REVIEW PAPER

TRANSPORT
ISSN 1648-4142 / eISSN 1648-3480
Special Issue on Smart and Sustainable Transport / 2015 Volume 30(3): 372–381
doi:10.3846/16484142.2015.1079552

APPLICABILITY OF ICT SOLUTIONS IN PASSENGER TRANSPORT – CASE STUDIES FROM DIFFERENT EUROPEAN BACKGROUNDS

Monika Bąk, Przemysław Borkowski

Chair of Comparative Research of Transport Systems, University of Gdansk, Poland

Submitted 10 November 2014; resubmitted 6 February 2015; accepted 17 February 2015

Abstract. Impact of Information and Communications Technologies (ICTs) on sustainable transport development is indisputable. It can be tested through various methods. The identification and detailed analysis of specific types of ICT solutions, case studies approach or scenarios analysis are examples of perspectives for impact assessment that can lead to the proof that successful applications of ICT solutions entails optimised, more accessible, less resource consuming and less emission intensive transport. The impact of ICTs in travel induction and substitution and resulting decarbonisation effect is difficult to assess isolated from other social, economic and technologic drivers. Financial applicability reflects initial investment cost as well as operation maintenance costs. Organizational feasibility refers primarily to the necessary changes in organisation and conduct of operations created by introduction of ICTs. The social factor results from user and public acceptance or lack of it. User acceptance is combination of many sub factors of which most important are: D2D travel time, D2D travel costs, comfort and convenience, safety and security. The objective of the article is to present the applicability of ICT solutions in passenger transport from the perspective of transport users taking into consideration real case studies from different European background. These case studies were identified as a result of specific selection process in order to receive a complex and differentiated sample. The first element of the selection process was the identification of ICT solutions to be applied in case studies. The next element was the choice of regions corresponding to varied economic and geographic characteristics. In addition, cultural factors have a strong impact on the behaviour of users. The resulting multidimensional factor matrix allows for the selection of best fitting case studies, which have potential to cover most of the ICT applications. Five European settings are selected for in-depth research. Each case represents different geographic, social and economic area, which forms a good European sample across differentiated setups. Case studies are supported by user surveys. Surveys allow for direct answers regarding user attitudes towards proposed ICTs. Based on this approach findings could be reported. The main conclusion is that users in various regions with very different characteristics as to the wealth, GDP levels, geography, and cultural backgrounds represent surprisingly similar attitudes towards ICTs. Specific findings regarding different types of solutions and different type of users are presented in the article. The analysis of selected case studies shows also that they could offer solution to many of transport sector problems including key issues from transport policy agenda: environment, mobility or accessibility. The paper is based on the authors research conducted within COMPASS project (Optimised co-modal passenger transport for reducing carbon emissions, project co-funded by the European Commission within the Seventh Framework Programme).

Keywords: ICT solutions; passenger mobility; case studies in ICT applicability; transport surveys; acceptability of ICTs.

Introduction

Information and Communications Technology (ICT) solutions are being perceived as a future of European transport. They are intended to become a tool, which might help to solve many transport sector problems including key issues from EU transport policy agenda: environment, mobility or accessibility. In passenger transport applications, they improve efficiency of transport providers and make travelling seamless and better experience. From the economic point of view, they promise additional wider economic benefits through optimisation of time-savings and reduction of individual costs of movement. Certainly, those goals cannot be achieved by ICTs only but ICTs play important role in advancing transport system into higher level of development.

Smart solutions implementations are in line with a growing concern that transport sector must tackle today's challenges in trying to mitigate its negative impact on the environment.

Additionally it has to be noticed that most ICT solutions in passenger transport are introduced in local

Corresponding author: Monika Bąk
E-mail: *monika.bak@ug.gda.pl*

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environments. Then, the question arises what factors influence implementation success. This article analyses conditions that have to be met in order to adapt ICT solutions in different European regions from the perspective of transport user.

The ICTs analysis framework applied in this paper is based on the original authors research conducted in COMPASS project (Optimised co-modal passenger transport for reducing carbon emissions), co-funded by the European Commission within the Seventh Framework Programme realised in the years 2011–2013 (COMPASS 2014).

1. Potential Impact of ICTs in the Context of Sustainability

More efficient and more sustainable transport system can be achieved by ICTs implementation on a wide scale. Already ICTs are involved in many aspects of transport processes. In COMPASS project, ICT applications in passenger transport have been classified in six categories (Bielefeldt *et al.* 2013):

- *Transportation Management Systems*, helping to plan and run efficiently the transport system;
- *Traveller Information Systems*, in which the key characteristic is to assist the traveller with several basic information (travel time, routes, traffic conditions, etc.);
- *Smart Ticketing and Tolling Applications*, addressing new ways to purchase tickets and to pay for using transport services;
- *Vehicle-to-Infrastructure (V2I) applications*, which can be generally defined as wireless cooperative interaction between vehicles and infrastructure, based on systems that can improve safety and traffic management;
- *Vehicle-to-Vehicle (V2V) applications*, leading to tighter integration among vehicles operations and disclosing a wide range of important transport services to the traveller, in particular concerning safety, mobility and efficient infrastructure use;
- *Demand-Responsive Transport (DRT) services*, which provide a mechanism whereby passengers can be picked up and dropped off at their chosen locations, at a price usually associated with fixed route bus services.

ICT solutions in passenger transport may influence many sustainability spheres. On the one hand, the impact concerns private motorisation and drivers' behaviour. For example, the reduction of accidents rates can be expected due to improving accident management and in-vehicle tools or assisting the driver during drive and operations. On the other hand, modal shift in favour of public transport can be achieved. Integrating public transport planning information (e.g. real time information on bus schedules) is an objective desirable by passengers. In addition, saving time and trips can be achieved by providing additional feeds into the navigation systems and assisting passengers by serving information on transport services, timetables and interconnections. More generally, ICTs improve communication through better safety and comfort but also offer some savings in congestion and travel time.

In COMPASS project, the impact that ICT solutions could have on transport so called de-carbonisation was discussed in:

- the handbook of ICT solutions for improving co-modality in passenger transport;
- 11 case studies;
- the European assessment of ICT solutions through scenarios analysis.

As a result of the impact assessment from all above mentioned perspectives and taking into consideration different methods and contexts it has been proven that successful applications of ICT solutions entail optimised, more accessible and less resource consuming transport which is also less emission intensive.

The handbook consisting of more than 90 specific solutions can be used as a reference case database by all those willing to introduce ICTs. Solutions could be evaluated against major factors determining their performance. These factors might be grouped in four divisions:

- feasibility (including investment costs, operational and maintenance costs, financial viability, technical feasibility, organisational feasibility, administrative burden, legal feasibility, user acceptance, public acceptance);
- interest to travellers (including door-to-door travel time, door-to-door travel cost, comfort and convenience, safety, security, accessibility for mobility impaired);
- impact on modal change (including car usage, bus and coach usage, rail usage, ferry usage, aeroplane usage);
- other impacts, which covers mobility, congestion, CO_2 emissions, contribution to user pays principle, contribution to European economic progress.

Case studies test the applicability of ICT solutions in passenger transport in the context of real-world situations in order to assess their real impact on the transport system and user behaviour.

Case studies provide local scale impact analysis while the handbook gives insights into the variety of possible tools which can be used in ICT role. Then additionally the EU assessment combine those findings into scenarios representing possible futures of EU transport on a large scale. The results show that the extent to which ICTs will affect travel times, travellers' value of time, operating costs, and fees for long-distance travel as well as total CO_2 emissions depends on the specific ICT system being used and the specific place where it is implemented. The key findings of this theoretical approach must be tested against real cases in order to establish actual impacts. This is important since the impact of ICTs in travel induction and substitution and resulting decarbonisation effect is difficult to assess isolated from other social, economic and technologic drivers.

2. Factors Affecting Applicability of ICT Solutions

Applicability of ICT solutions is a result of number of factors of financial, social, technical and organisational nature. Financial applicability reflects high or low initial investment cost. There are two additional factors: subsidies and the relative scale of the cost. If the development of a system is subsidised by particular national state or transnational body (e.g. by the European Commission) than development costs for actual investor might be reduced. The relativity of the investment reflects the fact that various ICT systems have to be compared not only in terms of overall expenditure but also in terms of expenditure within investment type. It is easy to notice that creating new transport network utilizing ICTs or even equipping old one with modern ICTs falls into different range than developing ICT oriented smartphone application.

The financial factor further must be considered in relation to operation and maintenance costs. Maintenance cost is borne by operator and might be transferred onto user (through ticket price increase) but does not necessarily have to be transferred. In addition, the general time horizon of ICT lifetime must be considered. Even high initial investment if compared to 20 years timeframe of operation might be relatively less than moderate maintenance cost multiplied by number of years particular solution is in operation. Operating cost represents user payment for access to particular ICT (for instance annual fee for use of mobile phone application). Again, relativity of those figures must be considered. For instance even very small fee of €1 may be regarded by many as expensive for a mobile app, while it is a non-issue in most other contexts.

Organizational feasibility refers primarily to the necessary changes in organisation and conduct of operations created by introduction of ICTs. This is often additional burden on the transport service provider side and results from the need to process data. Moreover, if the operator wishes to utilize ICT potential to optimize fleet operations it most likely needs to create special operations centre and improve skills of employees through training. ICTs paradoxically might also increase administrative burden on both operator and public administration through increased reporting needs. There might be also some legal problems preventing or handicapping introduction of ICTs especially due to the violation of privacy laws through extensive personal data collection.

The social factor results from user and public acceptance or lack of it for ICTs. The users are not necessarily the travellers, but those who buy and install the system, i.e. those identified as targeted users. Users and especially potential users acceptance is key for ICT's. There are certainly situations where users are forced to use particular ICT (e.g. airline policy of electronic tickets issuance) but in modes where user has alternatives introduction of ICTs against user will may significantly reduce demand. User acceptance is therefore combination of many sub factors of which most important are (Bielefeldt 2011):

- D2D travel time;
- D2D travel costs;
- comfort and convenience;
- safety;
- security.

Most ICTs contribute to travel time reduction and comfort increase. Travel cost can increase or decrease due to a change in fuel and vehicle operating costs and/or to fees and charges. An increase in punctuality and reliability and a reduction in delays are often first visible effects of ICTs on operator side. This is strengthened by change in user behaviours – ICTs allow to be exactly on time and thanks to electronic prepaid or smart tickets, avoid waiting.

From the society point of view ICTs could contribute to achievement of transport (or economic) policy goals. Thus their attractiveness from government perspective is a feature of:

- impact on CO_2 emissions;
- contribution to user pays principle;
- contribution to economic progress;
- impact on territorial cohesion.

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.

The user pay principle could be regarded by the government as a method to reduce financial responsibilities of the government. Territorial cohesion is usually improved when cross-borders or internal borders between different modes and/or within single mode are reduced due to ICTs. Economic progress is probably most difficult to measure among those factors due to indirect influence ICTs might have here.

Among above factors the primary importance has to be given to the user acceptability. If there is no user acceptance for introduction of particular ICT it simply cannot or should not be introduced into transport system. Moreover, user acceptance influences strongly financial viability of ICTs. The higher the acceptance the more promising perspective that users will use particular service and generate additional revenue from the increase of ticket sales. There is also an option of direct payment for ICTs nevertheless as case studies detailed in next section show willingness to pay on the user part is usually small (although still better among users who accept particular ITC to the fullest extent).

In the next sub-chapters, main results of selected case studies are presented, accompanied by discussion of conducted user surveys as they are most interesting from the point of view of applicability. Surveys allows for direct answers regarding user attitudes towards proposed ICTs and key factor here is user and potential user acceptability.

3. Results of Survey Assessment of User Attitudes Determining Applicability of ICT Solutions

3.1. Framework for Analysis of ICT Case Studies

Theoretically, developed ICT solutions need to be tested in real world situations in order to assess their actual impact on transport system and user behaviour. The analysis of a balanced set of cases in terms of topics and geographical coverage as well as diversity of ICT solutions should be applied for the discussion of the effects of different conditions existing at different urbanisation levels on proposed ICT solutions. The methodology for testing ICT solutions could be adopted from COMPASS project to choose finally well diversified case studies to be further researched in-depth (Bak *et al.* 2012). The first element of the selection process is the identification of ICT solutions to be applied in case studies. In order to capture as wide range of effects as possible it is advisable to cover all six categories (as indicated above) of ICT solutions in case studies.

The next element of the selection process is the choice of regions. The differences between European regions lead to different reception of ICTs by local citizens, authorities, transport organisers and planners. For those reasons practical tests of different ICT solutions should be conducted in varied environments. Regional differentiation should be based on major factors which are responsible for creating regional differences, including economic, geographic and culture/tourism factors.

Economic factors are represented by the GDP per capita indicator. The rationale behind its selection is that it allows for establishing which regions are wealthy and which are poor in regard to EU average. This criterion has significant impact on the possibility for ICT introduction. ICTs are usually capital-intensive tools and as such are more likely to be considered by transport planners and organisers active in wealthy regions. Lack of capital and general poor financial ability of transport users must be perceived as serious barriers to the introduction of ICTs.

Geographic factors could be represented by a number of features impacting the need for ICT solutions. Among those accessibility is crucial as it is often a function of peripherality. As such, it dictates the need for efficient long distance travel and increases the need for ICT solutions improving long trips. On the other hand, core areas tend to be heavily congested thus needing ICT solutions allowing for better handling of large numbers of passengers using transport in short periods of time. For this reason, different ICT tools are necessary for urban and rural areas. Moreover differentiation should be even more detailed as metropolitan areas tend to create different demands on transport system than cities. Similar distinction could be drawn between rural regions close to the cities and those, which are remote. Specific locations on coastal, mountain or border territory also contribute to differing needs for ICTs.

Cultural factors have a strong impact on the behaviour of users. Culture when it manifests itself in various national heritage sites or through historical landmarks impacts tourism. Tourism could be used as a proxy for cultural factors in the case study selection because areas, which happen to be main touristic destinations, require more ICTs and of more advanced type to handle increased traffic and very diverse needs of international travellers.

The resulting multidimensional factor matrix allows for the selection of best fitting case studies, which have potential to cover most ICT applications. Over this selection one more constraint exists – data availability. The in-depth research is only possible when sufficient information could be gathered. The selected case studies represent differentiated countries in the EU, both urban and rural regions, with diversified GDP and accessibility level and tourism potential.

Five European settings are selected for in-depth research. The acceptability of solutions and barriers preventing their use are subjected to analysis based on qualitative field research augmented by qualitative assessment through focus groups and interviews. The below summarised results of five case studies represent very different areas and thus could be considered as good European sample.

3.2. Accessibility Applications for Disabled People (London)

This case study looks at a range of smartphone travel applications (apps) with a range of different attributes with the potential to improve accessibility to the transport system for disabled people. The apps considered in this case study target disabled car drivers, disabled car passengers, disabled public transport users and disabled pedestrians. As part of the case study, an online survey on the usefulness and value of smartphone apps to provide travel assistance to a specific sub-group of disabled people – those who have a physical mobility impairment – was conducted amongst UK residents during spring 2013. Acceptability of the proposed solutions is rather high not surprisingly if almost two thirds of the sample (65%) reported that their mobility fluctuated from day to day, and more than four-fifths (82%) reported that, even on a good day, they would be capable of comfortably walking no more than 100m without needing to take a rest.

Nearly three quarters of our sample (71%) uses the internet in connection with their travel, and nearly all possess a mobile phone, with almost half (49%) being smartphone users. Yet, only just over a half of our sample (52%) report that they use their mobile phone to assist with travel at present, and very few (7%) reported having specific travel apps which they use. The stated choice experiment conducted within the survey demonstrated user preferences (Table 1).

For car-users, the most useful attributes of the apps presented to them were those which provided them with en-route directions and those which enabled them to request assistance via road break-down services and to pre-book a disabled parking space. For the public transport users, the most useful attributes were those, which

Table 1. User acceptance of different ICT types designed for disabled passengers (Matthews, Wardman 2013)

ITC application purpose	All users	Car users	Public transport users
Getting into/onto the vehicle	69 (33%)	50 (31%)	19 (40%)
Getting out of/off the vehicle	77 (37%)	59 (37%)	18 (38%)
Information about the accessibility of facilities (e.g. services stations, parking, railway stations etc.)	63 (30%)	44 (28%)	19 (40%)
Satellite navigation	47 (23%)	46 (29%)	1 (2%)
Other	57 (28%)	42 (26%)	15 (31%)

enabled them to pre-book staff assistance and to pre-book an accessible taxi, and those, which provided them with information on next station/stop and arrival time, with up to date connection information and with accessibility information about the arriving train or bus. Financial barrier could be important in introducing those ICT's. Although cost of particular application is limited the costs of owning a smartphone and their usability for older and disabled people is an important factor which, at present, appears to serve as a limitation on take-up. By opening up information sources and support services, smartphone travel apps offer huge potential to help and liberate disabled and older people who face challenges with other methods of communication and information-gathering. Whilst our survey indicates that people do place value on particular aspects of these apps, their potential is, as yet, under-utilized, and so actions to improve take-up should be explored further.

3.3. ITS Solutions for Barcelona's Local Bus Network (Barcelona and Barcelona Region)

This case study researches the possibilities for improving public bus transport performance in Barcelona region with the introduction of ICTs into the system. Barcelona's bus operator TMB is doing a series of improvements in the organisation of the service operation, the comfort of vehicles, the equipment of bus stops and the information services to travellers in order to increase the attractiveness of the bus in relation to other competing modes, e.g. metro or tramway. This includes several ITS features to assist the guidance of users in the Barcelona public transport network (touch screens with integrated travel planners, information on expected time of arrival for next services), as well as facilitating the sales of riding tickets (electronic ticket issuance, sells booths). At the same time, TMB is enhancing its smart phone application with innovative features aiming at becoming increasingly useful to users. In order to test user acceptability and existence of barriers preventing widespread ICT use case study was augmented with survey among users. It surveyed level of awareness and use of smart apps and the interest of citizens in other potential smart phone applications. Another ICT scheme tested was Smart Bus Stops: interactive multi-modal travel planners for public transport services in Barcelona and its metropolitan region; real time information screens on expected times of arrival of buses (updated every 30 seconds); information on eventual service disruptions; audio systems assisting blind people; ticket sells booths. Final component of the survey was user response to DRT services in Barcelona mountain neighbourhoods.

Acceptability for new ICT based services is high and area inhabitants have shown relatively high awareness of initiatives by TMB to improve bus services in Barcelona, especially regular and frequent users of the municipal public transport. In particular, 3 out of 4 respondents were accepting the reorganisation of the bus services in Barcelona, and 2 out of 3 welcomed the existence of neighbourhood proximity bus services providing access to the mountain neighbourhoods. Observation at new pilot bus stops seems to indicate that new ITS equipment at bus stops has a fairly good public acceptance (time indicators, ticket booths), but in particular, the use of on-stop interactive travel planners seems low at this point, probably due to user unawareness. The TMB smart phone tool for user information is clearly considered easy-to-use and user acceptance of the app is high. Amongst those owning a smart phone and knowing of the existence of the app, more than 1 out of 2 used it regularly. With such a warm reception there is huge potential for further development of this tool – especially by extension of user base which will come with increase in smartphone ownership (1 out of 3 does not own a smart phone yet), and awareness rising of the service (another 1 out of 3 does has not tried/does not know the app – see Fig. 1).

Willingness of citizens to pay for additional services provided with smart phone applications is substantially lower. Applications attracting most interest by users are directly related to guidance, personal safety and emergency assistance (1 out of 2 surveyed revealing they

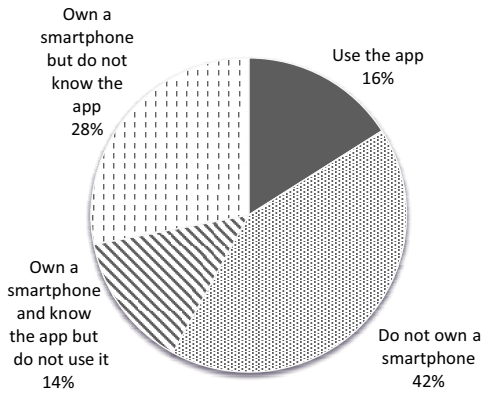


Fig. 1. Public transport users' response to the introduction of ICT smartphone based applications (Biosca *et al.* 2013)

would pay for their acquisition). Other applications are less suggestive, like parking booking applications, and more complex proposals for services like DRT linked to smart phone applications (with around 1 out of 5 willing to pay for them; still 25% of bikers suggested might be interested in such services). It also seems that user acceptance of services is rather linked to their level of clarity and simplicity.

3.4. Bike sharing in Vienna and the Surrounding Region (Vienna and Vienna region)

In this case study, the focus is set on the bike sharing schemes in Vienna and the surrounding region Lower Austria (*Niederösterreich*). A Computer Assisted Telephone Interview (CATI) was carried out to capture user responses to two different bike-sharing schemes in and around Vienna. The first one is Vienna based City-Bike which has been in operation since 2003 and currently has about 100 stations within approximately 3 km radius from the city centre. The other one in Lower Austria, next-bike, started in 2009 as a replacement and an extension of its manually-operated predecessor Freiradl. It is installed not only in cities but also in small towns and villages as well as in several rural touristic regions such as Wachau along Danube. The acceptability levels for bike-sharing ITCs are rather high (Fig. 2).

Many people will accept automated booking/identification methods. Especially, card-based or phone-based identification is preferred. The fact that most of the respondents are familiar with the automated ticketing and Internet-based services confirms this. However, other state-of-the-art identification methods seem to be hardly accepted. About half of the people in Lower Austria and about 30% of the Viennese people still want to pay in cash rather than other methods such as debit or credit cards. Further development of reporting broken bicycles by users (e.g. through apps), app indicating general conditions of bicycles and short-term reservation (if there are only a few bikes available at the station) are considered useful by the users.

Awareness of bike-sharing schemes in general is high in the surveyed region, especially in the one in Vienna that has been in operation for a decade. There might be some demand related barrier due to the fact, that the proportion of the people who use the scheme regularly is fairly low, and among those who use it regularly, the leisure trips are dominant. The current pricing that is set low appears to be well accepted. Typical willingness to pay is around €0.50 to €1 per hour – well within current price levels.

Among non-users, certain proportion between one-third and two-thirds find themselves as potential users of the shared bikes. However, they require denser network of stations, easy booking system, and better bicycles to be shared. Making the stations denser and/or extended and better managed due to ICTs is an important development so that more population can be covered within a reasonable catchment area from the stations. This will eventually help to increase the awareness through on-street visibility of the bicycle. Such enriched 'hard' infrastructure for the bike-sharing will capture more potential users. Several ICT-based developments could be recommended including short-term reservation to guarantee bike available at the station, diversification of user identification methods especially with phone or bank/credit cards, and further easy booking/identification systems, as well as the smartphone apps to show availability and conditions of bicycle and to

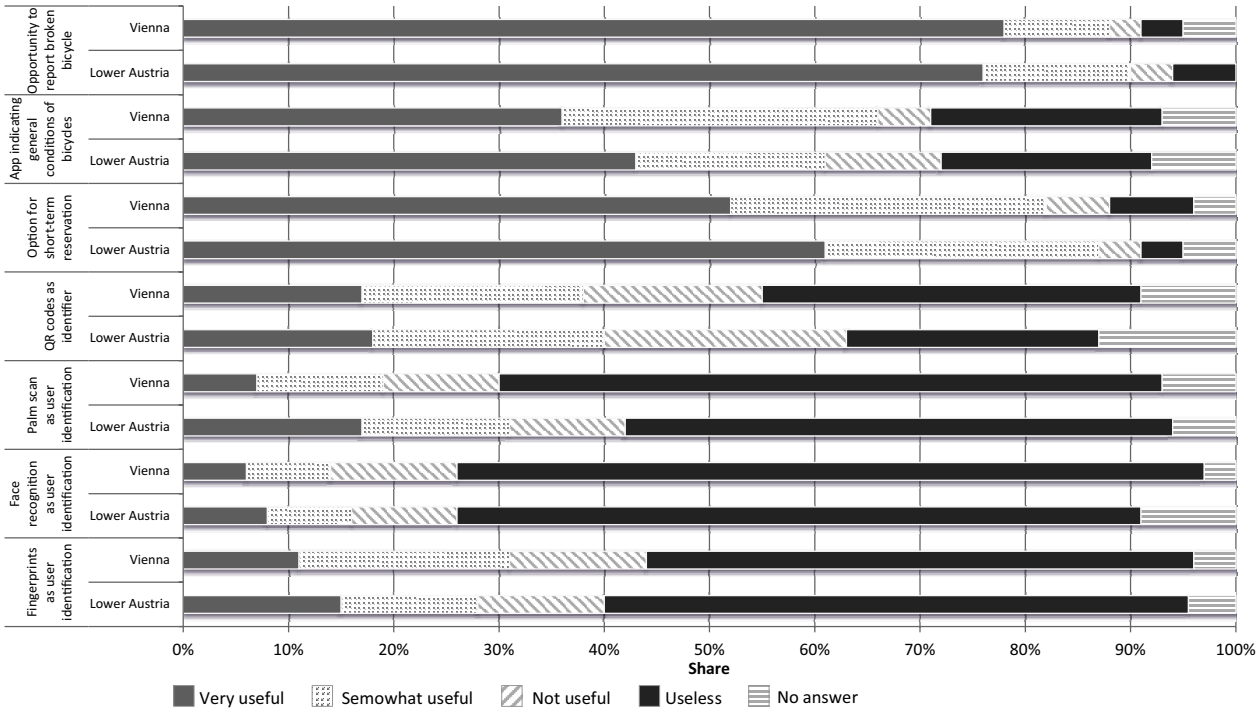


Fig. 2. Acceptability of potential bike-sharing ICTs (Lemmerer *et al.* 2013a)

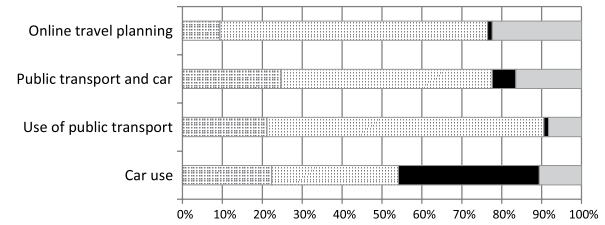
report broken bikes. Regarding booking/identification system, integration of various schemes in one user account has some potential. Through it one user account from a scheme can be recognized automatically by another schemes as bike-sharing schemes require the users to create an account for it. Especially in light of the fact that a certain number of people from rural areas use the system not at home but rather at the urban destination such as Lower Austria using the shared bike more in Vienna, such integrated user account may be fairly useful to motivate people to use bicycle. There are no technology barriers and technology used is fairly mature. The financial barriers however could be considered a serious handicap. Initial investment cost is high with approximately €25000 per station if the one employing docking station with touch-panel terminal is chosen. The maintenance cost per bicycle is between €1500 and €2500. This solution is thus suitable for medium-sized to large cities. The one operated fully by mobile phone is less expensive and it costs around €5000 with lower maintenance cost and thus it is more suitable for small cities and also for rural areas.

3.5. Grass-Root Cooperative Smartphone-Based Car-Sharing (Austria)

This case study is an example of one of most commonly attempted uses of ICTs – demand responsive service. It sets its focus on newly-appearing grass-root cooperative car-sharing, called CARUSO, in Austria. It has several interesting features possible only due to introduction of ICTs:

- it is used not only in urban areas but also in rural areas;
- the scale is small with one or a few cars to be shared among up to 30 users and users form car-sharing group spontaneously based on their needs;
- the reservation and usage-logging platforms on board are provided as an Internet application;
- the user fee can be set in a flexible way and each group adopts different pricing models such as linear per-km tariff with or without annual fee or just 6-month user fee divided based on the approximate usages by users;
- there is a system provider who provides a web-based reservation and logging system, smartphone-based on-board system.

The user response to ICTs have been tested based on three level survey – focus group interviews to the users, an online survey to the users, and a telephone survey to the users and non-users. Regarding the user responses to the grass-root cooperative car-sharing it could be said that acceptability is high for users and low for non-users. It seems that the threshold is commitment decision. Important common factor is the curiosity whether this system will work or not. It seems important for people to try out such systems to know whether car-sharing fits to his or her mobility behaviour or not. Saving automobile-relevant costs and saving a second car are often strong motivations for starting car-sharing. If the car is seen just as a mean of transport out of many and not as a status symbol and/or is used for special purposes, the willingness for car-sharing is higher. Most of the participants of the focus group interviews own a car and the car-sharing car replaces their second cars in the households. However, the focus group interviews show also that, in some cases, sharing a car can actually substitute the main car even in remote rural municipalities with scarce public transport. The trip made with the grass-root cooperative car-sharing is for various purposes including shopping, short-term leisure, carrying heavy luggage, private such as visiting doctor or friends, and so on. The usage is typically within 30 km driving range, and the usage on weekdays and weekends balances well. This is in contrast with the peer-to-peer car-sharing, with which the leisure trips longer than 50 km in total on weekends are dominant. The actual CARUSO users find a number of advantages in the private grass-root car-sharing model, especially in the exclusiveness of the car among the car-sharing community and the low costs for the car usage this results in changing view on car-sharing (Fig. 3).



	Car use	Use of public transport	Public transport and car	Online travel planning
More frequent	19	18	21	8
Same as before	27	59	45	57
Less frequent	30	1	5	1
Do not know	9	7	14	19

Fig. 3. Evolution of users' attitudes towards car-sharing (Lemmerer *et al.* 2013b)

Many users also recognise the easy user interface of the booking system as an important advantage. As for the experiences with ICTs, there seems no practical barrier as most of the users recognise themselves as fairly experienced with the Internet or any other ICT-based services. There are no significant financial barriers due to the fact that cars are provided by scheme members and additional insurance is provided by scheme management company and comes with only small fee.

3.6. Future Interurban Public Transport in the Warmian–Masurian Voivodeship (Warmia–Masuria Province)

This case study uses test bed approach for identification of possibilities and barriers for introduction of some ICT solutions into rural areas. It is based on transport users response to the proposed ICTs as recorded through qualitative and quantitative survey carried out in one of

the lowest GDP and population density regions of the European Union. It is interesting to compare potential applicability of ICT's in such a region with wealthier and more densely populated regions from other case studies.

Users of public transport were asked about their reaction to the several ICTs: internet based travel planners, electronic real time information at bus stops, ticket purchasing via mobile phones/internet, real time information on services via mobile phones/internet, real time information on estimated arrival times, stops, route on board of vehicles and demand responsive services – possibility for direct pick-up/delivery of passengers in response to prior demand. Five different user age classes have been established: 15–18, 19–29, 30–45, 46–60 and 60+ years old. This allowed for testing the acceptability as well as user willingness to pay for ICTs if introduced among different user segments. In addition, price elasticity has been tested.

The overall result of the study is that neither rural character of the region nor the low disposable income reduce demand for modern transport system. To the contrary, many ICTs are considered as essentials, which might help to remedy typical failures of public transport system in those areas. For instance lower frequency causes increased necessity for perfect information provided through ICTs – which is even more important in rural setting than in urban areas characterised by better service frequency. User acceptance for majority of tested ICTs is high or very high with clear picture of younger users being more enthusiastic. The highest score in this regard is attributed to the youngest respondents who are most familiar with the technology and more inclined to accept innovations. This reflects better knowledge of modern technology and better access to the Internet and/or smartphones within this group. Overall clear majority of all users are in favour of ICTs although some solutions (especially those oriented at information provision) score better than the others (lowest score is noted for demand responsive services). This translates to more than 75% in favour of travel planners, electronic information at bus stops and on-board electronic information. At the same time, electronic ticketing or real time vehicle positioning information is sought after by about 50% of users. Lowest interest is expressed in regard to demand responsive services with only 37% in favour of this measure (Fig. 4).

Interesting point could be made by analysing which advantages of ICTs are considered as most profitable to potential users. The convenience factor seems to be most important. For all information, providing ICTs users pointed out that main advantage is possibility to better plan their journey. Also psychological effect of better assurance that particular service will be offered was important. Scores differ between age groups – for the group of youngest users are considerably higher. In the age group of 15–18 years old real time information scored highest 3.74 points out of 5 possible for those of 19–29 years it was 3.63, for travellers aged 30–45 the score was 3.5. At the same time, older users were not impressed with those aged 46–60 rating this innovation at 2.18 and those over 60 years of age at only 1.56. Time-savings on the user part for D2D travel are another factor which in theory should be crucial to users. The study shows that passengers expect to save about 14 minutes on average through the use of ICTs. Interestingly the highest time-savings are expected by members of age group 30–45 (20 minutes) while those who pointed at the proposed solution as most useful (youngest users) expect to save due its introduction on average only 13 minutes.

The possibility of introduction of ICTs in rural areas is seriously handicapped by financial barriers. The research among operators shows that initial investments needed are high and beyond financial means disposable to the local service providers. This unfavourable condition is reinforced by the fact that additional maintenance costs must be considered for operating ICTs and

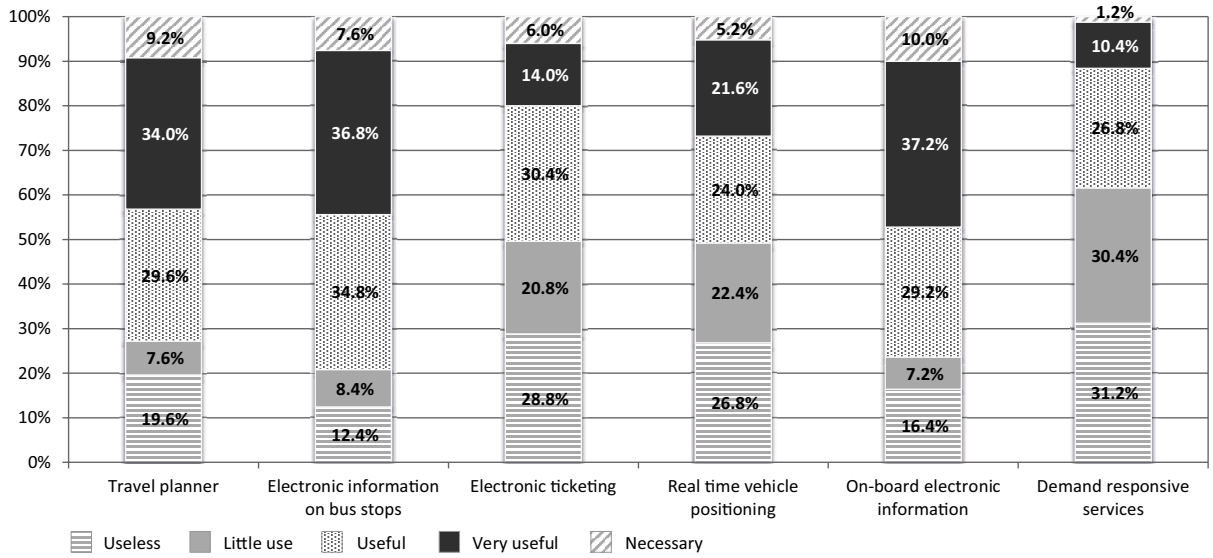


Fig. 4. User acceptance of ICT solutions in rural areas (Bak, Borkowski 2013)

this cannot be compensated through increase in operator incomes. While there is some potential for modal shift generation caused by ICTs it is difficult to say how strongly the declarations reflect reality. About 55% of current car users rejects possibility for switching from private car to public transport even if it is ICT intensive. The rest declares that they will certainly change to public transport when ICTs are introduced (slightly more than 2%) will likely do so (about 16%) or will do so on occasions (remaining percentage). At the same time higher operator costs cannot be compensated by ticket price increase due to strong user unwillingness to pay for ICTs. Among all users acceptance to pay extra is as low as 20% and even among those willing to pay for additional services three-fourth majority accepts only symbolic payments (up to €0.2).

Conclusions

The EU regions are far from uniformity. Differences between them should therefore lead to different reception of Information and Communications Technologies (ICTs) by local citizens, authorities, transport organisers and planners. For those reasons in order to assess both possibility and usefulness of ICTs practical tests of different ICT solutions have to be carried out in varied environments. Solutions need to be tested in EU regions with various levels of economic development, geographical location, touristic and economic attractiveness, and different population sizes.

Specific case studies results summarised in this article represent those differentiated geographically, socially and economically areas and could be considered as good European sample. Whenever ICTs are employed in practice sufficient data needs to be collected in order to assess their actual features. For this reason, it is advisable not only to rely on official statistics depicting their usage but also to survey users and potential users. This allows for direct answers regarding user acceptance towards proposed ICTs. Users in differentiated regions with very different characteristics as to the wealth, GDP levels and cultural backgrounds represent surprisingly similar attitudes towards ICTs. The major findings are that ICTs do not raise doubts concerning general positive acceptance by the users. The most useful ones are those aimed at pricing and ticket integration as well as those improving interchange. Very highly rated are also ICTs, which help in integration of transport system. Transport on demand facilitating solutions are on the other hand accepted with some reluctance. Users seem to seek firstly upgrades in existing transport schemes treating completely new tools as addition. This pattern explains why in richer areas (Austria) DRTs are relatively easily introduced while in poor areas there is some reluctance toward them. One more important finding is that users expect ICTs to be delivered at cheap prices or in some instances (electronic information) for free. This might be a significant barrier for introduction of ICTs in poorer regions. For this reason majority of working solutions could be currently found in cities and metropolitan areas. In addition, specific ICTs aimed at narrow groups of users (e.g. apps for disabled) could currently be only introduced in those areas. The still existing barrier is availability of modern technology on the part of user. Not all are familiar with Internet nor have smartphones. Yet the change in this area is rapid and will not rather be a handicap even in near future. Results of the surveys and all case studies can be used to further transferability analysis.

Applicability and user interest are important transferability factors besides interest for operators or governments or feasibility in the context of financier, technology supplier for operator and non-users. ICTs seem to be buzzword currently. However, as analysis of selected case studies shows they could be much more. They could offer solution to many of transport sector problems including key issues from transport policy agenda: environment, mobility or accessibility. In passenger transport applications, some ICTs like integrated or electronic ticketing as shown in case studies could be applied almost universally. Others like for example demand responsive services need specific conditions to be met. From the microeconomic perspective, ICTs improve efficiency of transport providers but initial investment might be costly. From the transport users perspective they make travelling seamless and better experience. From the macroeconomic point of view, they promise additional wider economic benefits through optimisation of time-savings and reduction of cost of movement.

Acknowledgements

This is original research based on the field-work conducted within COMPASS project.

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