ROADMAPPING ITS AND ICT TO IMPROVE MOBILITY GAPS IN THE NORTH-WEST EUROPEAN REGION

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ABSTRACT

Mobility management is at the heart of the low carbon future. Whilst globally significant nations are racing to set the target to meet reductions in greenhouse gas emissions from transport by 2050, technology and travel demand reduction are thought to be the ultimate solutions. However, it is less clear how this will fit with the current and projected demand of travel. The research question addressed in this study is to gain insights into how Intelligent Transport Systems (ITS) and Information and Communication Technology (ICT) can be used to promote mobility management over the next 25 years using the North West European region as a case study. The detailed objective is to have a better understanding on how ITS/ICT can contribute to improve the (so-called) 'first and last miles' of local journeys thus reducing the "mobility gap". A questionnaire methodology is used to capture four objectives; current experience of ITS/ICT procurement/deployment/evaluation; future technology requirements; consideration of a variety of future technology scenarios; and anticipated challenges in achieving the future requirements. Local authorities, public transport operators and transport consultancies are the major respondents across 7 North West European nations. The analysis shows that the Public Transport (Management) and Environment ITS policy themes are the stated top priorities to play a role in improving mobility gaps across different organisation types. Real-time information that reflects the importance individuals place on time was highlighted as the key aspect that all stakeholders wish to address. Furthermore, the trends of first and last mile solutions in different regions may differ to meet local needs. It may be concluded, however, given the need to address the social exclusion issue and the trend of an ageing population with high life expectancy, that Demand Responsive Transport (DRT) has particular potential to address mobility gaps in the wider context.

Keywords: ITS applications, technology roadmap, first and last mile, North-West Europe

INTRODUCTION

Improving Connectivity and Mobility Access (ICMA) is a European Commission (EC) funded project which aims to draw together and disseminate good practice in relation to how the 'first mile and last miles' of local journeys can be improved. The initiative is derived from the commitment of the EC White Paper on Transport (2001) which emphasized that to achieve European prosperity in terms of economic growth, social development and the environment, effective transport systems are essential. The White Paper highlighted three major challenges towards achieving sustainable transport, namely: reduction in congestion with optimum use of the existing capacity, improvement in traffic safety improvement and reduction of environmental impact reduction through greater energy efficiency and decreased fossil fuel dependency.

Whilst the ICMA project is divided into a number of different strands, the research reported here is based on the ICMA study to develop an ITS technology roadmap to help address the above agenda set by the EC. The objective of this particular study is to assess the probable evolution and market access of future ICT relevant to mobility management over a 25 year horizon and to define a framework for North-West European cities to adopt ITS solutions suitable to their regions. An initial public consultation of ITS applications relevant to support the EC's sustainable transport targets – conducted by EC-ITS (2007) – shows that, despite the apparent presence of ITS to support the transport systems, there are obstacles to the deployment of such technology. This, in turn is the key issue this paper aims to address, especially in the context of improving public transport service quality and efficiency.

The structure of the paper is as follows: A brief literature review about the debate of the role of future ITS applications towards meeting sustainable transport practice is followed by the methodology of the technology roadmap questionnaire design. The analysis of the results from the questionnaire comes next before the concluding discussion. The term ITS and ICT are used interchangeably throughout the paper but in most cases these represent the same meaning[1].

LITERATURE REVIEW

The Rio Earth Summit in 1992 established the momentum for recognition of global climate change. Subsequently, the Kyoto Protocol in 1994 resulted in national governments setting targets of reducing CO_2 emissions where road transport has contributed intensively. The Stern report on the Economics of Climate Change (2006) suggested that developed countries like the UK will need to achieve 60-80% reduction in total emissions by 2050. Thus, the investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and beyond. At the European level, road transport has significant impacts on climate change with about 12% of the overall EU emissions of CO_2

[1] For example, a nomadic mobile device can be categorised as ICT, but when integrated with a web-based journey planning system, it is considered as ITS.

coming from the fuel consumption of passenger cars (EC-ITS, 2007). However, it is apparent that improvements in vehicle fuel efficiency have been neutralized by the growth in vehicle numbers. Whilst the EU as a whole has reduced its emissions of greenhouse gases by just under 5% over the 1990-1994 period, the CO_2 emissions from road transport have increased by 26% (EC-ITS, 2007).

In the UK, King's review of the low-carbon car (2007) argued that emissions reductions set by the Stern review of up to 80% are feasible. King's review concluded that cleaner fuel, more efficient vehicles and smart driver choices would be good tools to meet goals for sustainable road transport – now referred to as the low carbon future. This argument is also confirmed by a study in California, US, that advanced vehicle and fuels technology and travel demand reductions seem feasible to meet local targets (Yang et al., 2009). However, another study in London, UK, concluded that current carbon reduction targets are practically very difficult to achieve as yet (Hickman et al, 2009). The huge challenge, the study argued, is to map out and discuss a variety of policy pathways to carbon efficiency in the transport sector, and then to enable and achieve a level of consumer and behavioural change consistent with strategic aspiration. Nevertheless evidence from Japan shows that ITS can contribute to the development of eco-transport cities through a combination of positive measures that encourage the use of public transport and negative measures that discourage car usage (Morikawa, 2008). The use of ITS for optimising environmentally friendly cars, promoting Park and Ride in urban cities, Road User Charging using a Parking Deposit System, and ITS applications to promote 'traffic calming', are some of the solutions available for ITS to play a bigger role in sustainable cities and transportation. In the following sub-sections, ITS applications are discussed in detail based on the transport roadmap study conducted by European Commission (EC-ITS, 2007, 2008).

EC-ITS Roadmap study (2007)

The EC-ITS Roadmap set out the European Commission's policy framework (2007) and identified that there are three major challenges in the provision of sustainable transport. These include: reduction in congestion and optimum use of existing capacity; increase in traffic safety; and addressing the negative impact on the environment with increasing energy efficiency and reducing dependency on fossil fuels. In parallel with the transport technology roadmap, the recent emphasis of EC is on the deployment of ITS applications for road and their interconnections with other modes of transport (EU, 2008). The EC-ITS roadmap document (2007) also outlined the way forward to achieving a consistent and comprehensive policy framework (organizational, regulatory, funding and standardization), co-operation with the main stakeholders (Member States, industry and user organizations), proposals for creating real ownership of different ITS applications and a business case.

A number of core ITS applications were identified, including:

- Seamless real-time travel and traffic information, including multi-modal journey planning and information systems;

- Freight information systems combining operators' freight-flow and public authorities traffic flow requirements contributing to the optimum use of road capacity and the reduction of negative impact on the environment;
- eCall leading to a reduction in fatalities;
- Electronic Toll Collection as a key instrument for internalization of external costs;
- Traffic demand management leading to a cleaner road transport and less congestion;
- The integration of several core applications on an open in-vehicle telematics platform.

The roadmap outline approach identifies the main elements in the provision of transport which include: the vehicle, the infrastructure, the human elements and freight (EC-ITS, 2007). For each of these elements, ITS tools are identified to contribute to addressing the three major challenges of sustainable transport: additional capacity or reducing congestion ('Efficient'), improved safety ('Safe') and minimization of the adverse impact of mobility on the environment ('Clean').

EC-ITS Roadmap public consultation (2008)

Following the roadmap study described above, an Action Plan was developed. This initiative aims to launch and to support a limited number of targeted actions to unlock the full potential of ITS in serving EU policies in the field of enhanced road safety, improved transport efficiency and reduced environmental impact, and to create the momentum necessary to speed up market penetration of (rather immature) ITS applications and services (EC-ITS, 2008). The Action Plan attempted to answer two critical questions: Firstly, which ITS applications can best serve policy goals, and which are mature enough to allow Europe-wide deployment in the short-to-medium term? Secondly, what instruments available to the Commission services should best be used to speed up market penetration of these ITS applications and services. A questionnaire was developed by EC-ITS (2008) to address the issues and some of the important aspects relevant to this research are discussed below.

The questionnaire developed was targeted at stakeholders and carried out in March 2008. The results of the questionnaire show that the slow phase of the ITS deployment in the EU is a result of mainly the lack of full (EU-wide) coverage and the high costs for public authorities. Furthermore, a large majority of stakeholders believe that ITS provides most benefit via Real-time traffic information, Dynamic vehicle navigation, and Advanced in-vehicle safety features. The results also show that the EU can contribute to the development and deployment of ITS by supporting the production of standards and providing a co-ordination platform for synchronized deployment of ITS. This statement is also supported with the agreement of stakeholders that EU actions should concentrate on a limited mixture of mature core ITS applications.

The most important ITS applications that were considered to have reached a mature stage and merit support in the short-term (EC-ITS, 2008) are:

- Dynamic route guidance and guidance in case of incidents
- Real-time traffic information (RDS-TMC, **R**adio **D**ata **S**ystems **T**raffic **M**essage **C**hannel)

- Co-operative systems, based on vehicle-to-vehicle (v2v) and vehicle-to-infrastructure (v2i) communication

For the mid-to-long term, multi-modal door-to-door trip planning and access of mobile nomadic devices are identified as other ITS applications which need to be developed further. An additional issue which has been identified from the questionnaire is the agreement amongst most of the stakeholders on the importance of liability issues and data protection for ITS development.

The study also shows that the stakeholders expect the EU to further prioritize other issues such as: minimum road requirements for all EU, cross-border enforcement and awareness that ITS interoperability is a question of solving management problems and not technological ones. A large majority of stakeholders agreed that ITS should be interoperable between different transport modes which also includes the interoperability of in-vehicle devices with public transport systems. A number of benefits are predicted from the stakeholders on the interoperability issue:

- Accelerating the penetration of new services to the final customers;
- Higher efficiency of transport;
- More choice (of transport mode, private car or public transport) in pre-trip phase;
- Benefit for people who are not able to buy expensive navigator systems; and
- A better use of infrastructure for providing mobility of freight and people.

In the next section development of the questionnaire methodology for this ICMA study is discussed. Since the EC-ITS roadmap study has already been established at the EU level, the ICMA questionnaire design adapted the EC-ITS questionnaire but with particular focus on ITS application themes for improving the first and last mile of local journeys.

METHODOLOGY

The term ‘technology roadmap’ has been used quite frequently by various IT oriented institutions/organizations to present possible future development paths for technology. The aim of a ‘roadmap’ is to identify the challenges and obstacles that will need to be overcome for progress to be made in research and development, and for greater commercial adoption of the technology to occur. The roadmapping approach was first developed by Motorola about 30 years ago and has been adopted by many organizations, initially within other large technology intensive firms in the consumer electronics, aerospace and defence sectors (Phal, 2006). For ICMA the focus is on transport telematics where ITS applications are expected to be roadmapped for the next 25 years to address local mobility gaps as has already been identified to some extent in the EC-ITS (2007) roadmap outline.

Phal (2006) reported that a key benefit of roadmapping is the communication associated with the development and dissemination of roadmaps, particularly for aligning technology and commercial perspectives, balancing market ‘pull’ and technology ‘push’. Roadmaps can take many forms, but the most general and flexible approach comprises a time-based and multi-layered chart to enable the various functions and perspectives within an organization to be

aligned and provide a structured framework to address three key questions: Where do we want to go? Where are we now? and How can we get there? (Phal, 2006).

The UK Department for Transport (DfT) ITS policy framework document (2005) highlighted the importance of ITS applications for the road transport sector and this has created a foundation for the UK-ITS community to support and facilitate the economic, legal and administrative climate for widespread ITS deployment that benefits all road users. The framework document is a response to feedback from ITS stakeholders in both the public and private sectors who have asked DfT to provide a sectoral picture. Furthermore, the document also sets out the role of ITS to support the delivery of UK Government road transport objectives and proposes a number of strategic actions that DfT has taken in relation to ITS deployment (DfT, 2005). This step was followed by the development of The Intelligent Transport Systems Knowledge Transfer Network (ITS-KTN) in 2008.

ITS-KTN (2008) has developed an ITS technology roadmap based on the Seven *ITS policy themes* outlined by the UK Department for Transport (DfT) - ITS policy framework for the roads sector (DfT, 2005). Six out of the seven ITS policy themes are relevant to the ICMA study, namely: (1) public transport, (2) travel information, (3) road network management, (4) safety, (5) environment and (6) security. The seventh theme is the improvement of efficiency to the road freight industry. Besides the main themes above, three sub-themes (of which two are used in the questionnaire) are also considered to address the emerging issue of an ageing population and the trend of changing travel behaviour, namely mobility management and accessibility; resource management; and training. Mobility management and accessibility and training are envisaged to be sub-themes alongside the established main themes identified above. Accessibility as a sub-theme may expand the search of the relevant ITS applications in the terms of physical access and access to services/facilities or places. It is envisaged that an informed personal travel solution for individuals is very important in addressing this sub-theme. For resource management, issues such as vehicles, staff, other intelligent systems and finance are considered to be relevant as well. It is envisaged that monitoring and management information can be a driver for decisions relating to investment and technology applications. However, it was considered that this sub-theme could result in biased output as the respondents' organisations can vary substantially; therefore this sub-theme was not taken further in the questionnaire. With this framework, this paper endeavours to formulate a new roadmap approach to complement the existing UK-ITS roadmap.

For each of these themes, a number of *ITS applications* are documented. This is used as the basis of statements for structuring the questionnaire. The quantitative section is designed with a 7 level preference scale from 'least important' up to 'extremely important' to capture stakeholders opinion of the importance of specific ITS applications from the ITS themes structure. For example, in the 'Public Transport' theme, ITS applications such as real-time traffic information, multi-modal journey planning, smartcard use, etc. are measured in terms of importance against the theme. In the qualitative assessment following the quantitative exercise, the respondents were offered a blank space for text to report their opinion on each ITS theme that they deemed high in importance in the quantitative section. In total, 64 ITS applications were measured to its importance towards 8 different ITS themes. The preferred

scenario for the business case and types of obstacles against the ITS uptake within the stakeholders also featured in the questionnaire design.

The survey was conducted by ICMA partners across 7 North Western European countries in late summer 2009. The questionnaire was translated and distributed in 3 languages (English, German (2 versions, one in Swiss German) and French. The distribution of the questionnaire was handled by 10 different organisations. In total, 49 questionnaires were completed. The sample distribution by country and organisation type can be seen in Figure 1.

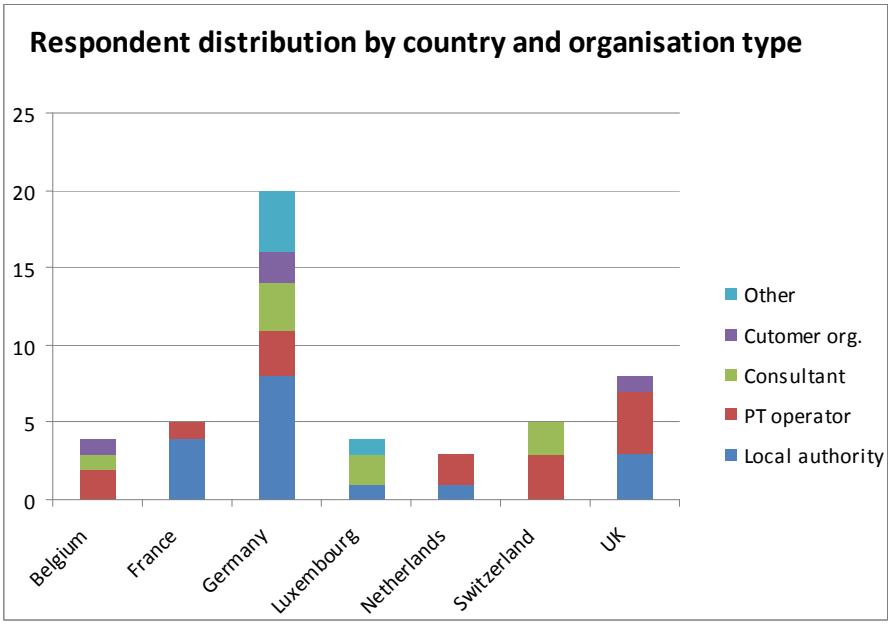

Figure 1 Respondent distribution by country and organization type (source: this study)

To conclude this section, this study adopts the concept of technology roadmap to develop a questionnaire. It is not the intention of the study to conduct a technology roadmap exercise. The framework of the questionnaire is fourfold: current experience of ITS solutions; future technology requirements; business case scenarios and ITS deployment obstacles. The next section discusses the analysis of results.

ANALYSIS OF RESULTS

Drawing on the output of the review and the selection of candidate technologies and possible future scenarios for their implementation, a questionnaire targeted at ICMA stakeholders and partners has covered the following broad themes:

- Current experience of ITS/ICT applications by respondent
- Future (ITS/ICT) technology requirements of respondent
- Consideration of a variety of future ITS/ICT technology scenarios
- Anticipated challenges in achieving future requirements

The following sub-sections describe the outcome of analysis drawn from the questionnaire.

Current experience of ITS applications

A list of ITS-based solutions derived from the EC ITS-Roadmap public consultation study (2008) and input from ICMA partners were used to represent the ITS applications that may be relevant to the target respondents in terms of first and last mile solutions. The results, which can be seen in Table 1, show that 'multi-modal door-to-door trip planning' is the most popular with the highest frequency (57%) of experience / use reported by respondents. This is followed by 'demand responsive transport (DRT)', with 53% respondents reporting using the application followed by 'access to nomadic mobile devices' with 35%.

Table 1 Respondents current experience of using ITS-based solutions (source: this study)

Rank to yes	ITS-based solutions	N	Yes	%	No	%	Don't know	%
1	Multi-modal door-to-door trip planning	48	28	57.1%	19	38.8%	1	2.0%
2	Demand Responsive Transport (DRT)	47	26	53.1%	20	40.8%	1	2.0%
3	Access to mobile nomadic devices	46	17	34.7%	26	53.1%	2	4.1%
4	Co-operative systems, based on v2i communication	47	16	32.7%	26	53.1%	5	10.2%
5	Real-time traffic information (RDS-TMC)	47	15	30.6%	31	63.3%	1	2.0%
6	Co-operative systems, based on v2v communication	48	12	24.5%	31	63.3%	5	10.2%
7	Dynamic route guidance and guidance in case of incidents	47	11	22.4%	33	67.3%	3	6.1%
8	Smartcard use for concessionary fare scheme	47	10	20.4%	35	71.4%	2	4.1%
9	Radio-frequency Identification (RFID)	41	8	16.3%	27	55.1%	6	12.2%
10	Web 3.0 and web 4.0 solutions	41	5	10.2%	30	61.2%	6	12.2%

It is interesting to note that 'smartcard use for concessionary fare scheme' appears as not popular among other ITS-based solutions. It was expected that 'smartcard use' should be widely practiced by the respondents, however the low response rate was perhaps due to the use of the phrase 'concessionary fare scheme' in the questionnaire as this may not be familiar to respondents. Furthermore, it is also acknowledged that in countries where multi-modal ticketing is already available, the change to smartcard technology may be considered relatively expensive with no real advantage for the consumer.

Importance of ITS applications across different themes

The next section in the questionnaire drew respondents' attention to the measuring scale of importance of ITS applications within various themes as discussed in the previous section. A frequency analysis was conducted with help of boxplot output from SPSS™ to ease comparison between different themes across different organisation types. The frequency analysis results show that the majority of the respondents across different organisation types prioritise 'Travel Information'. On average, the majority of the respondents indicate 'very important' or 'extremely important' for the 'Travel Information' theme. However, local authority, public transport operator and consultant respondents (82%) also prioritise the

'Public Transport Management' and 'Mobility Management and Accessibility' themes; they state 'very important' on average. The remaining themes are given less importance.

Frequency analysis by country shows that the 'Travel Information' theme is the top priority for respondents with average opinion between 'very important' or 'extremely important', except in Switzerland, where the opinion is averaged as 'important'. However, it is noted that there is no local authority representative from Switzerland in the sample, only public transport operators and consultants. The 'Public Transport' theme is next in the list of priority with average opinion of 'very important' and 'extremely important' in the Netherlands and 'important' in Luxembourg. Again, it is noted that in Luxembourg there is no public transport operator representative therefore this may not be the priority for either consultants or local authorities. At the third priority, 'Mobility Management and Accessibility' is averaged as 'very important', but in the UK it is averaged as 'extremely important' while in the Netherlands it is just 'important'. This may due to the Netherlands respondents' organisation type that is only from a public transport operator background.

The insights of respondents' opinion of ITS theme priority by organisation type and by country show a similar pattern. However, there is not an equal distribution of organisation type in every country; this may skew the interpretation of the result using boxplots output by country. For example, some countries only have respondents from public transport operators and none from local authorities. For this reason, in the next part of the analysis, only average opinion by organisation type is described. Comparing respondents' opinion across 8 different themes using the boxplots analysis, it is revealed that 'Public Transport (Management)' theme and 'Environment' theme are the most strongly prioritised by the respondents. The ITS application variables involved are 'real-time traffic information with estimates of travel time delay' and 'More efficient public transport'. These findings show that public transport, real-time information services and environment are the key issues that the respondents consider for ITS to play a role to address the EU target for efficient, safe and clean road transport. Table 2 demonstrates the ranking of the most important ITS themes and their applications. The theme of 'Travel Information' with the ITS application of 'Co-existence and interoperability with other systems' comes after the 'Public Transport (Management)' and 'Environment' theme.

From the qualitative assessment exercise, it can be interpreted that the priority measures to address the first and last mile of a journey as envisaged by the respondents are bicycle, car sharing schemes and Demand Responsive Transport (DRT). It is also envisaged that bicycles and car sharing as well as DRT can be incorporated in to existing multi-modal journey planning systems. Real-time traffic information, e-ticketing, smartcards, intermodality and access for all towards multi-modal transport services are the general message from the respondents about the preferred deployment of future technology, especially in the Public Transport (Management) theme.

"Time" is seen by the respondents as the most important aspect of a journey, therefore 'real-time travel information with estimates of travel time delay' is the most sought ITS technology application. This should be prioritised, although many places have already implemented such

technology to support public transport passengers, road management network and the environment. The paramount importance of real-time traffic information can be mirrored with the collected responses from all the respondents when asked about their priority for the 'Travel Information' theme across different countries: the majority of the respondents answered that real-time traffic information is the key future scenario. The arguments supporting this are that by the provision of real-time traffic information, intermodality and interoperability can be controlled to give better benefit for the passengers / customers.

Table 2 Summary of the most important ITS applications across different ITS themes (source: this study)

Rank	ITS theme	ITS application	Average opinion
(1)	Public Transport (Management)	Real-time traffic information with estimates travel time delay	very important. – extremely important
(1)	Environment	More efficient public transport	very important – extremely important
3	Travel Information	Co-existence and interoperability with other systems	very important
(4)	Security	Privacy preserving information security	important – extremely important
(4)	Mobility Management and Accessibility	Mobility aids for people with restricted mobility (electric wheelchairs, scooters, etc.)	important – extremely important
(6)	Road Network Management	Active traffic management	important – very important
(6)	Road Safety	Pedestrian/vulnerable road user protection	important – very important
(6)	Training	Computer-based interactive training tools	important – very important

For the Road Network Management theme, the stark highlight from the respondents is also about the presence of real-time traffic information to support active traffic management. However, variable message signs are already in many places in respondents' cities; an interesting suggestion from the respondents is about the use of this information to give public transport priority in cities. The qualitative responses from this theme suggest that the respondents have related this theme with the Environment theme. Despite some responses which argued that the environment theme has less relevance to the first and last mile of a journey, others' responses offer inspiration. Managed travel through Park and Ride is seen as one of the promising future technology scenarios to address the environment issue.

The Road Safety theme and the Security theme have had less responses in this assessment, perhaps because of the perceived relevance to the first and last mile agenda and because of the nature of the respondents' organisation type which has little control over the theme. The aspirations for these themes, however, are cyclist and pedestrian protection devices and vehicle occupancy monitoring (in Road Safety) and privacy preserving information security and vehicle tracking (in Security).

For the Mobility Management and Accessibility theme, the issues raised by respondents are around easy access to public transport for disabled travellers, inter-modality, smartcards and interoperability of modes. These are issues which also raise awareness of social exclusion

and ageing. To address the first and last mile agenda, the electric bicycle – as raised by respondents from Germany, Switzerland and the Netherlands – is seen as the solution. This is in contrast to the UK, France, Luxembourg and Belgium where the electric vehicle and DRT seemed to be the most promising answer to the first and last mile agenda. However, it should be born in mind that this consensus is only based from this very limited regional survey; it may be different if the survey was carried out more widely.

For the Training theme, it is interesting to note that UK respondents put much interest in this theme whilst not so much attention was given in other countries. However, reviewing the responses, it becomes clear that there are two perceptions of what the training theme was addressing. The responses are a mixture of answers on the idea of training as a scheme for the stakeholders or the customers / passengers. As a result, combinations of answers from driver simulator up to publicising existing multi-modal planners were reported.

ITS applications business case scenario

Respondents were invited to comment on three time horizons of business case (short, medium and long). The short-term had the most responses and concludes that ITS/ICT technologies can fall into a number of categories including: Information (journey Planning), Management information, Training, Communications, Asset management, Environmental management, Ticketing and Integration. In many cases the problems faced by partners relate to budgetary, training and procurement issues. There are a wide range of systems on offer and the challenge is deciding on the best long-term solutions. Other aspects that give cause for concern are the lack of standards to build confidence in long-term investment.

A multi-modal real-time information service and smart card ticketing system deployment have been envisaged as the priority in the short-term scenario in Germany, France, Switzerland, The Netherlands and Luxembourg. In the UK and Belgium, the priority for deployment is real-time booking systems and operation of DRT. A car-pooling improvement scenario is anticipated in Switzerland.

The aspirations of respondents in the medium-term are building on business plans developed within organisations. The need for greater co-ordination and development of integrated systems to provide multi-modal meaningful management information systems to respond to the customer needs is highlighted.

For the business case beyond 5 years, less clear responses were reported. One of the reasons, as also mentioned by one or two of the respondents, is that it is too far ahead. In many cases respondents repeated ITS applications as mentioned in the short and medium term business case. Moreover, it can be seen that many of the expectations after 5 years relate to the continuity of services that authorities or operators have already introduced to meet customers / passengers demand.

ITS solutions: deployment obstacles

The last section of the questionnaire asked about the main obstacles to the deployment of ITS applications in public transport operations. There were 8 suggestions included in this section plus one open blank space for respondents to report in their own words. The quantitative exercise shows that 36 respondents (out of 44 who answered the question) indicated more than one reason for obstacles to ITS deployment in public transport. Table 3 demonstrates the respondents' opinion of obstacles of ITS deployment in public transport.

Table 3 ICMA respondents on obstacles of ITS deployment (source: this study)

Rank obstacles	Obstacle Statements	Number of responses
1	Low penetration because too costly (in case of in-vehicle devices and applications)	23
2	Lack of awareness of decision makers	19
3	ITS applications have not yet demonstrated their full potential	16
(4)	Lack of transparency regarding providers and prices	15
(4)	Unsolved questions on privacy or security issues	15
6	Lack of full coverage or consistent deployment (co-operation between the main actors seems to be missing)	14
7	Low interest because of insufficient quality, services do not deliver what promised	10
8	Lack of customers' awareness	6

Notwithstanding the issues raised by partners there is a clear understanding that technology does and will play a significant role in the future development of multi-modal integrated public transport services. Many of the issues and concerns centre on awareness, cost and reliability. Over the past 10 years the costs relating to hardware have tumbled especially computer hardware devices. Mobile GPRS and GPS services are now beginning to reduce in price. At the same time mobile phone networks and 3G/4G networks have become more reliable. To conclude, there is no single solution to meet the varied needs and challenges faced by different organisation types. Perhaps, the interpretation by consultants and a public transport operator in Germany is correct in that different obstacles may apply to different ITS applications and thus to different organisation types, regions and countries too.

CONCLUSIONS

This study has addressed questions regarding ITS/ICT systems and their role in transport. Looking back 25 years, would people have now expected everyday access to mobile phones, Internet, PDA, GPS GPRS, real-time information, smartcards, virtual maps, air / sound / pollution monitoring, electric scooters, wheelchairs, Segway etc.?

Across different organisation types and countries, multi-modal door-to-door journey planning systems, followed by Demand Responsive Transport (DRT) and access to mobile nomadic devices are the current ITS applications deployed as core solutions to addressing mobility gaps and the first and last mile question. However, the future ITS application solution

foreseen by respondents is real-time information that reflects the importance that individuals place on time, although this particular application is already evidenced by some respondents in terms of their current ITS solutions experience. It can be concluded that a number of core technologies now exist that are unlikely to change significantly over the next 25 years and it would seem logical to build supporting technologies around the core products of Internet and mobile communications.

Table 4 Respondents' aspirations of future technology application for Public Transport and Environment (source: this study)

No	Country	Future ICMA technology for Public Transport Theme	Future ICMA technology for Environment Theme
1	Germany	Incorporate bicycles and car-sharing scheme in journey planning systems and pursue electronic ticketing (smartcard)	Incorporation of Park and Ride with multi-modal journey planning system and priority for bicycle and pedestrian
2	France	Give priority to alternative travel such as bicycle and Segway and address intermodality issues	Park and Ride and to include eco-driving training criteria
3	UK	Pursue smartcards for ticketing systems and extend for DRT; and pursue real-time information on mobile devices (i.e. in public transport)	Improving Booking, Scheduling and Dispatching (BSD) system for DRT, electric vehicle and car free cities with public transport nodal support
4	Switzerland	Pursue dynamic capacity model for public transport partnership (to address intermodality issue)	GPS system for route optimising, electric vehicle and electric bicycle with its connection to bus services
5	Luxembourg	Single payment ticket and intermodality	CO_2 reduction through legal incentives
6	Belgium	Easy ticketing, monthly travel invoices and bus priority lane	No issue raised
7	Netherlands	Universal payment device, logistics for bicycles in public transport	More cycle lanes and bus lanes

From the examination of the importance of ITS applications throughout different themes, the findings show that public transport, real-time information services and environment are the key issues that the stakeholders are interested in for ITS to play a role to address the EU target for efficient, safe and clean road transport. The main qualitative features captured from the stakeholders aspirations for the future technology applications on the Public Transport (Management) and the Environment themes can be seen in Table 4.

In the context of the first and last mile ITS/ICT solutions, the trends across different regions may differ to meet local needs, for example the DRT approach as opposed to electric bike approach. However, given the need to address the social exclusion issue and the trend of an ageing population with high life expectancy, the DRT approach would answer mobility gaps in the wider context. However, the issue of environment and community preference may need to be foreseen through research into the acceptability of such technology application in society.

A number of very insightful inputs about preferred future technology applications that can be transferable across stakeholders include:

1) Evidence of a smart ticketing system for multi-modal travel where the invoice only comes on a monthly basis (in Germany);
2) An automated system for booking, scheduling and dispatching of DRT (in UK);
3) Intermodality between bicycle, car-club and public bus; a practice that is very environmentally sensitive and can potentially be the benchmark of future mobility (in Switzerland);
4) Incorporating logistics issues of bicycles on public transport as a good solution for first and last mile (in The Netherlands).
5) Smartcard applications for public transport nationwide (in Luxembourg)

The current global economic crisis and global warming issues are highlighting the importance of maximising the use of resources to meet known demands. This study has shown that ITS contributes to the achievement of such a target. At the same time there has to be an acceptance from stakeholders that ITS can result in new ways of working and delivering customer focussed services. Messages of awareness raising on the benefits to the end user, society and the environment are captured from the study and need to be promoted. Too often the cost saving element potential is the only aspect that stakeholders focus on.

The cost of technology should not be seen as a stand-alone cost. Certainly there are costs associated to technologies' but do those outweigh the cost of the status quo? It is well established that technology can benefit the end user by identifying individual needs and sourcing appropriate solutions; e.g. Journey Planning systems are now commonplace across Europe. Consolidation onto mobile devices would currently appear to be the favoured approach and these can cover journey planning, GPS, Mapping, DRT booking systems, Smart Ticketing. For operators, the ability to identify the real needs and demands to aid procurement of suitable vehicles is essential. The growth in electric mobility devices like scooters, wheelchairs etc have created a new mode, however the associated problems like connectivity with other modes is a new dimension for research to address. This study, while limited to some extent by geographical coverage of organisation type amongst respondents, has shed light on technology selections adopted by (transport) authorities and operators across North West European Countries to address the gap with respect to the first and last mile applications. It is envisaged that notwithstanding advances in technology, the current ITS/ICT technology applications available are not necessarily the ones to address the (transport) authorities' needs over the next 25 years. Additionally, it has been reinforced that some of the obvious barriers to deployment/development are not technological but rather organisational (i.e. procurement, political support, etc.).

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