestion created by a bottleneck that originates from an excess of demand on one or more ramps of a motorway. Ramp metering aims at maintaining the full utilisation of the motorwaysôcapacity, even during rush hours and in case of incidents.

In generalised congested traffic conditions, the motorway network throughput is usually lower than the nominal motorway capacity, but the congestion cannot be dissolved (due to the generalised infrastructure degradation) before the arriving demand reaches sufficiently low levels. In fact, during generalised motorway congestion, it is not the high demand causing and extending the congestion, but the congestion-induced infrastructure degradation resulting from the fact that the motorway is factually operated as a vehicle storage space rather than a transportation facility. Ramp metering is the most direct and efficient means to regulate the "spontaneous" use of the motorway infrastructure, just like traffic lights were when they were introduced in the urban road networks. Ramp metering introduces short delays at on-ramps and motorway-to-motorway intersections to allow for capacity flow on the motorway itself, leading, if applied correctly, to substantial savings for each individual road user, including those users who enter the motorway from metered ramps.

A ramp meter consists of a traffic signal located on a motorway on-ramp that regulates the traffic entering the motorway from that ramp. In most cases, when the signal turns green one car in each lane is allowed to go. By regulating and making more uniform the incoming flow of vehicles into the motorway, the system prevents congestion waves to appear in the mainstream of the motorway. Without ramp metering, traffic enters the motorway at any arriving rate; if the mainstream flow temporarily exceeds the motorway capacity at some specific location(s), congestion is formed. In short, ramp metering temporarily holds out of the motorway a fraction of the arriving demand so as to keep the motorway infrastructure operating at maximum throughput.

Pre-ramp metering mainstream merging (left) and with metering in operation (right) in the same Amsterdam ring-road on-ramp.

Source EURAMP 2007

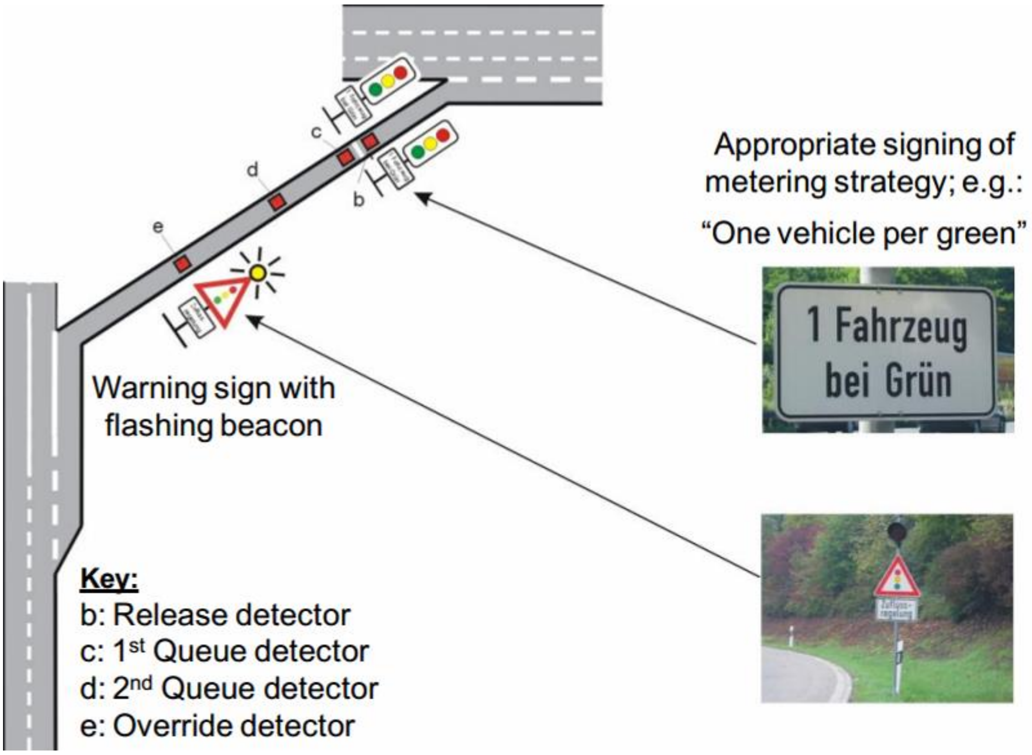
The traffic lights are generally operated in dependence of the currently prevailing traffic conditions on both the motorway mainstream and the ramps. The corresponding traffic-responsive control strategy (or control algorithm or control logic) is the connecting element between the measured traffic conditions and the operated traffic light settings. Several management options are possible:

- In a fixed-time ramp metering strategy, the traffic signal settings for the metered ramp are calculated off-line based on previously collected data on traffic demands at that location. There will be different signal settings for different times of day and for different types of day. This approach requires homogeneity in traffic conditions over time, and has evident limitations in terms to adjusting to eventualities not specifically foreseen.

- In a reactive ramp metering strategy, the signal settings are calculated based on real-time traffic data from detectors on the ramp and on the highway upstream and downstream of the ramp. According to the precise strategy adopted, this detector data is processed to produce the signal timings at the ramp, which are therefore reactive to changing traffic conditions.

- Predictive ramp metering strategies go one step further by using real-time traffic measurements along with appropriate estimation and prediction algorithms. Predictive strategies therefore take control actions in real-time to deal with anticipated problems.

The pertinence of the employed control strategy is crucial for the full exploitation of the potential benefits offered by ramp metering; therefore, the employed ramp metering strategy should be designed and configured with proper understanding of the potential benefits achievable. Ramp metering can be implemented in different ways, to optimise various traffic parameters: minimise average travel times, maximise entering flows with a throughput constraint, or maximise the rate of use of the motorway. Several projects have put forth voluntary objectives regarding safety that should be enhanced by ramp metering.



On Ramp Systems elements

Source: Traffic management services

A crucial question concerns the maximum amount of traffic that needs to be temporarily stored on the ramps. The maximum total amount of vehicles that need to be stored at the ramps in order to protect the infrastructure from oversaturation does not exceed a few hundred vehicles, which is a small fraction of the motorway's total throughput of several thousand vehicles per hour. However, as urban ramp layouts were not originally designed to store vehicles from control purposes, the available storage space may only allow for storage of some 10-50 vehicles per ramp, which may be insufficient to fully protect the mainstream from overload, and may obstruct traffic outside the motorway not bound for the on-ramp.

Potential improvements achievable via ramp metering measures include (EURAMP, 2007):

- Reduction of motorways congestion in space and time (or even elimination of congestion under certain conditions);
- Increase of motorway throughput;
- Reduced (or avoidance of) congestion spillback to the adjacent urban traffic network or to other merging motorways;
- Significant improvement of traffic safety due to reduced congestion duration, less congestion spillback and improved merging processes at on-ramps.

The introduction of ramp metering at some particular ramps or particular motorway stretches within the overall network can help alleviate some local traffic problems and to improve the local traffic conditions. However, the significant amelioration of the global traffic conditions in the overall traffic network calls for comprehensive control of all or most of the ramps, including motorway-to-motorway links, with the aim of optimal utilisation of the available infrastructure.

Ramp metering has been installed in several countries in Europe, including the United Kingdom (M1, M4, M6, M3, M27, M42), Germany (North Rhine-Westphalia), the Netherlands (A10-West near the Coentunnel, Delft-Zuid on-ramp to the A13) and France.

Targeted users. Motorway operators, especially in urban and metropolitan environments, suffering from recurrent congestion.

Barriers to Implementation

Financial issues. In The Netherlands, the implementation costs were ú150,000 for a one lane controller and ú175,000 for a two-lane controller including outside equipment. Red-light cameras add another ú 45,000. The maintenance costs are ú10,000 per annum. All these figures are exclusive of central equipment and the costs for infrastructural additions like the provision of extra queuing capacity.

For Paris, the total implementation of a new installation of metering for 20 ramp costs amounted to ú3.7 M, consisting of data processing (ú600,000), equipment ú150,000 per ramp (civil engineering, control devices, communication links), tuning, evaluation and an information campaign for drivers and administrations via flyers, posters and information boards ú100,000. The average costs per ramp are ú185,000.

The EURAMP study estimated in 2007 the socio-economic benefit of implementing alternative ramp-metering systems and strategies in Paris with benefits between ú 300,000 and ú1,400.000 yearly for conventional and coordinated strategies respectively. These numbers resulted in cost-benefit ratios of up almost 9 for the most efficient management strategies.

Technical barriers. No major technical barriers are to be expected for the physical implementation of this solution. However, an accurate calibration of the system is needed to establish optimal metering regimes and light phases at motorway on-ramps to maximise its positive impacts, a task being far from evident. The EURAMP study pointed out in 2007 that the motorway operators that had participated in ramp-metering trials were satisfied with relatively straightforward system implementation, operation and maintenance.

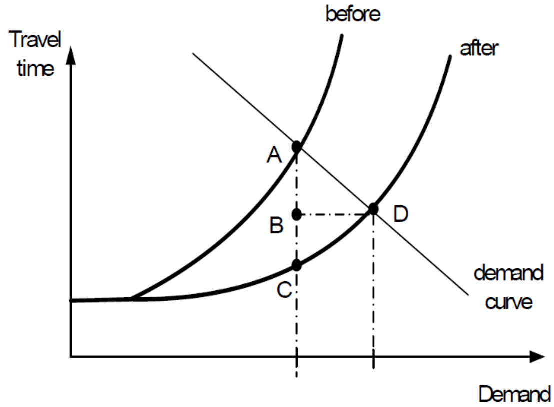
Organisational complexity. Although not critical, in contrast to other control measures that affect only the motorway itself the introduction of ramp metering in motorways may bring along a certain degree of complexity, as it involves both the managing authority responsible for the motorway infrastructure and authorities of the surrounding urban road networks e.g. local municipalities. If the system requires refurbishment of on-ramps, agreements might be needed between both authorities.

Legal issues. There should not be any insurmountable legal obstacles to this application.

User and public acceptance. Acceptance by users of ramp metering is high, provided that the system is successful in reducing motorway congestion. The EURAMP project pointed out that in their test trial in Tel Aviv (being a first such experience in that country) there was a small number of complaints by drivers who did not understand the function and purpose of the system. However, the system was overall well received by car drivers and press. Public acceptance should generally be high, provided the vehicle storage is contained within motorway on-ramps and does not induce congestion outside in close-by urban tissue.

Interest for Travellers

Door to door travel time. The ramp metering is expected to improve travel times due to decreased congestion in motorways. As a result, road alternatives may become more attractive and modal shift from other transportation modes may be observed.



Source: EURAMP 2007
Traffic demand and supply equilibriums

In the Netherlands, a pilot junction control project at the Diemen interchange resulted in a reduction of overall mean travel times of 7 and 8 % and reduced vehicle delay of 4% and 13% for both mainline and merging traffic, respectively. Downstream speed increased by 7.5%

In the EURAMP project, a travel time reduction of 17% was achieved in Paris for the Coordinated Strategy compared with No Control. But also with ALINEA and VC-ALINEA improvements of 13% and 10% were recorded. In Utrecht, improvements of 1.7 to 5% were achieved in the four control cases, and 6.7% was reached upstream of the KKL ramp in Tel Aviv. However it had also to be noted that where the metering strategy was applied too harshly, the travel time gains on the motorway were smaller than the travel time increases on the ramps, and that therefore every ramp metering implementation needs to be fine-tuned carefully.

Travel cost. Provided that ramp metering is saving travel times, this also implies cost savings in terms of fuel consumption and operational costs of cars.

Comfort and convenience. Ramp metering increases the capacity of motorways and lowers traffic congestion, resulting on increased comfort for car users.

Safety. Ramp metering systems are supposed to reduce the number of accidents. In Germany, ramp metering was found to reduce crashes with person and property damage by up to 40%, with no negative effects on the adjacent roadway network. However, EURAMP's test trials did not prove the starting hypothesis that ramp metering would increase traffic safety. The observation of the merging behaviour in Utrecht showed a very marked shift towards earlier merges, which indicates a possible reduction in the accident risk, but the observations in another trial in Tel Aviv showed a small shift towards later merges and therefore a possible slight increase in the accident risk.

Security. No impact is expected.

Accessibility for impaired. Not impact is expected.

Modal change

The difference between the decrease of travel times on the motorway and the increases on ramps are too subtle to lead to any modal change

Other notable impacts

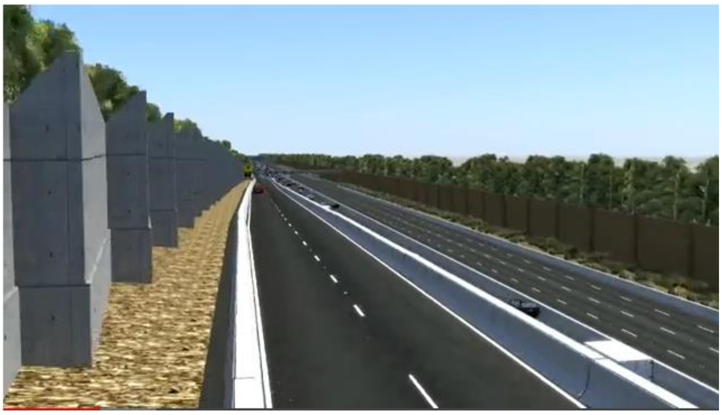
Where ramp meters are properly applied and reduce, or even prevent, congestion on the motorway, this will also lead to reduced CO2 emissions, even when taking account of increased delays on the ramps.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	0	Congestion	✓
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

VicRoads - Freeway Management System



http://www.youtube.com/watch?v=SYbceSqk_Mk

Kansas City Scout Ramp Meters on I-435

http://www.youtube.com/watch?v=TQOrP8tA4BY

1.2.4 High Occupancy Toll (HOT) lane

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: Metropolitan

Technology behind: DSRC

Status: Implemented

Links to relevant references

- SR 167 - HOT Lanes Pilot Project by Washington State Department of Transportation, Fourth Annual Performance Summary May 2008 – April 2012
- Kapsch Group
- Enhancing commuter travel by Patrick DeCorla-Souza, FHWA, USA, Traffic Technology International, August/September 2011
- Higher Occupancy, less traffic by Capital Injection, Tolltrans 2009 (p. 24-27)
- Relief Mechanism Projecting Hot Lane Travel Demand by TollTrans 2009 (p. 35-37)
- Congestion improves with high occupancy toll lanes
- Network Premiere – Not your father's hot lanes by TollTrans 2010 (p. 16-19)
- Now good to go works by WSDOT

Description

Concept and problems addressed. In the face of growing urban congestion and the high cost of creating new capacity on motorways, roadway authorities are considering new High Occupancy Toll (HOT) lanes or the conversion of existing High Occupancy Vehicle (HOV) to HOT lanes to improve highway quality of service and to make maximum use of existing highway infrastructure. HOV lanes are reserved for vehicles with a driver and one or more passengers in order to expand the passenger throughput of the respective lane. HOT lanes are HOV lanes, where single-occupancy vehicles (SOVs) are allowed to drive when paying a toll.

The HOT concept began in USA with SR 91 (Orange County, California) in 1995 and then has gained growing interest in the USA. Several road infrastructures are now currently implementing HOT lane operations in the nation with the most recent opening of SR 167 in Washington state and many more are under study or will be operational in the near future. Looking further afield many other of the world's cities could introduce the HOT concept. While Europe's cities are certainly congested, only a few have sufficient traffic lanes on major highway links for the HOT system to be viable. The Netherlands has been one of the most open-minded counties in Europe with regard to envisioning new traffic and transport solutions. As a major through-route for much of Europe's truck traffic, the Netherlands does experience heavy congestion on many of its highways as well as around its major cities. For the Netherlands, HOT lanes could be an alternative option to introducing distance charging for all road users. Similarly in Germany, the area around the cities of Cologne, Dusseldorf and Dortmund is notorious for heavy congestion in peak periods. Here also, HOT lanes could provide an answer.

The HOT lanes pilot project, between Renton and Auburn, runs northbound and southbound on approximately 10 miles of SR 167 between Renton and Auburn (Washington State, USA). The highway's two general purpose (GP) lanes in each direction remain toll-free and open to all traffic. The HOT lanes are separated from the GP lanes by a solid double white line, which is illegal to cross. In 2008, WSDOT converted the pre-existing SR 167 high occupancy vehicle (HOV) lanes to HOT lanes to make better use of the available space in the HOV lanes. The SR 167 HOT Lanes are HOV (carpool) lanes open to solo drivers who choose to pay a toll. To use HOT lanes, solo drivers must install a Good To Go! pass in their vehicle. Solo drivers with a Good To Go! pass have the option to pay a variable, electronic toll for a faster trip in the HOT lane when space is available. Good To Go! passes mounted on vehicles are read at highway speeds. An electronic sign displays the current toll price at each HOT lane access point. Solo drivers pay one toll per trip for the amount displayed when they first enter the HOT lane. When driving on a tolled facility, tolls are deducted from a pre-paid Good To Go! account. If Good To Go! customers plan to use the HOT lanes as a carpool, they should consider a switchable or movable pass that can be removed or turned on and off depending on the number of people in the car. SR 167 HOT Lanes tolling is all-electronic. There are no toll booths. Carpools of two or more people, vanpools, buses and motorcycles use the HOT lane toll-free, without a pass, just as they did in the HOV lanes. If the HOT lanes become too full, they switch to HOV only. Variable tolling is a tolling structure where the toll price changes over time according to certain performance criteria. The SR 167 HOT lane pilot project uses a type of variable tolling where the toll rate adjusts dynamically based on real-time traffic conditions. Traffic conditions are measured by sensors embedded in the roadway to determine vehicle speed and traffic volume data. When traffic is heavy, the toll price increases, and when it is light, the price decreases ï the law of supply and demand. On SR 167, the variable toll ensures that traffic in the HOT lane always flows smoothly. The system calculates a new toll rate (via a computer program) from 50 cents to $9 every five minutes. This helps the HOT lanes make the most efficient use of carpool lane space, while ensuring that buses and carpools still have a free-flowing, reliable trip.

The Capital Beltway HOT lanes project in northern Virginia, USA, has sparked a great deal of interest, both locally and internationally. It is an ambitious scheme that is set to revolutionise transportation in the area when it goes live in 2013. Virginia DOT (VDOT) and Fluor- Transurban are working together to finance, build and operate 14 miles of HOT lanes on the Capital Beltway, with a 75-year concession. Two additional lanes are being built in each direction between the Springfield Interchange and just north of the Dulles Toll Road in Fairfax County, expanding the capacity from eight lanes to 12. Tolls will be dynamically priced depending on demand, and vehicles with three or more occupants, buses and emergency service vehicles will travel for free. The overall aims are to ease the crippling congestion in the area and to improve travel-time reliability for all road users.

The main travellers targeted by the HOT facilities are commuters, preferably those with relatively long-distance travel patterns within the project corridor. Women drivers were found to be more likely to use toll lanes, citing better safety and urgent family commitments. The HOT lanes are shown to attract travellers in all income groups, although drivers with high incomes are shown to use them more frequently. Work-related trips are the primary trip purposes of HOT lane users during the peak hours, with discretionary trips encouraged to use the shoulder of peak periods through variable pricing or eligibility strategies.

Targeted users. Motorway operators.

Barriers to implementation

Financial issues. The HOT lane facilities have some unique operating characteristics that pose many challenges for travel demand and revenue forecasting, when compared to the techniques used for traditional toll road or bridge projects. To begin with, the free/ competing alternative is running directly alongside the road, whereby the benefit of using the HOT lane will mostly hinge on the congestion on the general-purpose lanes. Added to the complexity are the numerous pricing (variable or dynamic) and eligibility strategies (vehicle occupancy or type) that can be implemented to provide incentives or to manage traffic along the HOT facility.

The operating characteristics of HOT lane projects pose unique challenges in the revenue projection, given the volatility of the typical users of these facilities and the large uncertainty related to how key decision making characteristics will evolve in the future.

Revenue for the SR 167 HOT (Washington State, USA) lanes continues to increase and has exceeded operating costs since April 2011, however the projectõs primary objective remains unchanged: congestion management. HOT lanes continue to help reduce congestion and maintain free-flow traffic conditions in this corridor. Generating revenue is an added benefit. Extra revenue is invested back into the corridor but must first be appropriated by the Legislature. As far as the Virginia Beltway project, the design and build contract alone is US$1.4 billion, while the total cost is around US$1.9 billion.

With regard to funding, several proposed new HOT lanes costing billions are expected to be supported through voluntarily paid tolls. A regional system that uses one existing regular lane in each direction as a HOT lane could support many billions more in investment, including new lanes at bottlenecks, an express bus network, new park-and-ride lot, new bus stations and support for casual carpooling.

Technical barriers. During the four years of operation Washington State Department of Transportation (WSDOT) has partnered with a toll vendor to assist WSDOT in monitoring, maintaining and ensuring optimal performance of the HOT lanes system. The partnership has enabled WSDOT to ensure delivery of a reliable system while at the same time building the internal knowledge of WSDOT engineers and technicians. As well as using the education program to convince road users of the need to play by the rules, it is necessary to monitor how violation detection technology will progress in the next few years. Looking into vehicle occupancy detection and having international discussions could be a valid help; infrared and in-vehicle detection are also being considered.

Organisational complexity. One of the problems long associated with tolling projects that designate certain lanes for certain vehicles is enforcement. It is worth remembering here that no matter how ingenious a HOV or a HOT lanes project is: it is nothing, if it cannot be adequately enforced. Sole occupant drivers using HOV and HOT lanes can damage the efficacy of a scheme. Enforcement is therefore a crucial ingredient in the success of a program. There are always people who try claiming that they are an HOV, sometimes with dummies on the passenger seat, to get the toll discount. The needs for the manual checks that are necessary increase the burden of the enforcement authorities.

Legal issues. Due to the success of the HOT lanes pilot project of Washington the state legislature extended the authority for the pilot project until June 30, 2013. Further action from the legislature is needed in the 2013 session to continue operating the HOT lanes after June 30, 2013.

User and public acceptance. This application is, in spite of the investment costs, attractive to many motorway operators. It is also likely to have a good public acceptance, as HOT lanes are a way to operate highways more efficiently. It may be necessary to properly disseminate the aim and implications of such an initiative, especially when implementing an HOT lane implies the elimination of a conventional motorway lane.

Interest for Travellers

Door to door travel time. On the HOT lanes traffic conditions are maintained free-flow. HOT lanes speed is on average > 45mph. General speeds have increased and travel times have become more reliable. Congestion has also been reduced: daily general purpose volumes went down, daily tolled volumes came up as well as corridor transit volumes did.

Travel cost. Toll rates vary depending on traffic volume. It is completely market driven ï if the market demands that it be higher to get those free-flow conditions, so be it. If the market does not need those lanes on a particular day, then prices will be lower. Average solo drivers fee are between $0.50 and $9. The average toll is about $1.00. This will be partly offset with lower vehicle operating costs in the free-flow conditions.

Comfort and convenience. People who opt to use the HOT lanes save time and minimise the stress associated with their daily commute. When drivers choose to use HOT lanes, it also frees up space and improves speeds in the general purpose lanes. Throughout the four years of the pilot project, HOT lane traffic flowed freely during all hours of the day. The northbound peak-hour (7-8 a.m.) HOT lane travel time has remained consistent at an average of 11 minutes since 2008 and the 95th percentile travel time was 12 minutes. The two nearly equivalent travel time measurements indicate that the HOT lanes are successfully delivering reliable travel times and maintaining traffic speeds, even on some of the most congested days.

Safety. Preliminary data indicates that the average number of collisions is down 2 percent when compared to the five year average prior to HOT lanes opening in 2008. Though multiple factors can affect the safety record, (such as new legislation on use of hands-free cellular devices, more WSG enforcement) HOT lanes, thanks to double white lines preventing erratic lane changes and to a significant reduction in congestion, has impacted positively towards driversôsafety.

Security. No particular impacts apply.

Accessibility for impaired. No particular impacts apply.

Modal change

Thanks to reduced congestion, some increases in car modal share may be expected, but it is reasonable to expect an overall reduction in car usage. Road users may in fact decide to avoid trip or choose different transport mode, besides changing routes or departure time.

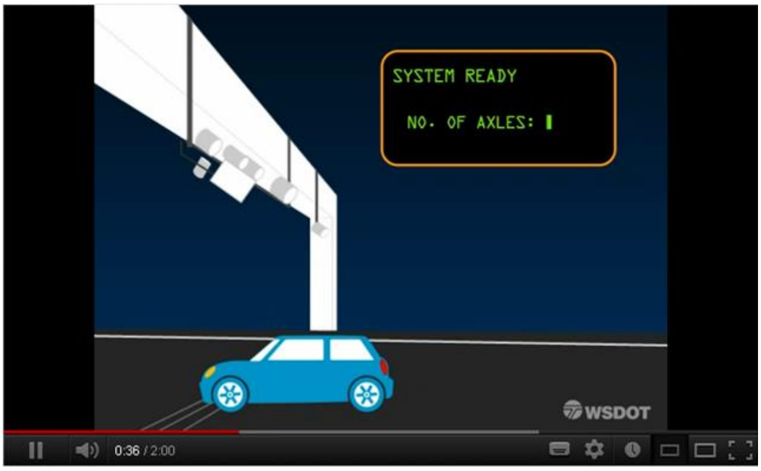
Other notable impacts

Mobility. Where HOT lanes have been newly built, they certainly encouraged more drivers to use the motorway capacity created, and will increase mobility. Where existing lanes have been converted, they will just redistribute traffic.
Congestion and CO2 emissions. The argument here is stemming from the above argument about mobility: new-builds will reduce congestion and emissions, while conversions will not necessarily achieve that.
User pays principle. This is independent of whether the HOT lanes are new-build or conversions: in either case, drivers will pay for getting free-flow conditions.

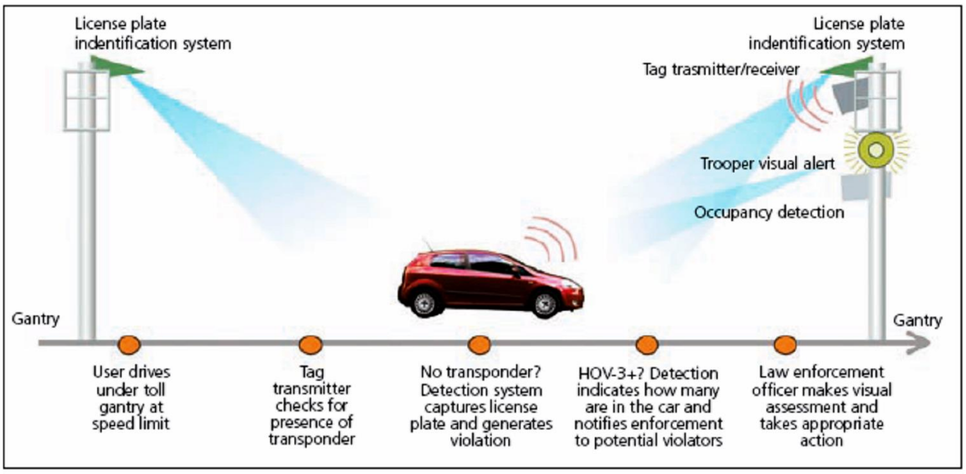
Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	(✓)	Car usage	+	Mobility	(✓)
Operation and maintenance costs	€€	D2D travel costs	(X)	Bus and coach usage	0	Congestion	(✓)
Financial viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	(X)	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	✓
Organisational feasibility	(X)	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	(X)	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials



http://www.youtube.com/watch?v=IX0rFjPuNV4&feature=youtu.be


License plate indentification system
License plate indentification system
Tag trasmitter/receiver
Trooper visual alert
Occupancy detection
Gantry
Gantry
User drives under toll gantry at speed limit
Tag transmitter checks for presence of transponder
No transponder? Detection system captures license plate and generates violation
HOV-3+? Detection indicates how many are in the car and notifies enforcement to potential violators
Law enforcement officer makes visual assessment and takes appropriate action


10.75

1.2.5 Variable congestion charging systems

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: urban (rural, long-distance)

Technology behind: GPS, RFID, DSRC, Cameras

Status: implemented

Links to relevant references

- *Lessons Learned From International Experience in Congestion Pricing. Final Report*, by U.S. Department of Transportation, Federal Highway Administration, 2008
- *Cost-benefit analysis of the Stockholm congestion charging system* by Jonas Eliasson, Transek AB
- *Technological solutions of road charging system*. by Ondrus, J., Dicová, J. University of Zilnia. (2011)
- *Implement variable rate road pricing* by San Francisco Planning and Urban Research Association (2010).
- *Variable Pricing. Mobility investment priorities*, by Texas Transportation Institute
- *Electronic Road Pricing* by Ministry of Transport of Singapore.
- *Lecture on Congestion Charging* by Brian Caulfield (Trinity College Dublin)
- *Cities Bet They Can Curb Traffic With Games of Chance*, by Josie Garthwaite for National Geographic News (15 June 2012)
- NXP and IBM announce results of Dutch road pricing trial
- *Congestion charging*, Transport for London.
- *Area C*, Comune di Milano

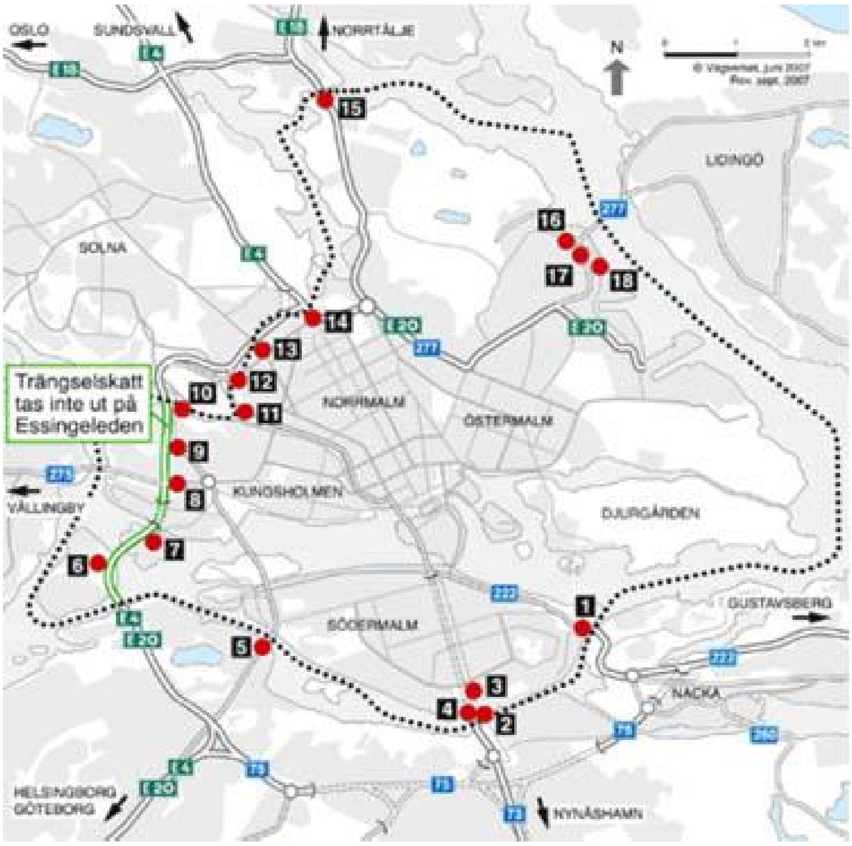
Description

Concept and problems addressed. A congestion charge can be defined as a special fee that is paid by vehicles for using a specific area of the road network in times of heavy traffic. Currently all such systems are confined to urban areas, but the Dutch system (described further below) could be rolled out from Eindhoven to the wider Brabant area and eventually to the whole of The Netherlands.

Electronic road pricing systems provide a targeted solution for combating urban congestion by allowing the authorities to pin-point specific congested areas or roads and vary the congestion charge according to prevailing traffic conditions. Therefore, the charges can either increase or decrease according to the demand of usage of the priced road or area.

By pricing congested stretches, electronic road pricing systems can help to moderate and spread out vehicle usage for optimal usage of the road network by encouraging motorists to consider alternatives. These would include using other routes to arrive at their destinations, travelling during the off-peak periods, switching to public transport or car-pooling.

Dynamic congestion pricing is an approach to control the traffic flow on the network by setting variable tolls that are adjusted with time based on the traffic condition. Different models have been developed in the past.
In the simple Stockholm congestion charging scheme, the amount of tax payable depends on the time of the day a motorist enters the congestion charge area. There is no charge on Saturdays, Sundays, public holidays or the day before public holidays, nor during nights (18:30 ï 06:29), nor during the month of July. The maximum amount of tax per vehicle per day is 60 SEK (ú 6.30). However, the tax amounts are not varied in function of real-time traffic conditions and level of congestion, but just according to a pre-established daily schedule.



Time	(SEK) Amount
06.30-06.59	10 kr
07.00-07.29	15 kr
07.30-08.29	20 kr
08.30-08.59	15 kr
09.00-15.29	10 kr
15.30-15.59	15 kr
16.00-17.29	20 kr
17.30-17.59	15 kr
18.00-18.29	10 kr
18.30-06.29	0 kr

Congestion Tax in Stockholm varies over time according to pre-established fare schedule

Even simpler are the congestion charging schemes in London and Milan, where there is only one flat rate per day for the entire charging period.

Electronic road pricing in Singapore (ERP) has been effective since its introduction in managing traffic congestion and resulted in traffic speeds remaining within the optimal speed range. The ERP system in Singapore makes it possible to vary charges by location, time of day and vehicle type, so that they can be related to the actual level of congestion caused. A method called shoulder pricing is used, which involves increasing the rate in steps every half an hour before the peak and decreasing it after the peak.

In an effort to improve the pricing mechanism, and, to introduce real-time variable pricing, Singapore's LTA together with IBM, ran a pilot from December 2006 to April 2007, with a traffic estimation and prediction tool (TrEPS), which uses historical traffic data and real-time feeds with flow conditions from several sources, in order to predict the levels of congestion up to an hour in advance. By accurately estimating prevailing and emerging traffic conditions, this technology is to allow variable pricing, together with improved overall traffic management, including the provision of information in advance to alert drivers about conditions ahead, and the prices being charged at that moment. The pilot results were successful, showing overall prediction results above 85% of accuracy. Furthermore, when more data was available, during peak hours, average accuracy rose near or above 90% from 10 minutes up to 60 minutes predictions into the future.

Source: Cities Bet They Can Curb Traffic with Games of Chance, National Geographic News (2012)
Singapore's Electronic Road Pricing (ERP) system charges motorists for road use during peak hours

In the late 2000s the Netherlands studied the possibility of implementing a pay-per-use road pricing program which would replace fixed vehicle (ownership and gas) taxes. In 2009 Eindhoven ran the first pricing trial. A meter was placed on the dashboard of cars. It showed the price of the trip: based on GPS technologies, the system tabulated a charge for each car trip by using a mileage-based formula that also took account of a car's fuel efficiency, the time of day and the route taken. At the end of each month, the vehicle's owner received a bill detailing times and costs of road usage. Approximately 70% of users in Eindhoven were found to avoid rush hours and travel off-peak to a higher extent, as the average costs per km of trips decreased by 16%, according to IBM. The data collected within this system, if suitably anonymised, could provide valuable insights into people's travel patterns for transport planning, and possibly even traffic control, purposes.

Equipment for smart road charging trial in Eindhoven

As the results in Stockholm show, the introduction of congestion charging can bring about a substantial modal shift from the car to public transport, in particular when the congestion charging goes hand in hand with improvements in public transport. Furthermore, if the charge distinguishes between fuel and electric cars, the charge will promote the increased use of electric cats in urban areas. Given that the need to achieve such shifts is increasingly recognised not just by planners and politicians but also acknowledged by the wider public, the introduction of congestion charges will be a valuable instrument for the future.

Targeted users. Road authorities and car drivers, in particular drivers of petrol and diesel cars.

Barriers to Implementation

Financial issues. In Stockholm, the implementation cost of the congestion charging system (six months trial) was estimated of SEK 1.8 billion (ú210 million). Operating costs of the Congestion Charging system are approximately 25% of annual revenues (Replogle 2008b), that is some SEK 220 million / year compared to a net income of SEK 763 million / year. In parallel, public transport has recorded a net revenue increase of SEK 184 million / year due to increased ridership, but this required additional investment on the public transport network, estimated on SEK 64 million. If social revenues were incorporated in the profitability analysis (time savings, accidents and emissions prevented), socio-economic profitability of Stockholmõs Congestion Charging scheme is large, around SEK 683 million / year (approximately ú80 million) excluding investment costs according to CBA appraisal performed by the infrastructure operator. Investment costs were estimated to be recovered (in terms of social benefit) in about four years, in view of the initial performance of the system (J.Eliasson, 2006).

In Singapore, the cost for implementation of the cordon based congestion charging system, including in-vehicle technology and installation, was approximately ú120 million. Annual revenue from the program is ú30 million, which compares with the ú9 million annual operation costs. Although the investment costs of ERP equipment are high, the cost-benefit ratio to the government is often positive ï obviously depending on the level of user fees (Pike, 2010). A study for the Singaporeõs ERP considered by the Jakarta government indicates a 4 years payback time (Dalkmann, 2010).

The operational costs for the AREA C system in Milan, the latest of the congestion charging systems are related to the IT-based system for access control and vehicle recognition and for the implementation and managing of the software for dealing with authorisations and various diversified methods of payment. The forecast for total annual costs for the first year of implementation (2012) was of ú 6,5 million to 31st December 2012. Revenues were expected to be about ú 23.5 million 31st December 2012.

Technical barriers. The overall functioning of electronic road pricing systems in cities such as Stockholm or Singapore is relatively accurate. However, some technical problems persist in the technology used to automatically identify licence plates of vehicles. Motorbikes are difficult to detect, so in most cases they are exempted from the congestion charge. In Stockholm, Finish and Lithuanian car plates are in some cases confused with Swedish plates (as formats are relatively similar, three digits and three letters), causing the system to erroneously bill wrong vehicles. Also stolen and forged plates have caused false payment demands on innocent people.

Organisational complexity. The main complexity lies in the collection of the charges. The simplest form is the sale of licences via the internet, but not everyone uses that and for those people who do not, phone lines and a network of physical sales points, for instance in shops, need to be established. Where charges are made with smart cards, a distribution network for those needs to be implemented. Where charges are fully dynamic, as in the Eindhoven system, the a network for the installation of on-board units is needed, and the question is then whether visiting cars are simply not allowed entry in the charged area or whether alternative solutions need to be found for them.

Legal issues. Legal issues should not be a major problem for this application. However, privacy issues need to be properly addressed.

User and public acceptance. In the past the introduction of road user charging systems was in several cases prevented by objection of the wider public and in particular those who would have been charged in the future, like in Edinburgh, where a referendum for the introduction of a cordon charging system failed. But as the example of Stockholm shows, public acceptance increases when the system is in place and people can see the benefits arising from a reduction in traffic volumes and congestion. It seems furthermore likely that acceptance increases when the congestion charge is at least partially compensated for by the scrapping of car taxes for local cars.

Interest for Travellers

Door to door travel time. Congestion charging schemes help to moderate and spread out vehicle usage for optimal usage of the road network. Although these systems are not popular, once implemented, acceptance among citizens grows as benefits in terms of alleviated congestion and decreased travel times become apparent. In Stockholm, queue times in the access roads to the city were estimated to have dropped around 30% after initial application of the system, the biggest decline happening during the PM peak period. There was an increase in travel time reliability as well. Under non-congested conditions, the system does not provide any direct benefits.

Travel cost. Travel cost is increased due to the charge. In Stockholm, trips are charged between SEK10 and SEK20 (ú1.0 and ú2.0 approximately), with a maximum daily charge of SEK60 (ú7.0). In London, the standard charge is £ 10 per day (ú12.5) and in Milan ú 5 per day. In Singapore, charges vary from ú0.0 to approximately ú3.0 per trip.

Comfort and convenience. No particular impact.

Safety. The Stockholm system suggested that traffic safety tended to increase.

Security. No particular impact expected.

Accessibility for impaired. No particular impact expected.

Modal change

A desired impact of introducing a congestion charge is that those individuals who previously drove would change to a more sustainable mode of transport. In Stockholm public transportation use increased by 6% to 9%, though this increase could not all be attributed to congestion charges. It appears that less than 50% of car users who gave up trips during the charge period shifted to public transport. Some changed time of departure. No significant increase was observed in cycling, carpooling or telecommuting.

Other notable impacts

Traffic level. In Stockholm, overall traffic to and from the inner city declined by 10% to 15%, with declines ranging from 9% to 26% in different sectors. Traffic dropped further out in the county as well. There was a 14% reduction in vehicle miles travelled in the charged zone and 1% reduction in VMT outside the zone. Part of this traffic moved onto the public transport system (increased ridership of 6% to 9%), other changed travel schedules. Traffic also declined in the evening after the charge period ended. There was no significant increase on bypass routes. After the six-month trial period, traffic volumes increased to about the same volume as before the trial began. Recent data shows that the permanent charging program, reintroduced in August 2007, appears to have reduced traffic by 18%.

Congestion and Green House Gas emissions. Variable tolling reduces congestion and provides opportunities for GHG emission reductions through mode shift, reduced travel frequency, better fuel efficiency due to congestion relief and the increase in the share of electric cars. Mode shift moves passengers from less efficient single-occupancy fuel powered vehicles to more efficient ỹgreenò cars, public transport, cycling, or walking. In Stockholm, a 14% reduction of CO_2 in the city centre, and a 2.5% reduction in the Stockholm County was measured along with a 7% reduction in NOx and 9% reduction in particulates. The proportion of exempted ῆgreenὸ cars has risen to 9%.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	- -	Mobility	X
Operation and maintenance costs	€€	D2D travel cost	X	Bus and coach usage	++	Congestion	✓
Financial viability	✓✓	Comfort and convenience	0	Rail usage	++	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	✓
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic Progress	0
Administrative burden	X	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	(X)						
Public acceptance	(X)						

Illustrative materials

Stockholm congestion charge

http://www.youtube.com/watch?v=cvIv2PXzLRc

London Congestion Charges

http://www.youtube.com/watch?v=8p6kZdQ0Q7w&feature=related

Singapore's Way To Improve Road Conditions - Electronic Road Pricing

http://www.youtube.com/watch?v=fyJiKUyZp2M&feature=related

Eindhoven pay as you drive trial (dutch only)

http://www.youtube.com/watch?v=XAuYU4E4NEs

1.2.6 Adaptive routeing applications based on real time congestion monitoring

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: Metropolitan, Urban

Technology behind: positioning and location referencing, RSU units, in-car communication units

Status: Pilot

Links to relevant references

- Cooperative Systems for Intelligent Road Safety
- Cooperative Vehicle - Infrastructure Systems (CVIS)
- SAFESPOT Integrated Project

Description

Concept and problems addressed. Public authorities define strategies in order to regulate traffic in case of serious disruption (such as recurrent traffic congestion, long-term road works or special events), and the urban Strategic Routeing Application provides enhanced routeing functionalities that take into account these pre-defined strategies. The new aspect of this application compared to existing approaches is that route suggestions take into consideration not only real-time traffic information but also network and give individualised routeing suggestions to each vehicle.

Currently personalised routes are computed on the basis of a (static) map of the network and available traffic information (e.g. traffic management centre, statistical traffic loads on road sections etc.), but are not harmonised with network management strategies. In the now widespread satellite navigation systems, information related to traffic (concerning motorways and main highways) and road conditions (such as queues, accidents, fog and similar events) is continuously broadcast through a digital channel (TMC, Traffic Message Channel). This information can be integrated with GPS navigation devices able to both capture the broadcast information and convey it in a visual or acoustic manner. Once a route to the destination has been established, the GPS navigation device can integrate TMC information and check whether some critical roads are included in the route. If this is the case, a warning can be delivered to the driver and the GPS device can suggest a new route avoiding the critical area. In any case the decision about the route to take is taken by the in-car satnav system.

With V2I systems, the network manager has the opportunity to take over the decisions on routeing recommendations instead of leaving it to the in-car satnav. The centralised system is aware of the state of the network and is able to make decisions for any one car with a view to optimising the traffic loads in all links of the network. A variation is the micro-routeing application that provides urban routeing advice for drivers (freight and private drivers) taking into consideration factors such as pollution levels, weather forecast, events or local congestion. The application is ñmicroò since travel information is given for a short time horizon of 1-5 minutes and only for the direct vicinity of an event.

Targeted users. Network managers.

Barriers to implementation

Financial issues. There are many actors involved in the deployment of cooperative systems. For a business model to be created, each stakeholder must see a business opportunity in the deployment of cooperative systems: this makes the business models complicated, to say the least, as different stakeholders have different perspectives. To take into account the different stakeholdersô perspectives, and to ensure a business model for all, applications could be introduced in bundles, and the bundle services should be developed according to different standpoints: the government perspective to support transport policy goals; the road usersô perspectives to increase comfort, risk reduction, efficiency and safety; the freight operatorsô perspective to build an effective logistics systems. The costs for an adaptive routeing application are made up of the costs of equipping the infrastructure and running services and can be split into the following elements: the on-board unit costs, RSU costs, the control centre costs (maintenance costs are also split along these three lines), the communication costs and the costs for providing services. The purchase and installation costs consist of: physical infrastructure costs determined on the basis of the generic equipment that is required (this is dependent on the application under question); installation costs for both the installation of roadside and in-station equipment. Operating costs consist of: staffing, taking into account how many operators and managers may be required; accommodation, taking account of office space; operators, managers and the in-station equipment; general day-to-day maintenance costs and equipment renewal costs (which are generally different for roadside and in-station environments); communication costs; other operational factors, such as the cost of using the services of various public or other communications service providers. However, at least in all cases where any introduction of the system would be considered in the foreseeable future, much of the control room and the related infrastructure would be in place already. Benefits of the application include fewer stops and less time delay at intersections for the vehicles and less travel time from origin to destination. These benefits are at first individual but also improve the network performance as a result of better balancing of traffic and providing the social benefit for the network operator.

Technical barriers. There should not be any insurmountable technical barriers to the implementation of the application.

Organisational complexity. Since every part of the system must be automated to allow any network optimisation, the administrative burden is low. However, where a system covers parts of the network run by different operators, complex preparation of the system parameters at the system development stage will be needed to satisfy the expectations of every operator involved.

Legal issues. Since no driver is forced to follow the routeing recommendations and retains the full control of the car, the legal status of the recommendation should not be much different from those given today by VMS signs or those given by satnav systems.

User and public acceptance. This application is likely to have high user and public acceptance, given that it addresses congestion, although some drivers may be weary that they may being sent on a socially optimal route and not the one best for them.

Interest for Travellers

Door to door travel time. This application implies an overall reduction of travel time due to the dynamic re-routeing of users on uncongested paths, even if not every driver may benefit for every single trip.

Travel cost. Reduced travel cost resulting from minimisation of delays leading to a decrease in fuel consumption and vehicle operating costs.

Comfort and convenience. An improvement of comfort and convenience results from having route advice synchronised with real time traffic conditions.

Safety. No impact expected.

Security. No impact expected.
Accessibility for impaired. No improvement is expected.

Modal change

No major modal change is expected, although some drivers may feel reassured by the system and therefore more prone to travelling by car.

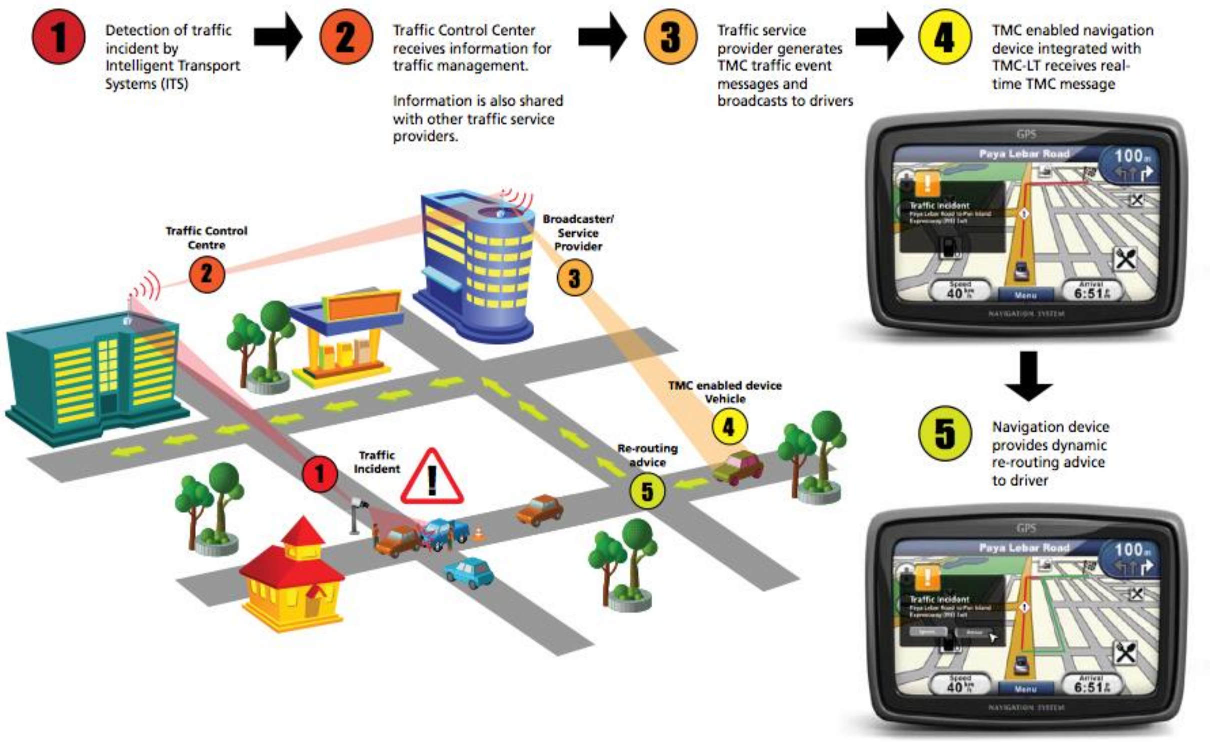
Other notable impacts

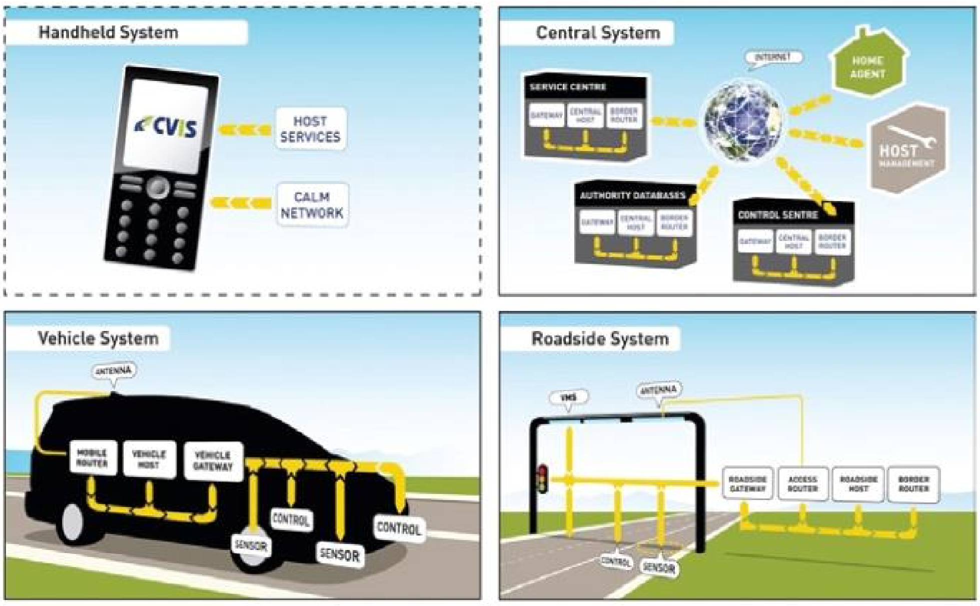
Congestion and CO2 emissions. The optimisation of traffic flows in the network is designed to reduce congestion and thereby also reduce CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	✓	Bus and coach usage	0	Congestion	✓
Financial viability	(X)	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials





1.2.7 Congestion monitoring based on probe vehicles and smart phones

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: long distance, metropolitan, urban

Technology behind: GPS devices, GSM, mobile phones, Bluetooth sensors

Status: Implemented

Links to relevant references

- S.M. Turner, W.L. Eisele, R.J. Benz, and D.J. Holdener. Travel time data collection handbook Manual FHWA-PL-98-035, U.S. Department of Transportation, Federal Highway Administration, March 1998.
- S. Turksma. The various uses of floating car data. In 10th Int. Conf on Road Transport Information and Control, pages 51ï 55, London, UK, April 2000.
- R. Bishop. Intelligent Vehicle Technology And Trends. Artech House Its Library, 2005.
- Google Maps
- The Connectivist on ñHow Google Tracks Trafficò

Description

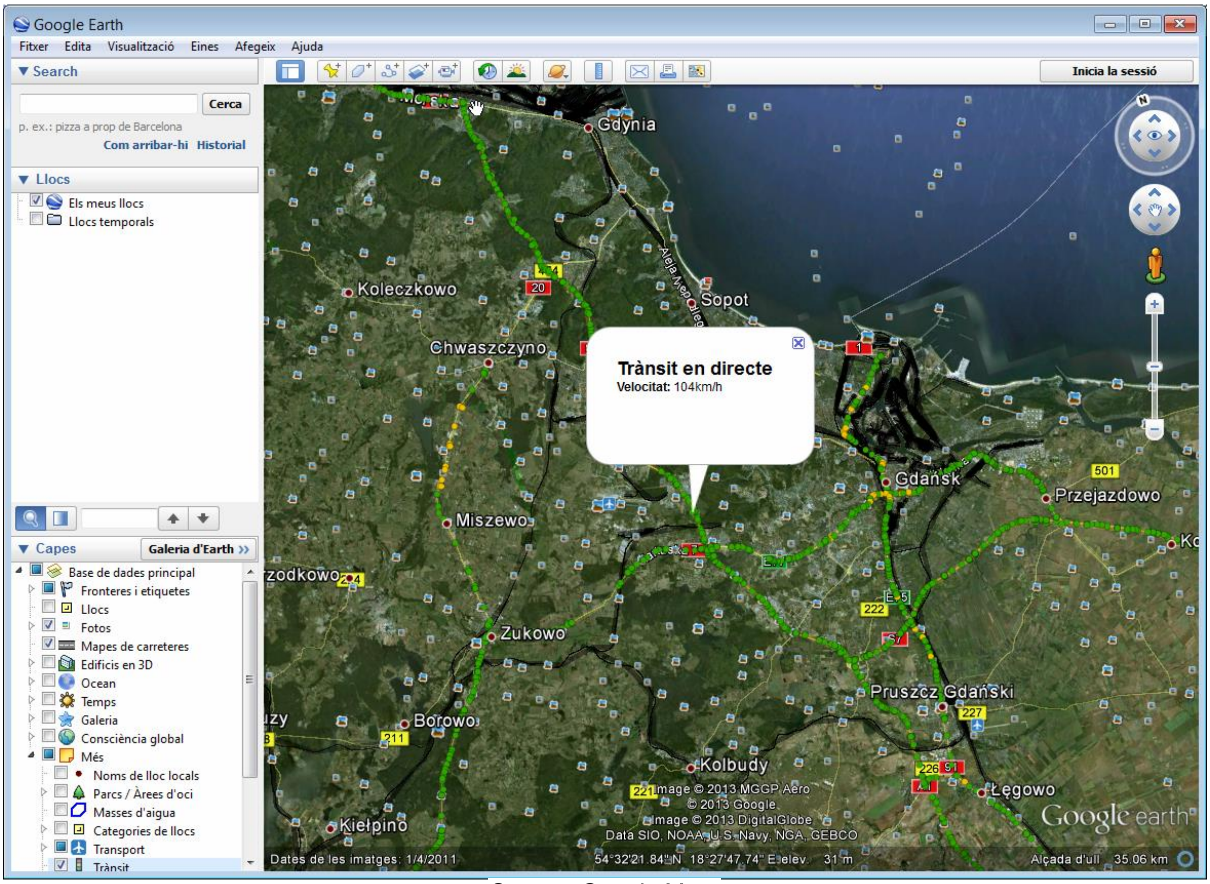
Concept and problems addressed. Due to the increased traffic congestion in heavily populated areas, there is a high demand for improvements in the efficiency of transportation systems. Acquisition of road traffic data is a crucial and necessary activity for a traffic management information system.

Probe vehicle data, or more technically termed Floating Car Data (FCD), can, once the fleet of equipped vehicles is large enough, provide continuous, more detailed and more widespread information on the status of traffic at any one moment than is possible with loop detectors or cameras, which only give information on the traffic volumes and speeds at specific points in the network. Probe vehicles cannot replace traditional data, because they only allow an assessment of the travel speed, but not whether any slow speed is due to an incident or due to high traffic volumes, and the knowledge of traffic volumes is still a base indicator for any traffic management system, but they considerably augment the overall data quality available and at the same time make it possible to use fewer sensors in the road or on the roadside.

The technological progress in positioning and communication systems (GPS and GSM or GPRS), made the extension of the method to fleets of appropriately equipped vehicles acting as moving sensors for the road network possible. They provide basic data to a traffic control centre where it is analysed and merged with other data to identify traffic congestion, calculate travel times and generate reports on traffic (Turksma, 2000). Prime candidates for probe vehicles in urban areas are taxis, which not only spend much more of their time actually moving around in the traffic than any private car, but may also be already appropriately equipped for their own fleet management purposes. In principal it is also possible to use buses and delivery vehicles, but especially buses only move in a defined part of the road network, so the data from them will be more limited in network coverage.

An alternative is the use of GSM based mobile phone data, as already demonstrated in a number of projects. Mobile phone operators know how not just a few probe cars, but millions of phones move through the network, and this knowledge can be tapped into, although it is much less accurate than GPS data and more difficult to interpret than GPS data, e.g. from taxis, for instance to distinguish whether the data from a slowly moving phone comes from a cyclist or a car driver stuck in congestion, or from a train or a parallel motorway.

However, since 2013 Google Maps has started to offer real-time views of congestion on the road network obtained through users owning Androind smart phones. The system is based on the fact that people can opt in sharing their travel data under their phonesôsettings (allow mobile phone localisation), providing in practice a large number of probe vehicles circulating on the road network. Colors on the map are determined based on the average speed of vehicles in the network. In fact, live speed can be consulted not in Google Maps, but yes on Google Earth. Real time speed records are then used to address user queries on shortest time travel intineraries along the network.



Source: Google Maps

Google Maps displaying life traffic conditions based on smart phone monitoring.

The integration of data coming from the different vehicles supports the creation of updated traffic status maps, and the realisation of high quality services for the users, for example to determine an alternative route in case of traffic congestion on the planned one. The enhanced FCD is now considered as a central element in extending the information horizon for improved telematics services and it is recognised as a reliable methodology to update traffic related maps, as witnessed by many research projects in this field (refer to Bishop (2005) for a list of activities until 2004).

The possible applications are endless. The information collected from the floating cars can be used in the traffic control centre to provide traffic status information or give routeing recommendations on Variable Message Signs, as a basis to switch on Variable Speed Limits or, in urban areas, be fed into the UTC system. It can be presented over radio with RDS-TMS or the internet directly to drivers to help plan the best route of travel.

Targeted users. Traffic control and management operators, traffic information service providers

Barriers to implementation

Financial issues. FCD is a more cost-effective method of data collection, along with a more consistent level of accuracy, when compared to traditional measurement techniques. As an order of magnitude, the U.S. public authorities are spending more than $1 billion each year to monitor traffic to cover only 1% of the national road network (it usually costs around $100.000/mile in roadside sensors). As mentioned before, FCD cannot replace all of this equipment, since FCD cannot provide the basis knowledge on traffic volumes required, but FCD can help strongly reduce the need for the density of roadside equipment and provide better information at a much lower cost.

Technical barriers. The main technical barrier in developing an efficient probe based monitoring system is the sample size. Sample size requirements associated with probe vehicle applications are inherently different than sample size requirements for test vehicle or license plate matching techniques. In typical travel time studies, the sample sizes are established by the test conductors prior to data collection. Typically, these sample sizes are established based on desired levels of accuracy associated with the purpose of the travel time study and on budgetary constraints. Since probe vehicle systems are designed to collect data for real-time traffic monitoring the sample sizes are determined by availability of instrumented probe vehicles in the traffic stream.

The problems of sample sizes are overcome with the use of mobile phone data, but the interpretation of this data is technically much more demanding.

Organisational complexity. The organisational complexity and administrative burden are low.

Legal issues. The collection, manipulation, storage and transmission of personal data are subject to European and national rules which secure the anonymity of data, and an international standard is being developed (ISO/TC204/WG16) to establish "basic principles for personal data protection in probe vehicle information services".

User and public acceptance. The actual users, i.e. information providers and traffic management operators generally welcome this cheap source of information very much. The latest scandal of secret services tapping into email messages may renew public concerns about the use of mobile phone data, but in general, the public is now very used to that fact their data is traced for all sorts of purposes, be it their mobile phone for roaming, their latest internet searches used by other website for advertising, or in googlemail even the contents of their emails being scanned to present them with related advertisements. So, overall, public acceptance is expected to be relatively high for this application.

Interest for Travellers

Door to door travel time. The collection of FCD data as such does not achieve anything in itself, it all depends on how this information is used. But it is an enabling technology that allows control and information systems to tackle congestion better and to information driver on traffic conditions, which will help reduce the door to door travel time.

Travel cost. Less congestion and better information on optimal routes reduces fuel consumption and vehicle operating costs.

Comfort and convenience. Less congestion means more comfortable travel, but this is already being accounted for under other criteria, and there are no further impacts to be expected.

Safety. No impact expected.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal change

No significant impact expected.

Other notable impacts

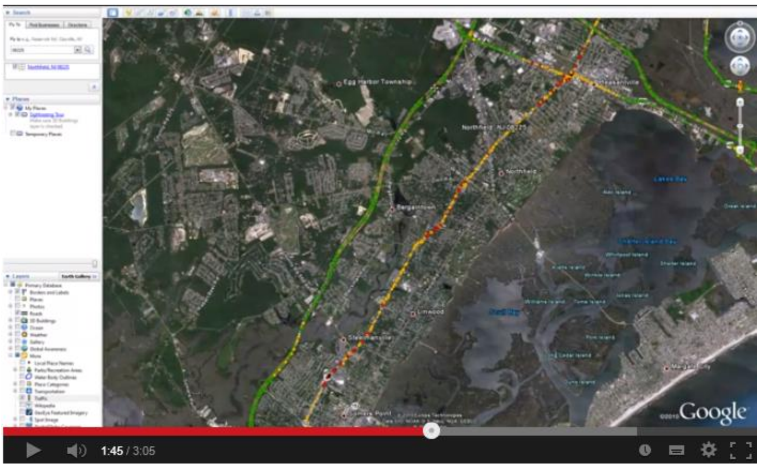
Congestion and CO2 reduction. The better monitoring of the state of traffic in the network allows the operator to diagnose congestion faster and to tackle it better, and thereby also reduce CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	0	Congestion	✓
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Checking live traffic conditions with Google Maps



http://www.youtube.com/watch?v=D5LgAc119t8

Snapshot of the results of the traffic monitoring system developed by Octo Telematics through GPS based vehicle localisation

1.2.8 Travel data collection based on twitter

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: urban, interurban

Technology behind: mobile phone

Status: implemented

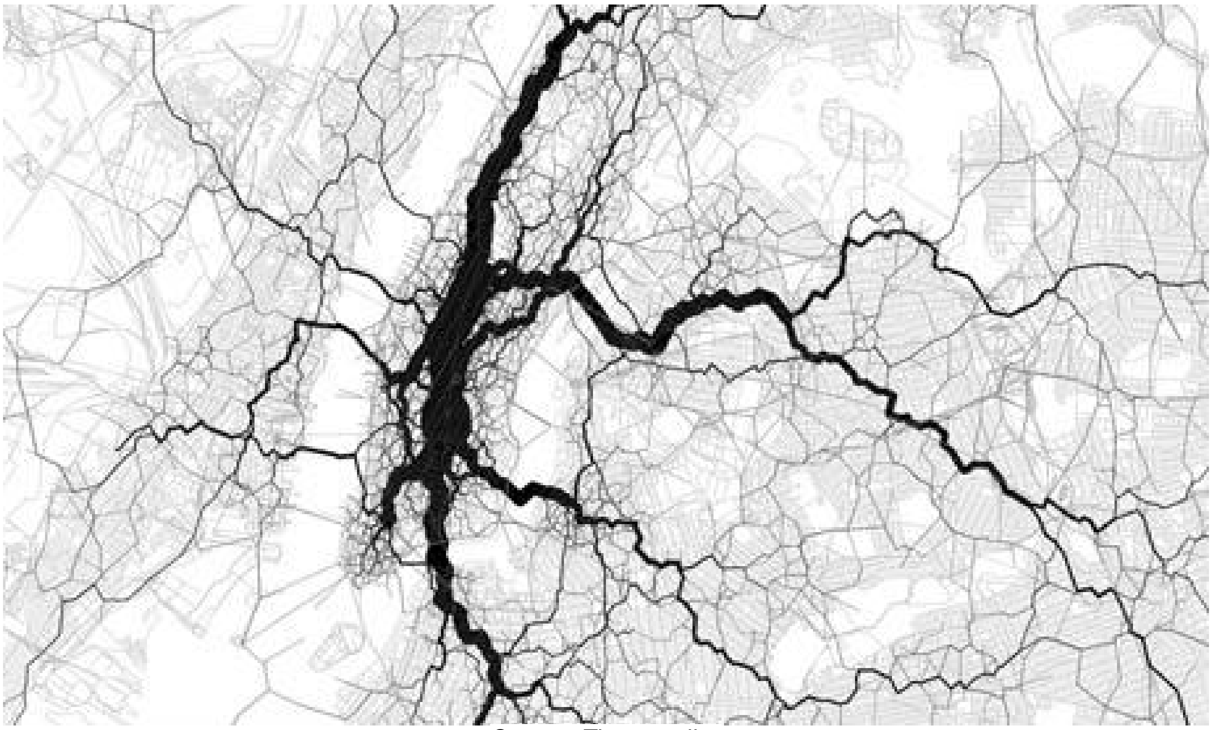
Links to relevant references

- The Guardian
- IEE SPECTRUM

Description

Concept and problems addressed. Geolocated tweets have been used to find the most frequently travelled routes in selected US and European cities (Eric Fischer, 2011). This sort of data could be used to optimise transport systems. If the volume of geo-tagged tweets is used as a proxy for traffic levels, transport planners could use this data to fine-tune existing transport networks and establish where new routes are needed. Furthermore, by comparing the data with known traffic volumes, the information could also give an indication to traffic control operators of traffic levels on routes not equipped with traffic detectors.

Fischer took millions of geolocated tweets from across the world, cross-referenced them with data on known transport nodes, and used the results to plot the most heavily used routes in cities, countries and continents. He then created what are in effect transit cartograms, with the thickness of a road or other mass transport line corresponding to the volume of tweets sent along its path.



Source: The guardian

Using data from Twitter E. Fischer created the above map of New York City's transport network.

Targeted users. Transport planners and traffic control operators.

Barriers to Implementation

Financial issues. This solution has only small investment costs associated.

Technical barriers. There are no technical barriers.

Organisational complexity. None.

Legal issues. None.

Interest for Travellers

Door to door travel time. No direct impact.

Travel cost. No direct impact.

Comfort and convenience. No direct impact.

Safety. No direct impact.

Security. No impact.

Accessibility for impaired. No impact.

Modal change

No direct impacts expected.

Other notable impacts

No particular impacts expected.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical Feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal Feasibility	0						
User acceptance	0						
Public acceptance	0						

1.2.9 Average speed checks for speed limit enforcement

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: Long-distance, rural, metropolitan

Technology behind: ANPR

Status: Implemented

Links to relevant references

- SAFETY TUTOR application

Description

Concept and problems addressed. The main cause of road accidents is the high speed of vehicles on highways. In order to reduce the road accident rate Italian Motorways infrastructure manager developed Tutor, that is a speed detector system, based on a check "on road section" rather than a check "on time". Tutor is the first system that can detect the average speed of vehicles on highway routes of variable length, ranging from 10 to 25 km. The routes are restricted by two installations connected to sensors placed beneath the pavement, that trigger the cameras installed on the structure when detecting the passage of a vehicle. Cameras record images of vehicle, the date and the time of passage. If the average speed of a vehicle exceeds the maximum permitted, the system looks for the owner of the vehicle, and traffic police sends him a notification report. The project had been co-funded by EC DG MOVE in the framework of the EasyWay project.

Since the first installations in Italy, many more have been implemented in other parts of Europe, for instance on Dutch motorways and on a 50 km section of the A77 in Scotland. Furthermore, in the UK they are now widely used on motorways when a reduced speed limit is in force during building works.

Targeted users. Traffic police.

Barriers to implementation

Financial issues. The installation costs for the ANPR system and the related communication system are not insignificant, and neither are the costs for continuous manual checking of the ANPR readings, but the fines then imposed on non-compliant drivers are generally larger than the cost of the installation and the running costs.

Technical barriers. There are no technical barriers, although there are limitations to application. Motorcycle number plates are not normally readable, and car number plates may be difficult to read in very dense traffic and in poor weather conditions.

Organisational complexity. There is no organisational complexity.

Legal issues. No legal barriers are relevant.

User and public acceptance. Despite proven benefits for user safety on motorways and trunk roads, in general such solutions do not have high user nor public acceptance.

Interest for Travellers

Door to door travel time. While the reduction of accidents due to lower average speed may reduce actual travel time, on the other side for those who would otherwise exceed the speed limit, travel time increases.

Travel cost. Lower consumptions and operating costs may be arise from the average speed reduction.

Comfort and convenience. No impact expected.

Safety. The improvement in safety management is the most important result of the application. The results on SAFETY TUTOR covered network confirmed the forecasts about the project and the estimated reduction of the death rate: after its introduction on the first 460 km, the SAFETY TUTOR has cut down the accidents rate of 20% and the death rate of 50%.

Security. No improvement expected.

Accessibility for impaired. No particular impact is expected.

Modal change

No particular impact is expected.

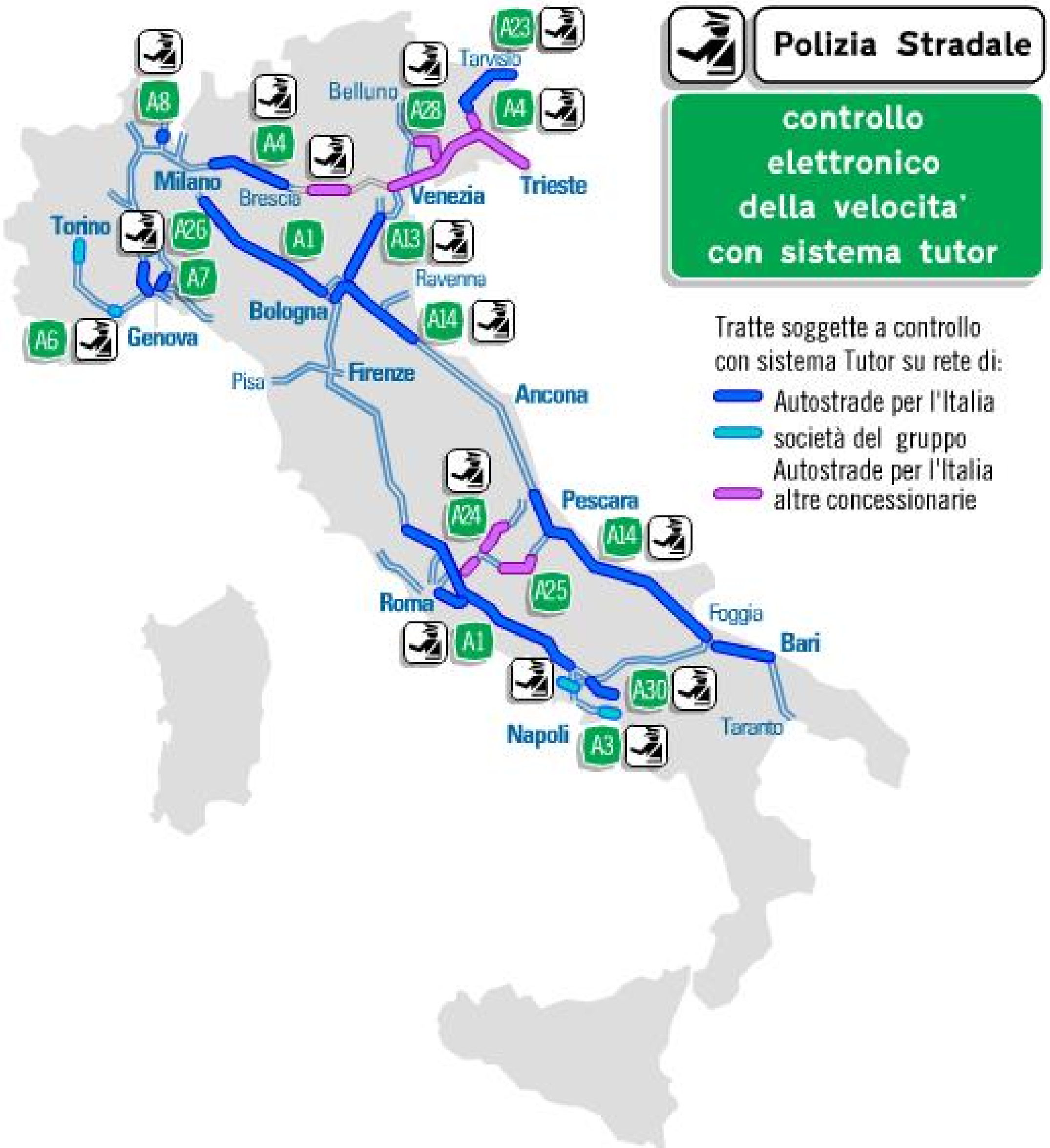
Other notable impacts

Investigation with the SAFETY TUTOR found a significant reduction of CO_2 emissions, resulting from both the fact that the average speed is reduced and a more uniform driving style.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	✓	Bus and coach usage	0	Congestion	(✓)
Financial viability	✓✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	X	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	X						
Public acceptance	X						

Illustrative materials



Source: SAFETY TUTOR application

1.2.10 Reduce speed for fun: speed camera lottery

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: urban, rural, long-distance

Technology behind: camera

Status: pilot

Links to relevant references

- The Speed Camera Lottery The fun theory - An initiative of Volkswagen
- Speed reduction measures - carrot or stick? ITS International
- Sweden Tests Speed Camera Lottery Daily Crowdsource
- Aggressive Driving: What Is It and What Can Be Done David L. Wiesenthal, Michèle Lustman, & James Roseborough, York University
- Changing Behavior with Positive Reinforcement: Speed Camera, Lottery and Beyond Gamification
- Speed Camera Lottery Wins VW Fun Theory Contest (NY Times, 30th November 2010)

Description

Concept and problems addressed. Is it possible to make people obey rules by making it fun to do so?
To compel drivers to obey posted speed limits, Kevin Richardson has provided a solution based on the belief that if motorists are given positive incentives to check their speed, they will not only do so, but will have fun doing it.

Kevin Richardson won a contest devised by the Swedish advertising firm DDB Stockholm for Volkswagen Sweden, whereby an open invitation was extended to submit ideas that made seemingly baleful social challenges ð environmental protection, speed-limit adherence, boosting public transportation ridership ð enjoyable.

The idea so appealed to the Swedish National Society for Road Safety in Stockholm & Volkswagen that they tested out the theory by placing strategic cameras which took snapshots of vehicles driving through them. Leveraging traffic camera and speed capture technologies, the Speed Camera Lottery device would photograph all drivers passing beneath it. Part of the subsequent fines levied against speeders would be pooled in a lottery, with a random winner periodically drawn from the group of speed limit adherents.

In the Stockholm demonstration (concluded in November 2010), installed speed cameras showed drivers their speed. It took snapshots of 24,857 cars in three days. The average speed which was 32 km/h before the test reduced to 25 km/h during the test, marking a 22% reduction in speed, thereby making the demonstration a success.

Targeted users. Road authorities.

Barriers to implementation

Financial issues. Relatively high cost for the additional system to provide driver rewards, according to authorities.

Technical barriers. Only those associated with automatic car plate recognition, which could cause to the system to erroneously award wrong vehicles.

Organisational complexity. No relevant organisational issues appear.

Legal issues. No relevant legal barriers appear.

User and public acceptance. A survey carried out suggested that drivers found the idea very appealing. Drive legally = Earn Money. Acceptance by road authorities is so far low.

Interest for Travellers

Door to door travel time. Lower speeds mean longer travel time, although is some cases the lower speeds may lead to a more harmonious traffic flow which can reduce the risk of traffic breakdown and congestion.

Travel cost. No significant impact.

Comfort and convenience. No significant impact.

Safety. An improvement in safety is expected from better enforcing speed limits.

Security. No particular impact.

Accessibility for impaired. No particular impact.

Modal change

No particular impact is expected

Other notable impacts

Congestion and CO2 emissions. Where the lower speeds prevent a traffic breakdown, this will reduce congestion and CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	(X)	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	(✓)	Bus and coach usage	0	Congestion	(✓)
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	0						
Public acceptance	✓						

Illustrative materials

The Speed Camera Lottery - The Fun Theory

http://www.youtube.com/watch?v=iynzHWwJXaA

1.2.11 Automatic incident detection with CCTV images

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: long-distance, metropolitan, urban

Technology behind: Camera recognition, GPS devices, Bluetooth devices, cellular phones, RFID sensors, induction loops

Status: Implemented

Links to relevant references

- Automatic Accident Detection: Assistance Through Communication Technologies and Vehicles article by Garrido, P. ; Martinez, F.J. ; Cano, J. ; Calafate, C.T. ; Manzoni, P. at Vehicular Technology Magazine, IEEE, Sept. 2012
- Transportation Research Board The Conceptual Framework of Detection System for Emergency Situations Associated with SMART Highway, 17th ITS World Congress
- JourneyLog

Description

Concept and problems addressed. Systems for Automatic Incident Detection (AID) are aimed at assisting infrastructure managers in identifying problem areas in their network and increasing safety levels for car drivers. The first generation of AID system was based on data on traffic volumes, occupancy and speeds from deductive loops. For motorway and trunk road applications there has been an array of algorithm developed over the last forty years or so, which all rely on loops based at regular intervals on the motorway, ideally every 500m. For urban applications, UTC systems may include loop based AID, most notably SCOOT, which incorporates the AID algorithm INGRID. A major draw-back of these systems is the need for the relatively dense coverage with loop detectors which is expensive to install and which are frequently fail for a number of reasons making their maintenance also very expensive. Another drawback is that, in particular at times of low traffic volumes, shockwaves from the incident will take a long time to reach the detectors, if they reach them at all. Furthermore, the false alarm rates are very high and frequently trigger traffic control responses that are unnecessary.

Many newer systems therefore use images from Closed Circuit TeleVision (CCTV) to detect events such as stationary vehicles, vehicles driving the wrong way or presence of pedestrians are automatically detected through digital processing of video streams. An Automatic Incident Detection System is capable to detect incidents happening around the coverage area and help to prevent follow-on accidents. The Automatic Incident Detection system relies on video image processing to calculate the average speed, count, occupancy etc of each lane of travel. Again, various camera based AID systems are now available on the market. Intelligent image processing enables the detectors to automatically alert operators about incidents and traffic slowdowns and may enable prompt rescue of crash victims. The data from these detectors can also form the basis for the development of a congestion map which relates flow speed and occupancy over a specific road link or network.

Targeted users. Traffic control and management operators.

Barriers to implementation

Financial issues. There are a number of systems available and the costs vary between them. The TrafiBOT is the most advanced system of Traficon, one of the most established providers, now part of FLIR ITS. The TrafiBOT is a high-end camera with built-in detection software and advanced IP video streaming, which reduces overall system complexity and wiring requirements. It is available, including lens, housing, PSU and mounting bracket for ú 4,200 and a license for the related FLUX software at ú 3,000. The operation and maintenance costs are equally very low, while the social benefit is very high. In another system installed in San Antonio Texas, it was estimated that the incident response times were reduced by 20 percent, the average delay savings reached up to 700 vehicle-hours per incident, and the fuel consumption decreased by up to 12,000 litres per incident. A study by Chowdury (2007) examined the effectiveness of traffic cameras at five metropolitan freeway sites in South Carolina using the traffic simulation software PARAMICS to simulate various incident scenarios and traffic camera operations through application programming interfaces. The authors used these interfaces to produce random spatial and temporal occurrence of incidents, including the incident start times, durations and locations. A benefit-cost analysis based on the simulation results suggested traffic cameras returned $12 for every dollar spent under the prevailing conditions at the study sites. Moreover, even if a system is installed by a private motorway operator, for whom the social benefits do not count, there are significant savings to be made in operational costs compared to a traditional AID system with its high false alarm rates and hence the need for constant human supervision in the control centre.

Technical barriers. There are no technical barriers.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no legal obstacles.

User and public acceptance. There is high acceptance of the system by the motorway operator because the camera based system improves system performance. The travelling public may be aware of the CCTV cameras, even without knowing their precise function, and will know that the traffic monitoring they imply increases the level of information they receive and the safety during their trip.

Interest for Travellers

Door to door travel time. Implementation of these applications allow for a reduction in travel times since the overall system can provides information on the incident localisation and enable the most appropriate incident response.

Travel cost. There is no direct impact on travel costs.

Comfort and convenience. Reduction of travel time through alternative routes or rapid emergency management can lead to an increased travelling comfort because road users spend less time in congestion.

Safety. The largest benefits are in this domain, and they can be high. The expected benefits involve mainly the safety: between 20% to 50% of highway accidents, in fact, are secondary accidents, i.e. they are caused by other accidents; in addition, over 50% of secondary accidents occur within the first 10 minutes into the incident primary (Busch, 1991). Prompt and reliable recognition of accidents can improve the effectiveness of the controls in several ways, among them the emergency rescue services, with the possibility of reducing the consequences of accidents and the implementation of a rapid removal of barriers to the movement, with a consequent reduction in the duration of congestion and hence the risk of secondary accidents.

Security. No direct impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

There are no changes expected.

Other notable impacts

Congestion and CO2 emissions. The AID system reduces congestion and thereby contribute to decreased fuel consumption and carbon emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	✓
Financial viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Source: *Verizon*

Verizon Networkfleet Demo

1.2.12 Vehicle miles travelled pricing

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: long-distance

Technology behind: GPS; GSM

Status: Implemented (freight), Pilot (passengers)

Links to relevant references

- Road pricing in Europe
- Automatic log-on with the On-Board Unit Toll Collect Service on the Road
- Economic Instruments in Environmental Policy: Air Quality School of Geography, Planning and Environmental Policy, University College Dublin
- Issues and Options for Increasing the Use of Tolling and Pricing to Finance Transportation Improvements AECOM Consult Team, International Urban Road Pricing, US Department of Transportation Federal Highway Administration (2006)
- The New Dutch Per-kilometre Driving Tax Bert van Wee (2010)
- In Auto Test in Europe, Meter Ticks Off Miles, and Fee to Driver Elisabeth Rosenthal, The New York Times (10-08-2011)

Description

Concept and problems addressed. Tolls, also known as distance-based charges, are charged for a vehicle travelling a given distance on the infrastructure, with the amount based on the distance travelled and type of vehicle.

In Europe distance based tolls are mainly applied to HGV and there are two main subcategories of tolls:

- **Nation-wide electronic tolling**: for which an On-Board Unit (OBU) is used for automatic payment.
- **Tolls with physical barriers**: ‟conventional” toll plazas (applied in Ireland, France, Spain, Italy, Slovenia and Greece) where tolls are generally manually collected while vehicles cross the toll plazas, although these may have lanes that allow electronic charging without the vehicle needing to stop.

Today, the majorities of EU Member States have either adopted *electronic tolling systems* or are in the process of doing so. Germany, Austria, the Czech Republic, Slovakia, Poland and Portugal have an Electronic network wide tolling systems in place; Denmark, Belgium, France and Hungary have an Electronic network wide tolling in development. France will only be applying the charges to existing untolled state owned motorways, so it will retain its present system of tolls with physical barriers.

Three primary types of electronic tolling systems are being used:

- **Satellite positioning**: GPS is the most widely used satellite technology system in use in electronic tolling across Europe. Its accuracy depends on the quality of the GPS receiver, the almanac it contains (describing the movement of the orbiting satellites) and its ability to model atmospheric conditions. There are a number of different technologies that are available to increase its accuracy, which use geostationary satellites to transmit location information (Clough and Guria, 2008).

- **Mobile communications using the GSM-GPRS standard:** GSM (mobile communication) require an on-board unit (OBU), which is used to identify the vehicle location, and this GPS position data is transmitted by GSM to a central system.

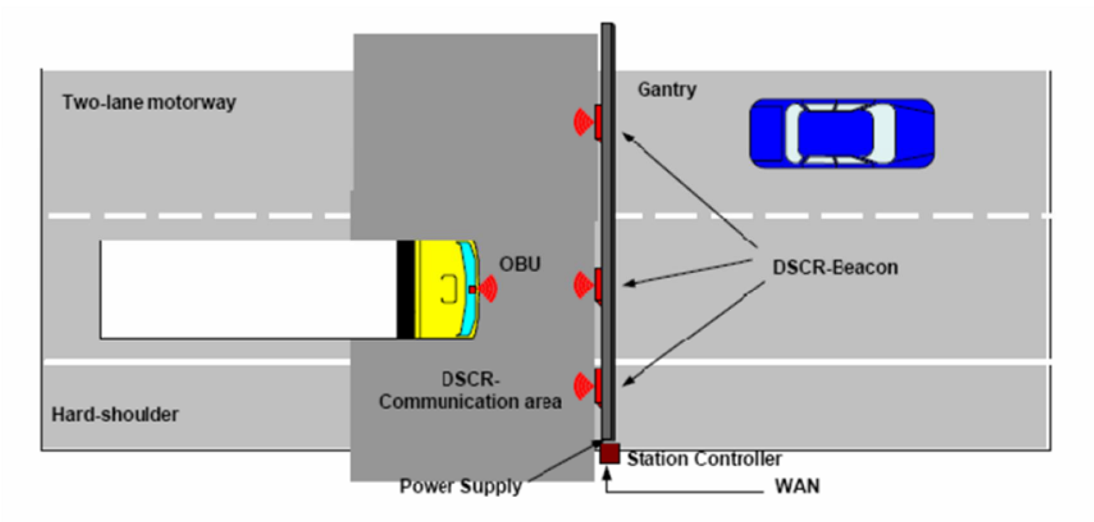
- **5.8GHz microwave technology - Dedicated Short Range Communication (DSRC):** DSRC systems require vehicles to have an On-Board Unit (OBU), which is essentially an electronic tag, that communicates with road side beacons and in doing so the gantry (using DSRC) charges the vehicle.

A number of different examples are featured below to give an insight into some of the technical systems adopted by a selection of European countries.

Austria

Austria introduced a distance-based electronic toll system in 2004 making it the first Member State to adopt a nationwide multi-lane free flow electronic toll system. The system had an initial volume of 400,000 commercial vehicles weighing over 3.5 tons, each of which was equipped with an On Board Unit (OBU) which can be purchased or rented, and installed for approximately ú 5. Tolls are collected from 111 toll lanes, 95 of which are electronic.

The system allows tolling to occur while vehicles drive at normal speeds using gantries placed above the highway lanes. These use 5.8 GHz microwave DSRC transceivers to communicate with OBUs installed on the windscreens of passing HGVs. Austria uses an óopen system,ô whereby tags are located on gantries across the road network.



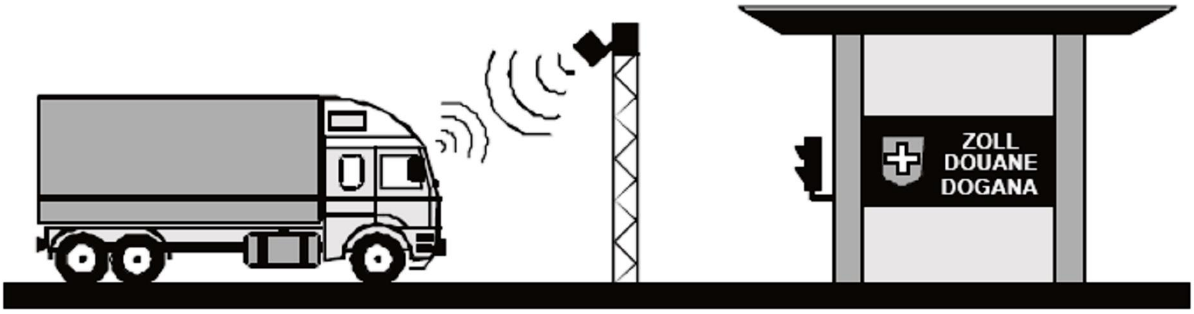
Source: Broaddus and Gertz, 2008.
The Austrian electronic toll system concept

Switzerland

The LSVA (Leistungsabhängige Schwerverkehrsabgabe) is a national distance based charge that is levied on HGVs that weigh 3.5 tons or more, and that travel on public roads. The charge entered into force in 2001, and is operated by the Swiss governmentôs Customs Authority (SCA). The system uses several technologies:

- Digital tachograph
- DSRC
- Chip-cards (for ascertaining the distance to be charged)
- GPS (as a back-up system).

It is mandatory for all domestic vehicles to have an OBU, which are provided free to the Government but that the vehicle owner has to pay to install. The OBU starts at the same time as the engine, and it records the trip data, and the distance travelled is recorded by a tachograph that is coupled to (and which sends electronic impulses to) the OBU. A GPS sensor and a movement sensor provide a second measurement in order to make sure that the tachograph signal is not intentionally interrupted or falsified. DSRC is used to trigger the beginning or end of the distance recording when any vehicle crosses the Switzerlandôs border, and DSRC beacons are installed at 82 border crossings for this purpose.



Source: GMZ et al (2009)
The LSVAôs electronic toll system concept

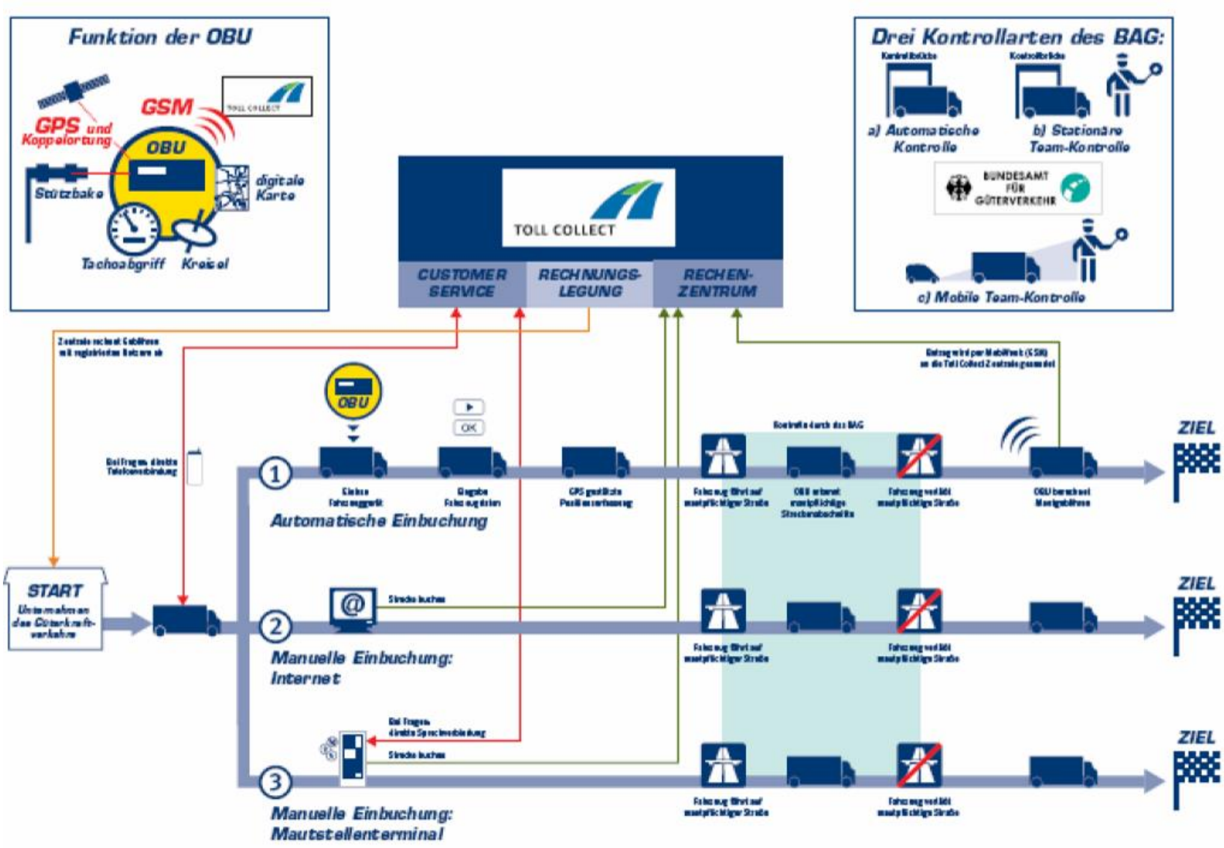
Domestic vehicle owners are required to declare how far they have travelled to the Swiss Customs Authority on a monthly basis. This requires the data from the OBU to be transmitted, either physically by chip card or electronically. The SCA processes the data, determines the amount due, invoices the vehicle owner and collects the fee.

The investment costs per user are between ú 450 and ú 565, and annual operation costs are approximately ú 100 per user.

Germany

The German government has implemented a GPS based toll system for trucks. The introduction of the system, which is called LKW-Maut, was debated for approximately 30 years before it was introduced in 2005. This was this first such system to be introduced, and so the development costs were much higher than originally anticipated (which led to the introduction of the system being delayed from August 2003 to January 2005). It uses the following technologies:

- GPS (satellite navigation locates the vehicle by communicating with its OBU, and verifies the segments of the road network that the HGV has travelled through ï with the OBU storing the geographical coordinates);
- Tachograph (to act as a back-up to record the motorway segments that the HGV has travelled through);
- GSM (this cellular network transmits the details of motorway segments that have been travelled through to the toll operator, and communicates the fees that are to be paid to the central office, which then invoices users).



Source: GMZ et al (2009)
Toll Collect system

The OBU contains:

- A GPS sensor for automatic position determination;
- An infrared communication device to communicate with support beacons for more precise position determination, and with enforcement units for compliance checking;
- A gyroscopic device, and a link to the tachometer for dead-reckoning;
- A GSM mobile telephone;
- A map of Germany, indicating virtual toll points;
- A user interface to set parameters such as number of axis of the truck, accounting code number, start of new tour.

The OBU sends the amount of toll to be paid with the mobile system, after a predefined period, or after the maximum amount has been reached. For enforcement, fixed control bridges and mobile control units are used. The control bridges span the entire road and determine whether a passing vehicle is required to pay a toll and if the toll has been duly paid. Each vehicle that approaches the control bridge is recorded by a detection and tracking unit, which determines in which lane and at what precise time the vehicle passes the bridge. This ensures that the vehicle can be properly classified.

The automated control bridges use DSRC (Dedicated Short Range Communications) technology to determine whether the vehicle is participating in the automatic toll collection system and if the On-Board Unit has been properly activated. If a vehicle subject to toll is not emitting an infrared signal, it has either logged on manually or is in violation. The number plate of each vehicle is photographed with an infrared camera and compared with the logged on number plate at Toll Collect headquarters. (The number plate must be input during manual log-on over the Internet or at a toll station terminal). After the vehicle is identified, it is determined whether it is required to pay toll, that is, if its total permissible weight is 12 tons or more. For this purpose, each vehicle is scanned three-dimensionally. The assessment technology recognises the contour of the vehicle and determines whether it is required to pay toll and how many axles it has. If no toll needs to be paid, then the data is immediately deleted.

In the German scheme the GPS signal is not used for calculating the distance covered. Once the road section is identified, the entire section is charged.

Czech Republic
The Czech HGV electronic toll collection system was introduced nationwide on January 1st 2007. The system is based on DSRC and consists of the installation of an OBU on the vehicles with pre-pay and post-pay capabilities. The OBU uses a DSRC CEN TC278 (a Standards body that is responsible for DSRC related standards) compliant multilane free flow system to ensure interoperability within Europe.
There are plans to roll the electronic toll collection system out across a wider range of roads.

DSRC may be a less suitable technology to use on any additional roads covered owing to the costs of acquiring sites for the gantries and the costs of installing them. It is therefore more likely that a GPS-based OBU, which requires no physical infrastructure at the roadside, would be more appropriate, although the realisation that DSRC cannot be used in any extension to the scheme has meant that the Czech government has delayed the planned implementation of the extension.

A pilot test has already occurred where a hybrid DSRC-GNSS implementation was used to allow charging in road networks with limited capacity for roadside infrastructure (Clough and Guria, 2008; GMZ et al, 2009).

Slovakia
Slovakia's national HGV tolling system is based on GNSS technology, and was implemented in 2010. The system is based on an OBU that is designed for automatic toll collection and is equipped with satellite localisation service (GPS), mobile communication device, and a 5.8 GHz DSRC module. The OBU uses the GPS signal to determine whether the vehicle is travelling on a toll-free road or toll route segment. If the vehicle is in operation on a tolled road, then the toll charge is calculated, transmitted to a central system, converted into payment data, and an invoice is generated (GMZ et al, 2009).

The electronic toll system may help in data gathering concerning types (environmental category) of heavy vehicles circulating on motorways. Thus, a detailed categorisation of the O/D matrix on vehicle environmental category is possible. Furthermore, if the toll were to be applied to passenger vehicles and combined with other data (total occupants, etc.) it could become a valuable instrument for collecting relevant data on road passenger demand.

Targeted users. Motorway operators, national and regional traffic authorities.

Barriers to implementation

Financial issues. A comparison of the type of technology used for road charging in different Member States, along with the costs of implementation (where available) is given in the table below.

Type	System technology	Country	Year of toll introduction	Investment cost (€m)	Operational cost as % of revenue	Network length
Network-wide tolls	Dedicated Short Range Communications (DSRC)	Austria	2004	750	10-12%	~ 2,000 km Tolled Network; ~ 800 Toll Segments
		Czech Republic	2007	780	10%	~ 2,000 km Road Network, ~ 850 Toll Segments
		Poland	2011	278	17% (as for other systems, this is	Total length 1,130km incl. motorways and expressways. Expected to

Type	System technology	Country	Year of toll introduction	Investment cost (€m)	Operational cost as % of revenue	Network length
					expected to reduce over time)	expand to about 3,000km.
	Global Navigation Satellite Systems	Germany	2005	1240	10.4-20% (High at first, but are thought to have reduced to 11-12% in 2009).	~ 12,000 km Motorway Network; ~ 5,000 Toll Segments
		Slovakia	2010	716	unknown	600km highway (900 segments) and 1,800km first class roads (1,500 segments).
		France	2013 (planned)	600	~20%	10,000km highways and 5,000km secondary roads

Notes: Operation costs as % of revenue are provided as a range, due to the varying figures depending on the year.

Sources: Evaluation of the implementation and effects of EU infrastructure charging policy since 1995, Ricardo-AEA 2012

The Interoperability Directive recommended that new electronic toll systems brought into service after its adoption use satellite positioning and mobile communications technologies. However, several countries have investigated satellite systems but did not implement them due to the high upfront costs.

For the Netherlands, where a distance based toll system was discussed over years and finally abandoned by the new Government in 2010, estimated costs in 2005 were ú 2.1-3.8 billion, and annual system operating costs were estimated at ú 0.4- 1.1 billion (European Commission, 2005).

In the UK, a distance-based toll for trucks >3.5t was investigated in 2004-2005. Tolls were to be differentiated by type of road, vehicle weight, number of axles, and emissions class, followed later by possible further differentiation by time of day and geographic area. However, it was not implemented due to the high cost of ú 3-4 billion.

More recent schemes in Slovakia and France appear to have lower costs, although no two systems are directly comparable.

Technical barriers. A number of lessons can be learnt from the German experience. These include:

- **Accuracy of positioning:** During the project it turned out that the GPS positioning system was not sufficiently accurate for all cases. Thus it was decided that gyroscopes and odometers would be used for road segments identification that is the main input for the charging computation. In addition, difficult cases include the presence of a road parallel to the highway, where the parallel road does not require toll payment, but the highway does. Because of this, 180 support beacons needed to be set up permanently, to communicate by infrared the precise location to the truck.
- **Map updating:** Because the OBU contains a map of Germany, indicating the virtual toll points, there is a need to update this map regularly. The updating process has resulted in huge (in some cases even unacceptable) loads on the GSM network.
- **Control and surveillance:** The costs of surveillance are quite high in relationship to the total amount of toll collected.
- **Back office:** The back office system implementation has been hugely complex and contributed its share to delays and cost overruns.
- **Cost of OBU installation:** The OBU needs to be connected to various systems inside the truck. The time to build the OBU into the truck is required to be less than four hours, which is acceptable for trucks, but not acceptable for cars.

- **Limitation to highways (Autobahn):** As a response to the toll on highways, some truck operators started to shift to non-tolled routes. This unintended impact was addressed by extending tolls to cover key secondary roads.

The two technologies are both considered to be well established, and are often referred to as ‚matureô technologies, with recent years having seen improvements in their coverage and ease of implementation (Oehry, 2010). Electronic tolling systems have, for example, been operational for several years in Germany, Austria, and the Czech Republic, which demonstrates that the tolling technology is mature enough to enable reliable toll collection and enforcement. It is as a result of this that a number of Member States are developing new distance based tolling, in part replacing existing vignette or barrier-tolled systems (GMZ et al, 2009).

Organisational complexity. The key factor that determines which system is taken up is the road network: for large or complicated networks, satellite systems are preferred, whereas for smaller networks DSRC is most likely the best option.

Changes or additions are made to the German motorway network each month: every On-Board Unit receives this information automatically at regular intervals. The data is transmitted to the On-Board Units via wireless interface. Software updates eliminate the need for roadside infrastructure as well as extra trips to the service centre. The intelligent technology works almost imperceptibly, usually updating three to four times a year. The number of updates and when they are to be implemented are agreed upon with the contracting body. In the last few years, over 500 additional kilometres of German motorways have been integrated into the digital card in the On-Board-Unit. Since early 2007, some 80 kilometres of federal roads have become toll roads. Compared with the total length of federal roads, 40,000 kilometres, this is obviously a small proportion. Yet this addition demonstrates that satellite-supported toll collection is also suitable for the intricate network of federal roads.

Legal issues. There are no major legal issues.

User and public acceptance. In Member States with electronic tolling systems, operators as we;; as public acceptance appears to be high. In most cases participation in electronic fee collections is greater than 50%, while several Member States have achieved close to full participation. Drivers may not like the idea of motorway tolls in the first place, but if they are there then at least most of the regular users prefer automated to manual payments.

Several stakeholders highlighted the importance of the integrity and accuracy of the charging system, as a key weakness of electronic tolling is that there is scope for errors that can result in the over / under-pricing of users.

Interest for Travellers

Door to door travel time. The pricing system in general does not have any direct impact on travel times. Nevertheless, the usage of electronic toll collection systems (especially free flow systems) might reduce travel times in comparison with traditional toll collection plazas.

Travel cost. In the German case the OBU is made available free of charge and remains the property of Toll Collect GmbH. Users bear the cost of:

- Installation of the On-Board Unit
- Removal of the On-Board Unit when the vehicle is taken out of use or sold and on ending of the commercial relationship with Toll Collect
- A change of vehicle registration (if this is necessary) and for changing the toll-relevant vehicle data
- Travel time to the service centre and vehicle idle time in the course of this work

However, the major cost element is the charge to be paid, which is calculated according to the estimated maintenance, upgrading and renewal costs for the motorway system attributable to trucks. The charge is designed to raise revenues to relieve public budgets of this expenditure and charge all users, including foreign trucks, equally.

Comfort and convenience. The toll system is more convenient that manual systems.

Safety. The toll system does not have any direct safety impact, as long as drivers stay on the motorway and do not divert on rural roads with higher accident rates to avoid the charges.

Security. Data protection and data integrity are crucial considerations when it comes to collecting, processing and invoicing road tolls. In Germany, the provisions of the Motorway Tolls Act are very restrictive and guarantee the customer the highest possible level of data protection. The data collected are used exclusively for invoicing the tolls.

Accessibility for impaired. No particular impacts apply.

Modal change

The charge is also explicitly intended to provide an appropriate financial environment for inter-modal competition for freight between road and rail. Some hauliers complain about the unfair tax on the logistics business in Germany. Even if there are medium/long-term effects, some shifts in goodsôtransport can be expected towards the railway system.

Other notable impacts

Congestion and C02 emissions. Since trucks have not to slow down, stop the vehicle, then to speed up again in order to perform the toll payment, considerable reductions in fuel consumption and in CO_2 and pollutants emissions can be saved in comparison to traditional toll collection gates, while also congestion at the toll gates can be avoided.

Contribution to user pays principle. Although the toll charged will in no way cover all external costs of truck usage, at least some of them, such as damage done to the road surface, will be addressed.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€€	D2D travel time	**0**	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€	D2D travel costs	X	Bus and coach usage	**0**	Congestion	(✓)
Financial viability	✓	Comfort and convenience	✓	Rail usage	**+**	CO2 emissions	✓
Technical feasibility	**0**	Safety	**0**	Ferry usage	**0**	Contribution to user pays principle	✓
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	(✓)						

Illustrative materials

Toll Collect

Toll colletct payment

1.2.13 Vehicle miles travelled insurances

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: long distance, metropolitan, urban, rural

Technology behind: RFID devices, odometer, GPS devices, mobile phones

Status: Implemented

Links to relevant references

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Description

Concept and problems addressed. Vehicle Miles Travelled Insurance (VMTI) reflects the principle that prices should reflect costs, and consumers who reduce costs should receive resulting savings. Reduced driving reduces crash risk and insurance claims. With current pricing, claim cost savings that result when motorists reduce mileage are retained as profits by insurers or returned to premium payers as a group. VMTI pricing return these savings to individual motorists who reduce their mileage.

VMTI pricing gives motorists a new opportunity to save money, providing an incentive to reduce mileage, allowing individual consumers decide which miles, if any to forego. To the degree that motorists reduce mileage, and therefore crashes and insurance claims, the savings that result are net benefits to society, not just economic transfers.

There are confounding factors that affect mileage and crash rates. For example, young and old drivers, people with disabilities, and urban residents, tend to drive a fewer annual miles and have higher per-mile crash rates. However, these factors can be incorporated into rating, either directly or by surrogates such as driving experience. Once these are taken into account (that is, for a given rate class) there is a strong positive relationship between mileage and crashes.

Available data suggest that a change in overall average vehicle travel provides about proportional change in claim costs by those vehicleõs insurers, and proportionally larger reductions in total crash costs since about 70% of crashes involve multiple vehicles and the average crash results in about 1.5 claims (Vickrey 1968; Edlin 2003).

Most motorists should benefit overall, including those who currently drive less than average in their rate class, those who would reduce their mileage to below average in response to this incentive, those who drive uninsured but would purchase insurance if offered VMTI, and motorists who drive high annual miles but value benefits such as reduced traffic congestion, accident risk and emissions.

Targeted users. Drivers with a low annual mileage.

Barriers to implementation

Financial issues*.* VMTI can provide these benefits:

- Increased actuarial accuracy. It makes premiums more accurately reflect the insurance costs of an individual vehicle, which is fairer and more economically efficient.
- Consumer savings. With VMTI pricing average motorists are expected to reduce their annual mileage, crashes and insurance costs by about 10%, providing about $100 annual savings.
- Increased insurance affordability (Litman 2004). Since annual vehicle travel tends to increase with income, most lower-income motorists would save.
- Increased traffic safety (Perry 2004). Mileage reductions reduce exposure and traffic density, and therefore total crashes. Higher risk motorists pay more per vehicle-mile and therefore have a larger incentive to reduce mileage, providing additional crash reductions. If broadly applied, traffic crashes should decline proportionately more than mileage, so for example, a 10% mileage reduction reduced crashes by 12-15% (Edlin and Mandic 2006).
- Reduced traffic congestion, roadway and parking facility costs.
- Energy conservation and pollution emission reductions (CCAP 2005; Harrington and Parry 2005). If applied to all vehicles it can achieve approximately a third of the Kyoto emission reduction targets for private vehicles.
- By increasing affordability it should reduce uninsured driving (Butler 2000).

VMTI implementation can also impose some costs:

- It requires new rate structures, administrative procedures and rate plans. Insurers bear these costs when rate structures change, but VMTI could increase these costs more than average.
- Most VMTI systems increase transaction costs (administrative costs per policy). Incremental costs range from less than $0 per vehicle-year for self-reporting systems (MileMeter 2009), to more than $150 per vehicle-year for pricing systems that track vehicle location.
- Until insurers gain experience with this rate structure there will be uncertainties about risks and therefore how to structure rates.
- It can make premiums less predictable to consumers. Motorists and insurers would not know total premiums until the end of the insurance term.
- If universally implemented it may increase premiums for some motorists (those who continue to drive high annual miles in their rate class), although most motorists should save money.

Apart from the concrete benefits demonstrated in pilot projects, an extensive analysis on real costs strictly depends on the size of the controlled area and the technology used.

According to a survey of 115 insurance companies, insurance company representatives agreed in large numbers that costs of technology remains the biggest barrier to VMTI market entry: 46% considered the cost of implementing core systems for VMTI products as the major barrier. This compared with 20% who selected consumer privacy concerns, 18% who selected the cost of telemetry devices, 14% who selected state insurance regulations, and 4% who selected existing VMTI patent infringement as the number one barrier. The top market driver for VMTI introduction was readiness to respond to protect their book of business from competitors. Entering a new market to grow revenue was second ahead of entering the market to gain market perception as exercising corporate responsibility with a "green" product.

Technical barriers. There are no general technical barriers apart from those related to costs, as mentioned above.

Organisational complexity. VMTI is implemented by individual insurance companies, although legal or administrative changes may be needed to remove regulatory barriers. Governments can implement incentives or regulations to encourage insurers to offer VMTI pricing, and public-private projects can help pilot and promote this pricing option.

Several methods can be used to calculate and collect premiums. One is to have motorists prepay for the miles they expect to drive during the term of coverage (typically a year), either in a lump sum or in several payments. For example, some motorists might pay for 12,000 miles at the start of the term, while others might pay for just 5,000 miles at first and make additional payments as needed. The total premium is calculated at the end of the term based on recorded mileage. Vehicle owners are credited for unused miles or pay any outstanding balance. Other insurance companies charge for insurance as they do now, but provide a rebate if, at the end of the policy term, a vehicle's mileage is below certain limits. Another approach is for insurance companies to bill motorists based on their monthly or bi-monthly vehicle mileage, similar to other utilities. This requires more frequent mileage data collection and a higher administrative burden.

Legal issues. There should not be major legal obstacles to this application.

User and public acceptance. Likely to have good acceptance.

Interest for Travellers

Door to door travel time. Travel time reductions can only result from the implementation of a GPS based VMTI system capable of travel time monitoring on the experienced routes.

Travel cost. VMTI is predicted to reduce vehicle travel and hence related costs for fuel consumption and vehicle operation as well as parking.

Comfort and convenience. No impact is expected.

Safety. Vehicle crashes should decline even more than mileage because higher-risk motorists (who currently pay high premiums per vehicle-year) would pay higher per-mile fees, and would therefore have the greatest incentive to reduce their driving.

Security. No impact is expected.

Accessibility for impaired. No impact is expected.

Modal change

Such systems potentially encourage users to more sustainable mode of transport.

Other notable impacts

Congestion and CO2 emissions. The expected reduction in car use will help combat congestion and CO2 emissions.

User pays. Those who travel most and contribute most to the negative impacts of car travel pay the highest premiums, while those showing a more sustainable travel behaviour benefit directly from lower premiums.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€-€€	D2D travel time	**0**	Car usage	**-**	Mobility	**0**
Operation and maintenance costs	**€€**	D2D travel costs	(✓)	Bus and coach usage	**+**	Congestion	✓
Financial viability	✓	Comfort and convenience	**0**	Rail usage	**0**	CO2 emissions	✓
Technical feasibility	**0**	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	✓
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**X**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Several insurance companies now offer VMTI products:

Aioi Insurance, Japan

Aryeh, Israel

Holland PAYD Coverage, South Africa

MileMeter, United States

MiDriveStyle

Pago Por Uso, Spain

Polis Vor Mij ("Policy for me"), The Netherlands

Real Insurance PAYD, Australia

1.2.14 Conventional weather detection systems

Solution family: Transportation Management Systems

Sub-family: Road Transport Management

Domain of application: long distance travel, in theory also on rural roads

Technology behind: weather monitoring stations, road side and in-road sensors

Status: Implemented

Links to relevant references

- Traffic Analysis Toolbox Volume XI: Weather and Traffic Analysis, Modeling and Simulation
- Clarus system

Description

Concept and problems addressed. Weather conditions affect the operation of the national transport system by changing the driving environment as well as the behaviour of drivers, who modify their individual headways, target speeds, or other travel parameters in reaction to specific weather events. The individual reactions of these drivers to weather, in turn, directly impact overall system performance. Transport system managers have to plan for the consequences of diverse weather conditions on a daily basis. By monitoring road conditions using pavement sensors or video, operations and maintenance personnel are able to assess how well their traffic management or winter maintenance strategies are performing, or to determine what additional actions are required. Roadside sensors can measure fog and wind. Conditions of interest include pavement condition (e.g., wet, snowy, icy, flooded), pavement chemical concentration or pavement freeze-point temperature, pavement temperature, soil (sub-surface) temperature, air temperature, wind speed and direction, precipitation (e.g., amount, occurrence, type), humidity, atmospheric pressure, radiation (solar and terrestrial), and visibility. Auxiliary sensors, such as lake webcams and riverbed scouring sensors, can provide opportunities to add information that can help monitor and detect events resulting from flooding. All of this information is used to activate automated warning systems and provide decision support to managers in traffic management centres, road maintenance facilities, and emergency operations centres.

Targeted users. Motorway or trunk road operators.

Barriers to implementation

Financial issues. According to typical capital costs for a weather information system average $27,000 to $45,000 per site (roughly between ú20,000 and ú35,000).

Whether stations should ideally not be too far apart, since during times of winter weather or terrain changes, a distance of less than 25-30 km can be critical in knowing where hazardous weather is located. Where terrain changes are drastic, even much shorter distances can make a drastic change to the weather, for instance for fog in a valley or for ice on a hill.

Costs for the monitoring have also to be seen in the context of the costs of distributing the relevant information gained. Where the information is used for road maintenance (winter or otherwise), the costs are minimal, since a phone call between the weather station and the maintenance centre is all that is needed. Where the information is used to inform drivers, there are two possibilities: information via local radio is again very cheap, but where roadside Variable Message Signs are deployed for the warnings and/or for Variable Speed Limits, the costs can be significant unless signs already existing for other purposes can be used. However, the social benefit in terms of saved accidents, can more than outweigh these costs. As an example, monitoring ITS in Finland consists of 11 central stations, about 200 workstations, and about 150 observation stations, which provide information to the system users. The associated road weather information system (monitoring and information services) was projected to yield a benefit-to-cost ratio of 5:1 by reducing annual vehicle costs, and improving motorist travel time and safety. In the US, through the Utah Department of Transportation Weather Operations Program, meteorologists based at the traffic operations centre use information from environmental sensing stations in the field to provide detailed forecasts to winter maintenance personnel, saving $2.2 million per year in labour and materials for snow and ice control activities, which is approximately 18 percent of the 2004-2005 labour and material costs. The program had an estimated benefit-to-cost ratio of 10:1. Finally, the Wisconsin Department of Transportation used an ice detection system and a snow forecasting model to aid in the dispatch of snow plows and de-icers saving 4 hours per person for each significant storm (a value of around $144,000/storm), and approximately $75,000 in salt.

Technical barriers. There are no technical barriers.

Organisational complexity. There is no major organisational complexity. The agencies that collect the data are also the main users and distributors of the data.

Legal issues. There are no legal obstacles.

User and public acceptance. Public acceptance will be high, as for other solutions addressing safety issues. Acceptance by the road operators are equally high, since they know not only that the social benefits are high, but that they can actually save money by optimising their road maintenance.

Interest for Travellers

Door to door travel time. Travel time may increase where drivers reduce their speed in response to weather related warnings. This is counterbalanced by the saving of delays, which can be considerable in case of accidents.

Travel cost. The lowering of speeds in response to weather warning will reduce vehicle operating costs.

Comfort and convenience. No specific impact.

Safety. The provision of weather related information to the different user groups significantly contributes to safety, reducing a great number of potential accidents caused by reduced visibility.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal change

No significant one expected, even though some car drivers may hear a weather warning on the radio before they start the trip and decide to use public transport instead.

Other notable impacts

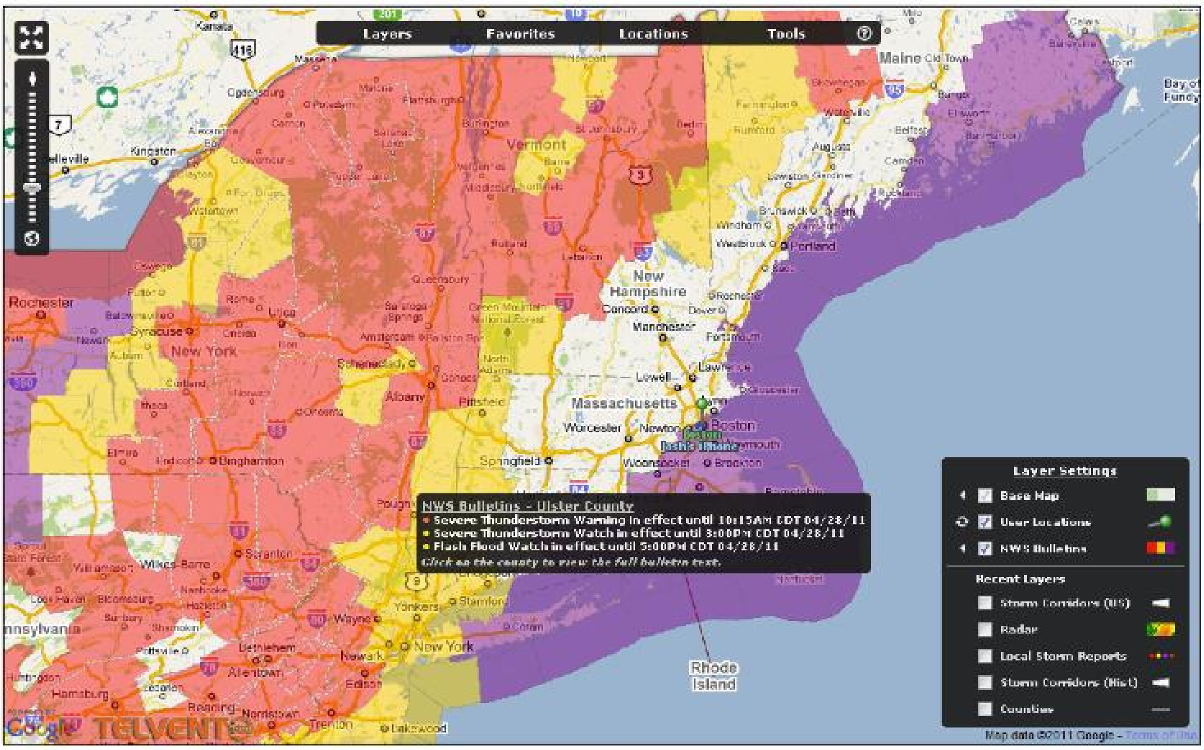
Congestion and CO2 emissions. Where the weather warnings prevent accidents on busy trunk roads and motorways, they will also prevent the resulting congestion. CO2 reduction will both stem from the reduced congestion and from the lower speeds.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	**€€**	D2D travel time	**0**	Car usage	**(-)**	Mobility	**0**
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	**(+)**	Congestion	✓
Financial viability	✓	Comfort and convenience	**0**	Rail usage	**(+)**	CO2 emissions	✓
Technical feasibility	**0**	Safety	✓✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Radar Showing Light/Moderate Snow Affecting I-87 North of Albany



Example of weather service warnings

1.2.15 Road Maintenance Data Via Crowd Sourcing

Solution family: Transport management systems

Subfamily: Road Transport Management

Domain of application: Urban, rural and long distance travel

Technology behind: smart-phone apps, positioning and location referencing

Status: implemented

Links to relevant references

- PotholeSnitch
- Fill That Hole
- Birmingham City Council
- *Pothole-spotting app could make it a busy winter for councils*, by The Guardian
- Just hit a pothole, Chron
- *Smartphone app identifies potholes and notifies council*, by BBC
- City of Boston
- *Smartphone app automatically detects and reports pothole locations to Boston city officials*, by ECN
- Potholes, West Sussex Country Council
- Intelligent speed adaptation, Wikipedia

Description

Concept and problems addressed. Crowd-sourcing is the practice of obtaining needed services, ideas, or content by soliciting contributions from a large group of people, and especially from an online community[9]. It has become an increasingly popular tool in the form of smart-phone apps for reporting the real-time traffic conditions and road infrastructure status such as congestion, road-works, abandoned vehicles and potholes. A typical example of such apps is the Driving Intelligence INRIX which (at the time of writing) has crowd-sourced more than 100 million drivers to collect users' driving times to provide better GPS routing and real-time traffic updates (http://www.inrix.com/). Many local authorities have also developed smart-phone apps to allow citizens to report issues related to the conditions of their living environments including potholes, graffiti, street light outages directly to their local government organisation using their phones.

This fact sheet focuses on the use of crowd-sourcing to collect road maintenance data, in particular potholes.

The windscreen provider Autoglass reported that 'councils in England and Wales paid out £22.8m in compensation for pothole damage in 2012, and the average cost of a car repair is £220'. In severe cases, casualties can also be caused and the costs can be more than just financial. The CyclistsôTouring Club indicated that 'several cyclists die in crashes as a result of potholes each year and 15% of the legal claims we handle stem from road defects'.

Despite the fact that the UK government has realised that there is a ósignificant increase in the number of potholes on the already fragile local highway networkôand allocated an extra £200 million for local highway authorities, the amount it would cost to clear the backlog of necessary road maintenance could run into billions as indicated by the following figures using data collated by the Asphalt Industry Association (AIA) for its Alarm survey. The data also shows that 'in England, the backlog of repairs has grown from an average £53.2m per local authority in 2009 to £61.3m in 2012. In Wales, the backlog grew about £22m a year'.

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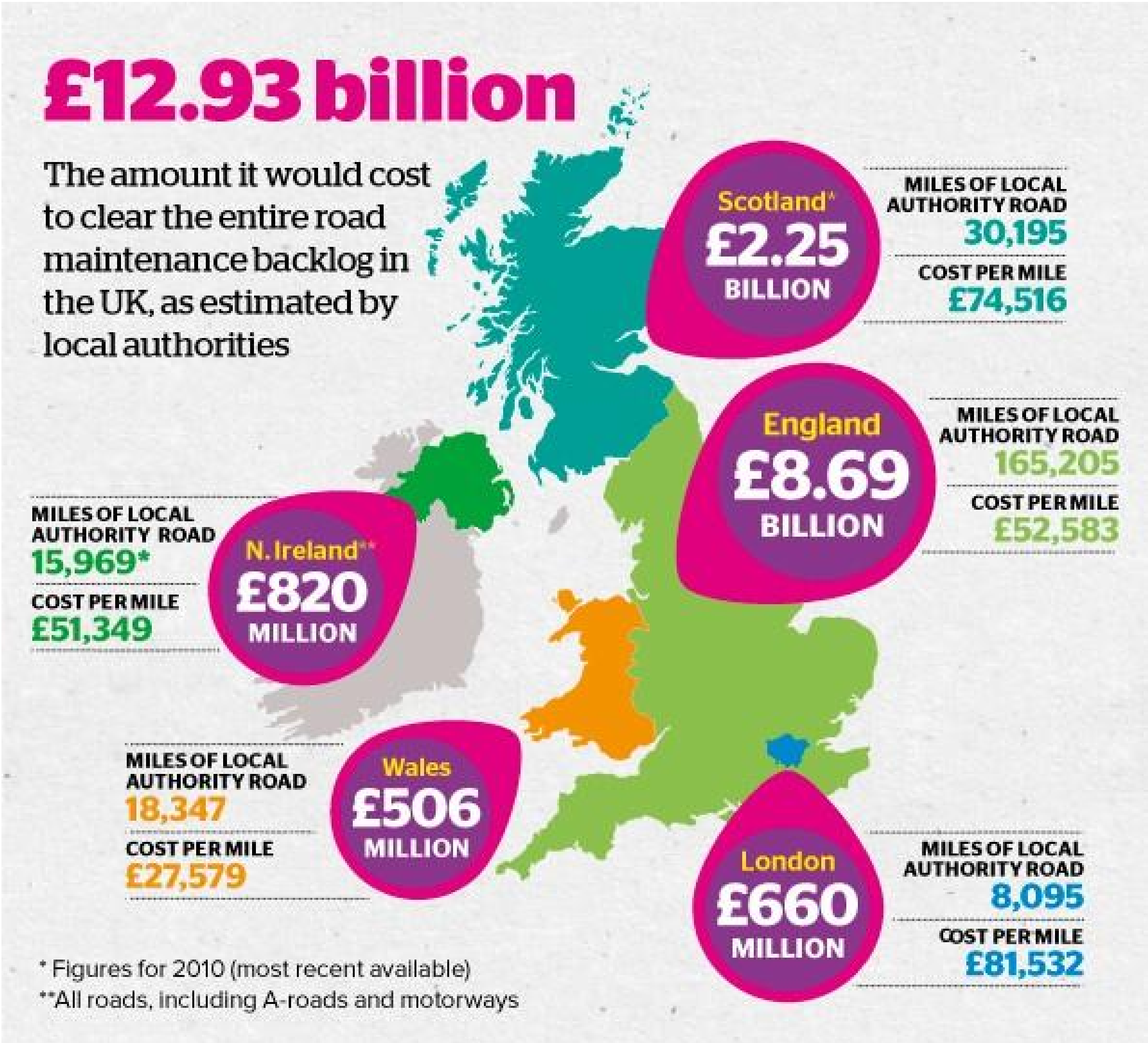
9 http://www.merriam-webster.com/dictionary/crowdsourcing



Source: Which?

A number of smart-phone apps have been developed for identifying and reporting potholes and can be categorised into two groups namely:

- Manual Reporting: These apps report the precise location of potholes or other issues to the authorities. They allow the user to set the report type and drop a pin onto his/her location on the map. To submit a report, the apps construct an email indicating the GPS coordinates, a nearby street address, and the details of each of the pinpoints so that the authorities know exactly where to go. These apps can also be used to report broken streetlights, illegal dumping in a remote area that has few landmarks, road kill, dangerous situations (e.g., debris in the road or flooding), and so on. Most of this type of smart-phone apps are free for downloading and examples include *PotholeSnitch*, *Fill That Hole app*, *Pothole Scout*, *Community Fix Mobile*, *Citizen Connect*.

- Automatic Detection and Reporting: A further development of these smart-phone apps enables the phones to automatically detect and report pothole locations. First developed by the City of Boston and then piloted in Bristol, *Street Bump* has attracted attention from other cities in the U.S., Europe, Africa and elsewhere that are imagining other ways to harness the technology. Using its accelerometer[10] (i.e. a motion-detector), the phone which is set either on the dashboard or in a cup holder senses when a bump or pothole is hit. The phone's GPS automatically records the location, and the app automatically transmits the report to a remote server.

Targeted users. The targeted users can be anyone no matter whether he/she uses the road for driving, riding, walking, or cycling. The app is particularly useful to local authorities as it might eventually allow them to save money by creating a real-time map of potholes that need to be fixed and eliminating the need to send out city trucks or contract an engineering company to troll hundreds of miles of roadways looking for damage.

Barriers to implementation

Financial issues. The use of the apps are free but their development is not. Street Bump cost a total of $45,000 from Boston city coffers and insurer Liberty Mutual Group Inc. to develop the prototype and the algorithms used to differentiate between potholes and other bumps.

On the other hand, as illustrated earlier, getting an accurate count of where every pothole is is traditionally a significant task, so making use of this technology would be very cost-effective. This would save local authorities from allocating workforce, and employing equipment to search for damaged surfaces. Savings can also be made from the saved claims.

Technical barriers. There are no technical barriers to the implementation of the application.

Organisational complexity. There is no particular organisational complexity.

Legal issues. There are no legal barriers.

User and public acceptance. Acceptance by both road users and traffic authorities is very high.

Interest for Travellers

Door to door travel time. This application does not save travel time.

[10] Mednis A. *et al*, "Real Time Pothole Detection using Android Smartphones with Accelerometers", 2011 International Conference on Distributed Computing in Sensor Systems and Workshops (DCOSS), Barcelona, 27-29 June 2011.

Travel cost. This application does not save travel cost.

Comfort and convenience. This app allows road users to see where potholes are and may be used to identify alternative routes which may provide better comfort and convenience.

Safety. This application provides a quick report to the local authorities about the location and severity of potholes, which need to be repaired, and hence may indirectly improve road safety.

Security. No improvement is expected.

Accessibility for impaired. No improvement is expected.

Modal change

None expected.

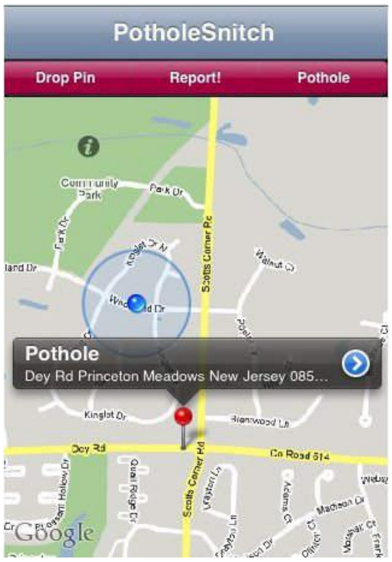
Other notable impacts

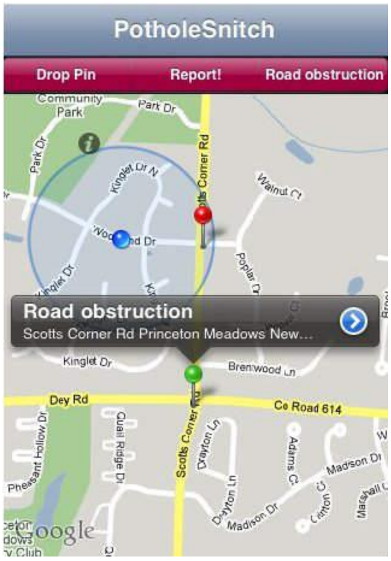
None expected.

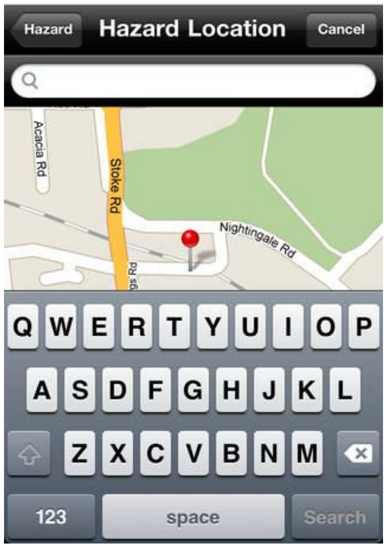
Summary of scores

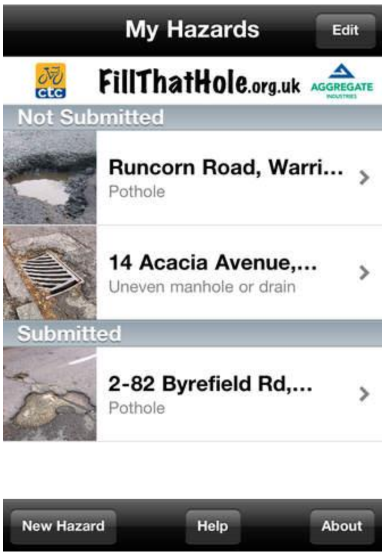
Feasibility		**Interest for travellers**		**Modal change**		**Other impacts**	
Investment Costs	ú	D2D travel time	0	Car usage	0	Mobility	0
Operation and Maintenance Costs	ú	D2D travel cost	0	Bus and Coach usage	0	Congestion	0
Financial Viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical Feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	0	European economic progress	0
Administrative Burden	0	Accessibility for mob. Imp. Passengers	0			Territorial cohesion	0
User Acceptance	✓						
Legal Feasibility	0						
Public acceptance	✓						

Illustrative materials









1.3 RAILWAY TRAFFIC MANAGEMENT

1.3.1 Programmed traffic control for railways

Solution family: Transportation Management Systems

Sub-family: Railway Traffic Management

Domain of application: Long distance, metropolitan

Technology behind: Signals; Remote control sensors; Software; Monitors

Status: Implemented

Links to relevant references

- Mannino C (2011) Real-time traffic control in railway systems, in Caprara A & Kontogiannis S (Eds.) *Proceedings of the 11th Workshop on Algorithmic Approaches for Transportation Modelling, Optimization, and Systems* (ATMOS 2011), Saarbrucken, pp. 1-14
- Persson J A (2007) N-Tracked Railway Traffic Re-Scheduling During Disturbances. *Transportation Research Part B: Methodological*, *41*(3). Available at
- Lérin C, Baumgard X, Dessagne G, Pinton F, & Weber C (2008) New paradigms and developments for the future of train traffic management. Proceedings of the 8th World Congress on Railway Research. Available at
- Carvalho Afonso, P A d (2008) Railway Traffic Management. Masters Dissertation, Technical University of Lisbon.

Description

Concept and problems addressed. A robust railway timetable should be able to accommodate and recover from the occurrence of minor delays, but dealing with more serious unexpected events such as technical failures, track incidents, etc., requires ongoing, real-time rail traffic management and control. In the first instance, the unexpected events cause primary delays, which affect the running times, dwelling and departing events. Added to this, the interaction between trains in a network means that these primary delays may be propagated as secondary delays to other trains, and so result in disturbance to the wider network.

This is particularly problematic in railway systems with high rates of capacity utilisation and where there is a mix of different types of rail traffic. Higher rates of capacity utilisation increase the degree of interaction between trains and, hence, increase the likelihood of a primary delay being propagated, whilst an increasingly heterogeneous traffic mix makes it more difficult to determine how to accommodate and recover from the secondary delays. For example, there may often be a choice to be made between a solution which minimises total delay time, which minimises the number of trains affected, or which maximises the number of trains run to time.

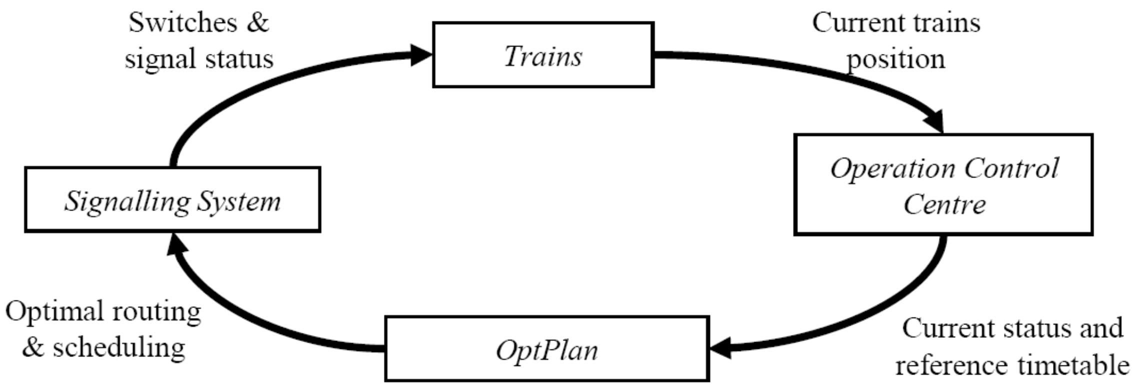
Systems need to be able to quickly re-compute a new train plan whenever a dispatcher intervenes to reroute trains, edit the official timetable or modify the available infrastructure in response to some unexpected event, and to show the recomputed plan immediately on dispatchersômonitors. This is especially important in peak hours when dispatchers come under severe pressure, simultaneously controlling several monitors, interacting with other operators and making radio calls to drivers.

Very few examples of real-time programmed railway traffic management have been implemented but typically, such systems control very simple rail lines and focus on supporting human train-dispatchers, such as for the Lötschberg Base Tunnel (operated by the Swiss BLS).

Nevertheless, one interesting implementation relates to the Milan metro. In 2007, the municipal transport company of the City of Milan, Azienda Trasporti Milanesi (ATM), implemented an automated traffic management system that can control, in real-time, the trains in the terminal stations of the Milan metro system so as to optimise specific performance indicators, such as punctuality or regularity.

An optimisation algorithm (referred to as Optplan) was embedded in the traffic control loop (as illustrated in the figure below): the position of the trains and the status of the switches and signals are captured by remote control equipment and input to Optplan, which returns a real-time plan and then indicates to the trains their next moves on their assigned routes.

Overall implementation of the software was assigned to Bombardier Transportation, with the University of Rome Sapienza subsequently joining to develop the core optimisation algorithms. Following a thorough test period, the system proved able to control the trains in the terminal stations in real-time, and to produce better real-time plans than human operators, significantly improving overall performance indicators.



Source: Mannino 2011
The control loop

Targeted users. Rail Infrastructure managers.

Barriers to implementation

Financial issues. Since one prototype exists applying the optimisation algorithms in a new environment will not have to start from scratch although adaption of the software will clearly be necessary. The operational costs should decrease because less human intervention and supervisions is needed, and the pay-back through an improvement of the services, and therefore also more customer satisfaction and attractiveness to new customers should be substantial.

Technical barriers. Automated real-time rail traffic management systems represent an extremely challenging mathematical problem, and require the implementation of intricate software packages, so Rail infrastructure managers seem generally reluctant to rely on them. The Milan application has proven that these barriers can be overcome, but the Milan metro is a closed system and applications for more complex rail networks will be even more challenging.

Organisational complexity. In many of the EU's rail networks, the increasingly heterogeneous traffic mix, involving passenger trains and cargo trains of varying characteristics and a number of different train operators all sharing the tracks, is making it increasingly difficult for infrastructure managers facing multiple conflicting requests and demands to conduct their rail traffic management role in a neutral manner. An automated system will reduce the complexity for humans.

Legal issues. No known legal issues. Where there is potential for the neutrality of rail infrastructure managers to be called into question then the possibility of train operators bringing legal cases will arise, but an automated system should reduce this risk.

User and public acceptance. User interest, on the part of rail infrastructure managers, has been limited, as stated above, but the operator who applied it, was very satisfied, and there is no reason to believe that any other operator who decided to invest in the system would not be too. As it is an operational solution, public acceptance is not an issue.

Interest for Travellers

Door to door travel time. To the extent that these solutions can and will reduce secondary delays throughout the network, there is a potentially major beneficial impact on journey times and reliability.

Travel cost. No real impact.

Comfort and convenience. No real impact.

Safety. No real impact.

Security. No significant impact.

Accessibility for impaired. No real impact.

Modal change

To the extent that a more reliable and punctual rail system is generally more attractive, a beneficial impact on rail's mode share over time can be expected.

Other notable impacts

None relevant.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	✓✓	Comfort and convenience	0	Rail usage	+	CO2 emissions	0
Technical feasibility	(X)	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	✓	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	0						
Public acceptance	0						

1.3.2 Programmed Earthquake detection and alarm system for railways

Solution family: Transportation Management Systems

Sub-family: Railway Traffic Management

Domain of application: Long-distance

Technology behind: Seismometers; accelerometers; computers; alarms.

Status: Implemented (throughout Japan and partially implemented in Taiwan, Mexico, Romania, as well as on the Tokyo and San Francisco metro systems).

Links to relevant references

- MIT Technology Review
- KTVU
- Earthquake Early Warning (Japan)
- 13 UrEDAS, the Earthquake Warning System:Today and Tomorrow

Description

Concept and problems addressed. In the event of an earthquake, the ability to rapidly shut down key facilities such as railways and to evacuate affected areas is key to minimising the quake's impacts. Whilst prediction of earthquake occurrences is still highly problematic, detection and early-warning is possible, and systems have been developed and implemented for this purpose.

Japan has been at the forefront of these developments, developing progressively more advanced systems over the past 5 decades. In particular, the Japanese Railway Technical Research Institute developed the "urgent earthquake detection and alarm system" (UrEDAS) for use along Shinkansen lines. Furthermore, the Japanese Meteorological Agency has led improvements to Japan's nationwide earthquake observation network to enable distribution of prompt earthquake early-warning information, and this has enabled UrEDAS to be further enhanced.

When an earthquake occurs, an initial, usually mild and harmless shock wave (the P wave) is detectable, followed by a second, more slow-travelling and stronger shock wave (the S wave) that is potentially much more destructive. Seismometers are used to detect the initial shock wave, which is quickly analysed in order to estimate the strength of the following shock wave. Where the second wave is estimated to be greater than a specified strength, the early warning system is triggered. Depending on the distance from the epicentre of the quake, the system may only be able to provide a few seconds warning of the impact of the shock wave, but these seconds can prove to be very important. For the purpose of the railways, systems are automated via the train protection systems so as to remove any source of human error or delay, enabling automatic shut-down of train power supplies when specified seismic thresholds are passed. This is thought to reduce the likelihood and extent of train derailments in the aftermath of the earthquake.

Targeted users. Rail infrastructure managers and train operators.

Barriers to implementation

Financial issues. It has not been possible to identify any specific cost information for this solution. In areas of high earthquake activity, it is thought that the benefits are likely to outweigh the costs significantly, whilst for areas of lower earthquake activity it is thought that this may not always be the case.

Technical barriers. The underpinning technology is well-developed and so represents no real technical barrier. However, the methods for analysing seismometer readings are subject to ongoing development.

Organisational complexity. No known issues

Legal issues. There are no known legal issues

User and public acceptance. Dealing with safety issues in such a delicate area as that relating to natural disasters, user (train operator) and public acceptance is expected to be rather high.

Interest for Travellers

Door to door travel time. No impact is expected.

Travel cost. Minor impact, if the costs of installation are passed on to the traveller via the fare this will represent a minor increase in day-to-day travel cost for the user.

Comfort and convenience. No impact is expected.

Safety. Major impact ï in the event of an earthquake occurring.

Security. No impact is expected.

Accessibility for impaired. No impact is expected.

Modal change

No notable impact.

Other notable impacts

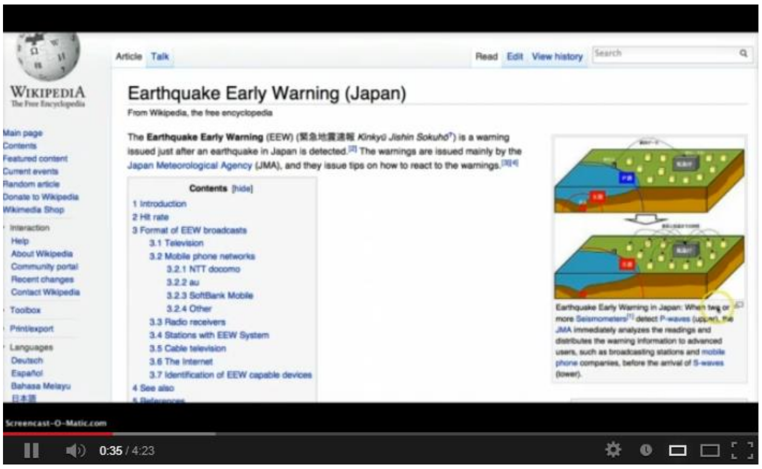
None are expected.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	**€€**	D2D travel time	**0**	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	**€€**	D2D travel costs	**(X)**	Bus and coach usage	**0**	Congestion	**0**
Financial viability	✓	Comfort and convenience	**0**	Rail usage	**0**	CO2 emissions	**0**
Technical feasibility	**0**	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Earthquake Early Warning in Japan



http://www.youtube.com/watch?v=rygXlEn400g

1.3.3 European train control system

Solution family: Transportation Management Systems

Sub-family: Railway Traffic Management

Domain of application: Long-distance

Technology behind: Eurobalise (radio beacons); On-Board Computer; Lineside Electronic Units

Status: implemented

Links to relevant references

- ERTMS, European Railway Agency
- ERTMS
- European Train Control System, Wikipedia

Description

Concept and problems addressed. The European Train Control System (ETCS) is a European technical standard for ón-cabôtrain signalling and speed control. Train Control Systems serve to automatically control the speed of trains so as to enhance safety. To do this, information is transmitted from the ground to the train, where an on-board computer uses it to calculate the maximum authorised speed and then automatically slows down the train if necessary; however, as of 2012, there were more than 20 different such systems in operation throughout Europe. Their incompatibility is seen as a major technical barrier to the growth of international traffic, as in order to be able to circulate on networks equipped with different systems, either the locomotives must be changed at the borders (resulting in considerable lost time) or the locomotives must be equipped with different on-board systems compatible with the different track systems used by the different networks (increasing costs and risk of breakdown). Consequently, each border adds significant extra costs and delays, damaging railõs competitiveness for cross-border traffic.

ETCS has been designed to be a European standard so as to reduce and ultimately eliminate these interoperability problems. It exists at four different levels:

- Level 0 ï defines the way in which ETCS-compliant locomotives interact with lineside equipment which is non-ETCS-compliant;

- Level 1 ï defines the way in which ETCS compliant and non-ETCS-compliant equipment can co-exist on the same line;

- Level 2- defines a dedicated system that has lineside ótrain integrity supervisionö, and

- Level 3 - defines a system in which ótrain integrity supervisionôis transferred to the train driver.

ETCS is part of the European Rail Traffic Management System (ERTMS). It is thought that ERTMS as a whole will significantly increase the competitiveness of rail transport, particularly in relation to freight when the system is deployed in a coordinated manner along a corridor.

One significant side effect of the systems is that, where it is implemented, there is significant scope for data collection, as the system is automatically recording location-specific data on train movements and speeds.

Targeted users. The users comprise rail infrastructure managers and train operators. Currently, in excess of 4,000 km of lines in Europe are equipped with ETCS, and contracts to equip more than

4,000 further kilometres are already in place. Furthermore, it has become the global reference standard for new rail lines outside of Europe.

Barriers to Implementation

Financial issues. Cost-benefit analyses for ETCS corridors indicate an expected positive outcome, though the incidence of costs and benefits do not fall proportionately across the industry. Investment costs are initially high, particularly for train operators investing in the on-board equipment. UK experience is of a cost of approximately £300,000 per unit, though over the medium term, standardisation is likely to lead to equipment costs falling due to a mix of competition and economies of scale effects. Once ETCS is implemented along a whole corridor, railway operation with locomotives including just one CC-system becomes possible, resulting in reduced equipment and training costs over the medium term. For example, eliminating the costs of adding additional national safety systems in existing locomotives and obtaining again all safety authorisations is estimated to save in excess of ú2 million per locomotive and takes more than two years. The shifting of the equipment from track to rolling stock results in lower maintenance costs for infrastructure managers.

Whilst there are no direct revenue benefits, it is reasonable to expect that the interoperability improvements brought about via ETCS will lead to enhanced efficiency of operation, faster journey times and increased rail demand ï both for passengers and freight.

Technical barriers. None, the system exists.

Organisational complexity. The certification process for ETCS components is still rather complicated and cost-intensive. Furthermore, migration to ETCS remains a difficult issue. ñNaturalò migration would mean that national legacy systems would be replaced by ETCS according to their particular end of lifetime, step by step. This would be highly different along defined corridors and implies that interoperability would be achieved only in the long term. Alternatively, ñfastò migration implies removal of national systems prior to their full depreciation, which becomes a financial challenge. It has been suggested that ETCS migration is a multi-dimensional optimisation problem.

Legal issues. None.

User and public acceptance. Neither the general public nor rail users will even be aware of the system, so their acceptance is not an issue. However, in this case it is the rail operators, who are the actual users of the system, and their acceptance of the system is high, since they are aware of the systemœs long-term benefits, and the only reason why it is not yet more widely introduced are the costs of migration.

Interest for Travellers

Door to door travel time. The deployment of ETCS will reduce travel times for cross-border traffic.

Travel cost. No impact is expected.

Comfort and convenience. No impact.

Safety. Standardisation of the technology will lead to harmonisation of RAMS figures at a high level in future ETCS networks, and thus to a safety improvement within international railway transport.

Security. No impact.

Accessibility for impaired. No impact.

Modal change

It is widely argued that the deployment of ETCS will greatly improve the competiveness of European railways and therefore lead to a mode change towards rail travel.

Other notable impacts

Mobility. The increased speed of rail travel may induce a small increase in international mobility.

CO2 emissions. The expected modal shift from car and air to rail travel will help reduce CO2 emissions.

Territorial cohesion. The encouragement of cross-border rail travel will make some contribution towards increased territorial cohesion.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	✓	Car usage	(-)	Mobility	(✓)
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	0	Rail usage	+	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	X	Security	0	Aeroplane usage	(-)	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	(✓)
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

1.3.4 GSM-R (voice radio system)

Solution family: Transportation Management Systems

Sub-family: Railway Traffic Management

Domain of application: Long-distance

Technology behind: GSM (Global System for Mobile communications); transceivers; control panels; handsets; antenna.

Status: Implemented (adopted in 38 countries worldwide, including all EU member states with railways).

Links to relevant references

- GSM-R ï the only approved world telecom standard for railways
- GSM-R - wikipedia

Description

Concept and problems addressed. GSM-R serves to provide secure voice and data communications between trains and ground based organisations and personnel. Specifically, it enables communications between various railway operations staff, including drivers, dispatchers, train engineers and station controllers. These communications can take the form of group calls, voice broadcasts, location-based communications and call pre-emption (in the case of emergencies); it also carries signalling information directly to the train driver. In turn, it facilitates various applications, such as cargo-tracking, video surveillance and passenger information services.

GSM-R was developed with the aim of being an interoperable and cost-effective digital replacement for a range of incompatible cable and analogue systems previously in existence across Europe. It was developed within Europe, and tested and established via the EU project MORANE (Mobile Radio for Railways Networks in Europe), but has since been adopted in countries throughout Asia and Australasia.

Its principal function is to transmit data between trains and railway regulation centres with ETCS levels 2 and 3. As trains pass over the Eurobalise they transmit their current location and speed and receive agreement to enter the next track section (or not), with notification of any change in maximum allowable speed. Where this occurs via a common, interoperable communications standard, average speeds can increase as a result of optimised breaking points, maximum speeds can increase as ôline of sightô signals can be replaced with radio, track capacity can increase as a result of minimising inter-train distances and border crossings are eased. A common standard also brings with it economies of scale for equipment manufacturers, which may be passed on to industrial purchaser in the form of cost reductions.

Targeted users. Rail infrastructure managers and train operators.

Barriers to implementation

Financial issues. The costs specific to GSM-R are explicitly omitted from the only systematic review of ERTMS financing, and so numbers are difficult to estimate. However the operational costs should be, if anything, lower than with the old system, given that it is easier to use.

Technical barriers. With adoption in 38 countries, these now seem to have been overcome.

Organisational complexity. There having been agreement on the technical standard, there is no significant organisational complexity.

Legal issues. There are no known legal issues with this solution.

User and public acceptance. Being an application intended for operators alone, the general public is likely to be rather indifferent to this application.

Interest for Travellers

Door to door travel time. Minor benefits, as average and maximum allowable speeds on Europe's railways are increased.

Travel cost. Minor disbenefits, depending on the extent to which the costs of the system are recouped from the passenger and/or freight customer.

Comfort and convenience. No impact is expected.

Safety. Minor to moderate benefits, as an already safe system is made safer.

Security. No impact is expected.

Accessibility for impaired. No impact is expected.

Modal change

Minor impact, depending on the combined effects of reduced travel times, potentially increased travel costs and on other factors extraneous to the rail network (e.g. road congestion).

Other notable impacts

Mobility. The increase in the capacity of the rail network, combined with the higher speeds could marginally increase mobility.

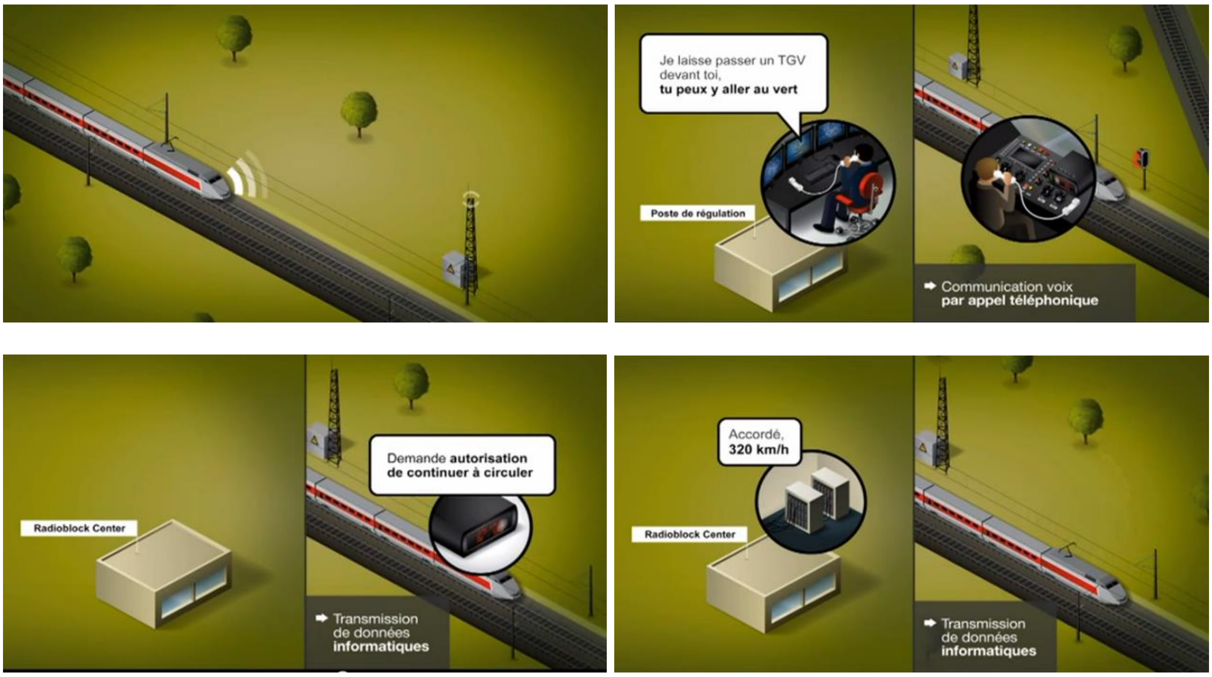
Territorial cohesion. The system eases border crossing

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	0	Mobility	(✓)
Operation and maintenance costs	€	D2D travel costs	(X)	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	0	Rail usage	✓	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	✓
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

GSM-Rail



http://www.youtube.com/watch?v=PGfy-sWzKDU

1.4 AIR TRANSPORT MANAGEMENT

1.4.1 Single European Sky ATM Research (SESAR)

Solution family: Transportation Management Systems

Sub-family: Air Transport Management

Domain of application: Long-distance

Technology behind: Not Available

Status: In development

Links to relevant references

- What is the SESAR project? Single European Sky ATM Research European Commission
- SESAR Joint Undertaking
- European ATM Master Plan SESAR Joint Undertaking

Description

Concept and problems addressed. Contrary to the United States, Europe does not have a single sky, one in which air navigation is managed at the European level. Furthermore, European airspace is among the busiest in the world with over 33,000 flights on busy days and high airport density. This makes air traffic control even more complex.

The EU Single European Sky is an ambitious initiative launched by the European Commission in 2004 to reform the architecture of European air traffic management. It proposes a legislative approach to meet future capacity and safety needs at a European rather than a local level.

The Single European Sky is the only way to provide a uniform and high level of safety and efficiency over Europeǒs skies.

The SESAR project (formerly known as SESAME) is the European air traffic control infrastructure modernisation programme. SESAR aims at developing the new generation air traffic management system capable of ensuring the safety and fluidity of air transport worldwide over the next 30 years.

The SESAR project is composed of three phases:

- A definition phase (2004ï 2008), to deliver an Air Traffic Management (ATM) master plan defining the content, the development and deployment plans of the next generation of ATM systems. This definition phase is led by Eurocontrol, and co-funded by the European Commission under the Trans-European Transport Networks programme and executed by a large consortium of all air transport stakeholders.
- A development phase (2008ï 2013), to produce the required new generation of technological systems and components as defined in the definition phase. This phase (budget: ú 2.1 billion) is managed by the SESAR Joint Undertaking.
- A deployment phase (2014ï 2020), for a large-scale production and implementation of the new air traffic management infrastructure, composed of fully harmonised and interoperable components which guarantee high performance air transport activities in Europe.

The key objectives are to

- Restructure European airspace as a function of air traffic flows;
- Create additional capacity; and
- Increase the overall efficiency of the air traffic management system.

The major elements of this new institutional and organisational framework for ATM in Europe consist of:

- Separating regulatory activities from service provision, and the possibility of cross-border ATM services;
- Reorganising European airspace that is no longer constrained by national borders;
- Setting common rules and standards, covering a wide range of issues, such as flight data exchanges and telecommunications.

The SESAR programme comprises of 16 work packages covering the fields of

- Operational activities;
- System development activities;
- System Wide Information Management; and
- Transverse activities.

To highlight just a few of the work packages of SESAR:

- Enhance operational procedures for the reduction of CO2 emissions for all phases of flight, for which Atlantic Interoperability Initiative to Reduce Emissions (AIRE) is an example;
- En-Route Operations, where e.g. Airborne Separation Assistance Systems (ASAS) are handled;
- En Route trajectory and separation management, where Performance-based navigation is a key issue;
- Airport Operations, like Advanced Surface Movement Guidance and Control Systems, A-SMGCS (see separate Application factsheet);
- Network Operations to which Airport Collaborative Decision Making (ACDM) is belonging,
- Aircraft Systems, like Airborne Separation Assistance System (ASAS) using Automatic Dependent Surveillance-Broadcast, ADS-B (see separate Application factsheet);
- En route & Approach ATC Systems for which the OSYRIS, Air Traffic Management software for Queue Management is an application; and
- Terminal Operations to which Approach Procedures with Vertical guidance (APV) using EGNOS belong.

One advantage of these systems is that there is significant potential for gathering data for seconday purposes. Aircraft movements can be monitored to 100%, differentiated by every distinct flight including airline, flight no, from airport, to airport, aircraft type, registration no. of aircraft, change of altitude, altitude, speed, track, time and delay information. The path information can then, for instance, be used for the calculation of area specific emissions in the atmosphere.

Targeted users.

- Airspace Users: Scheduled Airlines, Business Aviation (BA), General Aviation (GA)
- ANSP (Air navigation service provider) & Network Manager,
- Airport Operators,
- Military.

Barriers to Implementation

Overview. SESAR is expected to bring benefits in a variety of areas: reduction in fuel consumption through better flight profiles and fewer delays, a decrease in ANS[11] cost per flight, an increase in capacity at airports and in the airspace to meet traffic demand. The increase in capacity will also limit ATFM delays and reduce flight cancellations due to capacity shortages.

SESAR is also expected to improve predictability of operations by reducing the variability of flight duration (block-to-block). The benefits of improved quality of service have not been quantified at this stage but will further be assessed as part of SESAR activities.

The following table shows the targeted benefits per key performance area:

Key Performance Area	Validation Targets	Benefit
Environment/ Fuel Efficiency	-2.8% of fuel burn per flight	Fuel Cost Savings for Scheduled Airlines CO_2 Savings - Emissions Trading Scheme – reduced costs for Scheduled Airlines
ANS Cost Efficiency	-6.1% of ANS cost per flight	Reduction in ANS Charges per flight to Scheduled Airlines
Airspace Capacity	+27% of airspace throughput	Delay Cost Savings to Scheduled Airlines
Airport Capacity	+14% of runway throughput	Unaccommodated Demand - Value of additional flights at Airports to Scheduled Airlines Airport Capacity - Value of additional flights to Airports Flight Cancellation Cost Savings to Scheduled Airlines due to Low Visibility Improvements Avoidance of Reduced Profits for Airports from Flight Cancellations due to Low Visibility Conditions

Financial issues. The following table provides the detailed assessment of the Deployment Baseline consisting of operational and technical solutions that have successfully completed the R&D phase and have been implemented or are being implemented and the two packages (1: Basic Package, essential scenario; 2: Target package, full scope scenario). Investment costs for scheduled airlines, airports and ANSPs are given in low-high ranges of values reflecting the uncertainty and variability in costs. The variability and uncertainty result from factors such as the nature of the ground architecture and systems in place, type of aircraft and avionics, characteristics of the operating environment and the uncertainty in the technological changes required.

[11] *Air navigation services*

SESAR Step 1 and Deployment Baseline				Basic Package	Target Package
AIRSPACE USERS	Retrofit	Scheduled	Single Aisle	504-867 M€	1 725-2 736 M€
			Long Range	271-465 M€	927-1 471 M€
			Regional	287-695 M€	584-1 421 M€
			Scheduled Total	***1 062-2 027 M€***	***3236 – 5 628 M€***
		BA		1 100 M€	2 524 M€
			BA Total	***1 100 M€***	***2 524 M€***
		GA	IFR	183 M€	256 M€
			VFR	116 M€	246 M€
			GA Total	***299 M€***	***502 M€***
		Military		*Not Assessed*	*Not Assessed*
			Military Total		
	Forward fit	Scheduled	Single Aisle	666-771 M€	1 627-1 853 M€
			Long Range	357-413 M€	870-993 M€
			Regional	224-886 M€	506-1 492 M€
			Scheduled Total	***1 247-2 070 M€***	***3 003-4 338 M€***
		BA		1 603 M€	3 768M€
			BA Total	***1 603 M€***	***3 768 M€***
		GA	IFR	155 M€	224 M€
			VFR	66 M€	163 M€
			GA Total	***221 M€***	***387 M€***
		Military		*Not Assessed*	*Not Assessed*
			Military Total		
	Total (Retrofit + Forward fit)	Scheduled	Single Aisle	1 170-1 638 M€	3 352-4 589 M€
			Long Range	628-878 M€	1 797-2 464 M€
			Regional	511-1 581 M€	1090-2 913 M€
			Scheduled Total	***2 309- 4 097*** M€	***6 239-9 966*** M€
		BA		2 703 M€	6 292 M€
			BA Total	***2 703 M€***	***6 292 M€***
		GA	IFR	338 M€	480 M€
			VFR	182 M€	409 M€
			GA Total	***520 M€***	***889 M€***
		Military		*Not Assessed*	*Not Assessed*
			Military Total		
	Airspace Users Overall Total			***5 532-7 320M€***	***13 420-17 147 M€***
ANSP & NETWORK MANAGER	Civil including Network Manager			2 140-4 200 M€	3 562-6 500 M€
	Military			*Not Assessed*	*Not Assessed*
	ANSP & Network Manager Total			***2 140-4 200M€***	***3 562-6 500 M€***
AIRPORT OPERATOR	Civil			837-2 534 M€	3 070-5 289 M€
	Military			*Not Assessed*	*Not Assessed*
	Airport Operator Total			***837-2 534 M€***	***3 070-5 289 M€***
			OVERALL TOTAL	***8 590-14 054 M€***	***20 052-28 936 M€***

These costs outlined are expected to lead to the following estimated benefits.

Figure 25 **Yearly Benefits in M€ Deployment Baseline + Step 1 (2014-2030)**

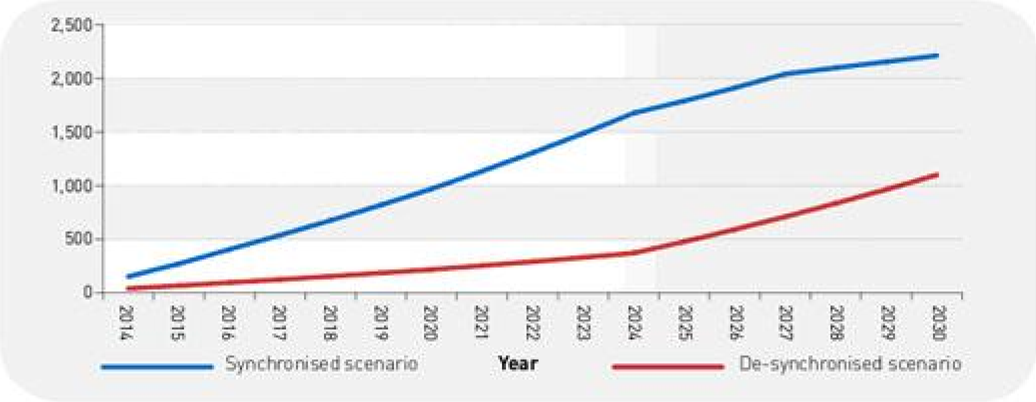
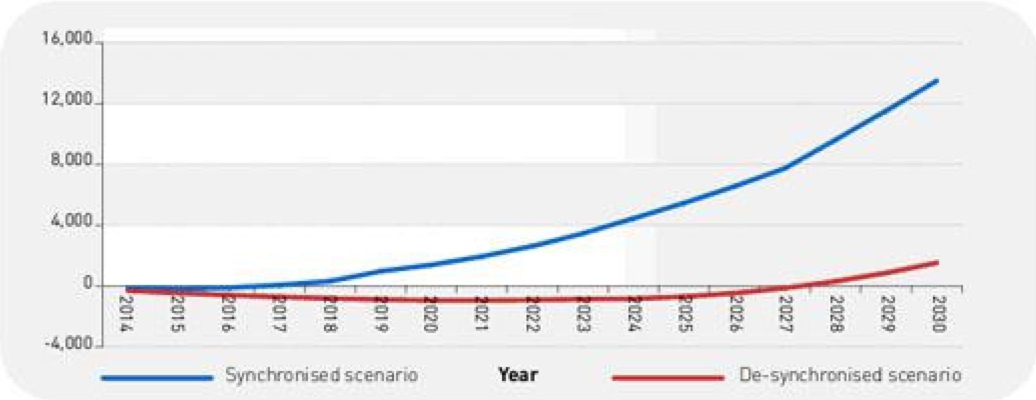


Figure 26 **Net Cumulative Benefits in M€ Deployment Baseline + Step 1 (2014-2030)**



and combine to a cost benefit synthesis:

Bn€ (2014-2030)	Synchronised Scenario	De-synchronised Scenario
Cumulative cost	-8.1	-5.3
Cumulative benefit	21.7	6.8
Net cumulative benefit	13.5	1.6
NPV 2014-2030	5.2	0.0

The main risk of SESAR deployment results from the partial disconnection between investments and the realisation of benefits. Not only is it the case that a timing lag is likely to occur between upfront investment costs and the gradual generation of subsequent benefits, but also that such benefits might only be realised when several stakeholders deploy in a reciprocal, synchronised and timely manner.

Technical barriers. Air traffic management (ATM) is linked to national boundaries and therefore fragmented in the application of national technical solutions. These have to be harmonised and consolidated, so that a technical compatibility is ensured. The same holds for air navigation installations at airports.

Organisational complexity. Stakeholders have expressed concerns regarding the extent to which they are reliant on the cost performance of other stakeholders, over whom they have no control, in order to obtain the expected SESAR benefits. The risk is to create a last-mover advantage whereby each stakeholder would wait until all others have proceeded with SESAR investments.

This should be addressed through the effective implementation of SESAR deployment governance and incentive mechanisms.

The ICAO framework is set through the Global Air Navigation Plan (Doc 9750), which comprises the ―Aviation System Block Upgrades‖ (ASBU) initiative, developing a set of ATM solutions or upgrades that exploits current equipage, establishes a transition plan and enables global interoperability. ASBUs comprise a suite of modules organised into flexible and scalable building blocks where each module represents a specific, well bounded improvement. The ASBU initiative describes a way to apply the concepts defined in the ICAO Global Air Traffic Management Concept (Doc 9854) with the goal of implementing regional performance improvements.

For the development of the ASBUs, ICAO made use of the material provided by SESAR and NextGen. From a SESAR perspective, mapping ICAO‗s ASBU initiative is important to achieve global interoperability and synchronisation where and when necessary. To support global interoperability it is necessary that the operational achievements in the Master plan are consistent with the elements in the ASBUs.

However, once the systems are widely implemented, they will help relieve the administrative burden in air traffic management.

Legal issues. The SESAR Joint Undertaking (SJU) is a Community Body which has been established under Article 187 of the Treaty. As such, the SJU possesses its own legal personality but is distinct from Community institutions such as the Council, Parliament, Commission, etc

Therefore, the SJU is subject to the provisions of the Financial Regulation applicable to the general budget of the European Communities, the SJU Financial Regulation and the relevant directives relating to the coordination of procedures for the award of public contracts.

The SJU calls for tenders, which are subject to the Public Procurement Directive 2004/18/EC for supply of goods, services and works, are advertised on the SJU website, once mandatory publication has taken place in the Official Journal of the European Union.

User and public acceptance. Air travellers and the general public will generally not even be aware of the implementation of any of the SESAR components, so their acceptance is not an issue. However, the target users here are the air traffic operators, and while they will see the potential advantages of the systems, they will, as discussed above, be reluctant to be the first ones to introduce these systems.

Interest for Travellers

Door to door travel time. Shortened flight paths, reduced times needed for ground movements of aircrafts, a decrease of delays caused by punctual capacity overloads as airports as well as in the air space will lead to shortened travel times in air transport and may be incorporated by the airlines into their published flight schedules.

Travel cost. Although significant cost savings are likely to apply when deploying the ATM master plan of SESAR for all stakeholders involved in air transport, it cannot be guaranteed thatthese cost savings will materialise in reduced air tariffs. However, in the current strongly competitive environment it seems likely that at least some airlines will reduce their prices, and other may then be forced to follow suit.

Comfort and convenience. No impact.

Safety. Several measures undertaken under the SESAR umbrella will significantly improve the safety of air transport. Especially Airborne Separation Assistance Systems, Performance-based navigation and Advanced Surface Movement Guidance and Control Systems have to be mentioned in this context.

Security. No particular impacts.

Accessibility for impaired. No impacts.

Modal change

Cutting the portion of actual flight time in the overall time needed for travelling by air which may increase due to enlarged check-in times (e.g. for the security checks at airports) and also increased fuel efficiency both resulting in competitive overall costs and travel times when going by air, strengthen the market position of air transport.

Other notable impacts

Mobility. The travel time savings may marginally increase overall mobility

Congestion and emissions. The projected fuel savings lead to a measurable reduction of emissions caused by air transport.

European economic progress. It can be argued that the efficiency improvements in air traffic will contribute to wider European economic progress.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	(-)	Mobility	(✓)
Operation and maintenance costs	€€€	D2D travel costs	✓	Bus and coach usage	0	Congestion	✓
Financial viability	✓	Comfort and convenience	0	Rail usage	(-)	CO2 emissions	✓
Technical feasibility	0	Safety	✓✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	(+)	European economic progress	✓
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	(X)						
Public acceptance	0						

Illustrative materials

Sesar Joint Undertaking Video:

http://www.sesarju.eu/news-press/gallery/videos?video=393

For a huge project like SESAR there is a special multimedia gallery

http://www.sesarju.eu/news-press/gallery

1.4.2 Enable air routes as the crow flies

Solution family: Transportation Management Systems

Sub-family: Air Transport Management

Domain of application: Long-distance

Technology behind: ATC (Air Traffic Control System). The operational implementation of Free Route Airspace Maastricht (FRAM) is closely linked with the technical deployment of features of the high-tech air traffic control system in place at MUAC (Maastricht Upper Area Control Centre). Systems are maintained and managed in-house in line with operational requirements. With only slight modifications to the existing software, technical and operational staffs were able to prove during real-time simulations that the system can fully support FRAM operations. Controller-Pilot Data-Link Communications (CPDLC) is an air/ground data-link application operated at the Maastricht Upper Area Control Centre, which enables the exchange of text messages between controllers and pilots.

Status: Implemented

Links to relevant references

- Free Route Airspace Maastricht - FRAM EuroControl
- Pioneering new technologies EuroControl

Description

Concept and problems addressed. Recent studies have demonstrated that air routes in Europe are not optimally designed. In 2009 a flightœs route was on average 47.6 km (or 5.4%) too long compared to its optimum flight trajectory. Deviations from the optimum flight trajectory generate additional flight and engine running time, fuel burn, gas emissions and costs to the industry. Extended air routes are due to several factors, e.g. sub-optimal airspace design, inefficient city pairs, constraints related to the need for civil and military airspace users to share the airspace, inappropriate flight planning and route utilisation or route restrictions.

So far, significant emphasis has been put on initiatives to improve airspace design and network management and to reduce flight route extension. One of the most significant developments in the core area of Europe is the introduction of a Night Route Network in the Functional Airspace Block Europe Central (FABEC) area, the busiest of Europeœs nine functional airspace blocks.

The FRAM programme complements the FABEC Night Network programme and provides an initial operational validation for conceptual elements of the Single European Sky Air Traffic Management Research (SESAR ï see separate factsheet) Air Traffic Management Target Concept. FRAM is all about planning, filing and flying direct routes in one of the densest areas of the continent. FRAM is therefore a first step towards the implementation of aircraft operatorsô preferred business trajectories, which will allow pilots to choose their entry and exit points freely in a given airspace and fly their preferred route.

Free route airspace refers to a specific portion of airspace within which aircraft operators may plan a route freely between a defined entry point and a defined exit point, with the possibility of deviating via intermediate navigation points without reference to the fixed route network. Within this airspace, flights remain at all times subject to air traffic control and to any overriding airspace restrictions.

Targeted users. Air traffic controllers, aircraft operators, pilots.

Barriers to Implementation

Financial issues. In 2011, MUAC❝s annual costs amounted to EUR 116 million while the annual route charges generated in the same year amounted to EUR 436 million.

With an economic gate-to-gate cost effectiveness indicator of EUR 238 per composite flight-hour in 2011, MUAC is one of the most cost-effective air navigation service providers in Europe. The European system average stands at EUR 544. The cost-effectiveness indicator in Europe ranges from EUR 179 to EUR 849 (Source: ATM Cost Effectiveness 2010 Benchmarking Report, May 2012).

The MUAC airspace covers 260,000 km2 of high-density cross-border upper airspace above the Benelux and north-west Germany. The annual benefits expected in this airspace alone as a result of the new 142 direct routes amount to 1.16 million km of saved flight distance and 1,300 hours of saved flight time. This equates to flying 29 times around the world.

Technical barriers. In a bid to constantly improve levels of service for the travelling public, air navigation service providers must remain on the look-out for innovative ways of doing things. MUAC's long tradition of being at the forefront of technology has contributed to introducing some of the industry❝s most innovative technological solutions. This new generation of air traffic control technologies will support the pre-operational validation of future concepts in support of the SESAR development phase in, or close to, a real operational environment.

- Flight data processing system
- Traffic Management System
- Mode S

Organisational complexity. Unrestricted free route airspace cannot be envisaged within the MUAC area of responsibility owing to the complexity of the airspace and the nature and density of traffic. Because flight profiles are no longer aligned with routes, there is a greater number of random crossing points. Airspace Management Cell manageable airspace structures remain unaltered. All airspace users have equal access to FRAM.

Legal issues. For a cross border application like FRAM the countries involved have to agree on a treaty enabling it.)n 2 December 2010, Ministers of Transport and high-level military representatives from Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland signed the FABEC Treaty in Brussels, which alos provides the framework for FRAM. With their signatures, the six States involved are establishing a common functional block of airspace. They have put a framework in place for air navigation service providers to improve their performance in terms of safety, environmental impact, capacity, cost effectiveness, shorter routes and military mission effectiveness.

User and public acceptance. The public is not aware of any of this, so their acceptance is not an issue, but acceptance by the users, in this case the flight operators, is very high, since they are the main beneficiaries of the system.

Interest for Travellers

Door to door travel time. Flight times are cut substantially and therefore also the total travel time for air transport.

Travel cost. Savings of flight time and related aircraft operation costs together with fuel savings lead to decreasing costs for flying, and in a competitive market, at least part of these savings are likely to be passed on to the customers.

Comfort and convenience. No particular impact.

Safety. In spite of high traffic density, dense climbing and descending air traffic patterns and airspace complexity, MUAC records the highest controller productivity among Europe's 37 air navigation service providers, i.e. 1.95 composite flight-hours per controller hour in 2011. The European average stands at 0.77 (Source: ATM Cost Effectiveness 2010 Benchmarking Report, May 2012). Increasing the productivity in ATC helps to keep the level of work load for the controller at a standard which ensures safety of air transport when traffic levels grow.

Security. No impacts.

Accessibility for impaired. No impacts.

Modal change

Cutting the portion of actual flight time in the overall time needed for travelling by air and also increased fuel efficiency both resulting in competitive overall costs and travel times when going by air, strengthen the market position of air transport.

Other notable impacts

Congestion. The more efficient use of airspace relieves congestion; however, the increased capacity is then used for additional flight routes, so the overall level of congestion remains the same.

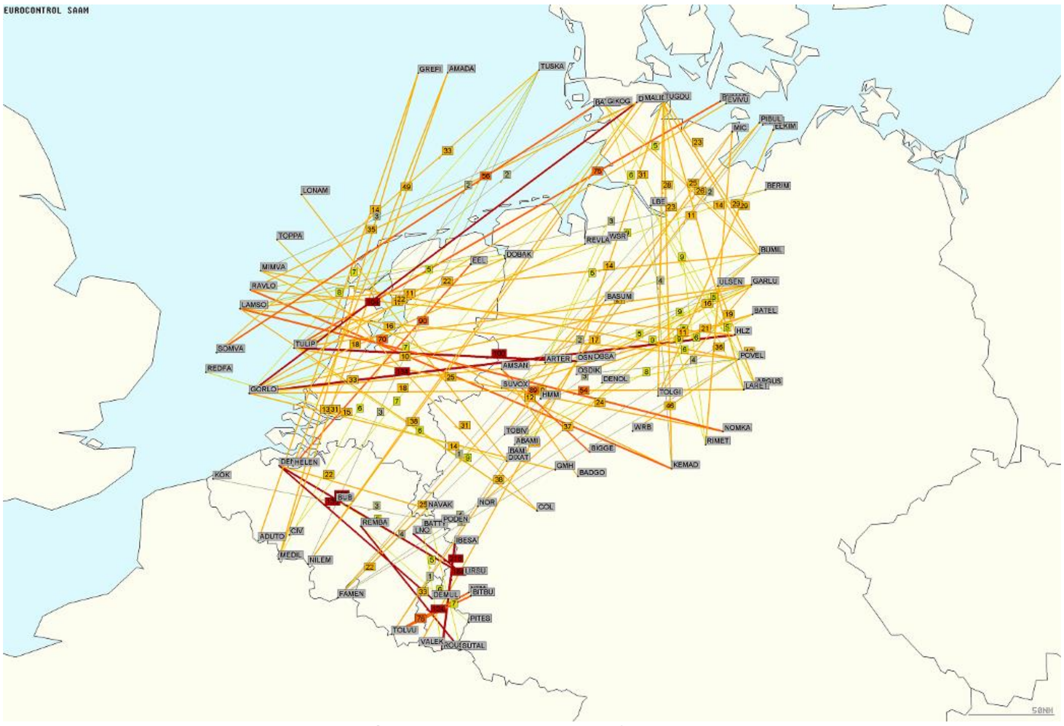
CO2 emissions. The annual benefits amount to a saving 3,900 t of fuel, 12,300 t of CO2 and 52 t of NOX (calculations are based on the average consumption of an A320). So a remarkable positive environmental effect applies.

European economic progress. The possibility to create to create new flight routes makes a small contribution to European economic progress.

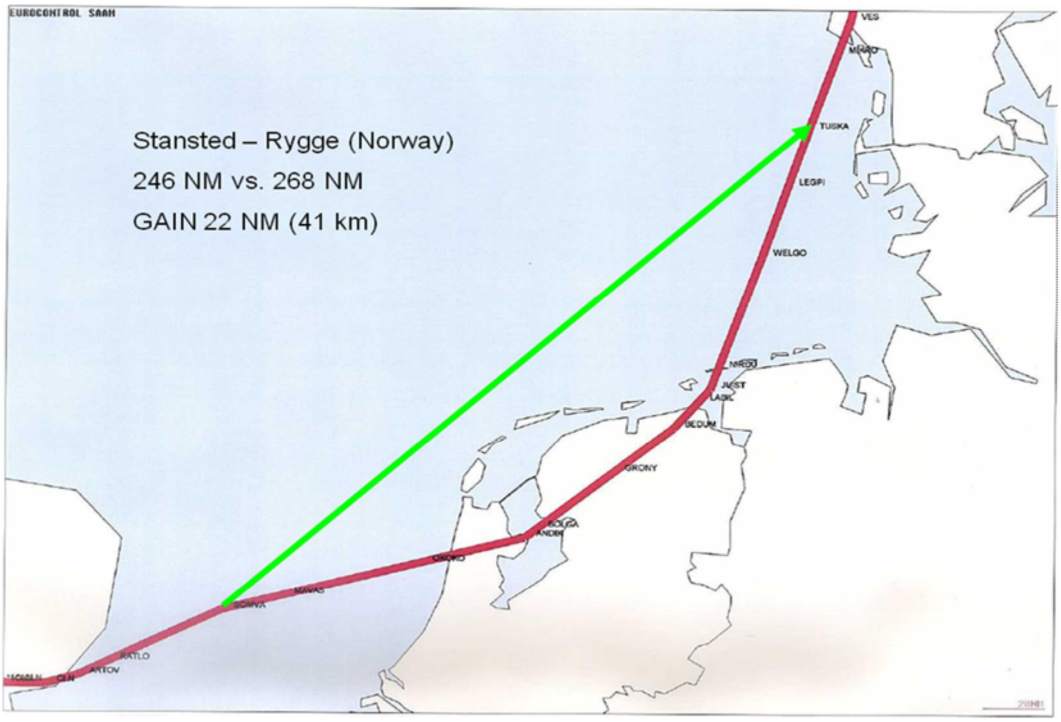
Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€€€	D2D travel costs	✓	Bus and coach usage	0	Congestion	✓
Financial viability	✓✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	(+)	European economic progress	(✓)
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials



The 142 new routes of FRAM



Shortening of the air route from London Stansted to Osly Rygge by FRAM

http://www.youtube.com/watch?v=0sfSC2fIAi0
The FUTURE. Today

1.4.3 Accurate weather information for air navigation

Solution family: Transportation Management Systems

Sub-family: Air Transport Management

Domain of application: Long-distance

Technology behind: Network enabled database via internet.

Status: Under development

Links to relevant references

- NextGen Network Enabled Weather (NNEW) US - Federal Business Opportunities
- NextGen Network Enabled Weather (NNEW) Research Applications Laboratory (RAL) - The National Center for Atmospheric Research (NCAR)
- NextGen Network-Enabled Weather Overview Oliver Newell (MIT Lincoln Laboratory), Aaron Braeckel (NCAR), Chris MacDermaid (NOAA/ESRL), 14 May 2009
- NextGen Network-Enabled Weather (NNEW) Aaron Braeckel, Briefing to NCAR and NOAA staff, Dec 2009, National Center for Atmospheric Research

Description

Concept and problems addressed. Next Generation (NextGen) Network Enabled Weather (NNEW) is a project to develop a 4-dimensional (all points, lateral, vertical and time dimensions) weather data cube (4-D Wx Data Cube) from disparate contributors and locations.

Weather has a considerable impact on aviation operations. Providing the accurate and timely weather information required by aviation decision makers is an element of the Next Generation Air Transportation System. This will increase airspace capacity, improve efficiency, and improve air safety.

NNEW will provide fast access to weather information to all National Airspace System users by the provision of the 4-D Wx Data Cube. The 4-D Wx Data Cube will consist of:

1. A virtual weather network containing data from various existing databases within the Federal Aviation Administration (FAA), National Oceanic and Atmospheric Administration (NOAA) and the United States Department of Defense (DOD), as well as participating commercial weather data providers;
2. Ability to translate between the various standards so that data can be provided in user required units and coordinate systems;
3. The ability to support retrieval requests for large data volumes, such as along a flight trajectory.

A subset of the data published to the 4-D Wx Data Cube will be designated the Single Authoritative Source (SAS). The SAS is that data that must be consistent (only one answer) to support collaborative (more than one decision maker) air traffic management decisions.

Weather data distribution mechanisms are being developed by the NOAA Research Applications Laboratory (NCAR), NOAA Global Systems Division and the Massachusetts Institute of Technology Lincoln Laboratory. Contributions to standards are being made to the Open Geospatial Consortium. Standards and specifications developed and/or used by NNEW will be layered on top of core services provided by the FAA System Wide Information Management (SWIM) program,

Targeted users. Weather stations, air traffic controllers, aircraft operators, pilots

Barriers to Implementation

Financial issues. The development of the data cube is funded by the FAA. In a later stage of the project it is planned to hand out the findings of the research project to the industry. Given the financial start-up of this project by the state, it is expected, that it then will be run profitably by private service providers.

Technical barriers. Since 2007 up to now a number of successful capability demonstrations took place. One of the key challenges was the definition of standards for interfaces for the data providers as well as for the data users.

Organisational complexity. No particular complexity has been identified.

Legal issues. As the principal of weather information (data providers hand out information to those asking for those data) remains unchanged, no legal issues arise.

User and public acceptance. Air operatorsô acceptance will be clearly very high, while public acceptance is not an issue.

Interest for Travellers

Door to door travel time. As the project targets on increased airspace capacity it will strengthen the reliability of air transport due to reduced delays caused by overload of the airspace.

Travel cost. No particular impacts apply.

Comfort and convenience. Improved weather information allows to adapt flight routings better by avoiding meteorological disturbances which increases the comfort of air travel.

Safety. Better weather information increases safety in air transport.

Security. No impacts.

Accessibility for impaired. No impacts.

Modal change

The system will help relieve air congestion.

Other notable impacts

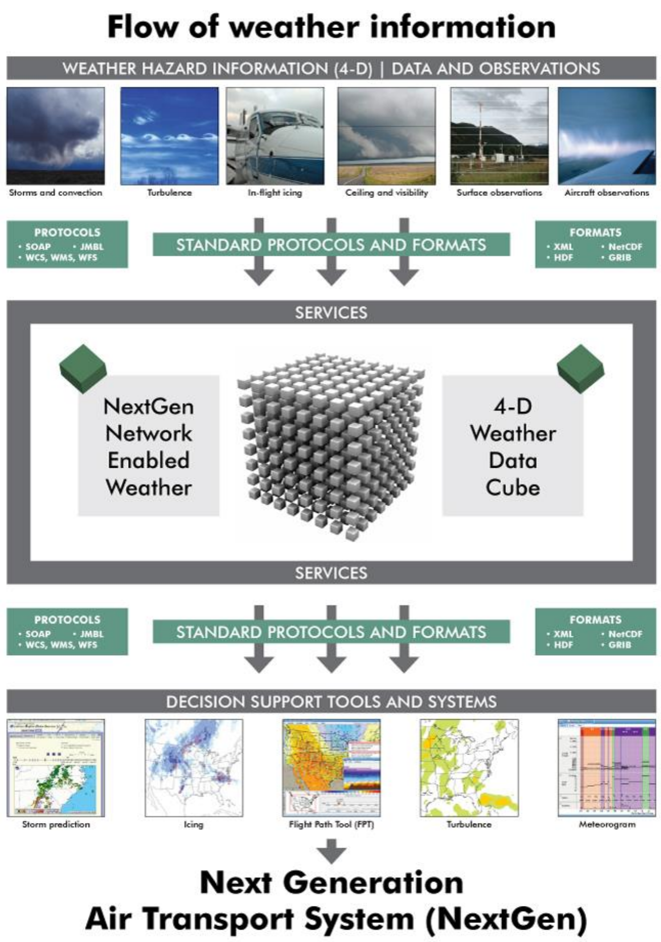
The increase in capacity means, at least temporarily a reduction in air congestion, which in turn leads to a small reduction of CO_2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	(✓)	Car usage	0	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	0	Bus and coach usage	0	Congestion	(✓)
Financial viability	✓	Comfort and convenience	(✓)	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

Video: introduction to NNEW http://www.youtube.com/watch?v=yIqqqQuYZnY



1.4.4 ADS-B: satellite-based successor to radar

Solution family: Transportation Management Systems

Sub-family: Air Transport Management

Domain of application: Long-distance

Technology behind: GPS

Status: Implemented (depending on the area: in service (Europe) or under implementation (USA))

Links to relevant references

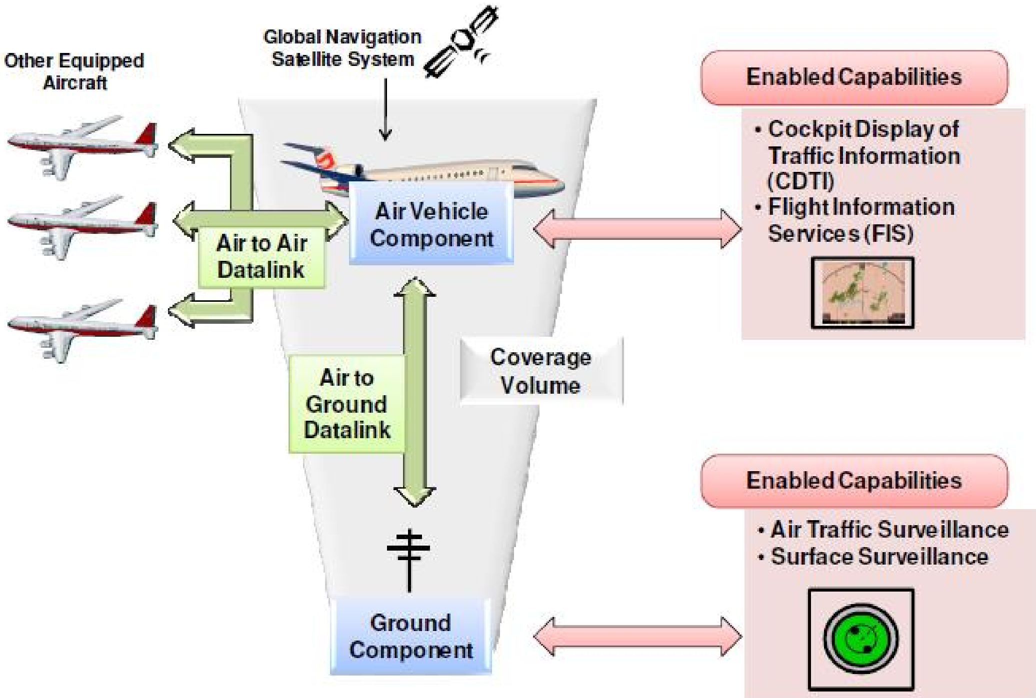
- Fact Sheet ï Automatic Dependent Surveillance-Broadcast (ADS-B) U.S. Department of Transportation Federal Aviation Administration
- Overview of ADS-B Cost Benefit Study CANSO (Civil Air Navigation Services Organisation)
- The fourth meeting of ADS-B study and implementation task force International Civil Aviation Organization
- Mozdzanowska, Aleksandra; et al. "Dynamics of Air Transportation System Transition and Implications for ADS-B Equipage", 7th Aviation Technology, Integration and Operations Conference (ATIO), September 18ï 20, 2007.

Description

Concept and problems addressed. Radar technology dates back to World War II. Radar occasionally has problems discriminating airplanes from migratory birds and rain ñclutter.ò ADS-B, which receives data directly from transmitters rather than scanning for targets like radars, does not have a problem with clutter.

Radars are also large structures that take up a lot of space, are expensive to deploy and maintain, and require the operator to lease the land upon which they are situated. ADS-B ground stations take up only 20 square feet, including the perimeter fence. Ground stations are the size of mini-refrigerators. In the US, under the terms of its contract with ITT Corp., the company that is installing the ground stations, the FAA will only pay for ADS-B signals. The equipment will be owned and maintained by ITT.

Unlike traditional surveillance radar which is a ground based system, ADS-B is a ground/satellite system as shown in the figure below. Its data link enables two-way communications: broadcast to other aircraft and the ground (i.e. ADS-B-in) and aircraft can also receive ADS-B information from other aircraft and receive information from the ground (i.e. ADS-B-out)



Source: Mozdzanowska et al., 2007
ADS-B Architecture

Typical data provided by ADS-B-in include weather, terrain, and traffic (e.g. whereabouts of other aircrafts concerned). Information provided by the ADS-B-out system includes call-sign, altitude, heading, position, squawk number, and speed, which would also enable the Airborne Collision Avoidance System (ACAS) to function.

Some of the biggest benefits provided by the flight tracking system to the Air Traffic Control Officers who manage the aircraft flying within controlled airspace are:

- Increased network efficiency of air transport
- Accurate merging and spacing information
- More consistent level of radar returns
- Alleviates some pressure by allowing improved in-cockpit information to pilots

However, applications enabled by ADS-B vary based on the characteristics of the particular ADS-B avionics and aircraft transponder and require separate standards and certification. Benefits delivered to users depend on individual or combinations of applications that are implemented and on a critical mass of equipage by other operators.

The ADS-B implementation in certain parts of the world such as Europe and Australia is well advanced and the majority of aircraft equipped with ADS-B transponders. In North America, projects like the NextGen ADS-B equipage project will change the way in which American air traffic control works and provide equivalent capabilities on the aircraft and in air traffic control.

Today, roughly 60% of all passenger aircraft (70% in Europe, 30% in the US) are equipped with an ADS-B transponder. This percentage is steadily increasing as ADS-B is set to replace radar as the primary surveillance method for controlling aircraft.

The improved accuracy, integrity and reliability of satellite signals over radar means controllers will be able to safely reduce the mandatory separation between aircraft. This will increase capacity in the skies.

ADS-B also provides greater coverage, since ADS-B ground stations are so much easier to place than radar.

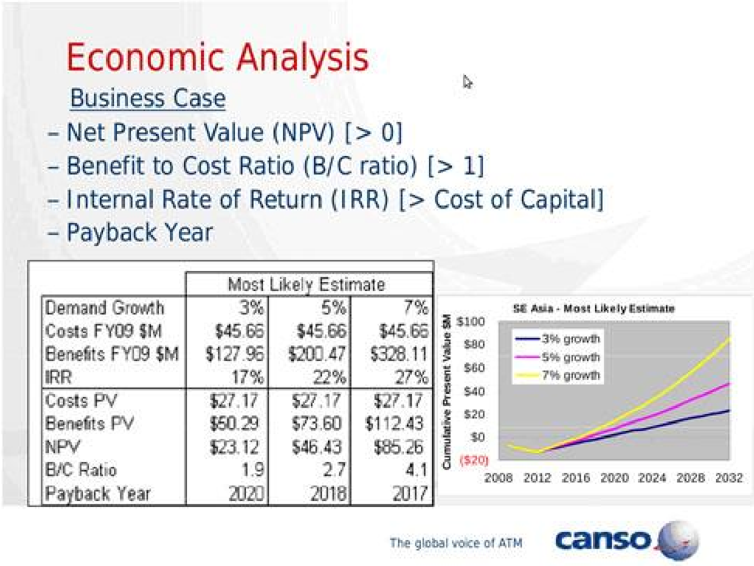
Relying on satellite signals instead of ground-based navigation aids also means aircraft fly more directly from Point A to Point B, saving time and money while reducing fuel burn. United Parcel Service voluntarily equipped approximately 100 of its aircraft with ADS-B avionics, knowing that it will recoup its investment by saving time and money on flights to and from its Louisville hub.
ADS-B will also reduce the risk of runway incursions. Pilots and controllers will be able to see the precise location of aircraft and properly equipped ground vehicles moving on the ground ï even at night or during heavy rainfall.

ADS-B makes it possible to record easily all flight movements. See Flightradar24 as an example, where quite several data are available for every flight in real-time, e.g. airline, flight no, from airport, to airport, aircraft type, registration no. of aircraft, change of altitude, altitude, speed, track, position.

Targeted users. Air traffic controllers, aircraft operators, pilots

Barriers to implementation

Financial issues. On an ICAO (International Civil Aviation Organization) workshop at Bangkok canso (civil air navigation organisation) presented a cost benefit analysis[12] for ADS-B for the area of South-East Asia which showed the following results for an implementation starting in 2009:



	Most Likely Estimate		
Demand Growth	3%	5%	7%
Costs FY09 $M	$45.66	$45.66	$45.66
Benefits FY09 $M	$127.96	$200.47	$328.11
IRR	17%	22%	27%
Costs PV	$27.17	$27.17	$27.17
Benefits PV	$50.29	$73.60	$112.43
NPV	$23.12	$46.43	$85.26
B/C Ratio	1.9	2.7	4.1
Payback Year	2020	2018	2017

Furthermore that analysis stated

- Annual saving of nearly 3 million lbs of fuel burn
- Annual reduction of 10 million lbs of CO_2 emissions
- Total economic savings of over US$ 4 million annually

Technical barriers. No principal barriers exist. The ICAO report mentions some smaller incidents concerning accuracy of transmitted signals. All new built aircraft and the majority of civil aircraft in service have an ADS-B transponder.

Organisational complexity. Full benefits of ADS-B apply only if all aircraft (including small, private ones) are equipped with ADS-B receivers. If frequencies used within ADS-B differ from country to country this may cause additional costs for the aircraft operators.

[12] Overviwe of ADS-B Cost benefit Study, CANSO

Legal issues. To ensure that ADS-B is used by the majority of aircrafts the FAA decided that ADS-B is compulsory equipment for any aircraft to enter class A, B, C or any airspace above 10,000 feet by year 2020.

User and public acceptance. No problems are expected in relation to public acceptance, and big aircraft carriers will welcome the benefits of the system. Only users of private aircraft required to purchase additional equipment may be concerned, although they too should see the benefits of the system.

Interest for Travellers

Door to door travel time. ADS-B increases the capacity of ATC, resulting in reduced delays caused in congested conditions.

Travel cost. For holders of private aircraft the costs for the necessary equipment for ADS-B of about US$ 20,000 significantly increases the costs of flying, while for those flying with larger carriers no change is ot be expected, because the cost of the equipment will be offset by benefits deriving from the increasing air capacity.

Comfort and convenience. No particular impact.

Safety. ADS-B for the first time allows pilots to see what controllers see: other aircraft in the sky around them. Pilots are also able to see ï and avoid ï bad weather and terrain, and receive flight information such as temporary flight restrictions. The improvement in situational awareness for pilots greatly increases safety.

Security. No impacts.

Accessibility for impaired. No impacts.

Modal change

No impacts.

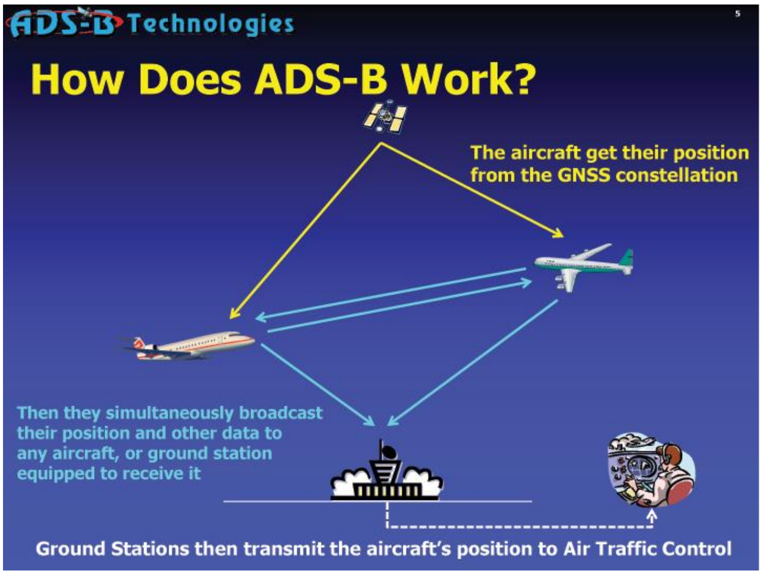
Other notable impacts

The increase in capacity means, at least temporarily a reduction in air congestion, which in turn leads to a small reduction of CO_2 emissions.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€€	D2D travel time	(✓)	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€€€	D2D travel costs	**(X)**	Bus and coach usage	**0**	Congestion	(✓)
Financial viability	✓	Comfort and convenience	**0**	Rail usage	**0**	CO2 emissions	(✓)
Technical feasibility	**0**	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	**0**						
Public acceptance	**0**						

Illustrative materials



Live tracking of aircraft e.g. at http://www.flightradar24.com/

1.4.5 Airplane Surface Movement Guidance and Control Systems at airports (A-SMGCS)

Solution family: Transportation Management Systems

Sub-family: Air Transport Management

Domain of application: Long-distance

Technology behind: DSRC (Dedicated Short Range Communication); CPDLC (Controllerï pilot data link communications); A-SMGCS (Advanced Surface Movement Guidance and Control System); planning/routing software like DMAN, a planning system to improve departure flows at airports by calculating the Target Take Off Time (TTOT) and Target Start-up Approval Time (TSAT) for each flight, taking multiple constraints and preferences into account.

Status: Pilot

Links to relevant references

- European Airport Movement Management by A-SMGCS
- European Airport Movement Management by A-SMGCS Project Summary
- SKYbrary
- Transport Research & Innovation Portal (TRIP)
- Economic Aspects of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) by Joern Jakobi, Michael Roeder, Marcus Biella (DLR), Jürgen Teutsch (NLR)

Description

Concept and problems addressed. Currently airports are considered as the main bottleneck of the Air Traffic Management (ATM) system. Airport delays are a growing proportion of the total ATM delay. An extension of existing airport infrastructures, e.g. building new runways, is very difficult. Therefore, the optimal usage of existing infrastructure becomes more and more important, particularly in adverse weather conditions. Despite the importance of optimal resource usage, operations on the airport airside are more or less managed "manually". To overcome these problems, a considerable amount of research effort in the last two decades concentrated on the development of Advanced Surface Movement Guidance and Control Systems (A-SMGCS).

This led to the development of "higher levels" of an A-SMGCS. Increased support for controllers and pilots through automation is the main characteristic of higher-level A-SMGCS services. New tools like electronic flight strips (EFS) enable faster access to and sharing of relevant information. This again leads to a better planning of airport activities and better monitoring of ground traffic. Overall, communication is made more efficient. Up-to-date information, optimised by planning systems such as a Departure Manager (DMAN), is provided to the controller through EFS. By clicking on the individual strips the controller can easily update and share flight plan data, and pass the flight strip to the next position. In the same way, an optimal taxi route can be calculated for each aircraft by a routing function. When assigned to an aircraft by the controller's click, it is made available electronically within the system. This provides a great safety advantage because, in addition to the aircraft's actual position, the system is now aware of the cleared taxi route. As a consequence a Route Conformance Monitoring function can detect any deviation from the assigned taxi route and warn controllers.

A taxi route which is digitally processed by the system has yet another advantage as it can be electronically transmitted to the cockpit. This type of communication with the cockpit is provided by a data link, "Controller Pilot Data Link Communication", or "TAXI-CPDLC" for short. Similarly, other instructions, such as start-up and pushback, can be transmitted by data link and acknowledged by the pilot. This will save valuable time on the radio channel, and help avoid misunderstandings by ensuring unambiguous transmission of information to the cockpit.

Targeted users. Air traffic controllers, aircraft operators, pilots

Barriers to implementation

Financial issues. All costs refer to the EUROCONTROL ôFinal Report on the generic cost benefit analysis of A-SMGCSö It is assumed that one surface movement radar (SMR) is already available. Main equipment for level 1 would then result in a multi-lateration system (receivers + transmitters), a sensor data fusion, an update of the controller working position, and the equipage of vehicles with Mode-S transponders or similar technologies. For level 2 two additional SMRs would be needed to reduce the probability of false detection (false targets). For both system levels operating costs were calculated. The following concluding cost table was produced:

	Stakeholder	one-off capital costs	one-off implementation costs	TOTAL one off costs	operating costs per annum
Airport A	ANSPs (10 receivers + 2 transmitter, 5 CWP)	2.6M€	0.593M€	3.3M€	0.274M€
	Airports (75 vehicles)	0.150M€	0.019M€	0.169M€	0.019M€
Airport B	ANSPs (20 receivers + 3 transmitters, 10 CWPs)	3.4M€	0.653M€	4.2M€	0.342M€
	Airports (150 vehicles)	0.3 M€	0.038 M€	0.338 M€	0.038 M€
	Airlines	Costs for airlines derive entirely from the service charge passed on by ANSPs and Airport Operators.			

Total Costs of A-SMGCS level 1&2 at a large and medium size airport

Simulations have shown a 5% average increase in throughput in all visibility conditions using A-SMGCS level 1&2. According to the APR business case a 5% increase in throughput would lead to a 25% decrease in delays. It is assumed that, on average, 60% of all delays are caused by bad weather (cross winds, snow, thunderstorms, low visibility, etc). It is further assumed that among those 60% of bad weather delays 40% are generally caused by low visibility where A-SMGCS is expected to have a positive influence (which is a rather conservative estimate). In a nutshell, 25% less delays out of the 40% of delay caused by low visibility would result in a 10% reduction in all weather-related delays.

In accordance to EUROCONTROL with delays being longer than 15 minutes, one minute of delay is assumed to cost 72 EUR. For a medium size airport with 50,000 minutes of weather delay per annum, this would result in savings of 10% * 50,000 minutes * 72 EUR = 360,000 EUR. For large airports with 100,000 delay minutes, this would even lead to savings of 720,000 EUR.

Concerning reduced taxi times simulations in EMMA and the EUROCONTROL A-SMGCS project proved an effect of at least 5% for A-SMGCS level 1&2. With higher level A-SMGCS, this effect is certainly further improved: departure planning (DMAN) as well as onboard guidance (EMM + cleared route) could (independently from each other) further reduce taxi times by an additional 5%.The Westminster Report estimates the costs of delay during taxiing (delays lower than 15 minutes and without additional network effects) at 5 EUR per minute. Assuming the rather conservative delay reduction of 5% of taxi time by an A-SMGCS this would result in 5% * 13 minutes of taxiing in average * 87,500 departures * 5 Euro = 284,000 EUR per annum. For a large Airport 569,000 EUR could be saved per annum. With higher level A-SMGCS services such savings are expected to be doubled or even tripled.

Summing up the savings outlined for the two airports a payback of the investment is possible within three years.

Technical barriers. Although no barriers for implementation apply, there are a number of technical requirements for both the ground side and the airborne side. For details on this refer to EMMA

Technical Requirements Document Part A ï Ground and Technical Requirements Document Part B ï Airborne.

Organisational complexity. For the implementation of A-SMGCS working at different airports under the same conditions and standards an authoritative set of rules has to be agreed, which led to the Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual issued by the ICAO.

Legal issues. An A-SMGCS, due to its potential technical complexity and radical procedure changes, emphasises the need to adopt a certification process that addresses the safety aspects not only of the equipment on board the aircraft, but also of the system or service as a whole.

User and public acceptance. No problems are expected in relation to public acceptance. For users, in spite of the high costs involved, acceptance is expected to be high, since also the benefits are high,

Interest for Travellers

Door to door travel time. The decrease in delays benefits the travellers.

Travel cost. A-SMGCS reduces costs caused by delays, butit can be assumed that these cost savings for the airline / the airport do not lead to reduced air tariffs or airport charges applying to the end-customer.

Comfort and convenience. No particular impact.

Safety. A-SMGCS increases the safety of the aircraft movements at airports in bad weather conditions.

Security. No impact.

Accessibility for impaired. No impact.

Modal change

The effects of A-SMGCS for the end-customer are too small to result in measurable effects on mode choice towards air transport.

Other notable impacts

The reduction in congestion also makes a small contribution to the reduction of CO_2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	(✓)	Car usage	0	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	0	Bus and coach usage	0	Congestion	(✓)
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

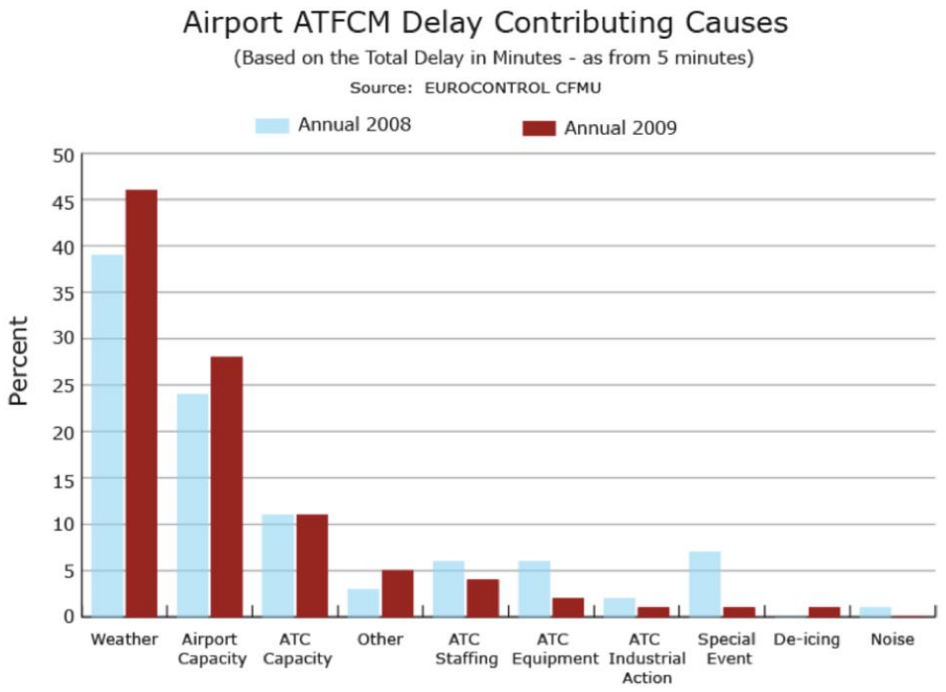


Figure 1: Delays to Air Transport in Europe, Airport ATFCM

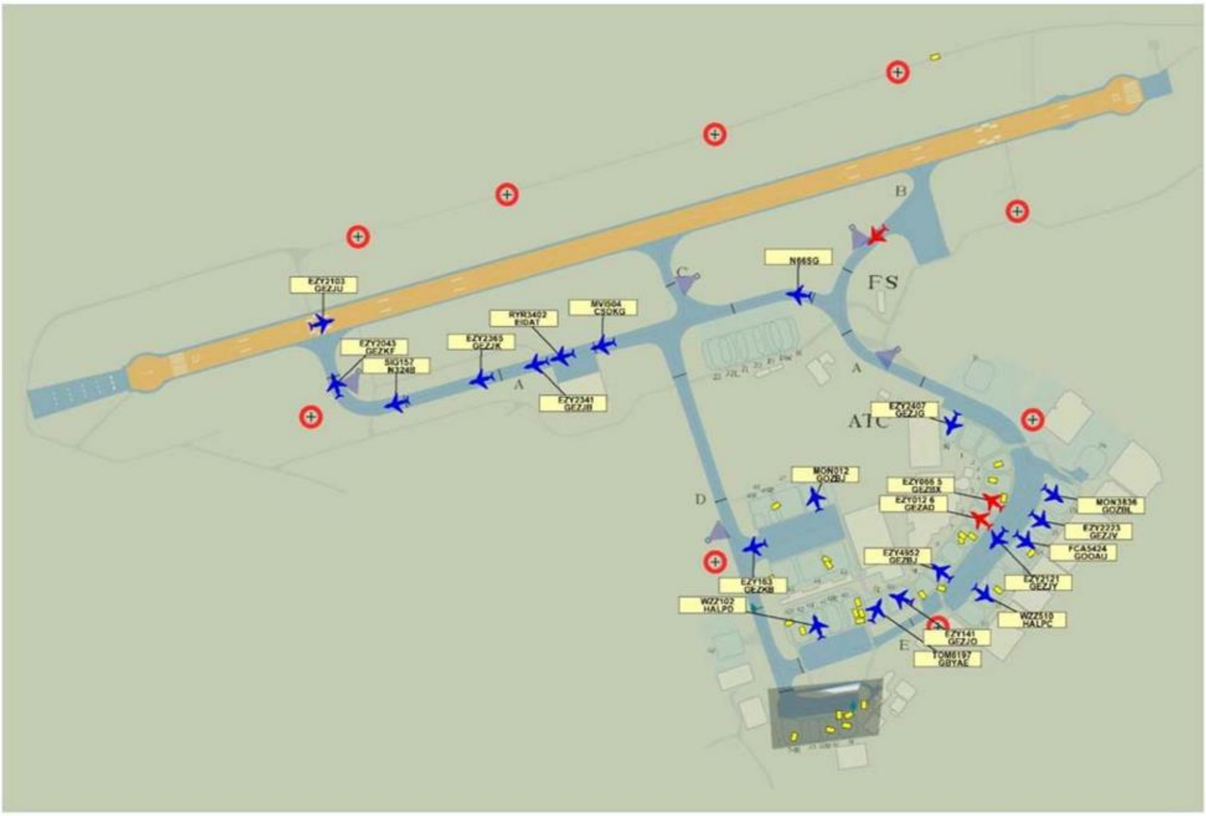


Figure 2: A-SMGCS traffic display at London-Luton Airport (EGGW, LTN)
Movement area of an airport = manoeuvring area + apron(s)

1.4.6 Radio frequency luggage identification at airports

Solution family: Transportation Management Systems

Sub-family: Air Transport Management

Domain of application: Long-distance travel

Technology behind: Dedicated short range communications (DSRC/RFID)

Status: Implemented

Links to relevant references

- Traceable Air Baggage Handling System Based of RFID Tags in the Airport, article by Zhang,T;Ouyang,Y;He,Y at Beijing University of Aeronautics and Astronautics, 2008.
- Radio Frequency Security System for User-Luggage Recognition, article by Nuñez,C.,Tosunoglu,S at the Florida International University, 2011
- Airport baggage systems go high-tech: handling with care, article by Lo,Ch. at Airport Technology bulletin
- Smart Baggage Handling Systems Improve Airport Baggage Operations, article by Heacock for AviationPros bulletin, 2005
- A hermeneutic analysis of the Denver International Airport Baggage Handling System, article by Lukaitis,S and Cybulski,J at Deakin University, 2011
- A vueltas con los equipajes

Description

Concept and problems addressed. This application is aimed at limiting delays associated with luggage check-in at the airport and locating luggage afterwards, and increasing reliability of luggage handling processes, while ensuring a smooth luggage drop and pick up for passengers, be that to the luggage conveyer belt in baggage collection areas in airports or even in check-in areas outside airports (e.g. in rail stations). Radio Frequency Luggage Identification involves the use of chips embedded into luggage tags to ensure that luggage can be tracked much more effectively than in the current system which uses labels with printed bar codes. RFID supplies a real time and accurate view of the baggage along the transportation, and significantly enhances the ability for baggage sorting, baggage matching and baggage tracking. The system can involve the use of DCVs (Destination Coded Vehicles), carts that transport the bags at high speed on a "mini" railway network inside the airport which communicate via RFID technologies to determine the path of the baggage they are carrying. Traditional baggage tagging is prone to problems related to either the labels themselves (they cannot be read if not directly in sight or if damaged) and the reading scanners themselves (dirt obscures what they can read etc.). The use of RFID chips alleviates many of the problems experienced by printed labels and increases the reliability and speed of luggage handling at airports, especially for early check-in passengers, or passengers on transfer. It is also relevant for passengers who check-in luggage before arrival at the airport at a rail station.

Targeted users. The main targeted users for this application are airport and airline managers. Airports are to improve reliability and efficiency of luggage management, as well as reduce handling times between flight connections, allowing more flexible slot allocation. Airlines benefit in the same way, they can offer tighter flight connections and have significant reductions in costs for lost or delayed baggage.

Barriers to implementation

Financial issues. The costs of installing a tailor made RFID luggage handling system are quite significant. For example the cost of Hong Kongȇs International Airport systems was ú70 million, Terminal 3 at McCarran International Airport contract sized US$92 million in 2008, and in Fuerteventura airport (Spain) a much smaller system coasted around ú32 million. On the other side, according to Zhang, Ouyang and He (Beijing 2008) statistics from Air China revealed a US$280,000 cost per year (2005-2006) owing to baggage errors (lost baggage, damage, lost articles, temporary cost of living during baggage recovery). The reduction of misread probability and error rate is to cut down this compensation cost for the airlines. In the aviation industry, out of 2 billion plus pieces of baggage handled per year, over 1% are mishandled and each instance of baggage mishandling costs on average $90. Upon full implementation, RFID could save the industry US$760 million annually (based on US$0.10 per tag cost). Furthermore, the processing cost including the labour and the maintenance cost is decreased due to the boosted productivity with a more automatic workflow brought by RFID. For example, in Hong Kong International Airport, the average cost of handling bags has gone from $7 per bag to $4, and the overall cost savings for Hong Kong airport are estimated at more than US$ 3.8 million a year. It is unclear who would pay for the system, air passengers, operators, airports or a mix of both.

Technical barriers. This technology is already in use at a number of airports (e.g. Hong Kong International, McCarran International airport in Las Vegas, Amsterdam Schiphol). However, major failures have been experienced in the past, mostly due to underestimation of the complexity of the system according to sources. Failure of the system implemented in the new Denver International Airport costed up to 2005 an additional $560 million to the cost of the airport on a system that rather than integrating all three concourses into a single system, supported only outbound flights on a single concourse while all other baggage was handled by a manual tug and trolley system that was built when it became clear the automated system would never meet its goals.

Organisational complexity. Issues might arise if a different FID standard were to be introduced. In order to combat this IATA has developed global standards for RFID baggage tags. This should encourage the uptake of the technology which needs to continue to ensure that luggage can be tracked effectively throughout its journey. Global standards would also have to be harmonised if RFID luggage systems was to cover more than one mode.

Legal issues. There are no legal obstacles to this application.

User and public acceptance. Passengers with luggage to check-in are likely to value this service, not just for the assistance it will provide to the other solutions mentioned in this section but also for the ability of RFID to drastically reduce the occurrence of lost luggage. No problems are expected in relation to public acceptance.

Interest for Travellers

Door to door travel time. Reduced delays to checked-in passengers associated with separate luggage check-in at the airport. Reduced times for luggage delivery to passengers after air trip, especially perceivable in large airport terminals. Possibility of shorter transits in connecting flights. Large gains of time for passengers avoiding the waiting time for luggage that does not turn up and the ensuing procedures for the reporting of the loss at the airport.

Travel cost. It is unclear who would pay for the system, air passengers, operators, airports or a mix of both. In principle travellers should perceive no additional travel costs, unless a premium were charged for use of this service.

Comfort and convenience. Passengers with luggage to check-in are likely to value this service, not just for the assistance it will provide to the other solutions like check-in at train stations, but also for the ability of RFID to drastically reduce the occurrence of lost luggage.

Safety. No particular impact is expected

Security. No particular impact is expected

Accessibility for impaired. No particular impact is expected for users checking-in at airports. However, this application allows for other services related to decentralised check-in procedures, for instance at train stations in city downtowns, which can simplify the check-in procedure and reduce the distance for which bags must be carried.

Modal change

As this application enables more reliable air transport for users checking-in luggage, the air mode of transport may gain in attraction potential for users with respect to other competing modes like high speed rail, which eventually could result in an increased share of air mode and therefore increased GHG emissions. However, it is not likely that this application on its own is capable to provide significant impacts into this direction.

Other notable impacts

None expected.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	(X)	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

Schiphol Airport baggage management equipment

http://www.youtube.com/watch?feature=player_embedded&v=RmUPDaoSstE

New RFID baggage management system at Las Vegas McCarran International airport

http://www.youtube.com/watch?feature=player_embedded&v=dmYyfJiZRNE

1.4.7 Electronic luggage tags

Solution family: Transport management systems

Sub-family: Air transport management

Domain of application: long-distance travel

Technology behind: NFC technology

Status: pilot

Links to relevant references

- Is this the end of sticky luggage labels on flights? British Airways ditches them in favour of reusable electronic tags, MailOnline
- GIZMAG
- QANTAS

Description

Concept and problems addressed. The development of the personalised electronic bag tag (a digital alternative to the traditional paper luggage tag) is targeted at improving the flow of customers, making it quicker, smoother and easier for travellers to check in and pass through airports. The tags could speed up the process of checking in bags, one of the last remaining time consuming activities when checking in for a flight.

The tags can be used by passengers who have their booking details sent to their smartphone using the official airline app. Each tag carries a special computer chip and has two small screens on each side. They can be bought at the airport of via the airline website, and then reused for all subsequent flights. Once checked in, customers just need to hold their smartphone over the electronic tag, and the app is then held over the electronic bag tag.

The phone then transmits flight details, destination and personal details of the passenger wirelessly using NFC technology[13] to the tag, which displays them on the screens in the form of a barcode. The rationale for using e-ink and barcode is that it will integrate with the infrastructure that is already in place at terminals worldwide. A written summary is also shown so passengers can check everything is correct (an easy-to-see view of their bag's destination). The electronic screens 'fix' the image on the tag for the duration of the trip, allowing it to be scanned electronically when going through luggage handling at departure, onto the plane, and through to the luggage collection carousel in the arrivals. The details stay on the tag until the customer

[13] NFC stands for near-field communication and can transfer data from one device to another simply by touching the devices together

checks onto a new flight. The barcode is then changed and updated for that new service. The tags can be used 'time and time again' with a different barcode generated for each new flight. The tag's battery switches off once the image is ôfixedô and a tag is supposed to last around five years.

In Europe Heathrow Airport is providing help with the trial of this application since July 2013. If tests are successful, the tags would launch in 2014. The electronic tags have been specially developed by British Airways in partnership with Densitron Displays and Windsor-based Designworks.

A similar application named Q Bag Tag is progressively being introduced across the Qantas domestic flights in Australia. This application is based on RFID (Radio Frequency Identification) technology, but tags do not have any display.

Targeted users. Airlines and air travellers.

Barriers to Implementation

Financial issues. Given the experimental nature of this application in Europe no information on expected costs is available yet. But some considerations can be done: the e-tags are expected to just replace the paper tags, and the airline operators are supposed to scan the e-tags as they already do with paper-tags. Therefore it can be argued that no huge investments are needed to implement such functionality in the airports worldwide.
Some information on RFID tagsôcosts is instead available for the Australian application: Q Bag Tags can be purchased for A$29.95 or 6,500 Qantas Points or A$49.95 for two or 9,500 Qantas points.

Technical barriers. So far the application is based on NFC data exchange, which is not common to all mobile devices. The final version of these e-tags will probably drop the NFC capabilities in favour of another communication technology such as Bluetooth, which is compatible with a wider range of smart devices. This could be the first step towards electronic tags with even more useful features, like the Trakdot's locating ability for instance.

Organisational complexity. No particular organisational complexity is envisaged.

Legal issues. No legal barriers are envisaged.

User and public acceptance. Acceptance by airlines is likely to be high, since it reduces the need for check-in staff. Acceptance by the travelling public is likely to be high by frequent travellers, who will accumulate saved time over many flights in return for purchasing the tag.

Interest for Travellers

Door to door travel time. Dispensing with the requirement for a traditional paper tag to be printed and attached for every flight will be quicker and more efficient. Customers can save time by having their electronic tag quickly scanned at the bag drop, going straight through security before catching their flight. While collecting a paper luggage tag can take around three and a half minutes plus considerably more for waiting in the check-in queue, this application is expected to take just 35 seconds.

Travel cost. The costs for the tag per flight are, for frequent travellers, negligable.

Comfort and convenience. Besides the reduction of check-in time, one of the advantages of such devices is related to the possibility to know the exact location of the baggage in case it gets lost. Lost luggage can be identified quickly by a tag-reader and passengers will be able to receive details of a bag's location by text message.

Safety. No impacts on safety are envisaged.

Security. No impacts on security are envisaged.

Accessibility for impaired. No improvements on accessibility for impaired are envisaged.

Modal change

No impacts on modal change are envisaged.

Other notable impacts

None expected.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment Costs	€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and Maintenance Costs	€	D2D travel cost	*0*	Bus and Coach usage	0	Congestion	0
Financial Viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical Feasibility	*0*	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational Feasibility	*0*	Security	0			European economic progress	0
Administrative Burden	*0*	Accessibility for mob. Imp. Passengers	0			Territorial cohesion	0
Legal Feasibility	*0*						
User Acceptance	✓						
Public acceptance	✓						

Illustrative materials

British airways trailing e-ink electronic baggage tags

British Airways trialing e-ink electronic baggage tags

http://us.tomonews.net/2013/07/05/106257/

1.4.8 Automated Solutions for Security and Boarding Control at Airports

Solution family: Transport Management Systems

Sub-family: Air Transport Management

Domain of application: Long distance transport

Technology behind: Cloud technologies, biometric recognition

Status: implemented

Links to relevant references

- European Aeronautics: a Vision for 2020 by ACARE
- IATAǵs Check Point of the Future concept leaflet
- eGate case studies on Future Traveller Experience
- Smart Gates by Australian Customs and Border Protection Service
- IEEE SPECTRUM

Description

Concept and problems addressed. The need to modernise and improve passenger security screening has been a focus of research and innovation across the aviation industry in the last decade, very especially since 9/11. For regulators, the conversations are driven by the need to adapt security in the face of continuously changing threats. For airlines and airports it is driven by the need to ensure compliance with regulations while balancing the very real issue of efficiency.

ACARE, the Advisory Council for Aviation Research in Europe, envisaged in 2001 with the publication of VISION 2020 the introduction of new management procedures and application of new technological solutions by 2020 in order to ensure that 90% of travellers within Europe were able to complete their journey, door-to-door, within 4 hours; that travellers did not have to spend more than 15 minutes in the airport before departure and after arrival for shorthaul flights, and 30 minutes for long haul; and that flights would arrive within 1 minute of the planned arrival time regardless of weather conditions. In this direction, many initiatives are already aiming at reducing times for formalities at airports, including self check-in, self luggage-drop, electronic smart luggage tags, and in particular automated security controls.

QANTAS is investigating how to improve the service in the Australian airports in order to have a better service for the passengers and avoid time losses at airports due to addressable inefficiencies. In Australia and New Zealand, new technologies for passport control are being applied. The SmartGate concept gives travellers who have an ePassport the option to self-process through passport control. It uses the data in the ePassport and face recognition technology to perform the customs and immigration checks that are usually conducted by a Customs and Border Protection officer. SmartGate is a simple, two-step process involving a kiosk and a gate. The kiosk checks if you are eligible to self-process; and the gate performs the identity check and clearance.

Source: Australian Customs
Two-step process in StmartGate; a kiosk and a gate

The Smart Gate concept has spread to many airports worldwide, including several European airports. A pilot is underway at Dublin Airport (May 2013), allowing certain arriving passengers to use self-service immigration through automated border control gates. SITA's iBorders biometric gates use facial recognition technology to identify each passenger, verifying that they are the passport holder and are authorised to enter the country. Up to 1,000 passengers per day are currently being processed, in as few as 7.5 seconds each. (FTE'13).

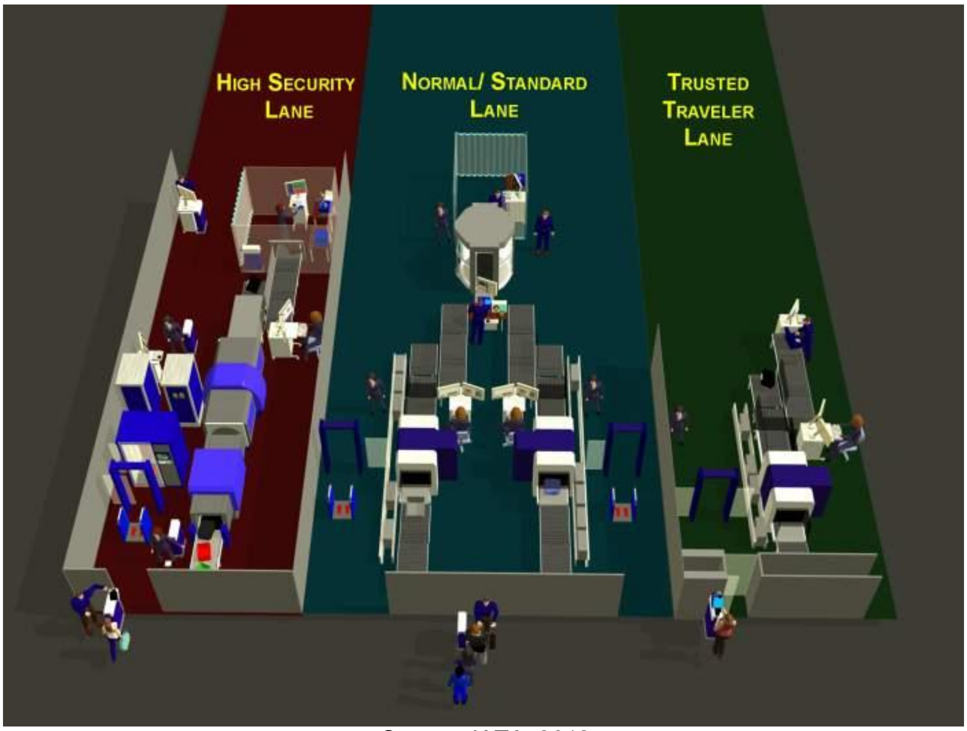
In parallel to the Smart Gate concept for border security control, more common are the Boarding eGates, touch-responsive systems, which work in a similar way to the Oyster card system in use at London Underground stations. They scan boarding passes and verify that passengers are in possession of passes with the correct flight number and date. The introduction of the new 'Smart Access' system is to make it quicker and simpler for passengers to reach the departure lounge. Lufthansa is one of the pioneers of self-boarding, with the first installation of its Quick Boarding Gates (QBGs) at Munich Airport dating back from early 2000s, and installing now second generation QBGs at Frankfurt. New self-service boarding pass scanners will also help increase the passenger experience for travellers at Copenhagen Airport. At Riga International Airport security e-gates automatically scan passengers' boarding passes to grant access to the border control area.

London Heathrow Airport and South African Airways have partnered on a self-boarding trial with passengers in Terminal 1, which uses biometric data to ensure more efficient, speedier boarding. When passengers reach the 'self-boarding' gate, they pass through an automatic electronic barrier, which takes an infrared scan of their face. This information is checked against biometric data taken at the check-in stage. If the two sets of data match, the barrier opens and the passenger can board their flight. The passenger data gathered is stored securely and will be destroyed at the end of the trial.

However, multi-million pound eye scanners introduced to speed up passport control in the UK have been recently ditched at Birmingham and Manchester airports, and are expected to disappear from Heathrow and Gatwick. The Iris Recognition Immigration System, known as IRIS, was brought in by the Labour government at an estimated cost of £9million. Scanners were supposed to process travellers quickly, however passengers often spent longer being scanned by the machines than when they went through traditional passport control.

Lufthansaøs Quick Boarding Gates

Within this line of research and innovation, IATA presented in 2012 a new integrated checkpoint concept aimed at improving security procedures at airports while minimising their impact on travellers. Passengers approaching this new concept of checkpoint will be directed to one of three lanes according to the results of a risk assessment of the passenger conducted by government before they arrive at the airport: ōknown travellerö lane, ónormalö lane, and óenhanced securityö lane.

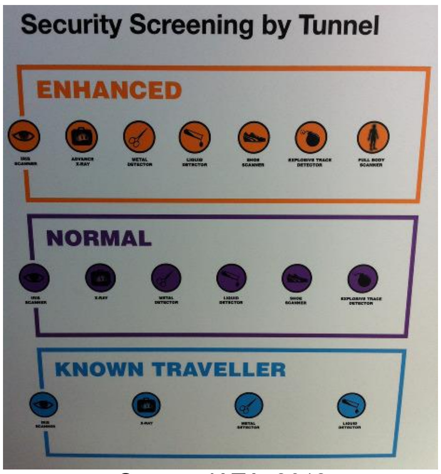


Source: IATA, 2012
Checkpoint of the Future concept by IATA

Source: IATA, 2012
Checkpoint of the Future 1:1 scale model by IATA

ñKnown travellersò who have registered and completed background checks with government authorities will have expedited access. ñNormal screeningò would be for the majority of travellers. And those passengers for whom less information is available, who are randomly selected or who are deemed to be an ñElevated riskò would have an additional level of screening. There is more embedded technology and security scans in the higher-risk lanes compared to that for frequent and pre-screened travellers. The determination of which lane travellers are directed to when they arrive at the checkpoint is to be based on a biometric identifier in the passport or other travel documents that trigger the results of the ña prioriò risk assessment.

The Checkpoint of the Future concept is based on the consideration that the aviation community needs to move away from the rigid and predictable ñone-size-fits-allò approach that characterises todayôs passenger security screening environment, to a risk based approach based on security outcomes, process improvement, and technology. The key strategy of IATAôs Checkpoint of the Future is strengthening security by focusing resources where risk is greatest; supporting risk-based approaches by integrating passenger information into the checkpoint process; and maximising throughput for the vast majority of travellers who are deemed to be low risk with no compromise on security levels.



Source: IATA, 2012
Different travellers are assigned different security control protocols.

The concept of personalised security controls at airports is already being applied in several hubs worldwide. In San José airport in the USA, terminals A and B ñCLEARò members can use dedicated security lanes to avoid having to queue at the security checkpoint. The programme makes use of a CLEARcard and self-service kiosks to identify pre-registered travellers via fingerprint and iris biometric technology to grant access to the expedited CLEAR security lane. Once the Transportation Security Administrationõs (TSA) PreCheck programme goes live at San Jose International Airport in October, CLEAR will be integrated into the service, meaning passengers who are members of both programmes can use the CLEARlane to avoid the queues and then use the expedited PreCheck lane for physical screening.

Targeted users. Airport authorities.

Barriers to Implementation

Financial issues. Stansted Airport has invested £1.2 million in its new ÔSmart Accessô system, which will automatically scan boarding passes as part of an airport-wide drive to enhance the passenger experience.

In relation to IATAõs Checkpoint of the Future, IATA points out that the speed in which the concept is developed depends largely on the government initiative and their pressure on manufacturers to come up with the technology necessary to screen a moving target, implying relatively important investments. According to IATA, this will largely depend on the need for manufacturers producing next generation of scanners to maintain current profit margins. (Bisignani, IATA 2012).

Technical barriers. Critics claim that systems involving biometric recognition procedures, e.g. facial-recognition technologies, are not accurate enough for the use of national security tasks.

Organisational complexity. No major organisational barriers are expected.

Legal issues. Data privacy issues are a relatively important issue, especially for processes beyond the security checks at border control. In relation to full systems such as the Checkpoint of the Future concept promoted by IATA, a difficult step will be achieving consensus from governments on the type of data required to assess passengers and place them in the relevant category.

User and public acceptance. As far as these systems reduce the intrusion of security controls onto passenger privacy (less requirements of undressing, emptying pockets, going through luggage), it will be well accepted because according to IATA, airport security procedures are the biggest hassle and frustration for passengers. However, at early stages some technologies may be distrusted, like full body scan or eye recognition. Cultural differences may be important in relation to user and public acceptance of these new technologies.

Interest for Travellers

Door to door travel time. If ACARE standards deriving from the checkpoint of the future were accomplished, travel time saving could be as much as 1 hour per passenger and per trip.

Travel cost. No additional costs for travellers for self-boarding and self-security eGates. For fast lane security control access, the CLEARcard program charges users $179 to engage, allowing the verification of their identity at an enrolment centre using their e-Passport. PreCheck Passengers will be able to fill out an online application, verify their identity and provide fingerprints at a TSA PreCheck enrolment centre, and pay $85 to join the scheme, allowing them to fast access at security controls. For $100, Customs and Border Protection of the US has a similar program for foreign travellers called Global Entry, which also qualifies fliers for PreCheck.

Comfort and convenience. Increased comfort derived from shorter queues at security controls. Fewer requirements related to undressing / emptying belongings onto scanners (liquids, laptops), in order to ensure same levels of security.

Safety. No effect on safety is expected.

Security. It is expected that overall security levels could increase while enhancing also the speed for formalities at airports.

Accessibility for impaired. No major impact expected.

Modal change

No dramatic direct modal change is expected from this solution, thought enhanced overall traveller experience at airports may present the air mode as a more user friendly means of transport, increasing its attractive versus other competing technologies such as High Speed Rail.

Other notable impacts

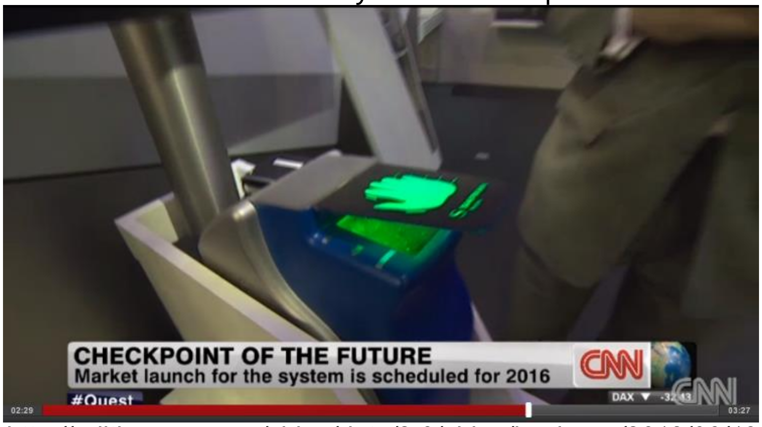
CO2 emissions. If air transport attracts users from rail, then emissions will increase.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment costs	**€€**	D2D travel time	✓	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€	D2D travel cost	**(X)**	Bus and coach usage	**0**	Congestion	**0**
Financial viability	**0**	Comfort and convenience	✓	Rail usage	**-**	CO2 emissions	**(X)**
Technical feasibility	**0**	Safety	**0**	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	✓	Aeroplane usage	+	European economic progress	**0**
Administrative burden	✓	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	(✓)						

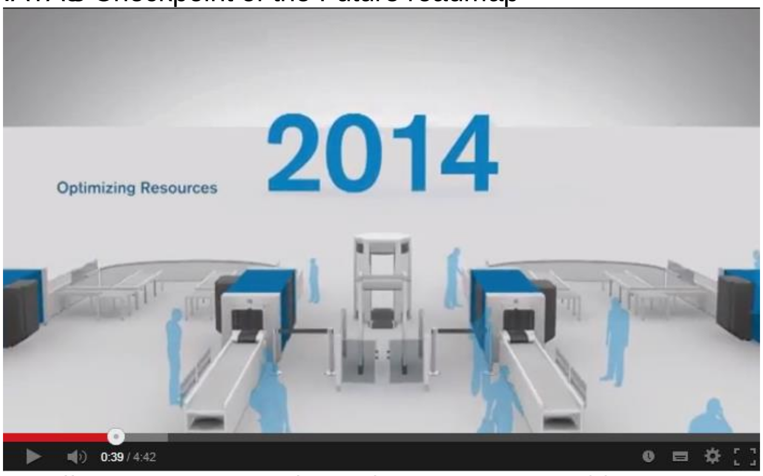
Illustrative materials

Innovations for faster security controls at airports



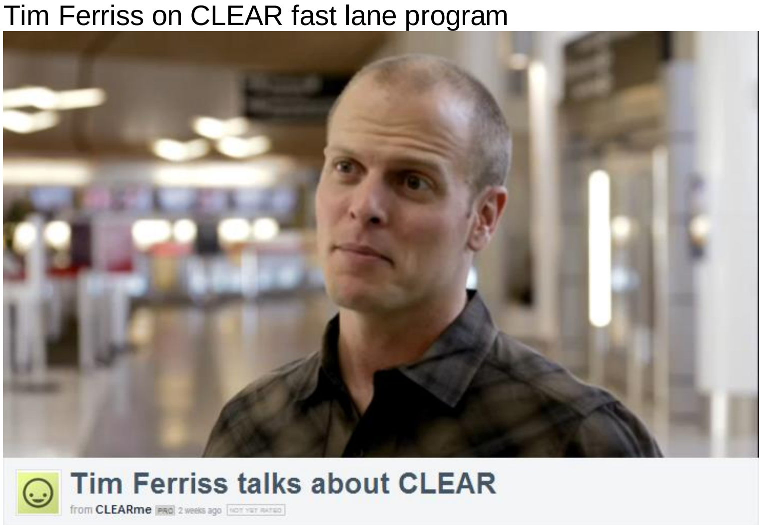
http://edition.cnn.com/video/data/2.0/video/business/2013/06/19/qmb-airport-checkpoint-of-the-future-pkg.cnn.html

IATA's Checkpoint of the Future roadmap



http://www.youtube.com/watch?v=oUI6Wi4xPAw&feature=youtu.be

Tim Ferriss on CLEAR fast lane program



http://vimeo.com/74671017

1.5 MARITIME TRANSPORT MANAGEMENT

1.5.1 Inland Automatic Identification System (AIS)

Solution family: Traveller Information Systems

Sub-family: Maritime Transport Management

Domain of application: Long-distance

Technology behind: GPS and VHF radio

Status: Implemented

Links to relevant references

- DORIS Technical Concept

Description

Concept and problems addressed. The core function of the DoRIS information system is to record and display vessels on an electronic navigational chart (ENC) containing the most important nautical information concerning the waterway and traffic regulations. AIS transponders are key elements of the DoRIS project. AIS stands for ñAutomatic Identification Systemò and enables to identify the current position of the vessels using global positioning systems (GPS). It is a system in which ships continually transmit their ID, position course, speed and other data to all other nearby ships and shoreside authorities on a common VHF radio channel. This data transmission is based on a standard specified for ñTracking and Tracingò by, the so-called Inland-AIS standard. This standard guarantees 100% compatibility with the maritime AIS system and has the capacity to expand its applications to meet the needs of inland waterway transport.

The DoRIS application processes static data entered by the vessel operator and updated periodically. These data contain information on the vessel or push convoy type, ship dimensions, maximum draught, dangerous cargo information, destination port and the estimated time of arrival. The dynamic data, on the other hand, are automatically transmitted via the AIS transponder and AIS radio channel and updated automatically every two seconds. A PC equipped with the corresponding ECDIS (Electronic Chart Display and Information System) viewer software can be connected to the transponder for displaying the current traffic image and for entering vessel information. The traffic image can also be underlayed with the current radar image for navigational purposes (Radar Map Matching). The base stations along the river bank are also equipped with transponders to receive and transmit the data from the vessels. Stored in a central database the data are either available for authorized groups for their own purposes, or can be accessed as needed, for example for reconstructing accidents.

DoRIS provides up-to-date information that can be used to plan voyages and calculate more reliable time schedules and allows optimised use and monitoring of resources. It allows flexible reactions in case of any deviation from the original planning.

Targeted users. National governments, shipping companies, port authorities, skippers

Barriers to implementation

Financial issues. Total costs of the project implemented in Austria are ú 5,000,000. Via donau (Austrian government authority for the Danube) started to equip vessels with AIS transponders with the beginning of 2006. On board equipment have been provided and installed by via donau and later on maintained by service partners. Certain selection criteria have ensured that only vessels that can prove to have cruised along the Austrian Danube in the past and will do so in future, have been equipped. A limitation of equipment per shipping company as well as a high priority for passenger and tank vessels towards dry cargo vessels has been foreseen. For the shipping companies the installation of the equipment is free of charge. The return of the investment is better river management and higher productivity.

Technical barriers. There are several critical paths. Data elaboration: DoRIS processes static data entered by the vessel operator and updated periodically. These data contain information on the vessel or push convoy type, ship dimensions, maximum draught, dangerous cargo information, destination port and the estimated time of arrival. The dynamic data, on the other hand, are automatically transmitted via the AIS transponder and AIS radio channel and updated automatically every two seconds. Data interchange: a PC equipped with the corresponding ECDIS (Electronic Chart Display and Information System) viewer software can be connected to the transponder for displaying the current traffic image and for entering vessel information. The traffic image can also be underlayed with the current radar image for navigational purposes (Radar Map Matching). The base stations along the river bank are also equipped with transponders to receive and transmit the data from the vessels. Stored in a central database the data are either available for authorised groups for their own purposes, or can be accessed as needed, for example for reconstructing accidents. However, all of these issues have been successfully solved.

Organisational complexity. The organisational aspects can benefit from a national-based organisation. In fact, working together with Austria's Supreme Shipping Authority, the national operator via donau (established in 2005 by the Austrian Federal Ministry for Transport, Innovation and Technology in charge with the maintenance and development of the Danube waterway) came up with a concept, realised by an Austrian system supplier, able to harmonise the overall process. Via donau has been coordinating the implementation of DoRIS and acting as the RIS operator in Austria since the operational start of the system in the 1st quarter of 2006.

Legal issues. No legal barriers are relevant.

User and public acceptance. No problems are expected in relation to public acceptance, while user acceptance is high.

Interest for Travellers

Door to door travel time. Better traffic management arising from information (monitoring of traffic vessel) is to be expected, resulting in reduced travel times.

Travel cost. None over and above the time savings.

Comfort and convenience. None expected.

Safety. An improvement in safety management can arise from the monitoring process. DoRIS provides vessel operators with additional and important nautical information thanks to the electronic navigation charts. The traffic image can be displayed with wider geographical range and gives the user a considerably more comprehensive overview than was previously possible with radar. The system supports vessel operators in making nautical decisions and represents a significant contribution towards increasing traffic safety.

Security. No particular impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

Logistics service providers can link freight data to the traffic data provided by DoRIS, enabling all partners in the logistics chain to track the transport cargo in real time. In addition to applications for the transport industry, DoRIS also provides statistical information for planning purposes. Furthermore, because DoRIS makes it possible to determine transport times more precisely, shipping companies can calculate journeys exactly and pinpoint deviations in itinerary using an automatic deviation management system. Therefore an overall increase in freight intermodality can be expected, but passenger intermodality will not be affected.

Other notable impacts

None expected.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

Benefits of DoRIS for the locks

Tactical Traffic Image

Source: DORIS

Benefits of the project

1.5.2 SERTICA Maritime Fleet Management IT Solution

Solution family: Transport Management Systems

Sub-family: Maritime Transport Management

Domain of application: Long distance transport

Technology behind: computing, internet

Status: implemented

Links to relevant references

- SERTICA
- Ship Energy Efficiency Management Plan (SEEMP), Lloydǒs Register
- Interview with ship engineer
- IEEE SPECTRU

Description

Concept and problems addressed. SERTICA is a widespread distributed computer system that supports shipǒs maintenance, purchasing and fleet management. Its first and main function is to give computer alerts when any part of the ship is due for routine maintenance, e.g. ǐchange filters in ventilationǒ. It also reports all ǐnear-missesǒ, i.e. all potentially dangerous situations that have occurred and transmits this information also to the headquarters as well as, as a warning, to all other ships of the fleet, as well as ǐnon-conformitiesǒ, i.e. any situation that is not compliant with the prescribed procedures. Furthermore, SERTICA can be used for stock control and ordering of any parts needed, including the provision of supplier information. Another important feature is that it supports SEEMP, the Ship Energy Efficiency Maintenance Plan, which encourages the trial of new features to increase the energy efficiency of the ship, e.g. though new propellers, the mounting of frequency converters on the ventilation system or new engine room ventilators.

Targeted users. Ship operators and ship engineers.

Barriers to Implementation

Financial issues. Compared to the overall cost of equipment on board a ship, the investment costs into SERTICA are very small, and by helping to improve maintenance and general efficiency financial pay-back is a given.

Technical barriers. No technical barriers.

Organisational complexity. It reduces the administrative burden.

Legal issues. No legal issues.

User and public acceptance. The system is highly accepted by ship engineers and operators, while the public is not aware of it.

Interest for Travellers

Door to door travel time. No impact.

Travel cost. SERTICA advertises that it can help increase the profitability of the companies that use it. In principle the increased efficiency could be used instead to lower passenger fares, but whether this happened anywhere is uncertain.

Comfort and convenience. No impact.

Safety. One of the features in SERTICA is the reporting of all accident prone situations, not only for the ship itself but also as a warning to the rest of the fleet, and although most of the situations do not concern the passengers, some situations where passenger safety is involved may arise.

Security. No impact.

Modal change

No impact.

Other notable impacts

CO2 emissions. The fact that SEEMP is supported by SERTICA means that it supports emission reduction.

Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel cost	(✓)	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

2 TRAVELLER INFORMATION SYSTEMS

2.1 PASSENGER ORIENTATION AND GUIDANCE

2.1.1 Integrated passenger guidance through transport terminals on mobile devices

Solution family: Traveller Information Systems

Sub-family: Passenger Orientation and Guidance

Domain of application: long distance, urban

Technology behind: mobile phones, internet, GPS, RFID

Status: existing / pilots

Links to relevant references

- Navigating the Airport of Tomorrow by Amadeus / Travel Tech Consulting (2011)
- The always-connected traveller: How mobile will transform the future of air travel by Amadeus / Travel Tech Consulting (2011)
- Improving passenger experience no. 1 driver for airport investment by SITA, (10 September 2012)
- Unisys Predicts IT Mobility Will Have Major Impact on Airport Operations and New Services for Air Travellers by Unisys (23 May 2012)
- Indoor GPS: Every step you take, every move you make, Google's got maps for you, by Asher Moses, The Age, Digital Life, (15 November 2012)
- A new frontier for Google Maps: mapping the indoors. by Google Official Blog (29 November 2011)
- Smartphone app could help blind navigate indoors by Devin Coldewey, NBC News, Future Tech, (May 2012)

Description

Concept and problems addressed. Transport terminals are increasingly making use of mobile apps, social media and intelligent technologies including geolocation services to provide new passenger services. With 4G networks becoming increasingly widespread, the speed of connectivity and the ability to interact with large amounts of data over the wireless system will enable new levels of customer information, for instance, keeping passengers informed about their flight status or waiting times in airports and railway stations. Moreover, the apps allow guidance through transport terminals (e.g. instructions on how to reach boarding gates or train platforms), expected waiting times at security checkpoints, eventual incidents, or information on retailer options or airport services.

Source: Navigating the Airport of Tomorrow, Amadeus (2011)
Passenger-centric mobile computing devices

Near Field Communication (NFC) could provide the passenger's location within the airport. NFC involves two pieces of hardware. One is an RFID (radio frequency identification) chip in a mobile phone (or other device) and the other is an NFC reader at a merchant or transportation facility. A passenger could be tracked all the way to the gate. Passenger location based tracking could also help airlines to anticipate their passengers' expected arrival at the boarding gate and allow them to send reminder messages to the ones who are missing.

Google has also launched indoor maps with detailed floor plans. The maps of the inside of airport passenger terminals can be used to guide customers to their gates, locate restaurants and retail shops.

Source: Navigating the Airport of Tomorrow, Amadeus (2011)
NFC monitoring of passenger location

As passenger numbers continue to rise at airports across the world, optimising the use of the available real estate is seen as a priority and passenger flow management will become more and more important; many airports see geolocation as a top priority for reducing passenger congestion. Within the next three years, new way-finding services are set to become commonplace on mobile devices, allowing passengers to navigate easily through the airport. Just 10% of airports provides them in 2012 but this is set to jump to 70% by 2015.

Transport operators may even offer promotions linked to terminal retailers, which in some cases may be specifically based on passenger status (e.g. passengers on long waits, delayed passengers), on their location within the terminal, on personal needs and other specific situations. Social media also provide passengers with the ability to instantaneously comment on customer services received.

Smartphones provide a unique platform for customer interactions. Innovative applications are needed to take advantage of location, situation and personalisation to deliver unique services to passengers. For the airport environment, the smartphone is becoming the preferred platform for customer communication.

Targeted users. Transport terminal operators. Implementation is more advanced in airports, but may also play an important role in large rail terminals and ferry terminals. Transport terminal operators may also have an interest in implementing these systems to increase their knowledge of passenger behaviour within transport terminals. End users are the passengers in any major transport terminals.

Barriers to Implementation

Financial issues. According to the SITA Airport IT Trends Survey improving the passenger experience is the number one driver of IT investment by the majority of the world's airports. Near Field Communication (NFC) requires a significant infrastructure investment, but returns can be important in terms of optimised commercial management of transport terminals. The app for the passenger should be free of charge.

Technical barriers. For airports to take advantage of NFC data gathering, a critical mass of NFC mobile phone penetration is required, and as a result, the move to NFC will most likely be evolutionary. Pilot tests have begun, but full implementation of NFC at airports is likely to take 4-7 years according to experts. In the near term, an alternative solution to passenger location tracking available today is the use of Wi-Fi based tracking, which provides the infrastructure for real-time passenger location tracking.

Organisational complexity. None if the data collected is simply assessed by the airport or rail station operator, and then simply communicated to relevant retailers or other stakeholders.

Legal issues. None

User and public acceptance. Terminal operators as well as passengers appreciate the added information they receive. Privacy concerns can easily be addressed with the guarantee that only anonymised data is held by operators. The non-travelling public will not be interested in this.

Interest for Travellers

Door to door travel time. Passengers may save time within terminals resulting from being better guided, which may allow for extended passenger times in retail and leisure areas, or in restaurants, and less at boarding gates / train platforms / ferry quays.

Travel cost. No impact expected.

Comfort and convenience. Increased comfort and convenience due to better guidance, information and increased services in transport terminals. Passenger location based tracking can facilitate connections between airport terminals with others transports, such as train or bus stations, making transfers between modes faster.

Safety. No impact expected.

Security. None relevant.

Accessibility for impaired. For a blind or visually-impaired person, getting around a large building like an airport may involve a lot of guesswork and asking for directions. A new system called Navatar created by engineers at the University of Nevada, Reno, uses the sensors in a smartphone to detect progress along a map of a building, allowing for natural navigation. All it needs is a 3-D map of the building, which in this case was created using Google's free SketchUp program, though it could conceivably be created automatically from blueprints or other records. The user puts in their starting point and destination ("South entrance, going to room 243") and the system gives them turn-by-turn directions, all the while counting footsteps and detecting changes in orientation in order to get a rough idea of where the user is in the building.

Modal change

No modal change expected.

Other notable impacts

No particular impact is expected

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

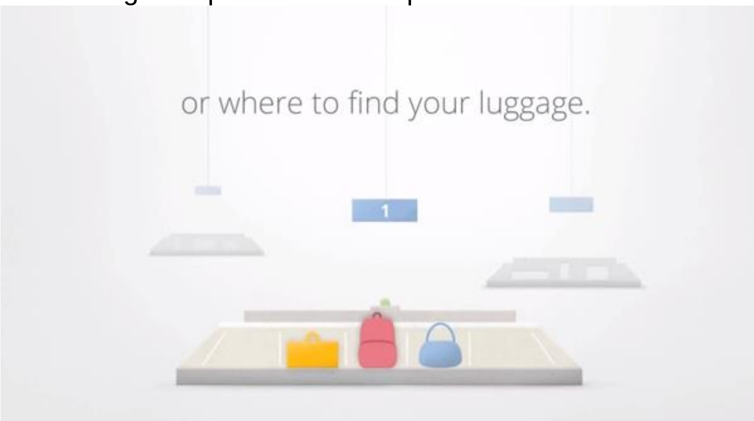
Navigating the Airport of Tomorrow

http://www.youtube.com/watch?v=KwCUwgk1oko

Future Traveller

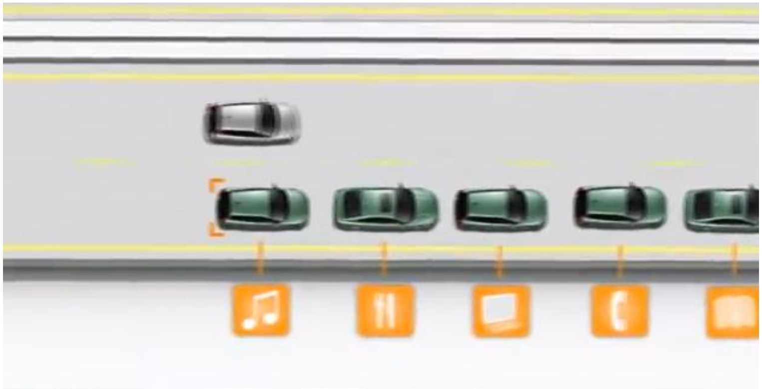
http://www.youtube.com/watch?v=zdi4-OsyEus&feature=related

Take Google Maps inside the Airport

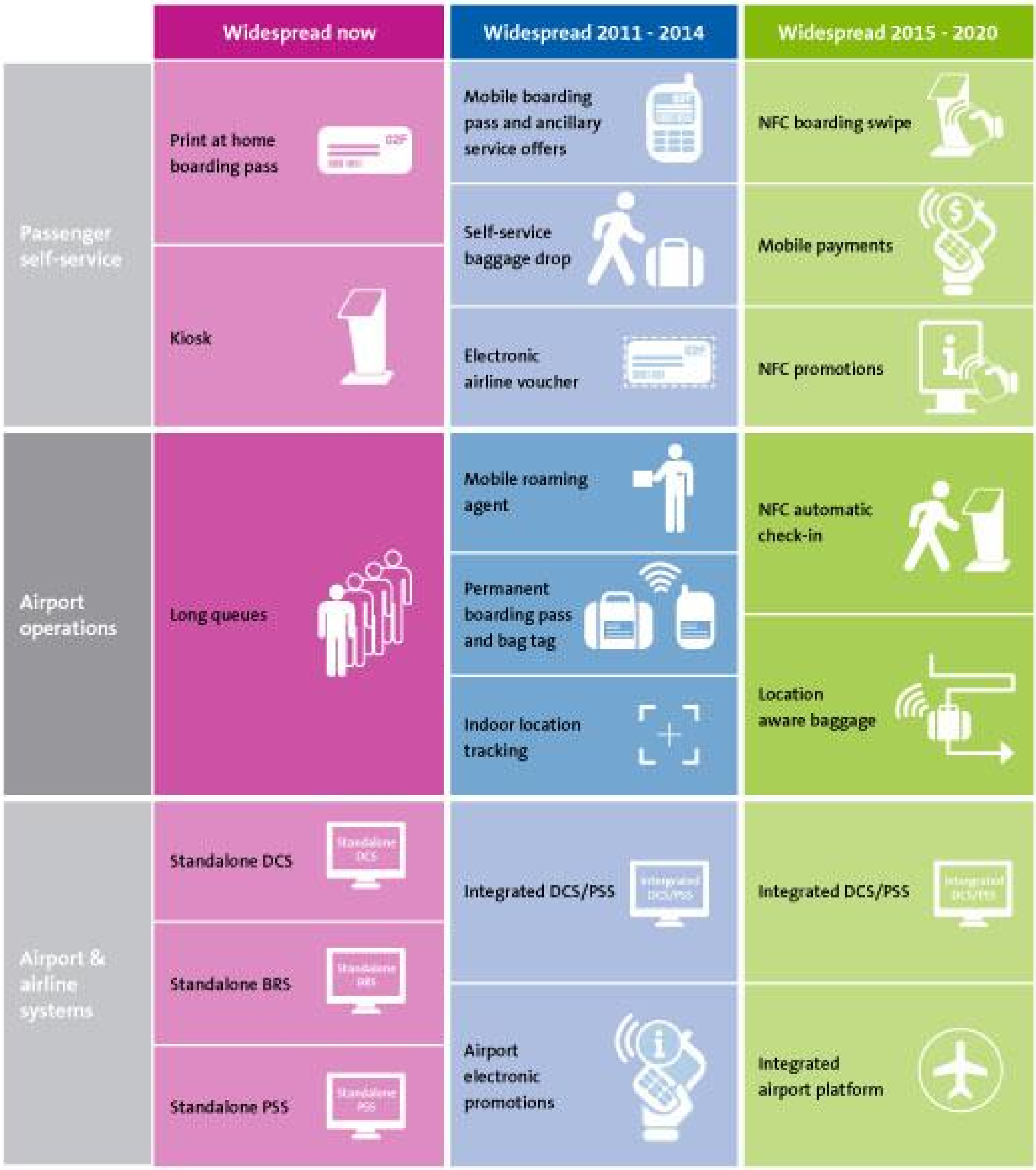


http://www.youtube.com/watch?v=P42INh3QATs

Future Traveller



http://www.youtube.com/watch?v=WFTiLKH1DW0



Source: Navigating the Airport of Tomorrow, Amadeus (2011)

Forecasting the airport of tomorrow

2.1.2 Passenger guidance for visually impaired people

Solution family: Traveller Information Systems

Sub-family: Passenger Orientation and Guidance

Domain of application: Urban, rural, long distance

Technology behind: GPS/GSM; digital mapping; screen-magnification; speech synthesis; mobile devices; mobile internet

Status: Implemented

Links to relevant references

- Worsfold J & Chandler E (2010) *Wayfinding Project: Final Report of Initial Project Work*, prepared for RNIB Wayfinding Project Board and Stream Lead, RNIB Innovation Unit.

Description

Concept and problems addressed. Passenger guidance for visually impaired people seeks to make use of satellite navigation technologies, in conjunction with screen magnification and speech synthesis technologies, in order to provide route navigation and wayfinding information to people with a visual impairment. One of the key ways in which visual impairment impacts on people is identified to be the way it affects them getting about as a pedestrian. Particular problems are known to include a lack of confidence in going out alone or to unfamiliar places, obstacles in the environment that make navigation more difficult, and fears about busy traffic. Consequently, for many visually impaired people, fear of getting around means they do not go out as much and/or that they spend more on taxis as a means of overcoming the need for mobility on foot.

Passenger guidance based on GPS and mapping technologies, often referred to as Personal Positioning Systems (PPS), has been implemented in two principal ways. Firstly, for much of the past two decades, implementation has been via specialist devices, designed for visually impaired people with the dedicated purpose of providing passenger guidance. The Trekker Breeze is the most recent example of this. The portability and cost of these specialist, dedicated devices has, historically, been relatively high. Whilst current models are much more portable and less expensive, their purchase price is still in the range of ú 400. Secondly, and more recently, implementation has also been via applications (apps) designed for internet-enabled mobile phones and smartphones, since the required technologies are often already integral to the mobile device. A number of such apps exist, but three examples are:

- Navigon ï this uses the mobile deviceõs GPS capability and links with digital mapping to provide a fully-functioning mobile navigation system, enabling text to speech voice guidance, turn by turn pedestrian directions, a ótake me homeô function, and links to the userõs contact list to provide directions to a selected contact.
- Blind Square ï uses the IOS deviceõs GPS capability to determine the userõs location, and then links with FourSquare and Open Street Map to look up and speak, in its synthetic voice, information about nearest street intersections, nearby shops, restaurants and other facilities, and distance travelled.
- SeeingAssistant-Move ï launched in 2013, this provides for route planning and route recording, advanced neighbourhood scanning with world directions, location search, ówhere-am-Iô functionality, input of sharing points and use of voice commands.

Targeted users. People with a visual impairment.

Barriers to implementation

Financial issues. The cost to the individual of the relevant devices has been a big barrier to uptake. This is changing, as prices of dedicated devices come down (in the UK, the hand-held Trekker Breeze device, for example, has recently come down from approx. £500 to £325). The new apps developed for smartphones are much cheaper: Blind Square is available for ú23.99 and the SeeingAssistant-Move comes free of charge. Even for those who come with a charget the pay-back is quick, if only a few trips by taxi become unnecessary.

Technical barriers. Accuracy and tagging remain big issues with the usefulness of the technologies. That is, accuracy is usually currently limited to that which is provided by the US satellites, which is generally good enough for car navigation, but not always adequate for pedestrians, and many points of interest that might be useful have not been tagged yet.

Organisational complexity. No known issues.

Legal issues. No known issues.

User and public acceptance. Take-up of these technologies is, as yet, relatively low amongst the visually impaired community. This is thought to be in-part due to the cost issue (as mentioned above) and in-part due to the willingness of visually impaired people ï many of whom are in the older age-groups ï to adopt new technologies, especially where there is no formal help or support mechanisms to provide for training in their use. Amongst the still small, but growing, cohort of visually impaired technophiles, however, there appears to be great enthusiasm for these technologies.

Interest for Travellers

Door to door travel time. A beneficial impact as instances of the visually impaired person losing their way reduce and as their travel becomes more efficient thanks to the improved access to information.

Travel cost. Since they enable people to switch from using taxis to using public transport and walking, there are potentially significant positive impacts for individuals.

Comfort and convenience. No known impact.

Safety. To the extent that they reduce the incidences of visually impaired people becoming lost and finding themselves in unfamiliar environments, there should be positive impacts from the technologies. There is, nevertheless, a caveat; if the technologies encourage visually impaired people to be more mobile ï as one would expect that they would ï then this increased mobility would give rise to some generic raising of the safety risk.

Security. No significant impact.

Accessibility for impaired. Clearly positive impacts for those adopting the technologies.

Modal change

There is likely to be some switch from taxi and óar as a passengerô to walk and public transport.

Other notable impacts

Mobility. The systems enable much greater mobility for the visually impaired.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	(-)	Mobility	✓
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	0
Financial viability	✓	Comfort and convenience	0	Rail usage	+	CO2 emissions	0
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	(✓)						
Public acceptance	0						

Illustrative materials

Trekker Breeze 2.0 - New features tutorial

http://www.youtube.com/watch?v=XmWCjD4CmyI

Scott Summers uses Trekker Breeze GPS

http://www.youtube.com/watch?v=fZ5Jt9o5rBk

2.1.3 Bluetooth based queuing estimated time at transport terminals

Solution family: Travel Information Systems

Sub-family: Passenger Orientation and Guidance

Domain of application: long-distance

Technology behind: Bluetooth

Status: implemented

Links to relevant references

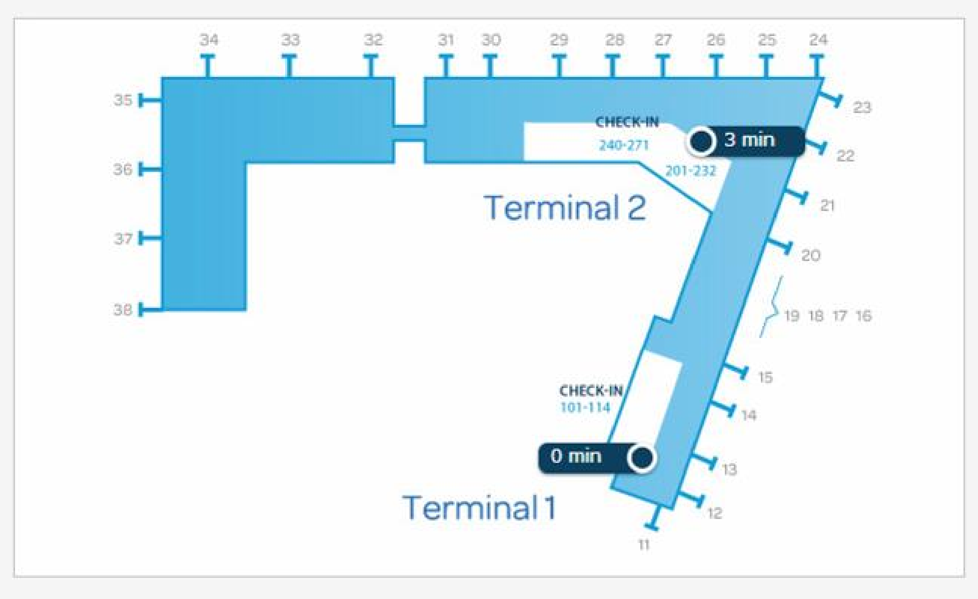
- *Bluetooth proves worth for passenger tracking* by Ryan Ghee, 2011
- *SITA to help improve passenger experience at US airport checkpoints* by International Airport Review (11 April 2012)
- Houston Airport System Uses Bluetooth Sensors to Measure Wait Times at Security Checkpoints by Kimberly Kaiser, Airport Improvement (2011)
- *Anonymous Bluetooth Probes for Airport Security Line Service Time Measurement: The Indianapolis Pilot Deployment* by Darcy M. Bullock, Ross Haseman, Jason S. Wasson and Robert Spitler, 2009.
- Helsinki Airport
- Houston airports adopt Bluetooth-based queue measurement by Future Travel Experience, 2012
- Fly2Houston

Description

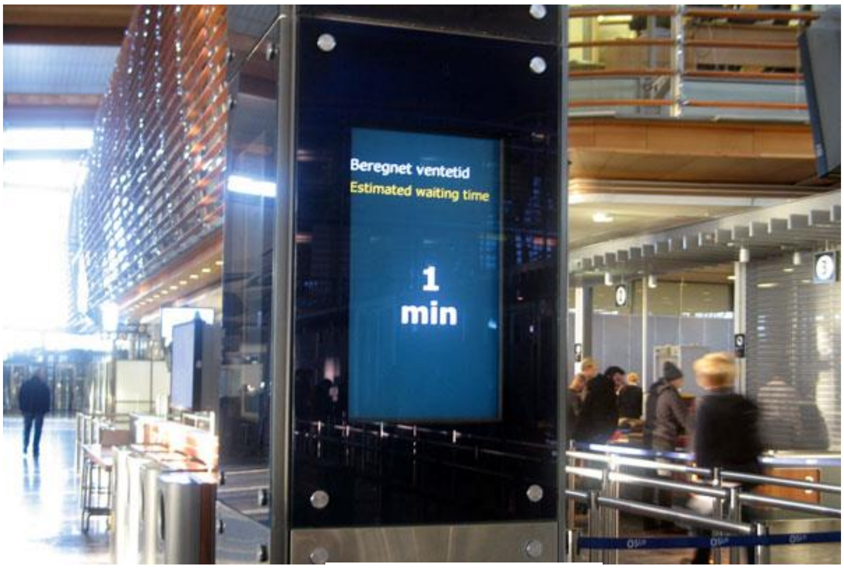
Concept and problems addressed. This system automatically measures and displays the waiting time of queuing passengers in lines. Airplane passengers are passively tracked using their Bluetooth enabled mobile devices, real-time queuing information is then generated, and accurate queuing times are displayed on the flight information display screens.

There are sensors installed near the security checkpoints that pick up the Bluetooth signal from passengers' mobile phones. Once a customer has passed the security check, the system uses the time stamps registered by the sensors to calculate the time spent in queuing.

The Bluetooth based system has already been introduced in, among other airports, London Heathrow, Oslo, Copenhagen and Helsinki. In Helsinki Airport, the security checkpoints at Terminals 1 and 2 use a queuing time measurement system. Waiting times are displayed on the airport website and on screens on terminals.



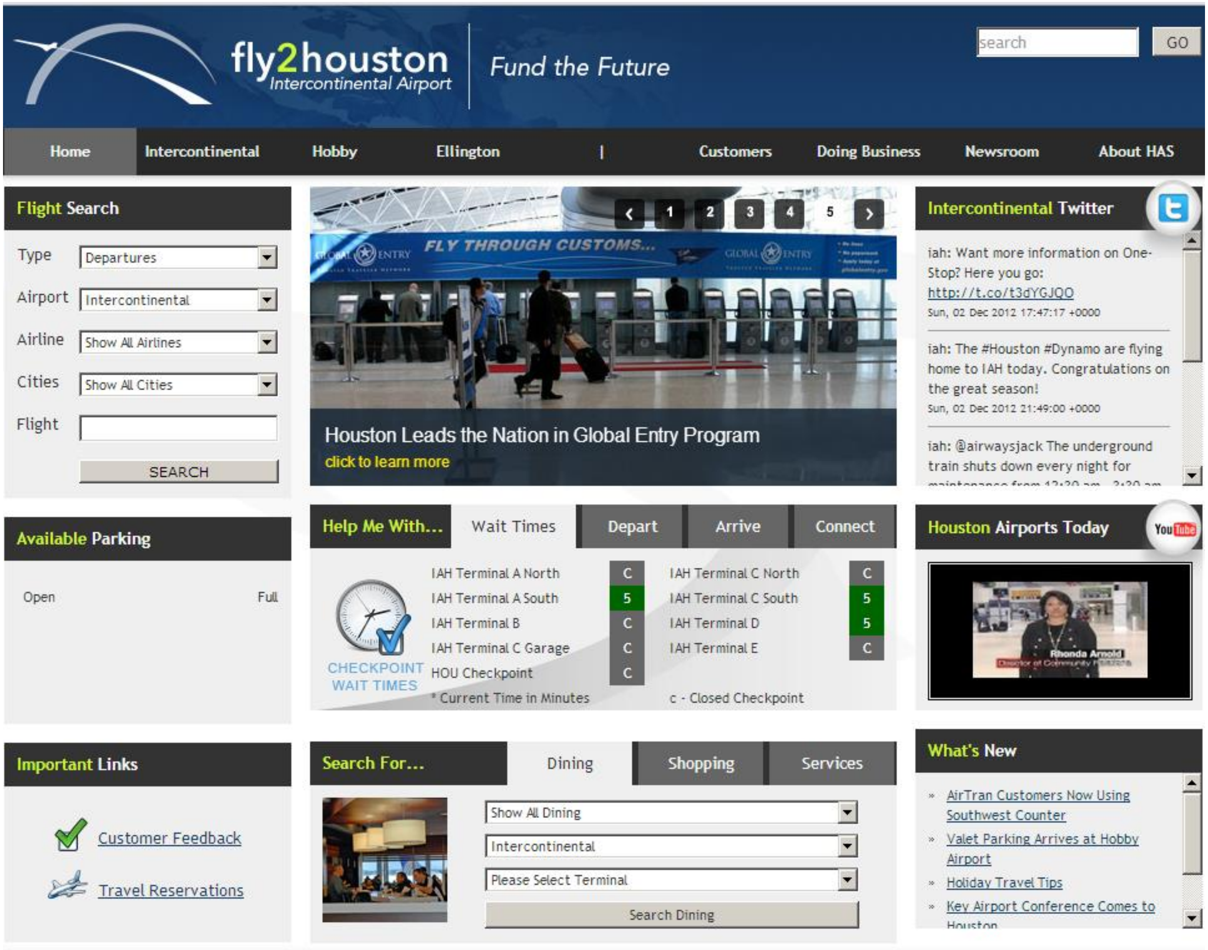
Source: *Helsinki Airport*
Average queuing time to security checkpoint at 11:59



Source: *Future Travel Experience*
Helsinki's Bluetooth-based passenger tracking

Houston Airport System has installed a Bluetooth-based, real-time queue measurement system at George Bush Intercontinental and William P. Hobby airports. The system has been launched across nine security checkpoints. This information is then updated every 15 minutes and displayed on the airport authority's website. The website displays one of three levels for each of the checkpoints to reflect the waiting time length:

- Green - waiting time is less than 10 minutes;
- Yellow - waiting time is between 10 and 15 minutes;
- Red - waiting time is more than 15 minutes.



Source: *Future Travel Experience*
Helsinki's Bluetooth-based passenger tracking

Bluetooth offers complete journey management. The signal that is received at the front door is the same as the signal that is received at security, immigration and at the gate. It is possible to measure the complete passenger journey from the car park to the gate. It allows compiling historical data and improving the level of service at the airport. It allows the airport to address bottlenecks and reduce queuing times, and thereby, in turn, it provides a more seamless journey for the passenger and an enhanced airport experience. By putting queuing times on the airport website, passengers have more information on delays they may expect from security checkpoints, and can better plan timings for their arrival to the airport. Managers responsible for staffing security checkpoints at a specific airport have quantitative information to schedule personnel necessary to respond to daily, seasonal, and special event/holiday traffic.

Targeted users. The targeted users for this application are both airport passengers and airport managers.

Barriers to Implementation

Financial issues. Not available. However, it appears a safe assumption that the costs are relatively low.

Technical barriers. A sufficient number of passengers need to have the Bluetooth device activated when they get into the airport. If they do not, the system is not going to work properly.

Organisational complexity. No particular organisational barriers expected.

Legal issues. This system should assure privacy. Only traffic patterns and movements are analysed and individuals are not identified. For example, the Indiana Department of Transportation has recorded over 1.4 million travel times and has based all of their travel time calculations on MAC address that have had 3 digits (octets) deleted. There is no need for an airport to keep the MAC address and it can be discarded after a few hours.

User and public acceptance. As long as users are assured that privacy is maintained, user and public acceptance can be expected to be high, since it is in the interest of the travellers that a) they are informed about expected waiting times and b) airport staff is aware of waiting times and can take countermeasures.

Interest for Travellers

Door to door travel time. As passengers know what are the expected delays for formalities at airports before departing from their office / home, they may better adjust their timings and in some cases save some minutes of travel time. Furthermore, if the system contributes to better planning of staff allocation, queuing times may be reduced.

Travel cost. No particular impacts on travel cost are expected.

Comfort and convenience. It is expected to improve the experience for passengers at airports.

Safety. No particular impact is expected.

Security. No particular impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

No particular impacts are expected

Other notable impacts

No particular impacts are expected

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€	D2D travel time	(✓)	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€	D2D travel cost	**0**	Bus and coach usage	**0**	Congestion	**0**
Financial viability	**0**	Comfort and convenience	✓	Rail usage	**0**	CO_2 emissions	**0**
Technical feasibility	**0**	Safety	**0**	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

The future of passenger tracking

http://www.youtube.com/watch?v=7Vy6YySy1YI

2.1.4 Augmented reality smartphone apps to locate closest public transport station

Solution family: Traveller information systems

Sub-family: Passenger Orientation and guidance

Domain of application: Urban travel

Technology behind: digital camera; geo-spatial information databases; internet connectivity

Status: Implemented

Links to relevant references

- ACROSSAIR
- London Tube, iTunes Preview
- TMB

Description

Concept and problems addressed. Augmented Reality refers to the overlaying of geo-information data onto the óreal worldô view, utilising the camera and connectivity of a smartphone, tablet or similar device. A number of travel-related augmented reality applications have emerged onto the market. In most cases, these focus on the metro, tram or underground network of a particular city. Specifically, apps exist for Paris, London, Barcelona, Madrid, Tokyo, New York, San Francisco and Washington DC. In each case, the nearest stations are highlighted on-screen as one points the smartphone's (or tablet's) camera at one's surroundings, and directions to the station entrances are then provided. In the case of London, indications are also provided of whether or not the London Underground station is óstep-freeô or not. Such applications are likely to be most useful for visitors to one of the cities covered, and mean that they should be able to make use of that city's public transport system with greater confidence and ease; always knowing that they will be able to locate and make their way to their nearest station.

Targeted users. Individual travellers, in particular those who are unfamiliar with the local public transport system, such as tourists and other visitors.

Barriers to implementation

Financial issues. No significant issues

Technical barriers. No significant issues

Organisational complexity. Some licensing of the relevant public transport maps is required, but again there are no significant issues

Legal issues. No significant issues

User and public acceptance. Acceptance of users is high, and with the proliferation of smartphones many members of the general public are able to use the app.

Interest for Travellers

Door to door travel time. In so far as the applications help the user to locate their nearest station more quickly and successfully than they otherwise would have done, it is expected that there will be a time saving.

Travel cost. No significant change

Comfort and convenience. No significant impact

Safety. No significant impact

Security. In so far as the applications will avoid people becoming lost, in search of a public transport station, it can be expected that there will be a modest improvement in personal security.

Accessibility for impaired. Where the applications provide information on whether or not the public transport station is óstep-freeô or not, and where the applications provide the possibility of spoken directions on how to find the station entrances, it can be expected that there will be some benefit for mobility impaired people.

Modal change

The app makes it easier for visitors to use the public transport network, which will persuade some of them to use that instead of a taxi.

Other notable impacts

Congestion and CO2 emissions. The move from taxis to public transport will make a modest contribution to the reduction of congestion and CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	√	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	(√)
Financial viability	√	Comfort and convenience	0	Rail usage	+	CO2 emissions	(√)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	√	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	√			Territorial cohesion	0
Legal feasibility	0						
User acceptance	√						
Public acceptance	√						

Illustrative materials

http://www.youtube.com/watch?feature=player_embedded&v=ps49T0iJwVg

2.1.5 On-street parking availability guidance application

Solution family: Traveller Information Systems

Sub-family: Passenger Orientation and Guidance

Domain of application: Urban

Technology behind: LPRN wireless network and GPRS/GSM (FL200 parking meter) and magnetic sensors (S200 sensor)

Status: Implemented

Links to relevant references

- Informed approach, article by Luca Ciscato on Intertraffic World 2011 Showcase.
- Intelligent management of the parking area by Smartparking System, 2010.
- Parking Meter (FL200) Factsheet
- Smart Parking Systems (S200) Sensor Factsheet
- SIRTI
- Con Park Tutor dimezzato l'abusivismo nei parcheggi
- SF Park
- A new "Smart Parking" System Infrastructure and Implementation by Y. Geng, C.G. Cassandras, compendium of Papers, Boston University, 2012.
- Smart Parking System (SPS) Architecture Using Ultrasonic Detector by A. Kianpisheh et al, 2012.
- Building a cyber-physical infrastructure for the smart city: the case of "smart parking" by Y. Geng, C.G. Cassandras, 2012.

Description

Concept and problems addressed. This application was launched in 2010 by the Municipality of Treviso for achieving a more effective parking management, both on the supply side and on the demand side. The two major issues affecting parking systems are: congestion caused by traffic looking for an available parking bay and effective enforcement. So the provision of real-time information on availability and implementation of smarter enforcement activities, are priorities in this field. Thanks to this ITS application it is not only possible to get real-time availability of parking facilities, but also enforcement personnel is helped in checking irregularities and parking payment can also performed via SMS or apps. The network system is based on wireless sensors that are located under every parking bay, and on intelligent parking meters. Wireless sensors are connected with parking meters and transfer data on single bay availability (whether each single bay is free or occupied by a car). Each bay has an identification number that the user has to enter in the parking meter for payment.

Parking meters collect data from all nearby sensors and transmit them via GPRS to the server which finally collate and process it. Thus, data on occupancy rate, turnover rate and payment status are always refreshed and available. This data is then available for supervisors (mobility managers) and for enforcement personnel: thanks to a PDA (Personal Digital Assistant), they instantly know for which bay the payment has already expired and where they are located.

A similar concept is also developed by Sirti with the name of "Park Tutor": the system is provided by Sirti and is made up of four elements. A central monitoring unit located in parking areas, underground sensors, smart cards that allow the system to identify the driver and a web platform for data exchange with central monitoring units located in the parking areas and for providing permissions. Park Tutor identifies vehiclesôoccupancy of parking spaces, recognises authorised users, and provides permissions (and if needed alerts police of law infringements): parking spaces availability is geo-referenced and the rate of parking occupancy are constantly monitored and stored. Park Tutor has been successfully tested in Milan, Turin, Padova and Rome, and it has been implemented in the city of Palmi (Reggio Calabria).

Other innovative parking management systems have been developed recently. In San Francisco, for instance, there is a parking guidance system which allows price fluctuations on the basis of parking spaces availability. In the Boston University Garage, a testbed has started in 2011 on a smart parking system which eliminates competition from parking search. With traditional parking guidance systems indications are only provided in relation to available parking spaces, but this kind of information is not sufficient for drivers to have the space reserved. The innovative smart parking system developed by researchers at Boston University is instead a real ñsmartò system which informs the drivers on parking availability but also enables them to reserve the ñbestò parking space for them, in relation to the distance to their destination and also to costs. Through this application, data on parking use, occupancy rate and time rotation for each bay are at disposal to be further exploited. This data supports transport planners and mobility managers in geo-referencing and analysing parking demand. Thus, parking policies can be built and implemented on consolidated data. Financial data is also available to the operator with information on daily revenues per street. The application can be potentially applied for managing bays in order to check whether time of occupancy of each bay is consistent with regulations.

Targeted users. The target of this application are car park operators and local authorities in the case of on-street parking.

Barriers to implementation

Financial issues. Cost for installation and operation of the systems are not in the public domain, but alone the costs of installing sensors underneath each parking bay are clearly very substantial, and maintenance costs for repairing or replacing faulty sensors are certainly also not trivial. However, on the benefit side one of the main issues is that these systems greatly increase the efficiency of parking enforcement for on-street parking and reduce the number of traffic wardens needed in a city. The introduction of the FL200 system also generated a revenue increase of 25% and made many parking places that were previously illegally occupied available to those willing to pay. Another result relates to improving the efficiency of existing parking spaces. Plans were in place to build an underground car park for 250 cars in a large square in Treviso where there are about 80 parking bays. The introduction of FL200 allowed the municipal administration to put the project on hold because the real-time data on available spaces showed that when the existing spaces are managed more efficiently, there is no need to add extra capacity. Concerning social benefits, relevant for local authorities managing on-street parking is also that park search traffic will be greatly reduced and therefore also congestion, especially in and around shopping streets.

Technical barriers. There are no technical barriers, even though at times there may be technical problems with sensors and data transmission.

Organisational complexity. The main relevant issue regarding the operability of this application its maintenance. Checks on sensors and transmission system have to be periodically performed in order to guarantee the function of the system. Identification numbers of bays have also to be constantly repainted in order to be clearly visible. However, this is largely counterbalanced by significant savings in enforcement effort.

Legal issues. No particular legal barrier is foreseen as far as the application of the system is concerned.

User and public acceptance. Such systems are expected to be of high interest for parking operators and to have a high level of public acceptance as they provide a good means to quickly locate available parking spaces.

Interest for Travellers

Door to door travel time. The i-park system abd the Boston system are a time saving applications for travellers. The total amount of time for travel is significantly reduced as they can rely on real-time information on parking availability while driving towards their destination.

Travel cost. The cost for travellers is not expected to change.

Comfort and convenience. Users take several advantages and benefits from the system:

- Payment receiptõs exposure in the car is no more required;
- Extra-time for parking can be easily added (and paid) from any other parking meter of the system or via SMS (there is no more need to come back to the car).
- Payment can be made in different ways (coins, pre-paid card, rechargeable time-card, SMS card).

Safety. No particular impacts.

Security. No particular impacts.

Accessibility for impaired. There is no significant impact.

Modal change

The system may induce an increase in car use away from public transport as D2D travel time can be reduced and parking search is made easier.

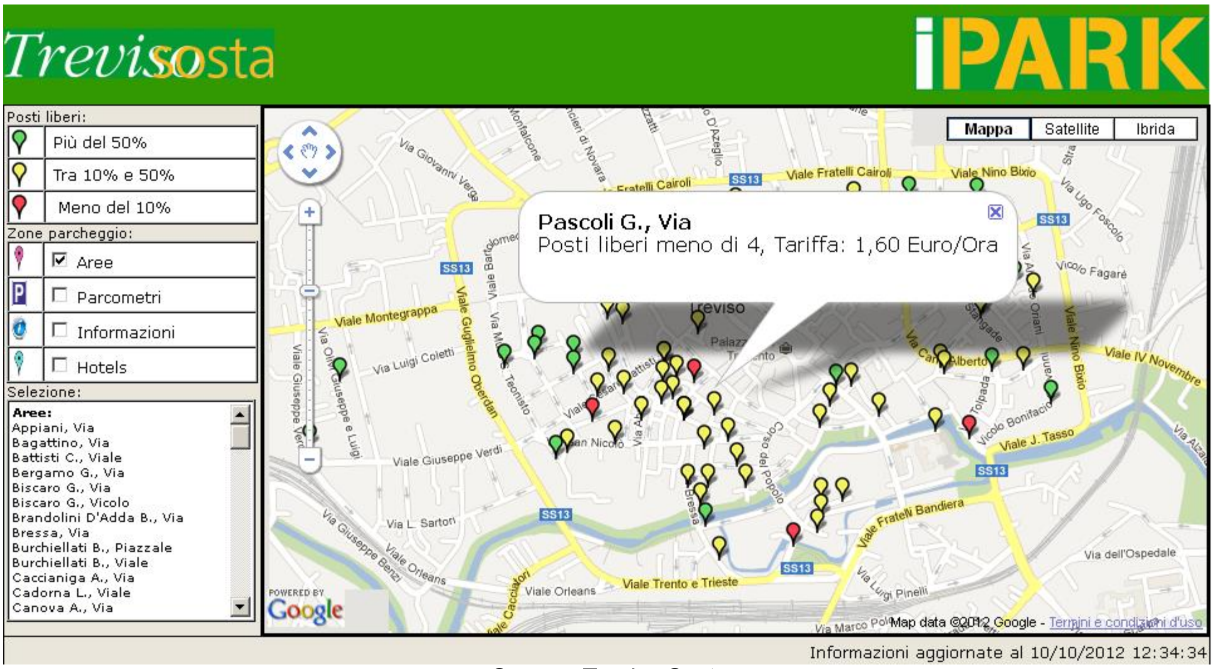
Other notable impacts

Congestion and CO2 emissions. On one side, due to an increase in car use congestion and pollution may arise, but on the other side, a reduction of it may be expected from the reduction in ñparasiticò traffic. However, on balance the effect from the reduced need to search for parking spaces should clearly be much stronger

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	+	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	0	Bus and coach usage	-	Congestion	✓
Financial viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials



Source: Treviso Sosta

Map of parking availability in Treviso

Smart Parking Systems FL

http://www.youtube.com/watch?v=54WP4rHXbas

Video Park Tutor

http://www.youtube.com/watch?v=0Pg6hvEs1-A&feature=plcp

2.1.6 Smart Park House Guidance

Solution family: Traveller information systems

Sub-family: Passenger Orientation and Guidance

Domain of application: Urban travel

Technology behind: vehicle detection via induction loops; video cameras; ultrasonic sensors; optical wireless sensors; and doppler radars.

Status: Implemented

Links to relevant references

- Shaheen, S (2005). *Smart Parking Management Field Test: A Bay Area Rapid Transit (BART) District Parking Demonstration*. Recent Work, Institute of Transportation Studies (UCD), UC Davis.
- Chinrungrueng, J; Sunantachaikul, U; Triamlumlerd, S (2007). Smart Parking: An Application of Optical Wireless Sensor Network. Proceedings of the 2007 International Symposium on Applications and the Internet Workshops (SAINTW'07).
- SFID Solutions ï SMART PARKING

Description

Concept and problems addressed. Smart parking refers to the utilisation of various technologies to efficiently manage the use of a parking garage (AKA parking house). Underpinning the system are traffic sensors that count the number of vehicles entering and exiting the parking garage. The data collected by these sensors is then pushed out to drivers via a variety of channels, permitting an optimisation of existing parking spaces. Early systems, many of which are still in use today, focused on displaying to drivers parking information such as the availability status and/or the number of available spaces. Recent technological developments have enabled more complex smart parking to be implemented. This includes:

- the facility to provide a reservation system, permitting drivers to reserve spaces at the parking garage via mobile phone, Internet or personal digital assistant (PDA);
- the facility, using the real-time information obtained from the sensors and the reservation system, to alert drivers of parking space availability via variable message signs leading to the parking garage;
- The facility, for parking garages in large shopping complexes, to direct customers to available spaces close to where they want to shop;
- the facility to collect vehiclesô license plate details and to verify these details when checking out, for the purposes of security;
- the facility to enable smart payment systems, such as via smart meters or smart cards;
- the facility, at park and ride sites, to display both parking availability and real time information on the departure and arrival time of the next bus or train.

All of these interventions are aimed at minimising the time spent by drivers trying to find a parking space, and making the experience of parking easier.

Targeted users. Car drivers

Barriers to implementation

Financial issues. Initial investment in the full suite of technologies can be off-putting to the parking garage owner.

Technical barriers. No significant issues

Organisational complexity. No significant issues

Legal issues. No significant issues

User and public acceptance. Acceptance by car park owners depends on the ability to invest. Acceptance by the public is very high.

Interest for Travellers

Door to door travel time. Indications are that up to approximately 25% of journey time in urban areas can be associated with parking search, so reducing this will lead to reductions in journey times.

Travel cost. No direct impact, but the owner of the parking garage may increase the prices to get a better return on his investment.

Comfort and convenience. No significant impact

Safety. No significant impact

Security. Some minimal impact, insofar as systems enable license plates to be checked.

Accessibility for impaired. No significant impact

Modal change

No significant impact

Other notable impacts

Congestion and CO2 emissions. The reduction in traffic that is searching for a parking space will help reduce urban congestion and CO2 emissions.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	√	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	(X)	Bus and coach usage	0	Congestion	√
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	√
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(√)	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	(√)						
Public acceptance	√						

2.1.7 Parking guidance for bicycles

Solution family: Traveller Information Systems

Sub-family: Passenger Orientation and Guidance

Domain of application: Urban

Technology behind: Wireless data transfer

Status: Implemented

Links to relevant references

- Bicycle Parking in Utrecht; smart solutions for facilitating cyclist in an already overcrowded environment, presentation by Rijk-Jan van Alfen at the CIVITAS Forum 2012
- FietsBeraad - Center of expertise on bicycle policy
- Bicycle parking detectors in Utrecht

Description

Concept and problems addressed. The project started in 2011 as a pilot initiative from ProRail (rail network manager) near the Smakkelaarsveld railway station as shortage of bicycle parking places at railway stations has been a relevant issue in recent years. Train passengers arriving at the station by bicycle see upon arrival at the parking facility a screen displaying empty spaces, allowing them to find a parking spot more easily.

The 2009 Action program for bicycle parking in the downtown area of Utrecht had the key challenge to close the gap between supply of and the demand for parking facilities. Occupancy rates are on average 200%. So, besides increasing the number of total bicycle racks (with innovative portable ones), there has been a general effort in better utilising existing racksô capacity. The ABPD-system helps in achieving this goal. An ABPD-system is an Automatic Bicycle Parking Detection system: it consists of an electronic device that detects if and how long a bicycle is parked in a bicycle rack. To that purpose each individual parking rail has a toggle-switch and a small battery. The toggle-switch is activated as soon as a bicycle is positioned on the rack: thus, the device sends a wireless signal to the receiver (usually on a pole positioned in the parking facility). All receivers transmit information to a central computer stationed at the company managing the system (on behalf of ProRail). The data collected is returned via the internet to the parking facility manager in order to have a clear and instant picture of bicycle parking availability and to check which bicycles have been parking for more than the time allowed. The main aim is to detect and make sure that a bicycle is parked no longer than 14 days in in order to ensure enough rotation. Bicycles parked longer than 14 days can be removed instantly by local authorities. Through this timely detection, the system is able to provide real-time information about the availability of bicycle racks, thus enabling cyclists to find even the last available bicycle rack.

Targeted users. The target of the application are providers of bicycle parking.

Barriers to implementation

Financial issues. The initial costs are well over ú100 euro per parking space, but they probably should fall over time. Operation costs are low. Since bicycle parking is usually free of charge, the only benefit for the operator is that they can minimise the number of racks provided to serve customer needs.

Technical barriers. Some faults in wireless communication may hamper the functioning of the system, but no other particular technical problems can be foreseen.

Organisational complexity. The management of picked-up bicycles requires additional facilities and personnel support in order to store the bicycles and decisions to put them on auctions, on sale or for rent, but since this only occurs occasionally and is paid back through recovery fees or rental respectively sales profits it is not a substantial burden.

Legal issues. Claims from users (as their bicycles are removed from racks in case they are parked for more than 14 days) could be expected. Specific regulations should be issued in order to avoid complaints and prosecutions.

User and public acceptance. The acceptance by the rack provider is clearly high and acceptance by users may be expected very high when parking availability is scarce. However, the enforcement possibilities raised by this solution may bring some level of public complaints.

Interest for Travellers

Door to door travel time. Thanks to this system, a more efficient parking facility management can be achieved. Thus, travellers may save several minutes in parking their bicycle. This advantage is of particular relevance at intermodal nodes such as public transport stations (urban rail, metro, etc.) when also a few minutes can be decisive to catch a train in time.

Travel cost. No particular impact.

Comfort and convenience. Except for the fact that management will be much easier, users of the parking facility can find their way faster thanks to digital screens at the entrance. At a glance it is clear where empty spaces in the parking are located.

Safety. No particular impacts apply.

Security. No particular impacts apply.

Accessibility for impaired. No relevant impact expected.

Modal change

Some initial research shows that 6% of the respondents (N=116) changed their behaviour and switched from car to bicycle when travelling to downtown Utrecht. Cycling may be boosted with bicycle parking improvements, adding ñquality to quantityò Extra services (free of charge and guarded parking) and the provision of real-time information on parking availability, together with the increase in parking racks (portable racks around the city) can result in a modal shift from car to bike.

Other notable impacts

No significant impacts expected. The modal change indicated is not large enough to make a change to urban congestion.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	(✓)	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	✓	Rail usage	(+)	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

http://www.youtube.com/watch?v=LJFr01r-PKw

2.2 CO-MODAL TRAVEL PLANNERS

2.2.1 Point-to-point traveller information system on mobile devices

Solution family: Traveller Information Systems

Sub-family: Co-Modal Travel Planners

Domain of application: Urban

Technology behind: Mobile device localisation (GPS, WLAN, GSM), AVL, internet-enabled mobile devices

Status: Implemented

Links to relevant references

- Japan JR East ï Development of the InfoPic onboard information system for individuals
- Overview of Mobile Passenger Information Systems in Public Transport, Technical Report
- Guidelines for Implementers of Mobile Travel Information Services for the Public
- HaCon Homepage

Description

Concept and problems addressed. The demand for quality of information in public transport is increasing, in consideration of the fact that classic information (print) media cannot provide real-time information and personalised data is not always accessible for disabled persons. Traveller information systems on mobile devices are electronic systems which offer assistance to travellers at all times and places, being multimodal and covering various modes of public transport as well as walking. Advanced ones provide multimodal information covering not only these two but also bicycles and cars as well as bike on public transport, bike & ride and park & ride. These applications give access to internet-based information services such as public transport timetables, route guidance including maps, road and traffic events as well as real-time information on public transport and road network conditions. Some apps enable users to access booking and reservation facilities or to obtain the latest tourist and destination information (e.g. points of interest). Traveller information systems on mobile devices are especially promoting public transport through increasing the quality of service, which can be location-based, tailored to individuals´ particular needs and based on real-time information.

Conventional services of passenger information systems via mobile devices are SMS (short message service), WAP (wireless access point) services and MMS (multimedia messaging service) used for ticketing. In using ŗpull technologiesò such as SMS, the passenger makes a request for information by means of SMS, and then the information is provided through SMS. With ŗpush technologiesò a central system forwards data to those passengers subscribed to receive specific information (e.g. delay information for commuters). Nowadays, with the increasing number of mobile devices (such as mobile phones, smartphones, portable computers and personal digital assistants) and associated technologies, applications for smartphones are replacing pull services more and more. Public transport operators are also providing information via social networks, such as the delay information provided by Dutch National Railway (NS) via Twitter (see separate factsheet).

Implementing such systems needs the integration of various information and communication technologies, such as mobile communication, wireless, dedicated short range communication, internet, satellite and computing technologies. The most important benefits of mobile devices are the constant availability of the internet, the ease of handling and the possibility to expand and combine these systems through various Web 2.0 applications (Apps). In addition, they have a special function for positioning (through GPS ï Global Positioning System, WLAN ï Wireless Local Area Network and GSM ï Global System for Mobile Communication) which is the precondition for dynamic navigation. If a mobile app supports real-time information, the data needed is collected from automatic vehicle location systems (AVL) with centralised control systems and provided to the mobile device. This information also can be compared by computers with the published service timetable to generate a prediction of how services will run in the next minutes or hours.

Many point-to-point traveller information systems on mobile devices already exist, such as ñScotty Mobilò and ñQandoò (Austria), ñDB Navigatorò (Germany) and ñInfoPicò (Japan), just to name a few. Typically, the information is transmitted via the mobile Internet (3G or 4G cellular data network or Wi-Fi) to the devices. Regarding real-time delay information, some systems including the Japanese system ñInfoPicò uses on-board channel such as Wi-Fi to transmit the latest information to the public transport passengers quickly.

Targeted users. The users for these services are public transport operators who implement them to provide information to, and attract, potential users. The users of advanced ones are, in addition to public transport operators, road infrastructure managers and parking managers. The end users of point-to-point traveller information systems are public transport users, cyclists, pedestrians and multimodal transport users.

Barriers to implementation

Financial issues. The apps are usually add-ons to existing internet based travel planners. There is no information available on the cost of the development of these apps, but it seems unlikely that they are very high compared to the original costs for setting up the information website. For the end users, the apps are usually free of charge.

Technical barriers. There are no technical barriers to developing an app, when a website with the same information already exists.

Organisational complexity. There is no organisational complexity to the app.

Legal issues. No legal issues.

User and public acceptance. The apps are regarded as positive both by the public transport operators for the reasons mentioned above and equally by the end users and the general public who receive information that is relevant to them free of charge.

Interest for Travellers

Door to door travel time. The door to door travel time can be reduced for travellers by providing constantly available real-time information on mobile devices. The traveller can choose the shortest route and gets information on duration and cause of delays and recommendations on alternative routes.

Travel cost. Many point-to-point traveller information systems are providing their services for free, the user only has to pay the monthly fee for the mobile phone operator. The costs for pull services (SMS) are depending on the prices of the mobile phone operator. If the ticket price is not flat rate the journey planner can also provide fare information and users potentially can choose from the route with the lowest travel costs.

Comfort and convenience. The constant supply of travellers with real-time information can reduce stress due to lack of information in case of disruptions. The provision of information is increasing the convenience of travellers, because they are flexible, can make their own decisions and are informed all along their journey, which is particular relevant for business travellers and tourists in unknown cities. Convenience is also increased through the possibility of online ticketing, if this service is combined with the traveller information system.

Safety. The latest advanced ones enables users to choose the profile of cycling routes (e.g. comfortable & safe route vs. fastest route) and suggest routes accordingly. This will allow the users to choose a safer route. In addition, such advanced ones provide the profiles of the cycling infrastructure (e.g. segregated cycle path or mixed traffic with cars, etc.). This raises awareness associated to safety, too.

Security. No significant impact expected.

Accessibility for impaired. Accessibility for users with impairment is enhanced through supply of on-trip information with the understanding of their specific needs. For example, hands-free audible information can be provided for visually impaired users.

Modal change

Point-to-point traveller information systems can contribute to a modal change through promoting the use of public transport by providing a higher quality of service. Informed users are satisfied users and with using such systems, the possibility that they will choose public transport for their next trip is higher. With the provided information, travellers are also informed about alternative routes in the case of delays and can therefore react more quickly to disruptions. Through that, they are more flexible and public transport can compete better with the private car.

Other notable impacts

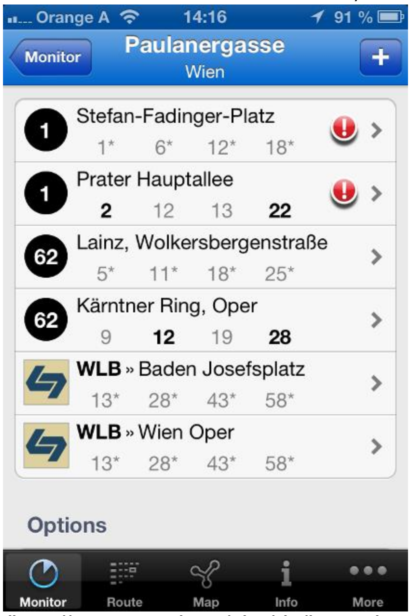
Congestion and CO2 emissions. If the apps are successful in attracting travellers from the car to public transport, this will reduce congestion and CO2 emissions.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€	D2D travel time	✓	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	✓
Financial viability	0	Comfort and convenience	✓✓	Rail usage	+	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

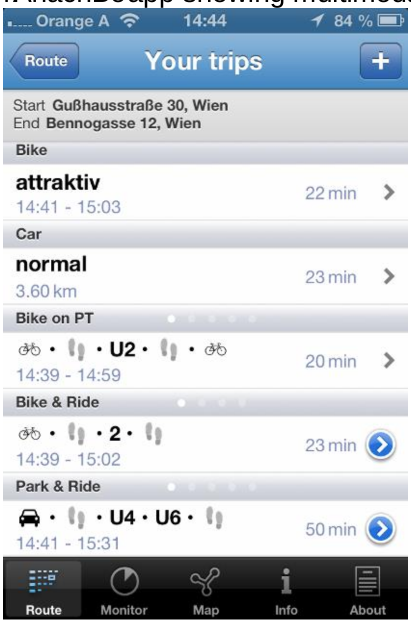
Illustrative materials

ñQandoò showing real-time public transport information at the closest stop using location information of mobile device, Vienna, Austria



(http://www.qando.at/site/de/home.htm)

ñAnachBòapp showing multimodal travel options for a route within Vienna



ñAnachBò app showing different characteristics of bicycle route in each segment in Vienna

2.2.2 Urban point-to-point traveller information system on personal computers (web based)

Solution family: Traveller Information Systems

Sub-family: Co-Modal Travel Planners

Domain of application: Urban

Technology behind: Internet, AVL

Status: Implemented

Links to relevant references

- AnachB and Scotty (Austria)
- Deutsche Bahn (Germany)
- Examples of existing national journey planners, EU

Description

Concept and problems addressed. Traveller information systems on personal computers are websites that offer assistance to travellers on their personal computer at home or on the way (laptops). These systems are multimodal, covering public transport, walking, and private cars. Advanced ones also cover bicycle as well as carrying a bicycle on public transport, park & ride and bike & ride. In addition, some of the latest ones can provide information on parking at the destination for car drivers. After entering a starting point and destination, users receive pre-trip and, if they have their laptop connected to a local Wi-Fi system, also on-trip information for their journey, consisting of different public transport modes and timetables, route guidance including maps, road and traffic events as well as real-time information on transport or road network conditions. Some of the advanced ones enable users to access online ticket purchase or to obtain latest tourist and destination information (e.g. points of interest) and print maps.

If real-time information is provided, the information needed is collected from automatic vehicle location systems (AVL) and from centralised control systems of public transport operators. This information can be compared by computers with the published service timetable to generate a prediction of how services will run in the next minutes or hours, and this information is made available for travellers via internet websites. Many point-to-point traveller information systems on PCs already exist, such as ñAnachBò or ñScottyò (Austria), ñDB Databaseò (Germany) or ñGoogle Mapsò, just to name a few. Many of the traveller information systems on PC are also available as application for mobile devices.

Targeted users. Those implementing these local planners are usually public transport operators. The end users of point-to-point traveller information systems are public transport users, cyclists, pedestrians and multi-modal transport users. These systems also benefit tourists enabling them to plan their journey in advance and door-to-door.

Barriers to implementation

Financial issues. The costs of point-to-point traveller information systems depend on the level of services that will be provided by the system. A high level of personalised and context-aware information services can be costly as a significant amount of data (e.g. individuals' dynamic needs and transport network data) must be collected, analysed and disseminated. But once the system is running the costs are marginal. Finding a detailed cost report for such systems is quite difficult; one provider revealing the development costs for the website of a multimodal journey planner is the Belgian ñScottyò platform, where the overall costs for development were 600,000 ú

(Source: Scotty, the multimodal journey planner and information platform by ELTIS), but this covers the whole of Belgium and local planners are clearly much cheaper to establish, although with fewer partners involved the costs per partner may be the same or even larger than for a nationwide system. Operating costs are low, and there should be a return of investment through increased passenger numbers.

Technical barriers. There is no significant technical barrier.

Organisational complexity. For urban planners the complexity is much lower than for national or even international ones, since the number of players involved is much lower.

Legal issues. None expected.

User and public acceptance. The systems are a positive development for operators and end users, i.e. the general public, alike.

Interest for Travellers

Door to door travel time. The door to door travel time can be reduced for travellers by providing real-time information mainly pre-trip, but also on-trip (laptops). The traveller can choose from different routes and gets accurate door-to-door information.

Travel cost. Point-to-point traveller information systems on PCs are providing their services for free. If the ticket price is not flat rate, the journey planner can also provide fare information and users potentially can choose the route with the lowest travel cost.

Comfort and convenience. Planning the route with such a traveller information system increases the comfort for passengers before starting the route. The system can reassure the passenger pre-trip that the chosen connection is in order and that the train for example is on time. The convenience is also increased through the possibility of online ticketing and reservation.

Safety. Latest advanced ones enables users to choose the profile of cycling routes (e.g. comfortable & safe route vs. fastest route) and suggest the route accordingly. This will allow the users to choose a safer route. In addition, such advanced ones provide the profiles of the cycling infrastructure (e.g. availability, segregated or mixed traffic, etc.). This raises awareness associated to safety, too.

Security. There are no expected impacts on security.

Accessibility for impaired. Accessibility for users with impairment is enhanced through the possibility to make reservations for wheelchair space or the display of arrival times of low-floor vehicles.

Modal change

Point-to-point traveller information systems on PC can contribute to a modal change through promoting the use of public transport by providing a higher quality of service. The provided pre-trip information is very important as it allows preselecting the transport mode. Informed users are satisfied users and with using such systems, the possibility that they will choose public transport for their next trip is higher. With the provided information, travellers can choose which route they want to take and thus are informed about alternative routes and can react more quickly in the case of delays. Thus they are more flexible and public transport can compete better with the private car.

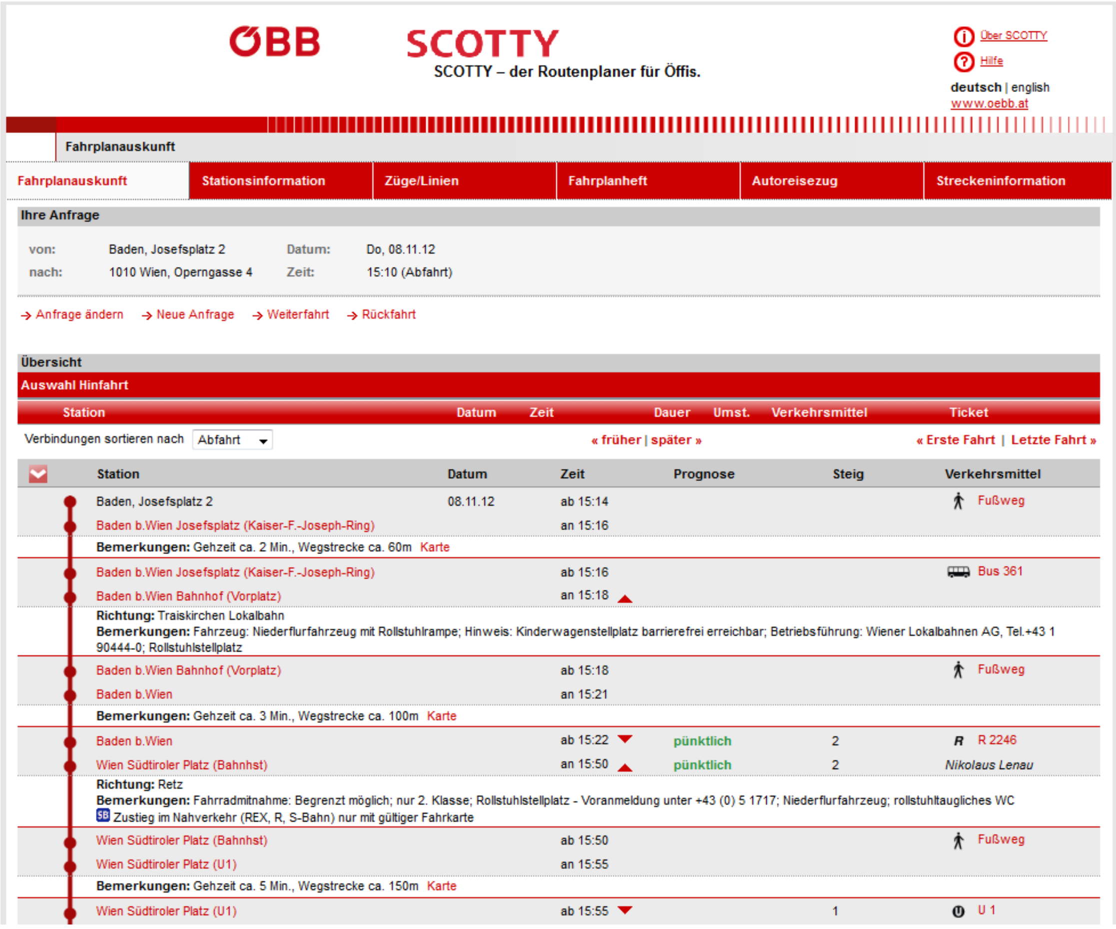
Other notable impacts

Congestion and CO2 emissions. The expected modal shift will help ease congestion and reduce emissions.

Summary of scores

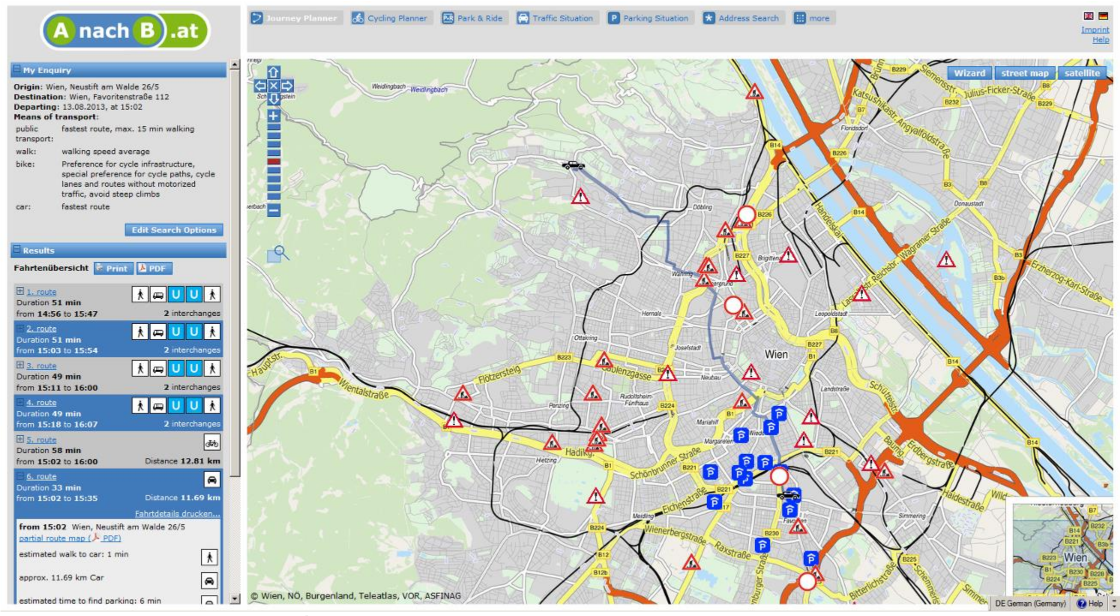
Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	✓
Financial viability	0	Comfort and convenience	✓	Rail usage	+	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials



Source: OBB

OBB Route planner ñScottyò showing public transport connection with punctuality information



ñAnachBò travel planner showing multimodal travel options in Vienna.

2.2.3 Interurban traveller information system on personal computers (web based)

Solution family: Traveller Information Systems

Sub-family: Co-Modal Travel Planners

Domain of application: Long-distance travel

Technology behind: Internet, Database

Status: Implemented

Links to relevant references

- Intermodal Information Co-operation
- EU-Spirit / EU-Spirit Short Description
- routeRANK

Description

Concept and problems addressed. City-to-city traveller information systems on PC are software solutions for long-distance travel planning, some of them including real-time information. Examples for systems that provide travellers pre-trip with travel information across borders, regions and different modes of transport are ñrouteRANKò and ñEU-Spiritò. These two examples are representing different approaches. The former is an integrative system including rough price information while the latter is a compilation of already existing detailed information systems. The information is derived from different providers for car route, flight, ferry and rail and coach information.

Travellers can choose at least from different routes, prices and means of transport. ñrouteRANKò is a system in which the traveller has the chance (beside the common features such as travel duration, departure or arrival time, price, or means of transport) to rank the search results by CO2 emissions to find the most ecological way of travelling and offset the remaining emissions by donating money to different carbon offset projects in the home country and in developing countries. The reservation and ticket purchase is not part of the system; to do this, the user is forwarded to the providers´ websites such as online travel agencies, airlines or rail operators. ñrouteRANKò is covering flight information of all major airports worldwide, the entire road network in Europe and North America and rail and coach schedules in Europe and increasingly North America.

The second example is ñEU-Spiritò, which offers the calculation of itineraries between European cities and regions which are covered by it on the base of urban public transport, rail, coach, airline, and ferry schedules. EU-Spirit itself is not a travel planner but a compilation of already existing internet-based information service systems for short and long-distance transport. The different information providers are public transport operators from diverse states of Germany, from Denmark, Sweden, Poland, Luxembourg and France. Different existing travel information systems are virtually connected through open interfaces. The system suggests international travel routes from and to every stop/address and displays the results in an integrated manner. These systems are mainly providing pre-trip passenger information, while there are already existing applications for on-trip information on mobile devices. ñEU-Spritò does not provide its own user interface, but the integrated result is shown in the travel planner offered by Berlin-Brandenburg Verkehrsverbund, a public transport association in Berlin and the surrounding region.

These two examples are multimodal planners covering wide range of modes, while there are a number of interurban travel planners that only covers limited ground modes, namely car and/or railway. This includes Google Mapôs travel planner that enables users to plan travels by cars and railway, and National Rail Enquire in UK that is managed by the Association of Train Operating Companies. These typically provide actual travel time based on current traffic in case of car and punctuality information in case of train for immediate departure. The German reiseauskunft.bahn.de calculates public transport routes based on real-time information, but also for comparison calculates the travel times by car and the emissions used for the train trip and car or flight alternatives.

Targeted users. Those implementing the system are either public transport operators (as those involved in EU-SPIRIT), or private entrepreneurs (as in the case of routeRANK). The end users of city-to-city traveller information systems are people travelling from one city to another, such as tourists, private or business travellers or commuters. Such systems are increasing the quality of service of public transport through providing real-time information for different modes of transport.

Barriers to implementation

Financial issues. The costs of city-to-city traveller information systems depend on the number of providers and on the level of services that will be provided by the system. A high level of personalised and context-aware information services can be costly as a significant amount of data (e.g. individuals´ dynamic needs and transport network data) must be collected, analysed and disseminated. But once the system is running the costs are marginal. Finding a detailed cost report for such systems is difficult; one provider revealing the development costs for the website of a multimodal journey planner is the Belgian ñScottyò platform, where the overall costs for development were ú 600,000.

As another example, EU-Spirit is based on the integration of new operators of national, regional or local Internet-based travel information service systems. The costs of the central EU-Spirit components are shared by the providers and paid in form of an annual fee. The fee consists of:

- A base fee of ú 9,000 for every provider;
- An area surcharge of ú 5,000 for providers whose information service systems cover an area bigger than 5,000 square kilometres;
- A surcharge of ú 4,000 for providers whose service systems count 30,000 or more API (application programming interface) requests per month of the EU-Spirit service system.

Thus, the fee comes up to an amount between ú 9,000 and ú 18,000. Additionally, one-off expenditures arise in order to connect the new travel information system to the central EU-Spirit components. The amount of the costs depends on the respective system and will be paid by the new provider. In general, the amount is between ú 2,500 and ú 10,000.

The public transport operators expect their return of investment from increasing passenger numbers and will hope that this will be sufficient to cover the costs. A private investor may earn from taking a percentage of the booking that results from his travel recommendation and / or from wider advertising and will certainly expect that he is getting a good financial return.

Technical barriers. The handling of a huge number of databases can lead to technical barriers. Such problems can be solved through the use of open and simple interfaces for integrating different travel information providers, as it is the case in EU-Spirit.

Organisational complexity. This could arise when various data sources are integrated into one travel planner, and depends on the technical design of the planner. In case the planner utilises APIs (application programing interfaces) that has already been made public by various timetable information providers, the complexity is lower. ñrouteRankò appears to fall into this category. However, this may only allow rough results. If a number of database from different providers has to be integrated so that a detailed and exact results can be provided, the complexity becomes fairly high to enable it.

Legal issues. There is no legal issue.

User and public acceptance. The systems are a positive development for operators and end users, i.e. the general public, alike.

Interest for Travellers

Door to door travel time. The door to door travel time, even on long-distance journeys, can be reduced for travellers by providing reliable real-time information for different modes of transport. The traveller can choose the shortest route and gets door-to-door information in advance for the journey.

Travel cost. City-to-city traveller information systems are providing their services for free, the user only has to pay the monthly fee for the internet provider. The city-to-city journey planner can provide fare information and users potentially can choose the route with the lowest travel costs.

Comfort and convenience. Planning the route with such a traveller information system increases the comfort for passengers before starting the route. The system can reassure the passenger pre-trip that the chosen connection is in order and that the train, for example, is on time. The convenience is also increased through the possibility of online ticketing and reservation.

Safety. There are no expected impacts on safety.

Security. There are no expected impacts on security.

Accessibility for impaired. Accessibility for users with impairment is enhanced through supply of information with the understanding of their specific needs.

Modal change

City-to-city traveller information systems on PC can contribute to a modal change through promoting the use of public transport by providing a higher quality of service. The provided pre-trip information is very important as it allows preselecting the transport mode for journeys. In the case of ñrouteRANKò passengers can even compare the CO2 emissions for different modes of transport along their journey. Informed users are satisfied users and with using such systems, the possibility that they will choose public transport for their next trip is higher. With the information provided, travellers can choose which route and mode of transport they want to take and thus are informed about alternative routes in the case of delays. Thus they are more flexible and public transport can compete better with the private car.

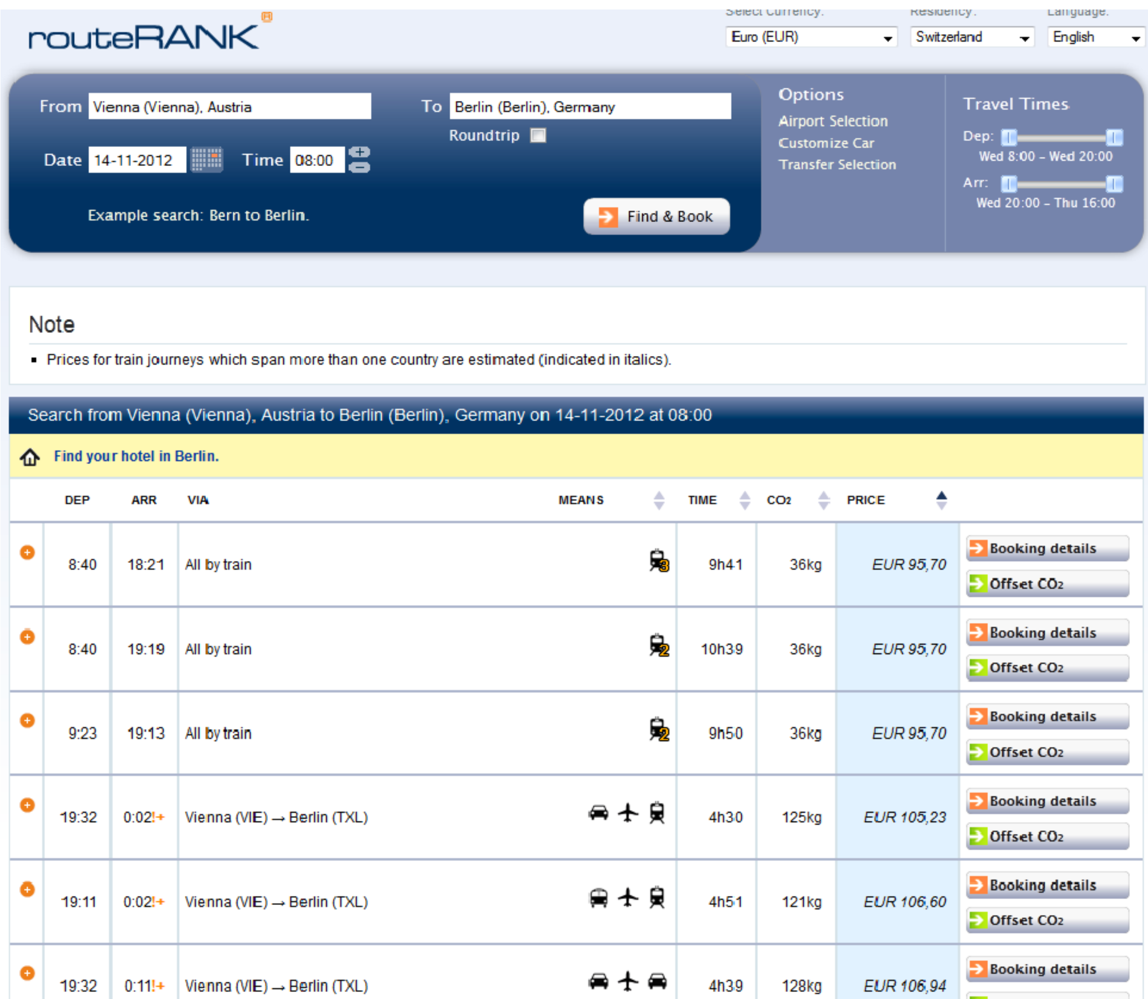
Other notable impacts

Congestion and CO2 emissions. The expected modal shift will help ease congestion and reduce emissions.

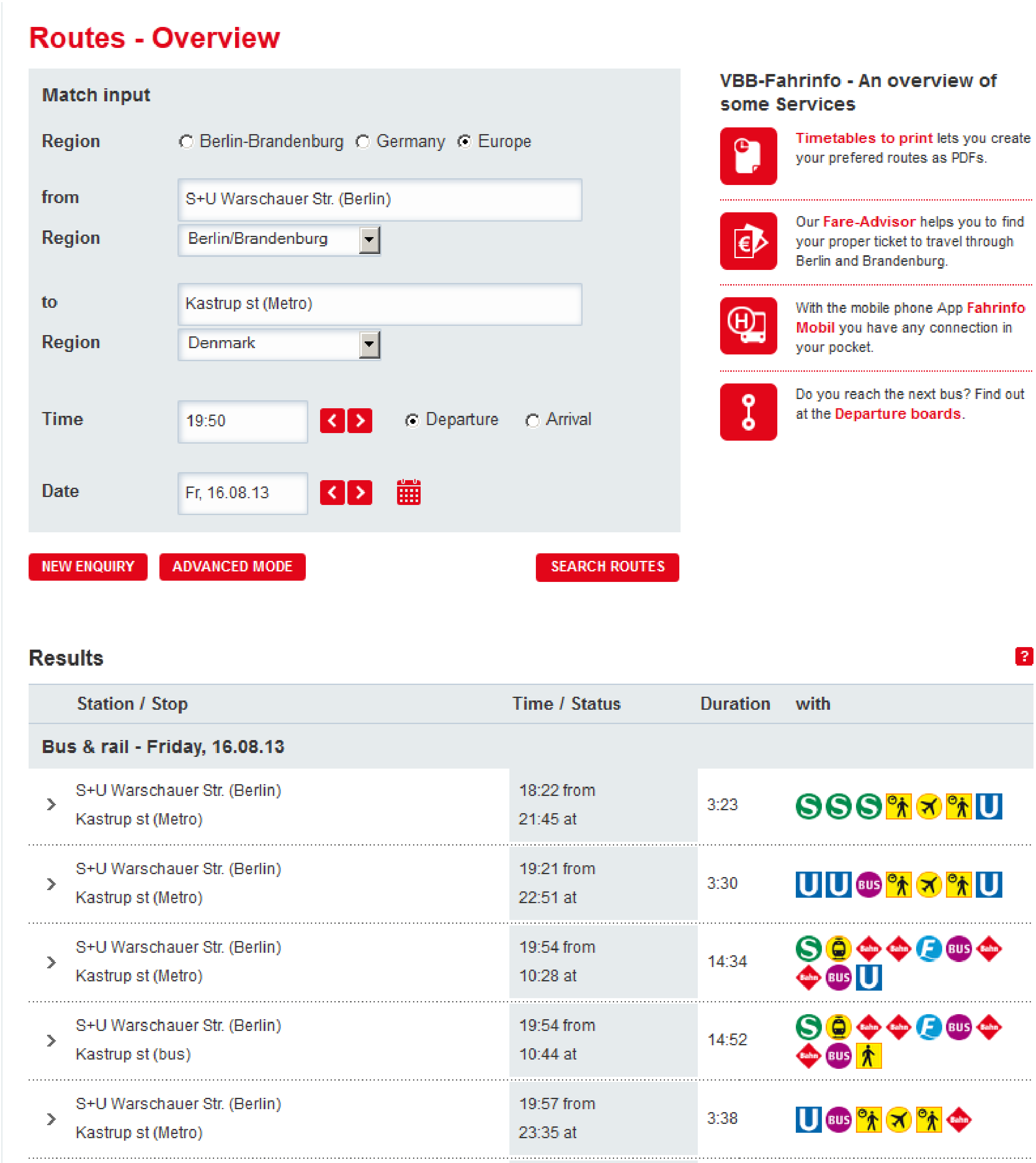
Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	✓
Financial viability	(✓)	Comfort and convenience	✓	Rail usage	+	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	+	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	+	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

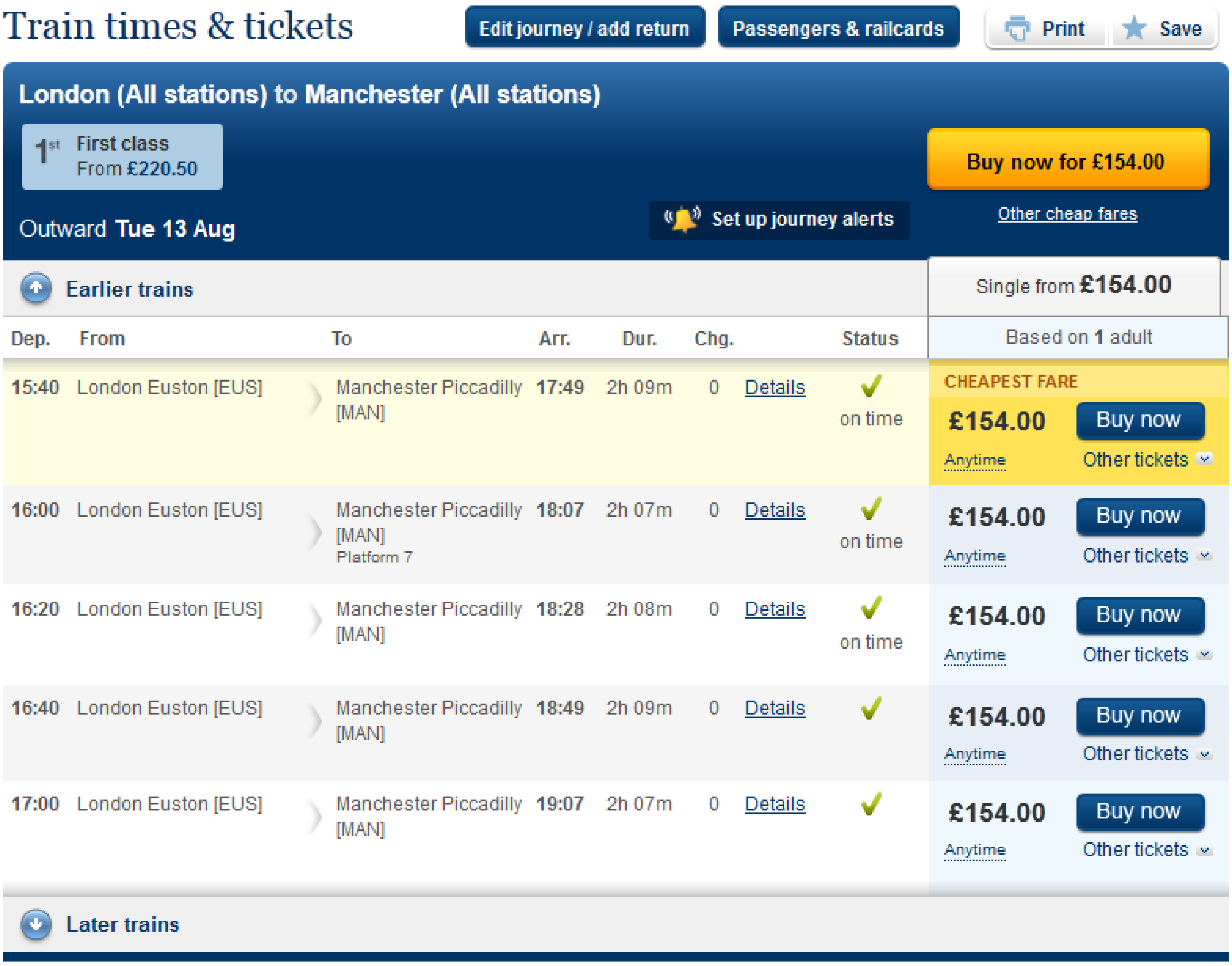


Travel planning via ńrouteRANKò



Source: OBB

Berlin-Brandenburg Verrkerhsverbundŝ webpage applying EU-Sprit showing multimodal search results from Berlin to Copenhagen



Source: NatinoalRail

National Rail Enquiry in UK showing fare and punctuality information

2.2.4 Route planners for bikes

Solution family: Traveller Information Systems

Sub-family: Co-Modal Travel Planners

Domain of application: Urban

Technology behind: Internet; Mobile devices; Mobile internet; GIS and related digital mapping

Status: Implemented

Links to relevant references

- Hochmair H H (2004) Decision support for bicycle route planning in urban environments. In Toppen F & Prastacos P (Eds.), *Proceedings of the 7th AGILE Conference on Geographic Information Science*. Crete University Press, Heraklion, Greece, pp. 697-706.
- Hertel O et al (2008) A proper choice of route significantly reduces air pollution exposureô a study on bicycle and bus trips in urban streets. *Science of the Total Environment* 389.1 (2008): 58-70.

Description

Concept and problems addressed. A number of online and mobile applications exist to assist cyclists in planning their cycle route. These vary in sophistication and the number of route selection criteria provided for, as well as in the type and number of additional facilities they offer. In general, they enable cyclists to set a series of selection criteria for their route choice, such as:

- Route with highest proportion of cycle lanes;
- Shortest route;
- Least trafficked route;
- Least undulating route;
- Most scenic route.

Drawing on different mapping sources, including Open Street Maps and Google Maps, the route planner will try to match the userôs specified selection criteria for the userôs specified origin and destination and present them with their routing options.

Considerable effort has gone into ensuring that the selection criteria of most interest to cyclists are adequately mapped. In some cases this has been conducted on a largely voluntary basis, e.g. via Cycle Streets, and in other cases it has been led by the relevant local or national transport authority.

Some of the route planners exist only as websites, whilst others have been developed into applications for the cyclistsô smartphones, capable of providing the cyclist with updated information along the route in real-time. Furthermore, some of the route planners provide additional features, such as related fitness and wellbeing information, tracking information and details of additional points of interest along the route. All of this serves to enable the cyclists to select an optimal route for themselves and to obtain the fullest benefit from their cycling.

Targeted users. Users, in the sense that they are those who pay for the investment, are in most cases traffic authorities or related entities, but in one very notable exception it is a grass roots initiative, the Cambridge Cycle Campaign, which has now become a registered not-for-profit company. End users are cyclists and potential cyclists.

Barriers to implementation

Financial issues. Ensuring that all of the key selection criteria of interest to cyclists are adequately mapped has been, and continues to be, a resource-intensive exercise. A UK Freedom of Information Request relating to the UK governmentõs travel information webpages ï Transport Direct ï revealed that development of a cycling component for 18 areas across the country cost the Government some £2.4m. On the other hand, the Cycle Streets route planner has been developed mostly through voluntary input and with donations. In the case of Cycle Streets it is explicit the company set-up that they cannot make any profits, in other cases some could be generated through advertising, but they are generally seen as serving a social function.

Technical barriers. No known barriers.

Organisational complexity. No known barriers.

Legal issues. No known barriers.

User and public acceptance. Investors believe in the social service they provide and therefore buy these planners or develop them in-house. Whilst there is no firm evidence of it, the anecdotal evidence is that cyclists. i.e. the end users and part of the general public, are increasingly making use of these planners.

Interest for Travellers

Door to door travel time. Whilst shortest/quickest route is generally one of the selection criteria used, for cyclists this criterion may actually be secondary to being able to make use of cycle lanes and/or being able to avoid heavily trafficked roads.

Travel cost. No impact expected.

Comfort and convenience. Moderate positive impact through being able to choose the most scenic routes.

Safety. Potentially major impact, as cyclists can select to avoid heavily trafficked streets and/or to use routes with dedicated cycle provision, and thereby markedly reduce their accident risk.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal change

At the margin, some switching of trips from private or public transport to cycling can be expected.

Other notable impacts

There are anticipated to be some significant beneficial impacts on health and wellbeing, but this criterion was not foreseen in the table below.

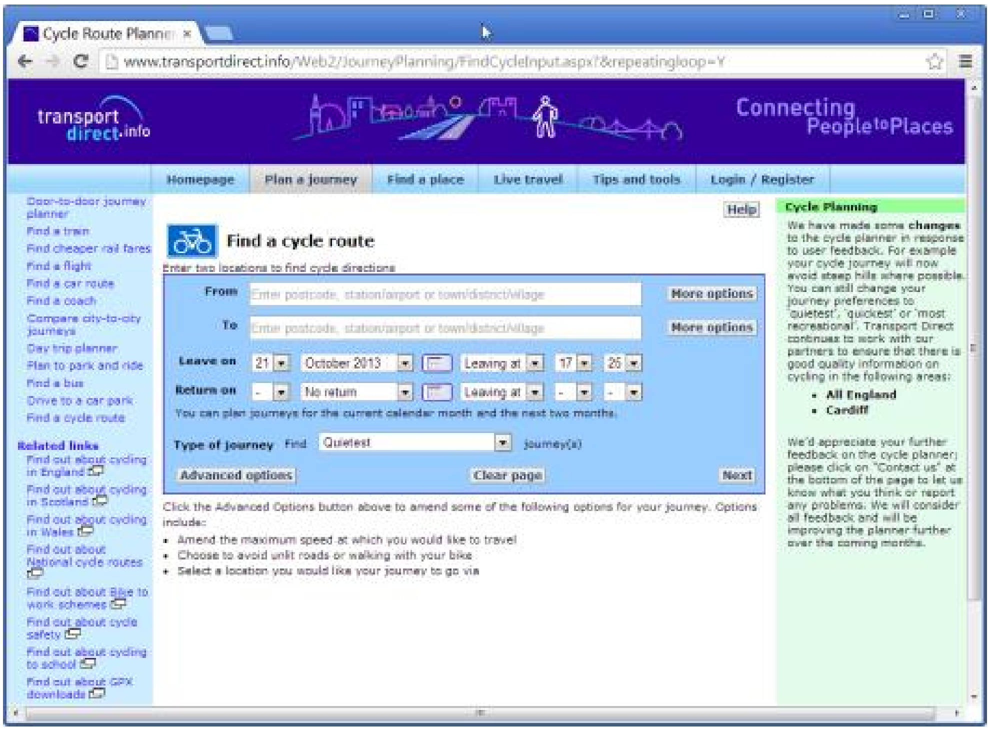
Congestion and CO2 emissions. If the availability of good information on cycling routes and opportunities attract more car passengers to use the car instead, this will reduce congestion and CO2 emissions. The likely impact from the cycle planners would be very small, but where traffic authorities are those who develop and offer these planners, they are likely start a virtuous circle by also improving the cycling facilities in their areas.

Summary of scores

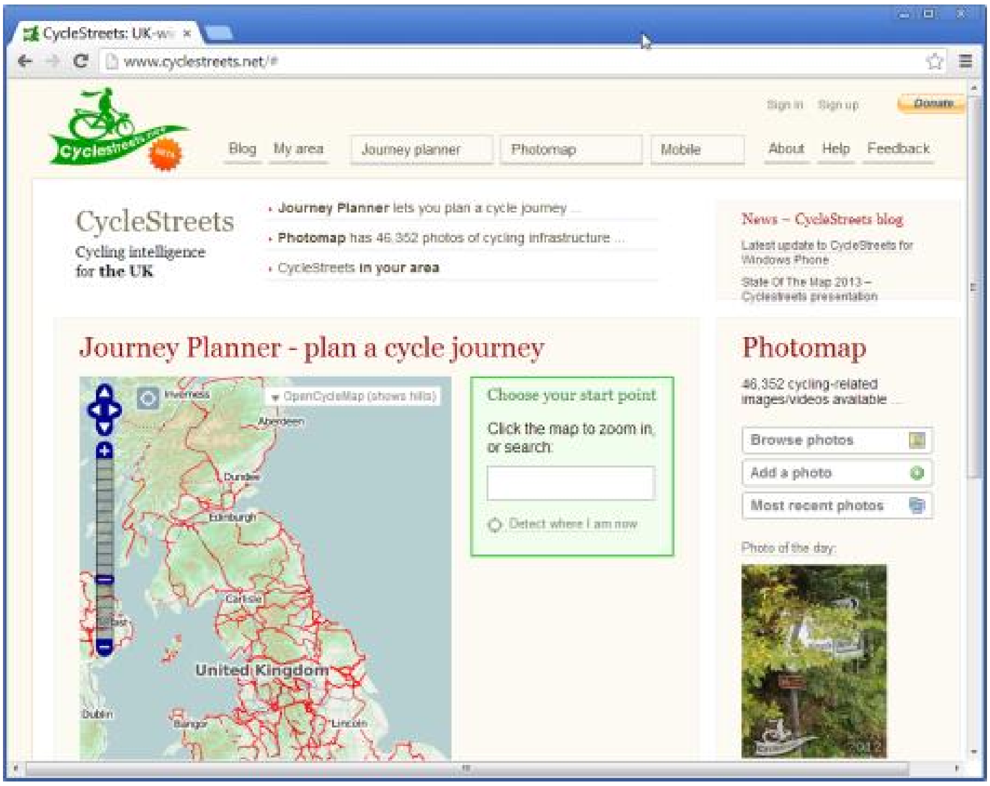
Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€-€€	D2D travel time	0	Car usage	(-)	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	(-)	Congestion	(✓)
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

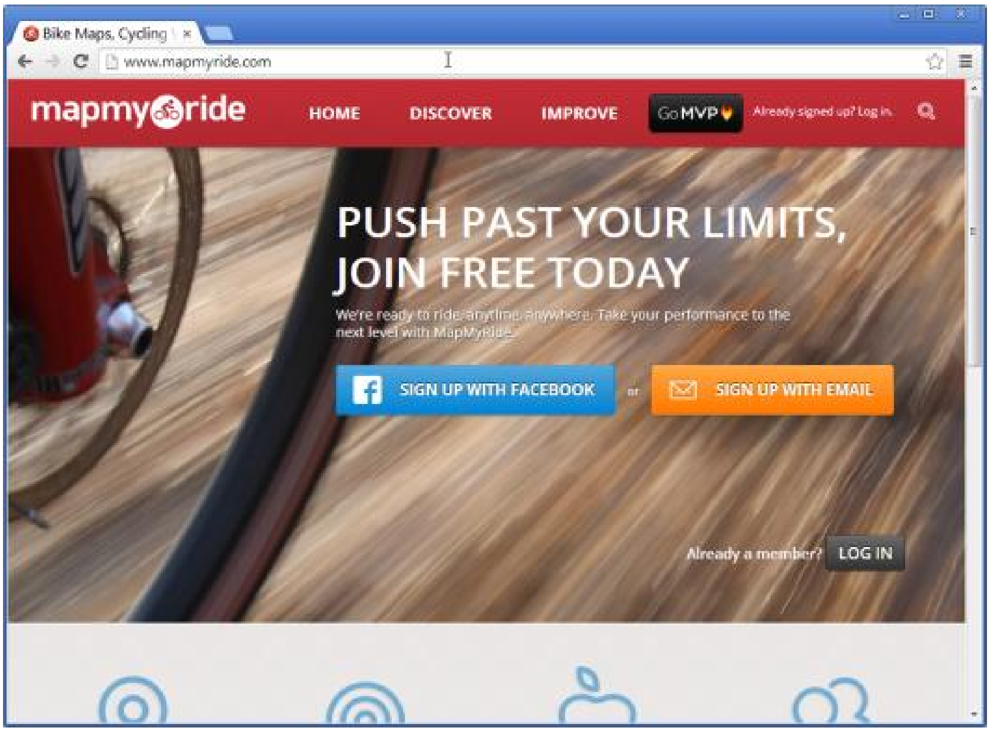
Transport direct



Cycle streets



Map my ride



2.3 REAL-TIME SERVICE INFORMATION SYSTEMS

2.3.1 Live travel time information on mobile phone / internet

Solution family: Traveller Information Systems

Sub-family: Real-Time Service Information Systems

Domain of application: Urban

Technology behind: GPS; AVL

Status: Implemented

Links to relevant references

- Use and Deployment of Mobile Device Technology for Real-Time Transit Information. Transportation Research Board, Washington, 2011
- Real-Time Bus Arrival Information Systems. A Synthesis of Transit Practice. Transportation Research Board, Washington, 2003
- Guidelines for implementers of mobile travel information services for the public, NICHES Project, Seventh Framework Programme for R&D, Sustainable Surface Transport, 2010
- Innovative information systems for public transport. Civitas, 2009
- Scotty, the multimodal journey planner and information platform (Belgium)
- RailTime rain information (Belgium)

Description

Concept and problems addressed. The real time travel information is aimed at offering correct and reliable real-time information for passengers before and during travelling to enable them to plan door-to-door journeys using the most appropriate departure time and route from the beginning to the end of their journey.

To improve the availability of the information, traveller information systems have adopted web and mobile phone platforms. Most of the real-time travel information services offered via web pages have their version for mobile phones. Delivery of travel information to mobile devices provides new options for travellers on the move. Mobile travel information services provide comprehensive information for a traveller during a trip. It allows utilising the mobile device and internet technology to provide integrated, multi-modal, real-time travel information and alerts to an individual's mobile phone or PDA. Such information can also be tailored to an individual's particular needs. Amongst other things it covers real-time and mode-specific arrival and departure times, timetable changes and detours in traffic. Transport operators have the possibility of displaying individual advice notices, for example in case of major delays, non-guaranteed transfers, diversions, or substitution traffic. Live travel time information on internet and mobile phones is used in urban transport and long-distance transport (rail, air).

The majority of real-time bus arrival information systems is based on the use of data from GPS-based automatic vehicle location (AVL) systems. The location information on each vehicle is transmitted from each vehicle to a central location with a frequency of 30 s to 5 min. The frequency of location update is critical to the accuracy of the real-time arrival predictions, which use vehicle location as one of their key inputs. The location data generated from AVL systems is used together with other information, such as current and historical traffic conditions, and real-time operations data from the last several buses that passed a particular stop to predict the arrival time of the next bus. The key to accurate predictions of real-time bus arrival times are the prediction algorithm or model, and the data that is used as input to the algorithm. There are different prediction models in real-time bus arrival information systems. The input data used by these prediction models and algorithms includes current and historical traffic conditions and current and historical bus operations data (e.g. running times between time points).

Live travel time information for rail and air transport concern online tracking of train arrival/departure from different stations on the network (aircraft starting/landing). It is possible to watch live departure boards in internet (PC and mobile phones) or via SMS/MMS. Live departure board services are a web-based representation of the departure and arrival line up for every station. They provide scheduled, expected and actual train/aircraft times and sometimes reason of delay (e.g. rail construction, technical failure in train). Users can see the current situation at a particular station/airport or navigate to get full information about a specific means of transport. Most transport operating companies are able to notify details of cancellations and schedule changes that affect their trains/aircrafts.

Another functionality enables the visualisation of stops/stations/airports and location of the means of transport on an interactive map.

Scotty and Realtime can be presented as examples of that solution. Scotty as the multimodal journey planner and information platform in Belgium is an example of such intergraded real time information platform. Mobility problems are imminent in Belgium. Year after year, the number of trips rises, not only in road traffic but also in collective transport. Good and reliable information about the mobility situation at any given moment is becoming a necessity. The technological evolution surrounding smartphones and tablets has provided an opportunity for improvement in this area. The aim of Scotty, a new mobility information website, is to provide real-time information about the current mobility situation and possible routes from A to B in Belgium using any available transport mode. The idea is to provide a multimodal route planner which provides reliable, non-discriminatory information.

The Scotty-platform offers 3 main services. First of all, there is a multimodal route planner. Via a series of choices to which a user is directed via easy-to-use forms, the planner provides routes for any transport mode (walking, cycling, bus/tram/subway, train, car and aeroplane) complete with travel times, exact location and extra info about the surroundings. For the user it is possible to make an educated decision about the transport mode that fits their needs best. As well as that, the website also offers a traffic map which shows actual speed of current traffic flows, accidents or traffic jams, car sharing locations, electric charging stations, bicycle sharing stations and so on.

Users can also create a personal mobility dashboard. He/she has to create a login first, using an email address or a Facebook, Twitter or LinkedIn account. Once logged in, the system will request details such as home address, work address, favoured train station, favoured parking lot and so on. Based on that information, the system will start to create personal mobility widgets on your own mobility dashboard. Once your dashboard is fully functional, it's possible to get real-time traffic information tailored to your needs, to access the information displays at your train station. All the provided information is sourced directly from mobility providers and is also available in printable format. Of course, every feature is also accessible via IPhone, IPad or Android-devices.

The Belgian railway infrastructure manager Infrabel has introduced Railtime, which is a new traveller information concept which compiles all available data about rail traffic into easy to use, easy to access and accurate travel information. The Railtime-website was launched in 2009. Railtime is twinned with the real time traffic management system that is used in traffic control for the management of railway traffic in Belgium. Railtime shows current delays or disruptions in the service and also offers a prognosis about the expected delay. Travellers have different options when looking for information: website, phone information or the Railtime app for smartphones.

Targeted users. The main targeted users of real time travel information systems are transport operators.

Barriers to implementation

Financial issues. Setting up a website and developing an app is not a major expense for a major transport operator and the pay-back in terms of an increase in customers can come very quickly. However, for a small operator with only a dozen buses or so the costs can be prohibitive.

The literature provides a limited amount of information regarding costs of providing real-time transit information. Several references that describe the costs of real-time information do not give the specific costs of providing that information on mobile devices or in internet. Costs are determined for the introduction of full real time information system with all media channels of transferring to passengers.

Technical barriers. No particular barriers.

Organisational complexity. The passengers need complex information about all transport modes, so it is necessary to incorporate information from different sources. Issues might arise if transport operators use different technical standards and it can be unable to share real time information between their systems.

Legal issues. There are no legal obstacles to this application.

User and public acceptance. User and public acceptance is likely to be high.

Interest for Travellers

Door to door travel time. Reduced waiting time and travel time as whole.

Travel cost. Travellers have no additional travel costs using internet as media channel. They may, depending on their mobile phone contract, have to pay for an SMS message or for data roaming, but most contracts these days include a significant provision of free texting and roaming at least in the home country. However, for example in West and South Yorkshire a text message is charged at standard outbound rate plus a maximum of 12p for the returned text.

Comfort and convenience. The principal advantage to travellers is shorter waiting time at stops, because they can plan their arrival time better.

Safety. No particular impact is expected.

Security. The shorter waiting time at stops, especially at night, can increase personal security.

Accessibility for impaired. Real-time information systems can facilitate travelling for impaired.

Modal change

Good real-time information system can encourage more people to choose public transport instead of private cars.

Other notable impacts

Congestion and CO2 emissions. The expected modal shift will also contribute to a reduction in urban congestion and CO_2 emissions.

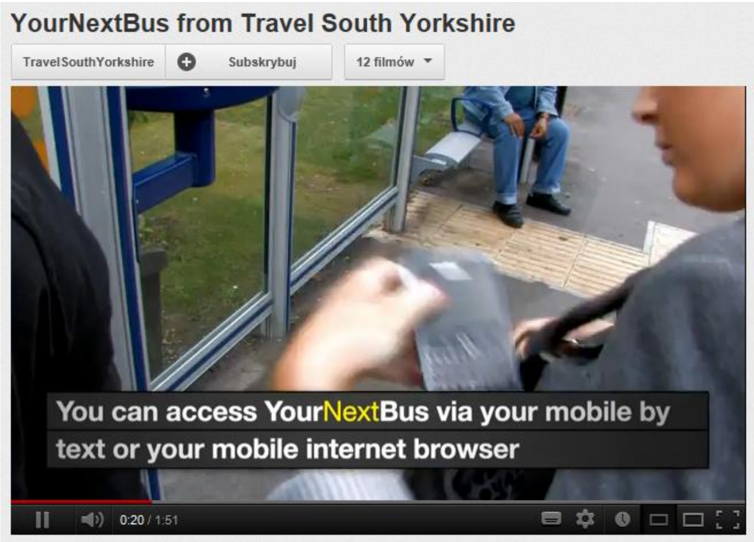
Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€-€€€	D2D travel time	✓	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	+	Congestion	✓
Financial viability	X-✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(✓)	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	(✓)			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

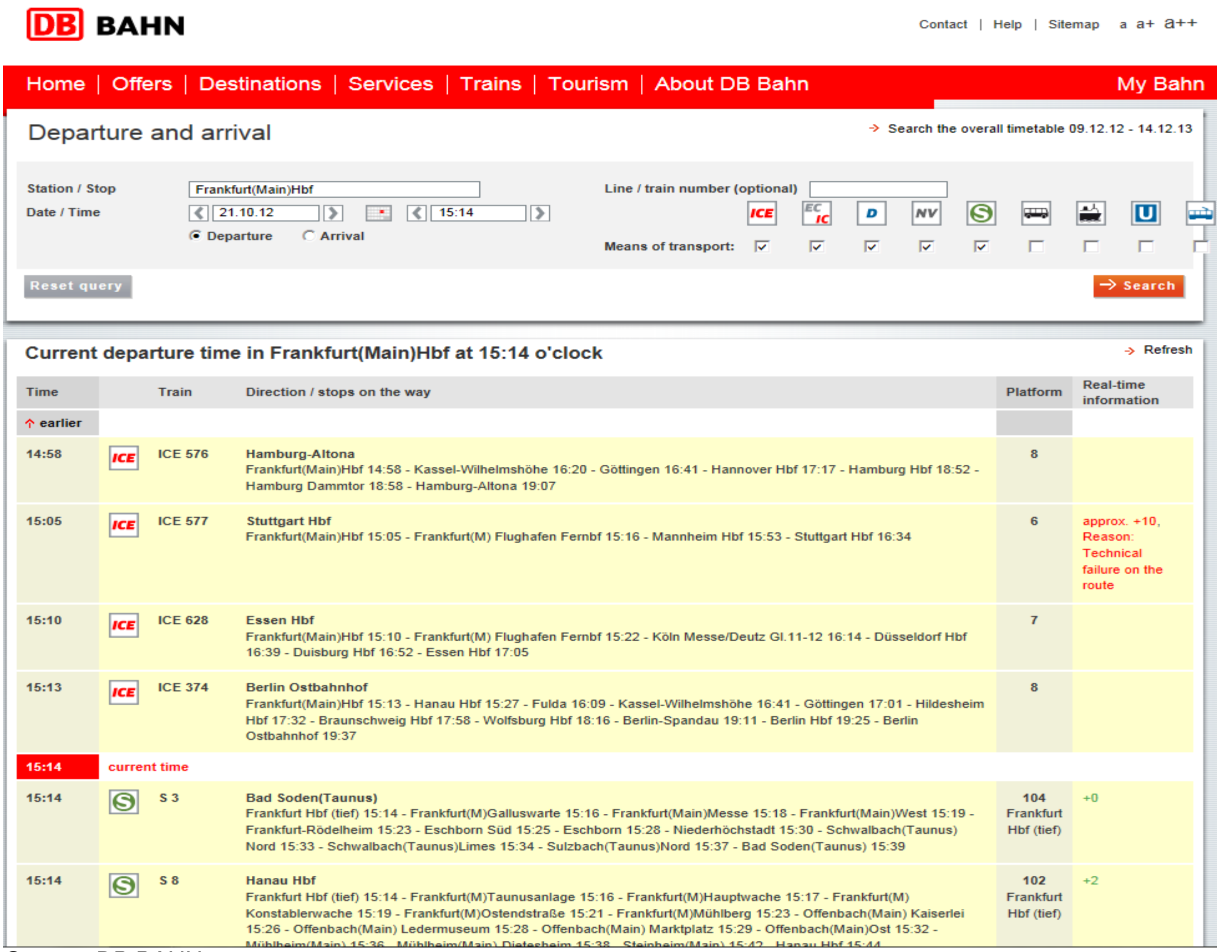
1) Urban transport

http://www.youtube.com/watch?feature=player_embedded&v=qqmzewVSZ0k

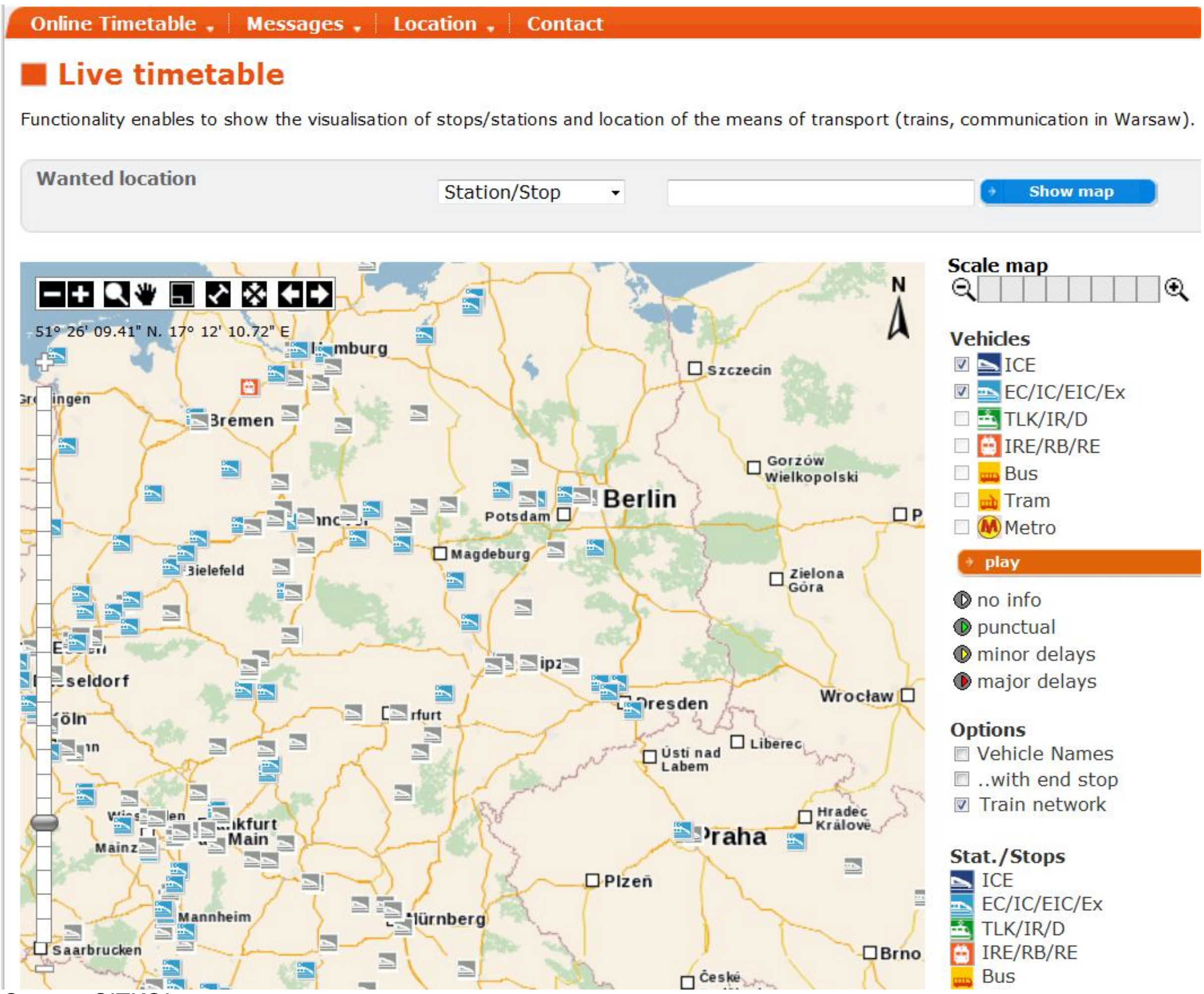


http://www.youtube.com/watch?v=VfPBOBsBU2E

2) Rail



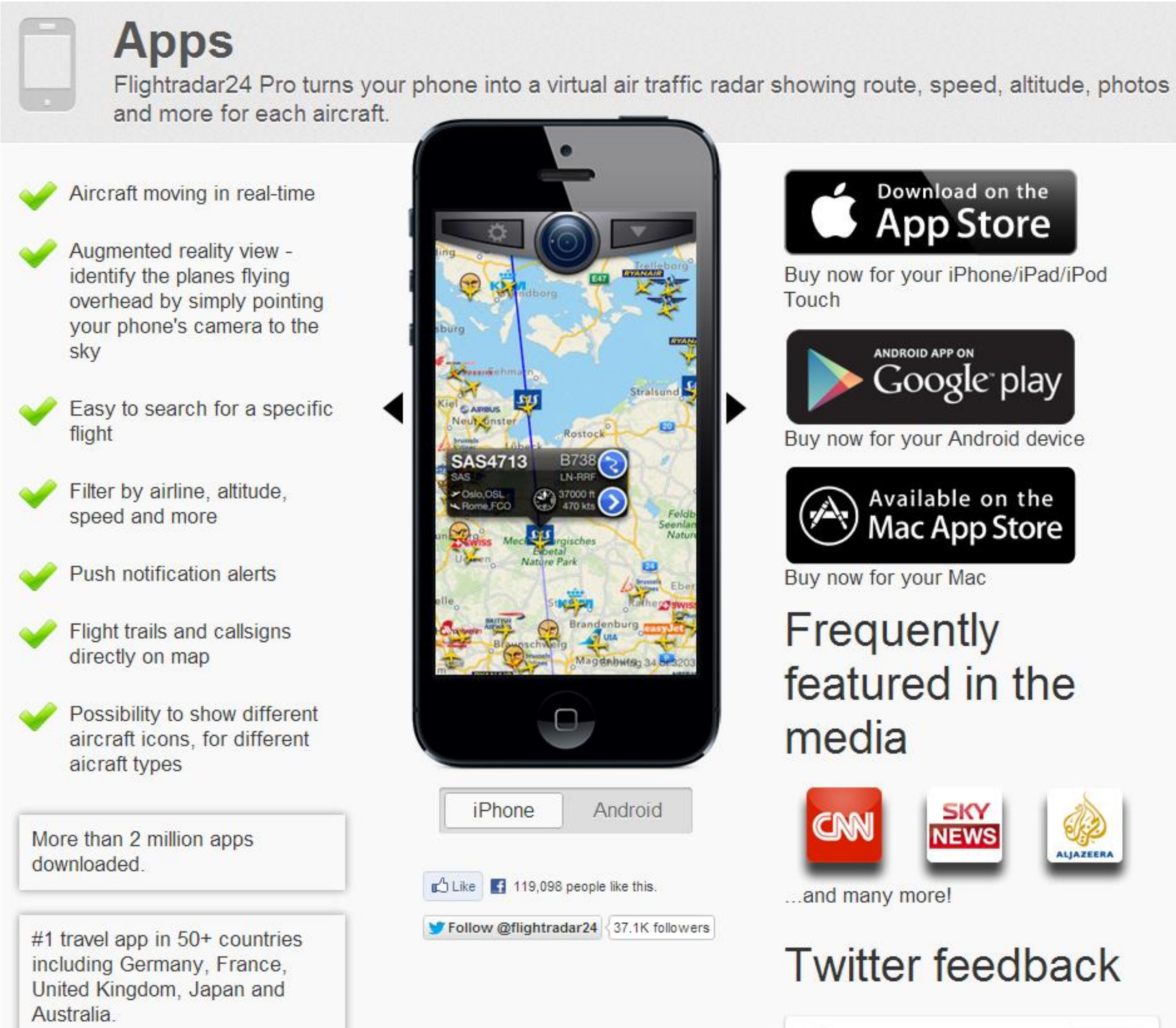
Source: DB BAHN



Source: SITKOL

3) Air transport

Source: Flight radar 24



Source: Flight radar 24

2.3.2 Live travel time information at local public transport terminals

Solution family: Traveller Information Systems

Sub-family: Real-Time Service Information Systems

Domain of application: urban

Technology behind: touch screen[14] kiosks for self-service (e.g. in customer offices) or LED displays and screens inside stations/stops, Zigbee technology[15], Computer-Aided Dispatching (CAD) and Automatic Vehicle Location (AVL) systems[16];

Status: Implemented

Links to relevant references

- Passenger Information System for city public transport in Gdansk
- Real-time passenger information at bus stops in Lille Métropole
- SIEL indicator systems in Paris (RER,metro, bus)
- East Kent RTI (The Business Case for RTI: long-term results of the East Kent Trial)
- Real Time Flight Information Athens
- Public transport priority system in Tallinn
- Real-time information for bus passengers - Donostia - San Sebastián/Spain
- Integrating transport management systems - Winchester/United Kingdom
- Establishing a travel information centre - Aalborg/Denmark
- Improved traveller information - Monza/Italy
- The Business Case for RTI: long-term results of the East, Kent Trial, RTIG Library Reference: RTIGPR005-D001-1.0, June 2006,

Description

Concept and problems addressed. A passenger information (display) system (PIS or PIDS) is an electronic information system which provides real-time passenger information. It may include both predictions about arrival and departure times, as well as information about the nature and causes of disruptions.

Real Time passenger information (RTPI) at transport terminals is a state-of-the-art system that provides accurate information as to when the next bus or tram is due to arrive. The main objective is to improve access to and quality of public transport. The vehicle is fitted with a tracking device in order for the RTPI system to know where it is. The system calculates how long it will take to arrive at each of the stops along the route. Using satellite technology the system then communicates for the bus or tram information to a display at the terminal/stop. The display shows when the vehicle is due to arrive. The displayed information is shown either in real time or timetable time, for example 6 minutes or 11:06.

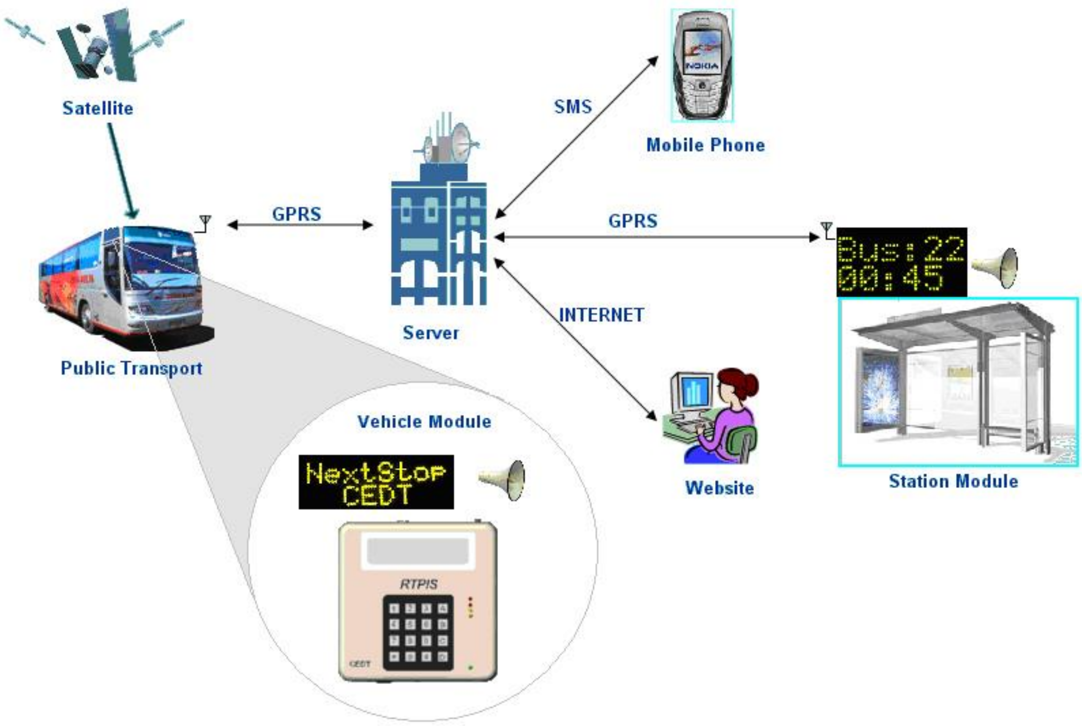
[14] There are a variety of touch screen technologies that have different methods of sensing touch. See more A.Sears, C. Plaisant, B.Shneiderman, (June 1990), A new era for high-precision touchscreens, *Advances in Human-Computer Interaction*, vol. 3, Hartson, R. & Hix, D. Eds., Ablex (1992) 1-33.
[15] http://en.wikipedia.org/wiki/ZigBee#Zigbee_technology
[16] http://www.brampton.ca/EN/residents/transit/Pages/Our-Technology.aspx.

As the system can track each vehicle location exactly, it can tell whether the vehicle is running on time, early or late. This information is then displayed on the screen at the terminal or stop.

RTPI, often introduced as part of modernisation packages for public transport, has been shown to improve perceptions and increase usage of services.

The objectives of the RTPI are to:

- Integrate public transport services in one unified system,
- Promote public transport as a "modern" means of transportation,
- Ensure reliable PT services throughout the day,
- Provide easy access to travel information,
- Pave the way for future ITS services in transport (e.g. electronic ticketing, widespread RTPI),
- Improve the working climate for drivers and user satisfaction.
- Application scenario of RTPIS



Source: K. Ganesh et al.: Implementation of a Real Time Passenger Information System
RTPIS Scenario

Targeted users. The main targeted users for this application are transport authorities and operators.

Barriers to implementation

Financial issues. The main cost of the system is the implementation of the AVL system, but where an operator considers the installation of an RTPI system, he will have in all likelihood have implemented the AVL system for the improvement of the system operation in the first place. The additional costs for the RTPI will depend on the precise design and functionality of the displays, but as a rough indicator the cost for a typical LED display, including installation is likely to be around ú 20,000 per stop or terminal. Typical maintenance costs are ú 500 ï 600 per year.

Technical barriers. There are no technical barriers. RTPI systems are available in many cities in Europe and around the world.

Organisational complexity. There is no organisational complexity once the AVL system is in place.

User and public acceptance. User and public acceptance is to be high.

Interest for Travellers

Door to door travel time. There is no direct impact on travel time. However, if a bus user knows that his next bus is delayed and will only arrive in 15 minutes, he can use this time for other errands.

Travel cost. There is no direct impact on travel costs.

Comfort and convenience. With regard to wayside information, research has shown that waiting for the bus and not knowing when it will arrive causes passengers to feel anxious and frustrated[17]. The provision of RTPI is therefore useful in reducing the perceived cost of waiting. This is primarily because waiting/interchange time is perceived by travellers as a strong deterrent to using public transport. It has therefore been argued that customer service and "goodwill" as well as the visibility of public transport's role in the community can be improved by introducing RTPI.[18]

Safety. There was no reported impact on safety.

Security. There was no reported impact on security.

Accessibility for impaired. No specific impact.

Modal change

The certainty of a bus or tram arrival time will help reduce frustration by bus users and may prevent them from taking their car for the next trip, and seeing the displays and therefore knowing about the availability of this information will attract some former car drivers, but the effects can be expected to be small.

Other notable impacts

Congestion and CO2 emissions: The improvement of quality and accessibility of public transport and the resulting small modal shift will help reduce urban congestion and CO2 emissions.

[17] K. Dziekan, K. Kottenhof: Dynamic at-stop real-time information displays for public transport: effects on customers, "Transportation Research" Part A 41 (6) / 2007, 489-501.
[18] T. Litman: Valuing Transit Service Quality Improvements, "Journal of Public Transportation" 11(2)/2008, 43-63.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	(✓)	Car usage	(-)	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	(+)	Congestion	(✓)
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Source: Flickr

LED information display at Joanic station on the Barcelona Metro. These LED displays count down to the last second the time needed for a train to arrive at a station

Source: Wikipedia
Vertical standing passenger destination information board used in CityRail-Sydney, Australia's train network

Source: FBB
Flight departure/arrival status information at the road access to Berlin's Tegel airport

2.3.3 Live public transport travel time information inside vehicles

Solution family: Traveller Information Systems

Sub-family: Real-Time Service Information Systems

Domain of application: Long and short distance travel

Technology behind: GSM and GPRS technology; GPS; AVL systems; Wireless Technologies; LED screen technology.

Status: Implemented

Links to relevant references

- T69.1 On-trip Bus Traveller Information in Aalborg. CIVITAS 2010
- On-board bus travel information Aalborg/Denmark CIVITAS ARCHIMEDES 2008-2012
- Innovative information systems for public transport, CIVITAS
- Cluster Report 7: Public Transport. CIVITAS 2010
- Real-Time Bus Arrival Information Systems. A Synthesis of Transit Practice. Transportation Research Board, Washington, 2003
- K. Ganesh et al.: Implementation of a Real Time Passenger Information System
- ÖBB Railjet ï Dynamic on board passenger information
- B.Caulfield, M. OöMahony (2003): Real time passenger information: benefit and costs.
- INIT - innovation in traffic systems
- NextBus technology
- Lufthansa FlyNet®: limitless communication on long-haul flights

Description

Concept and problems addressed. Modern transport telematics systems offer opportunities to make public transport faster, more efficient and to support passengers. The attractiveness and popularity of public transportation can be improved by providing passengers with reliable real-time information about services. Real-time information about actual arrival times improves the comfort for passengers and increases user satisfaction. This information is very important especially when the passengers have any transfer during their trips, especially if the transfer time is very tight, and there are delays on the current leg of the journey. Missing a connection and then having to wait from anything between half an hour and another day, depending on the mode of transport is frustrating for commuters and long-distance travellers alike. For bus or rail travellers, there might however be other routes that may lead to a shorter delay for their total trip when they transfer at another stop. The final problem can occur when passengers arrive at their transfer station and do not know at which platform their connecting bus or train stops, or that the connecting train or bus arrives at another platform than scheduled. With short transfer times that may become another reason why they miss their connecting train or bus. Travellers should therefore have an overview of the possibilities for the rest of their journey when they are approaching a certain station. This information could be given to the travellers through a display in the vehicle (trains, bus&coach, airplanes).

Especially useful in railway transport is another system which can help to improve the comfort of the ride for commuters ï it is a system which indicates how crowded the train will be. This improves the chance of finding a place in the train. Travellers are then able to gather the necessary information before the train even arrives at the transfer station so the transfer time at the station could fully be used to get on the next train. The system could also be extended with more personal travel information.

Real-Time Passenger Information System (RTPIS) uses a variety of technologies to track the locations of buses in real time and uses this information to generate predictions of bus arrivals at stops along the route. The majority of real-time bus arrival information systems are based on the use of data from GPS-based automatic vehicle location (AVL) systems. The location data generated from AVL on each vehicle is transmitted from each vehicle to a central location. This can be brought together with other information, such as current traffic conditions and current and historical bus operations data (e.g., running times between time points). When this information is disseminated to passengers via TFT or LED displays, they can spend their time efficiently and more comfortable or take alternate means of transport if the bus is delayed. The application of Next Bus technology is presented below:

Source: NextBus technology

The careful design of information, both at-stops and transport hubs and on-board vehicles, can enhance the confidence of disabled users. It also benefits many people without a visible disability. Oral (supplemented by voice announcements) and visual devices on the bus such as LCD information displays can provide real-time information based on an automatic vehicle location and electronic schedule system. There can also be automatic measurement and analysis systems for route times and passenger numbers[19]. As an example in Aalborg, the service displays the destination and upcoming stops, as well as the weather forecast, news and advertisements (see figure below).

[19] http://www.civitas-initiative.eu/docs1/CIVITAS_GUARD_Final_Cluster_Report_Nr_7_Public_Transport.pdf

Source: http://www.civitas-initiative.org/index.php?id=79&sel_menu=24&measure_id=544

Dynamic on board passenger information can also be found in rail transport. For example such a solution is implemented in the Railjet. It is the premium product of the ÖBB concerning long-distance high speed passenger transport. Each coach is equipped with a visual dynamic passenger information system. The screens show the actual travel speed, the travel route on a map, the actual position and distance to the next stops (see figure below). Connections which can be easily reached are marked in green. Real time information about actual arrival times and connections decreases uncertainty and improves the comfort for passengers especially on intermodal trips.

Source: http://www.seat61.com/railjet.htm#.UIPMCvKWN0M

Numerous airlines provide information on connecting flights within an aircraft approaching an airport. Either on request of specific passengers, announcements by the staff of an aircraft or display information on the monitors of the (personal) IFE (in-flight entertainment) systems are available in long-haul aircraft. Examples known for IFE solutions are Lufthansa (see figure below), Emirates when approaching their hub Dubai, Singapore Airlines, Austrian Airlines, Qatar

Airways, Air France, Air New Zealand, Japan Airlines, Air Canada2[20]. Providing information on connecting flights enables smooth connectivity at airports and therefore strengthens co-modality of air transport. More and more of long-haul aircrafts already have internet access.

Source: Lufthansa FlyNet®

Targeted users. The main targeted users for on-board applications are transport authorities, transport operators and vehicle operators in all modes of transport.

Barriers to implementation

Financial issues. The costs for these systems vary widely depending on the context in which they are installed. In the case of on-board information in planes, the existing displays, normally used for in-flight entertainment are being used. The only costs are therefore the initial costs for the programming of the flight related information. In the case of buses or trains, there are the additional costs of the on-board displays, which can add up for a bigger fleet. Furthermore, depending on the technology used, there may be also notable costs for data transmission, but they should not be substantial enough to be a barrier to implementation. For buses, trams or trains, special displays will have to be installed, but the costs for these are also not prohibitive.

Technical barriers. This technology is already in use and can be implemented inside vehicles in different modes of transport. There shouldn't be any insurmountable technical barriers to the implementation of the application.

Organisational complexity. The systems of travel time information system inside vehicles require high level of process and systems integration, as they rely on complex infrastructures made up of different subsystems in multiple operation domains (e.g. data analysis and elaboration, event and operation management, communications, etc.). All those systems need to be integrated in a single point of management, which determines the complexity of the structure and the many relationships among its technology. It is important to develop close cooperation between all partners and stakeholders involved (e.g. public transport operators).

User and public acceptance. User and public acceptance is likely to be high.

Interest for Travellers

Door to door travel time. If connections are displayed, then it is possible that a user realises he has to rush to get the connecting bus, and may therefore not miss it.

Travel cost. No impact.

Comfort and convenience. Real time information about actual arrival times improves the comfort for passengers and increase user satisfaction.

[20] http://80.33.141.76/origami/index.php?option=com_content&view=article&id=434:1019-real-time-information-on-connecting-flights-within-aircrafts-approaching-an-airport&catid=1:general

Safety. No impact.

Security. No impact.

Accessibility for impaired. No special impact.

Modal change

Real time information about actual arrival times increases user satisfaction and improves the comfort for passengers on intermodal trips, but in this case the users are already in the transport vehicle, so the effects will be rather marginal.

Other notable impacts

None expected.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€-€€	D2D travel time	(✓)	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Source: INIT
On-Board TFT Displays

Source: INIT
On-Board LED Displays

2.3.4 Real-Time public transport information based on social media

Solution family: Traveller Information Systems

Sub-family: Real-Time Service Information Systems

Domain of application: urban, rural, long-distance

Technology behind: mobile phone

Status: implemented

Links to relevant references

- Sanderijn Baanders (2012) *Impact of social media in public transport. Use of Twitter in The Netherlands*
- MOVEITER *Using Twitter in Public* (2012) *Transports*
- Bas Stottelaar *Detection of Public Transport Problems using Location Extended Community Based Sensing*
- Social Media in Transport CIVITAS Forum 2011 ï Notes by Andrew Nash
- Transportation Research Board - Transit Cooperative Research Program (2012) *Uses of Social Media in Public Transportation*

Description

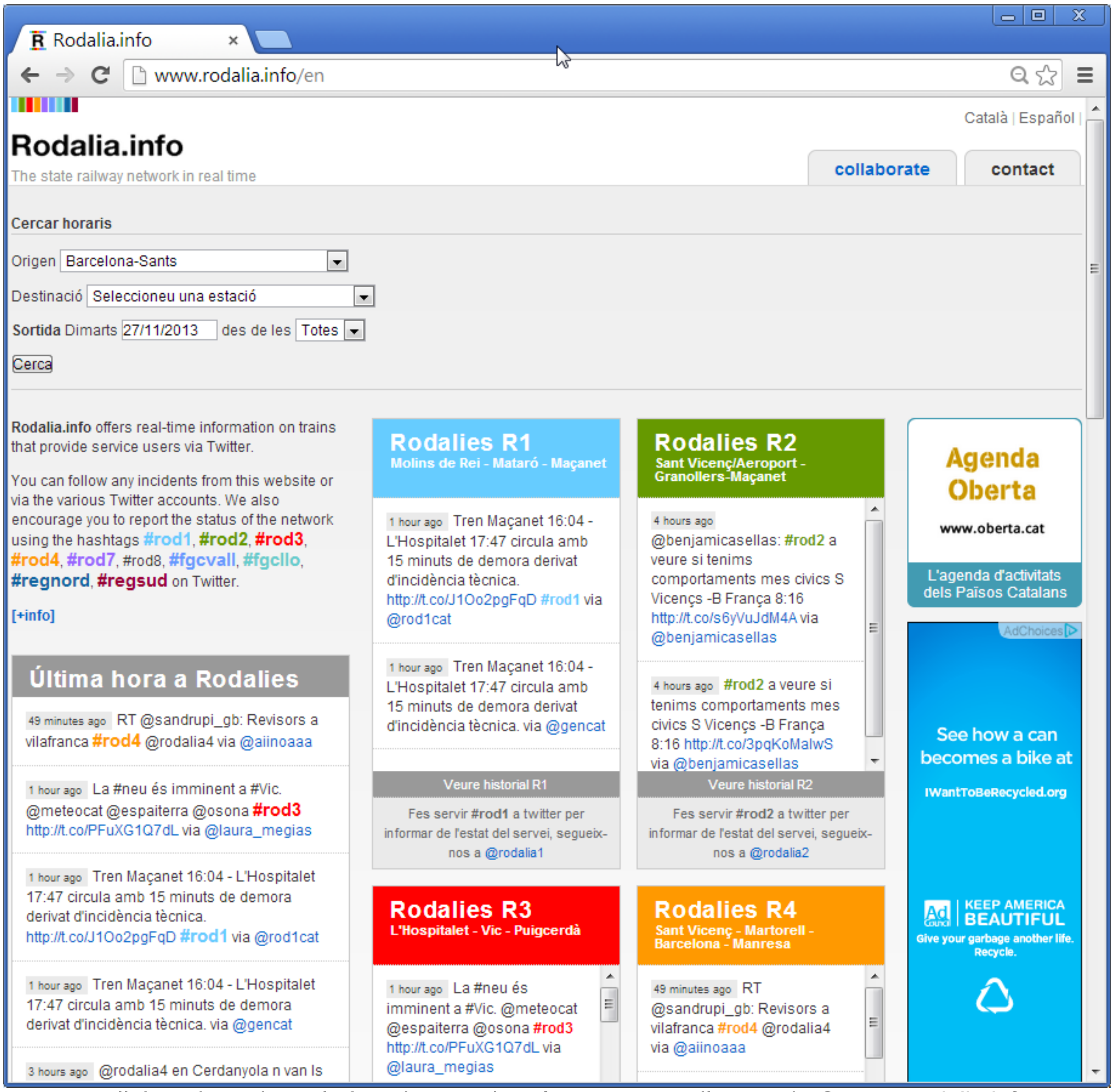
Concept and problems addressed. The usage of social media among public transport users and operators grows rapidly, with a flow of information that circulates from operators to passengers and vice versa or between the passengers of public transport themselves. Facebook is more often used for general information from the public transport providers to users, while twitter is the main channel for time sensitive services information and is becoming important in many public transport networks because of the poor quality of other communication during disruptions. In twitter, the system is organised through ñtwitterbotsò, programs used to spam twitter feeds, posts, or other information.

Twitter is shown as a valuable source of real time information. Twitter is a very easy tool to use, with a rapid growth in wide sectors of the population and in which the messages sent by the operators to inform their users about incidents or news related to public transport have a very good reception. Twitter is then an important information tool to be permanently updated about the interruptions or incidents in the public transport system, or on the road network.

There are three groups of information interchange:

- ***Between users:*** The information consists usually of messages on incidents and delays on the public transport system, or accidents and congestion in the network.
- ***Users to operator:*** The information generally consists of complaints about the service rendered by the operator, concrete or general questions, information about vandalism and to a lesser extent about suggestions for the improvement of the service.
- ***Operator to users:*** The information given in this flow of information is about the stops, time-schedules, news about the operating company, incidents, delays, disruptions of the service or answers to the most frequent questions of the clients.

The Dutch train operator twitter, for instance, has 46.000 followers with an average of 500 to 1,000 tweets per week. In Great Britain, the national rail information system was mostly switched off and some operators encouraged travellers to tweet about their journey status and experience, helping information circulate. In Barcelona, users tweet in the platform *rodalia.info* to provide information on service delays or other incidences in the commuter rail network.



Collaborative twitter platform in Barcelona's commuter rail network. *Source: rodalia.info*

There are sometimes uses of twitter which conflict with the operator interests, like twitter accounts used to inform about ticket controlling points in the network (e.g. 11,900 followers in the Netherlands, and an average of 250 ï 1,200 tweets per week).

Targeted users. Public transport operators and recurrent public transport users.

Barriers to Implementation

Financial issues. This solution does not have any investment costs associated with it. It is based on the initiative of transport operators and users in the transport networks, willing to share their experience through smart phone based social networks. If promoted by a transport operator or a transport authority, it may require some low level of server maintenance and dissemination campaigns. Since the increase of information about the status of the transport system and any delays or disruptions are known to the twitter users, they may be more inclined to use public transport and any small investment on the side of the operator may well get a manifold payback in increased ridership.

Technical barriers. There are no technical barriers to run these systems.

Organisational complexity. The transport operator needs to have some staff available to feed the social media and monitor any feed-back from users, which constitutes a low level of administrative burden.

Legal issues. Twitter could be a threat to working with roving ticket inspections in public transport networks.

User and public acceptance. Acceptance by users and the general public is very high. The only risk for operators is that negative comments or criticism related to transport incidents spread more easily and may damage their reputation.

Interest for Travellers

Door to door travel time. Though the application may not have direct impact on door to door travel time under normal conditions, users who become aware of incidents and delays in the public transport network may in some case be able to use alternative routes to their destination. In this case, travel time savings may be observed.

Travel cost. No particular impacts expected

Comfort and convenience. Being aware of traffic conditions ahead or of the magnitude of public transport delays may increase the comfort of users, either because they are able to reroute their journey, or because at least they have a notion of how much may they expect to be delayed.

Safety. No impact expected.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal change

The fact that delays and disruptions in the transport network are known may in some cases convince travellers to use their car instead, but more often it is to be expected that travellers who know from the twitter feeds that buses or rail are running on time may decide to use the public transport option. Therefore overall a small shift from the car to public transport may be expected.

Other notable impacts

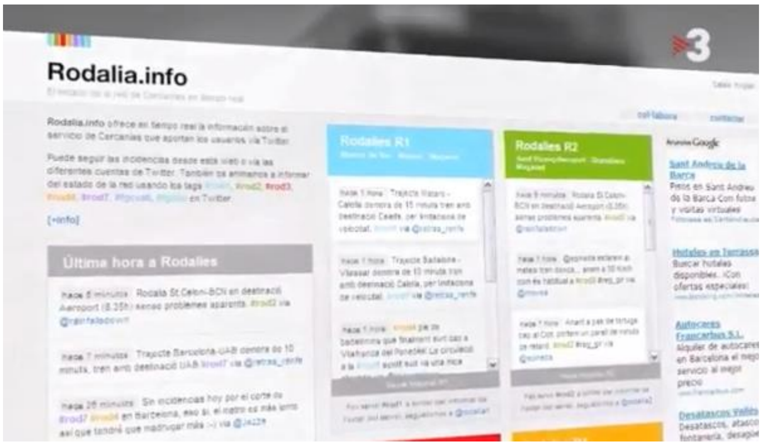
Congestion and CO_2 emissions. Any shift from the car to public transport will reduce congestion and CO_2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	ú	D2D travel time	✓	Car usage	(-)	Mobility	0
Operation and maintenance costs	ú	D2D travel cost	0	Bus and coach usage	(+)	Congestion	(✓)
Financial viability	✓	Comfort and convenience	✓	Rail usage	(+)	CO2 emissions	(✓)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	(X)	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	(X)						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Real-time user cooperative information in Barcelona *rodalia.info* (Catalan only, with automated subtitles in Spanish).



http://www.youtube.com/watch?v=5orM_D_NXRU

2.3.5 Bus location systems

Solution family: Traveller Information Systems

Sub-family: Real-Time Service Information Systems

Domain of application: Urban, metropolitan, rural

Technology behind: GPS; Radio.

Status: Implemented

Links to relevant references

- Live Bus Arribals ï Transport for London
- Travel plus
- Cambridge shire bus
- Real Time Travel
- ¡NextBus Realtime Bus Tracker
- Transport & Streets ï Leicester City Council

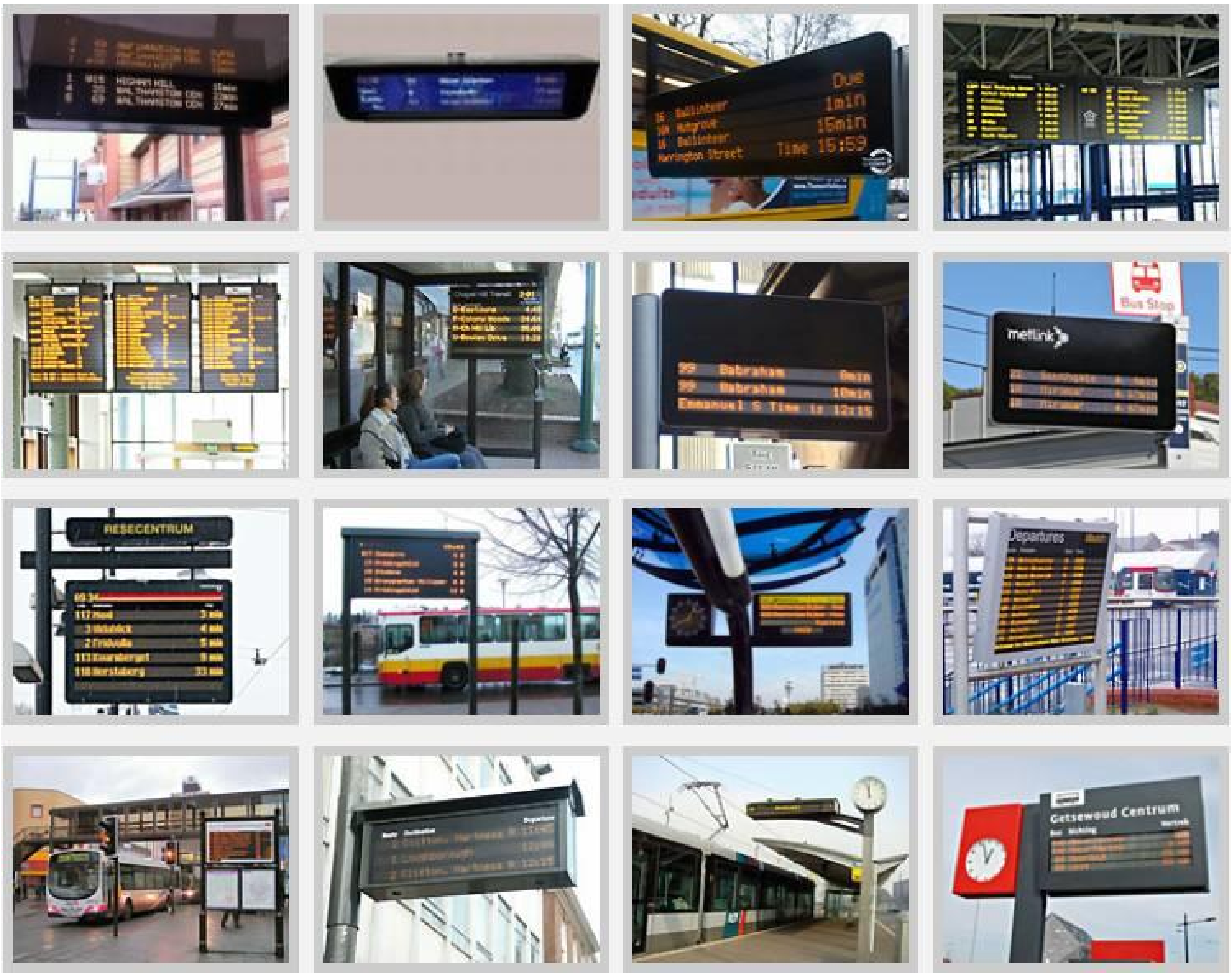
Description

Concept and problems addressed. This application provides accurate real-time or live information about selected bus services. Using on-board GPS technology, BLSs would enable passengers to find out exactly when the next bus is due to arrive.

This application requires buses to be equipped with an onboard computer, GPS navigation system and a communication media (e.g. radio) which sends the position of the buses to a central computer. The travel times of the bus to reach all stops along the route are estimated by the central computer, and the real-time bus arrival information can be accessed in a number of different ways such as at bus stops, as shown in the figure below, or websites and mobile phone apps. Other new technology has also been developed to improve the readability of the real-time information for all our passengers, for example, audio options at bus stops to help blind and partially sighted people.

Many bus operators in Europe have installed the BLSs on their fleet, for instance in the UK such as Arriva, First, Go-Ahead, Stagecoach, and many municipal bus companies. The accuracy and costs of the real-time information systems are two of the important factors in determining the viability and competitiveness of BLSs.

One of the first real-time bus information systems in the UK was Star-Trak which was created in 2000 by Leicester City Council to provide its citizens with a real-time system for the bus network in Leicester, Leicestershire, Derby and Derbyshire. It was abandoned in 2011 as Arriva Midlands decided to withdraw from the system and the city council found it unaffordable to operate the system without the participation of Arriva. However, the shutdown of the £3.8 million Star-Trak system saved the city council £200,000 a year in subsidies and staffing costs. The system was replaced by Germany's INIT, specialists in transportation telematics and fare collection systems and the signs are supplied by Swedish company Poltech. The costs for the setting-up of the new system were about £630,000. The running costs are estimated at between £160,000 and £200,000 a year, slightly cheaper than Star-trak but the new system is equipped with many modern features such as satellites and smart phones.



BLS displays

Targeted users. Public transport operators, especially in urban and metropolitan areas.

Barriers to implementation

Financial issues. The costs for the BLSs consist of the costs of installing the infrastructure, including the on-board unit costs, RSU costs, the control centre costs, the communication costs and the costs for providing services.

On the other hand, bus companies pay for the system to improve their bus services and to get more people to use them.

Technical barriers. There are no technical barriers.

Organisational complexity. Organisational complexity is very low. It usually involves the bus operators and the local authorities who are likely to form a publicï private partnership (PPP).

Legal issues. There are no legal obstacles.

User and public acceptance. Public acceptance of BLSs is generally very high, but the accuracy of the prediction of the bus arrival time is very important. Bus operators believe they will get a return of their investment through increased passenger satisfaction and therefore increased passenger numbers.

Interest for Travellers

Door to door travel time. This application can directly save door to door travel time by informing passengers through the web or through apps when the next bus or tram arrives, so that they know when to leave the house or office. Once passengers arrived at the bus stop and the displays there tell them that it is 20 or 30 minutes before their bus arrives, they have the chance to use this time with shopping or a walk in the park instead of just standing waiting at the bus stop.

Travel cost. This application is not envisaged to save the out-of-pocket travel expenses.

Comfort and convenience. BLSs may improve the convenience of travelling by bus.

Safety. No particular impact is expected.

Security. No particular impact is expected.

Accessibility for impaired. New technology means to improve the readability of the real-time information for all our passengers. For example, audio options can help blind and partially sighted people get the same information.

Modal change

Improving bus services is vital for getting more people to use public transport and BLSs are one of the solutions.

Other notable impacts

Mobility. BLSs may make a small contribution to increasing mobility, for instance for frail or elderly passengers who would not be able to stand and wait at a bus stop for half an hour.

Congestion. By shifting more road users to public transport, the BLSs may help reduce congestion and thus improve traffic conditions, in particular during the rush hours.

CO2 emissions. The environmental benefit of BLSs can be calculated through the reduced number of car users.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	**€€**	D2D travel time	✓	Car usage	-	Mobility	(✓)
Operation and maintenance costs	**€€**	D2D travel costs	**0**	Bus and coach usage	+	Congestion	✓
Financial viability	(✓)	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	**0**	Safety	**0**	Ferry usage	0	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage		European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	✓			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Live bus arrivals:

http://www.youtube.com/watch?feature=player_embedded&v=qqmzewVSZ0k

2.3.6 Vehicle tracking applications

Solution family: Traveller Information Systems

Sub-family: Real-Time Service Information Systems

Domain of application: Long-distance

Technology behind: positioning and location referencing, aircraft-to-infrastructure and aircraft-aircraft communications

Status: Implemented

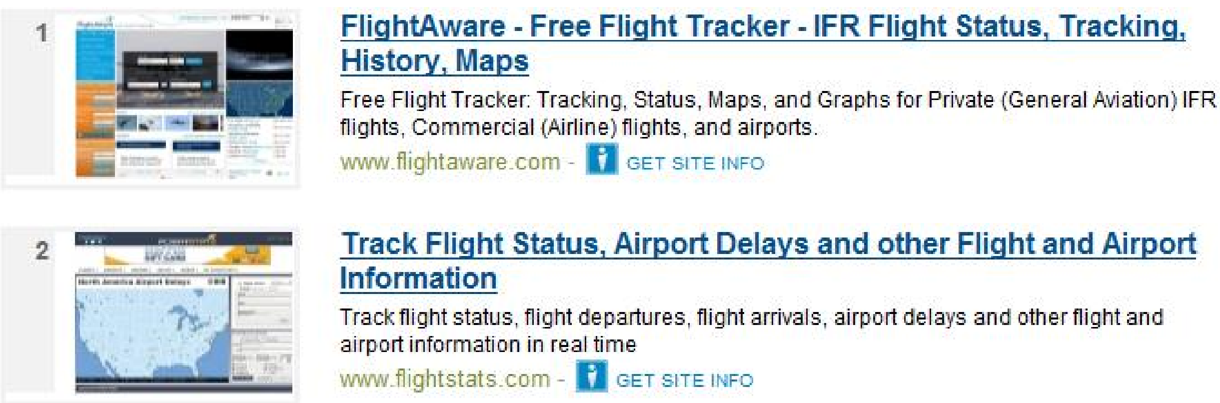
Links to relevant references

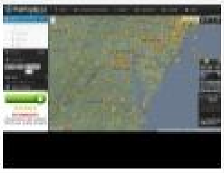
- Flight Radar 24 ï Live Air Traffic.
- Plane Finder
- Flight Wise plane tracker.
- Infrabelôs rail tracker
- Vessel finder for ships navigating in Worldôs oceans

Description

Concept and problems addressed. Vehicle tracking systems are web-based applications which show live air, rail or maritime traffic information from around the world or at regional level. They are also developed as mobile apps used on mobile devices such as Android smart phones, iPads or iPhones. A personal virtual radar on a mobile device tracking transport vehicles worldwide may include photographs, plane and flight statistics, rail schedules and eventual delays, vessel identification and routes. Such an information system has become very popular as a result of fast internet and mobile access. There is a long list of web-based applications developed.

Top 10 flight tracking applications are displayed below. On the air domain, the primary technology used by these applications to receive flight information is called automatic dependent surveillance-broadcast (ADS-B) which is a path-finding technology for the modernisation of Air Traffic Management and the Next Generation Air Transportation System (see separate factsheet), and a surveillance technology that broadcasts GPS-based position from aircraft to ground-based receivers and other aircraft (see separate factsheet).



3 

Flightradar24.com - Live Flight Tracker!

Flightradar24 is the best live flight tracker that shows air traffic in real time. Best coverage and cool features!

www.flightradar24.com - GET SITE INFO

4 

Real Time Flight Tracker & Airport Delays from FlightView

Look up the flight status info of any flight in North America and see live flight tracking maps with FlightView's real time flight tracker.

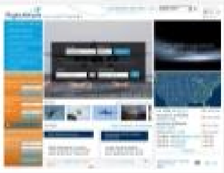
www.flightview.com - GET SITE INFO

5 

FlyteComm: The Most Accurate Free Flight Tracking/Tracker Tool in the industry!

FlyteComm offers the MOST ACCURATE Free and Subscription flight tracking services on the web: Tracker, Status, and Maps for Private (General Aviation) IFR flights, Commercial (Airline) flights, and airports.

www.flytecomm.com/cgi-bin/trackflight - GET SITE INFO

6 

FlightAware > Live Flight Tracker

Free Flight Tracker: Tracking, Status, Maps, and Graphs for Private (General Aviation) IFR flights, Commercial (Airline) flights, and airports.

www.flightaware.com/live/ - GET SITE INFO

7 

Real Time Flight Tracking from FlightView

Track flights in real-time by flight number or route to see live flight status information.

www.flightview.com/TravelTools - GET SITE INFO

8 

Flight Explorer

Flight Explorer - The world's leading provider of real-time, Internet-based, flight tracking and information systems. Track airline flight online with our Airline Flight tracking software, Aircraft tracking, Flight-tracking systems with Rea...

www.flightexplorer.com - GET SITE INFO

9 

Flight tracking-Free & Real-time

Flight Explorer provides premiere real-time flight tracking for travelers and aviation industry enthusiasts. Flight arrival and departure information is obtained by using official FAA tracking data, ensuring its reliability.

travel.flightexplorer.com - GET SITE INFO

10 

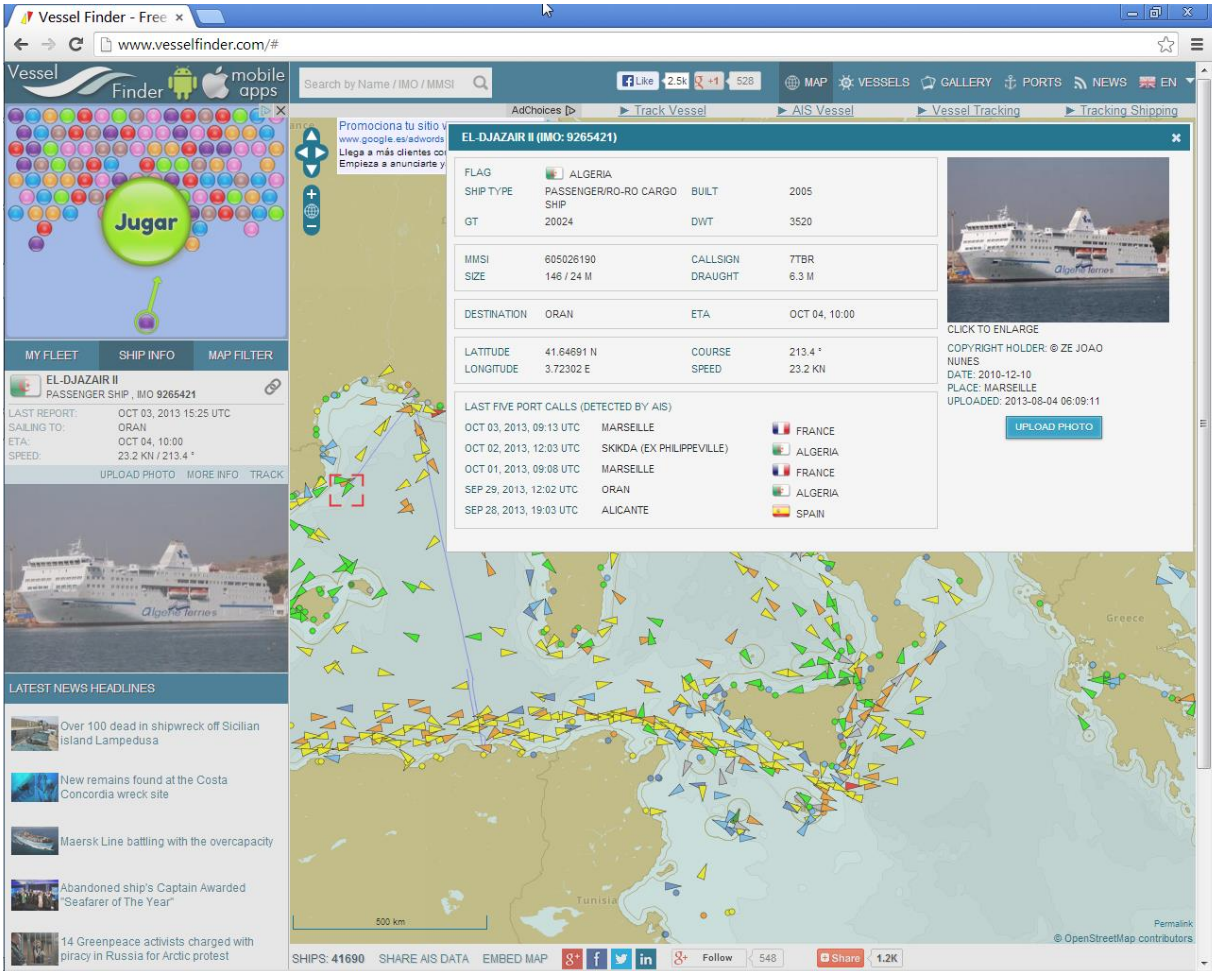
Aeroseek: Real-Time Flight Tracker - Flight Tracking

Real-time flight tracking for over 300 airlines world wide as well as general aviation aircraft. Provides info on altitude, airspeed and arrival times as well as departure and destinantion points.

www.aeroseek.com/webtrax/ - GET SITE INFO

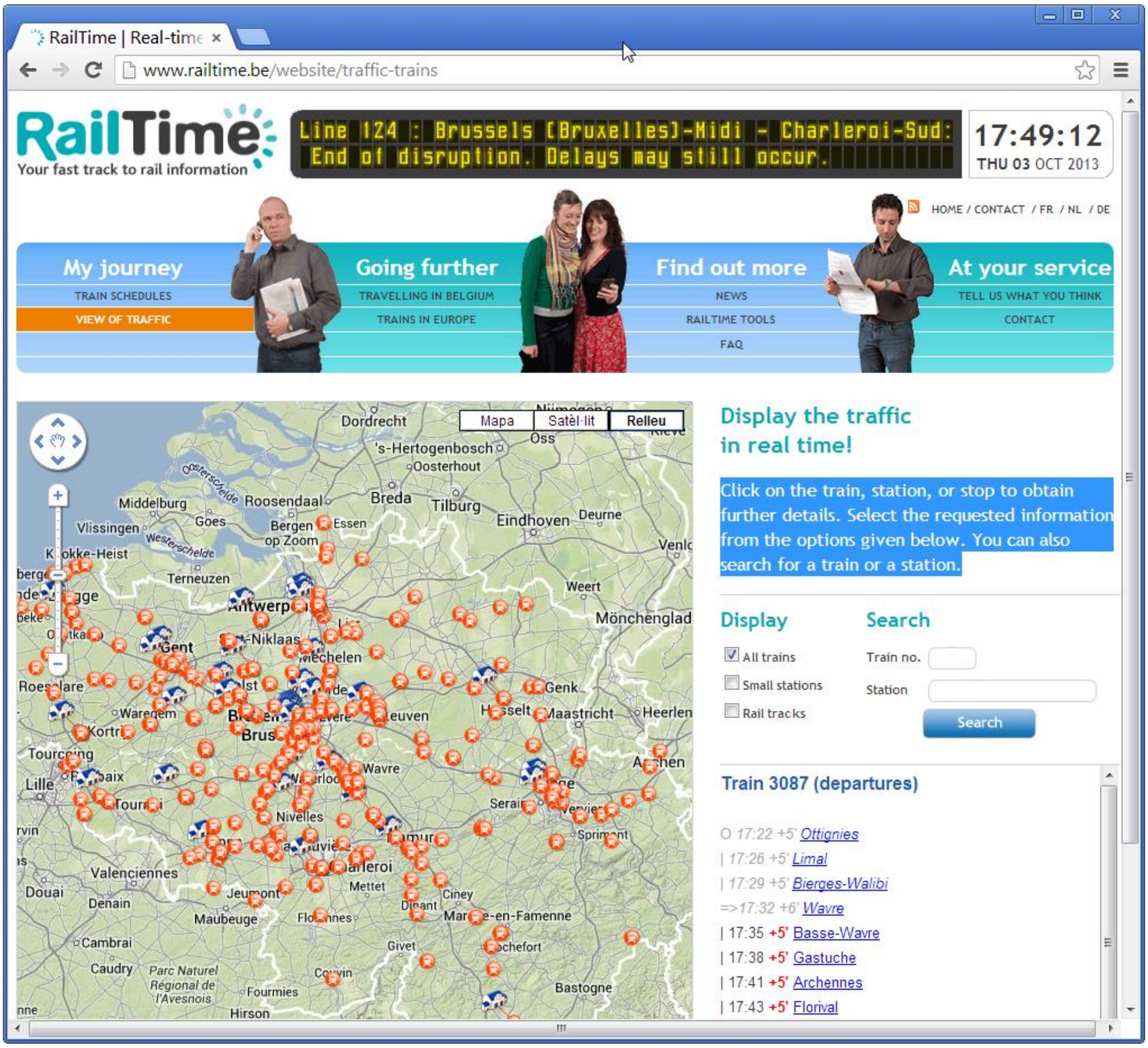
Vessel apps such as vesselfinder.com display vessels in the oceans over a world map providing information on their IMO identification, nationality, route, last reporting time, last port calls, speed, estimated time of arrival. Eventually, pictures of ships are included. It also allows tracking more than 13,000 ports in the World. Vessels are then displayed inside ports. Over 100,000 vessels worldwide are available within VesselFinder's database. The application is available online or for

Android, iPhone and iPad. VesselFinder is based on AIS technology (see separate factsheet). The Automatic Identification System (AIS) is the automatic tracking system used on ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations, and satellites. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.



Source: Vessel Finder
Ship route also displayed on the map

Railtime is the web-based application by Infrabel, Belgiumôs rail infrastructure manager, displaying rail services localisation over a map of Belgium, on real time. The application allows consulting real-time timetables for all trains in Belgium and planning current or future journeys optimising travel with regular updates, automatic alerts about delays and geolocation. The application allows users to click on a train, station, or a stop to obtain service details. For specific ongoing services, it is possible to get informed on delays or to know timings of station stops. For a specific rail station, it is possible to know the departure times of next expected services. The application is available online on the web, and as a smartphone application for Android and iOS.



Infrabel’s RailTime application to track rail services in Belgium

Targeted users. The targeted users are travellers, plane/rail/vessel spotters and enthusiasts, and by anyone who just wants to track a friend or is curious about the planes overhead or trains and vessels ahead.

Barriers to implementation

Financial issues. The real cost of the system lies in the cost for implementing ADS-B / AIS, but this is done for a variety of reasons and the publicly available flight/vessel/rail tracking systems are then simply cheap by-product, which is free of charge at the point of use. The financial viability of these sites is also given through the opportunity for advertising e.g. for flights.

Technical barriers. There are no more technical barriers.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no legal issues with publishing the flight information available from ADS-B (air domain).
However, as for public dissemination of AIS data (maritime domain), the IMO’s Maritime Safety Committee argued that the “publication on the world-wide web of AIS data transmitted by ships could be detrimental to the safety and security of ships and port facilities and was undermining the efforts of the Organization and its Member States to enhance the safety of navigation and

security in the international maritime transport sector.ò Others claim that ships have the option of turning off AIS when they are in areas with security concerns.

User and public acceptance. User and public acceptance is high. It has also been used by residents living close to airports, to identify airplanes which may not follow landing or takeoff manoeuver lanes and procedures, generating excesses of noise in the proximity of the airport.

Interest for Travellers

Door to door travel time. The may impact on travel time for the air traveller if they know their flight is delayed and they need to set off later. However, departure delays could be already relayed with conventional information systems. The main practical advantage of the new system is for those picking arriving passengers up, if they know that a flight will be considerably delayed long before the airportõs delay warning comes up. For rail tracking application, users may walk to the station later if they are aware of delays ahead.

Travel cost. Better knowledge of arrival times will minimise the parking charges at the airport or rail station for those picking up arriving travellers.

Comfort and convenience. No impact is expected.

Safety. No impact

Security. No serious impact is expected, although the systems could in theory help terrorists target incoming aircraft for rocket attacks or target vessels for robbery or kidnap.

Accessibility for impaired. No impact.

Modal change

Not expected.

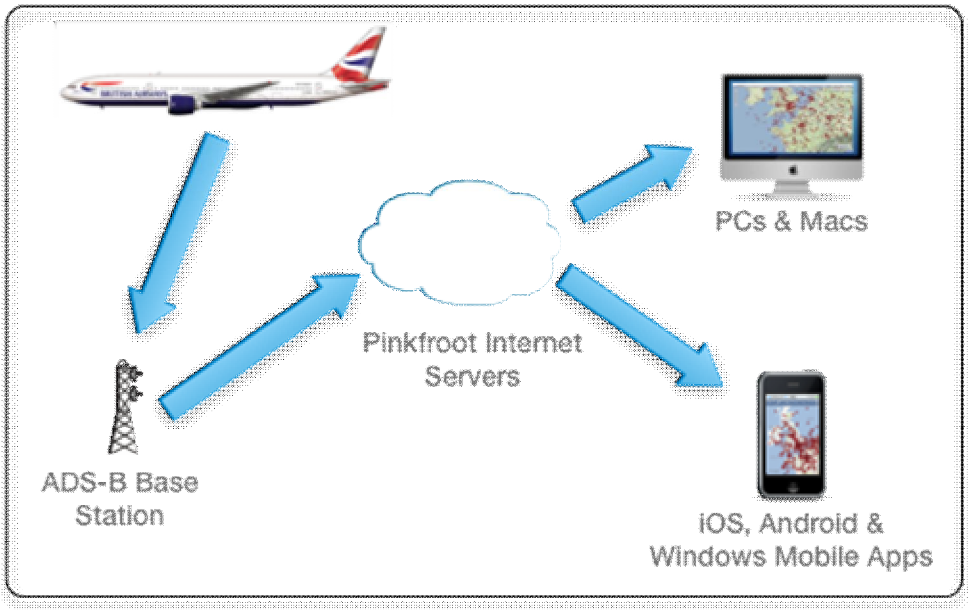
Other notable impacts

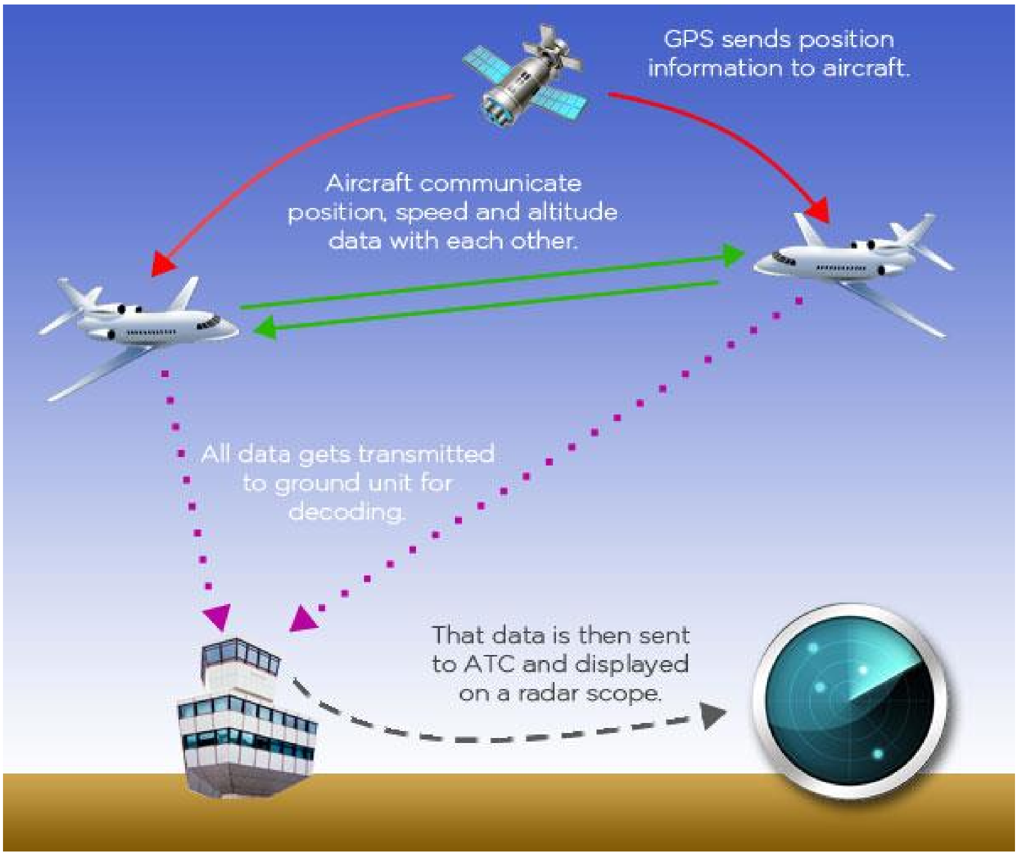
No serious ones expected, although there may be a very minor reduction in congestion in airport car parks.

Summary of scores

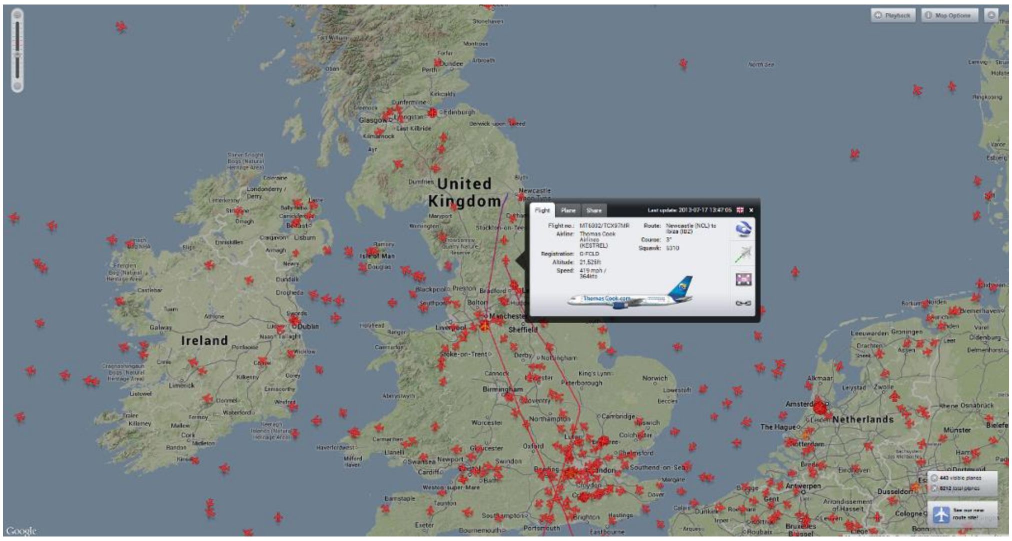
Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	(✓)	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(X)	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials




GPS sends position information to aircraft.
Aircraft communicate position, speed and altitude data with each other.
All data gets transmitted to ground unit for decoding.
That data is then sent to ATC and displayed on a radar scope.


North Pacific Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean


United
Kingdom
Ireland
Netherlands
Google

2.4 SMART PHONE JOURNEY ASSISTANTS

2.4.1 Travel organising assistants or passbook applications

Solution family: Traveller Information Systems

Subfamily: Smart Phone Journey Assistants

Domain of application: long-distance travel

Technology behind: mobile phone

Status: implemented

Links to relevant references
- Passbook app
- Worldmate app
- BlackBerry® TravelÊ app
- BLOG CIO
- TripIt app
- The Top 10 Free Travel Apps ï PCMAG .

Description

Concept and problems addressed. There are many "travel management" programs out there that help travellers keep track of things like flight confirmation numbers, hotel confirmation numbers and similar issues. One of them is TripIt. It stores the confirmation emails which the user gets from hotels and airlines. TripIt is available for Android, iPhone, iPad, BlackBerry, Windows Phone 7, and people can access their data from even the simplest phones by sending them to m.tripit.com. Another similar application is TripCase. Sabre's TripCase has more advanced functions then TripIt has. TripCase gives the user continually updated flight delay and gate status for flights, and suggests alternative flights if the user is about to miss his. TripCase is available for BlackBerry, Windows Mobile and iPhone.

Passbook is an application in iOS that allows users to store coupons, boarding passes, event tickets, store cards, 'generic' cards and other forms of mobile payment.

The WorldMate application is available for iPhone, iPad, Android, and Windows Platform. It is a feature that has yet to be implemented by itinerary-management rivals such as TripIt and TripCase. The free WorldMate app offers also hotel bookings, alerts for flights and meetings, Google Maps, currency conversion and 5-day weather forecasts.

Other similar applications are:
- Kayak Mobilec - for reserving a flight, room, or car on the go, rely on this easy-to-use app from one of the most comprehensive booking sites on the web),
- FlightTrack ensures details about someoneçs flight fast: gate changes, delay times, seat availability via SeatGuru, and baggage claim locations, the Pro version alerts the user to gate changes or flight delays (it can be synchronised with TripIt).
- GateGuru provides a map of the airport, including shopping and food options in all the terminals.
- HearPlanet Litec is the multiple guidebook. With the audio guides, the user can learn about the places where he is. HearPlanet alerts the user to nearby attractions, or search anywhere in the world.
- Oanda Currency Converter ï the user can compare dollars to more than 190 currencies, plus see what exchange rate he will get on his credit card purchases and ATM withdrawals. It is available for Android, iPhone, BlackBerry, Windows Phone 7.

- BlackBerry® TravelÊ app on BlackBerry 10 is an all-in-one travel app that allows the user to plan, book, manage and share his travel directly from his BlackBerry® smartphone. It claims to provide the ultimate mobile travel management experience by keeping users moving and adapting to his needs. The user can find a deal on hotel and car rentals, get real-time notifications if his flight is delayed or cancelled, and find a new flight.

Targeted users: All travellers

Barriers to implementation

Financial issues. Many of these application are free.

Technical barriers: There are no technical barriers to developing an app.

Organisational complexity. No particular organisational barriers expected.

Legal issues. There should not be any legal obstacles to this application.

User and public acceptance. User and public acceptance can be expected to be high, since it is in the interest of the travellers.

Interest for Travellers

Door to door travel time. No particular impact is expected.

Travel cost. No particular impact is expected.

Comfort and convenience. It provides easy and convenient way for access to information needed during a business or touristic trip.

Safety. No particular impact is expected.

Security. No particular impact is expected.

Accessibility for impaired. No particular impact is expected.

Modal change

No particular impact is expected.

Other notable impacts

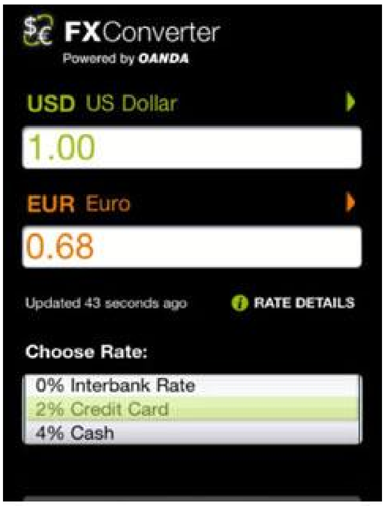
No particular impact is expected.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment Costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and Maintenance Costs	€	D2D travel cost	0	Bus and Coach usage	0	Congestion	0
Financial Viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical Feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational Feasibility	0	Security	0			European economic progress	0
Administrative Burden	0	Accessibility for mob. Imp. Passengers	0			Territorial cohesion	0
Legal Feasibility	0						
User Acceptance	✓						
Public acceptance	✓						

Ilustrative materials

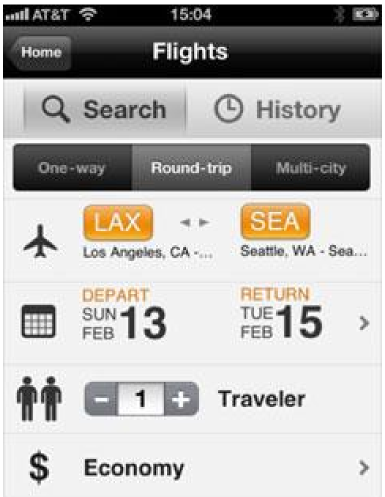
TripIt application



Oanda Currency Converter application

GateGuru application

FlightTrack application



Kayak Mobilec application

2.4.2 Informed seat choice applications for airplanes

Solution family: Traveller Information Systems

Subfamily: Smart Phone Journey Assistants

Domain of application: long-distance

Technology behind: smart phone, cloud technologies

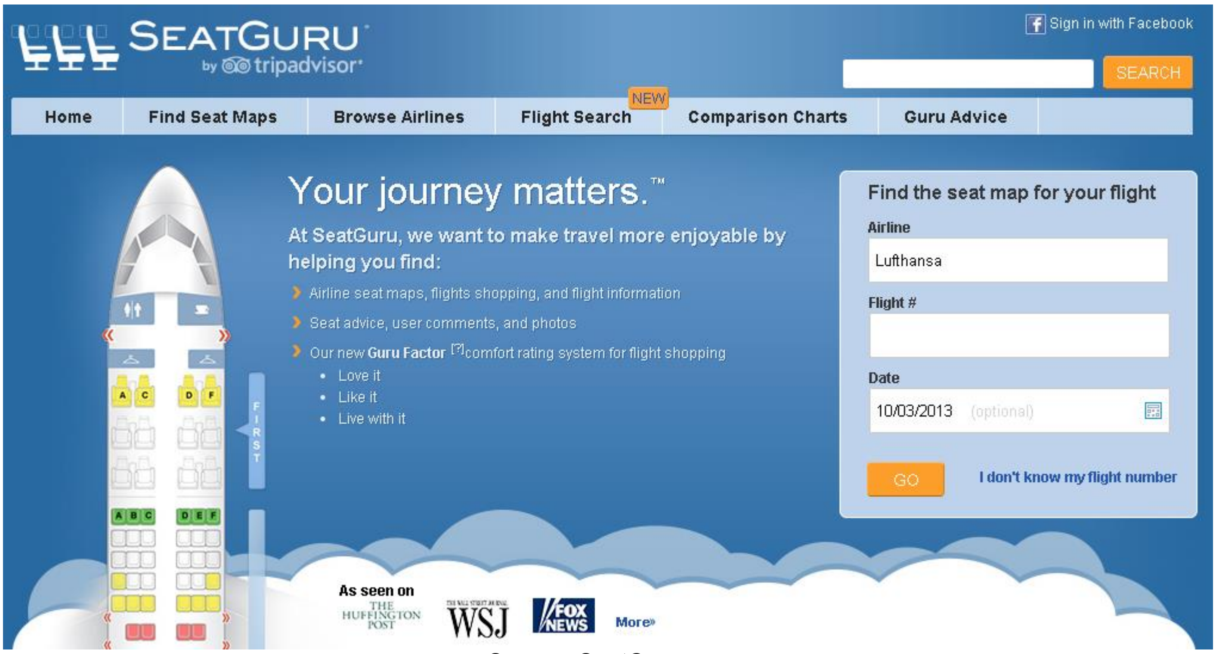
Status: implemented

Links to relevant references

- SeatGuru smart phone application home page

Description

Concept and problems addressed. SeatGuru[21] is an application for smart phones aimed at increasing plane travellersôcomfort by assisting them in taking informed seat choices (and even flights choices), in an attempt to make long-haul flights more pleasurable. With this application, travellers are informed on which seats to book and which to avoid based on the characteristics of each airplane, and even the specific customisations performed by each flight carrier.



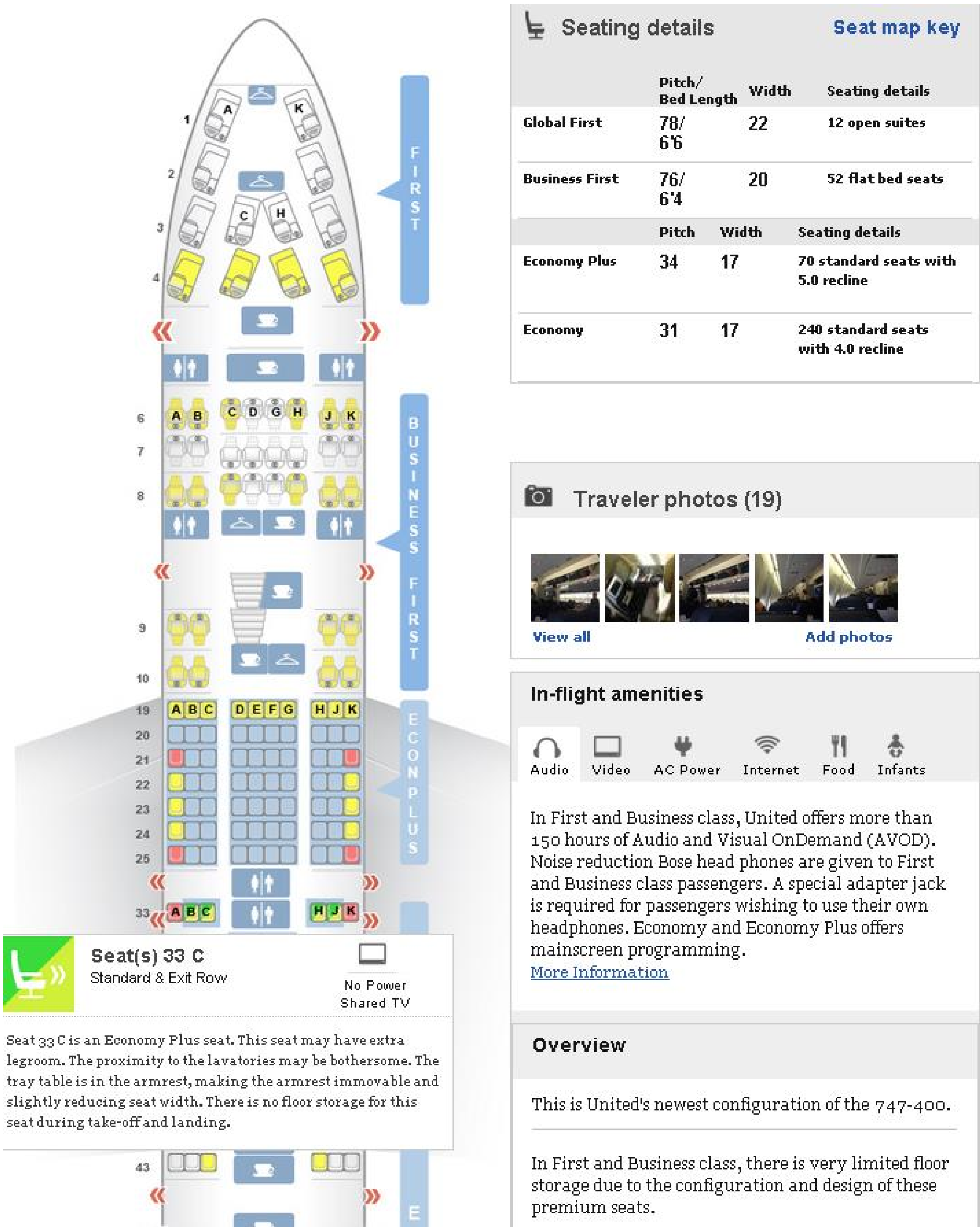
Source: SeatGuru.com

SeatGuru application for web and smart phone.

SeatGuru was created to help flyers recognise and understand the differences between airline seats and in-flight amenities. It is built on a database of over 700 color-coded seat maps backed by more than 50,000 reviews from flyers.

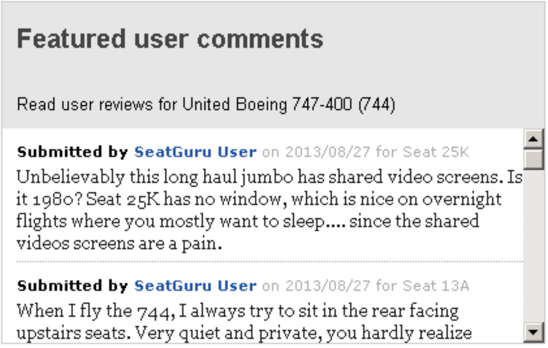
[21] In October 2001, frequent flyer Matthew Daimler launched SeatGuru.com with a single color-coded interactive airplane seating chart. He was determined to collect the vast differences between airline seats and share it with other travellers. In 2007, SeatGuru was purchased by TripAdvisor. Over ten million visitors later, SeatGuru is a major resource for the flying public.

When a traveller is looking to find the best seat on a plane, SeatGuru offers a general description of the aircraft, and the general characteristics of each of its departments (e.g. first class, business, economy plus, tourist). It also shows the seat map where all the seats on the plane are described according to their particular characteristics and services on board. The application highlights seats considered as the best in green; these seats are assumed to be superior because of features as having extra leg space or extra storage room. Seats displayed in yellow or red are stated to be inconvenient due to features like reduced leg space, reduced storage room, being close to lavatories or in a busy corridor, or not being able to recline. The rest of the seats are just standard.



Source: SeatGuru.com
United Seat Maps

Through the "Submit Comments" button on each aircraft page of the SeatGuru application, thousands of reviews have been added to the SeatGuru database by flyers who know a great seat when they sit in it. Users can also send pictures of the aircraft, or of special features or seat characteristics which are also displayed along with the seat map of the aircraft. Comments by users are used to maintain the accuracy of SeatGuru airplane seat information and to update the site with both community-submitted reviews and independent research.



Source: SeatGuru.com
Featured user comments

To assist their costumers in making informed flight choices, SeatGuru also publishes a comparison chart of aircrafts serving specific flight routes which helps people to identify the differences between seat pitch and width for different airplanes at different carriers; and also the comparison between amenities of the different companies. Seat pitch and width can vary greatly between airline carriers and aircraft type.

Airline	Aircraft with seatmap	Seat Pitch	Seat Width	Video Type	Laptop Power	Power Type	Wi-Fi	Seat Type
Aer Lingus	Airbus A319 (319)	31-32	17	None	None	None	No	Standard
Aer Lingus	Airbus A320 (320)	31-32	17	None	None	None	No	Standard
Aer Lingus	Airbus A321 (321)	31-32	17	None	None	None	No	Standard
Aeroflot	Airbus A320 (320) V1	30-32	18	None	None	EmPower	No	Standard
Aeroflot	Airbus A320 (320) V2	30-32	18	None	None	EmPower	No	Standard
Aeroflot	Sukhoi Superjet 100-95B (SU9)	30-32	18.3	None	None	None	No	Standard
Aeroflot	Airbus A319 (319)	30-32	18	None	None	EmPower	No	Standard
Aeroflot	Airbus A321 (321)	30-32	18	None	None	EmPower	No	Standard
Aeromexico	Boeing 737-800 (738)	31	17	Shared TV	None	None	No	Standard
Aeromexico	Boeing 737-800 (738)	34	17	Shared TV	None	None	No	Standard
Aeromexico	Embraer ERJ-145	31	17.3	None	None	None	No	Standard
Aeromexico	Boeing 737-700 (737)	31	17	Shared TV	None	None	No	Standard
Aeromexico	Boeing 737-700 (737)	34	17	Shared TV	None	None	No	Standard
Aeromexico	Embraer E-190	31	18.3	None	None	None	No	Standard
Air Canada	de Havilland Dash 8 (100)	31.0	17.0	None	None	None	No	Standard
Air Canada	Airbus A319 (319) rouge	29	18	None	None	None	No	Standard
Air Canada	Beechcraft 1900D	30.0	20.19	None	None	None	No	Standard

Source: SeatGuru.com
Comparison Chart

Targeted users. Flight travellers, especially frequent flyers and long-haul flyers.

Barriers to Implementation

Financial issues. This is a free application. SeatGuru belongs to the TripAdvisor portal, with incomes mostly originated from publicity.

Technical barriers. The main concern in this kind of application is keeping the database updated. It is important to have a critical mass of regular users providing valuable input to complement in-house independent research.

Organisational complexity. No major organisational barriers are expected.

Legal issues. No legal issues identified.

User and public acceptance. As far as this application improves the comfort and convenience for the passengers it is expected to have a good acceptability.

Interest for Travellers

Door to door travel time. No impact on this field.

Travel cost. This is a free application. No cost repercussions on the flyer’s trip.

Comfort and convenience. For those using the application, there is room for an important improvement in comfort, especially in long-haul flights. Choosing the right seat is an easy way to enhance the traveller experience. For those not owning the app, it is more likely that best seats are picked in advance by other flyers.

Safety. No safety impacts expected.

Security. No security impacts expected.

Accessibility for impaired. Being able to make informed seat choices may assist people with an impairment in getting most accessible seats, enhancing their travel experience.

Modal change

None expected

Other notable impacts

None expected

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	✓✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

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Illustrative materials

How to pick a great airline seat, by Howcast

http://www.youtube.com/watch?v=UXhy6QZZJbw

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SeatGuru iPhone app

http://www.youtube.com/watch?v=I1KQNFO36vE&list=TL1rPnAQ7KAMbFLIjRYVxiCZsuXI7oJrVN

2.4.3 Seat allocation based on travellers' social profile

Solution family: Traveller Information Systems

Subfamily: Smart Phone Journey Assistants

Domain of application: long-distance

Technology behind: cloud technologies (internet)

Status: implemented

Links to relevant references

- Is this seat taken? Airlines add social seating programs by Dennis Schaal, USA TODAY, 2012.
- KLM Meet and Seat
- MHbuddy by Malaysia Airlines
- MHbuddy by Malaysia Airlines(facebook)

Description

Concept and problems addressed. Tools to let passengers find out about interesting people who will be on board their flight such as other passengers attending the same event as them at the destination are being developed by some air carriers. Technology is based on sharing Facebook or LinkedIn profiles, checking other passengersôprofile details and where they will be sitting, and finally allocating a seat.

This solution is to be understood in the Adaptive Marketing framework, which some experts have called to be the next big trend. According to recent studies, a vast majority of consumers that have an existing relationship with a company are happy to share their information with it. Adaptive Marketing is an approach that enables marketers to tailor their activities in unparalleled ways to meet their customersôinterests and needs based on this data.

Two flight companies have implemented this system in their long-haul flights: KLM Royal Dutch Airlines and Malaysia Airlines.

Meet & Seat, from KLM, is available since 2012 for all passengers on all intercontinental flights and Business Class Passengers on flights within Europe. Passengers book their KLM flight, and then from 90 days to 48 hours before departure, they can access Manage my Booking on the airline's website and choose Meet & Seat if they want to opt in to share their Facebook or LinkedIn profiles with other passengers. You can edit your profile and photo, and thus share only the information that you want to provide other passengers. The seating map displays the seat choices and Facebook or LinkedIn profiles of other passengers who have decided to participate in Meet & Seat, and you can contact them before the flight and choose to sit next to them if the seat is available. When additional passengers select the Meet & Seat option and share their social-network profiles, you get an e-mail notification if you are participating in Meet & Seat. And, if you find before taking off that you are sitting next to someone you do not want to chat with during an eight-hour flight, you can change your seat and even withdraw your social-media profile. Your profile gets deleted after the flight.

Source: *KLM*
Discober Meet & Seat

Malaysia Airlinesô MHbuddy is a Facebook application, developed by SITA Lab, which allows passengers to book and check in for a flight while sharing their trip details with friends. When booking a flight, users of the app are reminded of friends who live near their destination; they are also prompted if any of their Facebook friends are planning to travel to the same destination. Then, if they want, they can share their itinerary with friends. Not only that, but during the seat selection process, passengers can see where their friends are sitting and choose their own seats nearby.

Source: *Malaysia Airlines' MHbuddy Facebook application*

Estonian Air also lets passengers peek and seat via Let Me Think Facebook integration. The technology, developed by Airsavings, enables passengers to integrate their Facebook profile into the booking path to save time and see who else is on their flight. By pressing a ôuse Facebookö button passengers are also agreeing to let others see their profile. Let Me Think also allows passengers to hold a fare for up to 48 hours enabling them to share potential plans with friends and family before purchase. Airsavings says other European airlines plan to follow suit with the initiative and that it opens up an additional revenue stream as well as new potential customer leads.

Airbalticõs SeatBuddy service, powered by Satisfly (www.satisfly.com), is aimed at assisting travellers in finding their best flight companion on board of their flights. The service allows choosing a flight mood (chat, talk business, sleep or work quietly) and whether the passenger would like his seat neighbour to be like them or different. In contrast to KLMõs Meet & Seat, SeatBuddy automatically identifies a best match and passengers get a message saying what they have in common with their ôseat palö.

Source: airBaltic
SeatBuddy

These systems allow for monitoring of the social profile of users by transport operators, which is relevant information for marketing purposes. If introduced more widely, it could also assist transport planners in better understanding the profile of users of selected transport modes, for instance to estimate the value of travel time.

Targeted users. Currently, the main targeted users for this application are airline operators and airplane passengers, especially business travellers. However, this application could be easily extended to other modes where passengers get to choose their seats, in particular high speed rail.

Barriers to Implementation

Financial issues. No information available, but it seems safe to assume that the system installation is not particularly costly and that maintenance and operation costs are very low. Furthermore, since it may attract passengers from other airlines, there could be a direct financial benefit for the operator.

Technical barriers. No particular technical barriers expected.

Organisational complexity. No particular organisational barriers expected.

Legal issues. Problems may arise related to data protection issues. However, companies operate a strict data protection policy and lots of information controls, and the users decide which social information becomes public.

User and public acceptance. Since this is an entirely voluntary scheme, nobody who may not like it, has to use it, but those who choose to do, clearly enjoy the opportunity to either make contact to new people or meet up with people they already know or, on the other hand, ensure that their seat neighbour also just wants peace and quiet during the journey.

Interest for Travellers

Door to door travel time. No impact expected.

Travel cost. This service may or may be not charged on the end user. Increased cost should be no more than a few euros (e.g. 12 euros per trip on certain commercial services existing today).

Comfort and convenience. This application allows passengers to choose who is seated next to you. It is aimed at promoting business opportunities and networking. It would improve social experience during the flight.

Safety. No particular impact is expected

Security. No particular impact is expected

Accessibility for impaired. No particular impact is expected.

Modal change

No particular impact is expected

Other notable impacts

No particular impact is expected

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	**0**	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€	D2D travel cost	**0**	Bus and coach usage	**0**	Congestion	**0**
Financial viability	✓	Comfort and convenience	✓	Rail usage	**0**	CO2 emissions	**0**
Technical feasibility	**0**	Safety	**0**	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	**0**						

Illustrative materials

KLM Meet and Seat

http://www.youtube.com/watch?v=eL2lWn7oup4

Book & check into flights from Facebook with MHBuddy

http://www.youtube.com/watch?v=bWK24zJtdas

2.4.4 Smart phone taxi apps

Solution family: Traveller Information Systems

Subfamily: Smart Phone Journey Assistants

Domains of Application: Urban, rural

Technologies behind: Smartphone applications, next generation planning and scheduling systems, positioning systems

Status: implemented

Links to relevant references

- Cooper J. and R Darbera (2012) The óappôeal of technology: opportunity and threats. Presentation to the IRU meeting, Cologne.
- IATR (2012) Uniform regulation for taxi apps
- Uber (2012) Regulatory white paper on apps

Description

Concept and problems addressed*.* The Taxi Smartphone Application ñAppò is a logical extension of the current rapid development of Apps for a range of smartphones, effectively handheld internet applications built to the technical and dimensional limitations of the Smartphone (technical: processor and óreal estateô). The app makes use of the phoneôs real estate to an extent that an internet site could not achieve, and has resulted in a significant growth in popularity matching that of the smartphone itself.

The development of a taxi app is a logical extension of other transport apps, allowing for the rapid booking of taxis and other similar vehicles, with the potential to allow for an easy method of taxi engagement. The development of the app itself represents a relatively small part of the overall market and operation, which can be significantly more challenging, and includes unresolved questions of legality and challenge, discussed in more detail in subsequent sections.

At the time of writing there are three primary categories into which taxi apps can be defined:

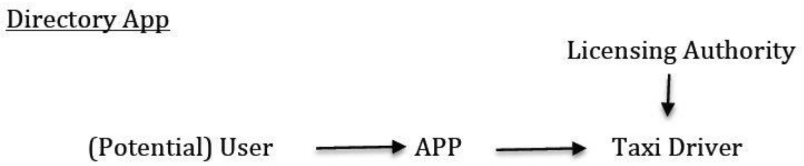
- Directory Listing Apps,
- Apps making bookings to a dispatch company, and
- Apps making booking directly to a driver.

A series of similar apps associated with the booking of Limousines (Private Hire Vehicles), and the recent development of óprivate arrangementô apps, also operate in the same market segments and need to be included in this analysis, though these will typically operate under differing regulations, and may be controlled by separate licensing authorities, or not controlled at all in the case of óprivate arrangementô apps.

Four primary óplayersô are identified with an interest in apps these being:

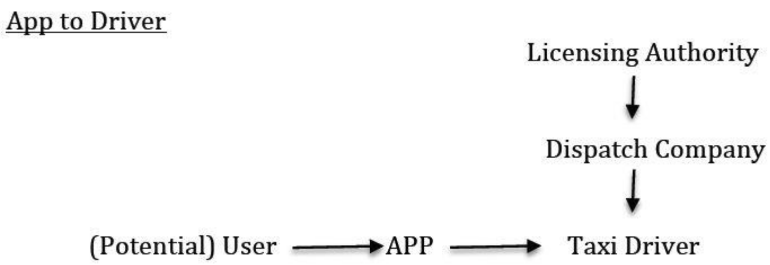
- (Potential) Passengers
- Licensing Authorities / Taxi Regulators
- Dispatch Companies / Taxi Operators
- Drivers

The relationships between app user and driver varies between the categories of app, and may be stylised as:



The directory App provides a directory, typically of telephone numbers, effectively offering a telephone directory of taxi companies, potentially localised to the vicinity of the app user. The functionality of the directory app is limited and has no direct regulatory oversight. As the impact of directory apps is limited it has been excluded from the subsequent discussion.

The app making bookings through the dispatch companies benefits from maintaining the regulatory relationships present in the industry prior to apps becoming available, which concentrate on the regulation of Quality, Quantity and Price, often applied via dispatch companies themselves, also subject to quality and safety controls in some jurisdictions.



Apps directed at Taxi Drivers avoid dispatch companies, and have received a very mixed response, in part related to the removal of business from dispatch companies; but also on the part of regulators reflecting the issue that the app may effectively circumnavigate traditional legal structures in which taxis operate, which may include, but are not limited to, vehicle fleet licensing and definitions as to what constitutes a taxi. The challenge to develop a regulatory structure is not helped by some “sharp practices” on the part of some app providers that have included: “Surge Pricing” (excess or unmetered fares above pre-determined levels), and supply using unlicensed vehicles. The extent to which apps may be considered legal differs significantly between jurisdictions, discussed below.

A potentially large opportunity for data gathering represented by the development of taxi apps relates to the ability for the app itself to contribute to regulation, rather than detract from it. The underlying issues faced by many regulators at the time of writing relates to the ability, or otherwise, of regulators to make fully appropriate decisions in relation to the control elements (QQE) with which they are charged. This appears ironic at a point in time where significant levels of data are produced and recorded by dispatch companies in the operation of taxi services. The inability or insufficient access to these datasets provides an opportunity to the app provider to contribute data upwards, ie: from app to regulator, to provide regulatory management information that would be appropriate to the correct functioning of the regulatory functions defined in many legislative instruments, including those set out by the Civic Government (Scotland) Act, 1982; and Local Government (Miscellaneous Provisions) Act, in the UK.

Large datasets, including those developed from apps offer a unique opportunity to develop taxi services in the interests of the travelling public and should be used to assess the complete taxi market, rather than the individual elements in isolation.

The app provider is closely marketed at the taxi driving community in the case of apps to drivers, and the dispatch companies in the case of apps to dispatch. The market circumstances of each differ, and many of the most successful apps devote a significant portion of their marketing budgets to recruiting and keeping drivers. An even larger proportion of investment budgets may also be devoted to maintaining regulator relationships, in the case of legal apps, or those close to legality; or to defending legal actions for others.

The most successful app providers have significant financial support, while a second and third tier of ‘technology’ providers seeking to develop taxi apps may often overlook the significance of the market across drivers and regulators. An app requires sufficient numbers of drivers to be signed up to provide a service able to compete with the larger fleet dispatch companies, while the driver may equally seek assurance of a realistic number of trips to justify additional expenditure on app bookings over and above the fees paid in traditional dispatch operations.

Targeted end users are passenger markets more likely to represent ‘users of apps’ rather than a specific demographic groups as ‘users of taxis’, though the market for App users has some limitations, as do other elements of the apps themselves, including the requirement for on-line credit card payments, present in the vast majority of taxi booking apps.

Targeted Users. Taxi dispatch companies, taxi drivers, app users

Barriers to Implementation

Financial issues. A significant difference is noted between the cost of development of taxi apps, and their successful application. The online presence, the development of the app itself, is a minor part of the total costs experienced by many of the successful taxi apps seen in the market to date. Those achieving ‘traction’ within the market tend to reflect large investments in driver recruitment and retention, and marketing within the regulator communities. Typical cost elements for the most successful apps can include:

- App technology, the cost all writing software code;
- Linking software [API] appropriate for combination with existing booking systems;
- Driver recruitment and retention, including agreement with existing companies;
- Marketing to passengers, including prolonged campaigns and price subvention;
- Marketing to regulators, including cost of required changes to basic software and any additional licensing requirements, such as the need to become a licensed broker (e.g. Toronto);
- Proactive legal advice, such as providing legal counsel supporting ‘e-hailing’ (e.g. New York)
- Reactive legal defence, typically defending action by existing taxi operators, taxi regulators and national competition and safety authorities (e.g. Colorado State Public Utilities Commission)

Most successful taxi aps have significant investment capital. In operation two methods of income generation exist in the long term, charging for use on a per use basis, or charging a subscription. The latter, subscription charges, is most common in apps to dispatch. The former, a pay-per-use charging scheme, has been applied in the majority of apps to driver. In this model the driver is responsible for a flat rate [or percentage] fee for each booking made through the app. This would typically be subtracted from the payment made by passenger by credit card to the app provider, and forwarded from the provider to the driver.

No jurisdiction allows for additional charges to be raised against the passenger, though some apps do make these charges, and may be considered to be doing so illegally. The most common method for additional passenger challenging relates to the requirement for compulsory ‘gratuities’, which can be as high as 20% of fare. Some systems go further in defining charges without reference to an existing defined tariff, which can diverge significantly.

Technical barriers. Relatively few technical barriers exist to the operation taxi apps. The most significant challenge relates to the development of API links between apps and existing software. An API link relates to the accessing of one system, i.e. the app, to a third party system, i.e. the dispatch system of an existing operation. This challenge exists in relation to apps to dispatch, not to apps to driver. Smartphone operating systems will also create a challenge, but this is typical of this range of technologies.

Organisational Complexity. The complexity within which the taxi app operates depends on the structure of the industry in each location, and the choice of operating model adopted by the app itself. Apps to dispatch tend to operate with greater organisational complexities than those to driver. Regulation may also have a role in enhancing complexities, particularly in locations where regulations prohibit many of the operating practices adopted by some apps.

Legal issues. Significant challenges exist in relation to each location. As the regulations pertaining to taxi control differ significantly between locations a single universal review on legality is not possible. Key issues relates to the actual definitions as to what an app achieves. This is sensitive around the discussion whether it replaces a pre-booked trip, i.e. is an electronic pre-booking; or replaces a street hail, i.e. is an electronic hail – e-hail. Further location specific issues will relate to the licensing requirements for booking offices and physical location requirements for these.

There are further, less contentious, issues specific to the handling of personal information, storage and wider application. These relate to the extent to which an individual may be tracked using a system. Most systems use anonymous information that reduces the legal impacts of such applications, with many systems automatically deleting data in a defined period. The external uses of information tend to require that further applications are not personally identifiable, though some service level and personal service contracts may justify proportionate use of personal information following currently appropriate data privacy approaches.

User and public acceptance. Taxi Apps are a current technology that appears to be welcomed by both potential passenger and many within the taxi trade, particularly taxi drivers. Taxi apps that are developed sympathetically in light of current legislation or in partnership with taxi regulators and operators are more likely to achieve initial success.

Interest to travellers

Door to door travel time. The ease off engagement achieved through appropriate Taxi apps provides benefits in reducing door to door travel time.

Travel Cost. Costs should not be impacted by the presence of a taxi app, although this has proven controversial in some locations.

Comfort and convenience. Booking with an app is a very convenient way of booking taxis.

Accessibility for impaired. Opportunities exist for further development of taxi apps to include access to wheelchair vehicles, and accessible vehicles scheduling. This area of development has not been fully explored to date.

Modal Change
No significant one expected.

Other notable impacts
No significant ones expected.

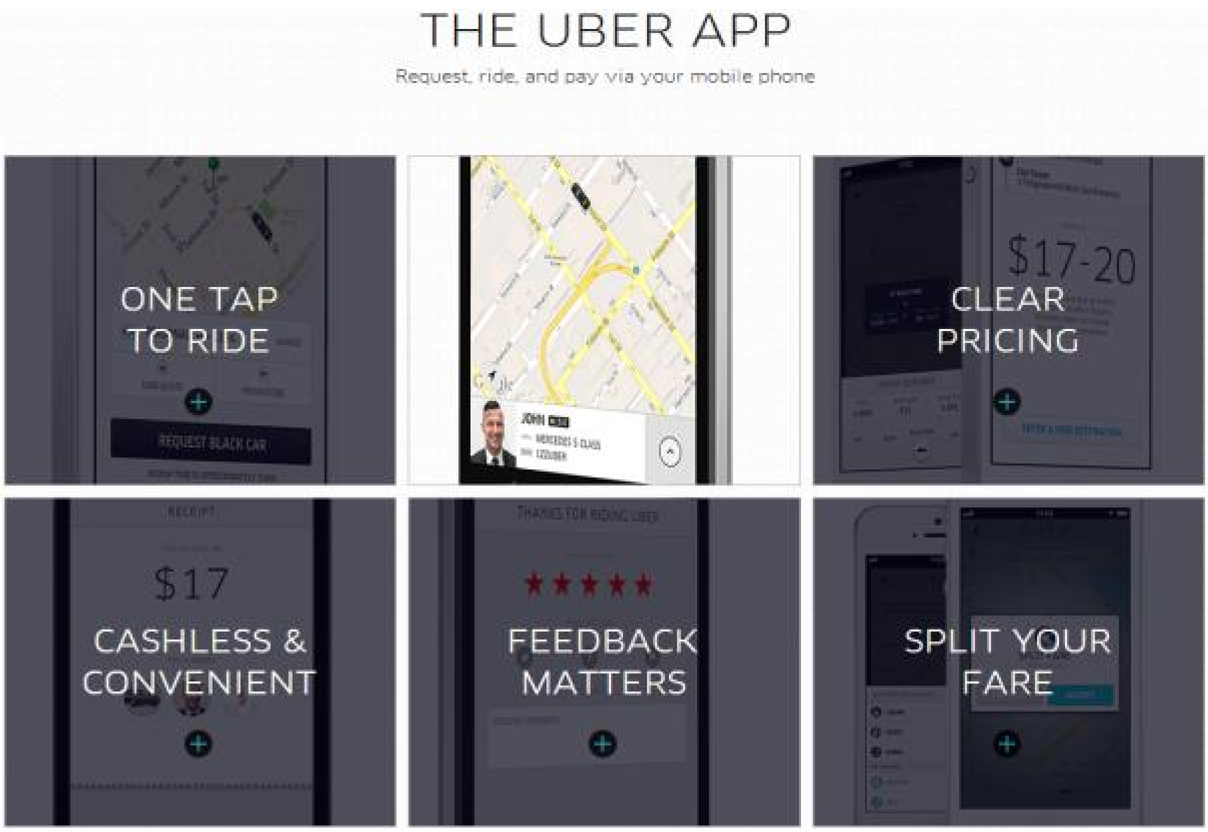
Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment Costs	€€€	D2D travel time	✓	Car usage	0	Increased Mobility	0
Operation and Maintenance Costs	€	D2D travel cost	0	Bus and Coach usage	0	Congestion	0
Financial Viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical Feasibility	0	Safety	0	Ferry usage	0	Contribution to User Pays Principle	0
Organisational Feasibility	0	Security	0	Aerplane usage	0	European Economic Progress	0
Administrative Burden	0	Accessibility for mob. Imp. Passengers	(✓)			Territorial Cohesion	0
Legal feasibility	(X)						
User Acceptance	✓						
Public acceptance	✓						

Illustrative Materials

HAILO Taxi App Homepage

Source: HAILO



Source: UBER

3 SMART TICKETING AND TOLLING

3.1 ELECTRONIC TOLL COLLECTION (ETC)

3.1.1 Integrated transnational highways toll payments

Solution family: Smart Ticketing and Tolling

Sub-family: Electronic Toll Collection (ETC)

Domain of application: Long-distance

Technology behind: DSRC

Status: Implemented

Links to relevant references

- An introduction to EasyGo by Arild Skadsheim, 2012
- NORITS - Nordic Interoperable Toll System by Mogens Hansen, 2012
- EasyGo ï The way to go by Søren Rasmussen, ASECAP Study Days Oslo, 31 May 2010
- Interoperability among several countries ï using a single on-board unit to pay tolls

Description

Concept and problems addressed. EasyGo is a partnership between the barrier systems, toll roads, bridge companies and ferry operators. The project is a contract system in Europe offering a cross border payment service for toll collection. The purpose is to enable users to drive through all the toll facilities they might encounter on their way through Northern Europe ï quickly and easily. The intention is to have a unique payment system throughout Europe (whether it is a BroBizz, an AutoPASS or an AutoBizz). EasyGo currently covers several locations in Denmark, Sweden and Norway, as well as ferry services between Denmark and Germany (a similar cooperation is already in operation between Toll Collect and ASFINAG bearing the name Toll2Go) and has been implemented at more than 50 toll chargers with a total of more than 2 million service users. The Austrian national tolling system for heavy vehicles will be included in the EasyGo service from the beginning of 2013 (the additional service will be named EasyGo+). To the individual service user, EasyGo is an additional service offered by his local toll service provider (TSP). The on-board equipment, or OBE, received from the national TSP can be used for payment at all toll chargers (TCs) connected to the EasyGo service. Payment for any use of a tolled infrastructure is charged the service userõs account/contract with his local TSP.

When a user pass through a toll station at a toll charger, the following flow of information is performed: the user enters into contract with a TSP, the TSP sends validation data to TC via the EasyGo HUB. The EasyGo HUB is the common router to which all TCs and TSPs connect. All TSPs and TCs in Sweden, Denmark and Germany are connected to this HUB. The user uses the tolled infrastructure of a TC paying with his OBE: transaction data is sent from the TC to the TSP via the EasyGo HUB. The TSP pays the TC for the fee associated with the use of the tolled infrastructure. The TSP invoices the user in the name of the TC and receives a payment. The TC pays the TSP an issuer fee as payment for collecting the toll fee in his name.

As EasyGo includes toll roads, parking and ferries in four different countries, thanks to the implementation of the system, it is possible to collect a greater quantity of data on transnational trips and demand, which otherwise would be much more complex and costly to collect.

Targeted users. Toll operators. End users are car drivers.

Barriers to implementation

Financial issues. The common costs of EasyGo include the following main components: interoperability management, development and maintenance of the EasyGo HUB and common information activities (including the easygo.com.). These costs are shared between the toll chargers based on the volume of EasyGo transactions at each toll charger. In addition each toll charger pays a compensation / issuer fee to the toll service provider based on the collected amount to cover the cost of collection, credit risk and customer relations. If a toll charger enters into a local contractual relation with a service user based on the OBE issued by another toll service provider, the toll charger shall compensate the toll service provider who issued the OBE to the service user on an annual basis for the use of the OBE. To finance the costs of the EasyGo administration an admission fee is paid by all new operators who want to enter the system.

The costs of the system are low compared to the benefits. In fact toll chargers can benefit as follows:

- An inexpensive method of charging non-frequent users;
- Avoiding multiple OBEs in each vehicle (which may cause reading errors);
- The need for manual toll lanes and personnel as well as queues will gradually decrease compared to toll stations with manual collection;
- Cross border enforcement needs are reduced when foreign vehicles are equipped with an OBE approved by the TC;
- The introduction of an automated toll station means that there is a significant reduction in collection costs for each vehicle equipped with an OBE compared to collection based on number plate recognition;
- And last but not least, more efficient toll collection means a higher percentage of income available for infrastructure and other purposes.

On the other hand, toll service providers gain the following benefits:

- Increased market size and business volume;
- International standards for equipment and services result in higher quality of tenders and supplies in an international market;
- The EasyGo service is designed within the framework for the European Electronic Toll Service (EETS) and will make the implementation of EETS easier for the TCs of EasyGo and for potential TSPs.

Technical barriers. A number of technical issues are still on the drawing board. Some of the most important are:

- The implementation of the declared vehicle category into the OBE eliminating the need for physical measurements or exchange of vehicle classification data
- The Eurovignette Directive requires toll fees to reflect the emission category of each vehicle above 3.5 tons. This will require an update of the functionality of EasyGo to personalise each OBE with the emission class of the vehicle. The planned EasyGo+ service includes such functionality.
- The EFC directive states that there should be a ñone vehicle ï one OBEò ï relation. This is not yet fully implemented in EasyGo. The architecture of the system is not fulfilling this requirement yet, because vehicle owners subscribe to the service and are charged

accordingly at the gates by using a valid OBE which could be both AutoPass and BroBizz alternatively.

Organisational complexity. As far as management is concerned, the intention is that the personnel already involved in similar local activities perform the day-to-day operational management of EasyGo as a whole. These responsibilities only moderately increase the workload of these personnel. Some issues regard invoicing and VAT and currency/exchange rates (caused by different currencies).

There is a need for efficient dialogue between TSPs and TCs across company and country borders when users complain. Detailed procedures are needed to avoid errors as well as language problems and frustration between customer relations personnel. Such procedures must not conflict with the privacy rights of the users.

The requirements stated by the local authorities concerning content of invoices to be sent between TSPs and SUs presently result in a complex and voluminous invoice. The complexity of this will increase when more countries are included in the service.

Legal issues. The introduction of EETS is underway, aiming for a European electronic toll service based on the EFC directive. The partners in EasyGo have taken active part in this work through the CESARE IV project, EU expert groups and more, offering valuable experience and know-how from the EasyGo service and making EasyGo better prepared for the implementation of EETS. Concerning legal aspects, no particular revision of legislation in the countries is necessary. Some other legal and institutional issues have yet to be defined, such as cross border enforcement. The possibility to enforce toll payment across borders is presently limited as many countries do not give access to their vehicle registers. There are also limitations in the possibility to collect from individual SUs who have not fulfilled their payment obligations in another country.

User and public acceptance. Acceptance by toll operators and the public alike may be expected to be relatively high.

Interest for Travellers

Door to door travel time. Total travel time can be considerably reduced thanks to this automated toll collection system, especially for transnational commuters.

Travel cost. Travel costs are not expected to rise: indeed some of TCs offer discounted prices if the toll fee is paid electronically.

Comfort and convenience. EasyGo makes trips more convenient. When arriving at the toll station, drivers just have to follow the signs for BroBizz or AutoPASS. There is no need to prepare payment at each toll station (What methods of payment are available? What is the price for my vehicle? What currencies are accepted? Which credit cards may I use?) and there is no need for local currency or credit cards. The only need is to be a customer with one service provider with the transponder properly fixed on the windscreen.

The EasyGo service does not require any action by the user. The contract with the TSP includes a paragraph, stating that the use of the OBE at ñon-localò toll stations automatically puts the EasyGo service into operation (it is, however, possible for a user to disable the use of the OBE at ñon-localò toll stations). EasyGo users can use any dedicated or combined EFC (Electronic Fee Collection) lanes in the toll stations or at the ferry terminals, which makes it possible to pass through without stopping or queuing: users do not have to bear queues at the toll stations.

Safety. No particular safety impacts are foreseeable in comparison to current traditional electronic collection system based on OBE and DSRC.

Security. The EasyGo application has adopted a security policy and is preparing a security plan. This work gives important input to the European work in this field. A supporting security policy was adopted in 2009. A security plan is being developed: security risks and requirements have been identified and also relevant security measures have been selected and implemented.

Accessibility for impaired. No particular impact is expected for mobility impaired users driving through toll stations.

Modal change

As car trips become easier (especially for transnational commuters), they may become more attractive, and some increasing modal shares can be expected as far as private car is concerned. A similar modal share increase can be expected for ferries, as the automatic collection system may encourage travellers to choose this mode, especially for daily commuting.

Other notable impacts

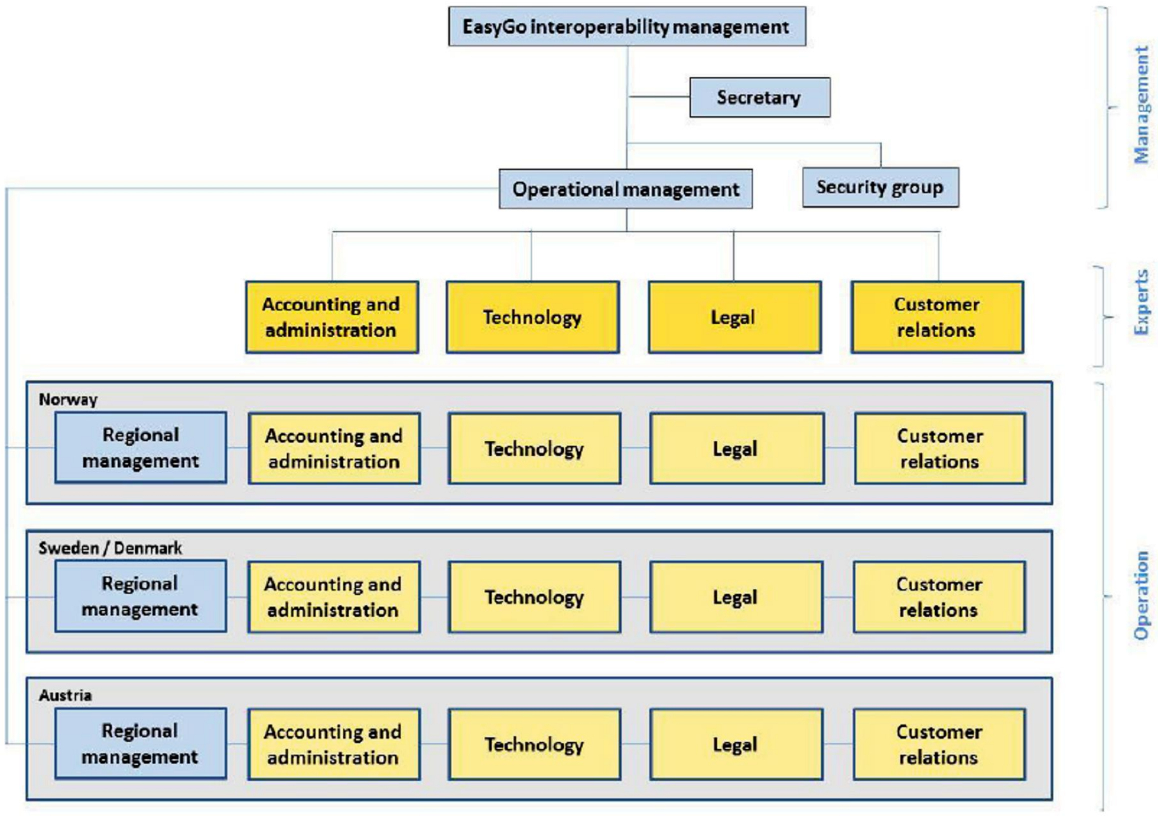
Congestion and CO2 emissions. Decreasing congestion at toll stations may result in significant reduction in GHG emissions, though they may be partially counterbalanced by an increase in car trips.

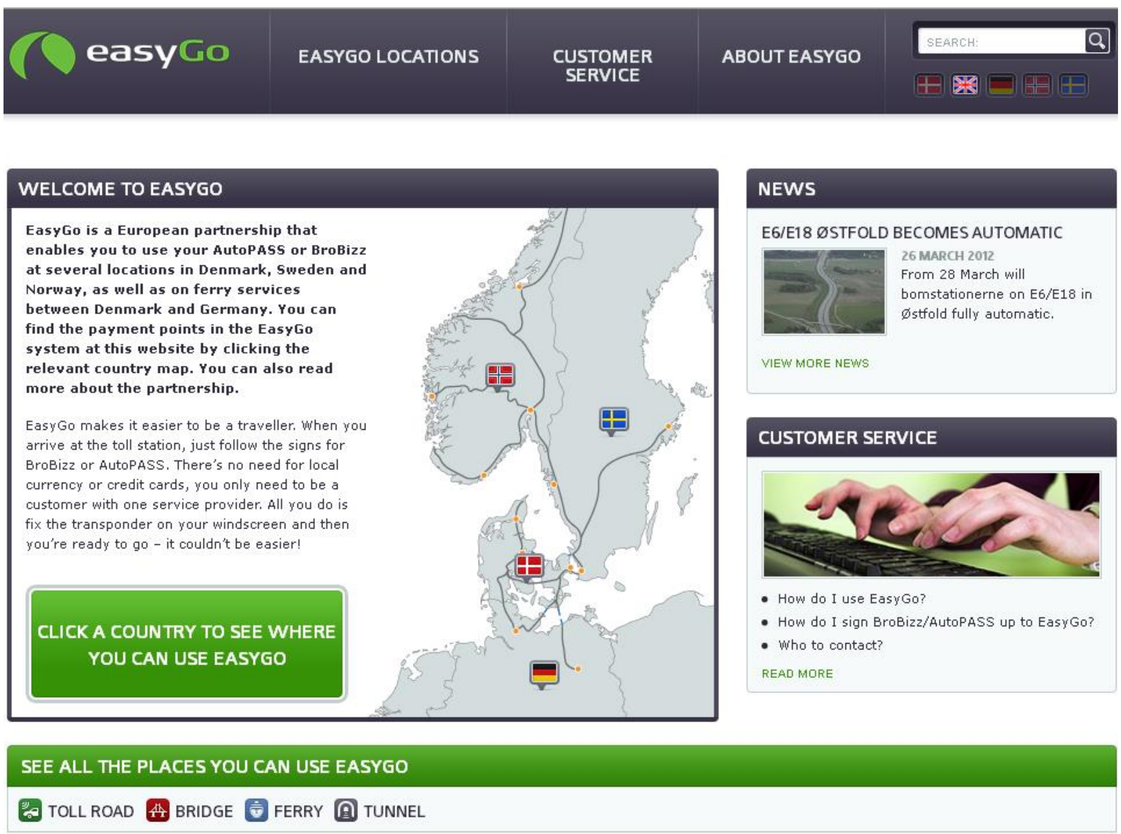
Territorial cohesion. Increasing transnational workers can gain benefit from this application, thus resulting in an increasing availability to be employed in a neighbouring country.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€€	D2D travel time	✓	Car usage	(+)	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	(✓)	Bus and coach usage	0	Congestion	✓
Financial viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	(X)	Safety	0	Ferry usage	(+)	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	(X)	Accessibility for mob. imp. passengers	0			Territorial cohesion	✓
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials





Source: EasyGo

The EasyGO operational organization

3.1.2 National Highways free-flow payment

Solution family: Smart Ticketing and Tolling

Sub-family: Electronic Toll Collection (ETC)

Domain of application: Long-distance, Urban

Technology behind: Dedicated Short Range Communication (DSRC); Automatic Number Plate Recognition (ANPR); Laser Imaging Detection and Ranging (LIDAR)

Status: Implemented

Links to relevant references

- Northwest Parkway - How to pay
- Cashless system in the USA, Brisa Innovation Free-flow tolling solution
- Sydney Cross City Tunnel, Worldǿs first underground multilane free flow
- Tolling in an urban scenario, Traffic Technology International, August / September 2010
- Common interfaces for US tolling, Traffic Technology International, April / May 2012
- Powerful Partnerships in Portugal - Nationwide Electronic Toll Collection by Q-Free
- Multi-Free-Flow Tolling System Update of the implementation Project, A. Amador from Brisa
- Free-flow tolling reduces Brisbane crashes by ABC News
- Multi-Lane Free-Flow tolling
- Queensland Motorways (Australia) - Free-Flow Tolling Project in Brisbane by Traffic Technology International, October / November 2010
- South Africa's first multi-lane free-flow tolling top of the line by ITS International, Sep-Oct 2010
- Tollchecker freeflow ® ï Keeping Things Moving

Description

Concept and problems addressed. There are many types of free-flow systems ï ORT (Open Road Tolling) or Multi Lane Free Flow (MLFF), AET[22] (All Electronic Tolling), HOT (High Occupancy Toll): they all aim at eliminating plazas and booths from tolled-roads. Vehicles are no more obliged to stop at plazas, nor even slow down and pass through reserved lanes for automatic electronic payment (RFID traditional systems by OBUs), but they simply continue their trip flowing on the road.

So, thanks to this innovation, on one side all road users, without exceptions, can use the road infrastructure without stopping and, on the other side, the road operator does not require any manual intervention.

[22] It is important to understand the difference between ORT and AET, although the terms are often used interchangeably. In the ORT model, the cash option remains a choice for the toll road user. It describes a configuration where the middle of the road is free-flow at highway speeds and toll booths are located on the side in each direction. With AET there is no cash option; gantries collect all transaction information. ORT is a more conservative approach to free-flow than AET. With AET, users passing a gantry without a registered tag are considered violators.

The MLFF technology has initially spread as a toll technology for long-distance roads (see the Northwest Parkway LCC in Colorado (USA) near Denver and national motorways in Portugal), but is also being applied in urban contexts for charging the use of specific infrastructures such as tunnels (SCCT – Sydney Cross City Tunnel) or bridges (Golden Ears Bridge and Port Mann Bridge - Canada).

In Europe there are several MLFF applications, in particular regarding heavy goods vehicles tolling (Austria, Germany and Slovakia). As far as passenger transport is concerned, the Portuguese MLFF system was the first one to be fully implemented. In 2006 Brisa (the national highway concessionary), selected Q-Free for the supply of this innovative tolling system. The project is in fact the first nationwide free-flow system to be implemented in Europe.

The MLFF system solution is based on the efficient combination of electronic toll collection (ETC) microwave technology, video processing and dynamic vehicle's classification technological services. The MLFF system architecture is based on: identification and charging of the vehicle, detection and classification of the vehicle and, finally, enforcement.

The system is composed of three successive gantries. The OBU is read for vehicle identification, associating the timestamp, and then registering front and rear license plates, which are associated with visual footage of the transaction. The three main subsystems are:

- The toll collection system including the roadside system to communicate and perform correct transactions with all the equipped vehicles in the toll site;
- The vehicle detection and classification system to handle vehicles passing through the toll area.
- The enforcement system for cases of non-compliance.

Identification of vehicles is based on DSRC technology communication between the vehicle's On Board Unit (OBU) and Road Side Equipment (RSE). The MLFF identification system is able to perform a transaction within 100 metres and dealing with vehicle speeds up to 180 km/h.

Vehicle classification is performed by measuring some physical parameters of the vehicle: it is based on LIDAR technology and it detects vehicle volume and shape.

The enforcement system is based on video cameras: they capture image of vehicles and uses an OCR engine (Optical Character Recognition) to obtain the license plate.

There are several payment options and customers may choose among them:

- Installing an OBU (on-board unit) by associating it with a prepaid account. Every trip on the open road toll plazas is automatically charged;
- Creating a GO-PASS on-line account with the road operator (https://www.go-pass.com/gopasswebsite/login)
- Each passage uses automatic license plate recognition (ALPR) for vehicle identification, which is then credited to the account.
- A last option is foreseen for those road users that do not need or want a predefined contract. Through the ALPR, a bill is sent by post to the vehicle owner registered address with the least amount of manual intervention. Within normally 30 days the payment can be reconciled by accessing the GO-PASS online web site and crediting a bank card through a secured and certified data transmission. This option is more expensive for the road user, due to administrative costs.

Targeted users. The main targeted users of this application are road operators and managers.

Barriers to implementation

Financial issues. A MLFF system is an option to improve business profits and sustainability as it combines the benefits of technologies applied to the transport domain. ETC systems enable decreases down to 1/3 of the transaction costs, when compared to manual toll collection. The implementation of the system requires a low level of investment costs. From the Portuguese experience, it can be stated that operational costs are less than expected due to the high level of system accuracy. A 35% reduction on O&M (Operational and Maintenance) costs can be achieved, thanks to a low cost maintenance design and optimising human intervention throughout the entire toll collection process. Main relevant benefits are: seamless road network operations, cost efficiencies with a shift from fixed to variable costs, minimum investment option and system conversion.

In South Africa, an MLFF installation has been implemented as part of the Gauteng Freeway Improvement Project (GFIP), being the country's first Multi-Lane Free-Flow (MLFF) tolling system. The installation itself is linked to a wider programme of infrastructural improvements. The GFIP grew out of a SANRAL (South Africa's National Road Authority) pilot study in 2004. The contract for installation and operation of the new MLFF system was awarded in 2009 to ETC Pty Ltd, a joint venture between Kapsch TrafficCom and local partner TMT; the two have been connected since 2007. The ú 450 million contract covers 42 Gantries for the Gauteng province only, a national Transaction Clearing House and a national Violation Processing Centre. It includes eight years of operations and maintenance starting in 2011, and will distribute an initial run of 1,000,000 tags under a separate contract (and for which a tender process has been launched).

Technical barriers. The system is very sensitive to atmospheric conditions and ambient light.

Organisational complexity. The maintenance is easier, if compared with traditional toll systems. Communications to the end users and to foreign drivers could be improved.

Legal issues. There should not be any insuperable legal barrier to this application, though some adjustments for the support law for enforcement is required. As far as legal framework statutory permissions for electronic tolling and standard to be used have to be checked. Also from the side of privacy protection, compliance with personal data protection regulations has to be guaranteed and finally may increase the chances of public acceptance.

User and public acceptance. Operators appreciate the system benefits. End users benefit from the fact that they no longer need to queue at toll stations, and non-users in ORT systems from reduced queues at their booths.

Interest for Travellers

Door to door travel time. Road travellers benefit from this application as it reduces the probability of queue formation at toll booths. In fact, no particular restriction on speed is applied and neither in lane discipline. Data from the Brisbane area where a free-flow tolling scheme has been implemented, confirm that motorists are enjoying travel time savings across the network of approximately 10 minutes for southbound travel, 13 minutes at morning peak, and 5 minutes during the evening peak for northbound travel.

Travel cost. No significantly impact, unless, as in Portugal discounts to frequent users and residents using an OBU are offered.

Comfort and convenience. Travellers have higher convenience as they can travel by car without worrying about the need to carry cash. A dedicated web site for online services is available for users.

Safety. Safety increases without toll barriers, allowing the road user to maintain the same cruising speed. In Brisbane (Australia) incidents around tolling points have reduced by as much as 80%. The system has proved to enhance safety conditions.

Security. The MLFF system is reliable and secure: different security levels are possible.

Accessibility for impaired. No particular impacts are envisaged for impaired travellers.

Modal change

Although notable reductions in time savings for payment activities are foreseeable thanks to the application of such a system, no significant increases in car modal share are expected.

Other notable impacts

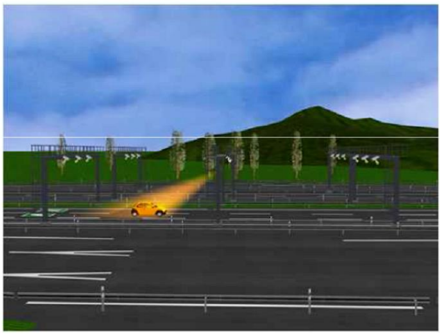
Congestion and CO2 emissions. Thanks to the application of the system it is possible to reduce congestion at toll plazas and achieve environmental benefits, such as significant reduction of noise, air pollution and GHG emissions (CO, Pb, etc.).

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€€	D2D travel time	✓	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	**€€**	D2D travel costs	(✓)	Bus and coach usage	**0**	Congestion	✓
Financial viability	✓	Comfort and convenience	✓	Rail usage	**0**	CO2 emissions	✓
Technical feasibility	**(X)**	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	✓	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

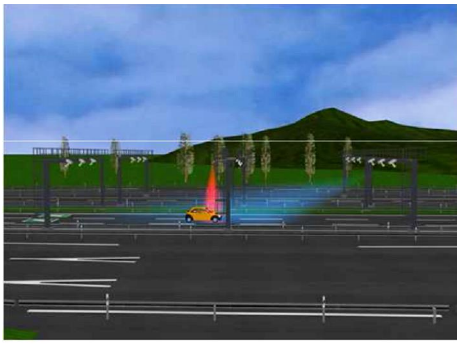
Illustrative materials

Vehicle aproach



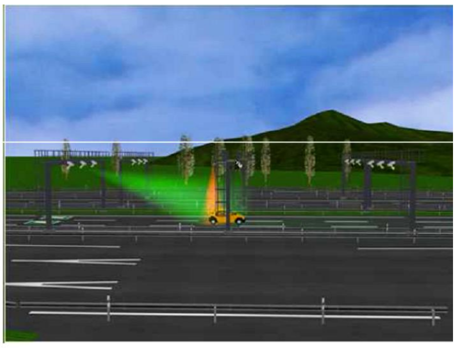
DSRC comunication zone

Vehicle detection



Front photo

End of vehicle detection



Rear photo

3.1.3 Semi-automated payment at highways toll plazas

Solution family: Smart Ticketing and Tolling

Sub-family: Electronic Toll Collection (ETC)

Domain of application: Long-distance, metropolitan

Technology behind: Dedicated Short Range Communication (DSRC)

Status: Implemented

Links to relevant references

- ETC in Japan
- Organization for Road System Enhancement
- M6Toll - Ways to pay
- Using your Tag - Cars and Vans
- National Roads Authority (Ireland)
- Automatic toll collection with DSRC (Telepass® system)
- Electronic toll collection systems - Kapsch
- J. Lopes, A. L. Osorio, Innovation in Road Transport, Opportunities for Improving Efficiency - Seminar 2 October 2009 Lisbon, Portugal
- The Future starts now by EFKON
- José Santa, Rafael Toledo-Moreo, Benito Úbeda, Miguel A. Zamora-Izquierdo and Antonio F. Gómez-Skarmeta (2011). Technological Issues in the Design of Cost-Efficient Electronic Toll Collection Systems, Vehicular Technologies: Increasing Connectivity, Dr Miguel Almeida (Ed.), ISBN: 978-953-307-223-4, InTech.

Description

Concept and problems addressed. ETC systems have been introduced in order to tackle the issue of increasing ―toll gate congestion‖. In Japan in 1997 toll gates delays were blamed of causing 30% of road congestion. Thanks to a public/private cooperation, the ETC system started to be introduced in 2001. Traditional manual systems for toll collection can only accommodate a maximum of 240 vehicles/hour, while with ETC systems this number has risen to 800 vehicles/hour. As of the end of March 2011, out of 1,508 tollbooths in Japan, 1,503 use the system.

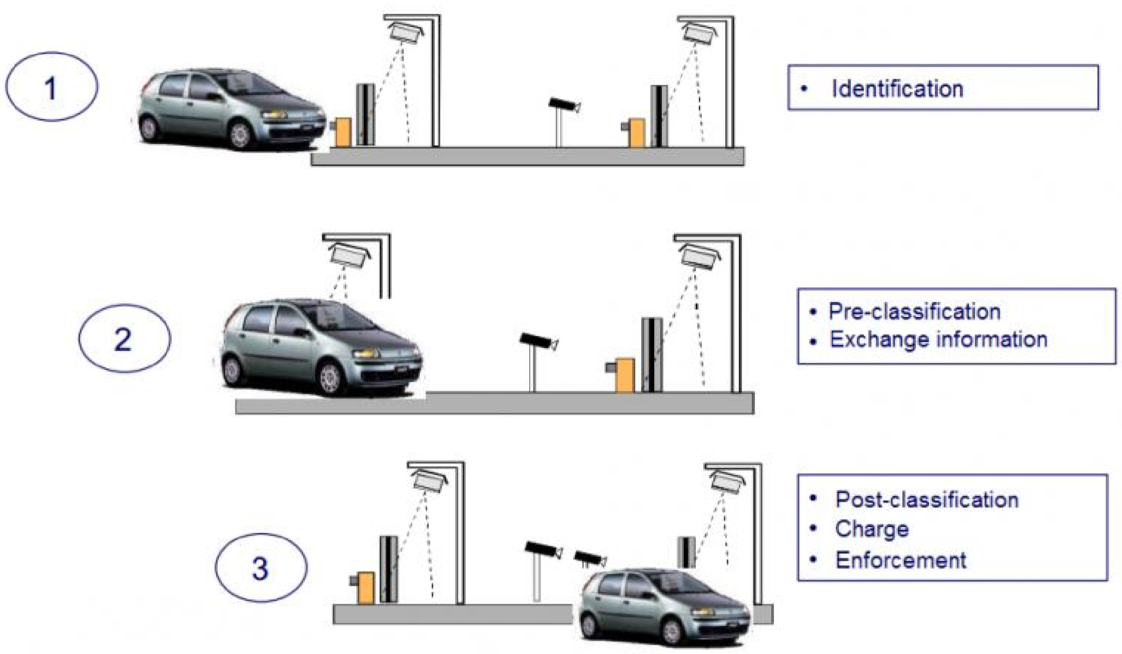
ETC systems can be broadly divided into two types: passive or active. Passive systems are simpler and they are generally adopted in North America in more straightforward toll segments, while active systems are more flexible. The system is available on roads with flat rates as well as on roads with rates calculated according to distance. These active systems are adjustable to a wide range of options, where, for example, it is necessary to make the toll vary according to different time of the day or to distance travelled.

Compared to manual systems, which are now getting more and more out of date, electronic toll collection systems process most of the interaction between the system and its users automatically thus increasing the comfort of the users and minimising the system costs. With the advent of ETC technologies, however, concessionaires have been confronted with a new business model from an operational standpoint – the problem of billing nonregistered users from other states or other concessions (while with traditional toll plazas, precisely where your customers were from was neither here nor there: they just paid their tolls and continued with their journeys).

Automatic Electronic Toll Collection with DSRC exists in almost all European countries that do operate toll roads (Italy, UK, Ireland, etc). DSRC tolling system mainly focuses on strong infrastructure, providing the lowest possible operational costs. In practice tolling stations (or gantries) are erected over one point within every single tolling segment and once passing this point, using DSRC communication between the antennae and the On Board Unit, the vehicle is charged for the whole segment based on its length, the weight of the vehicle, the number of axels in use and potentially many other factors. A DSRC tolling system provides high efficiency in toll charging, being fixed on the road and using enforcement equipment and procedures automatically detecting violators.

In Italy the Telepass® system makes it possible to collect tolls through a device called Telepass®. Telepass is a "semi-passive" transponder: it has an independent power supply but only transmits when interrogated by the reader. Telepass allows dynamic toll collection using microwave DSRC (Dedicated Short Range Communication) technology at a frequency of 5.8 GHz for communication between devices in vehicles and the infrastructure of the lane.

The automatic toll collection system with Telepass is applied on motorways with open and closed toll systems. Each Telepass gate, whether entering or exiting, has equipment that automatically manages transits, maintains the dialogue with the on-board terminal and the connection with the information systems to charge for the transit according to the logical steps illustrated in the following image.



Source: Autostrade Tech

Microwave DSRC technology using a frequency of 5.8 GHz is particularly suited to toll collection since it allows creating highly robust systems, in terms of transaction speed (more than 1,500 vehicles/hour), reliability (over 35 retries in a single transit), transaction security (unequivocal attribution of payments), enforcement (high control), ease of use (no activity by the customer). In addition, the lane software enables the coexistence of Telepass and ETS (European Teletoll Services) customers as it meets ETS safety requirements. For this reason in the rest of Europe, toll chargers can choose between a GNSS system and a DSRC system conforming to the European CEN TC278 standard. In Italy, toll chargers can choose to keep the Telepass technology (now European Standard ETSI EN 300 674-1). There are currently more than 8 million Telepass devices on the Italian motorway network.

In the UK, another similar system exists: the M6 toll road is the easiest and most reliable route through the Midlands bypassing the most congested section of the M6. Tags are the M6 toll's electronic pre-payment system. They are the easiest, most efficient way to pay, allowing passing through a dedicated tag lane, usually without the need to stop. A tag is a small self-contained electronic device which fixes to the windscreen. M6 toll tags are electronic pre-payment systems. Car drivers need to fix the tag correctly to the windscreen. Then, when approaching a toll plaza, they have to enter a dedicated tag lane. The tag is read and, provided the customer's account is in credit, the tag will bleep once, the barrier rises and green light appears. Users have only to drive through without the need to stop. Two bleeps are a reminder that credit is running low, while three bleeps occur in case there is no more credit is available. The system records journeys and debits personal account automatically. The tags contain a microchip which uses radio-frequency identification (RFID) technology. With the M6 toll tag there is no need to have the correct change or keep all travel receipts. By creating a tag account online it is possible to stay informed about journeys details and credit status.

In Ireland, the National Roads Authority has introduced a customer friendly toll payment system (eToll) which started to be in operation nationwide in 2007. eToll is the Irish symbol for electronic tolling. eToll uses a small electronic tag which is placed in the vehicle and is detected each time the vehicle passes through the plaza. The toll is then debited to the customers' account. The electronic tolling system will automatically recognise the correct toll for the class of vehicle driven. There are a number of companies in Ireland providing electronic tags to motorists. These providers use the eToll interoperability system which means a driver will only need one tag for all tolling facilities in Ireland.

Targeted users. The main targeted are toll operators, and the end users are car drivers using tolled roads.

Barriers to implementation

Financial issues. The volume of traffic is increasing throughout the world and requires a continual expansion of the road network. More and more regions are deciding to refinance this expansion by collecting tolls. Experience (EFKON data) shows that approx. 3-10% of the investment of a high-ranking road network is invested in the installation of toll systems and their operation. This is a relatively small percentage with huge effect, since this should cover up to 100% of the financing.

A DSRC minimises operative costs on for example data transfers as all communication between the vehicle's unit and the system is carried out from one single point for every segment - being a fixed line or GPRS connection from the tolling gantry – and not by data communication between the central system and every single unit as it is with satellite based systems. However, the cost efficiency of DSRC lies within many other aspects such as road user claims (DSRC delivers consequent proof of passage), potential violations (using fixed enforcement equipment, portable enforcement equipment, manual enforcement equipment and various mathematical algorithms to avoid cheating) and other aspects of electronic tolling.

Technical barriers. The ETC system has already been in service in more than 30 countries. However, these countries have difficulties in cross-border use due to difference in standards between countries and road operators. Therefore, standardisation and common use of the ETC system is a subject to be solved.

Organisational complexity. DSRC-based solutions present important problems, such as the cost of deploying roadside equipments when new roads need to be included in the system (a scalability problem) and a lack of flexibility for varying the set of road objects subject to charge (in this context, GNSS is lately considered as a good alternative). Interoperability among technologies and systems is a key issue for the OBU.

The Japanese system is quite complex but well structured. Issues may arise in gradual adoption of the system among all vehicles, and so to gradual adaptation of the toll boothsôdesign.

The European initiative EETS (European Electronic Toll Services) has the ultimate aim of one OBU, one contract, and one statement. On the technological side, all antennae in Europe need to be EETS compatible. This means that every antenna must have the capability to read any tag and once a tag is read, the operator then needs to find the right tag owner ï which is where the interoperability hub comes in. It means that one central system would be used to reconcile all the transactions of customers who use a single tag to pay for various services from different providers. The operator will improve leakage recovery and the customer benefits from receiving only one invoice.

In any case the administrative burden of collecting tolls is substantially reduced compared with manual collection.

Legal issues. There are no legal barriers.

User and public acceptance. Operators and regular users alike appreciate the advantages of these systems. The interest for this system may be limited for non-recurrent users, provided that the OBU transponder needs to be purchased or rented from a bank or a motorway operator.

Interest for Travellers

Door to door travel time. The application of ECT systems allows to save valuable time at toll gates.

Travel cost. Some road operators have implemented incentives in order to make the usage of ETC system attractive for road users. Tolling discounts and award with ñmileage pointsò are the most frequent examples. For instance in the UK tag users can automatically benefit from a 5% discount on trip rates (M6 Toll Tag ï UK): for a monthly lease fee of just £1 per tag, they benefit from a 5% discount per trip. For regular users the saving soon mounts up.

Comfort and convenience. Drivers have no longer to open their window and to look for coins and change: they simply drive through the gates in a safer and smoother way. This brings other benefits: for example, on wet and windy days the driver can be freed from the discomfort of having rain blow inside their vehicle when paying and comfortably conditioned vehicles do not have to fear cold or warm air escaping. In addition, drivers do not have to worry about exhaust fumes from the vehicle in front, thus making ETC a system that protects the comfortable in-vehicle environment.

Safety. Safety is enhanced through this application as the vehicle can flow slowly (20 km/h) and smoothly through the gates, without stopping and starting.

Security. Vehicle information in the in-vehicle device is always entered (setup) by a set-up shop as this task requires accuracy for security. Data security is guaranteed thanks to powerful encrypting algorithms. The ORSE (Organization for Road System Enhancement) was established to centralise this data and to efficiently manage it. All nationwide set-up companies have to be registered, so that their technologies and procedures are constantly monitored.

In general with these systems the security of transactions is guaranteed: payments are attributed unequivocally to the right transponderôs owner.

Accessibility for impaired. A discount for the physically disabled persons is for instance available in the Telepass system. In order to use it, an application form for toll discount for physically disabled persons must be submitted to a social welfare office. After reviewing the form, a certificate will be issued from the office.

Modal change

Especially in more congested metropolitan tolled roads, a small increase in car modal share can be expected, due to the time savings that the system allows.

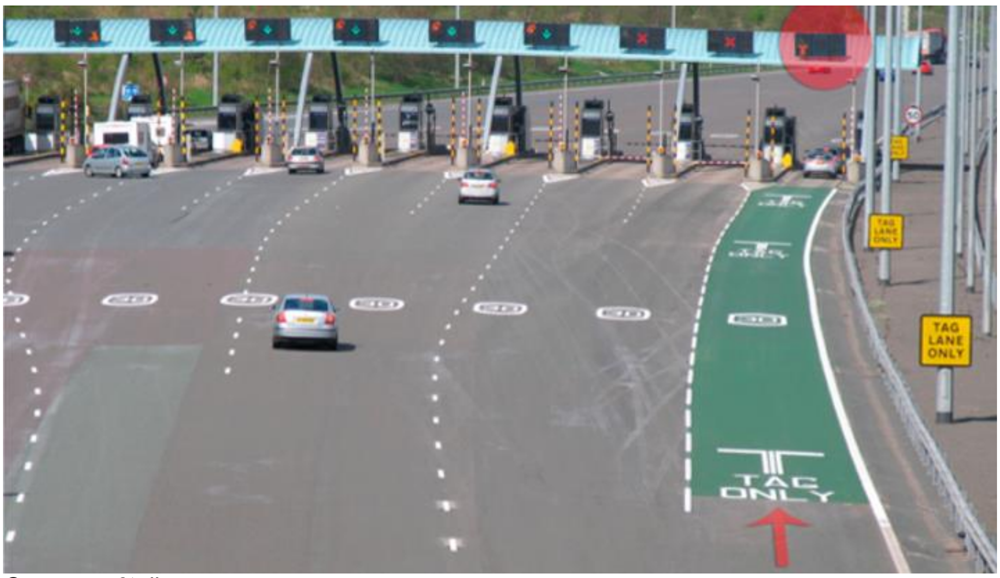
Other notable impacts

Congestion and CO2 emissions. In spite of the potential modal shift, congestion at toll gates are reduced or eliminated and, on balance, the CO2 reduction from this will outweigh the increase from any increased car use. At a Tokyo toll gate within two years congestion has decreased by 94%, and CO2 emissions fell by 52% at a Yokohama toll gate, as well as other pollutant emissions did.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	✓	Car usage	(+)	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	(-)	Congestion	✓
Financial viability	✓✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials



Source: m6toll

3.2 ACCESS MANAGEMENT

3.2.1 Camera-based vehicle access control

Solution family: Smart Ticketing and Tolling

Sub-family: Access Management

Domain of application: Urban

Technology behind: automatic number plate recognition (ANPR), infrared technology

Status: Implemented

Links to relevant references

- Choosing between ANPR and Transponder based vehicle ID
- Central London Congestion Charge Camera System
- Conference on Road Charging Systems: Technology choice and cost effectiveness

Description

Concept and problems addressed. Controlling the access of vehicles in defined areas (such as cities) can help to manage demand and generate revenue by charging fees to the drivers entering the defined zone. Vehicle access control applications very often rely on systems that are transmission-based, consisting of readers and tags or transponders. Over the past few years, a new type of technology which is camera-based is getting increasingly popular. Classically used as a means of speed control, cameras are used today for vehicle access control systems. Camera-based vehicle access control systems are making use of Automatic Number Plate Recognition (ANPR) technology and dedicated camera systems to monitor and photograph vehicles entering and exiting the access boundaries (see figure below).

Source: CChargeLondon
London Congestion Charge

The camera is operating with built in software for Optical Character Recognition (OCR). The camera takes a picture when it identifies a license plate, using infrared technology. Then, the camera isolates the plate, adjusts the brightness and contrasts and segments it into characters. The pattern of each character is analysed to convert the picture into text, and the output is sent to an access control or vehicle management system.

In contrast to transmission-based vehicle access control, camera-based systems are taking away the need to distribute and mount transponders or tags in vehicles. Also, tags that are not issued do not need to be revoked. Thus, typical usages are vehicle access control applications with short term authorisation (suppliers at city centres, short stays at exclusive parking sites), for managing cars that are rapidly changing but managed accurately (rental cars/trucks), for parking management and parking security and for situations where specific RFID bandwidths cannot be used because of interference.

Another application is law enforcement or border control. One example is central London´s congestion charge camera system with a network of 197 camera sites. Drivers are paying a £10 (about ú 12) daily charge for driving or parking a vehicle on public roads within the Congestion Charging zone, 7:00 to 18:00, Monday to Friday (see Figure below).

Source: The Telegraph
Where the streets are paved with gold

Weekends, public holidays, and the period between 25 December and 1 January are not subject to charging. Instead of using tollbooths, the drivers are paying to register their vehicle registration number (VRN) on a database via the Internet. The cameras then read the licence plates when entering or leaving the charging zone and check them with the database, calculating the right fee (depending on functions as Auto Pay, exemptions, etc.). A penalty charge notice is set if the drivers do not pay the charge by midnight on the day of travel or are not eligible for an exemption. The revenues are used to improve public transport in London.

Camera-based vehicle access control bears the potential for being used at parking sites or Park & Ride for a distinction of registered or non-registered cars. Another potential can be seen in the possibility for shopping centres to identify the origin of their customers using the registration information of the car number plate, using this information for marketing purposes.
Targeted users. Targeted users are road authorities as operators of such systems.

Barriers to implementation

Financial issues. Transport for London (TfL) is declaring preliminary estimates of quantifiable costs and benefits of the central London congestion charging scheme with total annual costs of ú 191 million, total annual benefits of ú 265 million, resulting in a net annual benefit of ú 74 million (See The central London congestion charging scheme), but in these costs the share of the camera system is only small. The costs of applications in other cities are not known, but the costs of an ANPR camera system itself, including the camera, the detection software and the data transmission system, is relatively low. A major ongoing cost factor in the operational costs is the need to check the pictures of vehicles that are thought to have violated manually, since the error rate in the detection system is too high to rely on that only for enforcement purposes. Any pay-back depends on the purpose the system is used for: if it enforces some form of payment system, payback may be very fast and direct, in other cases it may be only in social terms, for instance when it control access to an area by residents only.

Technical barriers. Due to the necessary visual connection to the license plates, light shining into the camera lens or dirt on the license plates can influence the accuracy of the picture. Also, camera-based vehicle access control systems can only support a limited driving speed ï measures for speed reduction maybe necessary. Another technical barrier can be the font on the number plates, which has to be easily recognised by OCR. Some countries already changed their fonts for an easier recognition.

Organisational complexity. In contrast to transmission-based systems, where charges can be individually set because the in-vehicle transponders can be moved from car to car, the charges in camera-based systems are always vehicle based. This can increase the administrative effort.

Legal issues. With implementing camera-based vehicle access control systems, concerns are increasing that the network of video cameras and the system for tracking vehicles is an invasion of privacy. Data must be handled according to the Data Protection Acts of the respective countries. Camera-based vehicle access control is no stand-alone system. The most difficult issues are the political decisions before implementing such systems and building a legal framework for road charging.

User and public acceptance. Acceptance by operators is a given, and the general public has also accepted the ANPR technology.

Interest for Travellers

Door to door travel time. The ANPR system does not affect travel time.

Travel cost. The ANPR system does not affect travel costs.

Comfort and convenience. The use of an ANPR system can be more convenient to car drivers than systems where they need to install some on-board equipment, but in other applications there would be no impact.

Safety. There are no expected impacts on safety through the use of such systems.

Security. Through the use of data in law enforcement, for example stolen cars can be detected and tracked.

Accessibility for impaired. There are no impacts for impaired persons.

Modal change

No impact expected.

Other notable impacts

Any impact would come for instance from a congestion charging the system that the cameras help enforce, but the use of the cameras as such has no notable further impact.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	(✓)	Comfort and convenience	(✓)	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(✓)	Aeroplane usage	0	European economic progress	0
Administrative burden	X	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

3.2.2 Transmission-based vehicle access control

Solution family: Smart Ticketing and Tolling

Sub-family: Access Management

Domain of application: Urban

Technology behind: DSRC; RFID; ANPR

Status: Implemented

Links to relevant references

- Road Pricing ï Singapore´s Experience by Chin Kian Keong, Land Transport Authority, 2002.
- Relationships with the Motorway Toll Collection Schemes: the cases of Florence and Rome in the experience of Autostrade SpA by Fabio Pasquali, 2008.
- Reducing Congestion and Funding Transportation using Road Pricing in Europe and Singapore by Federal Highway Administration, US Department of Transportation, 2010.
- World Bank Toolkit on Intelligent Transport Systems for Urban Transport

Description

Concept and problems addressed. Vehicle access control applications vary in terms of technology ï where a very limited number of vehicles are allowed such as private parking at a house, a simple system such as a physical barrier that is controlled with a remote-controller is often enough. Another type of access control is found at railway level crossings, where boom gates are controlled by trains with sensors detecting approaching and leaving trains.

However, to implement a complex vehicle access control application that has to be controlled by vehicles and that is used by thousands of private vehicles, a system relying on advanced transmission-based, namely DSRC, technology is often used nowadays. Such type of large-scale access control applications have been developed along with motorway toll collection system and road pricing in urban areas.

One of the first road-pricing schemes emerged in Singapore in the middle of the 1970s as a manual system, which had been developed to an Electronic Road Pricing (ERP) system in the middle of the 1990s. The worldœ first fully automatic electronic tolling system was the Italian *Telepass*, deployed in 1990. Singaporeœ current ERP system, as a most complicated example that is connected to the payment system, consists of the following three main components:

- On-board unit/transponder using dedicated short range communication (DSRC) and a stored-value smart card.
- On-site gantry equipment: antennae, vehicle detectors and the enforcement camera system (using automatic number plate recognition ï ANPR technology). All these are linked to a controller at each of the site. Collected data is transmitted back to the control centre continuously through leased telephone lines.
- Components at control centre: various servers, monitoring systems and a master-clock for synchronised timing at all gantries. Financial transactions are processed here before being sent to banks for settlement.

If necessary, boom gates that are automatically controlled by the access control system can be installed at the controlling points, while in case of singapore this is not the case.

This type of system is mainly used for road pricing in cities and tolled motorways. Simplified ones without payment function are employed for access control of special types of vehicles such as at an entrance to a segregated busway on which only public transport vehicles are allowed.

Targeted users. The end users of road pricing schemes are in general vehicle drivers who want to access beyond certain points (e.g. to the city centre) or use specific tolled routes (e.g. taking the motorway). Targeted users are road authorities and/or integrated transport authorities as operators of such systems.

Barriers to implementation

Financial issues. Large investment is needed for an implementation. In Singapore, for example, the infrastructure for ERP, including all on-board transponders, cost about ú130 million in 1998. The annual revenues are about ú50 million and the annual operating costs are about ú10 million (See Road pricing in Singapore after 30 years by Gregory B. Christainsen).

Technical barriers. The system is becoming mature and no technical barrier is expected.

Organisational complexity. In case of road pricing, the largest organisational complexity lies in the decision-making process for implementing road pricing. In case of replacement of manual toll collection, no organisational complexity is expected.

Legal issues. Collected data must be handled according to data protection regulations of the respective countries.

User and public acceptance. Operators, as key users, will welcome the ease of use of an DSRC system, and the avoidance of manual toll collection or manual control of the access point. In case the system is introduced as a replacement of manual motorway toll collection, most of the public would welcome the ease of use and the fact that they do not need to stop at toll gates. In the case of road pricing systems most public objections would be raised against the pricing scheme as such, but not against the DSRC system.

Interest for Travellers

Door to door travel time. The door-to-door travel time for car users can be slightly reduced if a manual system is replaced with an automated vehicle access control system, such as the case of toll collection points on motorway.

Travel cost. The use of the DSRC system is not expected to have any direct impact on travel costs.

Comfort and convenience. In systems where transmission-based charging is a replacement of manual toll collection, convenience for the driver is increased.

Safety. There are no expected impacts on safety through the use of such systems.

Security. There are no expected impacts on security through the use of such systems.

Accessibility for impaired. There are no impacts for impaired persons.

Modal change

The use of a DSRC system instead of other access control options Is not expected to have any impact on modal change.

Other notable impacts

Congestion and CO2 emissions. The avoidance of queues at access points that is made possible through the use of DSRC will also contribute to a reduction in CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€€	D2D travel costs	0	Bus and coach usage	0	Congestion	✓
Financial viability	✓	Comfort and convenience	(✓)	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Source: Own photo

ERP Gantry in the centre of Singapore

3.2.3 Smartcard-Based personal access control

Solution family: Smart Ticketing and Tolling

Sub-family: Access Management

Domain of application: Urban

Technology behind: Smart cards; RFID; NFC

Status: Implemented

Links to relevant references

- Smart Card Basics
- Transport for London ï Oyster Card
- Meeting the challenges of smartcard fare payment
- Study on electronic ticketing in public transport by European Metropolitan Transport Authorities, 2008.

Description

Concept and problems addressed. A smartcard, typically a type of chip card, is a plastic card that contains an embedded computer chip that stores and transacts data. This data is usually associated with either value or information or both and is stored and processed within the card´s chip. The card data is transacted via a reader that is part of a computing system. Cards are distinguished both by the type of chip they contain and by the type of interface they use to communicate with the reader. Depending on the functionality of the chip, three different types of chips can be distinguished:

- Memory-only integrated circuit (IC) chip cards (only for storing data);
- Wired logic IC chip cards;
- Secure microcontroller IC chip cards (containing a microcontroller, an operating system and an updateable read/write memory; possibility of executing and storing data; meeting security targets).

The secure microcontroller chip card is normally the version referred to as the ñsmartcardò. There are two primary types of chip card interfaces ï contact and contactless, which describe the means by which electrical power is supplied to the card and by which data is transferred from the chip to an interface device/reader:

- Contact smartcards: require insertion into a reader;
- Contactless smartcards: require only the proximity to a reader (generally within 10 cm) for data exchange, use of Radio Frequency Identification (RFID) or Near Field Communication (NFC) technology to establish a communication between the card and the validation device.

The smartcard as an application of access control is used in various settings as identification tool in healthcare, banking, public transport (e-ticketing), parking, bike sharing and entertainment. In public transport, contactless smartcards are already used for electronic ticketing in many cities, such as Singapore (EZ Link), Hong Kong (Octopus Card), Bilbao (Creditrans), London (Oyster Card), Netherlands (nationwide, OV-Chipkaart) etc. (see figure below).

Source: (Own photo)

The access control is either taking place at physical barriers or by the drivers of public transport vehicles. As an example, London´s Oyster Card needs simply to be touched on the card readers on buses or at stations (see figure below).

Source: The Guardian
The public sector's data gold mine

Travellers have the chance to carry a period ticket within the smartcard, or the card can be used for a new pre-pay facility. This pay-as-you-go function works out the cheapest fare for all the journeys in one day so the price is never higher than that of a Day Travel card.

Targeted users. Because of the variety of situation where the smartcard can be used, there are a large number of potential target users but in the context of co-modal transport the main target users are public transport operators.

Barriers to implementation

Financial issues. It is not easy to estimate the overall costs of the implementation of smartcard systems in a public transport network, as the costs are depending on the network´s size and the degree of equipment. As an example, the 2002 introduced EZ-Link system of Singapore had a total investment of around ú 150 million which comprises the on-board equipment of 4,000 buses, 1,100 gates at metro stations and the installation of 400 ticket vending machines as well as the central clearing house, which is a large figure, but seen in the context of it covering the public transport system of an entire city state with more than 5 million people where more than 5 million public transport trips are made every single day, these costs amount to ú 0.08 per trip over the first year of operation or ú 0.008 over then years. Operational costs can be reduced with smartcard-based personal access control systems due to improvements in distribution, equipment maintenance and lower costs through the removal of tickets printing. Furthermore, because smartcards are so easy to use for both regular users and visitors, they will also attract additional customers and thereby help raise revenue.

Technical barriers. There are no technical barriers for the implementation of such systems as a tool for personal identification and e-ticketing payment.

Organisational complexity. Implementing smartcard-based access control systems for e-ticketing solutions is a very complex issue, which requires major change throughout systems, processes, people and organisational structures. Connecting the different fare calculating systems from different public transport operators can cause difficulties and requires much time and money invested in project management. Thus, the organisational complexity can be very high in the phase of implementation, but is declining to a minimum in the operational phase.

Legal issues. Legal issues related to protecting privacy and personal data are playing an important role in smart ticketing schemes. As smartcards are used in more and more locations and have increasing amounts of data stored on them, personal data is potentially becoming available to more people and organisations. The card-administering agency can frequently monitor travel behaviour of individual users of a service. This information can be used to improve transport routes and schedules, but can also be potentially used for marketing purposes or to track the whereabouts of individuals. Another legal issue is concerning the card-readers, which can be recognised as a ñradio stationò and therefore need some legal adjustment. This was the case in Japan, where the radio-wave legislation was changed when Tokyo implemented the first e-ticketing scheme. Legal issues are also addressing the accounting, especially from pre-paid fares which can lead to debts in the balance sheets. But for smartcards, used as a key in user identification, there are no extra legal problems expected.

User and public acceptance. The acceptance by public transport operators is high in many locations all over the world, and public acceptance is equally high, as the smartcard allows quick and convenient access to access to metro stations and easy payment for bus and tram trips.

Interest for Travellers

Door to door travel time. The use of electronic ticketing can speed up travel by reducing the number of people paying cash to a bus driver and the number of trips travellers must make to the ticket office. The card also allows a more rapid movement through stations and makes it easier to switch between different modes of transport. Thus a seamless transportation can be provided and the door-to-door travel time can be reduced, at least for busses. In the case of railways, a reduction of the door-to-door travel time is very limited.

Travel cost. The travel costs can be reduced by automatically providing the cheapest fare for travellers. For example, London´s Oyster Card is calculating the cheapest route, so the travel costs are never higher than a single day ticket. Furthermore, they are an easy way to apply discounts, for instance for students or elderly travellers. Another aspect is that there are often combined actions like cheaper entry to a museum, etc.

Comfort and convenience. Smartcards offer a lot of benefits concerning comfort and convenience: they allow for using one card all day long across multiple operators, improve the speed of boarding, reduce queuing and allow a greater ease of access. Travellers do not have to worry about different fares and can be more relaxed, even if they are late for the train. Where smartcards are used as user identification, comfort is increased due to the fact that no extra key or PIN-code is needed. The use as an identification tool for bike sharing schemes can speed up the process for checking out at bike stations (e.g. Velib, Paris).

Safety. There are no expected impacts on safety.

Security. Applied as a tool for user identification, smartcards can increase security due to the ability of data collection for secure places such as airports, hospitals, etc. A more detailed log can be taken and this can increase security. Compared to conventional access tools such as physical keys or PIN-codes, it is very difficult to duplicate this form of user identification. In public transport, fraud can be prevented through the use of smartcards for access authorisation. Their use also makes it unnecessary to take out the wallet for payment, and therefore pickpockets cannot observe where the wallets are stored, which is particularly relevant in crowded buses and metro stations.

Accessibility for impaired. There are no clear impacts on the accessibility for impaired persons.

Modal change

The use of smartcards for electronic ticketing in public transport can simplify the fare system and will significantly improve the ease of payments most notably compared to those systems, where drivers have to hand over the correct fee to the driver and lose any change, such as in Edinburgh. With a smart card, visitors have much more confidence in using public transport than in systems where they have to find their way through complex fare structure, especially in a foreign language, and are much more likely to take public transport than using taxis.

Other notable impacts

Congestion and CO2 emissions. Through their contribution to achieving a modal shift from the car to public transport they will also contribute to reducing urban congestion and CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	0	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	✓
Financial viability	✓	Comfort and convenience	✓✓	Rail usage	+	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	✓	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

3.2.4 Biometric personal access control

Solution family: Smart Ticketing and Tolling

Sub-family: Access Management

Domain of application: Long distance travel

Technology behind: RFID; Computer vision; Digital object recognition

Status: Implemented

Links to relevant references

- A Complete Physical Biometrics Guide
- The Application of Biometrics at Airports by Airports Council International, 2005.
- Security in the Skies: Using biometrics to optimize airport security

Description

Concept and problems addressed. Biometric personal access control means a method of identifying or verifying an individual´s identity based on measurement of physical features or repeatable actions, which are unique to that individual. Biometrics can be used to ñverifyò or ñidentifyò a specific individual: verification (also called authentication) refers to the problem of confirming or denying a person´s claimed identity, whereas identification refers to the problem of establishing or authenticating a subject´s specific identity. Biometric security devices authenticate a person´s identity on the basic of physical and behavioural characteristics such a fingerprint, hand geometry, facial scan, retina/iris scan or voice pattern. Most biometrics are collected using optical devices (e.g. a scanner or a camera) which capture the biological information and convert it by means of a software to a digital form. When, for example, a thumbprint is captured, a template made up of a map of specific points of that feature is created. The template is then compared to a database of templates using algorithms, and a decision about the identity of the user can be taken when there is a close enough match between the scanned and stored patterns.

The fingerprint biometric identification technique is primarily used by law enforcement agencies and more and more businesses have also begun to use fingerprinting as a means of logging the working hours of employees. Fingerprints are used in various other applications such as identification for personal computers, as door key, and also for border control in some countries. Hand geometry identification systems are used by border control and immigration agencies. Facial recognition is mainly applied in high end security systems such as in airports. Also banks have started using this application as test programs for cashing checks without a human teller. Iris recognition is very reliable since the iris is always protected by the cornea and thus the pattern never changes. This technique is used in areas such as processing of passports.

One example related to transport is the biometric passport, which is a combination of paper and electronic passport containing biometric information. The biometric passport uses contactless smartcard technology, including a microprocessor chip and antenna embedded in the passport. The microprocessor chip and antenna combination is usually a radio frequency identification (RFID) chip, using radio waves for trading information with a reader. This RFID chip contains all the information printed on the physical document as well as a digital facial image, as face recognition being the primary biometric identifier for border controls at airports. The RFID chips may also contain fingerprint or iris information.

Targeted users. Depending on the field of application, end users for biometric access control systems are in general persons who want to gain access to a border, building, door, etc. The targeted users for implementing such systems are system operators who require high security for their fields of operation (e.g. at airports, border control).

Barriers to implementation

Financial issues. Biometric personal access control systems at airports differ in their overall costs, depending on their size and features. As an example, the contract costs for UK´s IRIS system (iris recognition immigration system, for registered frequent travellers) was around ú 4.2 Million. Of this, around ú 2.4 Million covered development, hardware and software plus installation at 10 sites, iris license fee, and initial training by supplier. The remaining ú 1.8 Million are for maintenance and support over 5 years (See BIOPASS).

Technical barriers. There is no significant technical barrier.

Organisational complexity. The implementation of biometric access control systems at airports is a national security and immigration issue. This requires a close cooperation between governments and airport operators, implying very complex issues such as financial aspects or legal matters. To overcome countries´ different standards concerning physical features and information format, the International Civil Aviation Organisation (ICAO) has set standards for ensuring interoperability of biometric passport systems. (For further information see ICAO)

Legal issues. The use of biometrics carries certain legal implications. Most significantly, biometrics pose new and complex questions about compatibility with individual´s right to privacy. One big concern regarding the use of biometrics is the issue of violation of privacy, as parts of the body are subject to scanning. Another concern is the issue of information security, as biometric readings are often stored in a database that can be accessed by the employer of government agencies. Due to the high sensitivity to privacy some legal protection of privacy and data should be enforced.

User and public acceptance. The London system, that controls the path through the airport, has initially raise issues related to privacy, but people with biometric passports appreciate the fact that they get preferential treatment at an increasing number of airports and no not have to stand in immigration queues that are often exceedingly long.

Interest for Travellers

Door to door travel time. Using biometric access control systems, for example at airports, can speed up processes at airports and reduce queuing, and allow shorter connecting times and faster egress from airports.

Travel cost. The implementation of biometric access control systems at airports could add to the airport charges, but there are also a savings due to a reduction of personnel costs. The overall impact of biometric personal access control systems on the travel costs is unclear.

Comfort and convenience. Compared to credentials such as documents or PINs, biometric traits cannot be forgotten, lost or stolen with the notable exception of biometric passports. Comfort is also increased through faster processes and less queuing at airports through automated passport control. But on the other side, the process of scanning people can mean an increased inconvenience for many people.

Safety. There are no expected impacts on safety through the use of such systems.

Security. In matters of security issues, biometric personal access control is far superior to simpler methods such as password or PIN and requires a person's physical presence. Also, unauthorised individuals can be restricted to get into controlled areas. Biometric access control systems guarantee very high security standards because the replication of biometrics is almost impossible.

Accessibility for impaired. There are no significant impacts expected.

Modal change

There is no impact on modal change expected.

Other notable impacts

Congestion. The biometric passports reduce queuing at immigration in airports.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	✓
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	✓	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Source: Schiphol

Self-service passport control

Source: Airlines
Automated passport control at Frankfurt airport

3.3 AUTOMATED FARE COLLECTION SYSTEMS (AFC) - TICKETING SYSTEMS

3.3.1 Public transport smart cards

Solution family: Smart Ticketing and Tolling

Sub-family: Automated Fare Collection Systems (AFC) - Ticketing Systems

Domain of application: urban

Technology behind: contact, contactless or both

Status: implemented

Links to relevant references

- Accenture, "Ticket to the Future: Smart card technology in public transportation"
- Wikipedia
- The EC Smartcards Study Consortium, "Study on Public Transport Smartcards ï Final Report", 2011.

Description

Concept and problems addressed. A smart card contains an embedded integrated circuit chip capable of storing information for identification, authentication, data storage and application processing. Most modern smart cards, especially those used on public transport, employ the RFID (radio frequency identification) technology between card and reader without physical insertion of the card and hence are contactless. They communicate at 13.56 MHz and conform to the ISO 14443 standard. Some cards utilise a dual-interface technology which provides both contact and contactless interfaces on a single card. An example is Porto's multi-application transport card Andante.

Smart card solutions, in the form of electronic fare ticketing and payment, promise to deliver on the demands of convenient, affordable and efficient travel options for public transport users who need convenient, affordable and efficient options for travel. They also allow rapid movement through stations and onto different modes of travel. Smart cards can be purchased and "reloaded" using automated processes and on-line services. Additionally, smart cards have greater security, higher reliability, and higher resistance to fraud than magnetic stripe cards because of the more advanced technology used than magnetic strip cards.

The potential of smart cards for public transport has received increasing attention during the past two decades. In the early 1990ôs, some small scale smart card projects for public transport were successfully carried out and tested in some countries, such as US, UK and France. For instance, in 1991, London underground implemented contact smart cards as yearly passes. In 1993, the New York MetroCard for the underground system was launched based on the same technology. Meanwhile, the rapid development of contactless smart cards resulted in a worldwide revolutionary change in electronic fare payment for public transport. The contactless smart card technology is an effective solution to improved passenger flows and integration in multi-modal payment schemes. Examples of widely used contactless smart cards are London's Oyster card, Hong Kong's Octopus card, Tokyo's Suica and Pasmo cards, Nigeria's ETC Card, Paris' Calypso/Navigo, the Dutch OV-Chipkaart and Lisbon's Lisboa Viva card, and more can be found at wikipedia.

A highly successful use for smart cards within the UK is in concessionary travel schemes. Mandated by the Department for Transport, travel entitlements for elderly and disabled residents are administered by local authorities and passenger transport executives. Smart cards have been issued as bus passes to qualifying residents; however these smart cards can now also be used by elderly and disabled people who qualify for concessionary taxi travel. These schemes are part of an additional service offered by some local authorities as an alternative for residents unable to make use of their bus pass. One example is the "Smartcare go" scheme provided by Ecebs.

The use of smart cards has been seen as an important improvement to the efficiency and reliability of public transport services. It contributes to an increase in revenue by increasing the number of passengers and reductions in ticket fraud, in comparison with a more conventional paper based ticketing system. By promoting modal shift away from private cars, the smart card solution also has the potential to contribute towards solving a wide range of transport and other problems including congestion, air pollution, climate change, quality of life of those living near main roads (through improved air quality, reduced noise pollution and road safety), and social exclusion as improved public transport can promote equality of opportunity, especially amongst those without access to private cars.

One of its future systems is the ITSO smartcard which can potentially hold all types of tickets on all modes of transport for seamless door-to-door ticketing.

Data from the smart card readers are automatically collected and also processed to provide a rich source for the information about the use of public transport, travel time and distance, trip frequency, ticket type and mode share. There is a significant and rapidly growing body of work using smart card data as a basis for analysis of OD estimation, reliability and travel behaviour.

The journey times derived from the smart card data can be compared with timetables to understand the excess journey time and the ôPublic Performance Measureô (punctuality). The system can also be integrated with traffic control and management systems for monitoring and improving the performance of multi-modal networks.

Targeted users. The main targeted users are stakeholders (e.g. transport authorities, transport operators, standards bodies, equipment suppliers and service suppliers) and the end users are public transport users.

Barriers to Implementation

Financial issues. The costs of the smart card solution mainly include infrastructure & management, revenue protection, product sales, customer information & service, and smartcard production & distribution. Using the London Oyster card system as an example, these costs count for about 14% of fares collected.

On the other hand, the stakeholders involved in the development, implementation and operation of integrated smart ticketing can gain benefits in term of efficiency of the system and of a general company profile as also environmental aspects are regarded. The solution greatly increases fraud protection and flexibility of revenue allocation. Contactless smart ticketing has delivered the business case. High gate throughput prevents bottlenecks constraining ridership growth on public transport and fast boarding time minimises bus fleet sizes and drives up appeal of bus vs. car.

For end users the cards are not only free, but some operators even offer points for usage, exchanged at retailers or for other benefits.

Technical barriers. There are no technical barriers. Smart card systems have already been in service in many countries.

Organisational complexity. The maintenance is easier if compared with traditional ticketing and fare collection systems.

Legal issues. There are no legal barriers.

User and public acceptance. Acceptance by both the operators and the travelling public is high.

Interest for Travellers

Door to door travel time. The smart card solution saves travel time in a number of ways as mentioned earlier.

Travel cost. There is a variety of discount and concessions available to different users, although many of these would also be given if smart cards were not used by the relevant operator. In London, they include students, children, pensioners and those who have a National Concessionary Pass. Also, there is daily price capping which means that a user will not pay more than the price of an equivalent Day Travel-card no matter how many pay-as-you-go journeys that he/she makes.

Comfort and convenience. The smart card travellers have higher convenience than cash users do as the former can travel without worrying about the need to carry cash, and also don't need to queue for buying a ticket.

For instance in Hong Kong, smart card users may also be able to use their cards for other purposes than for transit, such as small purchases.

Safety. No significant impact.

Security. The smart card system is much more secure than paper tickets. Furthermore, the fact that users do not have to take out their wallets to purchase tickets and thieves cannot see where they put them back to, helps against pickpocketing, especially in crowded metro stations.

Accessibility for impaired. No particular impacts are envisaged for impaired travellers although there is, for instance a Disabled Freedom Pass on the London public transport. The eligible disabilities include blindness, partial sightedness, profound deafness, walking difficulty, a learning disability and other physical disability.

Modal change

Especially in more congested urban cities, increases in public transport modal share can be expected, due to significant time savings that the system allows.

Other notable impacts

Congestion and CO2 emissions. As a result of reduced car travel, the smart card solution has potential to contribute reduced congestion and CO2 emissions.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment costs	**€€**	D2D travel time	✓	Car usage	-	Mobility	0
Operational and maintenance costs	€	D2D travel cost	(✓)	Bus and coach usage	+	Congestion	✓
Financial viability	✓	Comfort and convenience	✓	Rail usage	+	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	✓	Security	✓	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Source: Wikipedia

3.3.2 SMS boarding passes

Solution family: Smart Ticketing and Tolling

Sub-family: Automated Fare Collection Systems (AFC) - Ticketing Systems

Domain of application: Long distance

Technology behind: Mobile devices; Mobile internet; Barcode-reading technologies

Status: Implemented

Links to relevant references

- Bouchard T et al (2008) Mobile Telephones Used as Boarding Passes: Enabling Technologies and Experimental Results. Fourth International Conference on Autonomic and Autonomous Systems, 2008. ICAS 2008. Available at
- Boarding_pass Wikipedia

Description

Concept and problems addressed. A mobile boarding pass refers to the delivery of an airline boarding pass direct to the passenger's mobile device. The passenger can check-in to the flight online, and initiate the sending of their boarding pass directly to their mobile phone either via email or SMS, or within a specific smartphone app. The boarding pass will then be displayed on the mobile device's screen in the form of a two dimensional barcode. This barcode needs to include some very specific information, required by the IATA resolution no. 792 which specifies the mandatory fields and suggests optional fields to be included in the barcode.

All of this eliminates the need for airlines or passengers to print paper boarding passes, saving on paper and printing costs, and speeds up the process of check-in and passage through airport security points, saving time both for passengers and airport staff.

Two key difficulties are associated with their practical use. Firstly, there are concerns about the battery-life of the mobile device, and the possibility that the battery expires during the passenger's passage through the airport. Secondly, mobile boarding passes can have difficulties when there are multiple people travelling on a single reservation.

Continental Airlines (now United) were the first airline to start offering mobile boarding passes in 2007. Now most major airlines offer the facility at many airports.

Targeted users. Airlines, end users are air passengers.

Barriers to implementation

Financial issues. One of the key motivations for mobile boarding passes is the potential for cost savings associated with eliminating the need to print paper boarding passes. Once the switch from paper airline tickets to electronic airline tickets is fully achieved, it is estimated that this will save the worldwide airline industry $3bn per annum, and similar aspirations exist for the savings to be achieved by switching from paper to electronic boarding passes. There are development costs associated with making the technology work on the range of mobile devices in existence, but it is widely thought that the savings will more than outweigh these costs.

Technical barriers. There are many different models of mobile device, each with their own characteristics which must be known and accounted for in order to deliver the barcode component of the boarding pass appropriately. Work to enable this is ongoing and has meant, sometimes, that airlines only offer the mobile boarding pass for domestic but not for international passengers.

Organisational complexity. There are relatively few organisational difficulties, as each airline can assume responsibility for boarding passes for their own flights. Some organisational issues may arise where airlines operate flights jointly, e.g. via forms of code-sharing, but these are not expected to be insurmountable.

Legal issues. No known barriers.

User and public acceptance. As mentioned above, most major airlines now offer mobile boarding passes, indicating their acceptance of the technology. It is not known what proportion of passengers are choosing to use mobile boarding passes, but it is anticipated that acceptance on the part of passengers will be high.

Interest for Travellers

Door to door travel time. Whilst it is expected that mobile boarding passes will speed up the passengersôpassage through the airport, this will often not be a significant proportionate time saving, in relation to the duration of their overall journey. The biggest proportionate impact would be expected on domestic short haul flights.

Travel cost. No significant impacts expected

Comfort and convenience. Removing the need for the passenger to print their boarding pass, either at home or at an airport kiosk, or for them to have a boarding pass printed by a member of airport staff represents a marked increase in convenience for the passenger.

Safety. No impacts expected.

Security. The two-dimensional barcodes of the mobile boarding pass are acknowledged to be more secure (more difficult to forge) than the one-dimensional barcodes used on many paper boarding passes, and so this is viewed as representing a marked security improvement.

Accessibility for impaired. No significant impacts expected.

Modal change

No impacts expected.

Other notable impacts

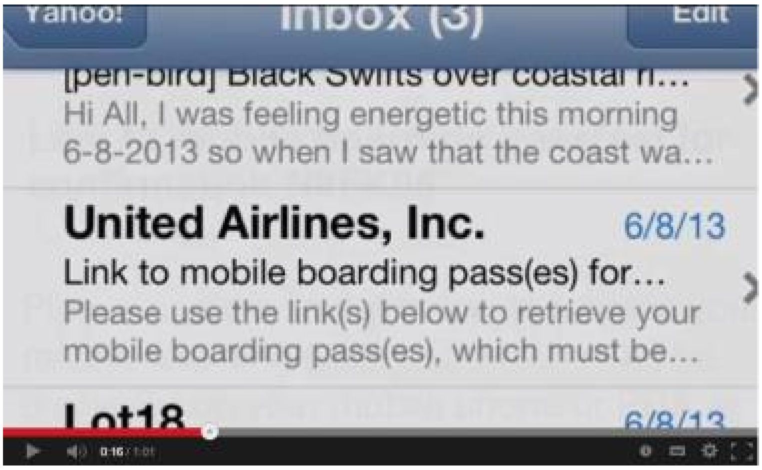
None relevant.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	✓✓	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	(x)	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	✓	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

On mobile boarding passes



http://www.youtube.com/watch?v=borYm99VMwI

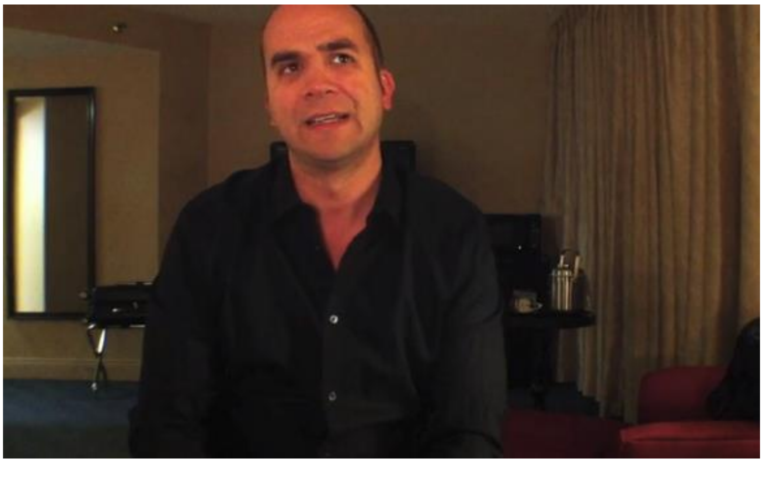
Mobile boarding passes introduction by Delta

http://www.youtube.com/watch?v=j-mnp7DnaGQ

On mobile boarding passes

http://www.youtube.com/watch?v=yVYHzuwcA2I

On mobile boarding passes



http://www.youtube.com/watch?v=W9K4F69eLqk

3.3.3 SMS ticket purchase in public transport

Solution family: Smart Ticketing and Tolling

Sub-family: Automated Fare Collection Systems (AFC) - Ticketing Systems

Domain of application: Urban

Technology behind: Mobile phone; Mobile networks;

Status: Implemented

Links to relevant references

- SMS ticketing system of public transport operator De Lijn, Belgium
- Prague public transport ticket paid by SMS
- Helsinki City Transport's SMS Ticket service is a success
- Stockholm Public Transport (SL) switches to Mobillö s secure and universal SMS-Ticket solution

Description

Concept and problems addressed. The SMS public transport ticket aims to provide an attractive and flexible alternative to purchasing a public transport ticket from the driver on the vehicle. The primary aim is to increase the proportion of tickets purchased in advance, and to reduce the journey time delay associated with on-vehicle ticket purchases. A secondary aim would also be to increase public transport ticket purchases and, correspondingly, public transport usage, by making it easier to purchase a ticket, and a third aim would be to save on the printing of paper tickets.

SMS public transport ticketing has been introduced in a number of areas, including Flanders (BE - the network operated by De Lijn), Prague (Cz), Bratislava (Sk), Vienna (At), Helsinki (Fi) and a number of cities in Sweden. These systems work by people wishing to purchase a ticket sending an SMS to a specified number prior to them boarding the bus or tram, in response to which they receive a unique confirmation SMS which serves as their ticket. The validity of tickets can then be checked via ticket inspectorsôPDAs. Payment for the ticket is via the passengersômobile phone operator, and appears as part of their mobile phone bill. The systems in Belgium, Finland and Sweden operate without the need for passengers to pre-register, adding to their flexibility. The price per ticket, for some systems, is discounted as compared with the price of purchasing the same ticket on the vehicle, as an incentive to purchase it this way. For example, the De Lijn SMS ticket is 28% less expensive than purchasing from the driver.

Targeted users. Public transport operators. The end users are passengers.

Barriers to implementation

Financial issues. Whilst there are costs in ensuring a secure SMS ticketing system, it is claimed that these are far outbalanced by cost-savings resulting from reductions in ticket sales staff, in physical ticket production and in the reduction of ticketless travel and by travel time savings of the buses and trams.

Technical barriers. There are concerns about the vulnerability of SMS ticketing, particularly regarding some systems (e.g. those in Austria, the Czech Republic, Poland and Slovakia). Firstly, where there is no connection between a userö s identity and the identity of their SMS ticket, it becomes possible for that ticket to be duplicated and shared. Secondly, there are concerns about the possibility of ‘hackers’ infiltrating the system and self-generating SMS tickets directly from their own phone. Whilst solutions exist to combat these problems, concerns remain. Another problem is the risk that the phone battery may run out during the journey and the ticket cannot be validated.

Organisational complexity. Where public transport is provided by a single operator, or where a single authority has strong powers to direct public transport operators under its jurisdiction, organisational complexity should not be a barrier to introducing SMS ticketing. However, where there are multiple operators who would need to come together and agree upon any plans to implement SMS ticketing, organisational complexity could be a barrier in those cases where they are not already operating joint ticketing in a tariff union, but this would probably be an exceptional case.

Legal issues. No legal issues.

User and public acceptance. The fact that an increasing number of operators install the system, is proof of high user acceptance. Furthermore, there is evidence to demonstrate a high level of public acceptance. For example, in De Lijn, almost 50,000 tickets were sold during the system’s first month of operation (February 2010) and monthly SMS ticket sales increased to 130,000 by December 2010 and, once the system was opened up to all Belgian mobile phone network providers in January 2011, to 157,440.

Interest for Travellers

Door to door travel time. SMS ticketing leads to reduced journey times as it will facilitate the reduction of dwell times at bus/tram stops thanks to fewer passengers needing to purchase tickets from the driver.

Travel cost. For schemes such as that in De Lijn there is a direct travel cost saving for those who switch from purchasing on the vehicle to the SMS ticketing, as the SMS ticketing option is deliberately 28% cheaper.

Comfort and convenience. The purchase of an SMS ticket is more convenient than a ticket purchase from a driver in those places, like for instance in the city of Edinburgh, where the drivers do not give any change and passengers have to have the correct fare or lose the difference between the fare and the change they have.

Safety. No impact.

Security. There is likely to be a minor beneficial impact, in that SMS ticketing removes the need for passengers to carry cash as a means of paying for public transport. Furthermore, they do not need to take out their wallets to pay, so pickpockets will not see where they put them back to, which can be particularly relevant in overcrowded vehicles.

Accessibility for impaired. There would be a minor beneficial impact, in that anyone with an impairment who wishes to purchase a ticket in advance but who finds ticket machines in accessible, has – via SMS ticketing an easier means of making that advanced purchase, but this assessment compare the benefits of SMS tickets against purchase from the driver.

Modal change

There a few results available as to whether there are more tickets sold in total as a consequence of SMS ticketing or whether there is only a shift from the sale on the bus to the sale through SMS-ticketing. However, during the De Lijn pilot in 2007, 9% of users indicated they used the bus more due to the system of SMS ticketing.

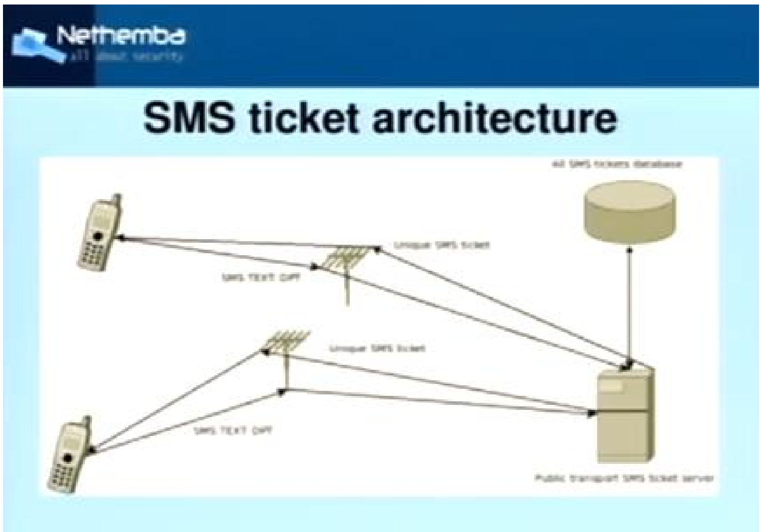
Other notable impacts

Congestion and CO2 emissions. Assuming the results from De Lijn are typical, then the mode shift towards more use of buses and trams will help reduce urban congestion and CO_2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	✓	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	+	Congestion	✓
Financial viability	✓	Comfort and convenience	0	Rail usage	+	CO2 emissions	✓
Technical feasibility	(x)	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	✓	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials



http://www.youtube.com/watch?v=RvEnV7BzYC8

3.3.4 SMS parking payment

Solution family: Smart Ticketing and Tolling

Sub-family: Automated Fare Collection Systems (AFC) ï Ticketing Systems

Domain of application: Urban

Technology behind: Mobile phone; Data communication between the machines and the application uses GPRS or CDMA technology

Status: Implemented

Links to relevant references

- System mobiParking, Poland
- The ParkBySMS, Sofia, Bulgaria
- TXT-a-Park, Wellington, New Zealand
- SMSnPark, Kuala Lumpur
- iPark, Bunbury, Australia
- Sosta Milano SMS, Milan, Italy
- mParking, Duabi, UAE

Description

Concept and problems addressed. Traditionally, parking time in large cities is billed through the sale of parking tickets or the use of parking machines. While these mechanisms have proven to be fairly reliable and useful, they are not always convenient for drivers and have a number of inherent disadvantages. Especially in cases when the machine is out of order or drivers have no small change for payment. It saves time and effort by eliminating the need for inconvenient cash payments and offers many additional conveniences to the users, including high availability, parking time notifications, ability to easily extend parking time remotely, and more.

An SMS payment parking system is usually implemented by municipalities in cooperation with the mobile operators, so that end clients can simply pay for their parking time by sending one or more SMS messages, charged directly to their phone bill. As an additional convenience, drivers receive notification SMS messages, reminding them when their parking time is about to expire. Another solution sends the information to a parking machine that the SMS payment is done and then the users receive the parking ticket.

In the Polish system mobiParking the user first selects a city in which the vehicle is to be parked. Next the registration number of vehicle should be inserted, and then the intended parking time is declared. The user receives a return confirmation SMS with payment details. The phone display will confirm the start of the parking indicating the vehicle's registration number and the location at which the vehicle is parked. To end the parking time for the vehicle the user has to send another SMS. At any time, user may send additional SMS to extend their parking time.

Parking SMS payable zones in Poland

The Bulgarian ParkBySMS parking payment system was introduced in Sofia in 2007. The payment process is illustrated in the next figure.

The user sends an SMS with the license plate number to a dedicated short number (e.g. 1302 for Sofia). The mobile operator charges the customer for the SMS service directly to their phone bill. ParkBySMS marks the vehicle as paid for 1 hour of parking time. The driver receives a return confirmation SMS with payment details. 15 minutes before the parking time expires, the customer receives a reminder SMS.

The parking system in Wellington in New Zealand is marketed in New Zealand under the TXT-a-Park brand (a registered trademark owned by Vodafone NZ), and is the first of its type that requires no pre-registration by consumers, which allows for the immediate use of this solution. As a result, after installing trial machines Auckland City Council saw an increase in customer satisfaction and a 27% increase in revenue from those machines. Wellington City Council reports that 13% of total parking revenue for the city is from TXT-a-ParkÊ phone payments.

Sosta Milano SMS is a system that enables users to pay to park in the parking areas defined by the City Council by sending an SMS. To be more specific, the first step is to buy a prepaid and rechargeable card (Sosta Milano SMS Card). The amount relative to the length of the stay will be progressively deducted from the credit on this card each time the user parks. The user just needs to send an SMS to the service operator to notify them of the start and end of his stay in the parking area.

Targeted users. The main targeted users for this application are municipalities. End users are car drivers.

Barriers to implementation

Financial issues.The costs of installation are not high. Also maintenance and integration costs are low, and it saves labour costs by reducing the need or manual collection of the parking charges from meters or pay points.

Technical barriers. This technology is already in use in a number of cities. Problems occur, if the battery of the mobile phone runs out during the parking time in those systems, where the user had to notify the operators of the end of the parking time.

Organisational complexity. There is a need of agreements with mobile operators. These agreements are standard, and they define the rights and obligations of operators, parking and service providers. Rights and obligations relating to: maintenance of the technical part, charges and interest in the collection, end-user complaints, confidential data, marketing activities, etc

Legal issues. There are no legal problems.

User and public acceptance. For municipalities this is a very convenient way of collecting parking charges. Public acceptance is also high. Older people may experience difficulties when starting to use this technology.

Interest for Travellers

Door to door travel time. No particular impact is expected.

Travel cost. No particular impact is expected.

Comfort and convenience. It provides easy and convenient way for parking fee payment.

Safety. No particular impact is expected.

Security. No particular impact is expected.

Accessibility for impaired. It makes the procedure of parking payment easier.

Modal change

No significant impact expected.

Other notable impacts

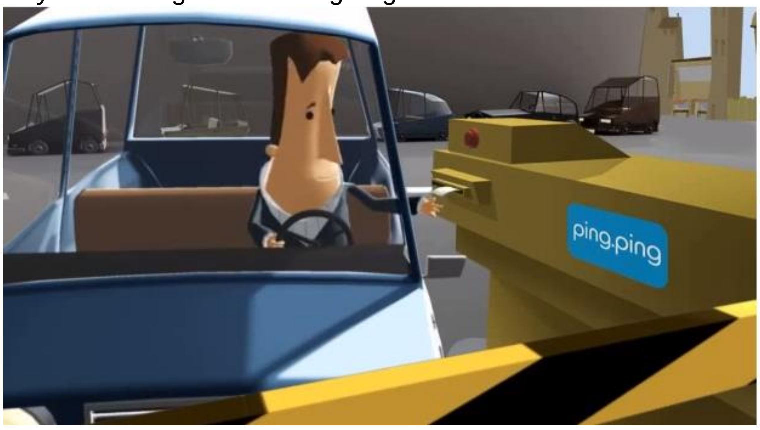
None relevant.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Pay for Parking via SMS in garages



http://www.youtube.com/watch?v=2_pcjLKaOB4

SMS-Parking in Singapore

http://www.youtube.com/watch?feature=player_detailpage&v=8IbNkEAUQa0

3.3.5 Integration of rail ticketing into airline GDS

Solution family: Smart ticketing and tolling

Sub-family: Automated Fare Collection Systems (AFC) - Ticketing Systems

Domain of application: Medium/long-distance travel

Technology behind: Computer Reservation Systems; Global Distribution Systems; E-ticketing.

Status: Being implemented

Links to relevant references

- Swedish Rail Operator SJ joins the Amadeus Rail GDS
- AirRail: a single booking and a single ticket for combined air and rail
- GDS distribution
- GDSs Note Flaws in Proposed European Air-Rail Ticketing System

Description

Concept and problems addressed. Global Distribution Systems are networks which enable automated transactions between vendors and booking agents providing travel related services, facilitating the linking, or consolidation, of service availability information, rates and bookings across different service providers. Initially developed for the airline industry, as a means of networking their computer reservations systems, they were then expanded to include hotels and car-hire. By networking multiple service providers, Global Distribution Systems enable a booking agent to choose and book different flights, hotels and associated services from any participating vendor in the world.

They are now being further expanded to include rail services. This is enabling booking agents to choose and book integrated air-rail tickets, through systems such as Syntigo's AirRail system, Amadeus's Global Rail Sales Platform and AccesRail's Rail & Fly.

Until this integration started to occur, it was not possible either to view rail travel options directly alongside air travel options for a given journey, or to book and purchase integrated tickets encompassing air and rail travel. This meant that rail's opportunity to provide an alternative or complement to air travel was suppressed and that, consequently, people's travel choices were not being optimised.

Targeted users. Travel/booking agents; GDS providers; airlines; rail operators

Barriers to implementation

Financial issues. No significant issues.

Technical barriers. No significant issues.

Organisational complexity. No significant issues.

Legal issues. No significant issues.

User and public acceptance. The system makes it easier for booking agents to see rail alongside air options, and travellers appreciate both the integrated air-rail rickets and the possibility to see alternative flight and rail options together.

Interest for Travellers

Door to door travel time. In many cases, it is expected that door to door journey times should reduce, as people can choose the fastest option out of air, rail and combined air-rail travel. This is most likely to be advantageous where high-speed rail services are available to link with air services, such as with Eurostar and Thalys, connecting with Paris, Brussels and Amsterdam.

Travel cost. In many cases, it is expected that travel cost should reduce, as people can choose the cheapest option out of air, rail and combined air-rail travel.

Comfort and convenience. The integrated ticket is more convenient than having to buy two separate tickets.

Safety. No significant impact

Security. No significant impact

Accessibility for impaired. No significant impact

Modal change

It is expected that some modal change will be facilitated, from short haul air services to medium and long-distance rail services.

Other notable impacts

Congestion. A shift from air to rail travel will free up of capacity at airports, enabling greater concentration on long haul services.

CO2 emissions. Any shift from air to rail travel will reduce CO2 emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	(√)	Car usage	-	Mobility	0
Operation and maintenance costs	€	D2D travel costs	(√)	Bus and coach usage	0	Congestion	√
Financial viability	√	Comfort and convenience	√	Rail usage	+	CO2 emissions	√
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	-	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	√						
Public acceptance	√						

Illustrative materials

The Future of Integrated AirRail Ticketing

http://www.youtube.com/watch?v=oqithLiT7YI

4 SMART VEHICLES AND INFRASTRUCTURE

4.1 AUTONOMOUS DRIVER ASSISTANCE SYSTEMS

4.1.1 Head-up display

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long-distance, rural, urban

Technology behind: holography, cameras

Status: implemented

Links to relevant references

- *Audi A7 Sportback. Head-up display and speed limit indicator*, by AUDI (2010)
- *What to expect in the field of visual in-car augmented reality in the next 10 years* by Ministry of infrastructure and environment; Rijkswaterstaat, the Netherlands and Delft University of Technology Faculty Industrial Design Engineering (June 2011)
- *Top 5 HUDs in modern cars today*, by John Brandon, TechRadar (August 28th 2012)
- *BMW 3 Series to get full colour Head-Up Display*, by Sanjiv Sathiah, LeftLane Nov 6th, 2011)

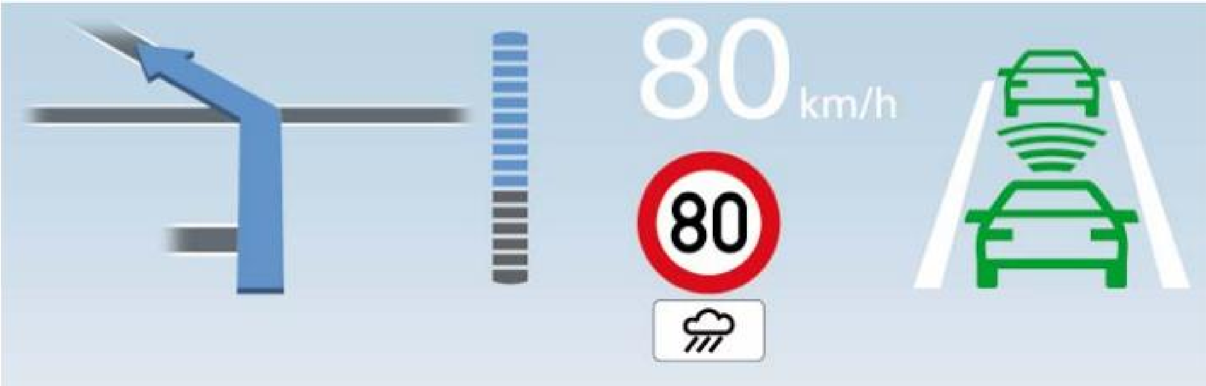
Description

Concept and problems addressed. Head-up display is the term used to describe optical systems that project information from various vehicle systems into the extended field of vision of the driver. To register these parameters, the driver does not need to change his head position to any significant extent; with an upright posture, he can keep his eyes on the road. The system has been named "head-up" display because the head can stay "up" and only the eyes need to be lowered slightly.

The head-up display enables the driver to register important vehicle information quickly and precisely. The use of special windscreens in the case of vehicles with head-up display gives rise to the impression that the display of the head-up display does not appear in the area of the windscreen rather at a pleasant distance of two to two-and-a-half metres away from the driver. The head-up display appears to hover above the bonnet.

The list of information and vehicle parameters that can be shown by the head-up display is long, and different car manufacturers chose to show different parameters. The most common are current vehicle speed and speed limits as well as navigation information. Others are active lane assist with warning for lane departure, current settings for adaptive cruise control (the sensor that adjusts the car's speed relative to the car in front), a night vision assistant, the RPM level to aid in manual gear changing and the 2013 Lexus GS has pre-collision detection, where the HUD will flash BRAKE! all in caps if the car is about to crash. But in other cars it is also possible to see whether the lights or turn signals are activated, see an icon for an incoming call, check the compass, see the outside temperature or available radio stations.

For the speed limit indicator there are two options: information can be based on data from satnavs or on an image processing system that records road signs with prescribed speeds with a video camera. The Audi A8 Audi speed limit indicator uses both systems and therefore has two sources of information so that the data can be checked for plausibility. In the event of failure of one of the sources of information or of both, the speed limit indicator continues to operate with restrictions. The driver is notified by means of a corresponding message in the driver information system.

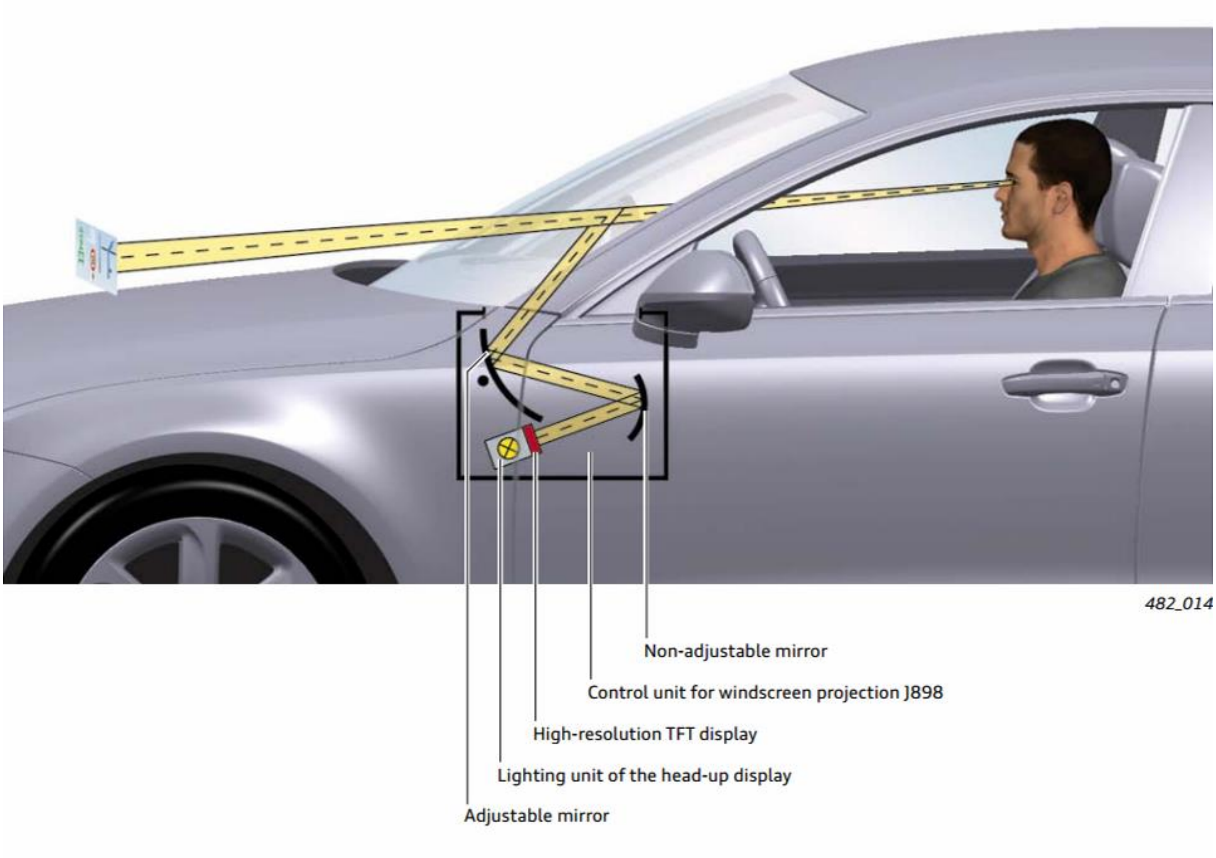


Source: Audi A7 Sportback. Head-up display and speed limit indicator
Display viewer

In the Audi A7, the central element of the head-up display is the control unit for windscreen projection. This control unit contains all the optical, mechanical and electrical components required for the head-up display. It is located in the dash panel directly in front of the instrument cluster.

The head-up display is generated in that a high-resolution TFT display is backlit by a strong light source. The light source comprises 15 LEDs in total. The technical structure is similar to that of a slide projector. The emerging light rays are projected via two deflection mirrors onto the windscreen. One of the two mirrors is adjustable and is used for height adjustment of the head-up display. This adjustment possibility is important to adapt the position of the head-up image to the seating position or body size of the driver. The mirrors also have the task of correcting distortions of the image caused by the curvature of the windscreen.

The light intensity of the displayed image is continuously adapted to the current ambient lighting conditions. To achieve this, the control unit evaluates the ambient luminosity values from the rain and light sensor. The driver also has the possibility to adapt the brightness of the display according to his needs. To do so, he has a setting option in the MMI and the controller for the basic setting of the display and instrument lighting in the light switch. The light intensity is configured in such a way that the display also remains easily legible in the case of direct solar radiation.



Source: Audi A7 Sportback. Head-up display and speed limit indicator
Optical System

The windscreen is an important part of the overall optical system of the head-up display. The projected image is also reflected by the windscreen, which means the windscreen more or less represents a third mirror.

The windscreen for head-up displays differs from the conventional windscreen in that the PVB foil between the two flat glass panes of the windscreen is not of a constant thickness, rather is slightly wedge-shaped. This means the thickness of the windscreen increases slightly in the upward direction.

Targeted users. The targeted users for this application are passenger cars as well as goods vehicles.

Barriers to Implementation

Financial issues. In all new BMW 3 Series, the technology that allows head-up displays (TFT, mirrors and windscreen) costs approximately ú1400. While many automotive brands offer a head up display in their top line models nowadays (BMW implemented its first head up display in 2004), the overall percentage of head up displays on the road is not growing rapidly. Due to current high production costs and a market demand too small to include it as standard feature, head up displays are currently offered as optional features to a car.

Technical barriers. None, this is established technology.

Organisational complexity. None.

Legal issues. No barriers known.

User and public acceptance. Although some drivers are known to find the head-up displays disturbing, the displays are becoming installed in more and more of the more upmarket cars, and their market share increases slowly but steadily. In principle, the technology could benefit in particular elderly drivers in an ageing society, but elderly people, who have developed firm driving habits, may also be the most reluctant population to get used to a new technology.

Interest for Travellers

Door to door travel time. No particular impact expected.

Travel cost. No impact expected.

Comfort and convenience. Increased convenience as drivers are more easily alerted to real-time road regulations in force.

Safety. It is expected that head-up displays improve safety during car journeys because the driver needs less time to move his or her viewpoint to the display, to re-accommodate the eyes and adapt to different lighting conditions in contrast with the road environment. Therefore the conclusion is that the projected information into the forward scene has less spatial separation then head down displays and costs less physical and cognitive effort, thereby increasing road safety.

Security. No impact expected.

Accessibility for impaired. This application may increase driving comfort of people with sight problems, as traffic signs are shown closer to the driving position.

Modal Change

No impact expected.

Other notable impacts

No particular impacts expected.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

BMW Head-up Display

http://www.youtube.com/watch?v=aoIgxnnK22Q

http://www.youtube.com/watch?v=s3oyY7mTtDo

4.1.2 Night visions in cars

Solution family: Smart Vehicle and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long-distance, rural

Technology behind: infrared

Status: implemented

Links to relevant references

- *Sensor fusion to enable next generation low cost Night Vision systems* R. Schweiger (2010)
- *Go to the Dark Side With BMW Night Vision* Wired Autopia (19 October 2009)
- *Night View Assist Plus: An Extra Pair of Eyes in the Dark* Daimler
- *Honda Develops Intelligent Night Vision for automobiles* Gizmag
- *How In-dash Night-vision Systems Work* Josh Briggs, How stuff works

Description

Concept and problems addressed. An automotive night vision system is a system to increase a vehicle driver's perception and seeing distance in darkness or poor weather beyond the reach of the vehicle's headlights.

Currently two types of Night Vision technologies are on the market with complementary strengths: Far-Infrared (FIR) and Near-Infrared (NIR) systems. FIR systems are passive, detecting the thermal radiation at wavelengths in the interval 8-12 εm. Warm objects emit more radiation in this region and thus have high visibility in a thermal image. NIR systems use a light source with a wavelength of approximately 0.8 εm to illuminate the object and then detect the reflected light. The main advantages of NIR systems are the high resolution and driver acceptance of the naturally scene representation in the picture. The NIR sensor technology is well developed and has a cost advantage compared to the FIR-based systems, but the FIR-based systems are able to image pedestrians at longer distances than their NIR-based counterparts.

The latest night vision system has people-spotting technology that distinguishes between animals and humans. The system was developed by the Swedish firm Autoliv Electronics. It is the latest evolution of technology that BMW, Lexus and Mercedes-Benz have offered since Cadillac introduced it in 2000.

Some systems also monitor speed and trajectory to warn the driver if he is on a collision course.

Source: Daimler
Display night view

Despite the added safety such systems offer, Cadillac and Lexus dropped them because few people bought them, but BMW and Mercedes-Benz still see a market for it.

In the context of a fast ageing society in Europe, there should be a growing market for these systems, since assisting vehicles with mechanisms to increase night driving capabilities would keep the growing numbers of elderly people in Europe mobile for longer.

Targeted users. Car drivers, with additional benefits for pedestrians and cyclists.

Barriers to Implementation

Financial issues. Widespread use of both technologies together is currently limited by the system cost. The main cost drivers of the FIR system are its resolution and its sensitivity.

Mercedes-Benz uses an active system or near-IR system that illuminates the night with projected infrared light, much like optics found in military-issue night-vision goggles. BMW's system, cost an extra ú2,200 on top of the base price of a 7 series car, which is ú 74,200, so less than 3% of the carõs base price.

The next generation of automotive night vision enhancement systems offers automatic pedestrian recognition with a performance beyond current night vision systems at a lower cost. This will allow higher market penetration, especially in luxury cars, but possibly also in compact cars.

Technical barriers. In urban locations, the presence of street lighting and illuminated commercial signs can reduce the contrast between target objects and the surroundings making interpretation of the night vision display more difficult, so the main application is on country roads.

Organisational complexity. None.
Legal issues. No major problems expected.

User and public acceptance. Due to the price of the system, the take-up has been very limited so far, but those who decide to invest in it, are clearly not only accepting it, but appreciating it.

Interest for Travellers

Door to door travel time. In bad sight conditions (fog, night, rain), this system may allow slightly higher driving speeds, and slightly reduce travel times, thought changes are not expected to be of great magnitude.

Travel cost. No impact expected.

Comfort and convenience. Comfort significantly improves when driving at night.

Safety. The main safety benefit of night-vision systems is to increase the driver's range of vision when using low-beam headlights and emphasise the presence of animals, pedestrians, cyclists and other vulnerable road users. This technology can significantly improve driversôvision, and that means safer roads for everyone.

However, there is potential for the night vision display to be a distraction, especially when the technology is initially being used. Drivers must make a conscious effort to focus on the regular driving tasks, especially scanning the road ahead, and only take occasional glances at the night vision display to assimilate the additional information that this can provide.

Security. No particular impact is expected

Accessibility for impaired. Drivers with reduced vision, especially at night, may enhance their driving conditions.

Modal change

Mobility. As mentioned before, in an ageing society these system may help keeping elderly people mobile for longer.

Other notable impacts

No particular impact expected.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	✓
Operation and maintenance costs	€	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	**0**	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. Imp. Passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

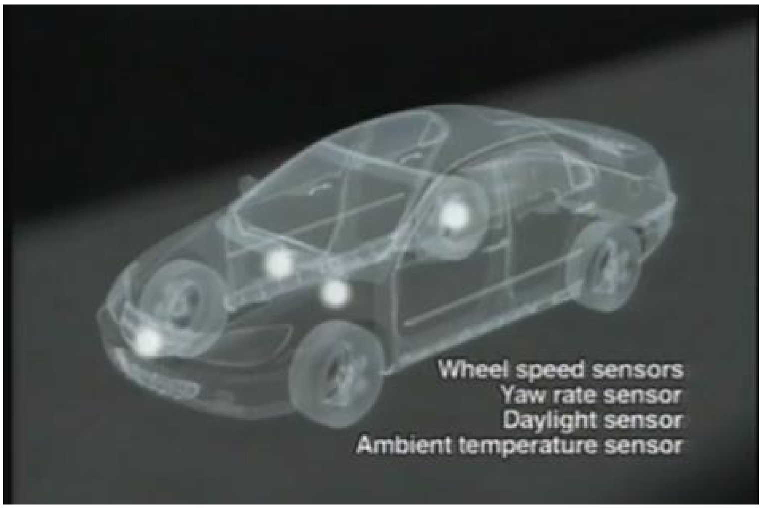
BMW Night Vision video city scene

http://www.youtube.com/watch?v=IuvwgjjoHmw

Mercedes-Benz S-Class Night View Assist Night Vision Video

http://www.youtube.com/watch?v=0UaTYX-ygG8

Honda Intelligent Night Vision System



http://www.youtube.com/watch?v=XmqxSKd3r0g

4.1.3 Driver drowsiness detection system for cars

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long-distance travel, rural

Technology behind: camera, infrared, sensors

Status: implemented / pilots

Links to relevant references

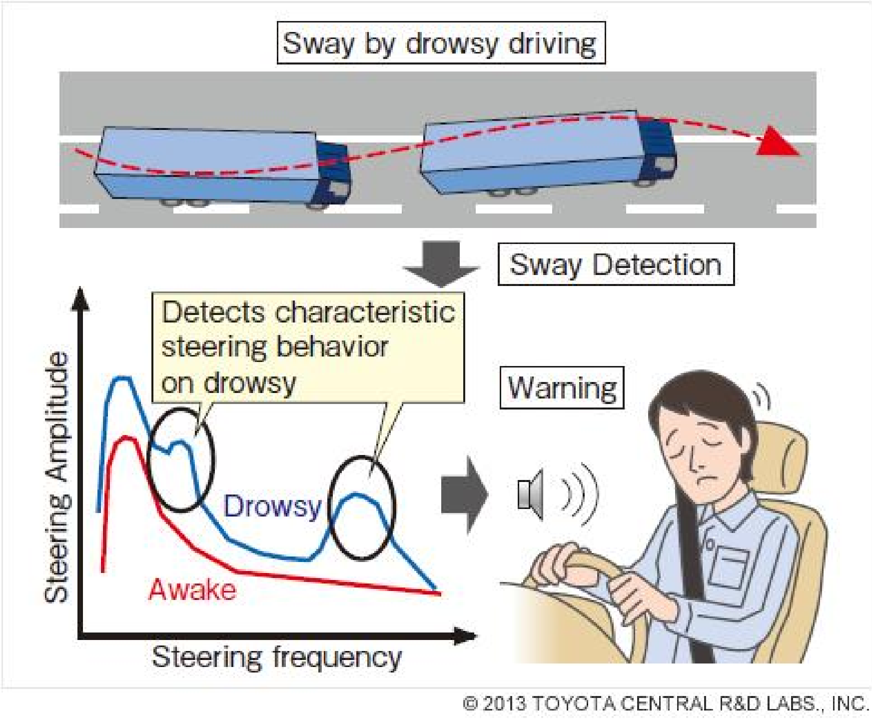
- Vision-based drowsiness detector for a Realistic Driving Simulator, article by at I. García, S. Bronte, L. M. Bergasa, N. Hernandez, B. Delgado, M. Sevillano Annual Conference on Intelligent Transportation Systems, 2010.
- eIMPACT (2008). *Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe*.
- Real-time Nonintrusive Detection of Driver Drowsiness by Xun Yu, Intelligent Transportation Systems Institute Center for Transportation Studies University of Minnesota, 2009
- Drowsy Driver Detection System by Neeta Parmar and Peter Hiscocks, department of Electrical and Computer Engineering, Ryerson University, 2002.
- Road Safety, European Commission
- Bosch Driver Drowsiness Detection
- Attention Assist Daimler System
- Ford Driver Alert

Description

Concept and problems addressed. The term Driver Drowsiness Detection (DDD) system refers to in-vehicle systems that monitor driver and/or vehicle behaviour. These systems monitor the performance of the driver, and provide alerts or stimulation if the driver seems to be impaired. It warns drivers when they are getting drowsy.

The techniques used to detect a driverõs sleepiness can be generally divided into three main categories:

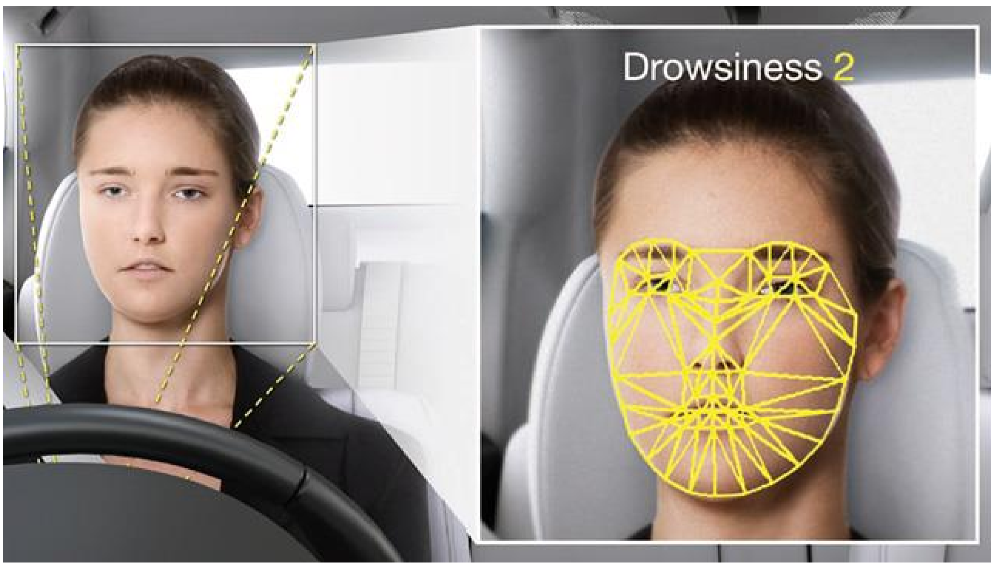
- The first category includes methods based on biomedical signals, like cerebral, muscular and cardiovascular activity. Usually, these methods require electrodes attached to the driverõs body, which will often cause annoyance to the driver, and cannot be expected to become commercially viable unless ways are found to measure such body signals without electrodes being directly attached to the body.
- The second category includes methods based on driver behaviour, which evaluate variations in the lateral position of the vehicle, in the velocity, in the steering wheel angle and in other signals recorded. The advantage of these approaches is that the signal is meaningful and the signal acquisition is quite easy. This is the reason why such systems have entered the commercial market (e.g. for Daimler, Volkswagen, Ford). On the other hand, these systems are subject to several limitations such as vehicle type, driver experience, geometric characteristics, condition of the road, etc. These procedures require a considerable amount of time to analyse user behaviour and, therefore, they do not work with the so called micro-sleepsö when a drowsy driver falls asleep for a few seconds on a very straight road section without changing the vehicle signals.



Source: Toyota

Sensor based drowsiness detection

- The third category includes methods based on driver visual analysis using image processing techniques. Computer vision can be a natural and non-intrusive technique for monitoring driverҁs sleepiness from the images taken by some cameras placed in front of the user. These approaches are effective because of the occurrence of sleepiness is reflected through the driverҁs face appearance and head/eyes activity. Different kinds of cameras and analysis algorithms have been reported in the literature for this approach: methods based on visible spectrum; methods based on IR camera; and methods based on stereo camera. Commercial products are still limited to some well controlled environments and they require difficult calibration processes. Then, there is still a long way in order to obtain a robust commercial product in this category.



Source: Denso

Driver Drowsiness Checker watching facial muscles instead of eyes

DDD systems can only warn a driver that he is drowsy. It is the responsibility of the driver to take a break and to ensure that the break is sufficient to restore his levels of attention. DDD system cannot judge the quality of the break taken by the driver. However, after a break, the system will continue to monitor the driving pattern and will warn the driver again if drowsiness is detected. It is expected that the warnings will provide the incentive needed to make drivers take a break.

Targeted users. The targeted users for this application are the road users, in particular truck drivers and long distance car drivers.

Barriers to Implementation

Financial issues. According to the eIMPACT project, a DDD system, which requires a warning module, a steering grip sensor, a driver monitoring camera and a mono camera for line monitoring can increase the cost of a vehicle on several hundred euros.

Technical barriers. Technologies based on biomedical signals are still under development. For example, research on heart rate variability (HRV), a physiological signal that has established links to waking/sleepiness stages, is analysed for the detection of driver drowsiness by electrocardiogram (ECG) signals. Although ECG measurement techniques are well developed, most of them involve electrode contacts on chest or head, for example the conventional fixed electrodes. To prevent discomfort of electrodes, technologies based on design of measuring heat beat signal from biosensors on the steering wheel or in the driver's seat are under development[23].

Technologies based on driver behaviour are already implemented on car fleets of Mercedes, Ford or Volkswagen. In extreme weather conditions such as very high cross-winds, the system may incorrectly characterise the steering pattern as that of a drowsy driver.

Technology based on driver visual analysis using image processing techniques to alert of drowsiness is only tested on controlled environments. Image face processing and light source are the main challenges of this technology.

Organisational complexity. None.

Legal issues. No difficulties expected,

User and public acceptance. User acceptance for those who are willing to install these systems in their cars is clearly high

Interest for Travellers

Door to door travel time. No impact.

Door to door travel cost. Not impact.

Comfort and convenience. No particular impact

Safety. It is estimated that drowsiness is a major cause of around 20 percent of all serious accidents in Europe. However, even modest assumptions regarding the numbers who are likely to respond leads to the estimation that Driver Drowsiness Detection system could prevent 1875 injury accidents involving a passenger car every year in Europe.

Security. No impact expected.

[23] Real-time Nonintrusive Detection of Driver Drowsiness by Xun Yu, Intelligent Transportation Systems Institute Center for Transportation Studies University of Minnesota, 2009

Accessibility for impaired. No impact expected.

Modal change.
No impact expected.

Other notable impacts

No particular impact expected

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	**0**	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€	D2D travel cost	**0**	Bus and coach usage	**0**	Congestion	**0**
Financial viability	**0**	Comfort and convenience	**0**	Rail usage	**0**	CO2 emissions	**0**
Technical feasibility	**0**	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisationalfeasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. Imp. Passengers	**0**			Territorial Cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	**0**						

Illustrative materials

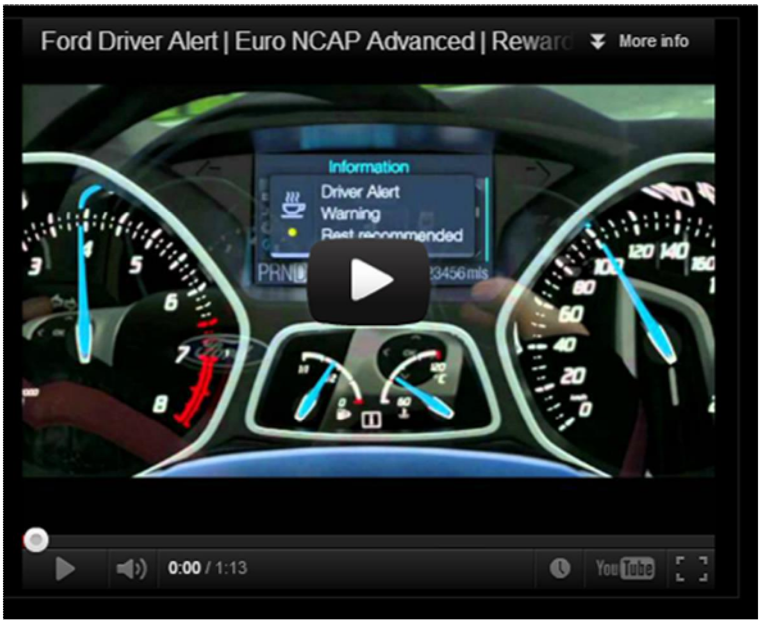
VOLVO XC60 Dirver Alert control

http://www.youtube.com/watch?v=d5_s1XwixK8

Mercedes ï Benz Attention Assist

http://www.euroncap.com/Player.aspx?nk=a299f606-1236-49d0-8bcb-2dc70574a637

Ford Driver Alert System



http://www.euroncap.com/Player.aspx?nk=a1701c1e-f028-4ad9-877d-ffdef7884a2c

4.1.4 Automatic car parking

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: Urban

Technology behind: Cameras, sensors

Status: Implemented

Links to relevant references

- Ditlea, Steve. "Self-parking cars." Omni, Sept. 1992.
- Horrell, Paul. "The Future of the Car." Popular Science.
- Paromtchik, Igor; Laugier, Christian (1996). "Autonomous Parallel Parking of a Nonholonomic Vehicle", Proceedings of the IEEE Intelligent Vehicles Symposium, Tokyo, Japan, September 1996, pp. 13-18.
- "Self-parking car hits the shops". BBC News. 2003-09-01. Retrieved 2011-07-20.
- "Toyota unveils car that parks itself". CNN. 2003-09. Retrieved 2009-07-28.
- Wada et al, "Development of Advanced Parking Assistance System", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 50, NO. 1, FEBRUARY 2003
- "The Lexus LS460: It Really Does Park Itself". KickingTires. Retrieved 2010-02-02.

Description

Concept and problems addressed. Car-park bashes are the most common single category of car insurance claims. A report produced by the UKĝs AA car insurance shows that "amazingly 20 per cent of all claims (which if scaled up nationally would be the equivalent of over 6 million) are for damage caused in car parksû It is believed that the true number of such accidents might be a lot higher than that as many people may not make a claim due to its effect on the no-claim bonus.

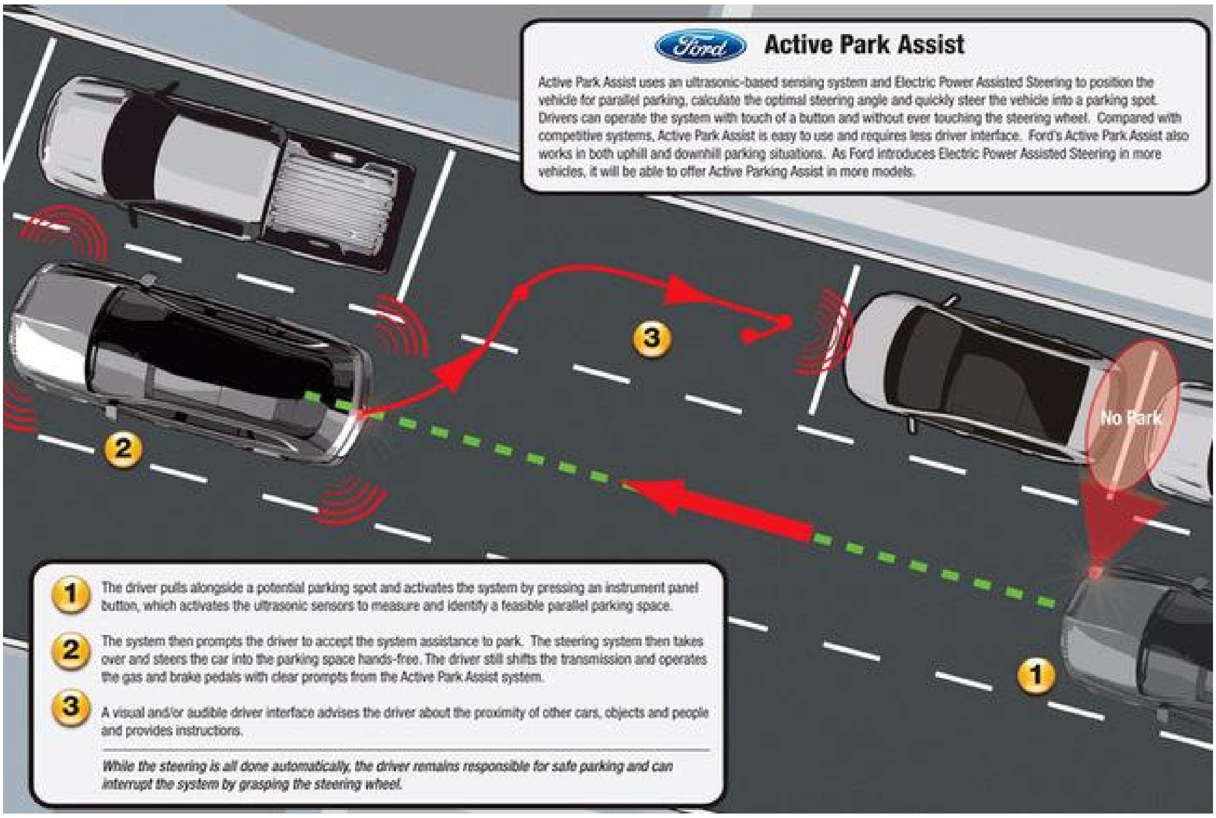
There are three basic modes of parking; namely parallel parking, perpendicular parking, and angle parking; which all require a number of driving skills to perform many different actions at the same time. It is easy to misjudge a gap, speed or corner. Removing the difficulty, stress and uncertainty of this chore is very appealing.

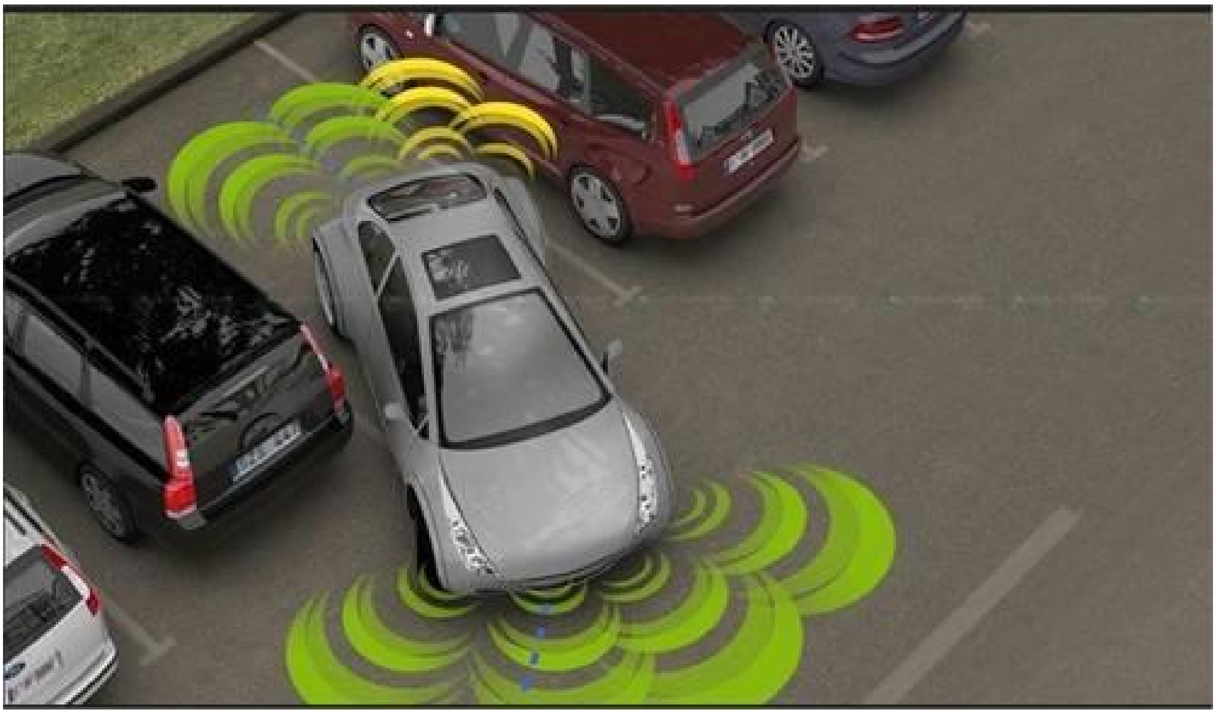
Automatic parking uses computer processors which are tied to a number of sensors (e.g. ultrasonic, optical etc) and image recognition technologies to enable the car to manoeuvre autonomously from a traffic lane into a parking place. It is also known as Active Park Assist, Intelligent Parking, and Advanced Driver Assistance.

The main procedures of automatic parking are to utilise ultrasonic sensors and cameras on the forward and rear bumpers to detect obstacles, the available parking space, and surrounding vehicles calculate optimum steering angles, and interface with the Electric Power Steering systems of the vehicle to guide the car into the parking spot. It typically involves the following steps:

- Parking environment recognition
- Path planning & tracking
- Vehicle localisation
- Electrical steering control
- Active gear shift and braking control

- Remote control module





Automatic parking systems are being developed by several automobile manufacturers. According to Wikipedia (http://en.wikipedia.org/wiki/Intelligent_Parking_Assist_System), Toyota Motor Corporation in Toyota Prius introduced a commercial version of automatic parallel parking in 2003; BMW recently demonstrated its Remote Park Assist system on a 750i; Lexus debuted a car, the 2007 LS, with an Advanced Parking Guidance System; and Volkswagen also debuted an automatic parking system on Touran, which is subsequently offered on the Passat, Passat CC, Golf, Tiguan, Sharan and Polo.

It must be noted that automatic parking described here, based on on-vehicle sensors and equipment, should not be confused with other types of automated parking systems, where the equipment is built on the parking infrastructure itself to automatically store a car, moving it over platforms and lifts throughout the garage up to an empty slot.

Targeted users. The targeted users are all car drivers. Others that might be involved are the insurance providers and operators/managers for urban road networks.

Barriers to implementation

Financial issues. The costs for the automatic parking system are mainly for the onboard units (e.g. computer processors, sensors etc). For a 7 series BMW, which has a base price of ú 74,200, the add-on cost for a Reverse Assist that only shows the distance to the surrounding cars in the display is ú420, while the Park Assist that not only identifies free parking spaces at driving speeds up to 35 k/h, but then also takes over the steering of the car during the parking manoeuvre (the driver still does have to accelerate and brake though) cost with ú 550 only marginally more, so both only represent less than 1 % of the carõs base price. On the other hand, car users pay for the system (as part of the purchase) which provides better and safer parking. Insurance premiums may be reduced as a result of fewer claims for damage caused in car parks or on street.

Technical barriers. A completely reliable automatic parking system that includes sophisticated sensors and tracking algorithms can be very complex, because it works within very constraint space and populated areas, but proven systems exist.

Organisational complexity. There is no organisational complexity Equally there is no administrative burden.

Legal issues. Like other units/parts, the liability of the automatic parking systems needs to be considered before they are installed to ensure that a liability structure is in place and that all stakeholders are assured of what will happen if something does go wrong.

User and public acceptance. Public acceptance is not an issue, and user acceptance, once somebody has decided to invest in the system, is clearly high.

Interest for Travellers

Door to door travel time. The system may help drivers find a parking space that would otherwise be too small for them, and thereby reduce the search time for a space, but the effect is rather marginal.

Travel cost. No notable impact over and above the marginal reduction in travel time.

Comfort and convenience. For many drivers parking, in particular parallel parking, is difficult to navigate, especially for elderly drivers who find it more difficult to turn round to observe the space behind them and the automatic parking assistant is designed to increase the comfort of everyday driving.

Safety. This application increases safety by providing greater control (if not fully autonomous) over parking.

Security. No improvement is expected.

Accessibility for impaired. This application may help impaired drivers, in particular those who have difficulties turning round to look what is behind them.

Modal change

The new in-car technology may encourage car use in particular for shopping trips involving High Street parking.

Other notable impacts

Mobility. The parking assistant may increase the mobility of people who find it difficult to navigate parking operations.

Congestion and CO2 emission. As automatic parking helps park the car quickly and easily, it may marginally help reduce High Street congestion, fuel consumption and emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	(✓)	Car usage	+	Mobility	✓
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	(✓)
Financial viability	0	Comfort and convenience	✓✓	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

2012 Ford Focus self-parking tech demo

http://www.youtube.com/watch?v=u-rxJkVzUxI

4.1.5 Blind spot detection for cars

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long-distance travel, rural, urban

Technology behind: camera, radar, infrared, sensors

Status: implemented

Links to relevant references

- Decoding Blind Spot Detection and Warning Systems by Jeremy Laukkonen
- Crash avoidance features reduce crashes, insurance claim study shows; autonomous braking and adaptive headlights yield biggest benefits by David Zuby, Insurance Institute for Highway Safety, 2012
- eIMPACT (2008). *Socio-economic Impact Assessment of Stand-alone and Co-operative Intelligent Vehicle Safety Systems (IVSS) in Europe*.
- ABI Research Technology Transport Intelligence
- Blind spot detection using vision for automotive applications by Sotelo M., and Barriga J., University Alcalá, 2008
- A priori evaluation of safety functions effectiveness ï Results on safety increments by Menelaos Pappas-LMS, Michael Stanzel-Volkswagen, Yves Page-LAB, Thierry Hermitte ï LAB, Julie Lahausse - MUARC, Michael Fitzharris-MUARC, Brian Fildes ï MUARC, TRACE Project, 2008.
- Mazda Rear Vehicle Monitoring System by EURO NCP, 2010
- Audi Site Assist by EURO NCP, 2010
- LaneFX Auto Safe Series.
- Insurance Institute for Highway Safety
- EuroFOT

Description

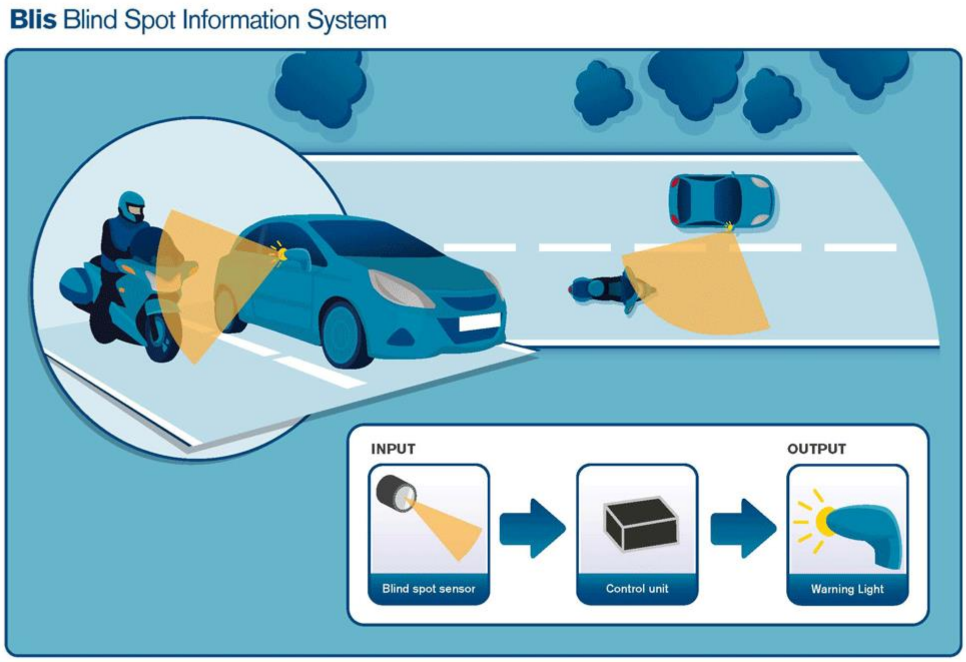
Concept and problems addressed. Blind Spot Detection (BSM) uses radar, camera or ultrasonic technologies to monitor the blind spot area of the vehicle. If a moving object is detected within the specified zone, a warning signal is issued. Warning signals vary from one version of the system to another and include visual, audio or haptic signals.

Blind spot detection systems use either radar or rear-looking video cameras to detect vehicles in the driver's blind spot. The systems only flag moving vehicles; they do not react to fixed objects such as traffic signs at the roadside that the subject vehicle is passing.

Detectors are located on both sides of the vehicle to facilitate safe lane change manoeuvres. The system only identifies objects in close proximity, to the vehicle. Generally, the system will illuminate a warning light, often located on the appropriate side mirror, to advise the driver of the presence of the adjacent vehicle. Some systems vibrate the steering wheel if the driver attempts to initiate an unsafe passing manoeuvre.

Systems with video cameras as detectors use computer-based image processing to identify objects of interest in the field of view and issue appropriate warnings.

Some systems feature powered side mirrors that, when a turn signal is activated, swivel outwards to provide a view outside of the regular field of view.
Blind Spot Detection (BSD) systems first began to appear in top-of-the-line cars around 2005, with Volvo leading the way. In 2011, such systems will be available on high-volume models such as the 2012 Ford Focus and Mercedes-Benz C-Class. By 2016, annual BSD installations are forecast by ABI Research to reach 20 million (just over 25% of the predicted world vehicle market), with a worldwide market value of over $12 billion.[24]



Source: euroFOT
Blind Spot Information System

Targeted users. The targeted users for this application are car drivers.

Barriers to Implementation

Financial issues. According to eIMPACT project, a Blind Spot Detection System requires the followings components: warning module and mid range radar or cameras which cost approximately ú 130.

Technical barriers. None in principle, although the system has some limitations. In low radius bends, blind spot detection system may give false warnings, mistakenly identifying vehicles as being in an adjacent lane when they are in fact following in the same lane. Similarly, if lanes are unusually narrow (in road works, for example), the system may warn of vehicles in a non-adjacent lane. Radar detection might be impaired in adverse weather conditions (very heavy rain or snow etc). A mounted trailer might interfere with the radar's operation.

Organisational complexity. No barriers.

Legal issues. No barriers expected.

User and public acceptance. User acceptance is high and public acceptance is not an issues here.

Interest for Travellers

Door to door travel time. No particular impact expected.

[24] ABI Research Technology Market Intelligence

Travel cost. Not particular impact expected

Comfort and convenience. No particular impact.

Safety. The system helps avoid side swipe collisions in lane change situations. According to the FP6 TRACE project (Traffic Accident Causation in Europe) blind spot accidents represent 43% of the injury accidents, and 4.0% of serious injury accidents. According to the FP6 eIMPACT project, It is estimated that in Europe the system could save approximately 975 lives each year and avoid 2100 injuries, if all cars were equipped with the system.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Other notable impacts

No particular impacts expected.

Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and Maintenance Costs	€	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial Viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical Feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational Feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative Burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal Feasibility	0						
User Acceptance	✓						
Public acceptance	0						

Illustrative materials

Blind spot detection by Insurance Institute of Highway Safety

http://www.youtube.com/watch?v=B93tfG4ZydY

Audi Site Assist

http://www.euroncap.com/Player.aspx?nk=674e218f-0fd3-4c98-87b0-cc3c0df251dc

Blind spot detection system by Ford

http://www.youtube.com/watch?v=56HRrE108eA

4.1.6 Collision avoidance system for buses (pre-crash system)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: Urban

Technology behind: Sensors

Status: Implemented

Links to relevant references

- Project web site page of the RITA (US) collision avoidance systems

Description

Concept and problems addressed. Nearly 46% of bus accidents across the United States each year occur on the left or right side of the bus. These collisions result in property damage, and they can negatively impact on revenue operations and public perception. The first commercially available side collision warning system for buses entered the market in 2004. The system is designed to help bus operators navigate tight manoeuvres at speeds below 15mph and with lane changes at speeds greater than 15mph.

Targeted users. Bus operators.

Barriers to implementation

Financial issues. There are several applications related to the collision avoidance systems (e.g. obstacle detection, lane change assistance, lane departure warnings, etc). The average costs range from ú 900 to ú 3,000 per vehicle, a relatively low amount in relation to the total costs of a new bus.

Technical barriers. *Sensor location in buses*. This is important as sensor location impacts the object detection zone; in other words what the sensors are able to ñseeò. For example, at one agency the evaluation team noted that the front corner sensors were positioned quite differently depending on the front-end design of the bus. According to the installation manual, the front corner sensor should always point towards the corner of the bumper. The evaluation team, however, did not always find this to be the case. In some cases the sensors were placed on the side of the front corner, while in others, they were located on the front panel itself. *Sensor height.* Another consideration is sensor height placement. In order for the system to detect optimally, sensors must be placed between 25 and 106 cm from the ground. This provides the bus manufacturer with options in sensor height placement. The system controller must then be programmed to the installed sensor heights. Sensor location variation from bus to bus results in differing system detection characteristics. This can, and understandably did, lead operators to perceive the system to be unreliable and ultimately this led to distrust of the system among operators.

In addition to sensor placement and height considerations, the operating environment must be considered. Sensor sensitivity may be adjusted to account for specific characteristics of agencyôs routes such as utility poles placed close to the roadway. Sensitivity, when properly adjusted, will permit the system to ñseeò that a bus is not encroaching on the object more closely than might be reasonably expected. Appropriate sensitivity adjustments are critical to the operation of the system and increase operator confidence in the system.

Organisational complexity. Proper training is as critical to the successful deployment of the system as selecting the best location for the audible alert and visual display. If operators do not have the proper understanding of the system, they are not likely to accept or trust the technology, and they are then not likely to react in a way that makes the most of the system. Due to the lack of operator understanding, some of the participating agencies reported problems with operatorsô initial system acceptance.

Legal issues. Legal barriers are not relevant.

User and public acceptance. The public acceptance is not an issue, since they will generally not even be aware of the system, while acceptance among operators is to be high if the systems are installed properly.

Interest for Travellers

Door to door travel time. The reduction of accidents may very marginally reduce average travel time.

Travel cost. No impacts on travel costs.

Comfort and convenience. No impact expected.

Safety. The improvement in safety management is the most important result of the application.

Security. No impact expected.

Accessibility for impaired. No particular impact is expected.

Modal change

No particular impact is expected.

Other notable impacts

None expected.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	V						
Public acceptance	0						

Illustrative materials

4.1.7 Pedestrian and cycle scanning for cars

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: Urban

Technology behind: Radar scanner, On-board camera, Image recognition

Status: Implemented

Links to relevant references

- Video: Volvo Pedestrian Detection
- Daily Mail Online: Smashing idea: Volvo installs pedestrian detection system that brakes car automatically
- Daily Mail Online: A new era of road cycling safety: Volvo car scanner applies the brakes when it detects a bicycle swerving across its path
- Volvo XC60 Preisliste

Description

Concept and problems addressed. The vehicular technology to recognise pedestrians and cyclists was developed by a Swedish car manufacturer, with the one to detect pedestrian having been demonstrated in 2011, and the one detecting bicycles demonstrated in 2013.

The system consists of a radar scanner, on-board high-resolution cameras and an on-board computation unit. The radar scanner is set in the front grill of the car and scans the area ahead of the car continuously and measures the distances to any object that may be a cause of an accident. The camera is set in front of the rear-view mirror and it takes photographs of the object detected by the radar. The image is sent to the on-board computation unit and it compares the image with its large database to identify if the object is a pedestrian, a cyclist, a motorbike or anything else. Then, this system monitors the movement of such detected object.

If there is any movement with a critical risk of crashing such as a cyclist suddenly wobbling or swerving, the driver is warned automatically. This warning is made with an audio and a red right flashing in the windscreen, in a similar way to the head-up displays equipped in the modern aircrafts, and, if there is no immediate response from the driver, the car automatically breaks with its full breaking power.

Although some detection error could happen and the driver still has to drive carefully, this is particularly expected to increase the traffic safety in urban area where different types of traffic, namely cars, cyclists, and pedestrians, are mixed in the same road space. It has to be noted that this function is practically functional when the car is running at up to 30km/h and thus the effect of this advanced system is best utilised in 30km/h zones in urban areas.

Targeted users. The targeted users are car drivers, while indirectly pedestrians and cyclists could benefit through increased safety.

Barriers to implementation

Financial issues. As this is realised with on-board equipment, financial issues could arise among car owners. The newer one with bicycle detecting function is provided as a component of the

manufacturer's Driver Assistant Package that is provided as an add-on to the car and this package costs approximately € 2,000 at a retail price.
Since such on-board system is at the moment an optional component when purchasing cars, this will probably not penetrate into all of the vehicles. If a government decides to make it obligatory to install such devices for all car owners, it could incur up to € 2,000 per vehicle, although prices are likely to come down, when the system is starting to be mass produced. This could be a cost for the government when it decides to subsidise or a cost for the car owners when it decides not to.

Technical barriers. No known technical barriers.

Organisational complexity. This is on-board device and thus no organisational complexity is expected.

User and public acceptance. The acceptance by the drivers is expected to be high. Public awareness of the system may be fairly low at the moment even though pedestrians and cyclists can benefit through increased safety.

Interest for Travellers

Door to door travel time. No impact.

Travel cost. No impact.

Comfort and convenience. No impact.

Safety. This technology will increase the traffic safety in an urban environment where car traffic and pedestrians and cyclists are mixed. Besides classical urban space where the cars and the pedestrians have segregated lanes, this especially will be useful in the recent context that urban space redesigns utilising the concept of Shared Space, which demarcates vehicles and pedestrians by eliminating markings and traffic signs and by other measures such as new traffic regulations, are becoming widespread throughout Europe.

It has to be noted that the impact on the safety is limited within the area where cars are running at a speed of 30km/h or slower. Thus the impact on the safety is best put forth with safety-oriented speed limit settings such as 30km/h zones in the urban area.

Security. No impact.

Accessibility for impaired. No impact.

Modal change

No particular impact is expected.

Other notable impacts

No particular impact is expected.

Summary of scores

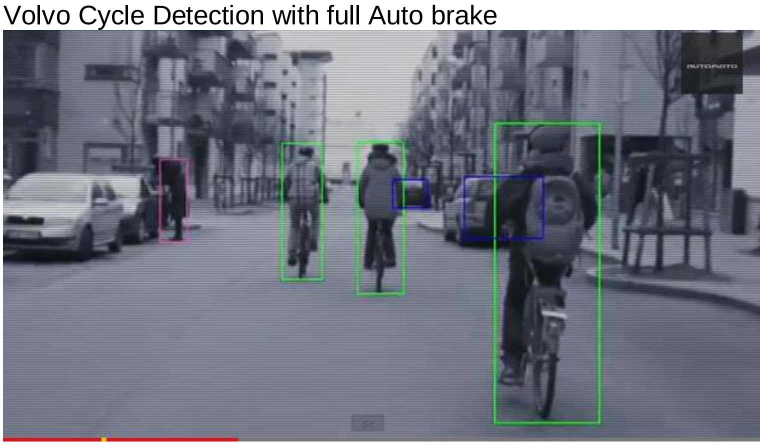
Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	(✓)						

Illustrative materials

Warning (left, red one in the windscreen) to the driver with detected bicycle.

Source: Daily Mail Online

Volvo Cycle Detection with full Auto brake



http://www.youtube.com/watch?v=cOn4729TcJ0

4.1.8 Lane Departure Waning System (LDWS) for cars

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long-distance travel, rural

Technology behind: camera, infrared

Status: implemented

Links to relevant references

- Federal Motor Carrier Safety Administration (2005). *Concept of Operations and Voluntary Operational Requirements for Lane Departure Warning Systems (LDWS) On-board Commercial Motor Vehicles.* US Department of Transportation.
- Assessing the impact of Intelligent Vehicles Safety Systems (eIMPACT) FP6 Project , 2008
- Visvikis, C., Smith, T., Pitcher, M., Smith, R. (2008). *Study on lane departure warning and lane change assistant systems.* Transport Research Laboratory.
- Barickman, F., Smith, L., Jones, R. (2006). *Lane departure warning system research and test development.*
- Batavia, P. (1999). *Driver- Adaptive Lane Departure Warning Systems*. The Robotics Institute Carnegie Mellon University.
- Kozak, K., Pohl, J., Birk, W., Greenberg, J., Artz, B., Blommer, M., Cathey, L. (2006). *Evaluation of lane departure warnings for drowsy drivers*. Ford Motor Company.
- Insurance Institute for Highway Safety.

Description

Concept and problems addressed. Lane Departure Warning (LDW) System monitor the position of the vehicle with respect to the lane boundary. They warn drivers when the vehicle is travelling above a certain speed threshold and the vehicleś turn signal is not used to indicate the intention of lane change or departure, but nevertheless the vehicle is about to leave its lane. Lane departure warning systems are a means of reducing the number of collisions and hence the number of people killed or injured.

Several different technologies have been utilised to create LDW systems. There are currently two types of LDW systems that have been introduced to the market; a camera based system and an infra-red system.

- The typical camera-based LDW system utilises a forward-looking camera mounted behind the windscreen that continuously tracks visible lane markings. This is linked to a computer with image recognition software that may also compute inputs for vehicle information such as speed, yaw rate, and steering angle. Camera-based LDW systems rely on the lines painted on the roadway to calculate the lateral divergence and divergence angle from the lane's centre. It then estimates the future vehicle position through sophisticated algorithms. If the data suggests that the vehicle is leaving its intended path unintentionally, the system alerts the driver.

- An infrared-based LDW system uses a series of infra-red light sensors mounted under the front bumper of the vehicle to identify the lane markings on the roadway. Each sensor contains an infra-red light-emitting diode and a detection cell. The sensors detect the variations in the reflections from the infra-red beams emitted by the diode onto the road. When the vehicle moves over a lane marking the system detects a change and alerts the driver if the indicator signal has not been used.

The advantage of a camera system is that potential hazardous lane drift is identified ahead of time and warns the driver prior to lane departure occurring. The only drawback of camera systems is that they can be limited by the weather and visibility of the road marking. However advances in camera technology and the calculation algorithms have resulted in systems that can compensate for adverse road conditions.

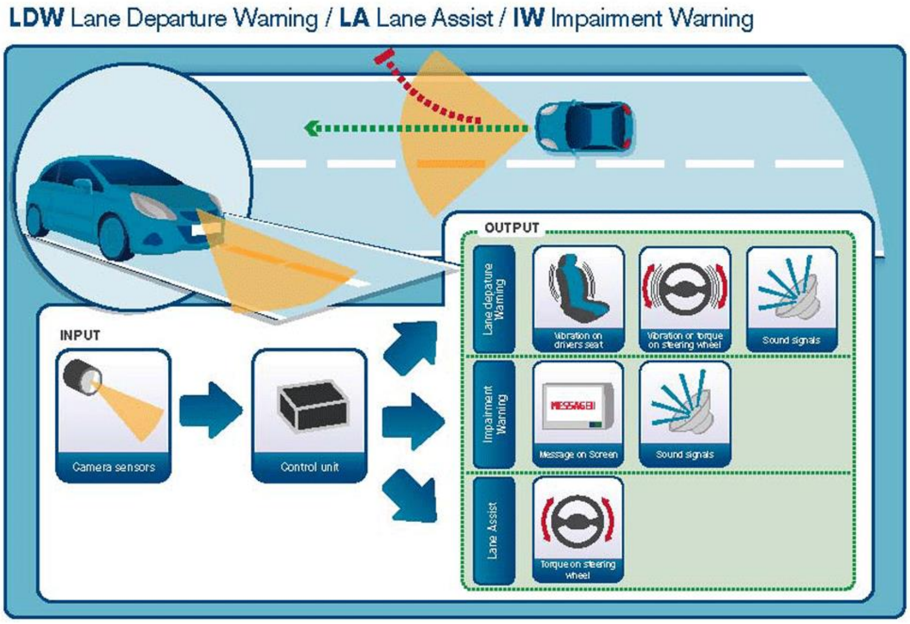
The infra-red systems are able to detect white lines as well as coloured temporary road markings. The infra-red system also has the advantage that it is unaffected by poor visibility conditions and is a lower cost system. However this system can not predict the vehicle path and therefore can only detect lane departures as the event is occurring.

The majority of LDW systems currently available alert the driver via any combination of the following:

- Warning tone resembling the sound of a vehicle driving on a physical rumble strip. This can also be oriented to only sound on the side of the vehicle that the lane departure is occurring.
- Visual warning on the instrument panel. This can be integrated into the driverǿs dashboard or located separately.
- Heptic feedback via vibrating the steering wheel or driver's seat, which can vibrate on the side of the seat that the lane departure is occurring.

It is also important that the driver is informed when the system is not functioning correctly or temporarily unavailable.

One complication in the design of the systems is that an effective lane departure warning system will need to function irrespective of the lane boundary type, while the boundary geometry differs from country to country.



Source : EuroF8T

Targeted users. The main targeted users for this application are passenger cars, goods vehicles and users in general of roads because LDW has the potential to reduce the number of road traffic accidents.

Potential for data gathering. It is not expected.

Barriers to Implementation

Financial issues. LDW systems are currently only an optional extra for the more exclusive vehicle models costing ú380 - ú480 or can be included in a package, such as with adapted cruise control (Visvikis, 2008). According to the FP6 eIMPACT project, LDW cost is around ú 300.

Technical barriers. There are no technical barriers in principle, although there are limitations to functioning of the systems, in particular for camera based systems in bad weather, as indicated above.

Organisational complexity. There is none.

Legal issues. There should not be any legal obstacles to this application.

User and public acceptance. User acceptance will be high, while public acceptance is not an issue.

Interest for Travellers

Door to door travel time. LDW is expected to prevent accidents in specific circumstances. The immediate benefit of this is a potential reduction in casualties. However, it is increasingly recognised that accidents contribute substantially to congestion and delays on the road network. So LDW systems could indirectly save time for other drivers of the road, especially in heavy traffic conditions.

Travel cost. No significant impact expected.

Comfort and convenience. No particular impact.

Safety. The European Commission funded project eIMPACT estimated that if all vehicles in Europe were equipped with the LDW systems, the number of deaths would decrease by 15% and the number of injuries by 8.9%. Given todayÕs number of deaths in Europe this would represent 6300 lives saved each year.

Security. No impact is expected.

Accessibility for impaired. No impact is expected.

Modal change

No particular impact is expected.

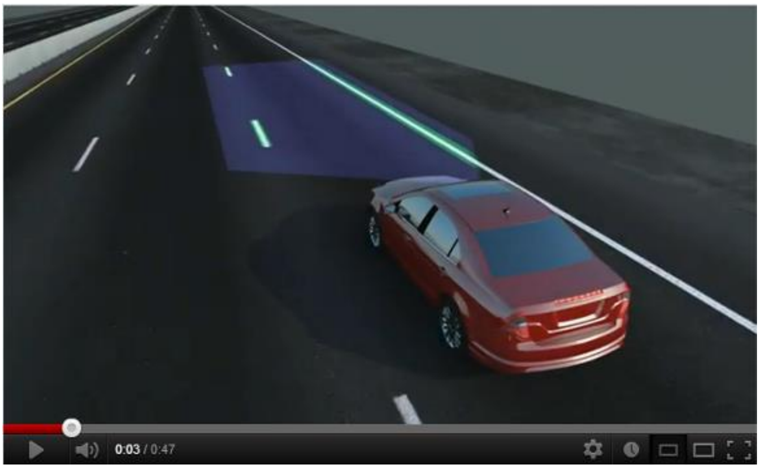
Other notable impacts

No particular impact is expected.

Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment costs	ú	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	ú	D2D travel cost	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials



http://www.youtube.com/watch?v=xdX6J5KQXS0

http://www.youtube.com/watch?v=is7S_m4SdjY&feature=youtu.be

4.1.9 Traffic jam assistant

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long-distance, urban, rural

Technology behind: radar, camera, sensors

Status: pilot

Links to relevant references

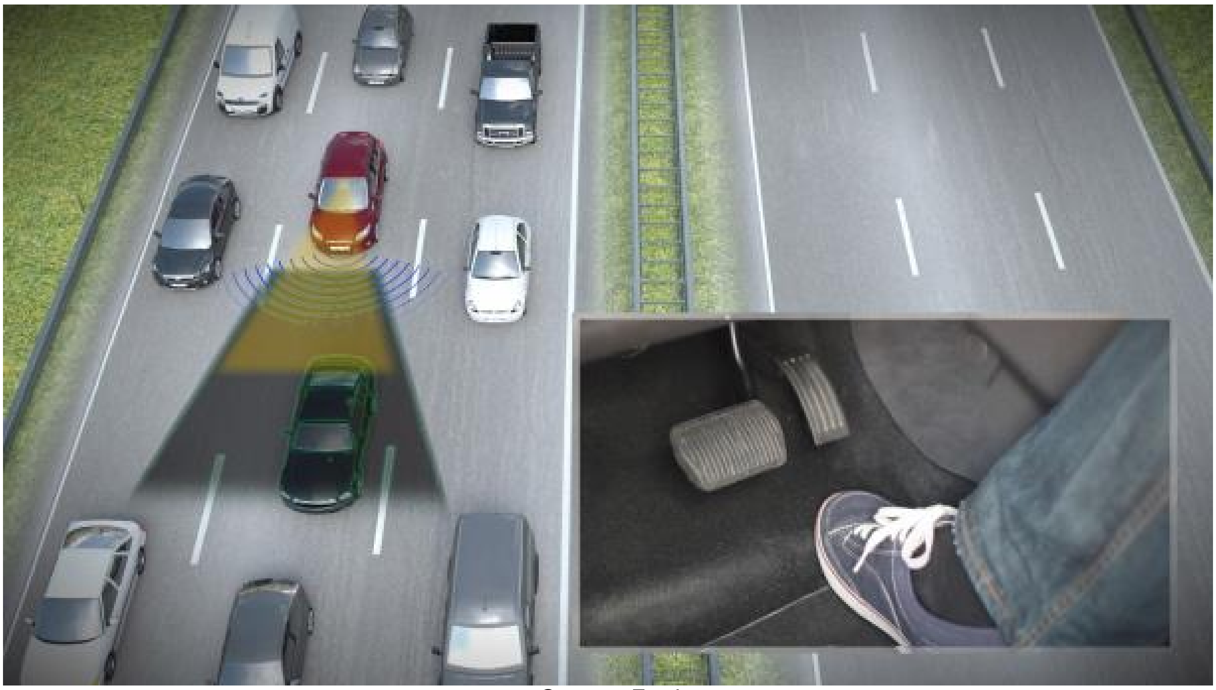
- Autonomous Driving Traffic Jam Assistant Coming to Audi A8 by Viknesh Vijayenthiran, Motor Authority, 2012
- Ford Develops ÒTraffic Jam AssistÓ and New Parking Technology to Help Address Future Mobility Challenges
- Traffic Jam Assist for the masses? In about five years by Liane Yvkoff, CNET, The Car Tech blog (27 June 2012)
- Volvo announces traffic jam assistant for semi-autonomous driving
- Audi Traffic Jam Assistant
- New Audi will take over and drive itself in traffic jams By Terry Box, Dallasnews.com (20 February 2012)
- Mercedes-Benz F 800 Style Research Vehicle
- Mercedes-Benz F800 Style Concept

Description

Concept and problems addressed. The Traffic Jam Assistant is a system designed for slow moving traffic jams. The system is designed to work at speeds between 0 and 60 km/h. Some automotive manufacturers have announced that the autonomous driving Traffic Jam Assistant will be included in the next years: Audi plans to debut a traffic jam assistant in the A8, and the same feature can be expected in the BMW i3 in 2014. Mercedes was the first to demonstrate this technology in its F800 Style research vehicle. Although Ford is the first non-luxury brand to announce this feature, it is not expected to arrive on the market within the next five years.

Two radar sensors monitor fan-shaped fields, each with a 21-degree scanning angle and a field of measure stretching some 250 metres in length. A wide-angle video camera monitors the lane markings, and it can also detect objects such as other vehicles, pedestrians and guardrails. Eight ultrasonic sensors monitor zones directly in front of the car and at its corners.

If it is necessary to make room for emergency vehicles or manoeuvre around an obstacle, the system follows the car ahead. The radar sensors not only detect the vehicle ahead, but also other vehicles in front of it. Importantly, it also reacts to cars moving into or out of the lane. Based on these measurements, the traffic jam assistant then regulates the vehicle speed.



Source: Ford
Using traffic jam assistant

Source: Ford
Ford's Traffic Jam Assistant

Targeted users. The main targeted users for this application are car drivers.

Barriers to Implementation

Financial issues. The Traffic jam assistant should be available in luxury cars in the coming years, but the additional costs for the system are not known yet. It can only be speculated that in relation to the total price of a luxury car, the marginal costs for the system will be low.

Technical barriers. Technical problems being addressed are mostly related to the capability of ensuring a sufficient level of reliability of the system. A major challenge is being able to detect any obstacle surrounding the vehicle under all conditions, especially under adverse weather conditions and for elements smaller than vehicles, such as pedestrians, cyclists or animals. In an early stage, most systems are only expected to work in relatively bound environments such as restricted access motorways.

Organisational complexity. No difficulties.

Legal issues. No particular difficulties expected.

User and public acceptance. User acceptance will be high and public acceptance is not an issue.

Interest for Travellers

Door to door travel time. Ford claims that they have found in simulations that, if one in four cars had the Traffic Jam Assist or similar technologies, travel times can be reduced by 37.5% and delays reduced by 20%, , but these figures are totally unrealistic as general figures without a specific context. Moreover, as a general principle, it is not physically possible that the travel time is decreased by a higher percentage than the delay, since the delay is part of the travel time. However, a system that smoothes out traffic by reducing the brake, speed up, brake cycles typical for congested traffic may help reduce the severity of a congested situation and reduce overall travel times to some extent.

Travel cost. It can be expected that the improvement in efficiency will slightly reduce fuel consumption and vehicle operating costs.

Comfort and convenience. The system substantially reduces the stress for drivers in dense traffic, as it regulates the distance from the vehicle in front even at very low speeds all the way down to a standstill.

Safety. It is expected that this system will improve traffic safety by minimising the crash risk under congested traffic conditions.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal Change

Even if this devices make cars more attractive, especially under recurrent congestion conditions (e.g. in daily commuting), car usage is not expected to increase by any significant extent.

Other notable impacts

Congestion and CO2 emissions. Road capacity would increase as the Traffic Jam Assist would allow vehicles to drive, in average, closer to each other in congested motorways, thereby reducing the severity of the congestion and, as a result, also the emission of greenhouse gases.

Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment costs	ú	D2D travel time	✓	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	ú	D2D travel cost	(✓)	Bus and Coach usage	**0**	Congestion	✓
Financial viability	**0**	Comfort and convenience	✓	Rail usage	**0**	CO2 emissions	(✓)
Technical feasibility	**(X)**	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. Imp. Passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	**0**						

Illustrative materials

Ford traffic jam assist - semi autonomous driving

http://www.youtube.com/watch?v=fCR5OOUMHQA

Volvo's autonomous traffic jam assistance in action

http://www.youtube.com/watch?v=9u2IyZUqB8E

4.1.10 Adaptive Cruise Control (ACC)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: long distance

Technology behind: GPS device, laser-based, radar-based

Status: implemented

Links to relevant references

- Autonomous cruise control system, Wikipedia
- DAF - Adaptive Cruise Control
- SAFESPOT

Description

Concept and problems addressed. Automatic cruise control is used to maintain the speed of a vehicle set by the driver through the automatic operation of the throttle of the vehicle. In steady traffic conditions, it is effective and improves driver comfort. When traffic is busy or congested or in urban areas, however, speeds vary widely and these systems are no longer effective. All cruise control systems must be capable of being turned off both explicitly and automatically when the driver presses the brake, and often also the clutch. Cruise control often includes a memory feature to resume the set speed after braking, and a coast feature to reduce the set speed without braking. When the cruise control is engaged, the throttle can still be used to accelerate the car, but once the pedal is released the car will then slow down until it reaches the previously set speed.

However, ACC cannot only be used for dynamic set-speed type controls but also for automatic braking. The automatic braking uses a sensor system to measure the headway (i.e. the distance or time) between two vehicles. It automatically reduces the speed of the vehicle when the distance to a car in front, or the speed limit, decreases. It can also be used to keep pace with the car it is following, accelerating again to the preset speed when traffic allows.

There are two typical ACC systems, namely laser-based and radar-based, competing in quality and price. The former does not either work effectively in adverse weather conditions or reliably track extremely dirty (non-reflective) vehicles. Laser-based sensors must be exposed, the sensor is typically found in the lower grille offset to one side of the vehicle. Radar-based sensors may be installed behind the upper grille in the centre, and behind a solid plastic panel that has painted slats to simulate the look of the rest of the grille.

ACC technology is widely regarded as a key component of any future generations of intelligent cars driven autonomously by themselves. When it operates effectively, the safety improvements that ACC could potentially yield are obvious. By taking responsibility of maintaining a following distance out of the hands of the driver human error can be avoided, and collisions (specifically rear end collisions) could be avoided. Having greater control over speed and better reaction time to possible dangers, the following gap between vehicles can be reduced and hence road capacity could be economised. By maintaining a common steady speed and avoiding unnecessary stopping and starting, ACC would prevent and eliminate burning up excessive fuel, and prolong the life of the vehicle.

Targeted users. The targeted users are all road user (car and trucks).

Barriers to Implementation

Financial issues. Adaptive Cruise Control is currently available in new high end vehicles. As ACC begins to penetrate the market there will certainly be further research and information available on how well it may or may not be performing, against the road usersôperspectives to increase comfort, risk reduction, efficiency and safety.

The costs for an adaptive cruise control application are now around ú 1,500 to ú 2,000, which is a small percentage of the cost of a high end car, and prices are coming further down.
Benefits of the application have been discussed in earlier sections.

Technical barriers. There are no critical technical barriers.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no more legal barriers, the systems are commercially available all over Europe.

User and public acceptance. Public acceptance is not an issue for an in-car system and user acceptance is high.

Interest for Travellers

Door to door travel time. No direct impact expected.

Travel cost. This application has some potential for a reduction of travel cost resulting from the avoidance of unnecessary stopping and starting which may burning up excessive fuel.

Comfort and convenience. For long distance travel, this application provides effective driving assistance to the driver.

Safety. This application increases the safety of driving by providing greater control over speed and better reaction time to emergency stops.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal change

No modal change expected.

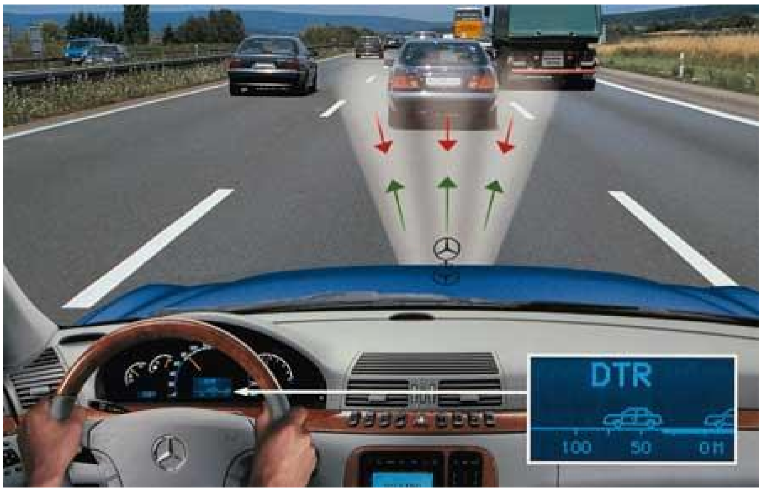
Other notable impacts

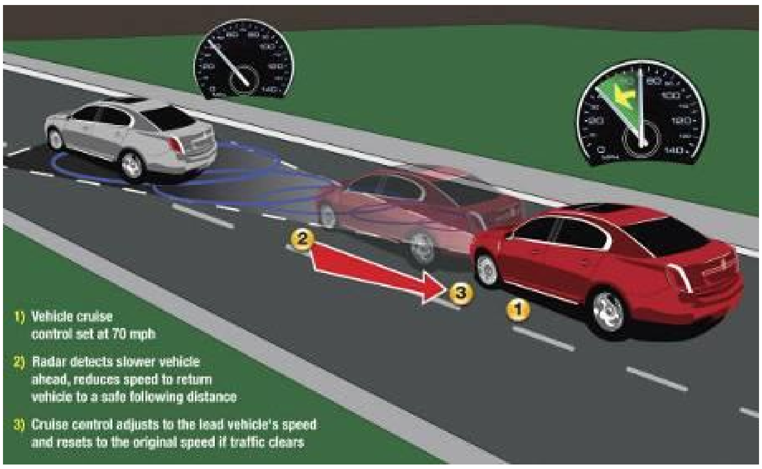
CO2 emissions. The smoother driving cycles will help reduce fuel consumption and emissions.

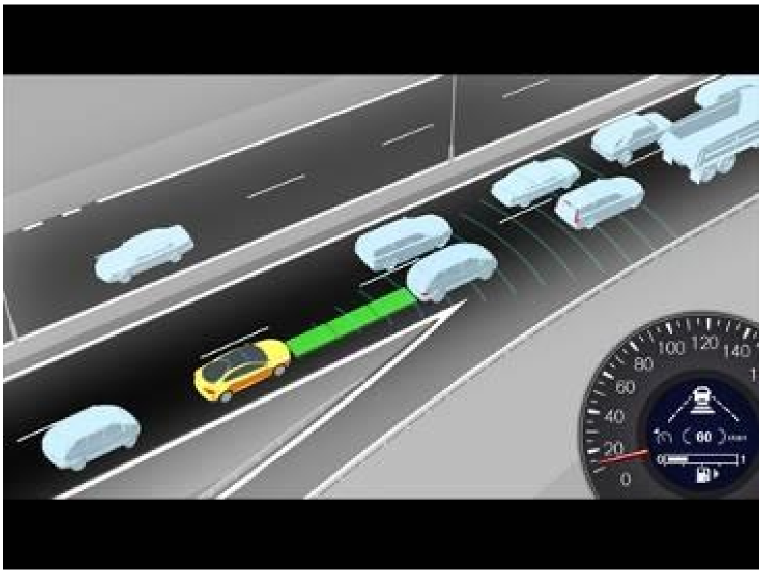
Summary of scores

Feasibility		Interest for travellers		Modal change		Other impacts	
Investment Costs	€	D2D travel time	0	Car usage	0	Mobility	**0**
Operation and Maintenance Costs	€	D2D travel cost	✓	Bus and Coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials







Youtube: http://www.youtube.com/watch?v=own_VaRZ9M8

4.1.11 Autonomous vehicles

Solution family: Smart Vehicles and Infrastructure

Sub-family: Autonomous Driver Assistance Systems

Domain of application: Long-distance

Technology behind: GPS; Wifi; Camera; Sensors, Other

Status: Pilot

Links to relevant references

- Self-driving cars: The next revolution, KPMG, Center for Automotive Research, 2012
- Look, no hands. Automotive technology: Driverless cars promise to reduce road accidents, ease congestion and revolutionise transport. The Economist, September 2012
- Google Cars Drive Themselves, in Traffic. Markoff, J. (2010, October 9). The New York Times
- Autonomous Audi almost matches veteran race car drivers' lap times Brian Dodson (2012, November 11). Gizmag

Description

Concept and problems addressed. A driverless car is a vehicle that does not need human intervention to function. It is also called autonomous, autopilot or auto-drive car. In driverless cars, drivers now turn to be passengers.

Autonomous vehicles aim at mimicking the decisions made by a human driver, mostly using artificial-intelligence software combined with a wide range of sensors to identify anything near the car. The system interprets the information and processes it to be able to choose the most suitable routes, the driving speed (as a function of the road and traffic characteristics, and the speed limits in force), and to identify and avoid obstacles. Cartography is to be constantly updated by the system in case any routes or laws change.

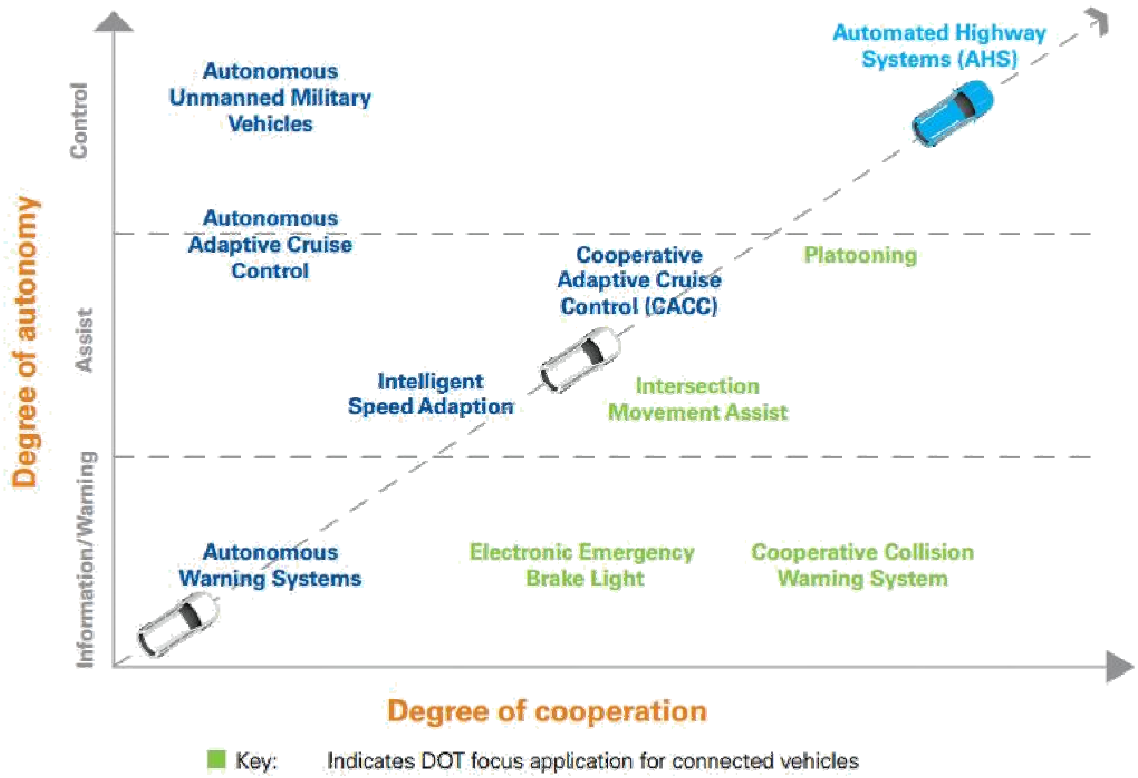
Before reaching the development of fully autonomous commercial vehicles, several stages can be traced:

The automotive industry is already since many years developing several sensor-based solutions to increase vehicle safety in zones where driver errors are most common: at lower speeds, when the driver is stuck in traffic, and at higher speeds, when the driver is cruising on a long stretch of highway. These systems use a combination of advanced sensors, such as stereo cameras and long- and short-range radar systems, combined with actuators, control units, and integrating software, to enable cars to monitor and respond to their surroundings. Some ADAS solutions are already being implemented in vehicles commercialised today, such as lane-keeping and warning systems, adaptive cruise control, back-up alerts, and parking assistance.

The next generation of driver-assist systems will likely offer greater vehicle autonomy at lower speeds and may reduce the incidence of low-impact crashes. For example, Audi, BMW, and Mercedes have all demonstrated semi-autonomous "traffic jam assistants" designed for slow moving traffic jams (speeds up to 50km/h), allowing vehicles to crawl in stop and go driving and even navigate curves completely autonomously. Audi and BMW have announced that both the A8 and the i3 will be equipped with this functionality in 2014, and Ford is planning its mainstream deployment from 2017 on. General Motors is also designing a ‶super cruise″ option that steers the car automatically in slow traffic, following lane markers and avoiding other vehicles.

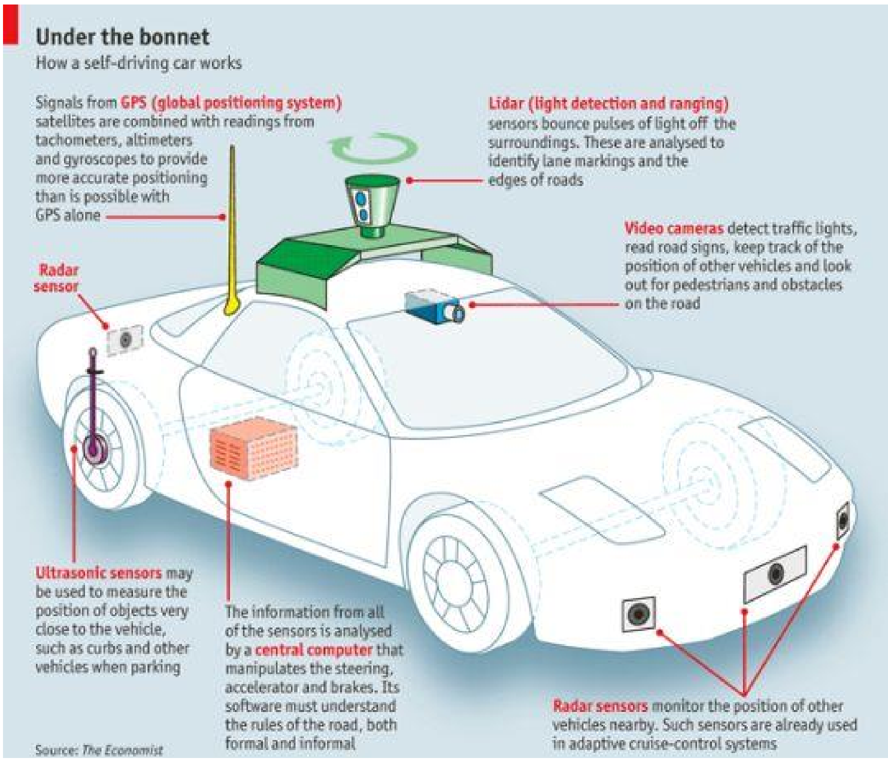
In 2012, Volvo has been publicly demonstrating the outcomes of the SARTRE project with platoons of several cars automatically following human driven trucks in Spanish and Swedish motorways, while Audi, Volkswagen or Google are testing fully driverless cars based on artificial intelligence software combining GPS information and in-vehicle equipment such as cameras, radars and sensors. However, fleets of fully or partially autonomous vehicles are already being used in the mining industry since years ago thanks to vehicle to vehicle communication and satellite tracking in some of the World's largest iron mines in Western Australia. Several US States have legalised the use of driverless cars, anticipating a possible commercial development of this technology. Some experts suggest this could happen already by 2020, while others argue that the prospect of genuine driverless operations on conventional roads in the next few decades is very low.

The transition to autonomous vehicles will be gradual. Before fully autonomous vehicles arrive, drivers will remain behind the wheel, gradually handing over more and more driving tasks to an autopilot. Owners of cars with advanced driver-assistance features have already embarked on this transition. In the view of prototypes on the roads today, some analysts in the market-research business predicts that such vehicles could be on within 10 years.



Source. KPMG 2012
Path towards automated driving mechanisms

The use of artificial-intelligence is the carõs most important attribute to reach autonomous driving. An array of sensors allows the car to navigate public roads. An inertial motion sensor and a GPS receiver are the first elements to have. Prototypes have a rotating sensor on the roof that generates a precise three-dimensional map of the zone in which the car is travelling. It is called a ñlidarò. In addition, there is a position estimator which is a sensor mounted on the left rear wheel. It measures small movements made by the car and helps to accurately locate its position on the map. Furthermore, a camera is built near the rear-view mirror which detects traffic lights and helps the carõs on-board computers recognise pedestrians and bicyclists. Lastly, there are four standard automotive radar sensors, three in front and one in the rear which help to determine the positions of anything that is far way.



Source. The Economist 2012
Technological equipment of autonomous cars

Driverless cars are likely to increase road safety and vehicle energy efficiency. The vehicle's instant reaction time and 360-degree awareness would allow them to drive closer together on the highway than humans can, reducing traffic congestion. They could be more careful when operating the accelerator, reducing fuel consumption. They would be able to drop someone off and then go and park themselves. They might even usher in an era of widespread car-sharing, with vehicles dispatched on demand to people who need them, rather than spending most of the day sitting idle by the side of the road.

Targeted users. Car travellers, and also people not driving today.

Barriers to implementation

Financial issues*.* Technologies required for creating a 360-degree view of the vehicle's environment include a combination of sensors today still cost more than consumers are willing to pay. Light Detection and Ranging (LIDAR)-based systems to provide 360-degree imaging are complex, expensive, and not yet ready for the market. The LIDAR system used in the Google car, for example, costs approximately $70,000. Value chain stakeholders will need to have a clear and compelling business model before investing in this technology.

As more people adopt the new technologies, greater economies of scale will bring costs down, attracting more consumers. If slow economic growth continues, it would likely curtail capital spending, especially by automotive companies, which struggled during the recent recession. Some claim it is unlikely that traditional automotive companies would be willing to spend heavily on technologies for which the Return on Investment time line is unclear. Other say that the industry might be willing to introduce a new technology that would induce a relatively fast and complete substitution of today's car fleet, generating an important business opportunity for car manufacturers.

Technical barriers. Much of the technology needed to turn ordinary vehicles into self-driving ones already exists. Most of the underlying sensor-based technologies exist today, although not all of them are robust enough to be considered automotive grade. They will require further testing and validation and will be subject to the automotive industryӳ long development and sourcing cycles. The problems of transition from aids to a driver who retains ultimate responsibility onto a fully driverless system are immense. However autonomous vehicles can be more easily developed to work safely in a restricted environment, e.g. autonomous vehicle lanes on motorways, only open to fully equipped vehicles and strongly monitored by infrastructure based equipment.

Organisational complexity. There is no organisational complexity with autonomous cars.

Legal issues. A legal framework will be necessary to deal with the potentially complex liability issues that may come with self-driving cars. Appropriate regulation will be needed to ensure safety and reassure other road users. Legislation, or lack thereof, will impact the speed and trajectory of adoption. Bureaucracy and excessive risk avoidance could derail autonomous vehicles. In America, however, Nevada has taken the lead in this regard. In May 2012, the stateӳ Department of Motor Vehicles (DMV), based in Carson City, issued its first three autonomous-vehicle licences to Google. These actions help increasing awareness of the emergence of self-driving vehicles and create environments where further testing and validation of the technologies can occur. More mature prototypes of autonomous vehicles are likely to increase legal initiatives to ensure a uniform and cohesive approach to deployment of this technology.

User and public acceptance. Even though the concept of a self-driven vehicle may raise concerns to some at the beginning, the acceptance of a solution promoting more comfortable and safe vehicles is likely to be high.

Interest for Travellers

Door to door travel time. As driverless cars are operated without human intervention, the chances of committing errors are minimised and this allows vehicles to drive closer together on the highway than humans can, increasing the capacity of road networks and reducing traffic congestion. This would lower travel times, especially in urban areas during peak hours. Driverless cars may be able to go get parked autonomously after dropping passengers at their final destination, reducing again door to door travel time.

Travel cost. Autonomous driving dynamics may be adjusted to promote ѥco-drivingӠstyle. Accelerating and breaking less often, maintaining a more laminar driving pattern, vehicles are likely to reducing fuel consumption. With less chances of crashing, insurance costs are likely to drop.

Comfort and convenience. This solution introduces some railway properties to car traffic, autonomous cars offer the flexibility of the road mode with the comfort of being driven by someone else. Carsԡoccupants will no longer need to keep their eyes on the road. During commutes, instead of driving, one could either be productive or entertained in the vehicle, doing work on a wireless Internet connection or read the morning paper. The design of cars would undoubtedly change: if the controls are not needed, steering wheels and pedals will vanish, and cars will be built instead for comfort.

Safety. The technology represents a potential leap forward in car safety. Computer driven cars could reduce traffic deaths by a very significant degree because computers are supposedly better at driving than humans in the right circumstances. Autonomous cars would have faster reaction time than humans and standardised response protocols to incidents (being able to anticipate their reaction). There would be fewer crashes and traffic congestion will be reduced so people would be able to circulate easily. As cars are programmed, they will choose the more secure paths and will no excess the speed limit or ignore the traffic signs such as lights.

Security. Vehicle-control software has to made ѨackӠproof, otherwise this could cause chaos and mass accidents.

Accessibility for impaired. Fully autonomous cars can be driven by people who are visually and/or otherwise physically impaired or even by people who are mentally handicapped and would never pass driving test. Furthermore they can be used by elderly people who have impediments that would no longer allow them to drive.

Modal change

Autonomous vehicles would promote modal change towards the car mode.

Other notable impacts

Mobility. Autonomous vehicles will make people mobile, who had no chance to use conventional cars, because they are too young, too old or in any way handicapped.

Congestion. Autonomous transportation infrastructure could save society the costs of congestion (increased fuel consumption, noise and pollution in busy corridors, net time savings for the society) through increasing the capacity of transport infrastructure.

CO2 Emissions. Optimised ñeco-drivingò patterns and reduction of congestion would impact on lower vehicle fuel consumption and consequently on reduced environmental impacts.

European economic progress. Autonomous vehicles would provide a step change in mobility. Their widespread introduction would mean that large parts of the population who are now, for whatever reason, not able to drive and for whom in many cases also public transport is not an option, could get easily from door to door. The carsôability to drive themselves to where they are needed also means that car sharing would be a much more attractive option, and not just for car clubs with a limited membership, but that for instance the local or even regional authority could own them and let them out on demand, which means car driving would become possible for people who, today, cannot afford to buy a car or even pay for driving lessons. Furthermore, if cars are more or less constantly on the move by driving passengers or themselves to a new location, the need for urban parking spaces would be much reduced and precious urban land could be put to much more productive use, including the possibility to provide more urban living space that would reduce the need for car use in the first place. All of these factors together could significantly aid European economic progress.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€€	D2D travel time	✓	Car usage	+	Mobility	✓✓
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	-	Congestion	✓
Financial viability	0	Comfort and convenience	✓✓	Rail usage	-	CO2 emissions	✓
Technical feasibility	X	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	✓
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Sebastian Thrun: Google's driverless car

http://www.youtube.com/watch?v=bp9KBrH8H04

Google Road Testing Driverless Car

http://www.youtube.com/watch?v=6LYi2NAi8zE

AUDI TT

http://www.youtube.com/watch?v=85HvO4GGZLY

GM Cars of the Future Driverless Drive Themselves

http://www.youtube.com/watch?v=T1T-yerIKw8

4.2 COOPERATIVE VEHICLE TO VEHICLE (V2V) APPLICATIONS

4.2.1 Vehicular ad-hoc network

Solution family: Smart Vehicles and Infrastructure

Sub-family: Cooperative Vehicle to Vehicle (V2V) Applications

Domain of application: long-distance, urban, rural

Technology behind: Dedicated Short Range Communications (DSRC) GPS, WIFI, sensor node, internet

Status: pilot

Links to relevant references

- Car2Car Communication Consortium
- Simtd
- *Vehicular ad hoc networks (VANETS): status, results, and challenges* Sherali Zeadally · Ray Hunt · Yuh-Shyan Chen · Angela Irwin · Aamir Hassan (2010)
- *Vehicular Ad Hoc Networks: A New Challenge for Localization-Based Systems*. Boukerche A., Oliveira, H., Nakamura, E., Loureiro, A. (2008)
- *Current Trends in Vehicular Ad Hoc Networks.* Ghassan M. T. Abdalla, Mosa Ali Abu-Rgheff, Sidi Mohammed Senouci. (2008)
- *Safety and infotainment applications in vehicular ad hoc networking* J. Vanhala Oulu University of Applied Sciences, School of Engineering, Oulu 2009)
- *Smart city for VANETs using warning messages,traffic statistics and intelligent traffic lights.* Tripp, C., M. A. Mateos, P. Regañas, A. M. Mezher, and M. Aguilar (2012)
- *"VANETs: The Networking Platform for Future Vehicular Applications"*, Department of Computer Science, Rutgers University. Gayathri Chandrasekaran, (2008)
- *Overview of Security Issues in Vehicular Ad-hoc Networks* José María De Fuentes, Ana Isabel González-Tablas and Arturo Ribagorda (Carlos III University of Madrid, Spain) (2011)
- *Efficient data gathering and position dissemination protocols for heterogeneous vehicle ad hoc and sensor networks* Mohammad Nozari Zarmehri and Ana Aguiar (Universidade do Porto) (2009)
- *Vehicular Ad-Hoc Networks: An Information-Centric Perspective* Bo Yu, Chengzhong Xu ZTE Communications (2010)
- *Security Analysis of Vehicular Ad Hoc Networks (VANET).* G.Samara, W.Al-Salihy,R.Sures, Universiti Sains Malaysia 2010.

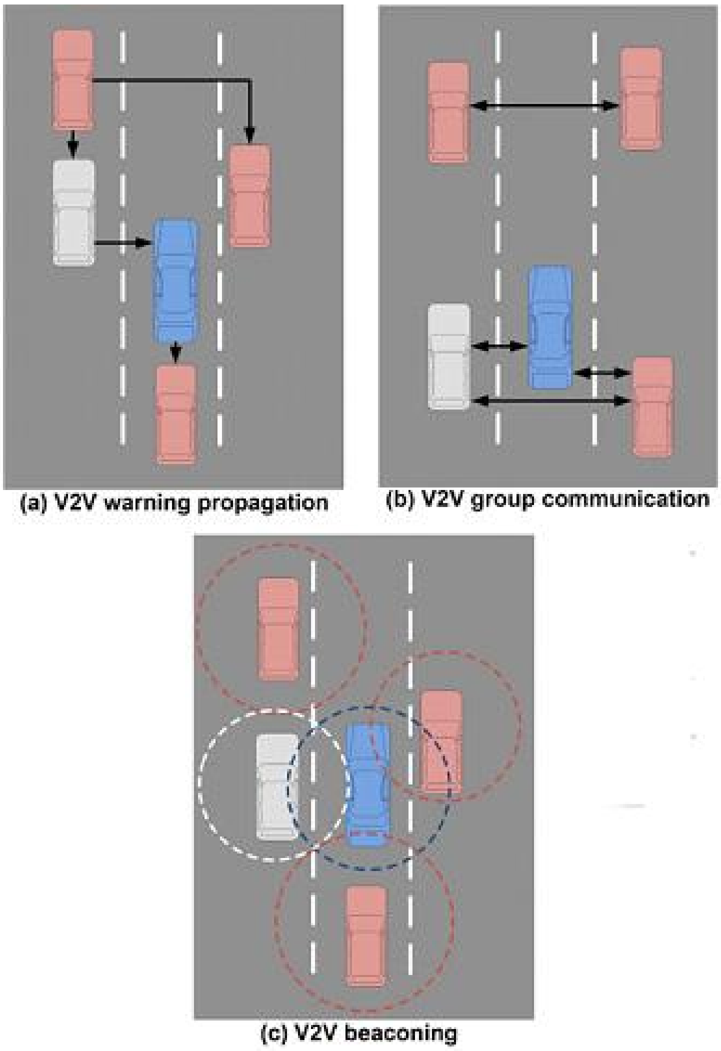
Description

Concept and problems addressed. Vehicular Ad-hoc Networks (VANET) are self organised communication networks providing services for intelligent vehicle-to-vehicle and vehicle-to-infrastructure communications and applications that try to improve active safety, traffic management, and performance. The information exchange in VANETs occurs at any time, while moving, and in many small fragments, conveyed by nearby vehicles. In principle the information could also be exchanged with static Road Side Units (RSUs), but this then becomes a Vehicle to Infrastructure (V2I) system, which will be described in that section of the handbook.

VANET's technology uses moving cars as nodes in a network to create a mobile network. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 metres of each other to connect and, in turn, create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile internet is created. It is estimated that the first systems to fully integrate this technology will be police and fire vehicles to communicate with each other for safety purposes.

The convergence of computing, telecommunications (ýxed and mobile), and various kinds of services allow the deployment of different kinds of VANET technologies. In the past decade, many VANET projects around the world have been undertaken and several VANET standards have been developed to improve vehicle-to-vehicle communications.

An advanced field where VANET is being developed is road safety. VANET can be used for alerting the driver of emergency vehicles in the area: emergency cars serving incidents may then launch alert signals which are transmitted car to car along the road so that drivers can pull over way before the incident site is being reached and allow the emergency vehicle to advance quicker. Also, vehicles approaching an intersection or stopped on the hard shoulder may send a signal to warn other vehicles about their position. In the event of an accident, an early collision warning system could be used to prevent approaching cars from crashing as well.



Source: Wireless communication patterns in a VANET
Simplified VANET model

Targeted users. Car drivers

Barriers to Implementation

Financial issues. The development costs for the system are very high, but their implementation costs will be low. Unlike infrastructure-based networks (e.g., cellular networks), VANET networks are constructed ˜on-the-flyò and do not require investment besides the wireless network interfaces which should be a standard feature in the next generation of vehicles. Thus VANET provides much lower cost per bit than cellular systems, at the expense of reduced coverage. The intelligence needed in the cars for processing the information obtained and sent should, in the case of mass production, also not be a major cost factor. However, the first tens of thousands of cars equipped with the system in any one country will not get any benefit out of the system until there is a sufficient number of cars in the network with which to exchange information, and car owners will therefore be reluctant to spend any additional money on extras which have no use for them for years to come.

Technical barriers. High mobility of vehicles in a VANET introduces frequent topology changes that negatively affect existing solutions and poses significant challenges to developing effective localisation and data gathering mechanisms.

Existing VANET solutions either apply on-demand querying for local dissemination within the VANET, sometimes keeping the data in the location it pertains to, or rely on delay-tolerant networking and open Wi-Fi access points for sending the data to the internet backbone. However, the ýrst are inefýcient for real-time trafýc or environmental monitoring due to the query overhead and the need to globally access the data, and the latter cannot guarantee up-to-date data. Knowing the updated state of the various relevant variables for a city or other road network is necessary for applications such as navigation using real-time trafýc information for regular and for emergency vehicles, or personal mobility and environmental monitoring.

A VANET requires fully decentralised network control since no central entity could or should organise the network. Moreover, VANETs hold an additional complexity due to special conditions (i.e., the above mentioned timing and reliability requirements, together with probable saturation when VANET technology is fully deployed.

Because of the number of vehicles that could be incorporated into vehicular networks, VANET may become the largest ad hoc network in history. Undoubtedly, scalability will be a critical factor. The advantages of hybrid architecture, together with in-network aggregation techniques and P2P technologies, make information exchange more scalable.

Protocols should be adaptable to real-time environmental changes, including vehicle density and movement, traffic flow, and road topology changes. On the other hand, protocol designers should also consider the possible consequences the protocol may have on the physical world.

Organisational complexity. The organisational complexity lies in the constantly changing partners in the communication network, but this is a technical issue, and there are no organisational issues requiring human intervention.

Legal issues. No major legal problems expected.

User and public acceptance. Once a sufficient number of cars are equipped to obtain any relevant information exchange, user acceptance is likely to be high, but a critical mass of cars need to be equipped to allow a sufficient number of drivers to join a vehicle network. Given the likely costs of the equipment, car drivers will be reluctant to pay for it, when it is still uncertain when, and if, they will ever be able to make good use of it. Acceptance by non-users should not be an issue.

Interest for Travellers

Door to door travel time. VANET does not directly improve travel times. However, it should reduce the number of accidents and thereby avoid the resulting congestion effects.

Travel cost. VANET slightly reduces door to door travel cost for car users in the case of avoided accidents and resulting congestion.

Comfort and convenience. Likely to increase the comfort of car travel.

Safety. Passengers safety is one major reason and the driving force for developing VANET. Vehicular Ad Hoc Networks (VANET) should, upon implementation, collect and distribute safety information to massively reduce the number of accidents by warning drivers about the danger before they actually face it.

Security. The security of VANETs is crucial as they relate to critical life threatening situations. It is imperative that vital information cannot be inserted, erased or modiýed by a malicious person. The system must be able to determine the liability of drivers while still maintaining their privacy. These problems are difficult to solve because of the network size, the speed of the vehicles, their relative geographic position, and the randomness of the connectivity between them. Malicious vehicles may attempt to provide false congestion messages and can cause accidents.

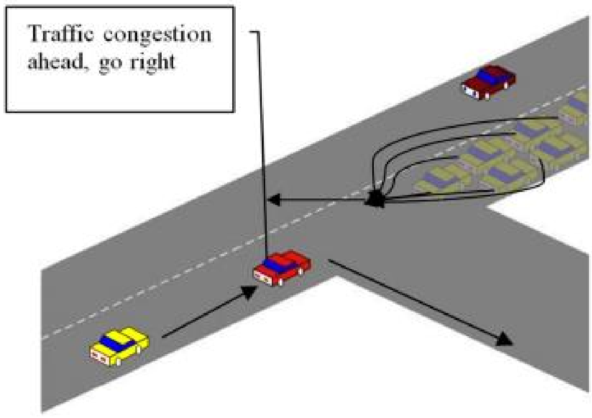


Fig. 3 Sybil Attack.

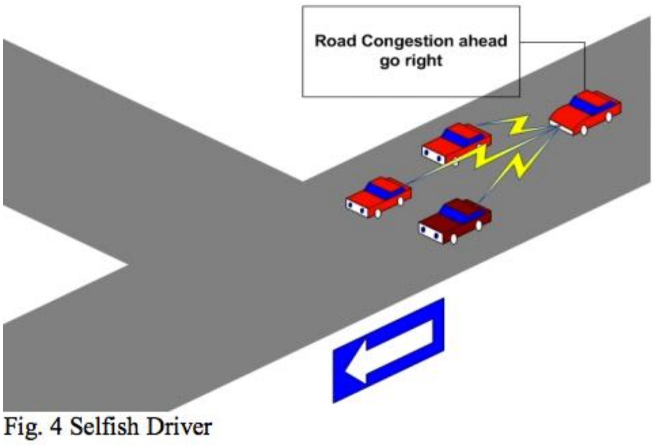


Fig. 4 Selfish Driver

Source: G.Samara,W.Al-Salihy,R.Sures, 2010

Examples of malicious behaviours in VANETS

Modal change

No direct impact on modal change expected due to VANET.

Other notable impacts

Congestion and CO2 emissions. The reduction of accidents will avoid the resulting traffic jams and possible congestion at times of heavy traffic and thereby also decrease the amount of CO2 emissions.

Summary of scores

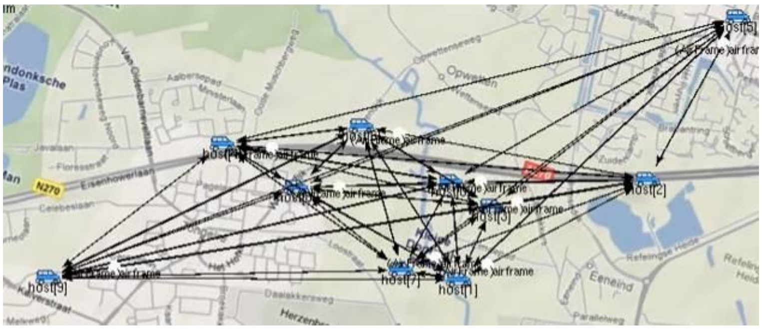
Feasibility		**Interest for Travellers**		**Modal change**		**Other Impacts**	
Investment costs	ú	D2D travel time	(✓)	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	ú	D2D travel cost	(✓)	Bus and coach usage	**0**	Congestion	(✓)
Financial viability	X	Comfort and convenience	✓	Rail usage	**0**	CO2 emissions	(✓)
Technical feasibility	X	Safety	✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	(X)	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	**XX - ✓**						
Public acceptance	**0**						

Illustrative materials

Demonstration VANET Project

http://www.youtube.com/watch?v=XSbRskv192E

Simulating beaconing Vehicular Ad hoc Network



http://www.youtube.com/watch?v=7lGnO63N0pw

4.2.2 Enhanced driver awareness system

Solution family: Smart Vehicles and Infrastructure

Sub-family: Cooperative Vehicle to Vehicle (V2V) Applications

Domain of application: Long-distance, metropolitan, rural

Technology behind: Cooperative V2V, V2I, I2V communications

Status: Pilots

Links to relevant references

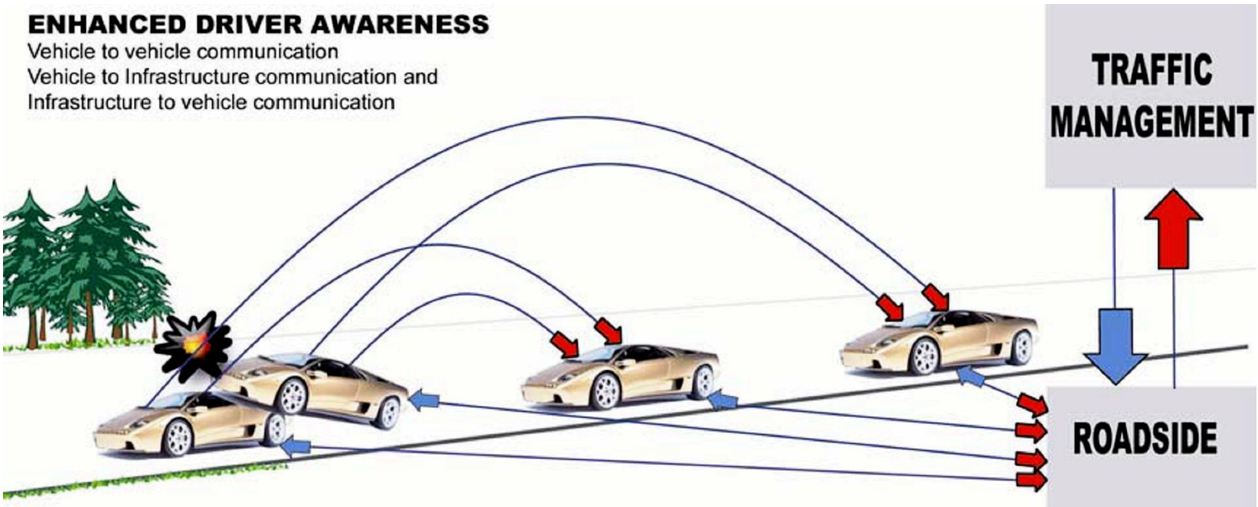
- Cooperative Vehicle-Infrastructure Systems CVIS
- The Fully Networked Car
- CVIS

Description

Concept and problems addressed. Enhanced Driver Awareness (EDA) is a cooperative safety application designed to keep the driver aware about his/her nearby environment and keep the traffic manager informed about the dynamic situation regarding the road network. EDA can have a variety of applications depending on the levels and types of assistance that the system provides to the driver. The two applications tested in the CVIS project in France and Sweden were:

- Ghost driver detection and management, which deals with exceptional circumstances under which the safety of road users may be severely affected as they are informed by the EDA that there is a vehicle driving in the wrong direction. The ghost driver can be detected by a roadside unit or directly from passing cars and then from them be reported to the traffic management centre via roadside units.
- Dynamic speed alert which detects a situation where the speed limit is exceeded by comparing the speed of the vehicle with the current mandatory speed limit which can be static (limits indicated on the road signs and have a long duration of validity), temporary (limits occurring for a scheduled duration of for instance road works), or dynamic (limits set due to unexpected events such as congestion or pollution).

The general system architecture is shown in the figure below, although the crash detection shown there was not part of the CVIS trials.



Source: CVIS

Targeted users. The targeted users are all road users, and road network operators/managers. Others that might be involved are the insurance provider and traffic information service providers.

Barriers to implementation

Financial issues. The costs for the cooperative system functions consist of the costs of equipping the infrastructure and running of cooperative services, including the onboard unit costs, RSU costs, the control centre costs, the communication costs, while the costs for providing services should be covered through the general operational costs of the traffic management centre. For the road users, the equipment should not be very high once it is mass produced, though initial costs for the first systems may be considerable.

Technical barriers. There should not be any insurmountable technical barriers to the implementation of the application.

Organisational complexity. Organisational complexity is not envisaged in this application.

Legal issues. Like other units/parts, the liability of the cooperative systems (in particular the in-vehicle units) needs to be considered before they are installed to ensure that a liability structure is in place and that all stakeholders are assured of what will happen if something does go wrong. Careful consideration should be given to the type of aid that is given to drivers via their on-board unit.

User and public acceptance. No problems are expected in relation to public acceptance and user acceptance should be high.

Interest for Travellers

Door to door travel time. This application mainly contributes to road safety which could indirectly save door to door travel time due to the fewer disruptions from road accidents.

Travel cost. This application has some potential for a reduction of travel cost resulting from avoidance of congestion.

Comfort and convenience. No improvement is expected.

Safety. This application increases the safety of driving by providing greater control over speed and warning of ghost drivers.

Security. No improvement is expected.

Accessibility for impaired. No improvement is expected.

Modal change

No modal change is allowed since the communication exchange is actuated when the trip is started.

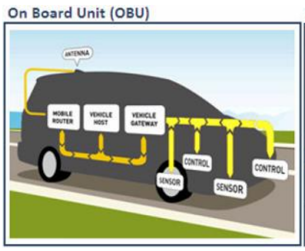
Other notable impacts

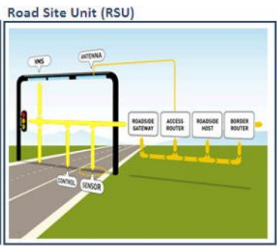
Congestion and CO2 emissions. The avoidance of accidents leads to lower number of congestion events and, as a result, reduces CO2 emissions.

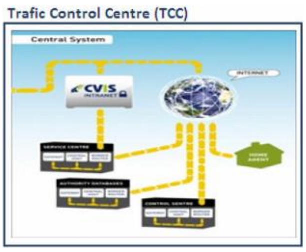
Summary of scores

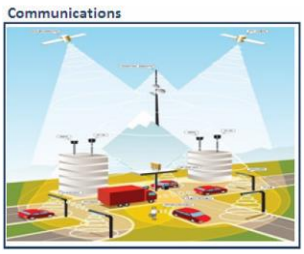
Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€-€€€	D2D travel time	(✓)	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	(✓)	Bus and coach usage	0	Congestion	(✓)
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	(✓)						
Public acceptance	0						

Illustrative materials









Lorry driver drives wrong way on M6, 2012-07-08, 10.30pm:

http://www.youtube.com/watch?v=Tfshtop5jUw

4.2.3 Cloud sourced safety map

Solution family: Smart Vehicles and Infrastructure

Sub-family: Cooperative Vehicle to Vehicle (V2V) Applications

Domain of application: Urban

Technology behind: Vehicle telematics, cloudsourcing

Status: Tested

Links to relevant references

- Press release by Honda Motor Company
- SAFETY MAP

Description

Concept and problems addressed. The cloud-sourced safety map is an online application designated to visualise the accident risks of streets with different sources of data and thus to raise awareness of any traffic-related risks in the urban area. The prototype was launched in March 2013 and it is tested in a suburban area of Tokyo, namely in the prefecture of Saitama, Japan. The application is accessible via web browsers on PCs and smartphones.

It combines the following three main data sources:

- Traffic accident database held by from the prefectural police;
- Locations of sudden deceleration of cars (sort of ñemergency breakò detected by on-board system) collected through a vehicle telematics service;
- Postings from users about potential risks.

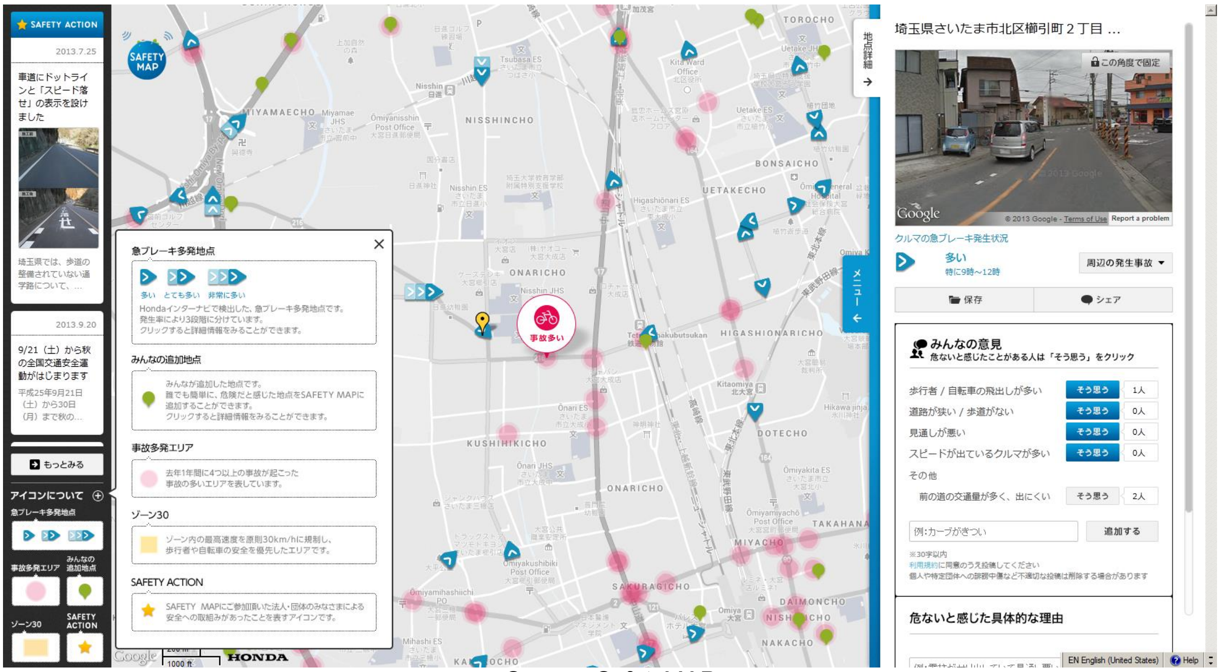
The data provided by the prefectural police is geocoded and the areas with four or more traffic accidents are projected on the map. Red circles represent these on the map, with information what types of vehicles are typically involved by icons (e.g. cars, bicycles).

The locations of sudden deceleration are collected from the users of a vehicle telematics service. This vehicle telematics service called Internavi is developed by the car manufacturer Honda Motor Company and provided to drivers in Japan. It features, as add-ons to the classical GPS-based navigation system developed by the same company, various on-board telematics services via mobile data network including real-time travel planner, traffic jam forecast, real-time parking information, and weather forecast broadcasting. To enable some of these services, the on-board system is equipped to provide floating car data to the central server, and via this function data from sudden decelerations that are considered to be emergency breaks to avoid accidents is collected. In the map, the places where such sudden decelerations tend to happen are shown with blue arrows with three different sizes representing the frequency of such events. As the collected data contains timestamps, the detailed view on the map refers to when such deceleration tend to happen (e.g. morning, daytime, evening).

In addition to these two data sets, users of the website can post risks they feel that are associated to a potential traffic accident, such as ñlimited visibilityò, ñtoo narrow road/street and/or no sidewalkò, ñcars tend to drive fastò, ñpedestrians / cyclists often tend to cross suddenlyò, and so on. Such postings can be voted on by other users whether they agree or not. In addition, users can add some comments about the risks they post, such as ñthere is a utility pole limiting the view.ò

In addition to these main data sources, it combines the GIS data representing ñZone 30ò which means 30 km/h zones in residential areas and information about recent improvements of the street in a Twitter-like way.

The Map has, in addition to the main map view, a feature to open a sub-window to show information in detail. In this window, as the Map is constructed on Google Map, a picture of street derived from Google Street View is shown with the detailed information.



Source: SafetyMAP
Screenshot of Safety Map

Targeted users. The main goal of this map is to raise awareness of any traffic-relevant risks and thus the main targeted users are drivers, cyclists and pedestrians, while road infrastructure managers also can utilise this application to a large extent as they can improve the street utilising the data collected through this map, especially the user-posted information serving to them as feedback.

Barriers to implementation

Financial issues. Financial data is not published at the time of writing this, while the cost to create this application is estimated to be almost the same as building a somewhat large online database application and thus it should not be expensive. At the moment, the application is run as a project funded by a car and navigation system manufacturer.

Technical barriers. There are no technical barriers for the implementation of such systems as a tool for personal identification and e-ticketing payment.

Organisational complexity. Cooperation with the police, who has the detailed data about traffic accidents, is the key to make this application possible. It could be difficult under some circumstances where the police would be reluctant to provide such data.

User and public acceptance. The acceptance by the public is high simply because it straightforwardly contributes for them to recognise the potential risks in the city.

Interest for Travellers

Door to door travel time. No impact.

Travel cost. No impact.

Comfort and convenience. No impact.

Safety. It raises the awareness on potential risks for traffic accidents for all stakeholders including road users (drivers, cyclists and pedestrians), as well as road infrastructure managers. Through awareness of the road users, this application contributes to safety, while if any improvement on the road is made by the road infrastructure managers utilising the information from this application, there is another potential to make the road safer.

Security. No impact.

Accessibility for impaired. No impact.

Modal change

No particular impact is expected.

Other notable impacts

No particular impact is expected.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€	D2D travel costs	0	Bus and coach usage	0	Congestion	0
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

4.2.4 Automatically driven car trains (SARTRE)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Cooperative Vehicle to Vehicle (V2V) Applications

Domain of application: Long-distance

Technology behind: GPS; Camera; Wifi; Radar; Other

Status: Pilot

Links to relevant references

- The SARTRE Project
- "Challenges of Platooning on Public Motorways", by Carl Bergenhem, Qihui Huang, Ahmed Benmimoun, Tom Robinson, 17th World Congress on Intelligent Transport Systems, 2010 October 25-29th, Busan, Korea
- Project SARTRE (Safe Road Trains for the Environment) by Roadtraffic-technology
- Road trains technology - SARTRE project takes the lead with urban vehicle platoons by Roadtraffic-technology (30 May 2012)
- All Aboard the Robotic Road Train by Erik Coelingh, Stefan Solyom / (November 2012)
- Volvo's self-drive 'convoy' hits the Spanish motorway, by BBC News Technology, (29 May 2012)

Description

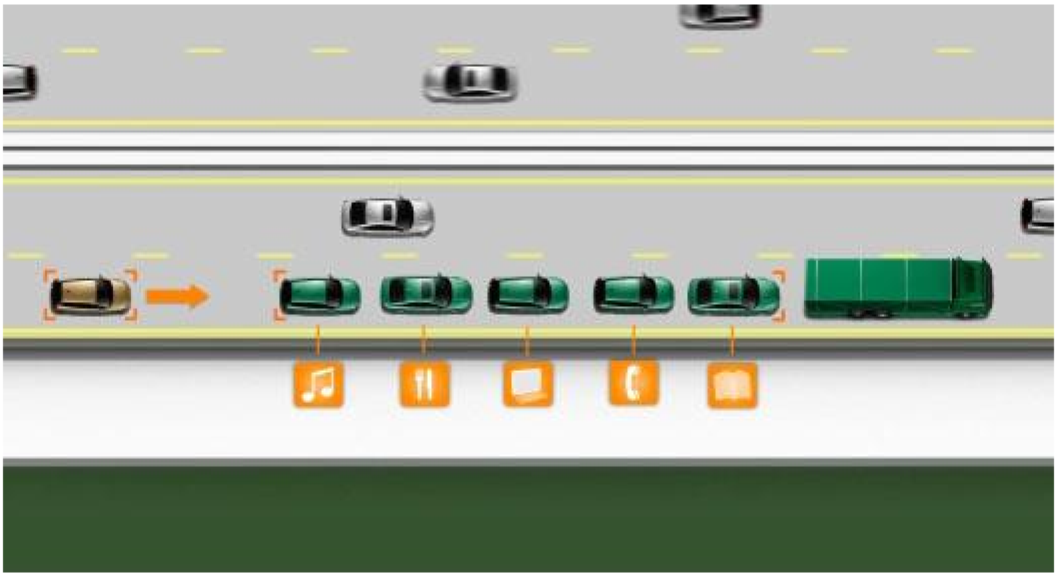
Concept and problems addressed. In May 2012, for the first time ever a road train, comprising a Volvo XC60, a Volvo V60 and a Volvo S60 plus one truck automatically driving in convoy behind a lead vehicle, has successfully operated on a Spanish public motorway among other road users. The trial was done by the SARTRE EU FP7 project (SARTRE - SAfe Road TRains for the Environment).

A road train consists of a manually driven lead truck, which is followed by vehicles that are driven autonomously at speeds of up to 90 km/h, in some cases with no more than a four-metre gap between the vehicles. The road platoon can include six to eight following vehicles which have both auto and self-driven modes. They can automatically join a platoon and act independently after reaching the destination.

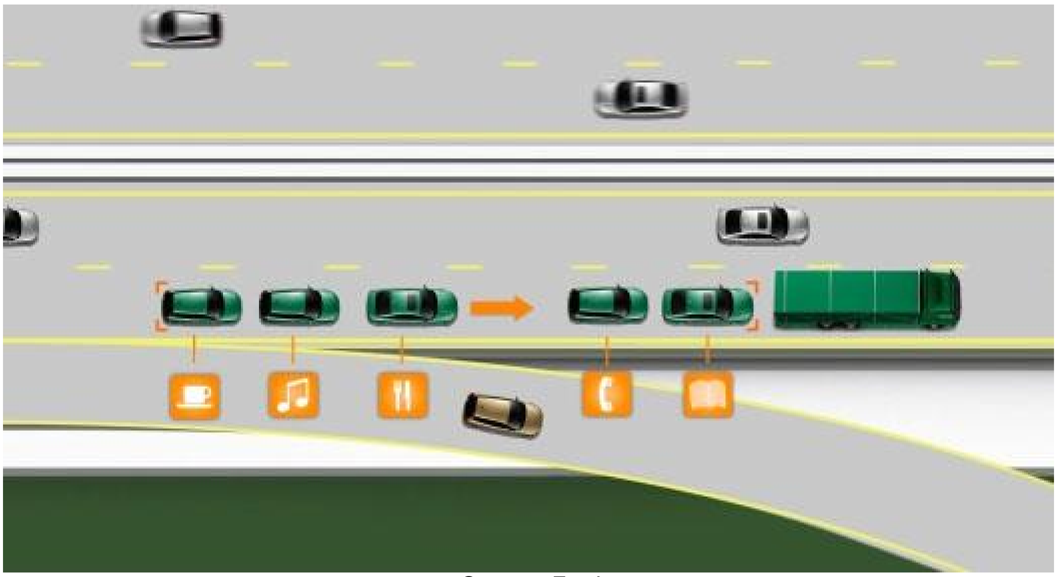
Road trains can be implemented on conventional motorways without any change to current infrastructure, since they will use wireless technology to facilitate communication between the lead and following vehicles. Each vehicle in the platoon is equipped with a human-machine interface (HMI), in which the platoon's Organisation Assistant (OA) software is running.

The lead vehicle is driven by a professional driver and has total control over different functions. The vehicle could be a taxi, truck or a bus. The joining vehicles will be equipped with collision mitigation, adaptive cruise control, lane departure warning and brake control systems to allow autonomous drive. The lead vehicle will control the vehicles in the platoon longitudinally and laterally through signals.

Each semi-autonomous ‟slave vehicle” (following the lead vehicle) in the platoon is equipped with an in-car transmitter and receiver unit and a navigation system for communication. The acceleration, traction, steering and brakes of a road train are operated by an active safety system operated in sync with the lead vehicle to allow autonomous driving. Each car measures the distance, speed and direction and adjusts to the car in front. All vehicles are totally detached and can leave the procession at any time.



Source: Ford
A slave car approaching the cars in platoon to join the convoy

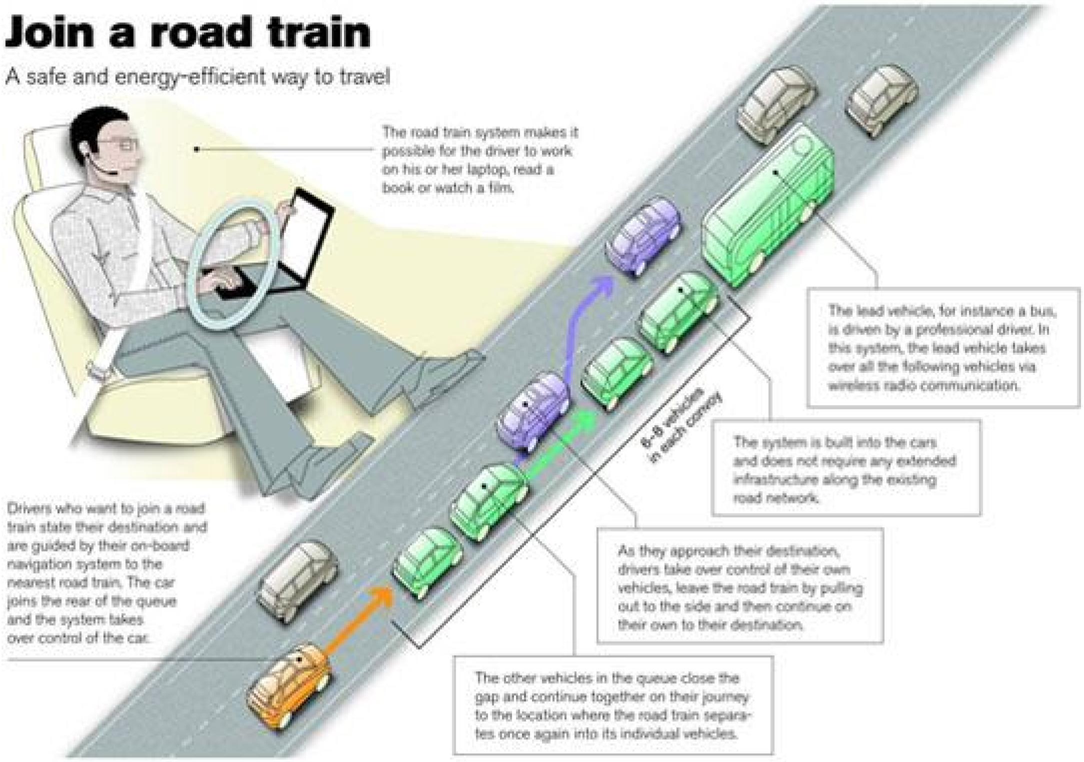


Source: Ford
A slave car leaving the cars in platoon

When road train technology is commercialised, a driver equipped with platooning software could use an in-vehicle navigation screen to find the nearest platoon and drive to the end of it. At that point, the car could wirelessly connect to the platoon and take over braking, acceleration, and steering, and drivers could safely start sending text messages or watching a movie, work on their laptops, read a book or sit back and enjoy a relaxed lunch.

The road trains are considered to be a viable solution for comfortable driving to commuters who travel long distances along the motorways.

It is also expected to benefit both the lead vehicle and the platoon subscribers such as commercial vehicles, coach vans, buses and trucks.



Source: SARTRE Project

Targeted users. General car drivers. They still require driving skills as autonomous driving only takes place in selected links of the road network (e.g. motorways).

Barriers to implementation

Financial issues. According to SARTRE, the major challenge is to create a system that handles the cost aspects. It is expected that taking the road train will include a fee or an income, depending on whether you own a lead vehicle or a following vehicle. To keep costs down, the technology for the system is to be achieved through off the shelf components. A major issue is the return of investment for the car owners: until a critical mass of cars is equipped ï and that may well be for many years ï they will not be able to make any use of their equipment.

Technical barriers. A challenge has been to develop reliable communication between the vehicles in the platoon. Vehicle to vehicle communication is essential to ensure safety at high speeds and short vehicle spacing. Trailing only 5 meters behind a heavy vehicle meant getting a windshield full of salty spray and gravel. The windshield must be constantly cleaned to keep the forward-looking camera unblocked; during the trial it sometimes seemed as if it was consuming more washer fluid than gasoline. When road trains have been tested in Scandinavia, they have shown proper functioning under adverse weather conditions.

Source: VOLVO
SARTRE tests in a closed field track near Göteborg in December 2010

Organisational complexity. Professional drivers would lead each platoon. As bus drivers are required to have special licenses, road train lead drivers should probably have special qualifications for the job.

Legal issues. The biggest challenges will probably be legal ones. Right now driving on autopilot is not allowed in most areas in Europe and North America. National laws and the Vienna Convention on Road Traffic currently imply the driver shall always have final control over the vehicle, and there is no consensus on who would be responsible for any accident. Although the lead driver of any platoon would be obliged to have additional training because of the extra responsibility they would be taking on, there's no way of predicting whether the 27 EU member states would be willing to integrate this concept into their road safety legislation.

User and public acceptance. User acceptance for more comfortable and autonomous driving is likely to be very high in principle, but a critical mass of cars need to be equipped to allow a sufficient number of drivers to join a road train. Given the likely costs of the equipment, car drivers will be reluctant to pay for it, when it is still uncertain when, and if, they will ever be able to make good use of it. Acceptance by non-users should be high, since the road trains create additional road capacity.

Interest for Travellers

Door to door travel time. On free flow conditions, road trains are likely to circulate at a lower speed than other vehicles (approximately 90km/h in the SARTRE project). However, in dense traffic conditions, road trains would allow smoother flow of traffic, reducing traffic congestion by reducing speed variations and headways.

Travel cost. Using road trains in a motorway would most likely involve the payment of a fee to finance the system. However, falling into formation behind one another, a group of travellers can reduce the amount of energy each individual would otherwise have to expend alone to cover the same distance. Translating that concept onto ȓroad trainsò could cut gas consumption by some 20%, resulting on similar direct economic savings for the user in each trip.

Comfort and convenience. The advantage of such road trains is that with the car in the platoon, its driver can pursue different activities in the journey such as reading, watching TV and resting, or even have time to get on with other business while on the road, for instance when driving to or from work.

Safety. A professional driver leads the vehicle platoon, for instance in a truck. Inter-vehicle reaction response times are very quick thanks to the co-ordinated technology. Around 80% of accidents on the road are due to human error. So using professional lead drivers to take the strain on long journeys could, they say, see road accidents fall.

Security. Like in other autonomous vehicle technologies (e.g. VANETs) a major security threat to their operation is the interference by third parties of the vehicle to vehicle communications. It is imperative that vital information cannot be inserted, erased or modiýed by a malicious person.

Accessibility for impaired. No particular impact is expected, as car platoons do not fully substitute the human operation of vehicles, unlike other autonomous vehicles like Googleõs or Audiõs.

Modal change

No particular direct impact is expected. However, as road driving is likely to be more comfortable and convenient, it may favour car mode respect to other modes like train.

Other notable impacts

Congestion. The reduced headways and speed variations improve traffic flow and create more road capacity.

CO2 emissions. Environmental impact is reduced. The cars drive close to each other and reap the benefit of lower air drag. By falling into formation behind one another, a group of travellers can reduce the amount of energy each individual would otherwise have to expend alone to cover the same distance. Translating that concept onto ñroad trainsò could cut petrol consumption by some 20 % and thereby also reduce CO_2 emissions.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€€	D2D travel time	(X)	Car usage	+	Mobility	0
Operation and maintenance costs	€	D2D travel costs	(X)	Bus and coach usage	0	Congestion	✓
Financial viability	X	Comfort and convenience	✓✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	(X)	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	(X)	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	(X)						
User acceptance	XX - ✓						
Public acceptance	✓						

Illustrative materials

Volvo - SARTRE Road trains, tests with several vehicles in high speed

http://www.youtube.com/watch?v=WFTiLKH1DW0

Road trains platooning project

http://www.youtube.com/watch?v=2JYKmC8hiFk

4.3 VEHICLE TO INFRASTRUCTURE (V2I) APPLICATIONS

4.3.1 Personal Rapid Transit (PODCars)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Vehicle to Infrastructure (V2I) application

Domain of application: Urban

Technology behind: Camera, sensor, cooperative vehicles, navigation

Status: Implemented

Links to relevant references

- Guidelines for Implementers of Personal Rapid Transit NICHES + Project (*funded by the DG Research under the 7FP*)
- CityMobil project (*funded by the DG Research under the 6FP*)
- Daventry PRT Scoping Study, by SKM
- Advanced Transit Association (ATRA)
- Vectusprt
- Wikipedia page on PRT
- Masdar City PRT system. Interview with developers
- Masdar City abandons transportation system of the future

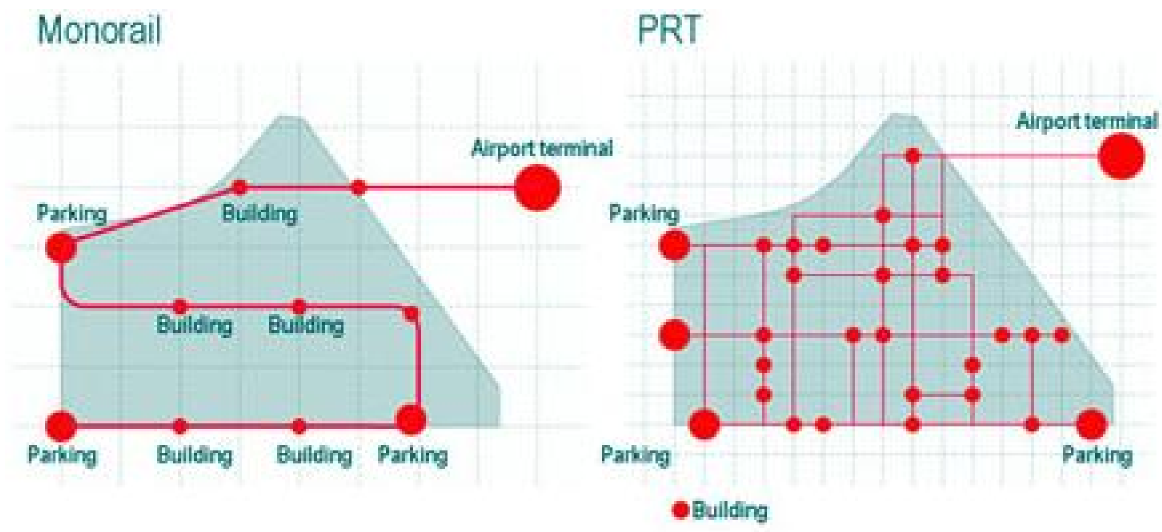
Description

Concept and problems addressed. Most mass transit systems move people in groups over scheduled routes. Personal Rapid Transit (PRT) is a form of public transport that uses small automated electric ǿpodcarsôto:

Å provide a taxi-like service for individuals or small groups of travellers;
Å provide demand responsive feeder and shuttle services connecting facilities such as parking lots with major transport terminals and other facilities such as shopping or exhibition centres.

The ultimate goal of PRT is to provide a system of transportation which combines the sustainability of a light rail with the convenience of the private car, allowing trips to be customised to optimise how travellers reach their destinations (e.g. like driverless taxis). Once in a PRT pod, users chose any station available at the network and the system selects the optimal route to reach the destination. According to the developers, PRT is not a system aimed at moving huge masses of people, for that other solutions like light rail or a metro would be needed.

The podcars run on a segregated guideway in order to ensure unhindered direct trips between origin and destination. Passengers select the destination, but an automated system drives the pod car through an optimal route and coordinates the fleet. They provide clean, green, efficient and sustainable transportation. With high vehicle speeds and very small headways, PRT provides fast, individual, on-demand and point-to-point PT with very short waiting times. This reduces operating costs from driverless operation and is highly efficient since vehicles are only used when there is a demand.



Source: nextbigfuture.com

PRT network organisation (right) vs a conventional Monorail linear system.

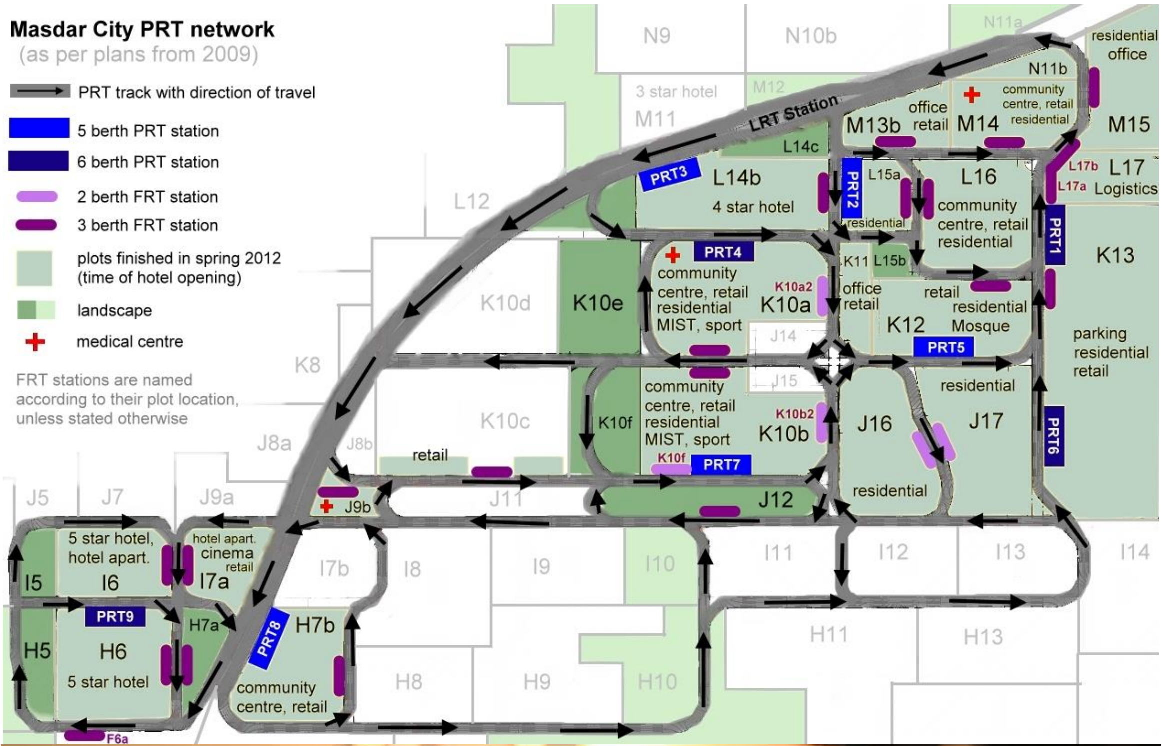
As of July 2013, two PRT systems are operational: since 2010 a 10-vehicle “2getthere” system at Masdar City, UAE, and since 2011 a 21-vehicle Ultra PRT system at London Heathrow Airport. A 40-vehicle Vectus system was expected to open in Suncheon, South Korea in April 2013 but has now been delayed; the track is largely complete and the company website says trials commenced in April with full passenger service due in (northern) "autumn". Expansion of the Masdar system was cancelled just after the pilot scheme opened; however, additional systems have been announced at London Heathrow Airport and Amritsar, India. Numerous other PRT systems have been proposed but not implemented, including many substantially larger than those now operating (Wikipedia).

The PRT scheme at Heathrow Airport (UK) provides transport for travellers between the business car park and Terminal 5, about 2 km away. 21 low energy, battery powered, driverless, zero emission vehicles are capable of carrying four passengers and their luggage along a dedicated 3.8km guide way, giving the passengers a smooth and virtually silent five minute ride. The journey is on demand and non-stop from start to destination at the touch of a computer screen and the pods even recharge themselves at battery points when not in use so they are always ready to go.

The system at Masdar City was the first attempt at implementing a PRT system at a larger urban scale, rather than conceived as a people mover for airport mobility between terminals and parking lots, university campuses or within large shopping malls or theme parks. Original plans were for implementing 3,000 units that could transport 2 to 6 passengers, with 85 to 100 stations and making 150,000 trips a day. The systems was intended to provide the experience of travelling on a private vehicle, sitting in the comfort and privacy, via a public transport / shared vehicle solution. Vehicles travel at 7 metres per second, giving an approximate trip length of 7 to 10 minutes for 2.5 km journeys. The system autonomously manages congestion in the network, and when eventually capacity is approached, the system does not allow more pods to leave stations (passengers will be asked to wait for a few minutes). No elevated ways were introduced in Masdar, vehicles are running underground.

Masdar City’s plan involved using the same dedicated guideways to run two-pallet flatbed vehicles as part of a Freight Rapid Transit program. The entire system was designed to allow up to 5,000 trips per day, with each of the 810 vehicles having a maximum payload of 1,600 kg, delivering all necessities to residents and businesses.

However, Masda City has abandoned plans to extend the today functioning network beyond a pilot stage. The major concern is the high cost of the implementation of the system in a large scale project.



Source: Advanced Transit Association (ATRA)
Masdar PRT system

The capital cost is reckoned to be about half that of an equivalent tram scheme and with the potential to provide a similar passenger carrying capacity. The capacity of the Heathrow pod is 164 vehicles per hour per direction, equivalent to a maximum of 656 passengers per hour per direction. The normal capacity of Masdar PRT is approximately 60 passengers per hour per direction, equivalent to approximately 200 passengers per hour per direction based on 4 passenger occupancy. In practice the average occupancy of the system ranges between 2.1 and 2.4 passenger per vehicle depending on the day of the week and the time of the day.

Source: Advanced Transit Association (ATRA)
Heathrow PRT system

Targeted users. Mostly operators of airports, tourist attractions, shopping parks and malls, university and hospital campuses, industrial business parks, eco towns, new urban city developments, park & ride, extensions of existing modes. Applications at urban level have up to now failed.

Barriers to implementation

Financial issues. Operating costs are stated to be less than for an equivalent bus scheme using drivers, and less than for a tram, according to promoters. Capital costs are needed to procure the podcars; provide the control system/centre and a depot for vehicle maintenance/charging; and also to provide and equip the guideway, stations and security measures. PRT schemes require a dedicated guideway and small 4 to 6 seater (i.e. car sized) driverless vehicles. The guideway is likely to be elevated for all or part of its length, though the structure can be relatively light.

According to the *CityMobil project*, representative costs for a variety of systems and 24/7 operations are:

<u>*Capital costs:*</u>

Å cars cost ú75,000 each
Å infrastructure costs ú3.8 million per km (compared to ú5 to ú10 million for lightrail systems)

Operating costs:
Costs are made up from a base cost for 5 km of track and 25 vehicles (including staff) plus additions for infrastructure per km and per vehicle, and for staff per km and per vehicle, which total to:

1,600 + 67.0(L-5) + 11.0(N-25) K€ per year

Where L is the length of single track guideway (in km) and N is the number of vehicles.

Source: various authors
Podcar shuttles. View of the inside

According to another source, SKM in the Daventry PRT Scoping Study, feasibility studies suggest that PRT costs could be higher:

Detailed costings for a 5 km pilot PRT scheme with 5 stations and 25 ópodcarsô have been produced by SKM (Consulting Engineers) for Daventry District Council in the UK.

Capital costs were estimated in 2006 to be £14M with operations and maintenance costs of £1.7M pa.

PRT was compared with a High Quality Bus scheme in a discounted cash þow analysis over a scheme lifetime. The results showed similar total costs, but the beneýt to cost ratio for the PRT scheme was substantially higher at 2.4 compared with 1.7 for the bus.

According to City Mobil Project, the Heathrow PRT system, which took six years to develop, had a cost of £30 million, and around £17 million to reprovide.

Technical barriers. The most important barriers to large-scale introduction of automated transport systems are not of a technological nature. However, the following issues could arise.

Visual intrusion caused by elevated sections of guideway, and of severance caused by sections at-grade, although these can be mitigated by using ócut and coverô or tunnels.

Continuous monitoring of operations is needed to ensure the system performs as required in terms of factors such as reliability, safety, usability, user satisfaction, etc.

Evaluation will be needed in the early days to ensure user needs and the performance specification are fulfilled, and at a later phase to confirm usability and public acceptance as well as the costs and benefits.

Organisational complexity. The introduction of new transport systems requires a good dialogue between stakeholders like politicians, planners and transport providers in order to identify objectives and define strategies. Besides, it is necessary to have the appropriate population density to run this form of mass transit.

Legal issues. The legal issues of automation can only be outlined according to todayǿs legal situation for road traffic. At least full automation in open traffic is, from a legal point of view, a completely new field. The legal grounds for such applications remain unsolved to a very high extent as the legal situation is specific to manually driven vehicles.

User and public acceptance. Potential for high user and public acceptance in confined spaces like airports, while the visual intrusion through the guide rail system makes it likely that general public acceptance would be low, it the system were to be introduced in an urban space.

Interest for Travellers

Door to door travel time. Low waiting times (almost DRT system) and hence time savings for passengers.

Travel cost. Where these systems are in use now, they are free of charge, but if they were to be introduced in public spaces, the charging structure could take any shape and is therefore totally uncertain.

Comfort and convenience. Travel comfort and convenience will be improved.

Safety. The most important barrier to application in general public spaces is safety, and more specifically certification. Until a set of generally accepted certification guidelines exist, it will be difficult for system developers to convince authorities and operators that automated systems are safe. However, in the closed airport environments, in which they are running now, no major problems have been reported.

Security. The absence of staff in vehicles may reduce the feeling of security of users of the system.

Accessibility for impaired. An improvement in accessibility respect to other modes is expected overall for wheelchair users and other physically disabled travellers and visually impaired travellers.

Modal change

If they could eventually be used in general public spaces, PRT would provide a new system of public transport offering personal, on-demand and direct origin to destination services similar to a taxi. These advantages offer great potential for achieving modal shift, and combine with the safety and cost savings arising from automated i.e. driverless operation.

Other notable impacts

Reduced noise and environmental pollution locally from using electric, automated and quiet vehicles.

The Heathrow pods, which use 70% less energy than it takes to power a car, and 50% less than a bus, are expected to eliminate 50,000 bus journeys on the roads around the airport each year.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€€	D2D travel time	✓	Car usage	0	Mobility	0
Operation and maintenance costs	€€€	D2D travel costs	(✓)	Bus and coach usage	0	Congestion	0
Financial viability	✓	Comfort and convenience	✓✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	(X)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(X)	Aeroplane usage	0	European economic progress	✓
Administrative burden	0	Accessibility for mob. imp. passengers	✓			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	(✓)						

Illustrative materials

PORT - Personal Overhead Rapid Transit

http://www.youtube.com/watch?v=PdXPA1jDgUI

ULTra PRT sustainable transit

ULTra PRT sustainable transit

http://www.youtube.com/watch?v=B7hgipbHBK8

4.3.2 Passive Intelligent Speed Adaptation (ISA)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Vehicle to Infrastructure (V2I) application

Domain of application: long distance, rural, urban

Technology behind: GPS, radio beacons, optical recognition, dead reckoning

Status: implemented

Links to relevant references

- ITS
- Centre for Automotive Safety Research
- Tate F. & Carsten O. (2008), "ISA ï UK: implementation scenarios", Institute for Transport Studies, University of Leeds and MIRA Ltd.
- Intelligent speed adaptation, Wikipedia

Description

Concept and problems addressed. Intelligent Speed Adaptation (ISA) is an in-vehicle system that uses information about the speed of the vehicle in relation to the speed limit in force at a particular location, and hence supports drivers to adhere to the speed limit. There are fundamentally two types of speed adaptation systems, namely passive and active. The fundamental difference between passive and active ISA is that passive systems warn the driver when the speed limit has been exceeded whereas active counterparts intervene and automatically correct the vehicleφs speed to conform to the speed limit.

Passive ISA is an example of general driver advisory systems which provide alerts and warnings to the driver to make a choice on what action should be taken. Numerous trials of ISA over the past two decades have demonstrated that it is effective in reducing the risk and severity of accidents and has other societal benefits such as reduced emissions and fewer major traffic disruptions resulting from road accidents.

There are four types of technology currently available for determining local speed limits on a road and determining the speed of the vehicle. These are Global Positioning System (GPS) receiver based systems, radio beacons, optical recognition and dead reckoning.

A GPS-based ISA system has a built-in GPS receiver which picks up the signals transmitted from a network of satellites, and processes them to pinpoint the vehicleφs location to within a few meters. The main problem with GPS is the accuracy of the determined position which can be affected by a number of factors including the GPS technique employed, environmental conditions (e.g. heavy clouds, tall buildings in urban canyons, trees), the number of satellites received, satellite geometry, and quality of the GPS receiver used in the ISA system. GPS signals can be deteriorated or even lost completely when the vehicle is underground or in a tunnel.

If there are radio beacons installed at roadside, the receiver of the ISA system would be able to pick up data related to the local driving information such as speed limits, school zones, variable speed limits, or traffic warnings (V2I application). With a sufficient number of beacons in place, the vehicle speed could be calculated based on how many beacons the vehicle passed per second.

Some ISA systems are equipped with optical recognition systems (e.g. scanners or cameras) which recognise speed signs (autonomous application). The speed limit data is obtained and compared to the vehicleφs speed. The system would use the speed limit from the last sign passed until it detects and recognises a speed sign with a different limit. This is a particular problem when exiting a side road onto a main road, as the vehicle may not pass a speed sign for some distance.

Dead reckoning makes use of the data from the sensors of the vehicleӳ driving assembly in terms of the wheel diameter, wheel rotations and steering direction, to predict the path taken by the vehicle. By measuring the rotation of the road wheels over time, a fairly precise estimation of the vehicleӳ speed and distance travelled can be made.

Unlike active ISA systems which need to be mechanically connected to the vehicle to control the fuel supply, passive ISA systems can be developed as software which can be installed on many mobile GPS-based units such as iPod, iPad, iPone or in-car navigation units like TomTom and Garmin.

There are also specialised passive ISA products such as SpeedAlert, Coredination ISA. SpeedAlert is marketed by Smart Car Technologies, based in Sydney. It offers full national speed zoning information embedded within a GPS-based navigation system, providing drivers with information on speed limits and vehicle speed, as well as related information on locations such as schools, railway level crossings, speed camera sites, etc. Coredination ISA owned by Coredination in Stockholm is a smartphone-application for Android and iPhone. It offers full national speed zoning information, providing drivers with information on speed limits and vehicle speed. The product is very lightweight and no separate hardware or fixed installations are necessary.

As ISA systems can serve as on-board vehicle data recorders, this application provides information about vehicle location and performance which can be used for later checking and fleet management purposes. It also provides information about the driving behaviour of the vehicle, and traffic characteristics which can be useful for monitoring the efficiency of the network such as delays and stops.

Targeted users. The targeted users are all road user (car and trucks).

Barriers to Implementation

Financial issues. The cost of an ISA system mainly includes the costs associated with mapping and the cost of the ISA device. According to Australian sources, the costs of in-vehicle ISA devices given by the industry representatives during the Australian ISA trials vary considerably depending on sales volumes and the type of device. More specifically, the experts estimated that[25]:

- For the Speed Alert advisory device, a single unit costs $800, and one million units cost $400 per unit;
- For the Speedshield advisory device, a single unit costs $1200, large orders could bring the price as low as $300;
- For the Speedshield supportive and limiting device a single unit costs $1800, and one million units cost $520 per unit.

There may also be a subscription for up to date advisory ISA functionality on a navaid device costs $29.90 per year.

The key perceived benefit of ISA is a reduction of accident risks. The Australian research suggests that advisory/passive ISA would reduce injury crashes by 7.7% and save more than ú 800 million ($1,226 million) per year.

Technical barriers. There are no critical technical barriers.

[25] Doecke S., Woolley J. & Anderson R.W.G. (2010), ""Cost Benefit Analysis of Intelligent Speed Adaptation", 2010 Australasian Road Safety Research, Policing and Education Conference, 31 August ï 3 September 2010, Canberra, Australian Capital Territory.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no legal issues with passive ISAs.

User and public acceptance. For a passive ISA, which only advises and does not interfere with the driving, user acceptance is very high, while for an in-car device, public acceptance is not an issue.

Interest for Travellers

Door to door travel time. This application mainly contributes to road safety which could indirectly save door to door travel time due to the fewer disruptions from road accidents, but on the other hand if drivers adhere better to speed limits that will slow them down and increase their travel time. On balance the big savings from one-off events and the small everyday increases may not lead to a large difference to the current situation.

Travel cost. This application will reduce vehicle operating costs through lower travel speeds, as well as savings from the avoidance of congestion after accidents on busy roads.

Comfort and convenience. No improvement is expected.

Safety. This application increases the safety of driving by providing greater control over speed.

Security. No improvement is expected.

Accessibility for impaired. No improvement is expected.

Modal change

No modal change is expected

Other notable impacts

Congestion and CO2 emissions. The avoidance of congestion after accidents will also lead to a reduction and CO2 emissions. Emissions will be further reduced through the decreased travel speed.

Summary of scores

Feasibility		Interest for travellers		Modal change		Other impacts	
Investment Costs	€	D2D travel time	0	Car usage	0	Mobility	**0**
Operation and Maintenance Costs	€	D2D travel cost	✓	Bus and Coach usage	0	Congestion	(✓)
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative materials

4.3.3 Active Intelligent Speed Adaptation (ISA)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Vehicle to Infrastructure (V2I) application

Domain of application: long distance, rural, urban

Technology behind: GPS, radio beacons, optical recognition, dead reckoning

Status: implemented

Links to relevant references

- ITS
- Intelligent speed adaptation

Description

Concept and problems addressed. The ISA project, ITS:

"Every year thousands of people are killed on UK roads. SPEED is a major contributory factor in a large percentage of road traffic accidents. Despite the introduction of speed calming measures such as road humps, lane narrowing and speed cameras, and speeding continues to be the norm on the majority of UK roads.

Intelligent Speed Adaptation (ISA) is a general term for Intelligent Transport Systems that serve to limit the speed of a vehicle. By restricting the vehicle to the posted speed limit, ISA potentially provides one of the most effective strategies for reducing inappropriate speeds"

An active ISA system intervenes in the driving when the vehicle is travelling at a speed in excess of the speed limit, and actually reduces or limits the vehicle's speed automatically by manipulating the engine and/or braking systems. Most active ISA systems provide an override system so that the driver can disable the ISA, if necessary, on a temporary basis.

There are four types of technology currently available for determining local speed limits on a road and determining the speed of the vehicle. These are Global Positioning System (GPS) receiver based systems, radio beacons, optical recognition and dead reckoning.

A GPS-based ISA system has a built-in GPS receiver which picks up the signals transmitted from a network of satellites, and processes them to pinpoint the vehicle's location to within a few meters. The main problem with GPS is the accuracy of the determined position which can be affected by a number of factors including the GPS technique employed, environmental conditions (e.g. heavy clouds, tall buildings in urban canyons, trees), the number of satellites received, satellite geometry, and quality of the GPS receiver used in the ISA system. GPS signals can be deteriorated or even lost completely when the vehicle is underground or in a tunnel.

If there are radio beacons installed at roadside (V2I application), the receiver of the ISA system would be able to pick up data related to the local driving information such as speed limits, school zones, variable speed limits, or traffic warnings. With a sufficient number of beacons in place, the vehicle speed could be calculated based on how many beacons the vehicle passed per second.

Some ISA systems are equipped with optical recognition systems (e.g. scanners or cameras) which recognise speed signs (autonomous application). The speed limit data is obtained and compared to the vehicle's speed. The system would use the speed limit from the last sign passed until it detects and recognises a speed sign with a different limit. This is a particular problem when exiting a side road onto a main road, as the vehicle may not pass a speed sign for some distance.

Dead reckoning makes use of the data from the sensors of the vehicleǿs driving assembly in terms of the wheel diameter, wheel rotations and steering direction, to predict the path taken by the vehicle. By measuring the rotation of the road wheels over time, a fairly precise estimation of the vehicleǿs speed and distance travelled can be made.

A current active ISA system is SpeedShield marketed by Automotion Control Systems, in Australia. It offers speed zoning information embedded within a GPS-based navigation system, providing drivers with information on speed limits and vehicle speed and is combined with technology that intervenes and controls the vehicle speed to no faster than the posted speed limit for that section of roadway. The technology is generally transferrable across vehicle manufacturers and models, but must be configured for an individual make and model.

As ISA systems can serve as on-board vehicle data recorders, this application provides information about vehicle location and performance which can be used for later checking and fleet management purposes. It also provides information about the driving behaviour of the vehicle, and traffic characteristics which can be useful for monitoring of the efficiency of the network such as delays and stops.

Targeted users. The targeted users are all road user (car and trucks).

Barriers to Implementation

Financial issues. It was reported that the cost of an ISA system like SpeedShield is variable depending on vehicle type and number of vehicles to be fitted. It mainly includes the costs associated with mapping and the cost of the ISA devices. Mapping the Australian states is estimated to cost $15.6 million with a further $2.4 million per year required for updating. Dedicated ISA devices cost between $800 and $1,800 for a single unit.

The key perceived benefit of an ISA is a reduction of accident risks. Research suggests that almost ú 1.8 billion could be saved every year if all excessive speed was eliminated as might be expected with a properly functioning active ISA system on every vehicle in Australia.

Technical barriers. There are no critical technical barriers.

Organisational complexity. There is no organisational complexity.

Legal issues. Like other units/parts, the liability of the active ISA systems needs to be considered before they are installed to ensure that a liability structure is in place and that all stakeholders are assured of what will happen if something does go wrong. Careful consideration should be given to the type of aid that is given to drivers via their on-board unit.

User and public acceptance. In contrast to a passive ISA, which only advises and does not interfere with the driving, user acceptance is more uncertain when an active ISA actually slows the vehicle down, while for an in-car device, public acceptance is not an issue.

Interest for Travellers

Door to door travel time. *T*his application mainly contributes to road safety which could indirectly save door to door travel time due to the fewer disruptions from road accidents, but on the other hand if drivers adhere better to speed limits that will slow them down and increase their travel time. On balance the big savings from one-off events and the small everyday increases may not lead to a large difference to the current situation.

Travel cost. This application will reduce vehicle operating costs through lower travel speeds, as well as savings from the avoidance of congestion after accidents on busy roads.

Comfort and convenience. No improvement is expected.

Safety. This application increases the safety of driving by providing greater control over speed.

Security. No improvement is expected.

Accessibility for impaired. No improvement is expected.

Modal change

No modal change is expected.

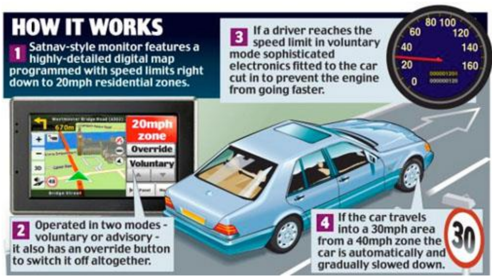
Other notable impacts

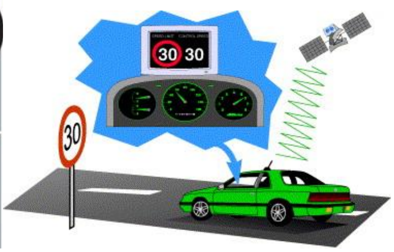
Congestion and CO2 emissions. The avoidance of congestion after accidents will also lead to a reduction and CO2 emissions. Emissions will be further reduced through the decreased travel speed.

Summary of scores

Feasibility		Interest for travellers		Modal change		Other impacts	
Investment Costs	€€	D2D travel time	0	Car usage	0	Mobility	**0**
Operation and Maintenance Costs	€	D2D travel cost	✓	Bus and Coach usage	0	Congestion	(✓)
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	(✓)						
Public acceptance	0						

Illustrative materials





4.3.4 Weather detection by vehicles

Solution family: Smart Vehicles and Infrastructure

Sub-family: Vehicle to Infrastructure (V2I) application

Domain of application: long distance travel (in principle also rural, although the necessary communication infrastructure will not be there for the foreseeable future)

Technology behind: in-car sensors, vehicle positioning, V2I communication system

Status: Pilots

Links to relevant references

- Road Weather and the Connected Vehicle

Description

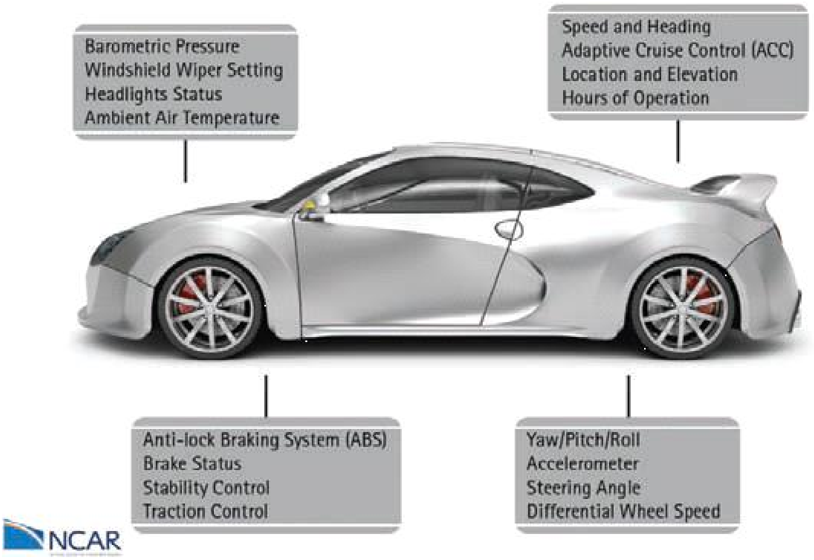
Concept and problems addressed. Conventional weather monitoring with roadside and in-road sensors are limited through the fact that the information is only as dense as the density of the monitoring stations. If one station shows fog, or rain, or snow and the adjacent one not, then nobody knows where in between the adverse weather conditions starts. This could be overcome by information constantly collected in the car and then transmitted to roadside communication units together with the precise positions in which the data was collected. The roadside units then relay this to the traffic control centre, which then in turn can inform other drivers either again the V2I communication or to drivers, whose cars are not equipped with this, via Variable Message Signs, Variable Speed limits or local radio with both voice messages and RDS-TMC (Radio Data System-Traffic Message Channel), although the conventional ways of the information dissemination loses the advantage of pinpointing precisely where the bad weather starts and ends.

The US Department of Transport had conducted a research program where vehicle sensors collected measurements on temperature, pressure, and humidity and combined it with onboard information such as the use of windshield wipers, lights, and the activation of antilock brakes and traction control systems, and transmitted it wirelessly to a data network for distribution to other cars without the involvement of a traffic control centre.

Targeted users. Motorway or trunk road operators, car drivers.

Barriers to implementation

Financial issues. Some of the information collected comes from data that is anyhow already collected by most modern cars, like outside temperature. The figure below shows the elements that already exist in many new cars.



Source: US National Center for Atmospheric Research

Other sensors could be added to complete the weather picture. The other cost element is the communication system, but it is highly unlikely that any country or region in Europe would implement a V2I system just for weather information. More general vehicle and traffic information would be the reason for any implementation and the weather information would then just be one relatively cheap by-product, even if an important one. The return of investment in terms of safety increase through the precise weather information would outweigh the costs for the car drivers who have to install the on-board systems. For the road operators, the information from the cars would make a network of roadside weather stations and sensors unnecessary; so they would save the expense for those plus have even better information to optimise their winter maintenance operations and reduce the expense for that.

Technical barriers. There are no specific technical barriers for relaying the weather related information once the V2I system is in place.

Organisational complexity. There is no organisational complexity.

Legal issues. There are no legal obstacles.

User and public acceptance. Acceptability by operators, drivers and the general public is likely to be high, as for other solutions addressing safety issues.

Interest for Travellers

Door to door travel time. Travel time may increase where drivers reduce their speed in response to weather related warnings. This is counterbalanced by the saving of delays, which can be considerable in case of accidents.

Travel cost. The lowering of speeds in response to weather warning will reduce vehicle operating costs.

Comfort and convenience. No specific impact.

Safety. The provision of weather related information to the different user groups significantly contributes to safety, reducing a great number of potential accidents caused by reduced visibility.

Security. No impact expected.

Accessibility for impaired. No impact expected.

Modal change

No significant one expected: some car drivers may hear a weather warning on the radio before they start the trip and decide to use public transport instead, but who might have changed safer in public transport under uncertain weather conditions may now feel just as safe in their own cars.

Other notable impacts

Congestion and CO2 emissions. Where the weather warnings prevent accidents on busy trunk roads and motorways, they will also prevent the resulting congestion. CO2 reduction will both stem from the reduced congestion and from the lower speeds.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€	D2D travel time	**0**	Car usage	**0**	Mobility	**0**
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	**0**	Congestion	✓
Financial viability	✓	Comfort and convenience	**0**	Rail usage	**0**	CO2 emissions	✓
Technical feasibility	**0**	Safety	✓✓	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**0**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

4.3.5 Emergency vehicle notification system (eCall)

Solution family: Smart Vehicles and Infrastructure

Sub-family: Vehicle to Infrastructure (V2I) application

Domain of application: long-distance travel, rural, urban

Technology behind: phone, GPS, other (sensor)

Status: implemented

Links to relevant references

- *eCall-S.O.S. Road Accident Digital* Agenda for Europe. European Commission
- *E-Call System* JKK Technologies
- *Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/ legal issues. Final Report* European Commission (2009)
- *EU plan for cars to call an ambulance after crashes*, BBC (4 July 2012)
- Harmonised eCall European Pilot (Heero)
- *Scenarios of critical GPS positioning performance for e-call*, Renato Filjar, Kresimir Vidovic, Pavao Britvic

Description

Concept and problems addressed. The EU has been trying to introduce eCall for nearly a decade, but attempts to bring it in voluntarily have failed. The technology is already being used by some car manufacturers, but only a small proportion of cars in the EU (0.4%) are currently fitted with the system. The Commission now wants it to be compulsory for all cars made in the EU, at a cost of around ú 100 for each device, when fitted in the factory.

From 2015 onwards all new cars should be equipped with "eCall" which is expected to save up to 2500 lives in the European Union each year. As eCall will also mean speedier treatment of injured people, there will in consequence also be better recovery prospects for accident victims.

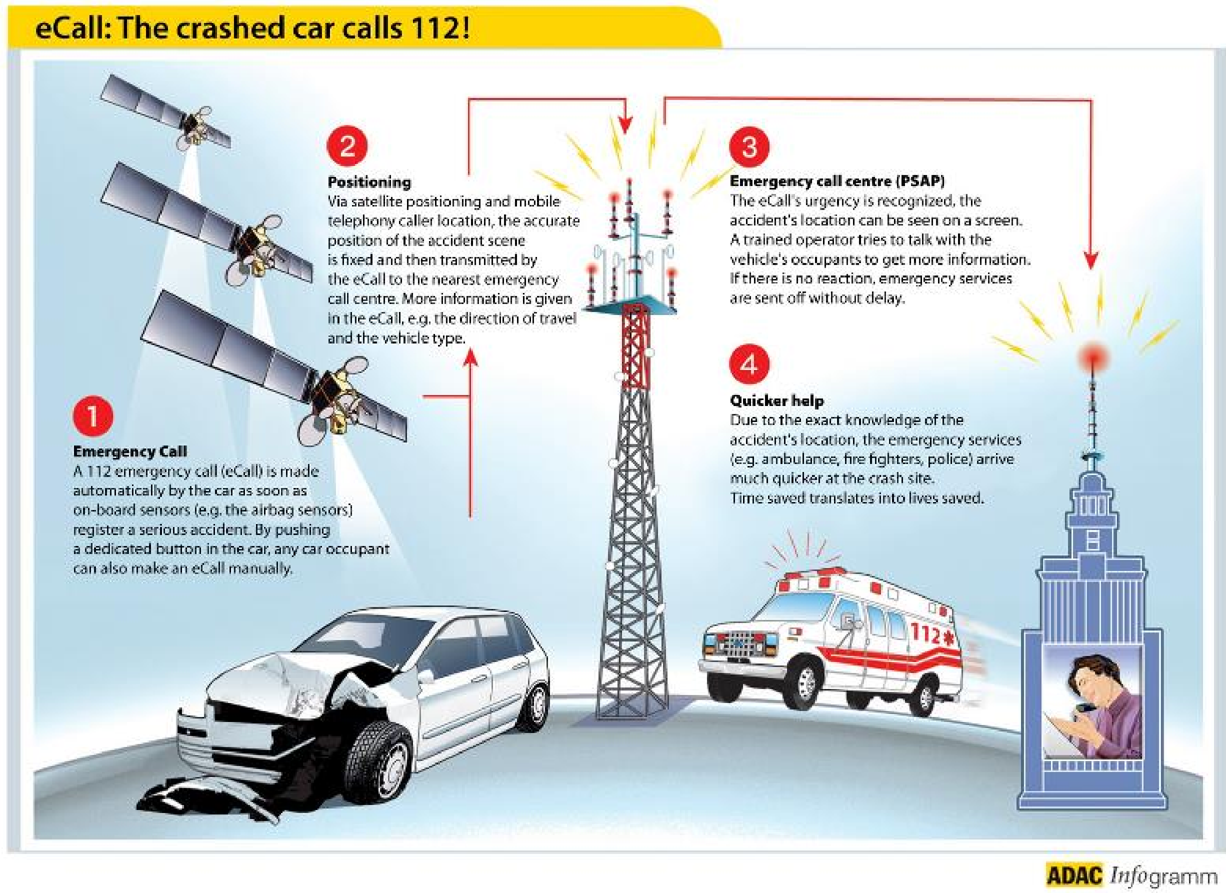
When a car fitted with eCall senses a major impact in an accident, the eCall device automatically calls the nearest emergency centre and transmits a set of data. The rapidity with which rescue services are mobilised is of utmost importance for saving lives or reducing the effects of injuries. The system provides the emergency services with instant information about the precise location of the accident, reducing response time up to about 50% in rural areas and 40% in urban areas. Thanks to the reduction in emergency response times, the system will also ensure a corresponding reduction in the number of traffic jams attributable to road accidents.

For that reason, eCall is linked to another initiative of the Commission, 112, the single European emergency number. eCall can either be generated manually by the occupants of the vehicle, or automatically by sensors' activation situated inside the vehicle.

The in-vehicle eCall directly establishes a 112-voice connection with the relevant Public Service Answering Point (PSAP), and sends crucial information such as time and location of the accident, and a description of the vehicle involved. With the same effect, eCalls can also be made manually, at the push of a button. The information sent to the PSAP may also include a link to a potential Service Provider by including its IP address and phone number. If the user has subscribed to a Service Provider, additional information can be sent from the service provider to the PSAP.

As 112, eCall is a joint initiative of the European Commission and the industry, which involved public authorities, car manufacturers, ICT companies and the European emergency centres.

When analysing the effect on congestion, eCall was considered to be most effective on rural roads where there is less traffic and therefore it is more probable that accidents happen without eyewitnesses, and it will take more time before a non-involved road user will come to the accident site. eCall was expected to be less effective on motorways and hardly effective on urban roads.



Source: Digital Agenda for Europe. European Commission
eCall System

One side effect of eCall is that it will allow a more precise monitoring of accidents in the European road network allowing to identify more accurately dangerous spots in the network and facilitating general road safety analysis and research.

Targeted users. Emergency services, car drivers

Barriers to Implementation

Financial issues. To ensure the proper functioning of eCall, the answering point services will need to be modernised to enable them to handle the automatic data transmitted by the vehicles; this will require significant investment. According to ADAC, the annual costs associated with introducing the system are estimated at 6 billion euros a year and relate specifically to the costs of installing the system in vehicles and modernising the public service answering points. Nevertheless, all the estimates indicate that the eCall system will have a very favourable cost-benefit ratio. Thus, it is estimated that the system would result in annual savings of about 32 billion euros (savings on accident and congestion costs). For car drivers the system will be relatively cheap.

Technical barriers. The assumption that the utilisation of the sole GPS positioning procedure for provision of accurate and robust vehicle's position estimate are over-optimistic according to some sources. The GPS vulnerabilities and limitations undermine the requests for reliable and robust position estimation system. However, GPS should stay as the fundamental position estimation technology for eCall, that is to be enhanced by assisting and augmentation procedures, as well as by integration with the other positioning-related sensing devices already embedded in modern cars.

False eCalls are considered a serious problem, the number of false alarms is crucial for the outcome and there have to be certification controls that ensure that only high quality devices are brought to the market. False alarms consume recourses and if the number of false alarms is high, the confidence in the devices is reduced (alarms are not taken so seriously anymore). The checking and maintenance of the devices was proposed to be done in periodical vehicle inspections.

Organisational complexity. eCall involves a large number of car manufacturers, and the agreement of all EU Member States. It requires as well the adaptation of all regional and local emergency centres. The EU has been trying to introduce eCall for nearly a decade, but attempts to bring it in voluntarily have failed. Proper organisation will require legislation.

Legal issues. Legal issues related to eCall may be found in the domains of privacy and data protection, regulation of emergency services, regulation of telecommunications, consumer protection and product liability. In some cases eCall may also produce self-incriminating evidence against an individual. However, according to the *Impact assessment on the introduction of the eCall service in all new type-approved vehicles in Europe, including liability/ legal issues. Final Report,* European Commission (2009), it can be concluded that the legal issues appear to be manageable in terms of further development and roll-out of eCall such that they are not expected to be a barrier to deployment.

User and public acceptance. *User and public acceptance can be expected to be high. Users benefit from faster emergency response, and non-users benefit from faster clearance of accident sites.*

Interest for Travellers

Door to door travel time. Indirectly, thanks to the reduction in emergency response times, the system will promote a corresponding reduction in the number of traffic jams attributable to road accidents.

Travel cost. Savings for a single driver are likely to be low. At an aggregated EU level, some studies have suggested that the avoided congestion costs by enhanced safety response in roads could be estimated up to 5 - 7 million euros in 2020 for the whole of Europe.

Comfort and convenience. No impact on confort or convenience.

Safety. eCall is estimated to have the potential to save up to 2500 fatalities annually in EU-27 when fully deployed, to reduce the severity of injuries, lower the cost of healthcare in society and reduce human suffering.

Security. No particular impact is expected

Accessibility for impaired. No particular impact is expected

Modal change

No particular impact is expected

Other notable impacts

The faster clearance of accident sites will make a small contribution to congestion reduction.

Summary of scores

Feasibility		Interest for Travellers		Modal change		Other Impacts	
Investment costs	€€€ - €	D2D travel time	0	Car usage	0	Mobility	0
Operation and maintenance costs	€€ - €	D2D travel cost	0	Bus and coach usage	0	Congestion	(✓)
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	(✓)
Technical feasibility	0	Safety	✓	Ferry usage	0	Contribution to user pays principle	0
Organisation feasibility	X	Security	0	Aeroplane usage	0	European economic Progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	0			Territorial Cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

eCall - Cars that 'dial' 112

http://www.youtube.com/watch?v=Oa9exFRI-KI

eCall explanation Cinterion modules

http://www.youtube.com/watch?v=kSF3SudcUA8&feature=related

4.3.6 Cooperative traveller assistance

Solution family: Smart Vehicles and Infrastructure

Sub-family: Vehicle to Infrastructure (V2I) application

Domain of application: Long distance travel

Technology behind: positioning and location referencing, infrastructure-to-vehicle and vehicle-to-vehicle communications

Status: implemented

Links to relevant references

- CVIS PROJECT
- CVIS PROJECT (LINKS)

Description

Concept and problems addressed. Cooperative Traveller Assistance (CTA) is concerned with balanced use of the road network (from a traffic manager perspective) and reliable travel time (form a driver perspective). More specifically, the assistance provided by the CTA system comprises pre-trip and on-trip planning; on-trip seamless service with tracking and rerouting if needed; and vehicle data feeding to traffic control centres. Compared to "traditional" solutions, the CTA system is capable of offering better prediction of travel times based on planned routes from cars, real-time assistance for drivers in rerouting to evade accidents and travel delays; and hence improving the efficiency of the overall system.

As the system consists of on-board vehicle data recorders and roadside monitoring units, this application provides information about vehicle location and performance which can be used for vehicle positioning and traffic management purposes. It also provides information about the driving behaviour of the vehicle, and traffic characteristics which can be useful for monitoring of the efficiency of the network such as delays, stops, emissions and so on.

Targeted users. The targeted users are all road users, and road network operators/managers. Others that might be involved are traffic information service providers.

Barriers to Implementation

Financial issues. The costs for the system consist of the costs of equipping the infrastructure and running of cooperative services, including the onboard unit costs, RSU costs, the control centre costs, the communication costs, while the costs for providing services should be covered through the general operational costs of the traffic management centre. For the road users, the equipment should not be very high once it is mass produced, though initial costs for the first systems may be considerable.

Technical barriers. There should not be any insurmountable technical barriers to the implementation of the application.

Organisational complexity. Organisational complexity is not envisaged in this application.

Legal issues. Like other units/parts, the liability of the cooperative systems (in particular the in-vehicle units) needs to be considered before they are installed to ensure that a liability structure is in place and that all stakeholders are assured of what will happen if something does go wrong. Careful consideration should be given to the type of aid that is given to drivers via their on-board unit.

User and public acceptance. No problems are expected in relation to public acceptance and user acceptance should be high.

Interest for Travellers

Door to door travel time. Since the aim from the operators perspective is to balance the traffic volumes in the system, some drivers may be sent on longer routes. However, overall this application should save door to door travel time.

Travel cost. This application has some potential for a reduction of travel cost resulting from reduced travel time, and avoidance of congsetion.

Comfort and convenience. No notable impact is expected.

Safety. This application cannot be expected to notable increase the safety of driving.

Security. No improvement is expected.

Accessibility for impaired. No improvement is expected.

Modal change

No modal change is allowed since the communication exchange is actuated when the trip is started.

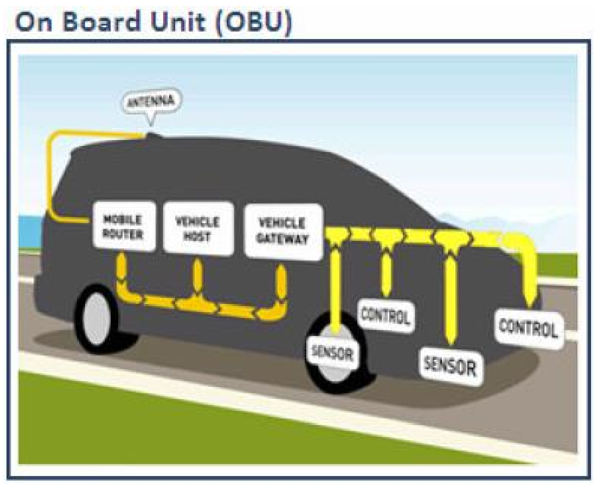
Other notable impacts

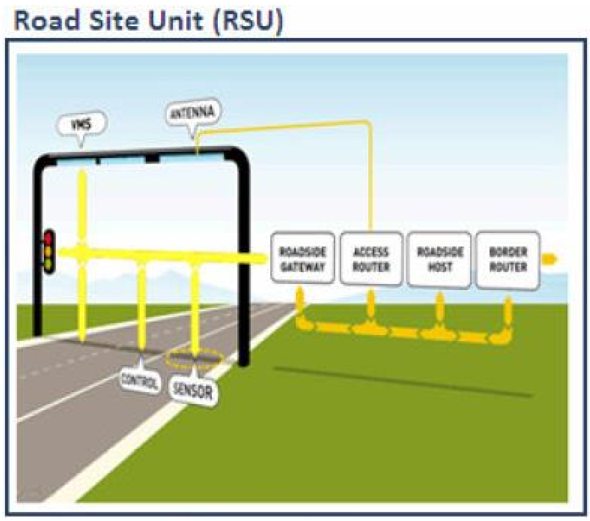
Congestion and CO2 emissions. By optimising the traffic flows in the system, there should be reduced congestion and a resulting reduction in CO2 emissions.

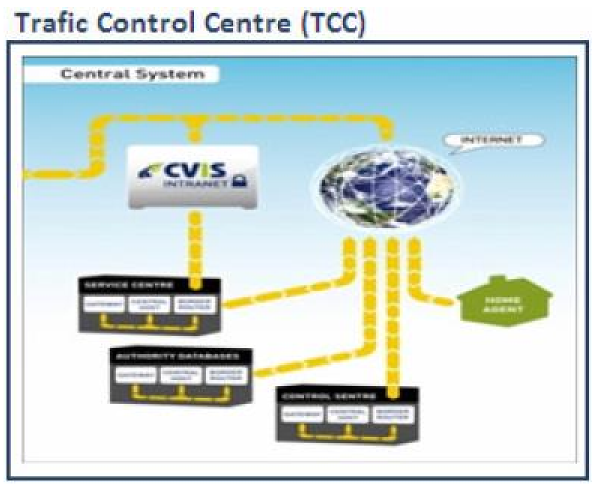
Summary of scores

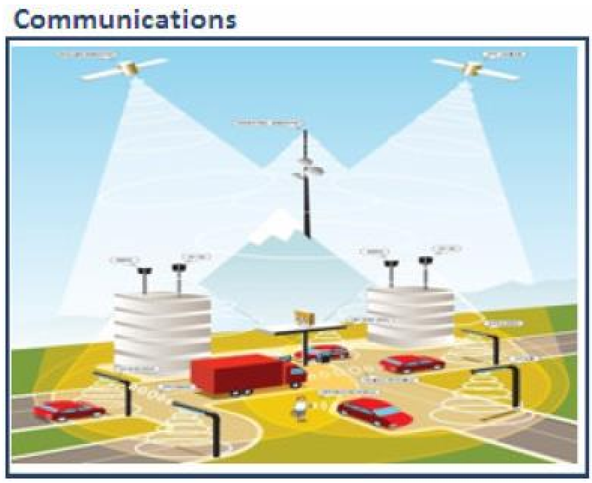
Feasibility		**Interest for travellers**		**Modal change**		**Other impacts**	
Investment costs	€-€€€	D2D travel time	✓	Car usage	0	Mobility	**0**
Operation and maintenance costs	ú	D2D travel cost	✓	Bus and Coach usage	0	Congestion	✓
Financial viability	0	Comfort and convenience	0	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Administrative burden	0	Security	0	Aeroplane usage	**0**	European economic progress	0
Legal feasibility	**0**	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
User acceptance	(✓)						
Public acceptance	**0**						

Illustrative materials









5 SHARED MOBILITY AND DEMAND RESPONSIVE TRANSPORT

5.1 PUBLIC TRANSPORT SERVICES IN LOW DEMAND SITUATIONS

5.1.1 DRT planning and scheduling optimisation systems

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Public Transport Services in Low Demand Situations

Domain of Application: urban, rural

Technologies behind: Route planning algorithms, GPS and GPRS based location identifiers, in vehicle management units

Status: In development and implemented (varies by business type and complexity)

Links to relevant references

- Shinya Kikuchi and Jong-Ho Rhee (2008) Scheduling method for Demand Responsive Transportation Systems. In the Journal for transportation engineering, 115 (6) pp 630 ï 645
- Ambrosino, G., Mageean, J.F., Nelson, J.D., Romanazzo, M., (2004) Experience and applications of DRT in Europe. In: Ambrosino, G., Nelson, J.D., Romanazzo, M. (Eds.), Demand Responsive Transport Services: Towards the Flexible Mobility Agency. ENEA, Rome, pp. 33ï 54.
- Ordnance Survey (2012) using geographic information to support schools transport. Report D09098, UK Ordnance Survey.
- Uchimura K, H. Takahashi and T. Saitoh (2002) demand responsive services in hierarchical public transportation systems. In particular technology, I EEE transactions on vehicular technology. Volume 51, issue 4.

Description

Concept and problems addressed. Demand Responsive Transport systems, often called dial-a-ride because of the initial need to book them by phone, has been known for some years and has generally emerged where the opportunity for large-scale bus services is limited by a lack of demand and/or a lack of available public funds to support these. Operations have typically emerged with very limited use of technologies, and may operate in some instances without any additional processing beyond that possible manually. The result of this has been a limit to the extent to which DRT services are delivered, coordinated or optimised. Moreover, the mix of planning technologies currently available and in use limits the potential development of the mode.

In recent years, local government authorities are increasingly facing very strict budgetary pressures to deliver public passenger transport with reducing budgets, and this has led to the closure of services and reduction of service levels in many areas. The move to route optimisation systems will allow for the continued provision of services, and potentially the delivery of better transport service levels with a reduced support budget. Coordination of system planning with public support budgetary constraint may also result in the development of a more passenger focused demand responsive transport system.

There is now an increased choice of planning technologies that optimise the use of DRT services, which in turn can increase availability and affordability. DRT planning and optimisation systems opportunities follow from the development of route planning algorithms, commercially available from a small number of suppliers including Stratagen, Mobisoft, DDS Digital, Trapeze, Cleric etc. The systems take advantage of improved computational power allied to in-vehicle systems and communication technologies. Route planning allows for a reduction in wasted mileage, referred to as dead mileage, and optimises total route distance to achieve a greater passenger number per vehicle.

Targeted users. Local authorities, district planning managers, bus operators.

Barriers to implementation

Financia issues. A major concern of most local public authorities has been the extensive costs of providing support in public transport. Many have moved towards electronic planning systems, with a number of preferred systems becoming apparent including the wide scale use of the Trapeze system in Scottish Authorities, and a dominance of the Cleric system in the UK ambulance service, including for the transport services provided to non-emergency patients. Moving from passive use of these systems to an enabled and optimised service will provide for reductions in transport costs, and may be further measured against the social returns on the investment that a planned scheme may provide.

Operating costs for rural DRT services can be seen as an issue, in particular, the high costs of route planning software compared to the potential incomes of a DRT service. The cost of new systems can vary significantly and is generally tailored to the physical size, number of vehicles and numbers of linked trips. The DDS MobiRouter system suggests that a cost around £ 2000/vehicle (ú 2,400) for set up and 20% operational overhead per annum is appropriate. In a fleet of 30 vehicles this would equate ú 72,000 set up costs in a mid sized fleet, with an annual operating cost of ú 14,400.

Alternative pay per use schemes are being developed by some of the larger manufacturers, including the OpenDRT system developed by Mobisoft, and similar concepts across other manufacturers.

Benefits arising can be identified in terms savings compared to the alternative provision of fixed route transport and overall transport efficiency, but where the alternative would have been no public transport at all in terms of social return on investment. Analysis of the efficiency and benefits and games in the transport to employment (T2E) scheme are set out in Wright et al (2009), indicating social returns in the order of £ 15,000 - £ 30,000 per traveller. These benefits arise from the impact of transport provision as compared to non-provision, provision being made possible by the application of the DRT planning system; and may not be consistent across all locations. Transport benefits may also arise from the more efficient use of vehicles, and this typically relates to fuel savings and time cost savings from the more efficient use of vehicles.

Technical bariers.There are no technical barriers.

Organisational complexity. A significant challenge exists in the extent to which a ‶mixed economyò of technology enabled and non-technology suppliers may operate together. In addition operating challenges exist in matching service complexity to market demand. An authority seeking to replace fixed route services with DRT will also need to inform and educate users of the differences in service engagement, booking requirement and use.

The most apparent complexities exist in relation to the ownership of systems, their application, and the challenge of collaboration between fleets and fleet managers. This can extend to differing uses within the same authorities, such as educational use of public transport, and direct authority support of ‶traditionalò services. In this example the interests of the differing departments of the same authority can result in an organisational barrier to the sharing of information, transport means and support funds. Technical differences may also present organisational challenges in bringing disparate authority systems, provider systems and optimisation systems together. A series of government reports in Scotland as in other countries (see Arbuthnot) identify the opportunity but have made little progress in achieving common aims. The challenge created by a financial and budgetary squeeze may result in a better solution and pressures to promote common working to achieve a (financial) optimising end.

However, in any case the automated systems will reduce the administrative burden of running a DRT service.

Legal issues. There are no major legal issues.

User and public acceptance. Operators are often reluctant to provide such services, but those who to decide to provide them see their social and potentially also financial advantages. The general public certainly appreciates the service quality provided by DRT services.

Interest for Travellers

Door to door travel time. The scheduling systems will optimise the DRT operation and reduce travel times.

Travel costs. With more efficient operations it should be possible to reduce the price charged to the passenger once the initial investment has been paid off.

Comfort and convenience. DRT systems which have been provided using a manual system will often fail to provide the extent of coverage and service level that the optimised system can facilitate. Moving from the manual system to an automated and optimised system will enhance the service level, and thus the convenience to the passenger.

Safety. No significant impact expected.

Security. No significant impact expected.

Accessibility for impaired. No particular impact expected.

Modal change

A potential benefits may arise with the enhancement of DRT and its optimisation. The availability of transport in instances where no public transport would otherwise be provided, may incentivise a shift of mode. In many rural locations the primary alternative is the private car, and in this instance optimisation systems have a significant role in modal shift.

Other notable impacts

Mobility. DRT services increases mobility in both cases, whether they replace conventional bus services or whether they are implemented in places where there was no public transport provision before, and the scheduling systems will make the services more adaptive to the user needs and hence more attractive.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	-	Mobility	(✓)
Operation and maintenance costs	€	D2D travel costs	(✓)	Bus and coach usage	+	Congestion	0
Financial viability	✓	Comfort and convenience	(✓)	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	(X)	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	(✓)			Territorial cohesion	0
Legal feasibility	0						
User acceptance	0						
Public acceptance	✓						

5.1.2 Computerised dispatch and positioning systems

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Public Transport Services in Low Demand Situations

Domains of Application: Urban, rural

Technologies behind: Next generation planning and scheduling systems, positioning systems

Status: implemented

Links to relevant references

- Mark E.T. Horn, (2002) Fleet scheduling and dispatching for demand-responsive passenger services, Transportation Research Part C: Emerging Technologies, Volume 10, Issue 1, February 2002, Pages 35-63
- Jamiat al-Imarat al-Arabiyah al-Muttahidah et al (2002) Matching GPS Observations to locations on a digital map. Paper 02-3017 prepared for presentation at the 81st annual meeting of the Transportation Research Board, Washington, D.C. January 2002.
- Soumia Ichoua, Michel Gendreau and Jean-Yves Potvin (2000) Diversion Issues in Real-Time Vehicle Dispatching. In Transportation Science, Vol 34 No 4 pp 426-438
- Gianpaolo Ghiania, Francesca Guerrierob, Gilbert Laportec, Roberto Musmannob (2003) Real-time vehicle routing: Solution concepts, algorithms and parallel computing strategies in European Journal of Operational Research Volume 151, Issue 1, 16 November 2003, Pages 1ï 11

Description

Concept and problems addressed. Dispatch, the action of dispatching vehicles to accommodate demand for transport, has a particular relevance in the taxi industry as it also relates to a defined legal definition distinguishing between taxis and other vehicle types operating in the same market. The taxi market, which encompasses a combination of Taxis (Hackney Carriages), Private Hire (Livery), Limousine and Shared Ride for profit vehicles, is in rapid flux, and has seen a variety of dispatch systems emerge affecting one or more of the vehicle types within the market. The Taxi (Hackney Carriage) has not been immune to the development of dispatch technologies, and has a particular interest in their success in promoting the taxi rather than other vehicles in the same market.

The nature of the taxi, as a vehicle that may respond to dispatch, pick up hailed trips, and operate at taxi ranks, also impacts on the ability of a dispatch system to function as the vehicle that is being dispatched is responding to a variety of other engagement methods in addition to the dispatch, and will respond differently to vehicles whose sole (legal) function is to pick up calls. Innovation in dispatch technology has thus split between the driver based system typically including app based limo services, and ‶shore basedô radio systems, more typical of taxi companies. In this instance the taxi company assumes responsibility for the financing, operation, and renewal of the dispatch system, and this is the taxi company (rather than the taxi driver) that is affected by the reliability of the dispatch system thus deployed.

Traditional problems relate to: Knowledge as to the whereabouts of the vehicles within the fleet; willingness or otherwise, of the taxi driver to respond to bookings sent via the dispatch system; and reliability of the shore based system to deliver services at a timely and cost effective rate to intending passengers. The application, the computerised positioning and dispatch system, is aimed at improving the supply of demand responsive services, improving operating efficiencies, and reducing support costs. The taxi dispatch system is driving this document relates to shore based, company oriented, systems as opposed to driver-oriented apps. Though both shore based and driver oriented systems suffer from similar issues of reliability in positioning and driver willingness to accept trips, the shore-based system is more typical of the company and association structure of the taxi industry.

Dispatch and Scheduling System architecture

In its basic description a scheduling system requires three elements: a land based dispatcher, able to receive and analyse demand for transport; a mobile location indication, identifying and reporting the location of supply; and a method of communication. Taxi services have operated on this basis for many years, with slow evolutionary development. Not all systems have been automated, and some manual systems remain in use today - typically based on an individualœs knowledge of a city, and radio reported locations. Manual systems, particularly those associated to allocation and routing, are sometimes referred to as ìNaiveî scheduling systems (Horn, 2002). More automated systems permit the identification and optimisation of booking against multivariate analysis, typically of vehicle position and route optimisation on the basis of automatically identified positioning systems such as GPS. Some concerns exist around potential inaccuracy of GPS locations and digital mapping (al-Imarat al-Arabiyah al-Muttahidah et al 2002), giving rise to development of assisted GPS and complementary location beaconing.

Current systems, and those in development, can contribute to fleet optimisation, on the basis of matching supply to demand, and optimising vehicle location and routing, and to increased transport supply in supported networks by lowering vehicle operating costs, including positioning costs. Taxi operations in particular suffer from a high proportion of empty running as drivers return from a drop off point to central locations where pick ups are likely. Positioning and dispatch systems have a role in reducing this by increasing the potential for intermediate business. The system allows for the targeting provision of transport and access to specific services to the benefit of the public, driver and operating company, but do so by changed working practices. For example it may prove more appropriate to allocate a vehicle returning empty to a job as distances travelled, as well as driver efficiencies may be greater; but this may be at odds to the more common practice of seniority within a zone, ie: allocating a trip to a driver who has been waiting longer regardless of their actual location within a zone.

Targeted Users. The main targeted users for this application are taxi companies and operating associations. The dispatch system itself is not visible, or should not be visible, to the member of the public seeking a taxi, but should be able to optimise service to the benefit of the passenger.

Barriers to Implementation

Financial issues. The costs of dispatch and positioning systems vary widely, largely influenced by the complexity of systems and the extent of functionality required. Dedicated Taxi Dispatch systems, owned in house by the transport provider, using the example of the Mobile Knowledge XDS system, are estimated at ú70,000 for system installation, though exact sales costs are typically tailored to a companyœs specific requirement. Additionally in-vehicle costs include on board equipment and communications costs that are estimated at ú30 / month. The financial return comes from the increased efficiency of the dispatch services and in many cases, as a result, the need for fewer vehicles and drivers.

Operating costs of shore-based systems also exceed many of those achieved by driver oriented systems, which will typically work on a charge per use basis, the most common systems in Limo based services charging 10% of the fare. Benefits do accrue, however, from the shore-based system, most notably in the ownership and responsibilities associated with a known company dispatching taxis, rather than a system based on drivers alone.

Technical barriers. A series of challenges are apparent related to the communication links between vehicle and land based equipment; in accuracies of GPS coordinates; and in the use of datasets in route optimisation. Communications technologies are typically based on the use of radio or mobile phone signals in transmitting data and voice. Remote rural locations can suffer from signal drop out and black spots. This is an underreported issue as the primary measurement applied is reception in population centres. As the use of mobile data relies on signal coverage and maintaining transmission to report location and operating characteristics this may pose a difficulty. GPS accuracy may also be a concern: while GPS coordinates tend to provide a reasonable estimation of location, inaccuracies may result from canyons, topographical features, and weather conditions which reduce the ability to locate a vehicle. Differences of small numbers of metres between indicated and actual location can result in a passenger being missed. The use of secondary beacons and local landmarks may have some benefit in reducing such inaccuracies. Resulting demand and location datasets may also pose a challenge in the nature and complexity of the information provided. Potential for misreporting or inaccuracies in input may also reduce the potential for route optimisation. However, the existing systems have proven that none of these are barriers to implementing well-functioning real world applications.

Organisational complexity. The computerised systems reduce the administrative burden. The organisational complexity is generally low.

Legal issues. There are issues specific to the handling of personal information, storage and wider application, but most systems use anonymous information and many systems automatically delete data in a defined period.

User and public acceptance. The general public will normally not be aware of these systems, so their acceptance is not an issue, but the operator will very much welcome them.

Interest to travellers

Door to door travel time. The computerised dispatch and location system offers a significant opportunity to reduce the response time until a taxi arrives.

Travel Cost. The cost of a taxi fare tends to be dictated by local regulation rather than through a competitive market system for each trip. This said, market impacts are included in many of the measurements used to determine fares. As the operating efficiencies of a dispatch system result in lower costs a downward pressure may emerge on levels of fares.

Comfort and convenience. Taxis and DRT services are anyhow a very convenient way to travel, but the convenience will be increased further by the high service standard enabled through the computerised dispatch system.

Safety. There is no impact expected.

Security. The computerised dispatch and location system can provide an enhanced level of personal security by direct and immediate identification of vehicle location, if some form of emergency button is also provided.

Accessibility for impaired. As vehicle fleets become more efficient in their use, so the ability of an operator to afford, and correctly position, accessible vehicles is enhanced.

Modal Change

The opportunity for modal change from private cars to public transport modes is significantly enhanced by the presence efficient taxi services, and computerised dispatch and location systems make them more efficient and more affordable.

Other notable impacts

Mobility. Taxi services greatly increase the mobility for non-car owners, and the computerised dispatch systems not only increase their efficiency, but in the case of large scale services could not even operate at all otherwise.

Congestion. Increased efficiency of taxis in urban areas will make a small contribution to easing congestion.

CO2 emissions. Where computerised systems encourage taxi services that increase mobility, they will also increase CO2 emissions. However, this should be outweighed by those cases where they enable the replacement of large buses driving around rural areas with only a handful of passengers, if any, on board, and by the increased efficiency of taxi operations.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	-	Mobility	(✓)
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	(✓)
Financial viability	✓	Comfort and convenience	(✓)	Rail usage	0	CO2 emissions	0
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(✓)	Aeroplane usage	0	European economic progress	0
Administrative burden	✓	Accessibility for mob. imp. passengers	(✓)			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	0						

Illustrative Materials

CS 6354 – Advanced Software Engineering, Section 581. Summer 2007

ADS+ Ambulance Dispatch System

Software Design Document (Deliverable 3)

CS 6354 – Advanced Software Engineering, Section 581
Summer 2007

UTD

The Fantastic 9

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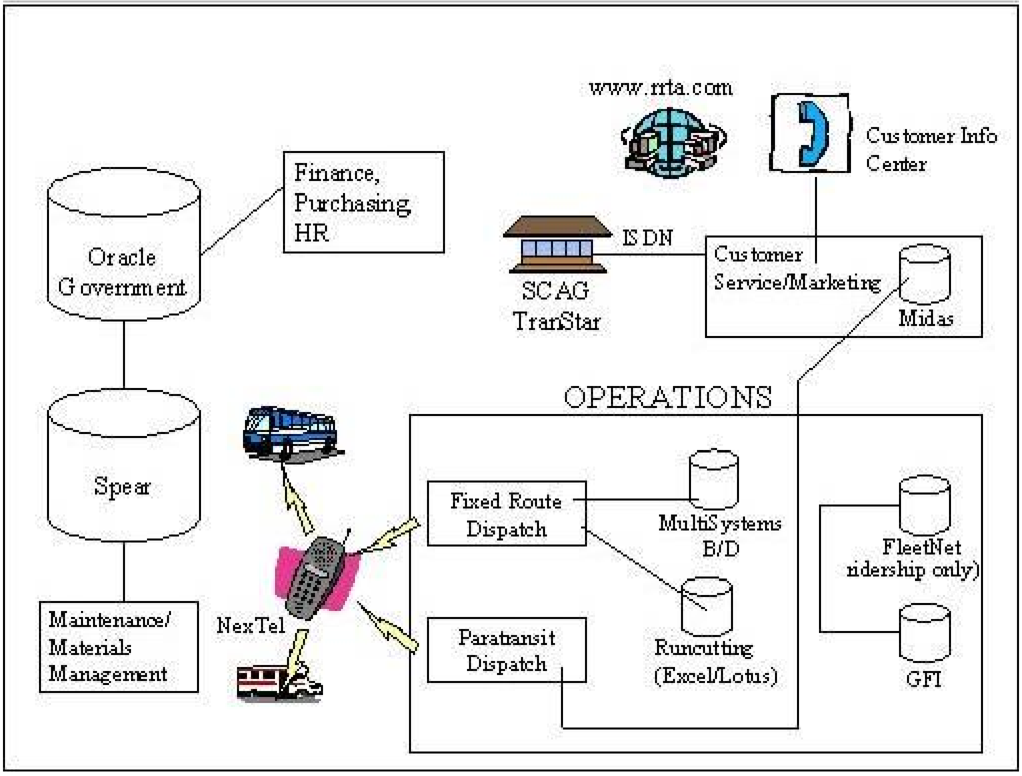
Riverside Country Transit ITS Demonstration Project: Phase II Evaluation Final Report. Existing System Architecture for RTA Operations



5.2 SHARED MOBILITY

5.2.1 Commercial Fixed Point Car Sharing (Zipcar)

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Shared Mobility

Domain of Application: urban, rural, long-distance

Technologies behind: Vehicle location equipment, Booking and membership services, GPS and vehicle communication

Status: implemented

Relevant references

- Ball, C., W. Best, A. Ray, and A. Seasman (2001) Achieving low car housing: the role of car clubs. A good practice guide for planners and developers. Produced for the Regional Assembly for Yorkshire and Humberside by a working group led by the Community Car Share Network, Leeds, UK, June.

- Bonsall, P. (2002) Car Share and Car Clubs: potential impacts. Final Report Institute for Transport Studies University of Leeds for DTLR and the Motorists Forum Under contract No. PPAD/9/82/11, February 2002

- Enoch, M. P., and J. Taylor (2006) A worldwide review of support mechanisms for car clubs. In Transport Policy 13 (2006) 434ï 443

- Firnkorn J., and M. Müller (2011) What will be the environmental effects of new free-floating car-sharing systems? The case of car2go in Ulm. In Ecological Economics 70 (2011) 1519ï 1528

- Harmer, C and Cairns, S (2011) Carplus annual survey of car clubs 2010/11. TRL: Bracknell, UK.

Description

Concept and problems addressed. Commercial Fixed Point Car Sharing schemes address the need to access a vehicle for short term exclusive use. The scheme thus described need be distinguished from a number of similar alternatives, set out here to avoid confusion:

- **Commercial car sharing (fixed point)** including óCar Clubsô *Examples: Zipcar* A commercial venture supplying cars for exclusive use (effectively under short-term rental agreement) from a fixed location for return to the same location, or an alternative fixed point maintained by the same scheme.
- **Commercial car sharing (floating vehicle)** including óCar Clubsô *Example: Car2Go* A commercial venture supplying cars on a similar basis to a fixed point scheme, but allowing for vehicles to be óreturnedôto a range of legal parking places (as defined within the scheme and that may differ between cities). The scheme technologies notifying the location of an available car to the intending user, which might thus be referred to as a floating vehicle.
- **Non-commercial car sharing / ridesharing.** *Example: Mitfahrzentrale* A not-for profit venture identifying spaces available in a vehicle with driver. Usually identified against a known origin and destination.
- **Commercial ridesharing.** *Example: Lyft, Sidecar, UberX* A commerical venture identifying spaces available in a vehicle with driver. Usually identified against a known

origin and destination. Payment is made to driver, although this may be defined as a ‘donation’ in some schemes.

This document describes commercial fixed point car sharing, defined as schemes providing short-term access to a vehicle for exclusive use, for a fee. (The other three forms of shared mobility with cars are described in separate factsheets). The concept has developed in the period from around 1987 (Enoch, 2006), and may often be associated with a particular pattern of residential development (Ball et al, 2001) contributing to the conditions under which such schemes may work most successfully.

Schemes themselves may vary between small cooperatives, often based on a specific community, and a number of larger branded schemes, including Zipcars being an example of a fixed point branded operation. Systems are "tethered", i.e. have fixed location for vehicle pick-up, return and storage, many of which are located alongside transportation hubs, metro stations etc. A fixed point location may not require any infrastructure, except for signage and defined parking bays, and most will not be staffed. The fixed point will provide security, however, in terms of defined and reserved parking bays, and a fixed point for the operator to access, repair or inspect vehicles.

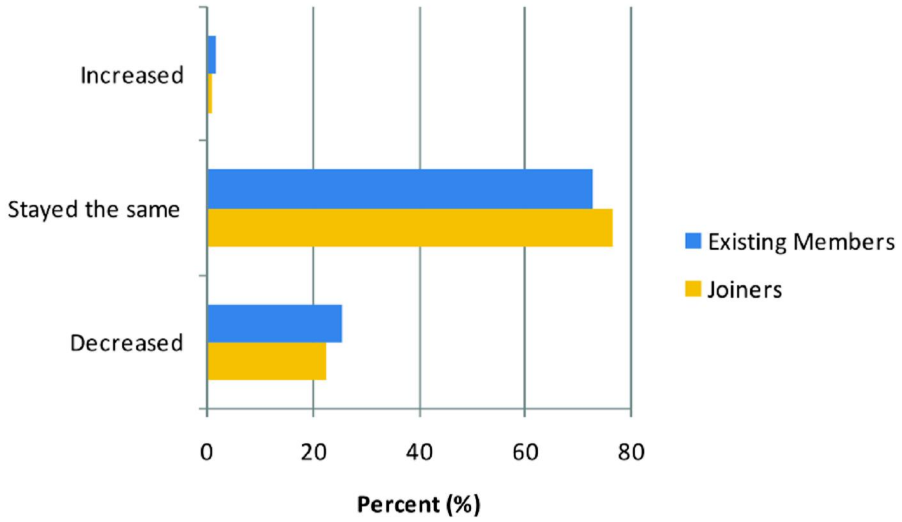
Technologies applied to the Car Share sector include location, technical status analysis, vehicle access/release and billing. Most systems provide a level of automation that includes remote sensing of vehicle status, being location and condition; allocation and return. Technical maintenance and other physical interventions may be called upon, including automated summoning, as a specified output of the planning system. A further nascent element may relate to the charging of electric vehicles held within the car club fleet, a feature of the Car2Go fleet in San Diego.

Car Share and Car Clubs share many of its user characteristics with other individual forms of personal transport. An individual has a choice between transport modes, including car share that may also include taxis, public transport or private car use as alternatives. The distinction being that a car share or car scheme allows for personal access without third party drivers (Taxi / Public Transport). Private ‘exclusivity’ of use may encourage wider application, particularly trip chaining, where multiple trips are combined. Use also extends to existing vehicle owners, which may include short city trips, trips within a city for commuters, and trips made in place of a second, or third, car. Some evidence of user demographics can be taken from the TRL Carplus analysis, see figures below, which indicate a younger adult age bias in use, and effective impacts of the car share schemes in reducing second vehicle ownership.

Age of member	Frequency	Percent
24 or less	73	10.5%
25-34	294	42.3%
35 - 44	186	26.7%
45 - 54	97	13.9%
55+	43	6.2%

Source: TRL / Carplus
Membership profile

Scheme membership also appeared to have an effect on the ownership of vehicles, with a sizeable minority of scheme members choosing to reduce the numbers of cars in their household.



Source: TRL / Carplus
Change in the number of cars owned by a household

Targeted Users. Non-car owners with a driving licence living in some proximity to the car share station.

Barriers to implementation

Financial issues. Costs of running a car club or similar scheme can be affected by the range of technologies supporting its provision. Further factors include the capital costs of setting up a car club, and the desire, in many, to maintain relatively new vehicle types within the scheme. Car clubs cannot compete in terms of cost with ownership of an old car for which the depreciation is minimal, whilst any move to equip the fleet with older vehicles would influence the perceptions and likely uptake of the scheme itself. Car clubs need not maintain brand new vehicles to achieve use (Bonsall 2002) but would suffer with a perception of an ageing fleet or one where (perception of) mechanical reliability were compromised.

Capital costs of operating a scheme include vehicle costs, purchase, maintenance and depreciation; with additional costs associated with the operating technologies, location and GPS systems, communication and membership. Whilst each location is likely to differ in operational characteristics, the numbers of miles driven etc., an approximation of delivery costs can be calculated using a fixed daily or annual operating pattern. In this example it is illustrated on an annual mileage of 11449, using a discount rate of 8%. Capital and maintenance costs are taken from FHV vehicles Atlanta, GA, USA.

Vehicle Costs, purchased new and operated for a period of 8 years, 0.18cents / mile
Vehicle Maintenance, 0.19cents / mile
Personnel, Infrastructure costs, capital equipment, communications, 0.37cents / mile
Total mile costs excluding fuel: EUR 0.74, annual operating costs/ vehicle EUR 8,472.26

Many schemes provide vehicles with fuel, requiring the additional cost to be calculated. A vehicle with an efficiency of 7 litres per 100 kms, with fuel at EUR1.50 / litre would experience a fuel cost of 0.17cents per mile, increasing vehicle capital, infrastructure and operating costs to EUR10,443 per vehicle.

A break-even point is reached where a vehicle earns EUR29 per day. Applying the current Zipcar use charge, which differs between day of week and user type, this would be achieved if a vehicle was rented for 3 hours per day.

Technical Barriers. The extent to which technical challenges exist depends on the nature of vehicles and services provided. There are no significant challenges beyond the operational parameters of the vehicles themselves and these have been built in to the cost estimates set out above.

Organisational Complexity. The primary elements of the system reflect the potential for automisation of operations. This suggests a potential scale benefit, with per vehicle operating costs falling as the fleet increases in size. A number of interfaces exist, between the operator and the roads authority, between the operator and any contracting organisation, such as vehicle for business models; and in following up on member qualifications which might include the checking of members eligibility and record.

Legal barriers. Whilst there are few immediate barriers to operation three areas might be considered in terms of operation; 1) Insurance and Liability; 2) Vehicle roadworthiness; 3) Personal Data. In the majority of instances the car, has responsibility for ensuring all of its drivers and the safety of its vehicles. However, the ability to ensure each vehicle is road safe on the commencement of a journey relies on the ability of the club to inspect or receive automated and manual reporting. Liability may follow where insufficient action is taken unreported incidents, mechanical failure, or danger; and this in turn impacts on the economic viability of the operating model. As in the majority of schemes process personal information, safeguards and privacy laws need to be considered. However, none of these issues have prevented the emergence of a plethora of car share schemes.

User and public acceptance. Once a car club reaches a certain size, an automatic distribution and booking system will be more than helpful to the organisers. The car club members will benefit from the smoother operations. The wider general public may become aware of the system if the car clubs use the existence of the automatic booking system in their marketing.

Interest to travellers

Door to door travel times. The booking system will not have a direct impact on travel time, but it may reduce the access time to the car. However, car sharing schemes of significant sizes, could not be run anymore without automated booking systems. In so far it is permissible to take also the effects that the widespread existence of car sharing into consideration. Hence, in more general terms, whether travel time is increased or decreased depends on whether it is compared with a trip by private car or taxi, or by public transport. For most car club users the latter will be the case, increasing travel time in these case often substantially, while the time added against private car or taxi use will be generally marginal.

Travel cost. The introduction of the booking system will, in spite of the initial cost, make the running of the car club cheaper and should help reduce the rental costs. In general terms, as for travel times, the question is with what the travel costs are compared: they will be cheaper than owning a car or using a taxi, but they may be higher than public transport.

Comfort and convenience. An automated booking system via the internet will be regarded by many as more convenient than making a phone call, especially if they find then that the phone is engaged. And again, using a shared car may be significantly more convenient than using public transport, while it is only slightly less convenient than using the own car.

Safety. No impact expected.

Security. No particular impact is expected.

Accessibility of impaired. No impact expected.

Modal change

The booking system will make it easier to use the car club, but it should not have, in itself, any significant impact on mode shift. On the whole though, there will be more new car club users who give up their car and now make more public transport trips and non-car owners now starting to make considerably fewer public transport trips.

Other notable impacts

Mobility. Car sharing increases the mobility of people who do not own a car, while it would slightly decrease the mobility of those who give up their car.

Congestion. Car sharing is most relevant in urban areas, where congestion is prevalent at least at some times of the day. Any shift from car to public transport will therefore also relieve congestion.

CO2 emissions. The effect of an increased mode share of public transport is expected to be stronger than from the increase in mobility, and on balance therefore CO2 emissions should decrease.

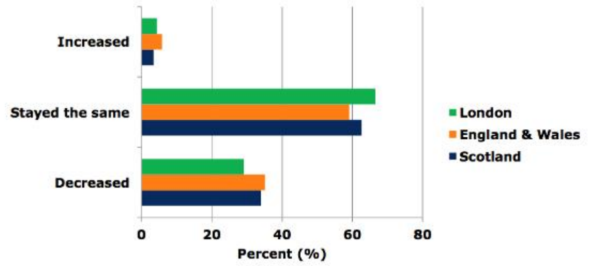
Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	(✓)	Car usage	-	Mobility	(✓)
Operation and maintenance costs	€	D2D travel costs	(✓)	Bus and coach usage	+	Congestion	(✓)
Financial viability	✓	Comfort and convenience	✓	Rail usage	+	CO2 emissions	(✓)
Technical feasibility	*0*	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	*0*	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	*0*	Accessibility for mob. imp. passengers	*0*			Territorial cohesion	0
Legal feasibility	*0*						
User acceptance	✓						
Public acceptance	✓						

Illustrative Materials

Extracts from Carplus Annual Survey

Change in car ownership



- 64-77% members do not own a car
- 3-6% members have increased the number of cars owned by their household since joining
- 29-35% members have reduced the number of cars owned by their household

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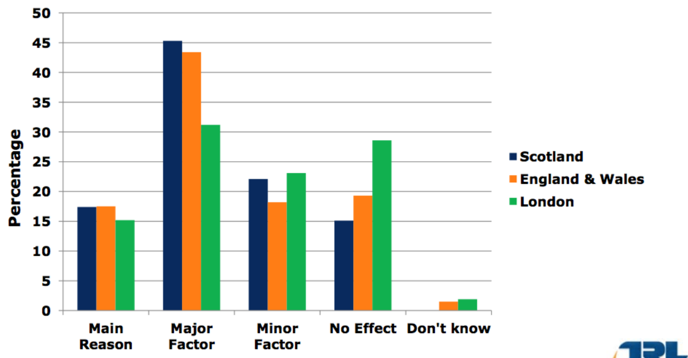
Effects of car club membership on decision to get rid of cars

- New question this year
- 46-63% said that it was the main reason or a major factor



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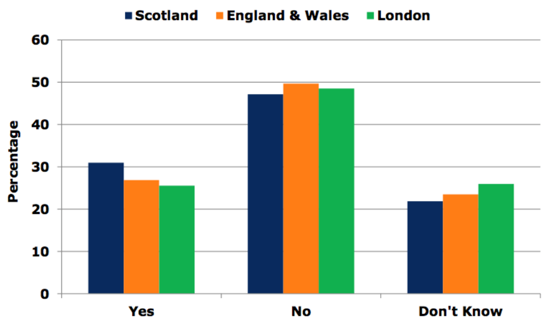
Effects of car club membership on previous car purchasing decisions



- 25-31% of all members said that they would have purchased a vehicle, if they had not joined a car club

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Zipcar Boston: Welcome the newbies

Zipcar for business in action: Next Space

5.2.2 Free-floating car sharing systems (car2go)

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Shared Mobility

Domain of application: Urban

Technology behind: Smartphones; GPS, Internet

Status: Established

Links to relevant references

- Car2go
- DRIVE NOW

Description

Concept and problems addressed. While the philosophy of classic car sharing (car clubs) focuses on:

- You donôt need an own car for your mobility
- If not daily used, itôs cheaper than an own car
- If you actually need a car, then have the right one for your specific needs

in contrary free floating (dynamic) car sharing e.g. car2go, which has been established first in Ulm, Germany and meanwhile in quite a few cities all over the world by Daimler motor car company, due to the following reasons

- Young people in urban areas less and less neither use a car, nor buy a car
- The buyer of a new Mercedes meanwhile is older than 50 years
- So people, who donôt want to buy an own car, should at least use one more often

The main differences in the working principle of dynamic car sharing like car2go when comparing with classic car sharing are:

- Pick up / drop off a car is possible freely in a defined zone of a city, as cars have no fixed positioning.
- Booking is just possible on the spot, preferably by smart phone app showing the position of the next available cars (but this is also feasible via internet or by phone call).
- The renting duration is fully flexible and does not need to be indicated when booking. Renting ends when dropping off the car.
- For registration, once a fee (if at all) applies, but neither a deposit nor a permanent membership fee is charged.
- Free usage of many public car parks in the defined zone (fees paid by the car sharing company), while on classic car sharing parking fees to be paid are under the responsibility of the user (beside at the fixed station, where a car is positioned).
- Instead of 50 different car types, the car2go fleet just consist of one type (Smart 2-seater).

In addition, the tariff structure of car2go in principle differs significantly from the one of classic car sharing. Originally (when starting in 2009) costs were charged just by booking time: ú 0.19 per minute, accompanied by maximum costs per hour / day / weekend / week respectively, without any distinction if the car is used for driving or just parked and blocked for other users to be booked. No additional costs per driving distance were charged. Fuel costs were included in the charged fee. Also no registration fee applied in the first months. This indeed very simple and easy to understand tariff structure from 2009 resulted in the acquisition of more than 10,000 users within the first months, which in majority used the offer as originally intended for one way short-distance trips within the city or region of Ulm. Unfortunately (for the car2go company) this tariff structure also enabled car usage for short-time but long distance trips at minimal costs; e.g. for a two day trip from Ulm to Berlin, with a one-way distance of 700 kilometres the costs charged were just ú 98 Euro, about 25% below the fuel costs for covering such a distance. Abolishing the day flat rate in 2010 minimised such trips, but in parallel also for a day trip to the countryside car2go became absolutely unattractive, when comparing with classical car renting, charging a day or a weekend flat, but fuel costs have to be paid by the user. So in 2011 the day / weekend / week rates came back, accompanied by a modification of time costs, now distinguishing between drive mode and park mode, where the car cannot be driven, but is still reserved for the user, bringing up the problem of long-distance trips charged below fuel cots again. In addition a prohibitive fee for using the car outside Germany was established, to reduce the shrinking of the car fleet due to theft (remember: no deposit is taken from the users). And finally in 2012 the tariff structure of car2go changed once more, now introducing a distance component in parallel to the time component of fees, similar to the tariffs of classical car sharing which remained unchanged in price and structure during the time period considered.

Targeted users. Targeted users are private persons, living in urban areas, preferably where public transport is of good quality so that car usage has decreased.

Barriers to implementation

Financial issues. For the implementation of such a system of free-floating car sharing, the operating company has to provide many cars already from the beginning when establishing such a system in a distinct town. This ensures that the users of the system have easy access to a car randomised located relatively close to their current geographic position with a high probability, as there exist no fixed locations where to pick up / drop off a car. For in the medium sized city of Ulm (200,000 inhabitants) car2go was established with an inaugural fleet of 300 cars. Obviously, such systems can only be established by large companies having a sufficient financial background to cope with such an investment. For the time being the car2go free-floating car sharing has not reached the state of financial viability, due to the limited efficiency of car usage, but the operator looks forward to achieve this in 2014.

Technical barriers. The system requires an electronic booking system, preferably implemented as smart phone app, displaying the actual location of the next available car.

Organisational complexity. In principle, this system has the same complexity than operating a classic car rental, with the difference that customers have to be registered just once. Due to the homogeneous car fleet, maintenance is less complex. On the other hand, varying locations where the cars are actually positioned affords slightly higher efforts on this topic.

Legal issues. The legal feasibility is given.

User and public acceptance. The principal user acceptance for car is given. Nevertheless the user acceptance varies strictly with the density of available cars and complementing circumstances like settlement structure or quality of public transport. The numbers of registered users in each area are very high, as this is backed by the companyœs policy, not charging any registration fees, when such a system is newly implemented in an area within the first months and also no monthly membership fees apply. However, different to a well-established classic car sharing system (car club) the usage intensity in free-floating systems is much lower: the average annual mileage per car is below 10,000 km at car2go, while values close to 30,000 kilometres per vehicle can be achieved in some classic systems). This can be characterised by: many cars rarely used by many people on rare occasions. On the other hand car sharing in general has a positive image and in addition free-floating car sharing is considered as a modern, cut-of-the-edge mobility concept, especially by people who never use it.

Interest for Travellers

Door to door travel time. Using car sharing instead of public transport may shorten travel times, while in comparison to usage of a private car a minimal extension of the time needed may apply, depending on the access distance to the position of the car sharing vehicle and the time needed for booking, check-in and checkout procedures.

Travel cost. Relying on free-floating car sharing is less expensive than owing a private car when calculating with its full costs, as long the annual mileage done by car is quite low. Higher costs apply in comparison to conventional car sharing or public transport in most use cases, but at least they beat cots for alternative taxi usage significantly.

Comfort and convenience. Due to the necessity of booking every trip, accessing the car station and undergo the check-in and checkout procedures comfort and convenience of car sharing is slightly lower than that for private car usage, while it may be more convenient to undertake a trip by car sharing than being reliant on the availability of public transport.

Safety. No significant impact expected.

Security No significant impact expected.

Accessibility for impaired. No serious effects apply for free-floating car-sharing systems.

Modal change

A modal change from public transport or taxi usage towards free-floating car sharing may apply. But if car sharing is taken for the substitution of a private car, resulting in partly undertaking some trips also by public transport, a mode shift towards public transport could also apply, although this is not the intention of the free-floating car sharing system.

Other notable impacts

Mobility. Car sharing increases the mobility of people who do not own a car, while it would slightly decrease the mobility of those who give up their car, but these are not the car2go target users.

CO2 emissions. The effect of an increased mode share of public transport is expected to be stronger than from the increase in mobility, and on balance therefore CO2 emissions should decrease.

Summary of scores

Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	úúú	D2D travel time	(✓)	Car usage	-	Mobility	(✓)
Operation and maintenance costs	€€	D2D travel costs	(✓)	Bus and coach usage	+	Congestion	(✓)
Financial viability	✓	Comfort and convenience	✓	Rail usage	+	CO2 emissions	(✓)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Car2go Tutorial video

http://www.youtube.com/watch?v=vEmYbjFNekU

5.2.3 Grass-root cooperative car sharing systems (CARUSO)

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Shared Mobility

Domain of application: Rural

Technology behind: Smartphones; GPS

Status: Experimental phase

Links to relevant references

- CARUSO Carsharing
- Carsharing 24/7
- Autoshare

Description

Concept and problems addressed. Grass-root cooperative car-sharing CARUSO is an application aiming at facilitating private car-sharing for a closed group through offering an easily accessible online platform. It enables bookings for people who need a car and for people who want to share their own car with others. The platform CARUSO is currently available as a combination of web-based user interface and a smartphone or CARUSO-Box installed in the shared car for logging. The system only provides the platform and it does not provide the car. The system can be easily implemented even in remote rural areas where no other car-sharing offers exist. The platform can be used by companies, communities and private individuals for free at the moment.

CARUSO car-sharing is mainly spread in Austria where it was founded, but there are also car-sharing groups in Switzerland and Italy. The shared cars are both conventional petrol-powered cars and electric vehicles. The shared cars belong to private persons, are cooperatively organised by group members or are leased by the municipality.

Car-sharing with CARUSO differs from conventional car-sharing but also from other forms of private or peer-to-peer car-sharing. In Austria, besides CARUSO, two other online platforms for private car-sharing exist, namely ñcarsharing 24/7ò and ñAutoshareò. The main difference is the group structure. CARUSO is a closed system of car-sharing members where the users can use only the vehicles that belong to his/her group. In most cases, users know each other before and form a group with a specific number of cars to share. The group size is up to 30 members and the group members decide the conditions for sharing a car such as tariff, car ownership and the key handling. Other private car-sharing platforms such as ñcarsharing 24/7ò and ñAutoshareò are open systems where people register and can choose cars from the pool of all registered members of the platform although there is a possibility of founding an exclusive group similar to CARUSO in one of them. The platforms for private car-sharing also differ regarding the targeted duration of using the vehicle. The private car-sharing platforms, ñCarsharing 24/7ò and ñAutoshareò offer day-based tariffs.

For car-sharing with CARUSO, it is not necessary to keep a manual logbook as CARUSO offers two generations of electronic logbooks. The first one is a special mobile phone in the car which records all trips automatically using GPS and sends the data to the CARUSO server. This electronic logbook analyses the driven kilometres of each user and even records the addresses of all stops for business trips. For private trips only the driven kilometres and the reservation note is recorded. The second generation of electronic logbook is a so-called CARUSO-Box which can be installed in the car. This box is connected to the on-board electronics of the car and records the trips automatically. Based on this data, the cost for the users can be calculated. In case electric vehicles are shared, the smartphone or the box can also indicate the battery power reserve and the mileage of the car.

One important issue for private car-sharing is the insurance. CARUSO offers a special insurance package for private car-sharing in collaboration with a regional insurance company. In Austria, for every car up to 1,500 kg, the car insurance makes use of the bonus-malus-system. In this system, each damage caused by the driver influences the level of the annual premium. The annual insurance premium conforms to the amount and frequency of damages and is classified in one of 18 levels. For people who share their own car with others, this bonus-malus-system could imply a higher annual insurance premium because more damages can happen. With the special insurance package for CARUSO users, for an annual fee of ú 30, the bonus-malus system is not applied for the insurance premium.

***Targeted users**.* Targeted users are private persons, communities, organisations or companies who want to share one or more cars effectively with each other, and those who want to use another personõs car to reduce the ownership and travel cost with vehicles. Although the users share one or more cars and the cost for it/them, this form of car-sharing generally does not seek for generating profit and thus it does not target those who want to earn through car-sharing.

Barriers to implementation

***Financial issues**.* The CARUSO platform, which is still in an experimental phase, receives currently public funding. The fixed costs are one-time payments for the smartphone or the optional CARUSO box installed in the car. The price for buying the CARUSO box is about ú 500 one-time and ú 21 monthly. At the time of writing this the CARUSO platform is in an experimental phase without any detailed information about financing.

***Technical barriers**.* In the older version using an on-board smartphone for logging, it had to have a wake-up function that the smartphone automatically starts when the vehicleõs engine is turned on. Among smartphones available in Austria, ones with such function were fairly limited and practically only one model from a Finnish manufacturer was available; however, the production of this model was discontinued and thus there were no smartphones available to be used as an on-board device. This was a barrier once, while this problem was solved with a development of the aforementioned CARUSO-Box

Organisational complexity. The CARUSO booking system can help to minimise the organisational complexity for administrations. For municipalities which offer car-sharing for their citizens this only involves a low effort because the people can easily book the cars by themselves. Due to the automatic on-board recording, the organisational complexity of calculating the costs for each user can also be kept on a minimum.

Complexity could increase with a growing number of group members. Somebody should take care of the condition of the car in terms of fuelling or cleanliness which is made difficult by an increasing number of car users. The sharing of electric vehicles can also lead to a higher complexity. Due to the limited driving range of electric vehicles, the charging time and location have to be planned in advance.

***Legal issues**.* The largest problem is the vehicle insurance. Although CARUSO offers a special insurance package with the support of a regional insurance company, problems can occur when shared cars are seriously damaged and the question of responsibility in such case is unsolved. Another important point is the national legal framework for renting a car which can differ from country to country. For example, in Austria, car-sharing is seen as a commercial activity if it is profitable (e.g. if the price for car-sharing is equal or higher than the government-set travel cost per kilometre). Thus, as far as CARUSO remains unprofitable, this problem does not arise, while once it becomes profitable, much complexity is foreseen in this term.

***User and public acceptance**.* Acceptance of car sharing systems is on the rise.

Interest for Travellers

Door to door travel time. Private car-sharing can reduce the door-to-door travel time especially in remote rural areas with scarce public transport for those who do not have access to cars. One important factor is the location of the car-sharing car as the access time to the car matters. In municipalities which offer car-sharing the car is located mostly in front of the municipal office which is centrally situated.

Travel cost. The costs for car-sharing differ in each CARUSO group as every group can choose the price model best suitable for their members and their usage and thus it is difficult to generalise the travel cost although cost per-km tend to set lower than the actual per-km user cost. CARUSO reduces the travel costs in terms of the fixed cost related to car ownership. Approximately 80% of the conventional car costs are estimated to be fixed costs that the owner has to pay even if the car is unused most of the day. Sharing a car on a private basis is cheaper than owning a car and is even cheaper than conventional car-sharing in that such fixed cost can be shared among the group members.

Comfort and convenience. Grass-root cooperative car-sharing platforms are increasing the convenience for people who want to share a car, especially in remote rural areas with scarce public transport and where no other car-sharing offers exist. People can be flexible without owning a (second) car. The ease of using the CARUSO booking system offers high convenience even for people with little experience of the Internet. One future development will be the function to offer ridesharing.

Safety. It is possible that members of private car-sharing groups such as CARUSO are driving more cautious with the shared cars. In contrast to conventional car-sharing schemes, in private car-sharing groups like CARUSO, the people know and trust each other and thus they tend to feel responsible for the other group members and the cars. Through that they drive the car more carefully.

Security. No impact expected.

Accessibility for impaired. At the moment, no particular platform for the mobility-impaired is provided. Should this be used to share a special vehicle for the mobility-impaired, accessibility for them will be increased. However, in such case, the user interface has to be updated to suit it.

Modal change

The availability of a car on 24/7 basis definitely improves mobility for people not owing a private car, while for people formerly owing a private car, mobility is almost constant.

Other notable impacts

CO2 emissions. Through private car-sharing, a second or even the main car can be saved within a household. If people in urban areas do not buy a car because they can share one, they are likely to make more trips by public transport. Due to a higher awareness of the own mobility behaviour and with the possibility of rideshares, greenhouse gas emissions can be potentially saved.

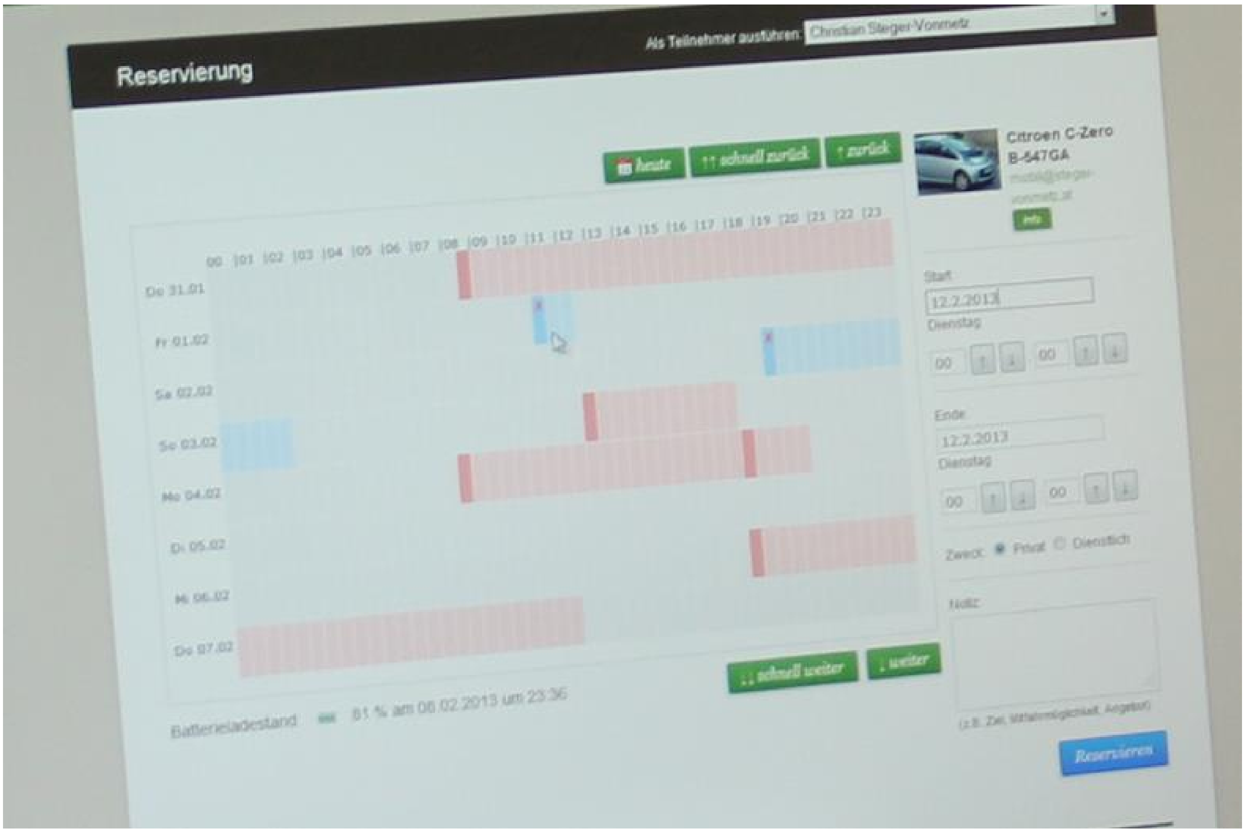
Furthermore, private car-sharing with electric vehicles is a good possibility to make such vehicles accessible for more people. As the driving comfort with electric vehicles is very high (at least in warm weather), this could lead to a positive attitude towards electric vehicles. Moreover, people will be encouraged to buy electric cars that they can share for short journeys, because they know they can get a petrol car for a longer journey from another member of the group for a longer trip, for which the batteries of an electric car are not sufficient.

Summary of scores

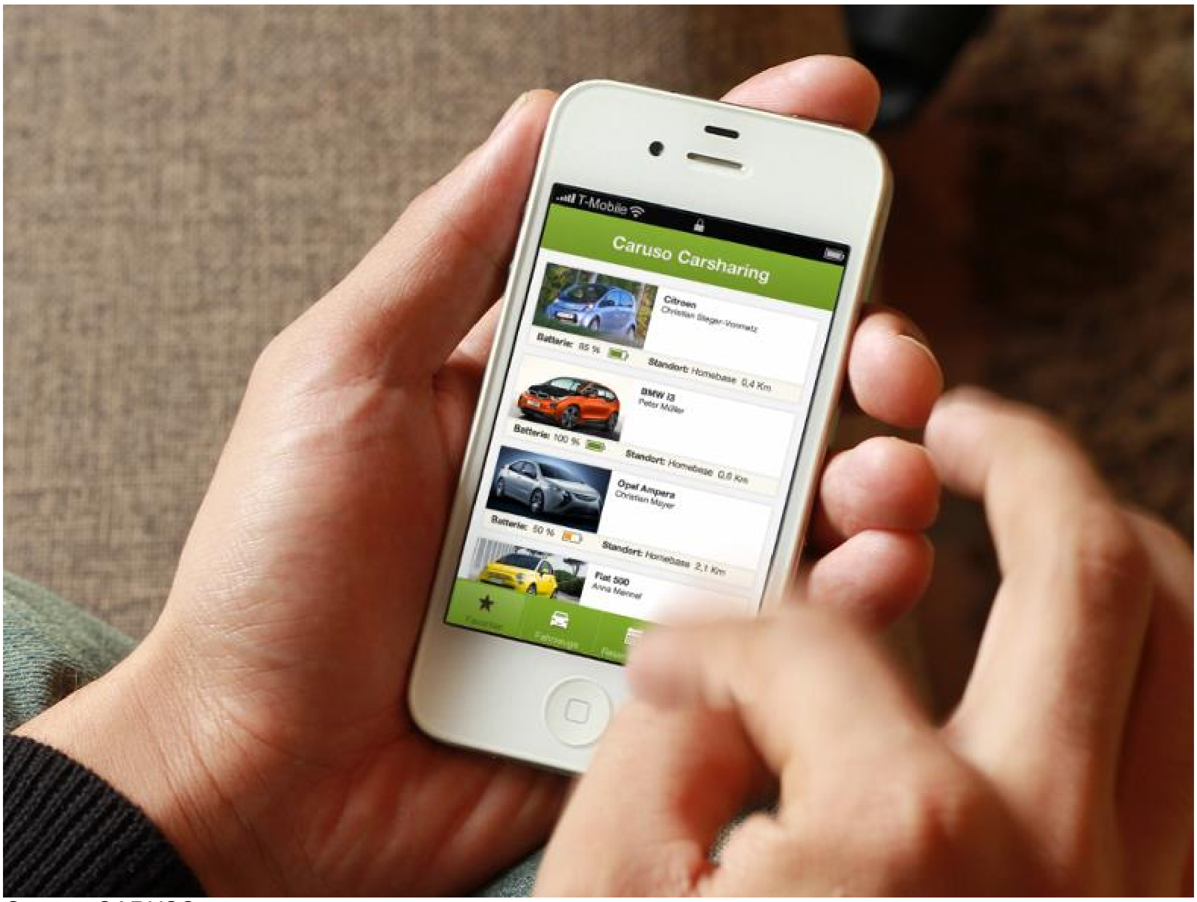
Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€	D2D travel time	(✓)	Car usage	(-)	Mobility	✓
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	(+)	Congestion	0
Financial viability	✓	Comfort and convenience	✓	Rail usage	(+)	CO2 emissions	✓
Technical feasibility	0	Safety	(✓)	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

CARUSO website

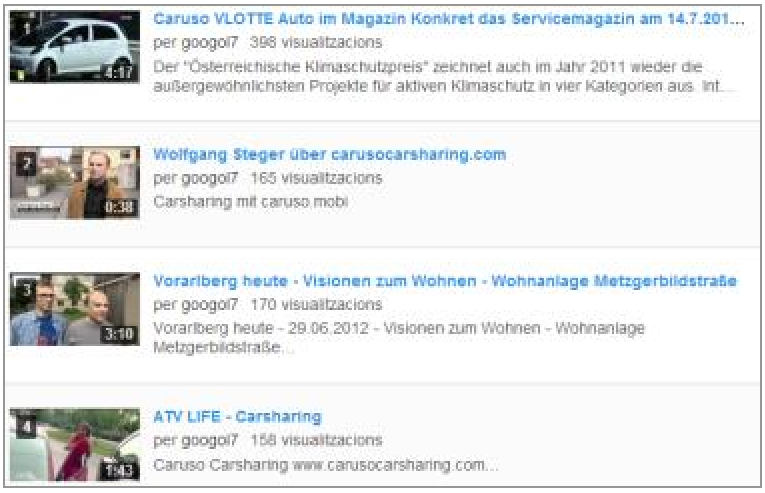


CARUSO mobile website



Source: CARUSO

CARUSO YouTube Channel



http://www.youtube.com/playlist?list=PLF01C4F5A824063D4&feature=mh_lolz

5.2.4 Carpooling, share-a ride schemes, booking systems (Mitfahrzentrale)

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Shared Mobility

Domain of application: urban

Technology behind: Social Networking, location based services

Status: Implemented

Links to relevant references

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Description

Concept and problems addressed. Car sharing and pooling technologies are live planning and booking systems designed to link car sharing providers, lift and ride share participants, and potential users. A distinction is made between car sharing and car clubs, which typically provide access to vehicles alone; and car pooling, where the driver and passengers share a ride. This factsheet addresses car pooling.

Car pooling provides an opportunity to share a trip with passengers travelling from similar origins to similar destinations, and will include a planning function in which drivers and potential passengers are brought together. A number of examples of good practice have existed since the 1970ôs including the German ñMitfahrzentraleò originally a manual system of posted trips often used by students as a result of the location of trip advertising in student oriented travel agencies. Examples of similar pooling schemes are noted in the USA (Pool-It) with more ad-hoc park-n-share schemes supported in Northern Ireland with fixed infrastructure provided by the DRD Roads Service (Tapestry, 2010[26]).

[26] http://www.max-success.eu/tapestry/www.eu-tapestry.org/p_dwl/csr/csr_c10_n_ireland.pdf

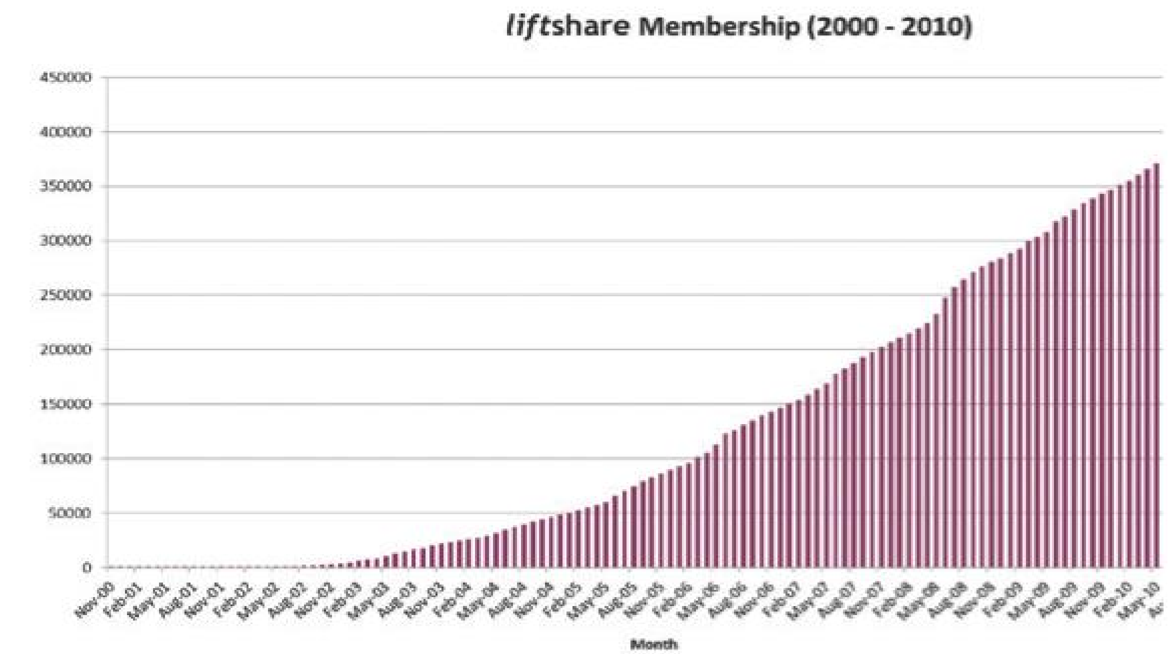
The development of booking technologies, particularly those based on web access and recent mobile applications, such as flinc[27], have allowed for the extension of the concept to a wider audience including regular commuting trips, and trip combinations adding reliability and booking apps similar to commercial offerings in the taxi-market.

Car pooling benefits can be measured across a number of metrics (Fellows and Pitfield, 2000), with the majority suggesting both economic and environmental benefits. In some schemes, such as the car pooling scheme in Singapore, the availability of services is suggested to result in car ownership suppression (Foo Tuan Seik, 2000), or in terms of diversion effects (TCRP, 2005) of around 20% movement, although this study includes car clubs in their definition.

A number of countries have sought to encourage multiple occupancy vehicles through the provision of High Occupancy Vehicle Lanes (HOV Lanes), in which only vehicles with two or more passengers are allowed to drive.

Three genres of technologies are defined: Manual, On-line and via social media. Manual technologies continue to play a role in an informal setting, such as workplaces and student venues, whilst the majority of systems have moved to automated paring algorithms. In the UK a number of councils have developed a common platform in Tripshare with some local branding (see: DGtripshare.com) but using a common planning platform. The development of liftshare schemes has been consistently growing in most countries since introduction, see table 1, with company schemes reporting the most significant shift from single occupancy vehicle use to multiple occupancy, table 2. On-line and app based systems mirror many of the technical attributes of their commercial car sharing cousins, such as UberX (UBER), and Lyft, but differ in the aims and commercial focus of their provision. This said, real technical differentiation is more readily seen in social media based schemes, such as Texxi.

As the systems encourage multiple occupancy, regardless of the booking technology, it is appropriate to consider the effect of multiple occupancy schemes on travel patterns, though the financial viability of each will vary dependent on the structure of and ability to charge for use.



Source: ITP et al 2004

Proportion of staff sharing before and after car-sharing interventions

Targeted Users. Local and regional authorities, employers, universities. The targeted end users for this application are lone drivers and occasional trip makers with an interest in trip sharing.

[27] https://flinc.org

Barriers to implementation

Financial issues. The costs of using trip share software are relatively low at point of use, with the majority of schemes not charging for parings. System costs are typically borne by the authority providing the scheme. The RAC foundation (Cairns, 2011) suggests in investment cost in the region of £25,000.

Technical Barriers. There are no technical barriers, these system are widespread.

Organisational Complexity. Organisational structures reflects the nature of the booking systems and the need to determine rides available for share. The basic organisation is therefore based around the provision of a notice board, whether electronic or provided by any other means. The extent to which complexities may arise is dependent on the number of users, the spatial areas covered, and the desire to maximise market share. A number of systems have concentrated on niche markets, including the use of a branded system in local authorities, in which instance a series of additional relationships and organisational structures will be required. Alternative models exist for those which cross boundaries and international borders. Many of these are associated with matching organisations, such as the ADAC (German automobile club), and such business models include inherent difficulties in national infrastructure and legislation. Extension of the basic system, that of an advert based exchange, which may include an element of tracking and personal identification, maybe justified on the basis of individual security and safety, but will also increase the complexity of organisation.

Legal Issues. In its base form, the exchange of information advertising lifts, the car sharing technology faces only limited legal liability. This increases, however, in relation to the provisional transport itself, with some of the carriersô liability related to individual safety and exchange of information. Whilst the majority of schemes seek to limit liability to that related to advertising, it is unlikely that all liability for trip safety can be avoided. Appropriate measures include the identification and certification of traveller identity, appropriate safety checks, and provision of feedback. Transnational transport may be affected to a greater extent than that entirely within the boundaries of any one nation state. Additional responsibilities will arise in relation to the handling and storage of personal information, and personally identifiable data. Legislation related to the maximum that may be charged for lift sharing exists in some countries, including the United Kingdom, typically related to the cost of fuel, and this will also be relevant to the operator.

User and public acceptance. Systems that facilitate car pooling through automisation of the process, have proven to be popular with who implemented them. Acceptance by end users is high, since most of the users are of the younger age groups well familiar with computerised systems. Acceptance of non-users is not an issue, since they are not even aware of the systems.

Interest to travellers

Door to door travel time. The automated systems allow the use of car pooling by many more users than manual systems would allow. For those users who would have used their own car instead, travel time may slightly increase, but for those who would have depended on public transport the travel time will in many cases decrease substantially.

Travel cost. The car sharing technologies described above provide an opportunity to share and reduce individual travel costs.

Comfort and convenience. Lift sharing schemes can provide significant improvement in comfort compared to some public transport modes, as the journey itself maybe more direct and quicker. Such gains will not be possible, however, in comparison to personal private transport available to individuals using their own car.

Safety. No impacts on safety expected

Security. A significant issue arises from the fear of inappropriate passenger all driver, with an increasing need to provide levels of assurance as to the suitability of the fellow traveller. Knowledge of systems remains low, with the most significant benefits arising from work schemes, trip sharing schemes run specifically for the benefit of an individual company or a group of companies. This reflects the benefit of a known audience and potential from recourse in the event of issues arising. Council based schemes, and those operating in wider areas continue to display issues in knowledge of fellow traveller, and a need for assurance.

Accessibility for impaired. It is unlikely that car sharing provides significant improvement for impaired travellers.

Modal change

A significant amount of data exists to suggest that car sharing schemes have an impact in mode shift. Mode shift in this respect reflects movement from private individual transport to shared transport, but may also include a diversion from public transport modes to private vehicles.

Other notable impacts

Mobility. Car pooling increases the mobility of non-car owners

Congestion and CO2 emissions. Where car pooling passengers are changing from using public transport, there is no effect on congestion and only a very marginal one from the increase of the carǿs weight for emissions. But where passengers leave their own car at home, they contribute to a reduction of congestion and emissions.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	(√)	Car usage	√	Mobility	√
Operation and maintenance costs	€	D2D travel costs	√	Bus and coach usage	X	Congestion	(√)
Financial viability	0	Comfort and convenience	0	Rail usage	X	CO2 emissions	(√)
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	(X)	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	√						
Public acceptance	0						

Illustrative Materials

http://youtu.be/E3Y-pHXRcTo

http://www.mitfahrzentrale.de

5.2.5 Shared bike scheme management system

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Shared Mobility

Domain of application: Urban

Technology behind: RFID; GPS; Smart-Card technology

Status: Implemented

Links to relevant references

- Bicycle-Sharing Schemes: Enhancing Sustainable Mobility in Urban Areas by Peter Midgley, United Nations, Department of Economic and Social Affairs, 2011
- Optimizing Bike Sharing in European Cities. A Handbook by OBIS, 2011.
- The Open Bike Share System, Copenhagen
- Bike-Share Schemes Shift into High Gear by Josie Garthwaite, National Geographic, 2011.

Description

Concept and problems addressed. Bicycle sharing schemes comprise short-term urban rental schemes that enable bicycles to be picked up at any self-service bicycle station and returned to any other station after use. Over the past ten years, bicycle-sharing schemes have been developed from being interesting experiments in urban mobility to mainstream public transport options in a large number of cities. Bicycle sharing schemes are aiming at integrating, expanding and promoting cycling in transport systems. Mobility choices for people can be increased, air quality can be improved and congestion can be reduced. Bike sharing schemes also serve as a missing link in the public transport system. Public transport is often integrated in bike sharing schemes through information (e.g. station locations on bike sharing maps) or physical integration (bike sharing stations are often located near public transport stations for Bike & Ride). System and fleet maintenance and management is a key aspect of bike sharing schemes for ensuring the bike sharing system is in good operating order and sufficient bikes are available. For that reason, it is likely that bicycles have to be redistributed from one station to another from time to time (e.g. peak times for business or because of topographic conditions). Information about bicycle usage and location is mostly gathered through GPS units, Radio Frequency Identification (RFID) tags and any other means used to track bicycle locations. Bike fleet and station maintenance (e.g. filling tires with air, repairing lock mechanisms) is very important to avoid downtime and rationalise maintenance, but also with regard to safety and liability issues. Operators get the needed information commonly over networked bicycle stations which communicate with a central computer system and RFID technology. Most operators are using websites and mobile applications which provide users with general information about the scheme, registration opportunities and real-time information about stations and bikes depending on the current position of the user (see figure).

Source : City bike wien

Screenshot ñCity Bikeò (Vienna): Location of stations and availabilities of bikes,

According to the hardware used at stations, the most common type of bike sharing station includes electronically controlled docking points for locking the bikes and a rental unit. These rental units (terminal or at the docking point itself) can include touch screen displays, card readers, RFID reader printer and keyboard. The software used in bike sharing schemes is needed to operate the system at the back-end (IT systems on operator´s side, invisible to customer) and at the front-end (all IT systems with interaction and usage opportunities for customers).

User identification in bike sharing schemes is diverse. It is provided by card-, mobile phone, or key-based identification or sometimes by a person in charge (manual, especially in small scale systems). Most schemes offer (smart)card-based access, where the bike can either be rented at a terminal or at the bike itself if the bike provides a card-reader (e.g. Stockholm, Vienna). Different type of cards can be used, such as magnet-/chip-/credit cards or Radio Frequency Identification (RFID) cards. RFID technology provides contactless communication and removes the need for card-reading slots which often become defective. In mobile phone based rental systems, the user calls a number or sends an SMS with the required data to a central number and, if identified, gets an access code or any other access information onto the mobile phone (e.g. Deutsche Bahn, Call a Bike, Germany). Then, the access code is inserted into an electronic or mechanical device at the lock or the docking point. Some systems, especially in Italy, offer key-based access. The users receive the key for a bike from a device or kiosk where they have to identify themselves before the rental.

For the assessment of impacts it needs to be noted that any serious bike sharing scheme, one that goes beyond the traditional bike rental as for instance frequently found in holiday resorts, can only function with the help of an automated management system, and therefore all of the benefits of bike sharing can be attributed to the automated system.

Targeted users. Advertising companies, street furniture providers or public services are targeted users for bicycle sharing scheme management systems, also publicly or privately owned transport companies (e.g. ñCall a bikeò, Deutsche Bahn, Germany), bike sharing businesses (e.g. ñNextbikeò), municipal operators or associations and cooperatives. The target of bike sharing schemes is shifting transport in the direction of using bicycles, thus the main targeted end users are people who do not use bicycles regularly.

Barriers to implementation

Financial issues. From an operational point of view the main costs can be divided in infrastructure & implementation and running costs. Implementation costs in large-scale systems add up to ú 2,500 to ú 3,000 per bike, depending on the system configuration. Running costs in large-scale systems are stated as ú 1,500 to ú 2,500 per bike and year (Source: OBIS). The main financing sources from an operational point of view are registration charges and usages charges paid by the customer, thus subsidies are needed for most bike sharing schemes. Depending on the type of contract between the operators and the administrations, the scheme is co-financed by direct subsidies, various advertising contracts, sponsorships, parking enforcement incomes or congestion charges making this financially viable for the operators; for the local authorities the ñreturnò of investment is the social benefit of cycle use, mainly in term of reduced congestion and emissions. In some cases, the concentration of the returned bicycles at certain stations can impose higher operational costs. To avoid this, a special bonus system has been implemented in Paris, where users get an additional 15-minutes credit for returning bicycles to specific stations, particularly those on hills. This bonus system encourages people to return bikes to underused stations and can therefore lead to a reduction of operational costs.

Technical barriers. Technical problems can occur with defective docking stations, bikes or rental terminals. Especially card-reading slots are vulnerable to failures.

Organisational complexity. Usually a contract between the municipality and the operator of a bike sharing scheme is agreed. The model of infrastructure and operation for which a single operator is responsible is the most common contract type. Organisational problems can occur when the infrastructure owner and the operator differ from each other. Beside possible organisational difficulties, another challenge is that if the bicycle sharing scheme is not installed in adequate size, an impact onto the transport system cannot be expected. Therefore, it is important to implement a scheme quickly, as it was the case in Paris: the initial 700 docking stations and 10,000 bicycles were installed in less than six months and the system doubled in size six months later. The speed of implementation was in this case the source of success.

Legal issues. There are no legal obstacles to this application.

User and public acceptance. Shared biking systems are in general well accepted in many European cities, even though there have been claims in the past that they are too expensive for the service they provide.

Interest for Travellers

Door to door travel time. Bike sharing systems can remarkably reduce the door to door travel time for users by providing a fast urban transport mode (sometimes even faster than public transport) and by serving as a missing link in the public transport system. The bikes can be used for short distances in the city or for the last mile from the public transport station to home. For ensuring reduced travel times a specific density and availability of docking stations and easy access to the bikes must be provided.

Travel cost. Registration is required in almost all bike sharing schemes to avoid the loss of bikes and to ensure billing and payment. Registration costs differ from ú 0 to some tens of ú depending on the registration period. The charges are mostly cheaper than other modes of transport and often include a free rental period of 30 minutes for each ride within the registration period. Some systems, notably in France, require a substantial deposit at the end of registration. The rental price increases exponentially after the free period with a high daily maximum. In other schemes the rental period with costs starts from the first minute with a linear charge per time unit reaching a lower daily maximum. Most bike sharing schemes also include fines or the userõs deposit for not returning or damaging bikes. But for the end users travel costs are reduced at large.

Comfort and convenience. Bike sharing schemes can increase the convenience of people by providing an additional possibility to public transport, especially for short distances in cities. Thus, inconveniences like crowded public means of transport or congestion can be reduced. Through a dense network of bike stations and easy access, users can enjoy an increased flexibility on their daily ways.

Safety. Regularly controlled and maintained bike fleets can account for higher safety for bike users (enough air in tires, control of brakes, lights, etc.). Therefore a comprehensive planning for maintenance is very important in shared bike scheme management systems. Furthermore, the successful implementation of bike sharing systems will most likely attract more users and therefore increase the demand for new cycling infrastructure. This may lead to a safer and more bike-friendly environment. However, where cyclist have to share the general road space with cars and do not have a dedicated cycle lane network, they are the most vulnerable road users with a far higher rate of serious accidents than car passengers.

Security. There are no expected impacts on security.

Accessibility for impaired. There are no impacts on the accessibility for impaired.

Modal change

The implementation of bike sharing scheme management systems can positively influence the modal split through a higher usage of bikes and the combination with public transport (ñmissing linksò supporting a consistent public transport system). Bike sharing schemes are increasing the attractiveness of riding a bike through easy and flexible rental and return facilities and also through charges that are cheaper than other modes of transport.

Other notable impacts

Mobility. The bike sharing schemes make it easier to get around a city. They will also encourage tourists to explore a city more widely than they would have done on foot. Both issues make a contribution towards increasing mobility.

Congestion and CO2 emissions. With more people using bike sharing systems, congestion and greenhouse gas emissions can be reduce and thus air-quality can be increased.

Summary of scores

Feasibility		Interest for Travellers		Modal Change		Other Impacts	
Investment costs	€€	D2D travel time	✓	Car usage	-	Mobility	(✓)
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	+	Congestion	✓
Financial viability	0	Comfort and convenience	✓	Rail usage	0	CO2 emissions	✓
Technical feasibility	0	Safety	0	Ferry usage	0	Contribution to user pays principle	0
Organisational feasibility	0	Security	0	Aeroplane usage	0	European economic progress	0
Administrative burden	0	Accessibility for mob. imp. passengers	0			Territorial cohesion	0
Legal feasibility	0						
User acceptance	✓						
Public acceptance	✓						

5.2.6 Shared Car Parking - We Smart Park

Solution family: Shared Mobility and Demand Responsive Transport

Sub-family: Shared Mobility

Domain of application: Urban

Technology behind: RFID, cloud

Status: Implemented

Links to relevant references

- WeSmartPark brochure
- WeSmartPark booking site
- WeSmartPark youtube channel

Description

Concept and problems addressed. WeSmartPark is a start-up business created in Barcelona in 2013, where people owning car parking spaces that are not being used over important periods of time can enrol to share them with other drivers. Users of this service register their parking spots on a pool allowing other members of the club to use them. Income raised from using pooled car parking is then shared at equal parts between the company and the owner of the car park.

WeSmartpark has estimated that each day 375,000 vehicles access Barcelona while there are only 280,000 parking spaces available. It also estimates that private parking spaces are empty for over 40% to 60% of the time. In making possible that private parking owners advertise their free parking spaces for the time of the day they do not need their bay, the available parking spaces are doubled in the city, and at the same time the private parking spaces become more profitable.

The pool of car parks is currently based on businesses and institutions (e.g. hotels) being able to provide several car parks at once in their buildings (10 to 20); in the starting phase, this makes it easier to manage the pool. In the mid term, the system can be extended to other general citizens. WeSmartPark is a similar concept to grass-root car sharing (e.g. CARUSO in Austria), only that instead of sharing a car, users share car parking spaces.

The functioning of the system is as follows:

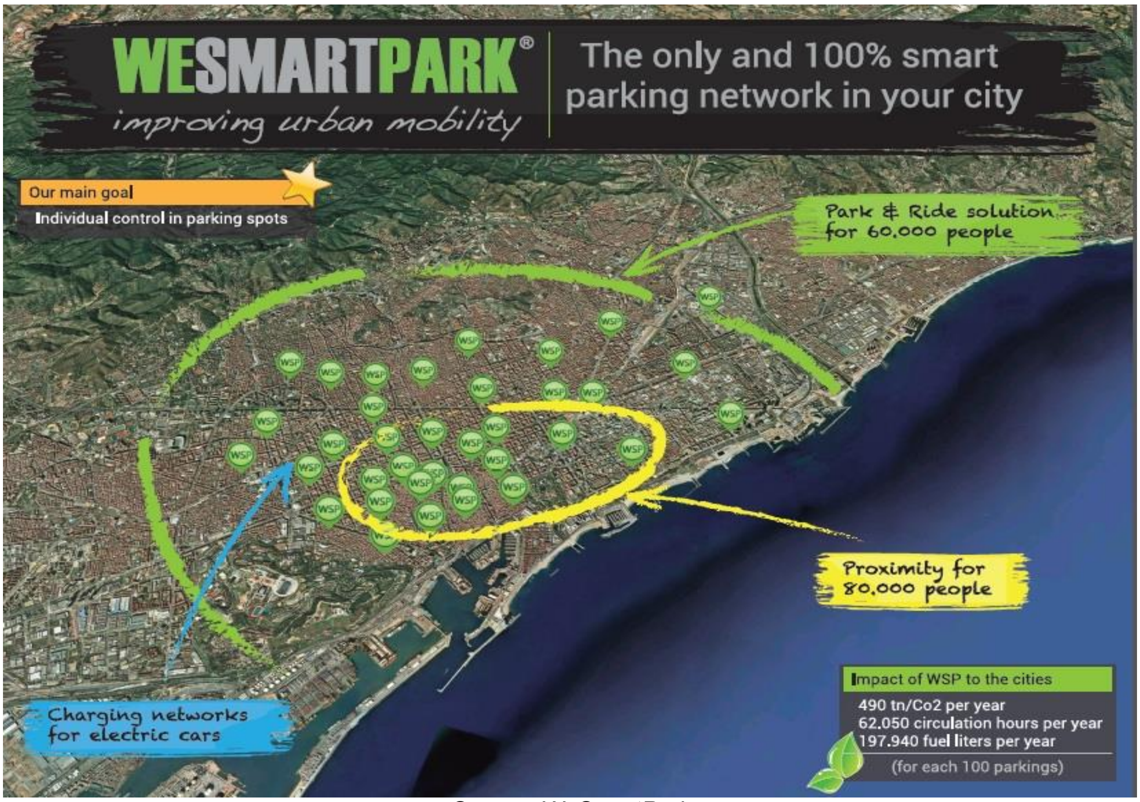
- Car park owners need to register WeSmartPark◊s pool, then the company installs free of charge the necessary equipment in their parking to allow car access and guidance. Equipment basically consists of an RFID reader at the entrance of the parking to allow vehicles in and out, and guidance signals to WeSmartPark spots within the parking. Installation can be done as fast as in 48 hours.

- Drivers register in the system and then they are sent an RFID card home. The system operates like common prepaid public transport smart cards (e.g. London◊s Oyster, Parisô Navigo), the user charging an amount of money in the card to operate. Once with a budget in the card, users can book car parks via the internet at home or via the mobile app AparcaYa (Park now), which informs the driver about the available parking spaces near his location. Users pay according to the length of their stay, at about half the fare of conventional park houses. When users get to the parking where they reserved a car space, the WeSmartpark system detects the car at the entrance, and if the reservation is correct, automatically lets them in.

Source: WeSmartPark
Car access and guidance control in park houses

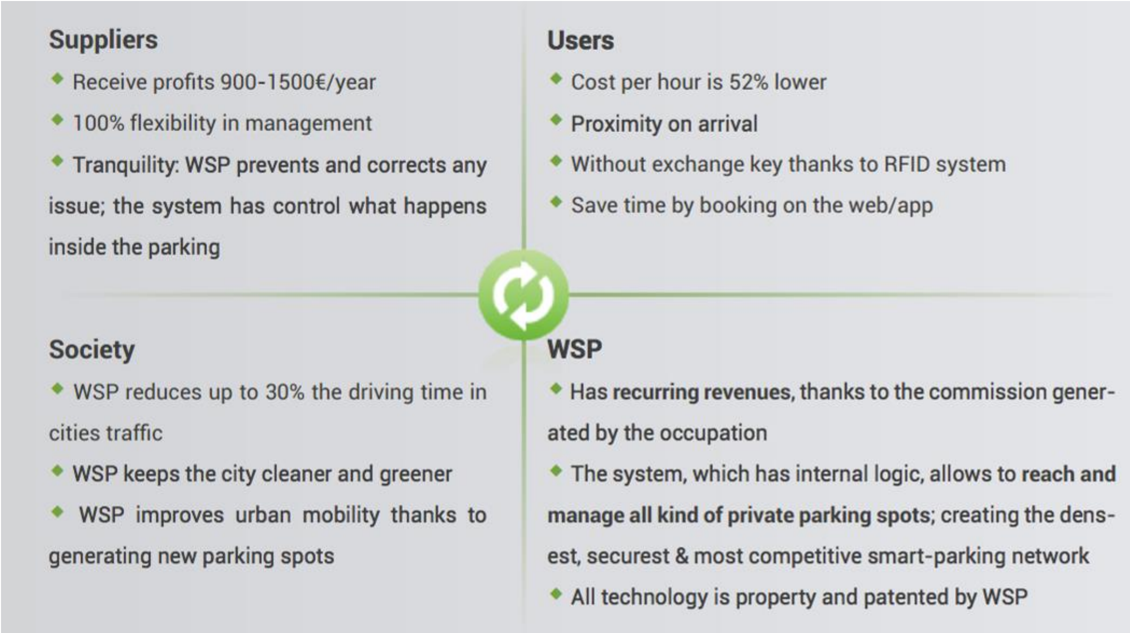
The WeSmartPark system can be summed up in the following characteristics:

1. Provides a large parking network in the city at a price 52% cheaper than the rest of the supply, with the highest number of park points close to the actual user destination.
2. The ability to book their parking spot at home or real time thanks to its WSP App with geolocation and directions to the spot selected.
3. Generating income for owners of parking spots at times when they are not in use.
4. Controlling access without exchanging keys and individualised internal control to prevent abuses and inconveniences.
5. Optimising the spots allocation depending on / according to supply and demand in real time.
6. Zero investment for users (the owner does not invest in installation costs, does not pay fees, only earns money)



Source: WeSmartPark
Currently available car parks in Barcelona.

Targeted users. Car drivers driving into the city, especially commuters. Owners of underused car parks.



Source: WeSmartPark 2013

Impacts of WeSmartPark on different groups of Stakeholders.

Barriers to implementation

Financial issues. The operator makes a profit based on keeping 50% of the revenue generated by parking sharing.

Technical barriers. The technical solution requires a relatively complex management software to handle reservations and monitor car park availability in real time. It needs basic equipment to be installed in park houses, mostly RFID detectors at entrances and guidance signalling to WeSmartPark parking spaces.

Organisational complexity. The organisation of the system is centralised by the WeSmartPark company, in charge of bringing users and owners into contact via their computer and smart phone applications. The largest organisational issue for WeSmartPark remains on the side of owners of car parks, whenever park houses are based on a horizontal ownership regime (e.g. multiple owners of car parks in one single park house). For one single owner to allow WeSmartPark to manage his own car park, he may need permission of a certain share of the owners of other car parks (60% in Spain). Of course, a private car park house may get organised as a whole to enter in the WeSmartPark pool.

Legal issues. No relevant legal issues exist.

User and public acceptance. User acceptance is likely to be high, both by car drivers who get to pay less for parking and eventually may find car parks closer to their destination; and by car park owners who earn an additional income for their underused car parks. In general, sharing initiatives are on the rise in Europe, and are well perceived by the society at broad.

Interest for Travellers

Door to door travel time. Travel time is reduced compared to those searching on-street spots. In comparison to those searching for parking in large parking houses, search time is still reduced in cities where there is no central parking guidance system. For all traffic, users and non-users alike, parking search time is reduced to the higher availability of parking spaces.

Travel cost. Parking cost is reduced by 52%, compared to average parking prices.

Comfort and convenience. The convenience of car commuting and driving into the city is likely to increase with car parks closer to destination at a cheaper fare.

Safety. No relevant impacts expected.

Security. No relevant impacts expected.

Accessibility for impaired. No relevant impacts expected.

Modal change

This initiative could bring a certain increase in car commuting in and out of cities, if only slightly, given the fact that car parking in the city becomes easier and cheaper, and also that freeing car spaces to go work by car owners becomes a source of income.

Other notable impacts

None relevant expected. Any gain is reducing car park searching time, may be offset by more people using their cars.

Summary of scores

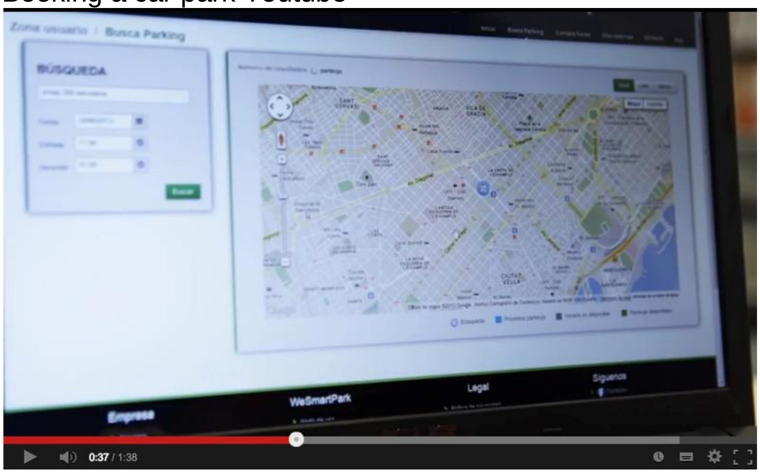
Feasibility		**Interest for Travellers**		**Modal Change**		**Other Impacts**	
Investment costs	€	D2D travel time	✓	Car usage	**+**	Mobility	**0**
Operation and maintenance costs	€	D2D travel costs	✓	Bus and coach usage	**-**	Congestion	**0**
Financial viability	✓	Comfort and convenience	✓	Rail usage	**0**	CO2 emissions	**0**
Technical feasibility	**0**	Safety	**0**	Ferry usage	**0**	Contribution to user pays principle	**0**
Organisational feasibility	**(X)**	Security	**0**	Aeroplane usage	**0**	European economic progress	**0**
Administrative burden	**0**	Accessibility for mob. imp. passengers	**0**			Territorial cohesion	**0**
Legal feasibility	**0**						
User acceptance	✓						
Public acceptance	✓						

Illustrative materials

Parking a car Youtube

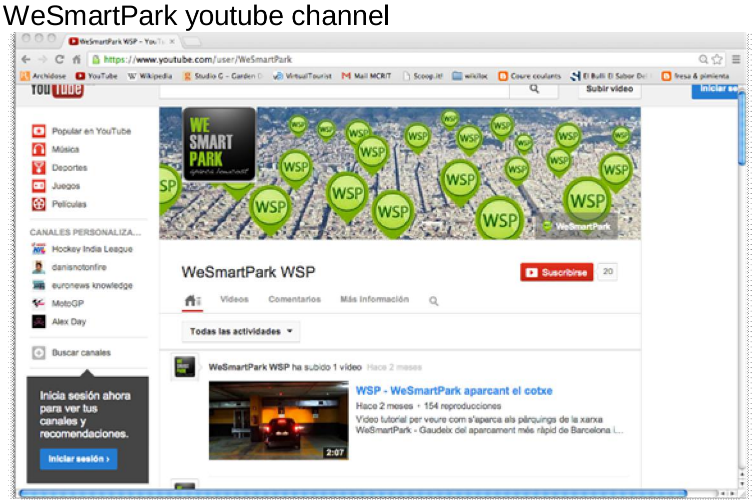
https://www.youtube.com/watch?v=L0AVMeL66_4

Booking a car park Youtube



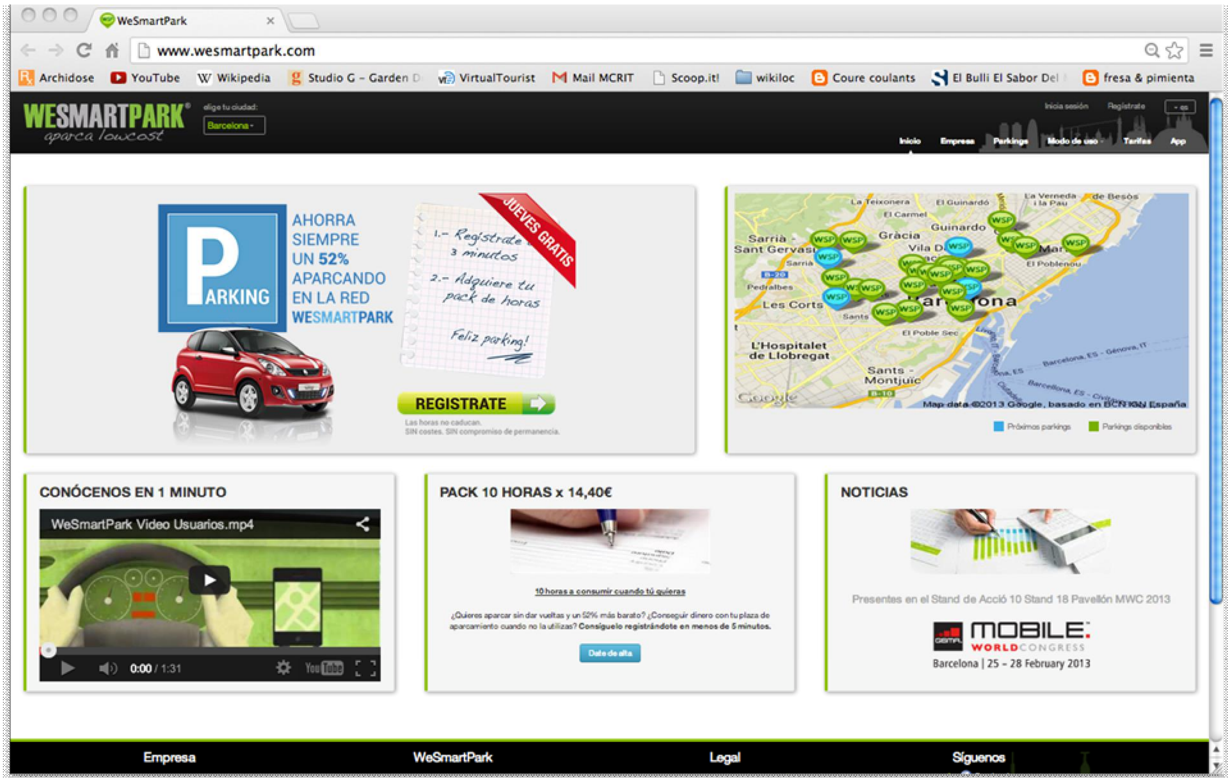
https://www.youtube.com/watch?v=NYhmOSuJFrs

WeSmartPark youtube channel



https://www.youtube.com/user/WeSmartPark

WeSmartPark homepage



6 BUSINESS MODELS

6.1 GENERAL APPROACH TO BUSINESS MODELLING IN COMPASS

6.1.1 General Approach to business modelling in Compass

The illustration of the benefits, including those about the money earning logic, and of the viability of selected ICT solutions is among the purposes of business modelling in COMPASS. Here, a handy guide to the elements of success of the applications favouring seamless co-modality under the business and decarbonisation points of view is presented. A set of **prototype business models** (BM)[28] is shown in this section, to be considered as reference for the business community and other stakeholders. Such models describe innovative configurations that organisations should aspire to become and that they can use to guide strategic transformation in organisations. In the project logic, the models give the fundamental operational elements to help the promotion and use of the selected ICT solutions in co-modal passenger transport.

6.1.2 Business modelling: value creation in different approaches

Business modelling approaches are under continuous investigation by scientific research, as well as in strategic planning and by business operations managers. Actually, there is no standard definition for BM; in this work the definition given by Osterwalder (2004) is adopted. He provides one of the most complete works among all those trying to provide a BM ontology, with a straightforward approach describing the BM as the *"a representation of how a company buys and sells goods and services and earns money"* (Osterwalder, 2004) or, differently put, the business model can be seen as *"an abstract representation of the business logic of a company" (Osterwalder, 2004)*. More in details, *"business model is a conceptual tool containing a set of objects, concepts and their relationships with the objective to express the business logic of a specific firm. Therefore we must consider which concepts and relationships allow a simplified description and representation of what value is provided to customers, how this is done and with which financial consequences" (Osterwalder, 2004)*.

Different schools contribute to develop the concept, the approaches, the instrument for analysis and the real-life application of the scientific results of business modelling; each author has its own view of the process and of the outcomes of business modelling. In some cases, the approaches present significant differences among each other in their process and outputs, and can therefore be used in different sectors and context. See the Osterwalderõs Business model ontology (2004) for a complete review of the many approaches.

[28] Conceptual business models that can represent a target model for business players in a real world situation (see also Osterwalder, 2004). They are not company specific and can therefore be customised by different enterprises working in the relevant industry sector

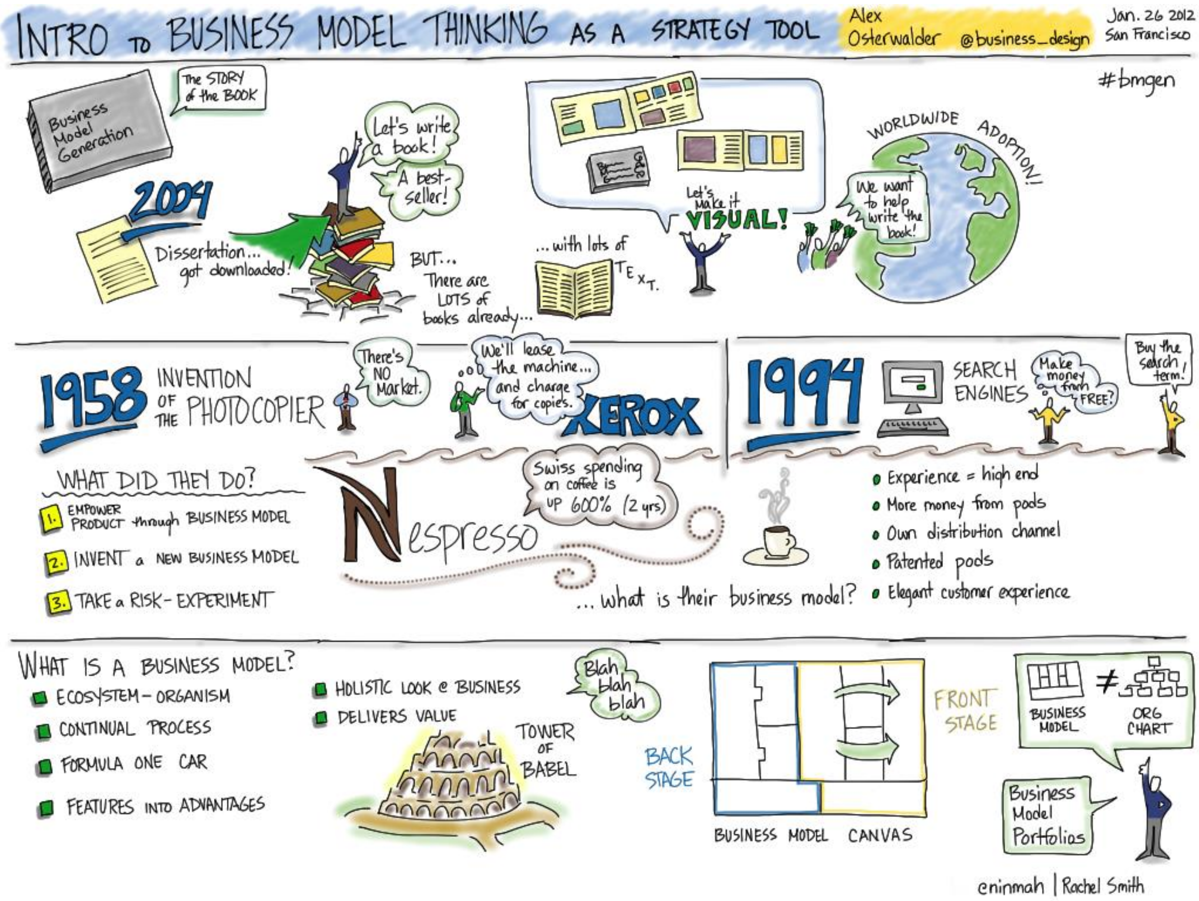


Figure 6-10 Business model thinking

At the enterprise level, it is possible to find low degree of diversification in the approach and of the results of business modelling across industry sectors. One of the reasons underpinning such observation is the senior businessperson should always know where and how ñto make moneyòand in this way he should orient the analysis of the required infrastructure to the most synthetic and effective outcomes.

In any case, we may agree with Osterwalder when he explains that the business model (BM) frames the business logic of an enterprise in creating and capturing market value from its products and services. Therefore, design and evolutionary management of the business model is fundamental for competitiveness and for the same existence of the business.

It is important to highlight that business modelling acts at the architectural level of the enterprises' logic of earning money (Figure 6-11); therefore, they have to do with strategic thinking and planning. *“Putting strategy, business models and process models together one can say that they address similar problems (e.g. the one of earning money in a sustainable way) on different business layers”* (Osterwalder, 2004).

Figure 6-11 Strategy, business and operations layers

ñA business model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company's logic of earning money. It is a description of the value a company *offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams*” (Osterwalder, 2004). The process of business modelling goes from design to implementation, as described in the picture below; it translates “*a strategy into a business model blueprint. Then the business model has to be financed through internal or external funding (e.g. venture capital, cash flow, etc.). And finally it has to be implemented into an actual business enterprise*” (Osterwalder, 2004).

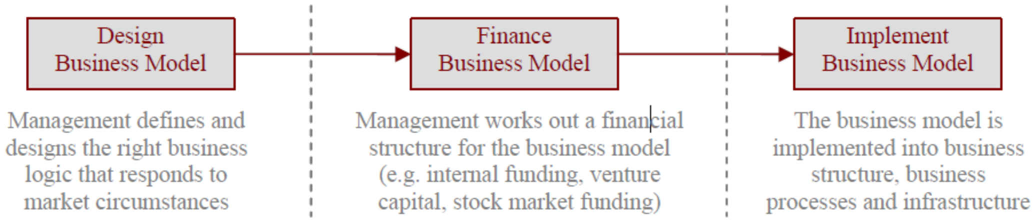


Figure 6-12 The business modelling process at enterprise level

Figure 6-12 illustrates the stages and elements of the business modelling process. As a research project, COMPASS focuses on the first stage of business modelling. The methodology steps for the business model analysis in COMPASS are the following:

1) Assess the ICT applications;
2) Review the assessment and identify a representative sample of innovative solutions for co-modality and decarbonisation of transport;
3) Select and involve the experts;
4) Desktop analysis and expert discussion to draw the prototype business models;
5) SWOT analysis of the identified innovative solutions;
6) Describe the methodology and the main results.

The sample of innovative solutions identified to draw the prototype business models should therefore include representative applications for long-distance, rural and urban mobility co-modality, which may effectively enable substantial greenhouse gases reduction in transport.

The strategic analysis for the SWOT of each solution, aims to provide to the stakeholders the most effective representation of the benefits to facilitate the take-up of identified models.

In this view, the BMs in COMPASS were investigated and designed as “prototype” business models to provide the largest audience of enterprises with the most effective business logic in creating value through the selected applications, which are reputed to better contribute to the achievement of the objective of minimising gaseous emissions in co-modal passenger transport. The COMPASS BMs are conceived as “product-oriented” in the analysis of the main business constituents of the ICT applications: in such approach, business through each application is isolated from other possible products in the portfolio of a company, and its configuration to deliver value is investigated, designed and presented to the audience.

The business models are investigated and illustrated with the businessperson eyes and a company-neutral point of view. Such approach is expected to enlarge and maximise the impact of the research outputs to the audience of business community and policy makers in Europe.

6.1.3 Selection of ICT Applications for Business Models

Business models have been investigated and designed by ITS and business specialists and discussed with over thirty external experts in T5.4, selected from academia, transport and ITS industry. The models design the most effective orientation and system structure in their business and market elements which allow companies “to make money” from the innovative solutions. The **business elements** frame the company capability, value configuration, partnerships, finance and cost/revenue structure in the model. The **market elements** frame actors, value proposition, relationships, channels, customers.

The business modelling process has been anticipated by the investigation of real-world conditions of the ITS market, which show high innovation density but is still waiting to take off, and by an internal debate at the initial stages of the COMPASS project about the scientific approach and methodology. Given the project objectives, and the internal and the external constraints, the óprototypeô version of business models is selected to widely describe the best performing configurations of the ICT applications which best improve co-modality and give the most effective contribution to greenhouse gases reduction.

The ICT solutions and applications for co-modality and CO2 reduction in long distance, urban and rural travels have been identified in WP3, then described and assessed in WP5 -T1, T2 and T3. An additional qualitative scoring on the overall contribution to co-modality and CO2 reduction was then given to the ICT applications and solutions. T4 takes the results for further assessment under the qualitative and quantitative (scoring) dimensions[29].

Technical specifications and the internal debate in the Project Consortium shape the final structure of the ICT applications analysis; section and contents initially laid down for providing baseline information for business modelling in the technical factsheets, are the following.

- Solution family and sub-family;
- Domain of application (long-distance travel / rural / urban);
- Status (implemented, concept);
- Technology behind;
- Links to relevant references (articles, websites);
- Description: 1) concept of solution and problems addressed, 2) what users are targeted, and how to reach customers in selling and in accessing the service, 3) potential for data gathering (value proposition of the offer);
- Applicability (pre-feasibility analysis): Financial (costs, revenue and return time); Technical (technical barriers; will the solution be performing enough to be actually used for the purposes it is intended?); Organisational (description of who does what in the solution, is it easy to organise?); Legal analysis (compliance with the legal framework, e.g. data protection, safety procurements, immigration rulesé) , (core capabilities);
- Interest for users (relevant impacts) door to door travel time, travel cost, comfort and convenience, safety, security, accessibility for impaired;
- Impacts on the system (most relevant impacts): increased mobility, modal shift, CO2 emissions, congestion on crowded corridors, contribution to user pays principle;
- Summary of overall scores received: evaluation table;
- Illustrative materials.

The selection of ICT applications for business models in COMPASS is intended to identify solutions for improved co-modality and greenhouse gases reduction, which may tackle such barriers. To this point, the following set of variables and scoring has been chosen to extract a sample of applications for business modelling. Such variables are divided into óprimaryô and ósecondaryô according to the degree of their importance, that make part of a sound scientific set of criteria in line with the project objectives based on scoring, indicators and qualitative assessment. Overall judgements on the application value for co-modality complete the set of criteria.

- Primary variables
  1. CO2 reduction
  2. Mobility
  3. Direct business interest ï drives the sampling, however public interest is considered
  4. Overall qualitative rating

- Secondary variables
  5. Door to door travel time
  6. Door to door travel cost
  7. Average score of the Solution from partners' assessment

[29] It is to specify the quantitative scoring tables of ICT applications are not presented in the final results of the COMPASS project.

8. Current and potential use of applications for long distance, urban and rural travels.

Such sampling approach demonstrates to be effective in ensuring internal and external consistency of the business modelling process and results, with fair distribution of solutions among domains and business interest, and strong positive impact on co-modality. The resulting choice led to solve the problem of solution identification (sample consistent with the project objectives, methodologically correct, and appropriate to the quality of available data), and those of significance of results and of appropriateness of methodology, as well as it helped to tackle the potential barriers in the project (like those of full interaction with business players, information availability and accuracy, intellectual property and business data protection, etc.). The table below illustrates the set of indicators, as given in their first elaboration in the project, which have been used for sampling.

Table 6-1 Sampling variables

		Applications		Feasibility								Modal change					Other impacts						Interest for travellers					
Qualitative Overall Rating -TTS	Qualitative Overall Rating -ISIS			Investment costs	Operation and maintenance cos	Financial viability	Technical feasibility	Organisational feasibility	Administrative Burden	User acceptance	Public acceptance	Car usage	Bus and coach usage	Rail usage	Ferry usage	Aeroplane usage	Mobility	CO2 emissions	Contribution to User Pays princ	Congestion in overcrowded cor	European economic progress	Territorial Cohesion	D2D travel time	D2D travel cost	Comfort and convenience	Safety	Security	Accessibility for impaired
4	4	**2.2.1.6**	**Public Transport Management**																									
4	4	28	Shared Bike Scheme Management System	0	2	0	0	0	0	2	0	0	0	0	0	0	2	4	0	2	0	0	2	1	1	1	0	0
4	5	**2.2.2.2**	**Real-time Co-Modal Traveller Information Services**																									
4	5	34	Point-to-point traveller information system on Mobile Devices	0	2	0	0	0	0	2	0	0	0	0	0	0	1	4	0	0	0	0	2	1	2	1	1	1
4	3	**2.2.2.5**	**Parking Management Systems (PGI)**																									
4	3	51	Paking detection and payment	-2	0	-1	0	-1	-1	2	1	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	1
2	3	**2.2.6.3**	**Collective Taxi**																									
2	3	97	Collective and Jitney Taxis	2	2	0	0	1	-1	2	-1	0	0	0	0	0	1	4	1	0	0	0	2	1	0	0	0	0
			Solutions mainly conceived and/or managed as public services with interest by enterprises																									

In order to model the business of ICT solutions by desktop and expert analysis, the selection of external experts to be engaged in the panel supporting the analysis started at the beginning of 2012. The European TTS network of automotive players, public authorities and other stakeholders was inquired to show the availability to participate to business modelling through their experts. After the response from the network, the best profiles for the project were selected through an online questionnaire. At the end of 2012, the expert profiles for the COMPASS Panel had been evaluated and the most interesting of them selected on a competence basis. Supplemental experts were then included during the following months until the number of 34 experts in the Panel was reached. The Panel was finally established at the end of 2012, when the online workspace was made available on the Web[30] and all the internal and external experts could start interacting. The business models reports produced in the desk analysis were then shared with the experts for discussion. Enrichment and integration of information and evaluation proposed by the models are the outputs of such stage.

The sampled ICT solutions enabling co-modality and emissions reduction in long-distance, urban and rural travels, have been investigated to deliver the following business models.

1) Bike Sharing Systems. Urban application with low/indirect business interest. BSS comprise short-term urban rental schemes that enable bicycles to be picked up at any self-service bicycle station and returned to any other station after use.

2) Car Parking Management Systems. CPMS are conceived as urban applications with direct business interest also interesting rural and long distance travellers. This solutions family may include systems with an array of functions, like parking guidance, enforcement, user/provider information, payment, booking, site automation, etc. However, the business model concentrates on the availability, enforcement and payment functions of such systems.

3) Share Taxis (or: Collective Taxi / Jitney / Blacktaxi / Taxibus). Urban and rural transport solutions with direct business interest. Such services originated in the early twenties of the nineteenth Century as an alternative (seldom illegal) to state transport in the US, and quickly became common in Europe with a variety of business and technology configurations.

[30] The tool selected is the webspace provided by the Huddle collaborative social network .

4) Traveller Information Systems for Mobile Devices. Urban, rural and long distance application with direct business interest. MTIS are built on ICT systems enabling information and communication flows, interaction and assistance to travellers at all times and places, being multimodal and covering public transport, bicycles, walking, private cars, taxis, etc.

The technology behind the modelled solutions is a mix of innovative and of legacy (although improved) ITS applications which can help to solve the problems addressed by the project. In the analysis of the business elements, both the point of view of transport operators and of final users have been taken into account: in most cases the views coincide; in other cases, where they differ, both points of views are separately considered and illustrated in the model.

6.1.4 How to read the Business Models

The BM Canvas provides the model framework, and presents the business features and the competitive strengths in the continual exchange process between the external system and the enterprise. The BM Canvas is a useful aid to the analysis that helps to individuate the key business questions to design an effective model[31]. The four pillars and nine elements of business models for the selected applications are described in COMPASS, each with different levels of granularity on the basis of the particular óproduct orientedô modelling, the specific information available and the importance and the relationships of the selected applications to project objectives.

It is useful to shortly illustrate the business model ontology[32] used in the analysis, coherently with the Osterwalderôs approach, influenced in turn by the Balanced Scorecard approach by Kaplan and Norton (1992) and by other business management works (such as Markides, 1999). The emphasis is on four business areas (also identified as ñ**pillars**ò) that a model should address. In the product-oriented COMPASS view, the pillars are the following.

- **Product**: what business the application is in, and the value proposition(s) offered to the market.
- **Customer interface**: who the target customers are, how to deliver them products and services, and how to build strong relationships with them.
- **Infrastructure management**: how the company offering the ICT application/solution efficiently performs infrastructural or logistical issues, with whom, and as what kind of network enterprise.
- **Financial aspects**: what is the revenue model, the cost structure and the business sustainability.

The Osterwalderôs analysis goes into a greater level of granularity, and splits the four pillars into nine interrelated BM building blocks or ñ**elements**ò, as presented in Table 2-2.

Table 2-2 The business model elements

Pillar	Element	Description
Product	Value Proposition	The overall view of a company's bundle of products and services that are of value to the customer.
Customer Interface	Target Customer	A segment of customers a company wants to offer value to.
	Distribution Channel	A means of getting in touch with the customer.
	Relationship	The kind of link a company establishes between itself and the customer.
Infrastructure Management	Value Configuration	The arrangement of activities and resources that are necessary to create value for the customer.
	Capability	The ability to execute a repeatable pattern of actions that is necessary in order to create value for the customer.

[31] A visual framework tool can be downloaded from http://www.businessmodelgeneration.com.

[32] The term ñontologyò is used here with the meaning of agreements about shared conceptualisations, as it is intended by Ushold and Gruninger (1996). They affirm that ñshared conceptualisations include conceptual frameworks for modelling domain knowledge; content-specific protocols for communication among inter-operating agents; and agreements about the representation of particular domain theories. In the knowledge sharing context, ontologies are specified in the form of definitions of representational vocabulary".

	Partnership	A voluntarily initiated cooperative agreement between two or more companies in order to create value for the customer.
Financial Aspects	Cost Structure	The representation in money of all the means employed in the business model.
	Revenue Model	The way a company makes money through a variety of revenue flows.

The COMPASS specialists conceptually separated the internal and external business environment of the enterprise in the selected application markets, into the four major constituents (or pillars) -the business elements of infrastructure management and finance, and the market elements of product and customer interfaces- and then analysed the variables and the attributes that shape the elements of pillars into a competitive business model.

The business models are intended to innovate the processes and systems which allow "to make money" from the ICT solutions identified. The business constituents frame the company capability, value configuration, partnerships, finance and cost/revenue sub-elements of the infrastructure management and the financial aspects. The market constituents frame actors, value proposition, relationships, channels, customers sub-elements into the customer interface element. The value proposition include all the non-technology aspects of the solution portfolio to customers too.

The BM analysis makes available structured knowledge about the target solutions and their business aspects to the target audience. Here, the nine elements describe the four pillars of the business models. Baseline information for the analysis of the elements in each pillar shown by Table 2-2, have been investigated in T5.4 by desk analysis and expert knowledge that shaped the business model constituents. Each element is described by a set of open questions and reported in a worksheets were the business requirements to "make money" are detailed for each solution.

It is important to notice how business models should not be confused with business plans: therefore, the Finance pillar with its cost and revenue elements does not necessarily need quantitative data to describe the model. To this point, the information provided in the analysis to define appropriately such business layer between strategy and operations are mostly qualitative.

6.2 Business Model: Shared Bike Systems

6.2.1 Overview

In this model we discuss urban application with low or indirect business interest. BSS comprise short-term urban rental schemes that enable bicycles to be picked up at any self-service bicycle station and returned to any other station after use.

Bike Sharing Systems are of recent introduction or have been re-engineered in major European cities. However, BSSs not always shows a successful track record; the prototype model and the SWOT investigate the main causes of failure and give operational and strategy suggestions for improvement.

6.2.2 Discussion

Product	Value Proposition
What value do we deliver to the customer?	Door-to-door mobility and fast urban transport mode. "Extension service" for the first/ last mile (the distance the users consider to be too far to walk between home and public transport and/or public transport and the workplace) and/or "missing links" Travel costs reduction. Environmental-friendly attitudes and behaviours. More leisure time options (e.g. for tourism).
Which one of our customer's problems are we helping to solve?	Urban transport faster than other modes. Problems in modal split where there may be "missing links" or time and/or topography constraints in urban routes (e.g. small city centres). Cheap and fast coverage of the first/last mile.
What bundles of products and	The scheme is basically built around one object, the bike rental service.

Product	Value Proposition
services are we offering to each Customer Segment?	However, other added value services may be delivered together with the core one. They are usually facilitated by the use of identification, tracking and control technologies in the bike sharing systems, and may bring optional and/or bundle services to the users -e.g. useful contents provisioning, booking/buying systems on the users' routes, tracking and assistance, etc.
Which customer needs are we satisfying?	Coverage of the first/last mile, and/or the ñmissing linksò as an extension service and/or coverage of other short distances. Increase flexibility (of public transportation) of the users' daily ways. Quick implementation and extension of city public transport. Supplement to public transport in the night time (e.g. ñleisure usersò).

Customer Interface	Target Customer
For whom are we creating value?	The main target in urban schemes is the daily user who rides to work or for leisure activities; regional schemes often focus on the tourist market. Different target groups are addressed by different communication channels and different charges.
Who are our most important customers?	People who do not own/use bicycles regularly.

Customer Interface	Distribution Channel(s)
Through which Channels do our Customer Segments want to be reached?	ñDirect channelsò by transport operators, advertising companies, street equipment managers and other public services are the best ways to distribute the services to customers. Their integration is possible and may benefit financing and return on investments.
How are we reaching them now?	The targeted users can find the service at the docking stations and may use other related services via mobile communication devices. They may interact in this case with the provider(s) and customise the service required, with previous identification. Depending on the distribution channel(s) selected, the customers may have a number of service choices and/or value adding options.
How are our Channels integrated?	The bike sharing systems usually are seamlessly integrated with the transport system of the city. The level of integration among distribution channels may be low in the introductory phases of bike sharing schemes.
Which ones work best?	Direct distribution of the service is the most important in this business model. Other channels are ancillary and may be used to extend the scheme penetration
Which ones are most cost-efficient?	Direct channels used by advertising companies, are the most cost-effective for the municipal budget. Direct channels by transport service operators, both public and private, need subsidies.
How are we integrating them with customer routines?	At selected places of heavy demand -e.g. train or bus stations- the docking stations are established. At these locations, a number of bikes are available and bikes must be re-located to these points as needed. Information from the management systems is used to identify places where more cycle parking and/or bicycle redistribution are needed (e.g. topographically higher places). The idea is to allow the potential customers to find the service on their own travel routes.

Customer Interface	Relationships
What type of relationship does each of our customer segments expect us to establish and maintain with them?	The largest interaction with the bike management systems is demanded by customers, in order to help them to find the service at the right time in the desired moment, and allow to hand the bike in the point nearest to their final or intermediate destination. The widest use of information and mobile communication technologies is required for responding to the customersô expectations.

Product	Value Proposition
Which ones have we established?	User identification allows to establish direct (one to one) relationships with the customers, but the preliminary approach to such a new service in the European cities is generally run on a mass basis, where the relationship with the customer is usually started at the beginning of the trip and closed at its end. The development of urban ITS infrastructures and of the marketing model of the bike schemes enhances the level of personalisation of the services and of the relationships.
How are they integrated with the rest of our business model?	The customer relationship management system should be tightly integrated in the management and business infrastructure of providers such as advertising companies and transport companies. In other types of operators, the integration level can be low.
How costly they are?	The cost of the customer interfaces is a relatively small portion of the overall investment and management costs, in the approximate order of 5% and 10% yearly, respectively.

Infrastructure Management	Value Configuration
What key activities do our value propositions require?	Station location choice and prompt bike placement and re-distribution are essential activities, as well as fleet and station maintenance and repair. Route and vehicle monitoring are other important activities for bike sharing systems. Where redistribution is required, this should be done in an environmentally friendly and efficient way. Appropriate data collection is required for CRM.
Our distribution channels?	The docking points require surveillance and maintenance activities. Communication lines with the bike sharing management system is essential.
Customer relationships?	The operators should put large effort in the communication with the customers to find out and fulfill their transport needs and establish solid relationships. The use of mobile ITS is important to develop such activities and reduce their costs. The bike sharing scheme needs to be visible and easily identifiable to its customers. Any potential scheme would be self-promoting, with more and more people using the scheme, increasing its visibility, promoting further growth in usage.
Revenue streams?	Large and timely availability of vehicles, their good efficiency, and safe bike lanes networks are keys for success: all the necessary activities are therefore among the most important for a bike sharing operator.

Infrastructure Management	Capability
What key resources do our value propositions require?	Vehicles, docking stations, network and bicycle communication systems, fleet maintenance and management systems, card readers. Secure and wide networks of bike lanes (with associated bicycle priority measures at intersections that enable users to cycle safely and continuously throughout the area covered by the bicycle-sharing scheme) enhance the business profitability and the user satisfaction, as well as tight integration with the public transport is a fundamental requirement.
Our distribution channels?	Docking stations should be equipped with RFID, card readers, ground network and/or mobile communication interfaces (GSM, GRPS, UMTS, GPS, etc.), touch screens, and with security infrastructures like cameras, locks and sensors. Maintenance must be easy, with as much work completed on-site as possible. Standardised parts, on site storage facilities and versatile trained staff will help this process run smoothly.
Customer relationships?	ICT resources are essential for bike sharing management systems to establish, maintain and grow the relationships with customers. Databases, CRM, communication systems and infrastructures are key for success
Revenue streams?	Card readers, RFID, and NFC-equipped mobile phone interfaces are essential to offer the minimum set of payment systems fitting to the users' needs and expectations. The duration of the free initial period can be leveraged for marketing purposes with immediate reflections on actual

Product	Value Proposition
	revenues.

Infrastructure Management	Partnership Network
Who are our key partners?	The main operators of bike sharing services are transport operators, advertising companies, street equipment managers and other public services. Public-private partnerships (PPPs) are the most diffused model and are the major source of funding for bike sharing schemes ï accounting for 48 percent of all systems.
Who are our key suppliers?	Bicycle manufacturers, spare parts producers and distributors, ITS providers, software and hardware OEMs, TELCOs. Partnership with suppliers can provide competitive advantage and financial sustainability
Which key resources are we acquiring from partners?	Fleet vehicles and spare parts, data and information services, system hardware and software, communication services are acquired from the key suppliers. Stable relationships with them may bring benefits to each side of the business, as for example cost reduction of supplies to the operators and brand/image/product promotion to the sponsors. Related and/or integrated services may be offered to customers and so enhance the value of the proposition.
Which key activities do partners perform?	Communication, joint and/or value adding services, co-branding, sponsorship, financing, supply of vehicles, parts and services.

Finance	Cost Structure
What are the most important costs inherent in our business model?	Running and operations costs are the most relevant financial components in bike sharing schemes -from ú1.500 to ú2.500 per bike per year. Infrastructure and implementation costs step up with the growth of the fleet, but are not much higher than the yearly cost per unit -from ú2.500 to ú4.000. The cost of the lane network is taken as external to the operators, but it is the most relevant capital cost.
Which key resources are most expensive?	Costs of maintenance take large share of the annual budget for a bike sharing scheme. Losses for thefts and damages can be very high where appropriate security measures are not taken. Security costs may require large investment and low running costs where the system is appropriately designed. The cost of acquiring and permitting dedicated areas to bike stations might be relevant.
Which key activities are most expensive?	The activity of re-distributing the vehicles may be very costly; for this reasons, efficient traffic and station planning with incentives to customers for returning the vehicle in specific stations (e.g. stations with higher traffic volumes or with lower availability of vehicles) must be carefully considered in the BSS business planning.

Finance	Revenue Model
For what value are our customers really willing to pay?	The customers are willing to pay for a reduction of a door to door travel time provided by a fast urban transport system, and for fast and accurate connections to public transport. Higher prices may be accepted for large coverage of the BSS lanes network and high perceived value of the service.
For what do they currently pay?	The customers pay for the coverage of the ñmissing linksò and/or ñlast mileò, and for a urban transport service which is sometimes faster than other modes.
How are they currently paying?	Debit/credit cards, RFID and ticketing systems integrated with other urban transport modes (e.g. public transport passes) are the most used payment systems. Most schemes offer the first 30 minutes free of charge with increasing prices for each additional 30 minutes to ensure that bicycles are available for users throughout the system.
How would they prefer to pay?	ñPrivacy maniacsò tend to use public transport passes/season tickets or smart cards. Other users may increasingly prefer the use of NFC-equipped phones. Smaller portions of demand still prefer to pay with

Product	Value Proposition
	cash.
How much does each revenue Stream contribute to overall revenues?	In order to make bicycle-sharing attractive and encourage its use, membership and usage fees are kept low. This implies that many systems need funding from advertising (e.g. billboards) and/or subsidies; funding mechanisms include user fees, municipal budgets and other sources of aid, and resources from public - private partnership agreements. The shortfall between user fees and total costs is made up through business models that use advertising revenues, core business revenues, parking revenues, government grants or sponsorship in decreasing order of relevance.

6.2.3 SWOT Analysis

The table summarises the outcome of the strategic analysis of a generic bike sharing scheme and its factors for success. It depicts the application in the scenario, focusing on the businessôSWOTs also in relation to other modes for urban mobility and co-modality. The analysis takes the optimal configuration and management of the business as an assumption (see the Strengths quadrant, for example), and the conditions of traffic, infrastructure, legislation etc. as external constraints.

Strengths	Weaknesses
Speed of other type of vehicles in urban mobility conditions **Bicycle re-distribution** with mechanisms to address asymmetrical demand for bicycles by location **Maintenance** of bicycles and access terminals in good operating conditions **Bicycles** specifications responding to user demographics and operating conditions **Docking stations** with visible terminals and good user interface **High system availability** -hours of daily service	**No central repository** of information on bike sharing **Low availability** of updated guidelines and manuals **Poor information** available and/or insufficient study of demand for bike sharing in most approaches **Low diffusion** of integrated management schemes with public and private operators
Density and trip demand for one way trips in multiple directions **Network configuration** with location-specific network design based on system objectives and travel demand **Good quality** of public transport **Public attitudes to cycling** with positive perception of mode, willingness to 'share the road', willingness to utilise mode **Safety & security** where terminals and cycling facilities are well lit and patrolled as necessary **Bicycle priority measurers** and bicycle lanes perception of safety by users **Global network** of bicycle-sharing cities **Cycling infrastructure** in terms of quality and quantity of designated cycling space –e.g. dedicated bicycle lanes, intersection facilities, slow streets **Stage of development and integration** of technology platform in terms of usability/access, real time information, privacy and security of data	**Theft** and vandalism **Helmets** where compulsory, have demonstrated to represent and obstacle to diffusion **Topography and climate**: hills, amount of precipitation **Exaggerated expectations** by public operators **Inexperienced** cyclists **Low diffusion** of electronic money and mobile phone payment systems in some Countries and/or Continents

Opportunities	Threats

6.3 BUSINESS MODEL: SHARE TAXIS

6.3.1 Overview

Share Taxis (or: Collective Taxi / Jitney / Blacktaxi / Taxibus) are an example of urban and rural application with direct business interest. Such services originated in the early twenties of the nineteenth century as an alternative (seldom illegal) to state transport in the US, and quickly became common in Europe with a variety of business and technology configurations. The business model here described is related to the ICT systems which are being introduced in such legacy system in order to enhance its efficiency and meet customer expectations.

The business of Share Taxis is an example of legacy transport system which can be drastically improved by the use of ICT solutions. In the prototype model, a wide range of solutions for booking, route management and payment is considered to enhance the operational capability, customer satisfaction, security of payment, service efficiency. The BM is investigated from the operators' and final users' point of view, being them respectively served by ITS OEM/developers and ST operators. Important legal issues are also analysed.

6.3.2 Discussion

Product	Value Proposition
What value do we deliver to the customer?	The ability to identify, book and confirm a trip in a shared vehicle. Additional value elements may include safety and security features, knowledge of driver, other passengers etc.
Which one of our customer's problems are we helping to solve?	Final users: the cost of travel; however, a more fundamental issue may relate to the ability of an individual to travel at all, particularly in rural communities. Operators: increase revenues, cut costs, expand the market, accomplish to law and regulations.
What bundles of products and services are we offering to each Customer Segment?	Final users: planning functions, location and trip alternatives; booking functions; payment services; security, including assurances of service and tracing lost property. Operators: feedback on the quality of the services and systems in relation to identifying and agreeing to fellow passengers; - follow up including tracing lost property; - upward management information to controlling authorities allowing for the optimisation of control and licensing functions; - bundles can also be spread across differing operator needs, and differing forms of transport, typically split between Taxi, Private Hire Vehicles, Limousines etc., but also including ride share types of service; security; - booking functions; payment services.
Which customer needs are we satisfying?	Final users: booking, reflecting choices arising from planning functions or from a known or repeated route; - secure, - cheap and flexible transport. Operators: organisational efficiency and effectiveness; increased profit; security; better relationships with Authorities.

Customer Interface	Target Customer
For whom are we creating value?	Final users: individual travellers; corporate travellers, or corporations on behalf of passengers; institutional travellers, or institutions on behalf of passenger. Operators: taxi drivers and companies.
Who are our most important customers?	Individual travellers. Taxi companies and drivers.

Customer Interface	Distribution Channel(s)
Through which Channels do our Customer Segments want to be reached?	Online applications for mobile and desktop clients. Advertising on media and 1to1 marketing.
How are we reaching them now?	Final users: telephone; door to door advertising and information; mobile push systems -low maturity level channel. Operators: advertising, business information and contact.
How are our Channels integrated?	Integration depends upon the extent to which a city administration incorporates shared services into the core transportation provision. The mode has often operated in isolation from transportation but in an integrated manner in Human Services, Health and Elderly transport. Online booking systems allow for integration through existing infrastructure such as Trapeze or Cleric booking systems that provide to the specialist transport users. Some additional API1 integration will be appropriate.
Which ones work best?	Allocation of share taxi services may not require a full integration of technologies, but rapid expansion in this area has created a new market demand, illustrated for example by UberX, Lyft and similar systems in the USA.
Which ones are most cost-efficient?	Mobile application based booking systems create the most cost efficient method of distribution to final users. Customer relationships are required by operators.
How are we integrating them with customer routines?	Customer routines based around smartphone news have increased use of booking services across all transportation modes. Integration of new apps (push, news, etc.) will create new uses and new demand.

Customer Interface	Relationships
What type of relationship does each of our customer segments expect us to establish and maintain with them?	Customer interface relationships can differ between user groups and different demographics. This is illustrated in the instance of smartphone apps having a wide but targeted interest. Operator and regulator relationships will also be significant in this development, and are often overlooked. Instances of regulator development are visible and include recent developments -e.g. Northern Ireland has allowed the operation of shared services, that had previously existed outside of regulation, within the developing regulatory framework. Regulatory frameworks that do not associate share taxi operators with transport ï for example those in the healthcare sector ï are generally more accepted than those appropriate to transportation.
Which ones have we established?	Interface between specific use transportation and collective supply is an established element in some locations. In addition share taxis operating to specific communities are well established in a number of cities, including Belfast (Black Taxi) and some US cities.
How are they integrated with the rest of our business model?	Individual patterns of share taxi operations differ, as will the extent to which each can be integrated to a wider business model. This will depend, in part, on the nature of the broader business proposition, which can range between Taxi based ǂtaxibusô operations; bus based operations ,etc. A single business model is unlikely to be appropriate in all circumstances, and this will very significantly depending on local circumstance, geography, and demography, and regulation.
How costly they are?	Customer interface management systems are usually provided to share taxis on rent and fee basis, where the provider may charge for a monthly subscription and a small share of the booking price; it may also cross-sell services (advertising, event booking, etc.) to the operators and/or the final users. Taxi operations can, in theory, be provided at no additional cost to the communities they serve. Taxis traditionally are provided without subsidy as commercial services, though this does not always hold for supported services including healthcare transportation. In all instances

	taxi based services are provided at a lower cost than own account dedicated transportation.

Infrastructure Management	Value Configuration
What key activities do our value propositions require?	A primary concern must be the identification of legal channels for share taxi operation. This is not a given, and will vary depending on local legislation and operating circumstance. Operating efficiencies will also rely on market identification and demand measurement. Delivery will depend on effective management allied to identification of alternative and competitive services.
Our distribution channels?	Distribution channels will depend upon the precise service models in each location, which will vary, but are typically based on demand identification, supply and service availability, local knowledge, and booking/marketing.
Customer relationships?	Share taxi operators should identify the appropriate 'customer' and establish the most effective relationships. Customers will vary depending upon the mode of operation and specific service requirement. For example, customers for specialist transportation may include health authorities as well as the individuals being transported.
Revenue streams?	A single revenue stream is likely based on farebox, the amount of money being taken by a driver in a single trip. Revenue streams then split further depending on the structure of the industry and the nature of support provided by third party, taxi association, or transportation planner. They may include inflows from advertising and cross-selling of other services.

Infrastructure Management	Capability
What key resources do our value propositions require?	Vehicles supplied, their management, maintenance, and replacement will be significant to the operation of the system. In addition payment systems, including electronic payment, and booking systems ï which may include payment means, are significant. Regulatory structures may also be required, or in place, and these are significant resources to consider.
Our distribution channels?	Management information systems allied to vehicle location and vehicle identification will be a significant element in the supply of planned services. Associated with this, the supply of apps ï as distribution / booking tools will be essential in automated, or more planned systems.
Customer relationships?	Passenger oriented relationships should be identified in app based systems, while those related to booking services provided by third parties, relationships with specialist transport agencies, and relationships to the regulator may require additional resources.
Revenue streams?	Cash based farebox; credit/debit card based farebox; app based payment; online payment; third party billing.

Infrastructure Management	Partnership Network
Who are our key partners?	Partners include transport suppliers, which may include individual taxi drivers (system to driver) or vehicle Associations (system to dispatch); third-party specialist groups, e.g.: health care; taxi regulators or licensing authorities; app developers.
Who are our key suppliers?	Hardware and software companies, car service and insurance companies, car manufacturers.
Which key resources are we acquiring from partners?	Mobile applications and portals for service provision ï vehicle location and availability, capacity, booking; supplemental customers; improved regulations and licensing.
Which key activities do partners perform?	Suppliers services; booking and other management services; licenses and regulations.

Finance	Cost Structure
What are the most important costs inherent in our business model?	The primary cost (vehicle costs including any lease or medallion costs, insurance costs, infrastructure costs, fuel costs) are related to the

	provision of supply. Costs vary depending on local models of supply, which may include regulated vehicle type, vehicle life, economic controls placed on charges, and quality requirements. Secondary costs are related to the booking systems, where these are in place; with an additional cost associated with marketing/legal defence.
Which key resources are most expensive?	The primary cost is associated with transport supply, where legal challenges are not common. The primary operation costs include the most expensive items such as (on average per year): vehicle costs between ú10.000 and ú12.000; insurance between ú3.500 and ú6.000; fuel cost for ú3.500; the infrastructure cost accounts for nearly ú3.500 per year and includes the cost of booking and ICT service provisioning. In some locations, particularly in North America, a significant cost is associated to legal services to deal with regulatory issues. In some instances such legal costs of provision have out weighted any other cost.
Which key activities are most expensive?	Transport supply and dispatch service(s); legal support and/or defence where required.

Finance	**Revenue Model**
For what value are our customers really willing to pay?	Transportation provision at an intermediate level between exclusive use taxi, and bus. A significant additional value is associated with the flexibility of the smaller share taxi vehicle ï for example the ability of the vehicle to serve multiple destinations away from fixed route buses.
For what do they currently pay?	Booking fee (as permitted). Driver fee. Dispatch company cost. Supply costs.
How are they currently paying?	Mainly through farebox.
How would they prefer to pay?	There is a significant demand for the use of credit cards in all Taxi type journeys, which is not always met. Online systems may make this easier, and this is a feature of the majority of apps. NFC2-equipped mobile phone interfaces might be necessary in the future.
How much does each revenue Stream contribute to overall revenues?	The sum of fares collected in shared use can exceed the single use measured fare. In all instances revenue collected through farebox, or automated alternatives represent the majority or sole income, which must cover all costs. A turnover around ú36.000 can be expected, assuming the average trip fare around ú12 and 10 shifts per day. However, advertising revenues may be collected on a taxi company or taxi driver basis. Cross-selling of third party services (e.g. booking for events) might be implemented where online/mobile application are used. A legal restriction for use of shared vehicles has been applied in some administrations, requiring the individual fair to be lower than that based on single use of a taxi.

6.3.3 SWOT Analysis

Strengths	Weaknesses
Mutual benefit arising from personalised transport on a demand basis **Lower cost** access to a taxi type of service **Increased patronage** for taxi providers **Reduction in excess demand** on existing services of transit operators **Reduced cost** of transit operators in case of sub-contracting to JT operators **Increased efficiency** in route planning and management -including all related business elements, e.g. costs and revenues.	**No consistency across applications** in a rapid changing market (some actively opposed by the trade they purport to serve.... specify) **Ambiguity of vehicle type** with related "surge pricing" charging what the market will bear rather than a defined tariff Excess or unapproved **booking fees** Compulsory **gratuities** **Unlicensed or incorrectly licensed** vehicle provision **Technology based solutions** may alienate or discriminate against parts of the population unable to access the technology.
Multiple beneficiaries exist to an appropriately designed and implemented share taxi system **Medium and long term cost reduction** to public authorities **Increasing amount and quality of data** about trip and users profiles by ICT applications **Reduction of fraud** and raised public safety by use of improved information Suppliers may (correctly) identify the move of multiple individual trips to a **single shared trip**. **Improved customer satisfaction** as a consequence of increased efficiency.	**Legal** challenges **Different legislative frameworks** among Countries "**Race to the bottom**" in case of undesirable practices, that can impact on more legitimate operators **Vast and increasing number of applications** (and providers) with little or no regard to, or knowledge of, the legal structures of the individual locations they seek to serve.
Opportunities	**Threats**

6.4 BUSINESS MODEL: MOBILE TRAVELLER INFORMATION SYSTEMS

6.4.1 Overview

This model deals with urban, rural and long distance applications with direct business interest. MTIS are built on ICT systems enabling information and communication flows, interaction and assistance to travellers at all times and places, being multimodal and covering public transport, bicycles, walking, private cars, taxis, etc. The approach in COMPASS is sufficiently broad, in order to encompass the many applications that provide information to travellers via mobile telecommunication systems.

MTIS are the family of newest ICT solutions considered for business modelling in COMPASS. Their market is expanding rapidly in conjunction with the growth of mobile telecommunication and devices such as PDAs, tablet and smartphones. The model is designed to encompass a variety of applications that may enter a single business strategy, oriented to satisfy a wide range of needs expressed by long-distance, rural and urban travellers

6.4.2 Discussion

Product	Value Proposition
What value do we deliver to the customer?	Extra flexibility, increased economic efficiency, reduced social exclusion, increased independent travel opportunities, with: improved mobility, accessibility and ease of use of transport systems; enhanced convenience and confidence when travelling; increased travel efficiency and feeling of being in control of the journey.
Which one of our customer's problems are we helping to solve?	Mobile traveller assistance with real-time information before and during the travel. The primary "problem" related to the extent to which travel information may be accessed once a passenger has started a journey1. Market diffusion of mobile communication devices has eliminated such concern, allowing for the largest diffusion of MTIS.
What bundles of products and services are we offering to each Customer Segment?	Accurate, real-time, location-based, personalised and context-aware information services for travels to any customer, with custom functions depending on the system scope and the customer targets. Most common functions are related to planning, real time calculation of routing, advanced knowledge of potential disruption, remote booking. Additional value may also be achieved through the provision of extra-services such as ticketing, payment, security facilities.
Which customer needs are we satisfying?	Assistance to travellers whilst they are on their journeys, anywhere and at any time. Service accessibility and physical use requirements, knowledge of appropriate vehicle types across all user groups, including accessibility. Enhancement of public transport modes by improving the quality of service. The rapid expansion of mobile technologies has a role in expanding and enhancing the needs that MTIS apps satisfy. The presence of planning tools has a role in creating a demand for their provision.

Customer Interface	Target Customer
For whom are we creating value?	Public transport users, multi-modal transport users, cyclists and pedestrians, travellers with special needs. Such targets are identified among individual travellers, corporate and institutional travellers.
Who are our most important customers?	Public transport users, multi-modal transport users, travellers with special needs.

Customer Interface	Distribution Channel(s)
Through which Channels do our Customer Segments want to be reached?	Smartphones, mobile phones, at-stop and on-board displays are the main distribution devices. Distribution of the service preferred tools (the apps) may be via defined distribution channels dominating the market (e.g. Apple and Android stores); however, own and independent distributors

	largely integrate them and provide useful independent and/or alternative channels.
How are we reaching them now?	At-stop displays, on-board displays, SMS, public interactive terminals, PDAs and smartphones.
How are our Channels integrated?	All distribution and supply channels should be integrated into a single system through hubs and middleware components delivering services via Web and email protocols.
Which ones work best?	Mobile communication devices via Web and email (etc.) based information systems.
Which ones are most cost-efficient?	Web and email services and applications for smartphones.
How are we integrating them with customer routines?	Pull/push or event based systems triggered by events, GPS and mobile networks positioning, user profiled services.

Customer Interface	**Relationships**
What type of relationship does each of our customer segments expect us to establish and maintain with them?	Personal relationships with the most friendly user interfaces, enabling push and pull services. Attitudes of ƒprivacy maniacsò should be taken into account with a balanced mix of added value delivered by the apps versus possible privacy losses of the user.
Which ones have we established?	1 to 1 relationships with increasing amount of personalised (push) functions are widely replacing the older (pull) services ï such as SMS based services for example.
How are they integrated with the rest of our business model?	Maximum integration with all the business components is required for transport operators delivering services and information via MTIS. Content and technology providers usually offer integration with IIIrd party technologies and repositories, allowing for compatible use of legacy systems of the operator.
How costly they are?	The integration interfaces and CRM systems are costly and may represent major cost components.

Infrastructure Management	**Value Configuration**
What key activities do our value propositions require?	Growth and continuous improvement of the relationships with customers, stakeholders, partners. Acquisition and development of relevant information flow (ôfeedsö).
Our distribution channels?	Direct distribution of services by transport operators and/or indirect channel through content or technology providers are to be selected on the basis of the business and communication strategy of the operator. Third party agreements for distributing or integrating the apps should be considered.
Customer relationships?	Continuous data monitoring, collection and update; ongoing consultation with end users and market surveys.
Revenue streams?	Effective marketing activities during the whole life cycle of the system. Feed provisioning with high relevance to each customer profile.

Infrastructure Management	**Capability**
What key resources do our value propositions require?	In-house and outsourced resources should be balanced depending on the type of provider: repositories, automatic vehicle location systems, road sensors, communication provisioning infrastructure or services, Web based services, integration systems (middleware), feeds, real-time information, extra contents to enrich the transport information services.
Our distribution channels?	Transport operators directly acting as content providers need a complex infrastructure of servers with repositories, middleware and Web based services. In case of outsourcing agreements with third parties, the operator can reduce the effort and may deliver its services via web based applications.
Customer relationships?	Database marketing/CRM tools, continuous data collection and provisioning, ubiquitous communication channels.

Revenue streams?	Marketing tools and staff, always-on systems, h24 technical staff

Infrastructure Management	Partnership Network
Who are our key partners?	There are multiple combinations of partners, in the light of the two-way relationship between third party service providers and transport operators. Public and private transport operators may opt to partner with content/service providers; public transport operators can be partner of private operators. Technology vendors and API providers are possible partners in any case.
Who are our key suppliers?	Passengers and (other) transport operators provide data; service, technology and content providers provide the other resources and (part of) infrastructure. Customers are one of the most important partners, in models using ĉrowd-sourcingô
Which key resources are we acquiring from partners?	Update and real time information on transport services, vehicles and conditions; ICT services; mobile communication services; marketing services for customer relationships management; third party information for value added services (e.g. tourism information). Live information are extremely important and can be acquired via crowdsourcing2 ï e.g. for the determination of service irregularities.
Which key activities do partners perform?	Data collection and transmission; information provisioning and elaboration; technology and communication services and infrastructure management.

Finance	Cost Structure
What are the most important costs inherent in our business model?	The cost structure assumes different configurations and dimensions in relation to the degree of data and/or technology integration and complexity and to the level o service personalisation. Others factors affecting the cost structure relate to the type of operator, e.g. info service provider or infrastructure manager/owner: in the first case, the provider need low investment and usually pays for acquiring raw or elaborated data; operators owning will have to invest in the physical infrastructure, instead. However, operating costs are usually lower than implementation costs, and outsourcing of data/application management tends to decrease the capital investment on hardware and software. Vehicle localisation systems, speed and traffic tracking systems, adaptive models development are among the most important costs.
Which key resources are most expensive?	The technology infrastructure is the business element with the highest cost of resources in terms of capital investment, staff, information and services. As an example, the capital investment on vehicle localisation systems with on-board blackboxes for floating car data from Italian motorways (a network of 6.600 km requiring 83.000 on-board installations), is about ú15 million -which may be paid by the MTIS operator or by insurance companies; payback in 3 years without third party revenues. Open data availability and multi-modal applications are among the most expensive intangible resources.
Which key activities are most expensive?	System development is the most expensive activity. Operation and maintenance costs, including information update, are potentially lower but they grow with the complexity, integration and personalisation of services.

Finance	Revenue Model
For what value are our customers really willing to pay?	Customers may pay or be willing to pay the following services with money and/or loss of privacy: trip planning and control; reduction of travel time and inconveniences; (perceived) safety and security; real-time alternatives for multimodal routes.
For what do they currently pay?	The services are frequently provided free to users: in the majority of such cases, they accept push advertising. Alternatively, a fee may be asked for high value contents and/or services. Some application providers may charge for selected tools they offer.
How are they currently paying?	Subscription or one-off fees, when the services are not delivered on a

	free basis.
How would they prefer to pay?	Customers tend to prefer free services. In case of very high added value they might opt for subscriptions rather than on-demand payments. Surveys show the customer tends to prefer to pay for mobile information and/or services when they are included into public transport fares.
How much does each revenue Stream contribute to overall revenues?	Core revenues of info service providers, actually come from third parties like advertisers and sponsors in the current European market conditions. Subscriptions and on-demand fares for highly customisable, personalised and integrated services providing real time valuable information can replace or integrate the revenues from third parties. Minimum unity break even price to retail customer may be in a range of ú20-40 per year, in the example of (custom) real time traffic information from floating car data from Italian motorways.

6.4.3 SWOT Analysis

Strengths	**Weaknesses**
Technology progress in development of mobile apps and devices, with decreasing prices **Mutual benefits** to transport operators and service/information providers **Design simplicity** and ease of access **Worldwide access** to local information Access to **linked or integrated services** from differing providers **Customer personalisation** of apps	**Reliability** of mobile communication networks **Privacy** of personal data **Infrastructure limitations** in some areas Scattered **presence of accurate data** from operators and authorities **Consistency of API**, effectiveness of middleware and protocol stability **Confusing array of similar apps** without prior indication of reliability or accuracy
Fast and pervasive penetration of mobile communications and devices May be seen as an effective way to provide **multi-agency transit information** **Increasing integration** of ICT infrastructures and services **Fast growing** trends of mobile communications **Change of customer's habits** in information gathering **Increasing availability** of customers to provide personal data for tailored services **Trend of decreasing costs** for mobile communications **Increasing direct access** of apps to API data from transport operators and infrastructure providers **Cost reduction** for transport operators	**Not always welcomed** by service provider **Unreliable electricity provisioning** in some Countries may originate data losses and services unavailable **Limited coverage** in certain conditions (meteo for GPS based services, geography, network, etc.) **Legal actions** against some screen scraping technologies **Potential conflict** between third party app providers and API providers (Open sourced) systems providing **limited reporting** or failing to fully reflect (real time) changes.
Opportunities	**Threats**

6.5 Business Model: Car Park Management Systems

6.5.1 Overview

CPMS are conceived as urban applications with direct business interest also interesting rural and long distance travellers. This solutions family includes systems with an array of functions, like parking guidance, enforcement, user/provider information, payment, booking, site automation, etc. The business model concentrates on the availability, enforcement and payment functions of such systems. The user point of view is presented, distinctively from the operators', where important.

Car Parking Management Systems combine multiple technologies to enhance efficiency, security, enforcement of payments, etc. The business model is investigated from the point of view of the public or private park operators, and shows how to improve the efficiency and effectiveness of such systems in functions like payment enforcement and alternatives, and in security.

6.5.2 Discussion

Product	**Value Proposition**
What value do we deliver to the customer?	Reduced travel time, traffic congestion (as a consequence of reduced ñparasiticò traffic) and gaseous emissions. Increased safety and security enabled by ICT functions, also supported by possible re-allocation of traffic wardens.
Which one of our customerõs problems are we helping to solve?	Final users: enhanced chances and reduced time to park the private car. Operators: increased efficiency in enforcement and payment.
What bundles of products and services are we offering to each Customer Segment?	Alternative payment methods with enhanced flexibility, security and speed/ease of use. Enhanced vehicle security.
Which customer needs are we satisfying?	Quick and safe parking and payment, with reduction of circulating cash.

Customer Interface	**Target Customer**
For whom are we creating value?	Final users: urban travellers primarily, followed by rural and long distance travellers. Operators: public and private actors, municipalities, third party beneficiaries (e.g. city shops)
Who are our most important customers?	Urban travellers. Parking operators.

Customer Interface	**Distribution Channel(s)**
Through which Channels do our Customer Segments want to be reached?	Road displays, mobile phones, smartphones, PDAs, onboard displays.
How are we reaching them now?	Road and parking displays, mobile/smartphones, PDAs. Structured customer relationships.
How are our Channels integrated?	All centrally integrated with database and system management.
Which ones work best?	On-site and mobile communication channels need to work together for the best performance and quality of service.
Which ones are most cost-efficient?	Mobile communication systems.
How are we integrating them with customer routines?	Well integrated in the customer routines. Public APIs1 are frequently available to integrate parking systems into other applications.

Customer Interface	**Relationships**
What type of relationship does each of our customer segments expect	Car drivers generally use ôpullô information for parking services, therefore ôpushô activities may be limited to integrated information in third party

us to establish and maintain with them?	route planning and management apps, at initial stages of development. Membership and fidelity plans, as well as ‘smart functions’ in route planning apps are a plus. Private parking operators and public operators/municipalities need structured relationships to manage large amount of technical information, financial simulations, market and customer information, etc.
Which ones have we established?	On site contact and remote communication as basic interfaces. Virtual assistants and other added value interfaces are a plus.
How are they integrated with the rest of our business model?	Customer interfaces have sufficient maturity and are usually well integrated with the other core activities of the business model.
How costly they are?	Final users: on-site communication and interaction are more costly than remote information via mobile and/or touchless interfaces, which will have to be preferred in the business model. Operators: structured customer relationships are costly when deployed by highly intensive human activity; the operational costs may be reduced by CRM systems, which however require initial investments for development, introduction and training.

Infrastructure Management	**Value Configuration**
What key activities do our value propositions require?	Parking availability planning and management, with extensive use and management of real-time data. Site/sensor maintenance and security. Multi-channel payment processing. Enforcement on payment.
Our distribution channels?	Real-time communication. Runtime data collection and mining offer the best solutions to each site/customer at the right moment.
Customer relationships?	Real-time communication for parking availability, forecast and information.
Revenue streams?	Multi-channel payment processing. Booking functions. Traditional B2B channels.

Infrastructure Management	**Capability**
What key resources do our value propositions require?	Final users: site acquisition, permitting, management and maintenance; enforcement personnel. Operators: network of sensors, server farm management. Value delivered to both categories of beneficiaries: centralised real-time processing power of parking data and vehicle traffic.
Our distribution channels?	Integrated communication systems, skilled sales force. Value added services.
Customer relationships?	Skilled personnel. Digital/unmanned communication interfaces.
Revenue streams?	Multi-channel payment systems.

Infrastructure Management	**Partnership Network**
Who are our key partners?	Public Authorities when different from the parking operator. Third party application developers.
Who are our key suppliers?	ITS suppliers, maintenance and enforcement providers. Software and hardware vendors/OEM; telecommunication companies.
Which key resources are we acquiring from partners?	Regulation information, licenses and spaces, infrastructures. Programming interfaces/services for parking system integration in other applications and systems.
Which key activities do partners perform?	Software applications; data, information, permits and regulations.

Finance	**Cost Structure**
What are the most important costs	Operations costs for enforcement and maintenance. Licenses, spaces,

inherent in our business model?	infrastructures. Investments for integrated systems with real time processing and communication capabilities.
Which key resources are most expensive?	Parking spaces are generally the most expensive resources, especially in urban ónodes of interestö, human resources for enforcement dominating the legacy cost model are reduced by intelligent parking systems; in this case resources for ICT (system/sensors) maintenance become relevant.
Which key activities are most expensive?	Enforcement and security. Maintenance of sensors. Capacity, location and car flows planning.

Finance	**Revenue Model**
For what value are our customers really willing to pay?	Final users: reduced travel time and stress. Value added services. Public operators: as an alternative to congestion tolling, parking pricing systems are increasingly attractive to manage congestion and generate alternative revenues which may outweigh the tolls. All Operators: better enforcement and related cost reduction; safe and quick payment.
For what do they currently pay?	Final users: parking availability for the time needed, with additional services in some cases.
How are they currently paying?	Final users: online payment, cash and credit/debit card to unmanned systems or to personnel on-site. Operators: usual B2B channels.
How would they prefer to pay?	Final users: on-site cash or credit/debit card as legacy system, in combination with alternative methods including mobile, touchless and remote payment.
How much does each revenue Stream contribute to overall revenues?	The introduction of parking detection and payment systems can rapidly generate revenue growth by 20-30% in legacy systems, due to improved effectiveness of enforcement capability and its cost reduction enabled by technology.

6.5.3 SWOT Analysis

Strengths	Weaknesses
High demand for parking availability services by final users **High demand** for enforcement and payment management by operators **Positive effects on revenue** of public and private operators **Technological systems** readily available on market, with low customisation **Reduced retention** and transfer of cash	Initial purchase and implementation **costs** **Maintenance** of sensors **Legal requirements**, e.g. for privacy protection, data retention, etc. System **scalability** and integration with legacy systems
Fast and pervasive penetration of mobile communications and devices **Increasing integration** of ICT infrastructures and services **Change of customer's habits** in information gathering and increasing availability of customers to provide personal data for tailored services Trend of **decreasing costs** for mobile communication	System **unreliability** or preciseness (e.g. optical recognition) Low **market penetration** **Different legislative frameworks** on privacy protection among Countries **Possible exposure** of ICT systems to external threats (e.g. hacking) or faults
Opportunities	**Threats**

6.6 CONCLUSION

The BM investigation and design in COMPASS deliver useful insights of effective solutions for co-modality and decarbonisation of transport, bringing their business perspective to the target audience, with an innovative approach to learn how to create and capture customer value in the business of co-modal transport systems. The four BMs highlight the benefit of co-modality and present a fair degree of feasible innovation for decarbonisation of transport.

The majority of ICT applications taken into analysis bring innovation to transport systems at maturity stage; MTIS represents instead a new kind of solution generating multiple new businesses. All the ITSs included in the analysis can considerably enhance co-modality and reduce greenhouse gases with the application of innovative technology. For such reason, the business models delivered by COMPASS, that help organisations to plan and introduce and/or change elements for business success, are expected to contribute to the European strategy toward the objectives of co-modality and decarbonisation of transport.

Bike Sharing Systems are of recent introduction or have been re-engineered in major European cities, although their implementation not always show a successful track record; the prototype model and the SWOT investigate the main causes of failure (such as poor business modelling at startup and/or management stages, high rates of thefts and vandalism in some areas/circumstances, difficult topographic conditions not adequately considered at planning stages, etc.), and give operational and strategy indications for improvement. Innovation for business success include radical ITS adoption and integration, public-private partnerships, user incentive schemes, subsidies to operators.

Car Parking Management Systems combine multiple technologies to enhance efficiency, security, enforcement of payments, etc. The business model is investigated from the point of view of the (public or private) park operator, and shows how to improve the efficiency and effectiveness of such systems in functions like payment enforcement and alternatives, and in security. The analysis shows how radically change the business after ITS introduction, in aspects as: reduced HR costs; increased maintenance costs (mainly on sensors); overall revenue growth; increased efficiency; better enforcement of payment; enhanced vehicle security; improved integration with other services/applications. Public operators of CPMS may also use them as an alternative/complement to congestion tolling, with increased revenue in most cases.

The business of Share Taxis is another example of legacy transport system which can be drastically improved by the use of ICT solutions. In the prototype model, a wide range of solutions for booking, route management and payment is considered to enhance capability, customer satisfaction, security of payment, service efficiency. Relevant legal issues are also analysed. Such BM explains the great enhancement in capability and efficiency in operations and organisation infrastructure, in route planning and time reduction, in facilitating and expanding upward information flows to networks and authorities. New payment choices and greater customer satisfaction are enabled by the introduction of ITS in the Share Taxi model.

MTIS are the leading edge solutions family among the COMPASS business models, representing the most pervasive ITS considered in the analysis. Their market is expanding rapidly in conjunction with the growth of mobile telecommunication and of the market penetration of devices such as PDAs, tablet and smartphones. However, the model is designed to encompass a variety of applications that may enter a single business strategy, oriented to satisfy a wide range of needs expressed by long-distance, rural and urban travellers. The BM investigation in COMPASS focuses on information functions, and user interaction and assistance of MTIS. The trade-off between user privacy and service level is evident in such model, where a networked approach will dominate. Many sources of revenues are possible in the MTIS BM, such as cross-selling, third party revenues, crowdsourcing and other innovative configurations. This is the only case where the 'free-lunch'[33] approach is feasible and remunerative, among those considered.

[33] A business situation where the customer is provided with products/services at no direct monetary cost, where the remuneration of the seller is guaranteed by other direct/indirect sources of income. It is becoming more and more diffused in many commodity and ICT markets, and will take place in investment goods markets too -e.g. electric cars and parts.

A SWOT analysis is delivered together with each model, as described in the project plan. The resulting indications complete the information layer given by the business models, and support the strategy analysis of business operators interested to adopt or customise the relevant business model. The SWOT analysis assists the strategic evaluation of internal and external factors influencing the competitive forces in the market and the strategic environment of each solution . Such analysis is obviously market focussed and is intended as a strategic snapshot taken from a company-neutral point of view, just as in the business models.

Adoption of the COMPASS business models can enhance the competitiveness of transport operators while creating the conditions for wider diffusion of co-modal transport services and helping to decarbonise the sector, whereas the diffusion of the co-modal solutions described in COMPASS will also help to tackle the ñlinks and nodesò barriers to co-modality (Macário, R., Viegas, J. M., Reis, V., Magalhães, L., 2012).

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