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EXECUTIVE SUMMARY

The motivation and the general objectives of the COMPASS project are deeply rooted in the European Transport Policy (ETP) in the first decade of the 21st Century, with a look towards the new challenges of the incoming second decade of the century. In particular, three topics must be stressed:

- Challenges from the key socio-economic trends.
- > Challenges from environmental concerns.
- > Challenges from technological changes.

Taking this into account, the general objectives of the COMPASS project were:

- To provide an overall picture of the future travellers needs in the light of the key socio-economic trends;
- To analyse how ICT and ITS applications can meet the new demands, favouring the integration of multimodal transport solutions;
- > To assess how these solutions can contribute to the de-carbonisation of transport activities.

In such a framework, the following collateral and important objectives were also addressed:

- The potentials of the ICT and ITS applications to provide behavioural data and information to improve travel surveys and fostering harmonisation;
- The validation of the ICT solutions with stakeholders rooted in the national contexts, due to the involvement in the project of TTS Italia, member of the ERTICO National Network of ITS Associations.

This final project report summarises the work carried out in the project and the findings from the project deliverables.

Key trends

Concerning the key trends in the social, economic, environmental and technological domain that will shape future mobility, an extensive literature research revealed that opinions about their future development varies widely and that it is in most cases hard, if not impossible to predict their speed and their intensity. More research is needed to clearly understand the magnitude of the impacts that the key drivers, on their own or in combination with others, might have on future mobility and transport. Moreover, the analysis of future European transport scenarios should require a more holistic approach than the one traditionally used and should be widened to properly consider the complexity of the system and its interactions with all the domains of human activities.

Traveller needs

Based on the evidence reviewed it was concluded that there are 16 main user needs for shortdistance intermodal journeys. These user needs are identical to those identified for long-distance intermodal journeys, which suggests these needs are generic for all intermodal journeys, irrespective of distances involved. But similar to the key trends, the relative importance of these user needs is still not fully established. What is known is that the relative importance attached to each user need is dependent on both personal and situational factors. There is also considerable evidence that if ærtainquser needs are unmet, this can prevent people from making certain journeys. However, the relationship between user requirements and modal choice decisions is complex, and to fully understand this complexity, further research is needed.

The general potential of ICT

Concerning the first objective of identifying the most promising ICTs application favouring seamless multimodal integration, it was shown that important ICTs enabling applications are represented by smart integrated ticketing options and multimodal traveller information systems. In particular, this latter category is deemed to be the most promising ICT application.





Concerning the second objective of identifying the potential role of ICTs application favouring transport data collection, it has been stressed that opportunities towards a better data collection process for passenger mobility surveys are continuously evolving to meet transport data needs, using a broad range of information and telecommunications technologies to detect people, drivers, vehicles, traffic and environmental conditions.

Transport demand related information

The review of available surveys showed that there is a strong lack of data on mobility for many parts of Europe, and that where data is available, its contents and structure vary strongly between surveys and countries, limiting the potential comparisons between national data sets. Therefore only tentative conclusions were possible, but one of them was that general travel behaviour varies considerably between European countries, as well as at a regional and local level (e.g. urban / rural) in terms of the number of trips made, distance travelled and modes used. Furthermore it is clear that travel behaviour varies according to several key socio-demographic factors, but these variations are not the same for all countries. Concerning transport use trends, it was found that the private car remains the dominant transport mode in the vast majority of European countries for both short and long-distance trips, and in the majority of countries the modal share for cars continues to grow. But for a more comprehensive analysis data and data collection need to me harmonised at the EU level and for each transport mode and new and existing data needs to be made more accessible across the EU.

ICT for data collection

While the main focus of COMPASS was the analysis of ICT in transport applications with regard to their potential to improve the transport system, a second question was whether the ICT solutions could also improve provision of behavioural data. The prospects for this are promising. ICTs could be used to collect behavioural data, especially travel behaviour indicators, for frequent and quick capture of user actions. They are also very resource efficient but limited to the evaluation of behaviours of those travellers who use ICT solutions and can therefore not replace traditional data collection methods altogether. However, with the spreading of ICT into transport systems their usefulness in data acquisition will be increasing.

The COMPASS handbook

One of the key aims of the COMPASS project was to recommend solutions that will allow improvements to the planning and operation of the passenger transport network to enhance comodality in transport thus contributing to the reduction of carbon emissions. 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 as a paper edition and for online internet consultation at <u>http://www.fp7-compass.eu/</u>.

The COMPASS case studies

Eleven case studies investigated a total of 21 solutions in a variety of settings ranging from urban and rural to Europe-wide. Some of these are already implemented and observed impacts could be studied, for others it was potential solutions to be offered and the user reaction and expected acceptance were explored. The subsequent transferability analysis indicated a high level of transferability for most of the solutions. The key barrier for some of them was the financial viability: while for governments the wider social benefits can justify investment in ICT, for private operators they must be profitable, and in particular in the case of public transport information systems it is not necessarily a given that any increase is users is large enough to justify the investment.

European assessment

Based on the findings at local scale from case studies and on knowledge gained from the analysis of ICT transport solutions in the COMPASS Handbook, quantitative modelling has then been used to assess the potential impact of ICT solutions at European scale. The assessment of long-distance ICT solutions is based on quantitative modelling of seven scenarios with different levels of ICT deployment using MOSAIC, the European-wide model developed in the FP7 INTERCONNECT project. A key



finding was that the modal share of road traffic increases further with each higher level of ICT implementation due to a higher decrease in the cost of interconnections involving the road, as the decrease in travel costs and fees is assumed to be the same for all modes simultaneously. The modal shift from air, rail and maritime to the road leads to an overall increase in fuel consumption, up to 4.5% with respect to the baseline, and a similar increase of 4.3% in CO2 emissions.



1 INTRODUCTION

1.1 MOTIVATION AND GENERAL OBJECTIVES

The motivation and the general objectives of the COMPASS project are deeply rooted in the European Transport Policy (ETP) in the first decade of the 21st Century, with a look towards the new challenges of the incoming second decade of the century. In particular, three topics must be stressed:

- \triangleright Challenges from the key socio-economic trends. The Communication from the Commission - A sustainable future for transport: Towards an integrated, technology-led and user friendly system (COM/2009/0279 final), summarising studies, stakeholders involvements and workshops in the context of the Communication on the Future on Transport, adopted by the Commission on 17th June 2009, has described the main socio-economic trends shaping the future of transport. Population ageing, that will place more emphasis on the provision of transport services involving a high level of perceived security and reliability, and which features appropriate solutions for users with reduced mobility. Migration and internal mobility, with migrants, generally young and mainly living in urban areas, which will entail more movement of people and goods. Urbanisation trends, according to which the proportion of European population residing in urban areas is projected to increase from 72% in 2007 to 84% in 2050 (United Nations, Department of Economic and Social Affairs/Population Division (2008), World Urbanization Prospects: The 2007 Revision.). This trend, in association with the related growth of urban sprawl can be considered among the main challenges for urban transport, as it brings about greater need for individual transport modes, thereby affecting the environmental quality. In particular, congestion, that is prevalent in agglomerations and in their access routes, generates large costs in terms of delays and higher fuel consumption. Further deepening of the Single Market, and the integration of the EU with neighbouring regions (Eastern Europe, North Africa) into the world economy is also deemed to have relevant impacts on transport, through the increased mobility of workers within the Union.
- Challenges from environmental concerns. There is growing concern that the transport sector must tackle dramatic challenges in trying to mitigate its negative impact on the environment. The EU has in fact recently adopted a Climate and Energy package that sets a target of reducing GHG emissions in the EU by 20% with respect to 1990 and transport is going to play a key role in achieving this goal (COM (2011)112). But an inversion of some of the current trends will be necessary and transport itself will suffer from the effects of climate change and this will necessitate adaptation measures.
- Challenges from technological changes. The EC Directive of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport (Directive 2010/40/EU of 7 July 2010) has stressed the potential benefits arising from the application of information and communication technologies to the road transport sector and its interfaces with other modes of transport, in terms of significant contributions to improving environmental performance, efficiency and safety. In particular, the potential for ensuring higher levels of integration between road transport and other modes of transport has been stressed (comma 5). It is in fact widely acknowledged from EU research projects (e.g. MIRACLES, 2006) that the potential of technological changes (ICT development and ITS applications) in developing a new model of transport, which links and integrates tram/light railway systems with conventional ones, and that can offer a public transport service which better matches the needs and expectations of the modern traveller by reducing mode changes, providing better accessibility, and improving journey times. ITS applications bring significant improvements in transportation system performance, including reduced congestion and increased safety and travellersqconvenience. This however requires the optimisation and operation of the network as a single entity, whereas currently modal networks are largely separated and even within modes there is a lack of integration between countries. In particular, with regard to passenger transport, the integration of aviation with high-speed rail will be a crucial development.

Taking all this into account, the general objectives of the COMPASS project were:

- To provide an overall picture of the future travellers needs in the light of the key socio-economic trends;
- To analyse how ICT and ITS applications can meet the new demands, favouring the integration of multimodal transport solutions;
- > To assess how these solutions can contribute to the de-carbonisation of transport activities.



In such a framework, the following collateral and important objectives were also addressed:

- The potentials of the ICT and ITS applications to provide behavioural data and information to improve travel surveys and fostering harmonisation;
- The validation of the ICT solutions with stakeholders rooted in the national contexts, due to the involvement in the project of TTS Italia, member of the ERTICO National Network of ITS Associations.

1.2 SCIENTIFIC AND TECHNOLOGICAL OBJECTIVES

The work carried out in COMPASS did not have to start from scratch, but could build on a substantial body of knowledge on co-modal and intermodal passenger transport already available from past and current projects, in particular KITE, LINK, INTERCONNECT¹, HERMES, CLOSER, ORIGAMI and USEmobility. From this basis, COMPASS specific scientific and technological objectives were:

- To identify key trends (social, economic, environmental, technological) that will affect mobility now and in the future;
- > To identify the mobility needs of current and future travellers;
- > To identify the potential role of ICT in promoting co-modality and data collection;
- To identify the information that would be needed from data in order properly understand mobility, to optimise a future co-modal transport system and to assess the impact of new solutions;
- To analyse existing surveys with regard to data available concerning long-distance, rural and urban travel;
- To identify solutions to improving behavioural data (from ICT or elsewhere) and needs and opportunities for harmonisation of the data collected, in particular in the various national surveys (this also includes new definitions of accessibility indicators);
- To identify and investigate ICT solutions to influence mobility patterns for long-distance, rural and urban travel towards increased co-modality;
- > To develop business models that enable and promote these solutions in practice;
- To assess the potential impact of the solutions identified both on local and on European level, in particular with regard to carbon emissions;
- > To derive conclusions and recommendations for national and EU transport policy and actions;
- To disseminate the findings widely amongst policy makers and other stakeholders as well as researchers and the transport industry.

1.3 OVERALL STRATEGY OF THE WORKPLAN

COMPASS comprised eight workpackages, most consisting of two to four tasks:

- WP1 Consortium Management
- > WP2 Technical Management
- ➢ WP3 Key Drivers
- WP4 Travel Surveys
- WP5 ICT Solutions
- WP6 Assessment
- > WP7 Dissemination and Exploitation.

WP1, WP2 and WP7 were horizontal activities, and were on-going throughout the project. Project management comprised general coordination and management tasks as well as quality control.

¹ www.interconnect-project.eu



WP3, which kick-started the project, identified the key drivers behind future transport developments, namely key trends, such as socio-demographic trends, traveller needs and policy needs, as well as co-modal opportunities.

WP4, which also started right at the beginning of the project, dealt with travel surveys and comprises five tasks. The first one identified which information would ideally be needed from the travel surveys, the next three what information is actually available from surveys for long-distance, rural and urban travel, and the final one identified solutions to improving behavioural data with ICT solutions.

WP5 identified and analysed ICT solutions for improving long-distance, rural and urban mobility and related business models.

Finally, WP6 provided the assessment of the identified solutions. A framework for the assessment had been developed and the effects of the solutions were identified both on local and on European level, before final conclusions could be drawn and recommendations derived.

The overall duration of COMPASS was, as scheduled, 25 months.

1.4 COVERAGE OF THE FINAL TECHNICAL REPORT

The structure of the Final Technical Report follows roughly the sequence of COMPASSos public deliverables.

One of the first deliverables combined the results of two COMPASS tasks, namely the identification of key trends of mobility patterns in the 21st century (chapter 2 of this report), and the analysis of the emerging traveller needs in urban, metropolitan and rural level (chapter 3). Although COMPASS also deals with long-distance traffic, the traveller needs for this type of travel have not been included in COMPASS, because this issue has already been comprehensively covered in COMPASS¢ predecessor project ORIGAMI that dealt exclusively with long-distance transport (Carreno, 2011).

Another early deliverable investigated the potential role of ICTs in favouring a seamless co-modal transport system (chapter 4). This report laid out the general areas where ICT can be effective and thereby provided the basis for the handbook that was developed later on in the project.

One dedicated workpackage in COMPASS dealt with travel surveys. In one part of it existing surveys, both National Transport Surveys as well as other available surveys, were analysed with regard to the data that is available for modelling purposes or general analysis of current transport patterns, and a number of issues with regard to missing data or data from different countries and surveys that is incompatible were found (chapter 5). A separate task within the same workpackage then investigated how and in how far ICT can help in filling the gaps that were identified and, more generally, enhance the quality and quantity of available data (chapter 6).

Chapter 7 introduces one of the key outputs of COMPASS, namely the Handbook of ICT Solutions for Improving Co-Modality in Passenger Transport. This handbook consists of a series of factsheets on transportation management systems, traveller information systems, smart ticketing and tolling, smart vehicles and infrastructure, and demand-responsive transport. In addition, the handbook contains four business models for different solutions presented in the handbook.

Another major part of the project was the conduct of a total of eleven case studies that covered a range of ITS applications in urban and rural areas as well as for long-distance transport. These case studies are introduced in chapter 8, where also some insight is given into the results of the transferability study that has been conducted for all of the case studies.

Chapter 9 introduces the assessment of the impacts of different types of ICT solutions on a European scale based on the MOSAIC model that has been initially developed in the INTERCONNECT project and later been refined in ORIGAMI.

The report closes with final conclusions and recommendations.

It should be noted that this report only contains a small number of key references. Full lists of references can be found in the related COMPASS deliverables, which are listed at the end of this



report and which can be downloaded from the COMPASS website under <u>http://www.fp7-compass.eu/deliverables</u>.

2 KEY TRENDS OF MOBILITY PATTERNS IN THE 21ST CENTURY

2.1 **OBJECTIVES**

The demand for transport is generally examined by placing the sector itself at the centre of the analysis, and investigating variables that influence the changes to mobility and transport patterns. Nevertheless it cannot be neglected that transport demand is generated by factors that are exogenous to the transport sector and that mobility rises to satisfy specific individual needs as clearly expressed by the purpose for which passenger trips are made (e.g. shopping, working, studying, holiday etc.).

In order to identify the drivers of transport demand and its dynamics a detailed analysis of sectors of activities outside the transport domain is therefore needed. The effort made by COMPASS was trying to overcome the boundary of consolidated transport sector research and expanding the investigation of factors potentially affecting mobility also to different domains of reality. Therefore the analysis framework is based on the scanning of the social, economic, environmental and technical domains in order to provide an in-depth snapshot of the main drivers (highlighted in the following sections) potentially impacting on mobility.

2.2 THE FOUR DOMAINS

2.2.1 Key Drivers in the Social Domain

Population ageing is an ongoing phenomenon that is expected to severely affect all domains. As shown in EUROPOP2010 (EC 2011), the overall size of the population is projected to be slightly larger in 50 yearsq time, but much older than it is now: by 2060, the median age of the Europeans is projected to be more than 7 years higher than today and the number of people aged 65 or more is expected to represent 30% of the population as opposed to 17% today.

An ageing population could represent a huge problem for the economy. Most of the projected increase in public spending will be on pensions, health care, and long-term care. Recent demographic projections show that in 2060 there will be only two active workers for every pensioner.

As far as mobility is concerned, transport supply will need to adapt to elderly people, especially in terms of accessibility, availability of public transport, user-friendliness of payment systems, safety and security. The effect of ageing on the total amount of transport demand is not straightforward to predict since it strictly depends on activity rates and income distribution. If the retirement age will be raised, everyday mobility patterns might not change dramatically, even if a tendency towards shorter distances and public transport could be observed. However, if elderly people will be able to enjoy many years retired with a good income, commuting daily trips could be reduced whereas leisure and tourist trips could be increased.

Even though the global economic crisis has slowed **emigration** in many parts of the world and the recent European crises is expected to do the same, with economic recovery and job growth, most consider this slowdown to be temporary. Recent projections for the EU as a whole show that annual net inflows are estimated to increase from about 1 million people in 2010 to 1.2 million by 2020 and thereafter decline to 878,000 people by 2060. The cumulative net migration to the EU over the entire projection period is 55 million, of which most is in the Eurozone (42 million).

Intra-European migration flows will probably intensify in a scenario shaped by weakened national borders and increased regional disparities.

Mainly concentrated in urban areas and with lower economic standards migrants, especially at the beginning of their experience, travel less and mostly by public transport. This daily mobility pattern is expected to easily change in case of improved economic conditions, thus reducing the difference in mobility patterns between the domestically born and migrants. When considering long distance mobility, an increased movement of people and goods between Europe and the origin countries can be easily forecast; it will further intensify Europe¢ ties with neighbouring regions as well as increase the demand for international and intercontinental transport services.

Mobility is strictly dependent on **income level**: lower incomes are usually accompanied by reduced trip rates while, on the contrary, higher incomes are associated with increased mobility.



The main source of income for individuals and households in the EU is earnings from employment. Recent analyses show that both earnings and income inequalities have increased in recent decades for most EU states, with the level of inequality varying between Member States as well as within them. In addition, new forms of social exclusion and poverty are emerging.

In the future private mobility might become unsustainable for an increased share of the population and reliable, safe, and affordable public transport options might have to be offered to an expanding number of poor people, thus putting more pressure on public transport policies and on the need for subsidies. The need for cheaper public transport options, both for short and long distances, might be also exacerbated by fiscal policies increasing fuel and car ownership taxes.

On the other side, people with higher income could increase their demand for faster transport modes. In a scenario of recovered economic growth and rising income levels, a rising demand for mobility might be expected, both in terms of number of trips and total length, with travellers shifting from public modes (bus, railroads) to the private car and increasing the demand for faster modes (high-speed rail and air).

Car ownership is an important determinant of passenger travel behaviour and it is fundamentally interconnected with residential location and decision-making regarding motorised trips. The car ownership rate is reaching saturation in most of the industrialised countries as well as in Europe and a confluence of events and changes in lifestyle may lead to a possible reduction in the next decades. Nowadays people living in urban areas are provided with several public transport and car sharing options to satisfy their mobility needs and slow mobility (walking and cycling) is gaining increasing attention. The ageing population will inevitably modify its long-term mobility patterns relying more and more on public transport as driving capability will expire; the observed trends of re-urbanisation and consumersq increased preference for walkable neighbourhoods will probably slow down the urban sprawl trends and reduce car dependency; there is an increasing preference of younger generations in technological gadgets and social networks over owing a car.

If shrinking in industrialised countries, on the contrary vehicle ownership is rapidly expanding in emerging economies with important implications for environmental policies, as well as for the global oil market.

In the past decades the development of European cities was driven by **urban sprawl** with cities becoming much less compact even in the absence of demographic pressure. This trend, dominant in post-war Europe, is not expected to disappear in the coming years, but for reasons linked to land scarcity and costs and to appreciation of city life, the increase in urban sprawl may diminish.

In parallel, a certain trend towards **re-urbanisation** is being observed with elderly people (baby boomers generation) moving back from outskirts to inner-city areas. The reduction of urban sprawl may have major implications for mobility and transport like reduced travelled distance, lower dependency on the car and reduced road congestion in the access to the city. Public transport can be more cost-effectively organised in compact urban environments, nevertheless it should be properly planned in order to avoid unsatisfied demand: by 2050 more than 80% of European population is expected to live in urban areas, thus putting more pressure on provision of mass transportation systems.

Like in the rest of the world, the European tourism industry was severely affected by the global economic recession in 2008-2009 with the region overall suffering a decline in arrivals and a fall in receipts. This trend confirms the great dependency between economic welfare and **touristic flows** and makes it extremely difficult to make forecasts for future trends.

In a suffering economy travellers may heavily change their behaviour by reducing tourism trips and shortening both distance and duration. Also business travel may be affected through companies curtailing business trips. As already registered, an economic recession may be associated with a decline in air travel. In contrast, in a scenario of a growing economy, tourist trips would increase both in number and distance, as witnessed by the growing domestic and intra-regional tourism also in emerging economies.



Mobility patterns are also heavily affected by **changes in lifestyle and values**, but it is difficult to make future estimates about the intensity and timing with which these will impact on demand levels and distribution. Virtually, these changes could affect both short and long-distance mobility.

Everyday mobility can be reduced given the home working and home entertainment options provided by new technologies. Different kinds of activities can be currently executed via the web (e.g. eshopping, e-banking, e-booking of different services) with these options becoming more and more available in the future together with increasing users due to the natural decline of digital illiteracy in the population. Additionally the diffusion of immersive networking technology, especially among young people, may lead to the development of a different set of mobility preferences with future generations likely to spend more time in virtual spaces.

Nevertheless it seems hardly believable that there will be a dramatic decrease in everyday mobility given the natural and psychological need of movements in human beings.

On the other side, the intensification of information flows is increasing the interest of Europeans towards international experiences. This factor, together with the reduction of air fares, has heavily changed mobility by increasing the demand for long-distance leisure trips and changing the way Europeans conduct business or, more in general, their lives: people are moving abroad for shorter periods, mainly to other Member States, to seek work, pursue their education or other life opportunities.

Changing values can also impact on demand distribution ‰ space+as in the case of re-urbanisation driven by a new perception of urban living, ‰ time+as in the case of flexible working times taking place in several economic sectors, and ‰ modes+ as in the case of increased environmental consciousness especially among young people. The degree to which travel behaviour actually changes will be also driven by current and future policy and planning decisions: travel demand will be increasingly amenable to alternative modes and mobility management strategies.

At the final COMPASS conference, participants were asked which they thought are the most important ones out of the social drivers and the results are shown in Figure 2-1 below (the percentages add up to 300%, because respondents were asked to name the three most important drivers).



Figure 2-1 Relevance of social domain drivers

The three domains that were clearly thought to be most relevant were % change of lifestyle and values+ followed closely by % copulation ageing+and % arbanisation+.



2.2.2 Key Drivers in the Economic Domain

A wealthier economy (namely, higher per-capita **GDP**) encourages people to change habits, beliefs and values for example increasing demand for more expensive transport modes, inducing higher car ownership rates, high speed train services and diversion to air transport. Nevertheless, the understanding of the whole interaction remains knotty and still difficult to disentangle, because of the complex causal and feedback mechanisms that are involved. Decoupling economy and transport is a cornerstone, as the historic link between GDP and traffic growth should be broken up towards a more sustainable economic growth based on a lower transport intensity rate. In the current European scenario any long-term forecast about the GDP trend is extremely hard.

The gap between regions is expected to enlarge due to the persistence of their current economic situation. Forward looking, **regional differences** will become more evident in countries where underlying drivers, such as population growth, agglomeration economies, diffusion and development of technologies, globalisation and favourable economic policies (e.g. sustained public investment) will continue to support a stable pace. Developing countries will become more urbanised, with higher motorisation rates and even more dependent on energy sources. This could determine an anticipated shortage of oil reserves, as well as an increase of the prices of the products related to oil with unavoidable consequences throughout all the transport sectors worldwide.

Emerging countries are still less inclined to address and issue measures to contain emissions, since these policies might slow down the rate of progress. Due to the present crisis, differences across regions will be more likely to occur, and environmental pollution will increase amongst countries until governments will develop an even awareness in this respect. In emerging economies major transport investments can be expected to improve their accessibility domestically, from/to neighbouring countries and even further. Migration and tourist flows, as well as the trade sector, will highly benefit from improved accessibility. In particular, an increase of the air transport market is expected in emerging economies: by 2030 the combined domestic markets in China and India are projected to overtake the current US domestic market which, in 2010, was the largest in the world.

Currently, in the EU27 **employment** is projected to record an annual growth rate of only 0.3% over the period 2010 to 2020 and to reverse to a negative growth rate of a similar magnitude over the period 2020 to 2060. In particular, the share of workers within the range 55-64 years old is forecast to increase from 46.3% in 2010 to 56.1% in 2020 and to 62.7% in 2060, reflecting the expected impact of recent pension reforms in many European countries, aimed at postponing the retirement age.

Scenarios seem to be not encouraging also because full employment has not been on the policy agenda since the faith in market and supply-side economics has restricted labour policies to those targeted on improving (or trying to improve) labour participation.

Socially, employment as well as unemployment may both drive migration flows between regions. In the first case, skilled workers seek job opportunities in places where advanced capabilities are more likely to be required, on the other hand, unemployed people living in distress and dwelling in depressed areas are more inclined to move to urban centres, where they could strive for becoming better off. If migration to specialised labour markets flows from rural and remote areas to the more urbanised ones, then occupation patterns will definitively also affect urban development and mobility.

The economy cycle impacts on public spending possibilities for **investments in the transport sector**. Under the current policy environment, budget constraints of Governments are manifold and hit transport mainly in terms of reduced funds granted to subsidise public transport and with respect to investments in new infrastructures.

From a macro-economic perspective, public investment in transport infrastructure may foster a suffering economy, although such a policy has not a clear and perfect cause and effect relationship. As a matter of fact, transport infrastructure may require a huge amount of financial resources and the returns on investments may not be perfectly overlapped with the real pattern of the economic cycle.

Europe invests on average 5% of GDP in transport infrastructure, with an increasing share of these resources being placed in upgrading and extending the trans-European rail network. The cost of EU infrastructure that would be required to match the demand for transport is estimated at over "1.5 trillion in the time span 2010-2030. Additionally it can be supposed that further investments might be



needed in the future in order to address the emerging mobility needs of the elderly working people: private and public vehicles will have to respond to new comfort and safety requirements and transport infrastructures will have to be adapted accordingly to reduced perceptions of aged people.

However, as introduced above, in the coming years and decades there might be an increasing difficulty in finding the means for investing in transport infrastructure, given that a larger amount of resources will be absorbed by social services provided to the ageing population. Additionally, the recent economic crisis has severely hit public budgets and private lending with direct impacts on the building of infrastructures and on the viability of companies providing transport services.

The **market structure** is going to influence future mobility trends to the extent that rules and regulations (e.g. more or less market liberalisation) will exert an impact on transport demand and supply via relevant drivers. The literature review has in fact established a correlation between market structure, ranging from lower levels of regulation (i.e. liberalised markets) to stricter rules (regulated markets), and important drivers of transport demand and supply, namely: a) GDP trends, correlated to higher market liberalisation, and leading to higher mobility rates; b) foreign trade and liberalisation, resulting from higher market opening and integration, leading to higher freight transport growth rates; c) technology development and innovation, assumed as a by-product of more competition and R&D investment, determining a positive impact on mobility of goods and people.

It is important to stress the implications of the market structure on the use of transport modes and the characteristics of travel, e.g. average distance. In market oriented economies, mobility is more likely to be based on open market structures that sustain economic integration through long-distance mobility (e.g. shipping and air transport), both for passengers and freight. On the other hand, a market structure with higher fragmentation and national inward orientation may have the opposite effect, namely favouring short-distance trips.



The relative importance given to the drivers in the economic domain by the conference participants are shown in Figure 2-2.

Figure 2-2 Relevance of economic domains drivers

In this case there were two drivers deemed to be much more important than all others, and these were % anergy availability and prices+and % availability of public and private resources and investments in the transport sector.



2.2.3 Key Drivers in the Environmental Domain

Many impacts of **climate change** are already visible in Europe and worldwide and these impacts will become more pronounced in the future. In the short and medium term climate change will increase the occurrence of extreme weather events, while in the long run it will lead to an increase in average annual temperatures, alter rainfall, and raise the sea level and the risk of coastal erosion.

As a consequence, there might be strong distributional patterns: the UN predicts that there will be millions of "environmental" migrants in the next decades with climate change as one of the major drivers of this phenomenon. The different distribution of population might produce variations in demand for oil and coal in electricity production, having implications also for the transport sector. Furthermore, since much of the world's hydrocarbon reserves are in regions vulnerable to the impacts of climate change, instability is likely to increase energy insecurity and competition for resources.

Most writing about climate change and transport emphasises the role of greenhouse gas emissions from transport as a contributor. However, the inverse impact is also significant, since the transport system is liable to be adversely affected by climate change, particularly as a result of extreme weather conditions that might have immediate impacts on travel and damages that cause lasting service interruptions events.

A great array of **GHG mitigation** measures can be undertaken to reach the emission targets set by the EU: technology measures, new policies and a change in lifestyle for all citizens. Current vehicle technology must be improved in order to achieve greater fuel efficiency through the improved aerodynamic design (especially in the air transport sector), the reduction of vehiclesq weight, the lowering of rolling resistance and the adoption of alternative propulsion technologies. Transport should become less dependent on fossil fuels, thus contributing to energy security, by relying more on low-carbon fuels to be provided at affordable prices and with an efficient distribution networks. Using a fuel mix of electricity and hydrogen, and to some extent biofuels, could significantly reduce the number of gasoline-powered passenger vehicles on the road by 2050.

Supporting policies will need to pull existing technology in the marketplace and to promote technological development for the future, requiring a combination of performance standards, pricing mechanisms and R&D actions. Planning measures, especially at urban level, will become more urgent for developing compact communities more conducive to an efficient provision of public transport as well as to shorter vehicle trips and non-motorised travel.

CO2 emissions can also be reduced through interventions aimed at increasing driversqacceptance of smaller vehicles and less powerful engines and changing driving behaviour, such as reductions in excessive vehicle acceleration and driving speeds. Eco-driving measures could be massively promoted both in the urban and interurban environment through training and information guides, and actively supported by technologies providing Infrastructure to Vehicle (I2V) And Vehicle to Vehicle (V2V) real-time information. All these measures have a great potential to highly influence both the transport system and demand structure in the future.

Energy is a basic need for the society and its pattern of **availability**, **production and consumption** are of greatest relevance in the context of the economic and environmental domains. Worldwide demand for energy is growing at an alarming rate and projections suggest that by 2030 world energy use will probably have increased by more than 50 per cent, thus exacerbating the competition for the primary energy sources.

Electricity production accounts for 32% of world global fossil fuel use and around 41% of total energy related CO2 emissions. Not only the burning of fossil fuels (coal, lignite, oil and natural gas) is the largest source of carbon dioxide emissions, but the extraction of coal, oil and gas, as well as leaks from gas pipelines are among the main sources of energy-related methane emissions.

In this context of great European energy dependence and environmental concerns, it seems hard to predict what might be the fuel mix of EU energy production in the next decades. Some studies predict that in 2050 more domestic energy resources would be used, in particular renewables.

While there is agreement that electricity will have a role in transport, opinions diverge on how large its potential is. Alternative sources of energy in transport might be biofuels; nevertheless the literature



review showed that the economics of conversion processes need to be further improved for biofuels to be really competitive with fossil fuels without subsidies in the longer term.

Despite the uncertainty surrounding the future sources of European energy production, it can be more certainly argued that energy & aving+and & ficiency+measures will become more and more prominent in the next decades especially in the transport sector.

Some literature suggests that the private economic cost of transport fuels will be by far higher than those of today, whatever mix of sources, carriers, and conversion systems there may be in the future. Therefore, the role of efficiency in the transport sector will become critical, not only in terms of the environment, but also in terms of the overall affordability of mobility.

While it is clear that the roadmap for the transport system is to shift from carbon to low-carbon energy sources, it is unclear when this shift would be completed and whether this might occur in time to avoid major problems arising from the **scarcity of fossil fuels** and especially from oil. Even though it cannot be said with certainty that fossil fuels will run out in the next thirty years, extracting and delivering the remaining oil to market is becoming increasingly difficult and costly: as reserves that are easy to access run out, the oil production has to rely on less accessible resources and on fossil fuels with lower energy content. Fossil fuels that are currently extracted from deposits would have been considered uneconomic two decades ago. This requires more transport and more energy with higher environmental impacts per unit of material or energy produced.

While improving vehicle efficiency is by far the most important low-cost way of reducing oil consumption and carbon emissions in the transport sector, biofuels are supposed to play a significant role in replacing liquid fossil fuels suitable for planes, marine vessels and other heavy transport modes that cannot be electrified.

The relative importance of the drivers in the environment domain, as seen by the COMPASS conference participants is shown in Figure 2-3.



Figure 2-3 Relevance of environment domain drivers

As already in the context of the economy, the driver considered most important is manergy availability, production and consumption+, followed by mollution levels and emission standards+, malimate change impacts+and mathematical mathematica



2.2.4 Key Drivers in the Technology Domain

On the technological side several factors are expected to contribute to the development of the future transport system and to influence mobility patterns.

In the field of vehicle innovation, **traction technologies** are the most explored and investigated. The internal combustion engine (ICE) will still play an important role in the future: obviously, many improvements are to be performed regarding GHG emissions, energy efficiency and costs, but, at the moment, though many alternatives are quite fully developed, none of these has proved to be totally successful in replacing the %dd+conventional ICE.

It is not feasible at the moment to state with any certainty which technology will be the real breakthrough in the traction of vehicles. Nevertheless, the most likely would be electricity. Until the massive diffusion of fully electric vehicles will take place, nowadays hybrid solutions are gradually gaining higher and higher market shares. Hybrid vehicles have many advantages in terms of energy efficiency, even though these advantages are still counterbalanced by the weight of the batteries, which make the vehicles heavier than traditional ones and also raise some safety issues. Thus, in parallel, research has started to look for new materials for lighter and high-performance batteries (super-capacitors). **New materials** will allow in general a reduction in the weight of vehicles and an increase in vehiclesqperformance, thus improving fuel efficiency and environmental impacts.

Besides the engine factor, the other main branch of research on new traction technologies regards fuels. Most alternative fuels come from bio-sources (biofuels): such a production still raises significant concerns about its sustainability in terms of biodiversity preservation, land-use mitigation and total life-cycle assessment emissions.

Other potential for fuel is considered to be in hydrogen, but in this case new technological improvements are needed to significantly reduce total GHG emissions.

From an economic point of view, large amounts of funds and investments will be of vital importance to further develop innovations and making them widely affordable. This aspect is of crucial importance especially if the target is a real breakthrough in traction. The public fiscal revenue from oil fuels still represents one of the strongest hurdles. However, smart and effective policies could help to get over such barriers.

New technologies are affecting almost every aspect of our life and have started to change our daily habits significantly. With a major focus on travel habits in particular, the most prominent role is played by **information and communication technologies** (ICT), which have great potential to lessen conventional constraints of time and space. New patterns of mobility are emerging since **%**eleworking+and **%**n-line shopping+, just to name a few, have become feasible. Nonetheless, it would be misleading to conclude that the increasing diffusion of ICTs could reduce the need to travel in general. Innovation per se has not this powerful influence and the introduction and the diffusion of technology may produce some **%**ebound effects+ in most cases the improvements in the efficiency of the transport system (increasing speed, decreasing congestion, improving transport conditions) may lead to an increase in travel demand. The awareness of this one-to-one connection between transport and technologies has to be widely achieved yet.

Technologies can not only be considered simply as one among all the external factors impacting on the transport sector: they have, indeed, a key role in shaping its development and their diffusion within the sector has become a more and more impelling need.

Nowadays Intelligent Transport Systems (ITS) applications are common both in urban (parking information, variable message signs (VMS), public transport prioritisation, etc.) and in interurban areas, managing problems connected for instance with rerouting (accidents or weather conditions), tolling or for automated enforcement for safety reasons.

Monitoring systems have been increasing in number and application in recent years. Sensors are being installed along roads for different purposes: for instance speed cameras to detect vehiclesq speed (for safety reasons), inductive loops to count traffic flows and measure speeds and send this data to traffic control and management (for information) and Closed Circuit Television for plate recognition (for road charging).



Traffic management systems are very important tools. With relatively small investments, they can lead to significant improvements in public transport, in reducing congestion, waste of time and avoiding further large investments, for example in constructing new roads. Especially under a global downturn in the economy, a deeper insight should be reserved to **%**oft+ innovations driven by technology improvements which proved to be the most effective in tackling transportation issues without major infrastructure investments.

Information systems are playing a key role in the transport sector: thanks to the wide spread of information, people are becoming increasingly more conscious of their mobility choices, discovering benefits of using public transport and taking advantage of well-planned intermodal journeys.

The first effect of an increasing availability of information on different modal options is the need for interlinked connections also from the point of view of tickets and fares. Information technology is fostering more and more the diffusion of electronic **booking and payment systems**. Ticketing systems present great advantages in terms of general efficiency for the transport sector. Users can save time (or even avoid trips to purchase tickets in advance) and can sometimes also save money (as electronic ticketing systems calculate the lowest fare for their trips); on the other side public transport operators may rely on precious data on usersqtravel habits and behaviour thus having a better chance to efficiently plan different targeted solutions.

Amongst the main barriers related to the spread of these technologies and systems there are regulatory issues and a digital divide. Regulatory actions should be implemented in order to diminish market fragmentation between different operators and to increase the interoperability of the different transport systems. A second aspect to be considered is the different level of digital skills across countries and within each country between people from different economic and social conditions; though the spread of %mart-phones+ is increasing very fast, purchasing them is not affordable for everyone, and today not everyone has adequate skills to exploit the transport applications offered by these devices.

Asked about the relative importance about the relevance if drivers in the technology domain, respondents replied in accordance with Figure 2-4.





We chnology development in general+ was ticked most frequently, followed by Waffic management systems+ and Waformation systems+, while Wanergy efficiency+ and Waew vehicle design+ were only ticked by around a third of participants.

2.3 MAIN CONCLUSIONS

The scanning of the social, economic, environmental and technological domains has revealed that all of them could play an important role in reshaping future mobility: every domain has relevant driving forces that, on their own, or in combination with others, could substantially impact on transport demand.

In most cases it is hard, if not impossible, to predict the intensity of such impacts as well as their rapidity in the course of the years: in fact, the speed by which environmental and technological mutations could take place is really hard to predict, and thus their implications on the planning and development of the future transport system remain uncertain.

As witnessed by the current European situation, it is also very hard to predict the development and the implications of economic, political and financial decisions on the global market, affecting in second order overall mobility of people and goods.

Less challenging could be the prediction of the impacts deriving from demographic factors whose dynamics, unless there will be disruptive events, can be more easily understood and forecast.

Future planning and policy interventions are crucial in addressing the new challenges deriving from the key drivers. Transport policy measures are supposed to increasingly address the characteristics of an ageing population in order to support both private and collective mobility of elderly as long as possible and the transport system should be adapted to cope with the reduced physical and cognitive capabilities of elderly.

As urbanisation continues to be a relevant phenomenon, urban and suburban transport networks must be properly planned to face an increasing number of people that will travel in and across urban centres. Measures to tackle congestion, air pollution and noise are expected to be applied more and more in metropolitan and urban areas. Public transport has to be properly planned and subsidised in order to satisfy the potential increase in demand.

The emerging & ustainable consumption+culture on transport which is contributing to and increasing the shift towards alternative mobility by walking and cycling in urban areas should be properly incentivised by adequate planning and policy measures. Awareness campaigns and training on environmental issues, already proven to be cost-effective, should become a major priority for policy makers.

In parallel with increasing efforts in enhancing environmental consciousness, appropriate fiscal policy measures and market regulation should be more and more implemented, in order to make environmental aspects enter the market (ETS, polluter-pays and user-pays policies to be extensively applied). In addition market regulation should be properly developed in order to prevent inefficiencies and/or inequalities while applying these mechanisms.

Increasing scarcity of fossil fuels and environmental concerns are accelerating the pace for technological development. Policy measures have to increasingly support the investments sustaining the spread of innovations in the % green transport+sector.

Future transport planning should take account of the possibility for the transport systems to be severely affected by extreme weather conditions and disruptive events in order to develop some resilience to these aspects and to prevent major damage from services and network interruptions.

It is up to all policy levels (European, national and local) to consider all the challenges deriving from expected trends and exploiting all the potential in order to drive the changes on a sustainable track and to satisfy future traveller needs.

However, the analysis disclosed that the relative importance of all future challenges and needs is still not fully established, due to lack of studies which have attempted to address this question. More research is needed to clearly understand the magnitude of the impacts that the key drivers, on their own or in combination with others, might have on future mobility and transport.



The analysis of future European transport scenarios should require a more holistic approach than the one traditionally used and should be widened to properly consider the complexity of the system and its interactions with all the domains of human activities.

Appropriate strategic modelling tools should be more and more deployed in order to investigate this complexity, to analyse wide-vision scenarios and to quantify the expected impacts on future mobility and transport.

Also data gaps are to be addressed by researching more on travel behaviour and needs of specific user groups (older, mobility impaired, migrant groups etc.) which are expected to be the majority of future European travellers.

To overcome all these gaps in knowledge major efforts and investments should be therefore devoted to R&D activities for properly supporting the definition of adequate planning and policy measures.

More information on key drivers and future challenges is available at: http://www.fp7-compass-keytrends.eu/

3 EMERGING TRAVELLER NEEDS FOR SHORT-DISTANCE TRIPS

3.1 **OBJECTIVES**

The identification and satisfaction of user needs have been an integral part of European transport policy. For example, the 2001 Transport White Paper stressed users at the *Heart of transport policy*' and a review of Common Transport Policy stressed the *Need to focus future European transport policy on the pursuit of an integrated, technology-based and user-friendly transport system...whilst ensuring that users, with their needs and rights are always kept at the centre of policy making.'*

Set against this policy background, the main objective of this COMPASS task was to perform a systematic and comprehensive review of available literature on <u>the</u> needsqof current (and potential) travellers, taking into account the forecast key mobility trends across Europe. This review included the needs of the full range of travellers, including more vulnerable groups, (such as older and mobility-impaired, people with young children), although the focus was on those groups identified as important in terms of forecast key trends. The review of user needs was structured to cover all transport modes both singularly and also in combination when making multimodal trips.

As user needs for long-distance trips had already been investigated in the ORIGAMI project (Carreno, 2011) the focus in COMPASS was on examining user needs for short-distance trips and on those modes that are typically used in short distances - rail, local bus, metro and ferries. Also, in line with current EU objectives to encourage sustainable transport choices (i.e. non-car use), there was no consideration of user requirements for car use *per se*, although there was an examination of the reasons as to why people are so attachedqto their cars, and the barriers that prevent people from switching to alternative modes.

3.2 **Key Findings**

Based on the evidence reviewed it was concluded that there are 16 main user needs for shortdistance intermodal journeys. These user needs are identical to those identified for long-distance intermodal journeys (Carreno, 2011), which suggests these needs are generic for all intermodal journeys, irrespective of distances involved.

A summary of these key user needs is presented below, and where personal and situation factors are known to influence the relative importance of each need, this is highlighted.

- > Network characteristics Users require:
 - Transport services that depart and arrive at interchange points that are of sufficient frequency to meet their needs for each journey;
 - Transport services that cover an area that allows them to travel to the places they want to go;
 - Transport modes that allow them to travel to their desired destinations matching their personal mode preferences, and;
 - Available transport services depart/arrive that are matched to times required by them (convenient); and
 - Available transport services that run on time.

For travellers making business or commuting trips fast (see Journey time later) frequent and punctual services are key aspects of importance, especially those living in rural areas (where services are typically less frequent), compared with those on leisure trips, or in urban areas.

> Interchange facilities - Users require:

- Interchange facilities that are designed, managed and equipped to a sufficient standard to allow them to make required connections between different modal stages of their journey as
 - safely (see personal security later);
 - quickly (see journey time) and;



- comfortably (see comfort) as possible.
- Interchanges also need to be fully accessible for users (i.e. barrier free), which includes use of facilities sited within interchanges including toilets, ticketing machines, shops, cafes etc.

Barrier free access is the primary concern for mobility-impaired travellers, in relation to both navigating within interchanges facilities as well as alighting / disembarking from transport vehicles.

- > Baggage handling facilities Users require:
 - Baggage handling / storage facilities to be provided that are safe, simple to use, and reliable.

For some travellers, including older / mobility-impaired people and parent travelling with young children, assistance may also be required.

> **Door-to-door information** - Users require:

 Information that is sufficiently detailed and of high quality and covers all aspects of their journey, i.e. for pre-trip, wayside and on-board journey stages to allow users to efficiently plan their whole journey.

For some travellers this information needs to be provided in formats that allow all users to fully use and understand the information provided (e.g. in Braille, talking maps etc.), and for some migrants and tourists who are unfamiliar with the transport services available more detailed, clearer information is required, and presented in languages they can understand.

- **Cost** Users require:
 - That costs involved in planning and undertaking the journey are affordable, according to their individual financial means.

This includes costs involved to access (first mile) and egress (last mile to desired destinations) transport terminals, as well as the costs involved in each main mode component of the journey.

Cost issues are more important for travellers on low incomes.

- > Ticketing and Tariffs Users require:
 - Simple ticketing arrangements that allow them to transfer between different modes, or same modes operated by different operators, as easily as possible, i.e. not requiring multiple tickets.
- **Comfort -** Users require:
 - Transport services (vehicles) and facilities (interchange terminals) that are designed and maintained to ensure users are comfortable throughout the whole journey.

This includes aspects such as ensuring facilities and vehicles are clean, and offer protection from weather conditions, seating and waiting areas, and food and drink facilities (see on-board facilities).

- Safety Users require:
 - The feeling of safety when making intermodal journeys (i.e. from the risk of accidents).



> Personal security - Users require:

• The feeling of security when accessing, and using different mode components of the intermodal journey (i.e. from theft, attack, intimidation etc.).

This aspect is important for all travellers, although is of greatest importance for women, older travellers, mobility-impaired and migrant groups.

- **Journey time** Users require:
 - The total journey time involved in each intermodal journey to be as short as possible (i.e. minimal access, waiting, transfer and in-main mode vehicle/vessel time).

This requirement is more important for travellers on business or commuter trips, compared to those on leisure trips.

- > Accessibility: Users require:
 - Transport terminals that are fully accessible by all feeder transport modes, as well as the vehicles that they are required to use for the main mode components of the full journey.

This aspect is of greatest importance for all mobility-impaired groups.

- **Employees -** Users require (or expect):
 - Transport employees at interchanges and on-board vehicles/vessels to be able to assist them (if required), provide the correct information to them, to be smartly dressed and courteous, etc.

For mobility-impaired travellers it is important for employees to have sufficient training and awareness of disability issues.

- **Effort -** Users require:
 - That the total effort (physical, cognitive and affective) they need to expend to undertake a journey is reasonable (i.e. is acceptable for them, not uncomfortable for them etc.).

For mobility-restricted travellers minimal effort is a key requirement for them to safely and comfortably use transport services.

- > In-vehicle facilities Users require (expect):
 - Services to be provided, or be available for them such as catering facilities (see comfort), communication facilities (wireless access, plug sockets) and entertainment facilities (newspapers, TV/films, games etc.).

For business travellers (and some commuters) wireless access etc. will be more important, compared to those travelling for leisure purposes.

> Environmental concerns - Users have:

• Expectations that transport companies and operators are taking actions to minimise the environmental impact of service vehicles (i.e. using low emission vehicles, fuel etc.).

> **Promotion of intermodality** - Users need:

• To be aware of intermodal services that are available to them and these need to be marketed in a way that is attractive to them.

However, the relative importance of these user needs is still not fully established, due to lack of research studies to address this question. What is known is that the relative importance attached to



each user need, as well as specific attributes of these broad user requirements, is dependent on both personal (age, mobility-impairment, gender and migrant status) and situational factors (trip purpose).

There is also considerable evidence that if *æ*ertainquser needs are unmet, this can prevent people from making certain journeys. However, the relationship between user requirements and modal choice decisions is complex and also dependent on the personal factors of travellers as well as their trip purpose, and prevailing conditions (service provision, costs) according to location. To fully understand this complexity, further research is needed.



4 THE POTENTIAL ROLE OF ICT IN FAVOURING A SEAMLESS CO-MODAL TRANSPORT SYSTEM

4.1 **OBJECTIVES**

The analysis of the promising ICT solutions in favouring a seamless co-modal transport system had two main objectives:

- > To identify the ICT solutions with potential to favour seamless co-modal journeys;
- > To stress their role in favouring data collection and management, providing indications on how they can improve data collection in the passenger transport sector (data collection methods).

4.2 WHICH ICTS TO CONSIDER?

The identification of the promising ICT solutions for favouring a seamless co-modal transport system has been carried out through an extensive background analysis mainly based on the outcomes and the insights of several current and past FP7 projects and a literature review dealing with the analysis of roles and potential of ITS; namely:

- STADIUM (2009-2012) Smart Transport Applications Designed for large events with Impacts on Urban Mobility, in particular the Deliverable 2.1 dealing with the State-of-the-Art of the use of Intelligent Transport Systems (ITS) in supporting large events in urban and metropolitan areas, e.g. Olympic games.
- ROADIDEA (2008-2010) studying the innovation potential of the European ITS sector by analysing available data sources, revealing existing problems and bottlenecks for data utilisation and service build-up, in particular, D4.3 % Itilisation of advanced information in public sector, which focused on the state-of-the art of the public authorities qmain intelligent transport services ITS in support of future transport services.
- ETISplus (2009-2012) Source uransport policy Information System- Development and implementation of data collection methodology for EU transport modelling+, in particular the Deliverable D2 Source report ITS pilot definition on usability for European data modelling+, in which the promising ITS applications and their potential usability to solve data collection and updating problems have been identified and analysed (barriers to implementation, strengths and opportunities, etc.).
- QUANTIS (2008-2010) Quality Assessment and Assurance methodology for Traffic data and Information Services+, identifying the relationship between ITS service quality and benefits/costs, and the optimum service quality in four European service cases, in particular, the Deliverable 1 Quefinition of Key European ITS Services and Data Types+, which describes a sample of key European ITS services.
- At broader level, of particular interest has been the international review of ITS applications described in ITIF (2010) Supplaining International IT Application Leadership+, by Stephen Ezell, which provides an analysis of the factors behind the adoption of ITS successful worldwide applications.

Taking into account of the above contributions and other input from literature review, e.g. transportation publications, academic papers, European Commission studies, e.g. the EC Intelligent Transport Systems (ITS) web page (http://ec.europa.eu/transport/themes/its/) the classification of the most promising ICT based applications has been influenced by the analytical framework of the COMPASS project. Namely:

- The freight transport sector is not considered.
- The time horizon for the analysis of the ICT based applications is the medium term (2020), which implies to highlight the ITS applications characterised by mature technologies able to be applied and producing significant results in the near future.

The resulting classification has led to the identification of six categories of ICT based applications:

1) Transportation Management Systems, helping to plan and running efficiently the transport system;



- 2) Traveller information systems, in which the key characteristic is to assist the traveller with basic 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;
- 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;
- 5) Vehicle-to-vehicle (V2V) applications, leading to tighter integration among vehicle operations and disclosing a wide range of important transport services to the traveller, in particular concerning safety, mobility and efficient infrastructure use;
- 6) Demand-responsive transport services (DRT), 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.

4.3 **K**EY FINDINGS

Concerning the first objective of identifying the most promising ICTs application favouring seamless multimodal integration, the following table shows that important ICTs enabling applications are represented by smart ticketing options combining tariff information of several transport modes (smartcards) and traveller information systems, informing transport users on timetables and travel time (multimodal traveller information systems). In particular, it must be stressed that in this latter category, the real-time co-modal traveller information systems are deemed to be the most promising ICT applications, to the extent that they can take into account of the dynamic context-related event, e.g. delays, traffic interruptions, etc., updating the travel planner and favouring seamless journeys. The qualitative assessment uses three categories: low capability (1/2), medium capability (1/2/2) and high capability (1/2/2).

	COMPASS MS1 ICT categories	Seamless multimodal integration
1)	Transportation Management Systems	1/2/2
2)	Traveller Information Systems	1/2/2/2
3)	Smart Ticketing and Tolling Applications	1/2/2/2
4)	Vehicle-to-Infrastructure Applications	1/2/2
5)	Vehicle-to-Vehicle Applications	1/2
6)	Demand-Responsive Transport Services	1/2/2

Table 4-1 ICT categories and multimodal integration

Concerning the second objective of identifying the potential role of ICTs application favouring transport data collection, it has been stressed that opportunities towards a better data collection process for passenger mobility surveys are continuously evolving to meet transport data needs, using a broad range of information and telecommunications technologies to detect people, drivers, vehicles, traffic and environmental conditions, and to communicate information to a variety of user groups. Transport data needs are complex, vary between sectors and are influenced by factors such as levels of transport system development, the degree of intermodality involved in the trips, etc.

The overview of the relationships between ICT categories by relevant applications and data needed for passenger transport surveys is given in the following table. It should be noted that the table only contains four ICT categories out of the six identified above, because it is thought that the other two will not be able to contribute to relevant data collection and information provision.



ICT	s categories	Relevant applications/solutions	Types of information provided
1)	Transportation management systems	 Urban Traffic Control systems Performance monitoring Traffic planning Priority management Public Transport Management Transport Demand Management Enforcement Traffic Control Traffic Forecasting 	 Network state estimation Traffic flows Capacity Delays Congestion Traffic composition, e.g. public transport share, private motorisation
2)	Traveller Information Systems	 Travel planners Pre-trip decisions tools Within-trip confirmation and recovery (Real time-Travel time tools) Route optimisation Destination findings Route following Dynamic route guidance 	 O/D flows Number of trips by link and zone. Time, cost, trip location Distance travelled, routes Route and journey time estimations
3)	Smart Ticketing and Tolling Applications	Electronic Toll Collection Access Management	 Cost information, charges, tickets, fees O/D flows Road characteristics, e.g. speed limits
4)	Vehicle-to Infrastructure (V2I) Applications	Floating probe vehicles	 Vehicle location Travel time O/D routes Traffic flows

Table 4-2	ICT categories a	nd types of information provided
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Concerning the third objective of identifying opportunities of the ICT solutions to meet the future challenges deriving from the socio-economic factors, e.g. population ageing, migration flows, urbanisation patterns, the following three sub-sets of drivers, relevant for ICT solutions, have been identified:

- Demographic factors (population ageing). The level and composition of the population in terms of person types, with considerable variation in trip making and trip distances between persons by age, sex, economic position, income, etc. is clearly one of the factors that influences transport demand. Particular attention is paid to the way trip rates change for each person category, and especially in relation to age and income dependent behaviour. From the 2012 Ageing Report (EC, 2011): Whe age structure of the EU population will dramatically change in coming decades due to the dynamics of fertility, life expectancy and migration. The overall size of the population is projected to be slightly larger in 50 yearsqtime, but much older than it is now+.
- Over the past 20 years, in the European cities car ownership rates have been growing and it is likely that in the near future the car ownership rates continue to grow, even if at slower rates. It should be considered in fact that income effect and behavioural patterns and lifestyles will continue to exert their influence in increasing the rate of private motorisation rates. This trend must be interpreted in association with the population ageing. In fact, in the future older people will comprise a larger share of the driving population than in the past. Older people will wish to retain their driving licence as long as possible and therefore licence holding among older people will be more similar to licence holding among younger and middle aged people now.



Concerning the urbanisation driver, urban growth is nowadays accompanied by urban sprawl . a relative shift in the location of activities (housing, industries, retail and other services) towards the peripheries of the urban agglomeration. This was and currently is an established trend that affects the growth of modern cities, which can be assessed by taking into account global trends in the housing, retail and business sectors, in order to understand why this phenomenon has steadily marked the development of urban areas over the last decades. Growing car ownership and the concentration of work and shopping in out-of-town locations have resulted . and may continue to result - in continuing increases in journey length for all purposes, but particularly for commuting.

The following table shows the relationships between the drivers of changes in transport demand, the identified broad ICT categories and the impacts on transport demand and passengersqueeds.

Change in passenger transport demand		Role of ICT solutions		
Drivers	Impacts	ICT Solutions	Impacts	
Population ageing	Growing mobility of older people: the need of improving safety and vehicle design	 Vehicle-to-Vehicle applications: Advanced Driver Assistance Systems (ADAS) Adaptive Cruise Control (ACC) Demand-responsive transport Services 	 Improve communication and safety and comfort Assist the driver during drive and operations Favouring mobility for disabled, and older people 	
Growing motorisation rates	 Growing mobility through private motorised transport means Growing congestion Safety problems 	 Traveller Information Systems: Real-time Co-modal Traveller Information Systems Transport Management Systems: Public Transport Management Incident Management and ITC Safety Services Vehicle-To- Infrastructure applications: Intelligent Speed Adaptation (ISA) 	 Integrate public transport planning information (e.g. real time information on bus schedules) Modal shift in favour of public transport Saving in congestion and travel time Reduce accident rates by improved accident management and in-vehicle tools 	
Urbanisation trends	 Urban sprawl and higher transport demand (road) Need to more frequent multimodal transport trips (e.g. commuting) 	 Traveller Information Planners: Travel planners Real-time Co modal Traveller Information Systems Vehicle-to- infrastructure Applications 	 Saving time and trips, by providing additional feeds into the navigation systems and make the information mix even richer by combining weather conditions en- route, feedback from commuters already on the road, measurements from road sensors, etc. Assist passenger providing information on transport services, timetables and interconnections: 	

Table 4-3 Key drivers in transport demand and ICT solutions



Drawing conclusions on the assessment of opportunities from ICTs applications, there are other important issues that need to be considered:

- 1) Do the solutions increase trip-making (i.e. generate new trips)?
- 2) Do the solutions reduce travel (i.e. shorter or fewer trips)?
- 3) Do the solutions promote modal shift (towards or away from *sustainableqmodes*)?

The following table provides an indicative assessment of the above questions (the same qualitative evaluation criteria of the above table has been used: low capability ($\frac{1}{2}$, medium capability ($\frac{1}{2}$) and high capability ($\frac{1}{2}$).

COMPASS ICT categories	Generate new trips	Increase travel distance	Promote modal shift
1. Transportation Management Systems	1/2/2	1/2/2/2	1/2/2
2. Traveller Information Systems	1/2/2	1/2/2/2	1/2/2/2
3. Smart Ticketing Applications	1/2	1/2	1/2
4. Vehicle-to-Infrastructure Applications	1/2	1/2	1/2
5. Vehicle-to-Vehicle Applications	1/2	1/2	1/2
6. Demand Responsive Transport Services	1/3/2	1/3/2	1/3/3/2

Table 4-1 ICT solutions wider assessment

Concerning the capability of ICTs solutions to curb unnecessary passenger transport, it is not clear whether ICT acts as a brake or as an accelerator in what currently seems a relentless growth in the demand for passenger travel. Timely information on traffic conditions and interconnections (Transportation Management Systems), could reduce congestion (and emissions), but at the same time it might encourage other longer distance travel, in particular by air.

The direct effects on transport may be some replacement of existing travel, but in the longer term new patterns of longer distance travel may emerge as the ICT becomes embedded in lifestyles (traveller information systems). ICTs may allow people to live in remote parts of the European Union and to develop locally based travel patterns with occasional longer distance journeys to the city. The improvement of accessibility made possible by ICTs, e.g. rural inaccessibility, may be overcome, increasing the total transport demand, by public transport modes or collective car services.

In the city (short-distance trips), the need to own a car may be reduced as the quality of public transport and information services is enhanced by ICTs. Car sharing and innovative forms of leasing favoured by ICTs applications may result in less city car ownership.

Concerning long-distance trips, the ICTs impacts may be different. The application of internet-based online booking and debiting systems can be combined with the use of travel information systems and smart ticketing, with embedded intelligence to ensure that high-quality options are presented to allow customised mobility. The increasing opportunities of last minute deals done through the internet have become increasingly important as the flexibility of the internet has been used to sell excess capacity, particularly for flights, hotels and holidays. The direct effects have been higher occupancy rates on airlines, railways and hotels, as space is sold at costs slightly above the margin. At one level, this may just be using up excess capacity and so there is little additional travel, but in the longer term it may result in additional capacity being designed as new markets are developed. In this case, the growth in long-distance travel is likely to be substantial.

All in all, similar to the findings on key drivers in chapter 2, there is still much uncertainty on the effect that the new ICTs will have on travel behaviour, and more research is needed to establish this with some degree of certainty.



5 TRANSPORT DEMAND RELATED INFORMATION OVERVIEW ON LONG-DISTANCE, RURAL AND URBAN TRAVEL

5.1 **OBJECTIVES**

The main objective of this component of COMPASS (WP 4, Tasks 4.2, 4.3 and 4.4) was to conduct a review of existing travel survey sources to establish current data availability/knowledge regarding long-distance, rural and urban travel.

More specifically the aims were to identify, collate and synthesise travel related data available in national and local (where appropriate) travel surveys across Europe, specifically to identify longdistance, rural and urban travel behaviours and trends. Whilst the focus of each task has been different, the methodology employed was broadly similar and outlined below.

The first step was to identify existing national, international and local travel surveys, and other relevant data sources². Once identified, a <u>meta-analytical typeqreview was performed</u>, and for each survey and data source a commentary provided on its availability, accessibility and cost (if applicable). Attention was given to disaggregating data by gender, socio-economic group, age and other key demographic trends. Finally, a summary of the key results of the identified surveys and data sources was prepared, providing a detailed overview of traveller behaviour, for example who travels, how often people travel, reasons for travel, specific barriers to travel.

A more detailed summary of the results obtained and a discussion of data quality and availability issues is provided in COMPASS D4.1 *Transport Demand Related Information Overview On Long-Distance, Rural and Urban Travel* (Carreno, Matthews, Schnell & Biosca, 2012), although, a summary of the main findings is presented here.

5.2 OVERVIEW OF DATA AVAILABILITY

The initial search of potential data identified a range of data sources related to individualsq travel behaviours and travel behaviour trends across Europe. These included National Travel Surveys, Eurostat repository data, data derived from European Commission statistical reports, UK national statistical reports, the Socialdata data repository, academic journal/report summaries, and data derived from non survey-based sources including Blue Badge Scheme holders, travel smartcards and personalised GPS tracking devices. Other potential data sources were identified (including use of online travel planning sites, border counts, ticketing sales, demand-responsive transport type services data, local and regional level travel surveys), although were not analysed due to accessibility issues:

- The data was not publically available;
- The data / data summary was not presented in English;
- > Access to the data was available at a cost not available within the project funds.

Apart from the issue of accessing data, where data was available, other issues include lack of continuity within surveys (specifically NTS data), compounded with changes in the survey instruments and methods used (e.g. question changes, different indicators used), inconsistencies with results published, which is due to how data is collected, which all prevent a comprehensive overview of travel behaviour and data trends to established.

5.3 NTS AVAILABILITY AND DATA ISSUES

Having identified the key sources of National Travel Survey data, the first main task was to assess the *±*vailabilityq of NTS data sources, based on the same considerations as for other potential data sources above:

- > Does the NTS contain variables relevant to the planned COMPASS analysis aims?
- > Is this information free of charge in report or online format and reported in English?

² This was achieved in an internal project milestone report. Carreno, M. (2012) Multidimensional overview: Travel survey metadata analysis.

Based on these considerations, and as indicated by the experience of similar project deliverables (e.g. in ORIGAMI, CLOSER and OPTIMISM), it became clear that only relatively few NTS¢ publish relevant analysis in ævailableqformats³. As such the analysis performed was limited to the main UK (UK NTS), Spanish (Mobilia Survey) and German (Mobility Panel Survey) NTS data, and to explore regional differences in travel behaviour includes relevant summaries of the German (Mobilität in Tabellen), Scottish (Scottish Household Survey) and Northern Irish (Northern Ireland Travel Survey) surveys.

For each of these surveys, the analysis has focussed on:

- Trip numbers, distance and main modes used;
- Segregated by:
 - Trip length (i.e. long distance / short distance);
 - Location level (i.e. regional, urban, rural);
 - Socio-demographic basis (i.e. specifically, age, gender, mobility-impairment and immigrant status);
- Data trends within the above factors.

A brief summary of the results obtained is included later in section 5.6 below.

5.4 NON-NTS SURVEY AVAILABILITY AND DATA ISSUES

Taking into account the wider issue of availability of data, in relation to European-wide travel behaviour data, only two main non-NTS data sources were identified:

- The Eurostat data repository: At a wider European level, the most comprehensive data source is the Eurostat database (http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/). However, the Eurostat database only provides summary annual modal share data related to three transport mode classifications, namely; passenger car, train, and motor coach/bus/trolley bus, which restricted a complete overview of modal share across Europe.
- European Commission summary data reports: In addition to Eurostat data, the European Commission publishes annual transport-related summary data. However, these too only present one measure (passengers per kilometre (PKM), which by its nature relates more to numbers of people using different transport modes.

A summary of the main modal share results is presented below, with greater detail provided in COMPASS D4.1, Transport Demand Related Information Overview On Long-Distance, Rural and Urban Travel.

In relation to non-NTS regional level data, no available (i.e. free of charge and in English) data sources were identified. This is likely to be due to two main factors:

- As most EU countries conduct NTS in various forms, regional travel data is derived via these existing sources, which negates the need for any further regional data collection;
- For those EU countries that do conduct regional based surveys (e.g. Austria and Finland), results of these surveys are not published in English and would entail translation costs to access this data.

Based on this restriction in accessibility, only three accessible regional surveys were identified: the German Mobilität in Tabellen; the Scottish Household Survey (SHS); and The Travel Survey for Northern Ireland. However, as these surveys are in the strictest sense NTS¢, they were analysed alongside the main NTS surveys.

Similarly, for local level travel data (urban and rural) a search was conducted to identify available data sources. However, based on COMPASS partnersqprior knowledge, and a further initial search for

³ Summaries of the Spanish and German NTS¢ were provided after translation on summary reports by COMPASS project partners.



data sources, it was concluded that whilst many local authorities across Europe do conduct local travel surveys, several issues were identified regarding accessibility to this data:

- Most cities/local municipalities (apart from the UK) do not publish the results of these surveys in English, and would thus entail translation costs to access this data;
- Some survey results are not published (at a public level) at all;
- Often these surveys are conducted on an ad hoc basis, and the latest survey data is out-of-date (including Socialdata results - below).

Therefore, and purely for illustrative purposes, a brief summary of modal share data collected by Socialdata in a selection of European cities was analysed.

Neither the Eurostat repository nor the European Commission reports disaggregate available data according to socio-demographic factor levels, so to supplement the NTS socio-demographic analysis (see earlier) a summary of published papers/reports was provided for each key socio-demographic factor.

5.5 NON-SURVEY DATA AVAILABILITY AND DATA ISSUES

To complement ±raditionalq survey data sources, a range of non-survey data sources were also sought. These included transport services patronage data, demand responsive scheme patronage data, travel smartcard data, concessionary travel card data, Blue Badge data, GPS data collection, border counts, transport ticket sales data. However, in line with the conclusions of CLOSER (2012) for most of these data types, data was found to be inaccessible, due again to a combination of cost issues (i.e. would need to be purchased), or data not being published in English.

Based on these restrictions, it was only feasible to analyse four main types of data:

- Transport services patronage data;
- Blue Badge scheme data;
- Smart travel card data;
- ➢ GPS data.

In relation to patronage data, the analysis was therefore limited to UK light rail and tram data, EU level maritime (including the Channel Tunnel) and air data. Further, the main limitation regarding patronage data concerns its basic nature, in that it provides only passenger numbers, and not other aspects such as trip purpose and passenger characteristics, which restricted further insight into transport behaviour.

In relation to Blue Badge data, whilst it does not allow much insight into the travel behaviour of individual card holders, it does provide an insight into trends in card numbers, thus the number of mobility-impaired car drivers across Europe. However, due to limitations in accessing data the analysis was limited to data from the UK and Belgium.

For travel smartcard data, there does appear to be a consensus that this data source does have real potential to address some of the issues with traditional survey data (i.e. improve accuracy of reported trips etc.). However, only a few real-life studies were identified, and as such did not allow any real insight into individuals' travel behaviours across Europe.

Similarly, in relation to GPS data collection, a few studies were identified, which highlighted the potential of GPS to complement /validate traditional travel survey data sources, although, as above, only a few real life application studies were identified, which limited any conclusions to be drawn related to actual travel behaviour.

5.6 CONCLUSIONS

Despite the limitations outlined in this report, some tentative conclusions can be made regarding individualsqtravel behaviours across Europe, as described below


1) General travel behaviour varies considerably between European countries, as well as at a regional and local level (e.g. urban / rural) in terms of the number of trips made, distance travelled and modes used. Specifically:

In relation to general travel data, the main observations are:

- People in Spain (946 trips) and the UK (960) make considerably fewer trips per year, compared to people living in Germany (1,245);
- Correspondingly, people in the UK travel considerably less (10,824 km) than people living in Germany (14,929 km);
- In the UK (78%) and to a lesser extent Germany (52.9%) the majority of trips made were by private car, whereas in Spain walking/cycling was the dominant travel mode (43.2%)

At a regional level, the main observation is:

Trip rates (Spanish and UK NTS data) and distance travelled (only available from UK NTS data) both vary considerably by region. For example, in relation to the UK, the UK average trip rate was 960, average distance travelled 6,726 miles and trip length 7 miles, whereas the numbers in Northern Ireland were 894 trips, 5,888 miles and 6.6 miles, respectively.

At a local level, the main observations are:

- People living in urban areas make more trips than people living in rural areas (German and UK NTS data);
- Correspondingly, people living in larger settlements make more trips than those living in smaller settlements (German, Spanish and UK data);
- Similarly, distance travelled varied according to region, although people living in rural areas travelled a greater distance by car and public transport than those living in urban areas (German and UK NTS data).

In relation to long-distance travel the main observations are:

- > The number of trips made varies on a seasonal basis (Spanish NTS data);
- The vast majority of long-distance trips are made by private car (German, Spanish and UK data)
- People living in large settlements make a larger number of long-distance trips, compared to those living in smaller settlements (Spanish and UK NTS data).
- 2) Travel behaviour varies according to several key socio-demographic factors. Specifically:
 - Males make more trips than females in some countries (German and Spanish NTS data), whereas in the UK females make more trips than men;
 - Older people (aged 60 years and older) make fewer trips than younger people (German, Spanish and UK NTS data);
 - People with mobility-impairments make fewer trips compared to the general population older people with mobility-impairments making the fewest trips (UK NTS data;
 - Native born citizens make more trips than non-native born people (Spanish NTS data), although, differences in ethnic background may be linked to where ethnic groups live (i.e. urban or rural areas. UK NTS data.

However, these key socio-demographic factors are often interrelated in determining travel behaviour, and also interact with other socio-demographic factors (e.g. income, household type, home location) not covered in this deliverable.



- 3) Transport use trends
 - The private car remains the dominant transport mode in the vast majority of European countries for both short and long-distance trips, and in the majority of countries the modal share for cars continues to grow.
 - Given these high levels of car dependency in most EU countries, the modal share for other transport modes is considerable lower, and echo the trends in car use, from 1995 to 2010, at an EU level:
 - **Bus/coaches**: A 1.5% decrease in modal share;
 - **Rail:** A 0.3% decrease in modal share;
 - **Ferry**: A 0.2% decrease in modal share.
 - In contrast (similar to car use) for some modes an increase in modal share is observed, namely:
 - **Air**: A 1.7% increase in modal share;
 - **Tram/metro**: A 0.1% increase in modal share.
 - However, like private car modal share, modal share (and trends) for other modes varies between countries, and often at a regional and local level.
 - Based solely on the UK light rail and tram data analysis, the only observation that can be made is that overall there does appear a trend for increased use (as with PKM trend data), although this varies on a regional basis and is dependent on the type of system;
 - In relation to maritime data, a more comprehensive European level overview is available. The main conclusions that can be made are:
 - Overall, at an EU level, passenger numbers (both for cruise and non-cruise trips) are decreasing, although in a few countries an opposite trend was observed.
 - Related to the above, at a port level, both decreases and increases in passenger numbers are observed.
 - With the exception of the UK, more detailed patronage data in unavailable (i.e. not published in English).
 - In relation to air travel (which is linked to NTS long-distance earlier), as with maritime data, a more comprehensive European level overview of data is available. The main conclusions that can be drawn are:
 - Air patronage numbers vary considerably across EU country, although this is linked to country population size and whether the country is a tourist destination or not, air-routes available, and also according to individual airports.
 - With the exception of the UK, for all EU countries where data is available, air passenger numbers have shown an increase since 2005.
 - Based solely on data from the UK and Belgium, the number of Blue Badge card holders was observed to be constantly increasing up to 2011, which is likely to be reflective of wider demographic trends across Europe (i.e. more older/mobility-impaired people).

5.7 **RECOMMENDATIONS**

To conclude, whilst a range of both traditional and non-traditional data sources have been summarised in this report, a similar range of other potential data sources were also identified, although could not be included due to their inaccessibility. Accordingly, it was not possible to provide a full summary of individualsqtransport behaviour and travel patterns across Europe, and for this knowledge to be obtained, there are three key requirements, namely:

Data needs to be harmonised at an EU country level, and for each transport mode. In relation to NTS\$, harmonisation of data collection is currently been investigated in the OPTIMISM Project (http://www.optimismtransport.eu/), although, despite been recognised as a limitation in their data by Eurostat and the European Commission, as yet this issue has not been addressed.



- Data needs to be made more accessible at an EU country level. As demonstrated by the analysis in COMPASS, whilst potentially key data sources were identified, they could not be included due to restrictions in their availability, i.e. data is typically published only in individual countriesquative language or not in the public domain at all. This is perhaps best demonstrated by NTSs, where only a few accessible data summaries were identified here.
- Data needs to cover all individual transport modes. Again, as illustrated by this analysis where data is available, such as with patronage data by Eurostat or PKM data by the European Commission, not all transport modes are included. This prevents a more holistic view of overall travel patterns and transport behaviour.

In addition, despite their potential usefulness, there have been only a few studies to date that have used smartcard data to examine individualsqtravel behaviour, and more studies are needed to validate the initial findings. Similarly, In relation to GPS data collection, despite its usefulness to enhance, in terms of accuracy, traditional data sources there have been only a limited number of \pm eal lifeq applications, and the majority of these studies have been conducted in the USA, and focussed solely on car trips. As such there remains a need for more European-based GPS studies, which include other non-car modes to fully appreciate the potential of GPS to facilitate travel behaviour data collection.

6 THE ROLE OF ICT IN TRAVEL DATA COLLECTION

6.1 **OBJECTIVES**

Data representing travel behaviour is needed because it represents the citizence current travel pattern. More importantly, it is necessary to forecast the future travel demand with models so that the decision making in transport policy, especially investments into the infrastructure, can be made more rationally. Travel surveys, in the form of national travel surveys or household travel surveys, have been carried out in some of European countries, while other countries have never conducted such surveys on a nationwide level.

In a Europe where more and more cross-border travel is undertaken, and where various mobile ICTbased devices are taken up by more and more of the population, two important themes arise. One is how to harmonise various national travel surveys throughout Europe, and the other is how best to exploit the potential given by ICT for new data collection. The OPTIMISM project, with which COMPASS has collaborated closely, focussed on the issues around harmonisation, while COMPASS focussed on the issues around ICTs.

The main objectives are set to reveal the following three dimensions of the relationships between the key elements of the travel surveys and its data usages.

- Forecast method to indicator: which indicators are needed by which travel demand forecast method?
- > User/stakeholder to indicator: which information/indicator is needed by which stakeholder?
- Indicator and data collection method: what types of method with/without ICTs can be best used to collect the data for each indicator?

In this section, research outcomes from Tasks 4.1 and 4.5, which dealt with these issues, are summarised.

During the course of research, the indicators used in the nine main travel demand forecasting methods (models) that are used in Europe were reviewed, and 208 indicators used to assess the future travel demand at a strategic level were identified. Among them, 23 indicators are identified as travel survey indicators. Then a web-based survey to stakeholders asking for their subjective evaluation of importance of these 23 indicators was carried out. An overview of EU legislation on transport-relevant data collection and a summary of the travel survey indicators that are studied or recommended by other research projects were reviewed as well as the data collection carried out by transport operators, namely rail, coach, air, road and urban public transport. Then, an extensive review of state-of-the-art ICT technologies that are or will be deployed in the transport sector was made, mainly focussing on GPS/GNSS-based travel surveys, mobile device localisation, and camera and sensor technologies.

This research straightforwardly corresponds to the aforementioned three key relationships, while other important aspects related to ICT-based travel survey were reviewed additionally. The main focus here was on data and privacy protection. Other important aspects that have to be considered for ICT-based travel surveys such as hard-to-reach population and data collection costs were also briefly reviewed.

6.2 GENERAL OUTLOOK AND ADVANTAGES AND DISADVANTAGES OF ICT IN TRAVEL SURVEYS

A synthesis of the information and data collected throughout this research is the main outcome from this part of the project. This synthesis was presented in the form of a long list of indicators subdivided by groups, with information about interests by different stakeholders (six stakeholder groups), current data collection status (widely collected, only in some countries, future potential), data collection intervals (current, desired), and data collection methodology (current, potential with ICT). Due to the limitation of the space, it is not possible to include the full list of the 130 indicators here, while the readers who are interested in this are referred to Table 8-1 in Deliverable 4.2, *The Role of ICT in Travel Data Collection*.



Overall, ICT technologies are still not yet widely used for travel surveys at the time of this research, although a number of experimental ICT-based travel surveys have been carried out in different countries including non-European countries. It is fairly likely that this tendency continues as the development goes on, and as other necessary components for ICT-based travel surveys such as a POI database (point of interest database) on a GIS system become more widespread in the near future. In the timeline at the focus of the COMPASS project, by the year 2020, it is thus reasonable to foresee that the ICT technologies will become widely deployable for travel surveys.

ICT-based surveys have several advantages such as low costs to carry out surveys, quick postprocessing and imputation, and affinity to survey harmonisation, while it has several disadvantages including ICT-specific hard-to-reach population, such as the elderly, and comparability to past surveys. Some difficulties that the ICT-based methods inherit such as data and privacy protection and cyber security have to be addressed through design and engineering processes. There is a general tendency that basic travel survey indicators can be collected automatically with ICT-based measures or can be entered by the survey respondents through touch-panel PDAs or smartphones.

The disadvantages of questionnaire-based surveys without such sophisticated ICT-based methods mirror the advantages of the ICT-based survey methods, namely high costs to carry out surveys, time-consuming post-processing process, as well as relatively less affinity to survey harmonisation, while the advantage of such questionnaire-based surveys is the reflection of the disadvantages of the ICT-based methods, although issues about the hard-to-reach population as well as comparability still remain.

The data collected by transport operators has to be better used within the context of travel surveys. Two large disadvantages of the operator-collected data, however, are that the data does not necessarily include the feeder transport (for example, access/egress on foot to/from railway stations), and that it does not cover the non-motorised transport modes which covers a significant modal share. The latter is fairly important as in many cities the non-motorised transport modes tend to have around 25% to 30% share of entire trips made within urban areas. Administrative data such as statistics of demography can also play a similar role, especially for the data illustrating characteristics of respondents. Overall, the operator-collected data and administrative data will potentially enrich the travel survey data as well as validate it, while travel surveys cannot be complete only with them.

6.3 RECOMMENDATIONS ON COMBINATION OF ICTS AND CLASSICAL METHODS

Considering these advantages and disadvantages, as well as the desired data collection interval of each indicator presented in Deliverable 4.2, it is recommended for the ICT-based surveys to collect basic travel behaviour indicators frequently, such as annually, while the questionnaire-based surveys that are designed to collect more in-depth travel behaviour indicators should be conducted less frequently. ICT-based surveys may not reach all of the different social groups; however, the frequency of the data collection has a great value so that the travel trend can be captured more often. In addition, if financial and human resources permit, ICT-based travel surveys can be carried out more frequently to enrich the travel survey database; for example, if this is carried out four times a year (quarterly), the seasonal fluctuation of the trips, which turned out to be desired by some stakeholders, can be identified. Although the indicators that can be collected with the ICT-based technique are limited, they tend to be the most basic indicators to describe travel behaviour (the aforementioned full list of the indicators will serve as a guideline to identify the indicators to be collected through this type of survey).

The questionnaire-based survey can employ the paper-and-pencil method and telephone-based method (CATI: computer-assisted telephone interview) as well as web-based surveys to cover a wider range of population compared to the ICT-based method, asking more in-depth data that cannot be measured or detected by ICT-based devices. These three media for questionnaires can be combined so that the survey respondents are able to choose the most preferred method to answer. It is likely that this costs " 50 to 60 per respondent. It is probably not feasible both in terms of financial and human resources to conduct this type of survey every year targeting a large population, and it is more reasonable to conduct this type of survey for instance every five years, while the aforementioned ICT-based survey can fulfil the basic needs for the travel behaviour information. This extended survey is an opportunity to collect the detailed indicators, such as respondentsqand householdsqcharacteristics, long-distance travel and second house, and subjective evaluations.



6.4 **RECOMMENDATIONS ON ORGANISATION OF DATA COLLECTION**

When it comes to the organisation of the data collection, it depends at the moment on the interest of different user groups . governmental institutions carry out their travel surveys, while there are some ad-hoc surveys by stakeholders such as researchers, and transport operators collect their own data. It is likely that most of the indicators collected are of interest to various stakeholder groups, though the extent of the interest may vary. Therefore it will be reasonable to conduct a single survey together rather than various surveys carried out independently by various stakeholders. In addition to this, the transport operators are fairly eager to collect data for their operational and customer satisfaction improvements; furthermore, their data collection is sometimes required by regulations for statistics or for security, and thus it appears that they have much know-how for the data collection from daily transport operation. On the other hand, researchers, modellers as well as statistical agencies have accumulated much know-how about travel surveys among the citizens. Operators are able to utilise such publicly-collected data. while researchers, modellers, statistical agencies and so on can benefit from the data collected by the operators.

In light of this, it is recommended that an association specialised in travel surveys, consisting of various stakeholders such as ministries, local governments departments, transport operators, infrastructure operators, other practitioners such as consultants, modellers as well as researchers, is formed to carry out a united travel survey reflecting the various needs for travel behaviour data. In addition to them, device manufacturers can also be a part of the association, if necessary to employ ICT-based methods.

Such association will enable on one hand the operators to obtain the data that is needed for their strategic decision-making on their business in a more transparent manner while on the other hand the authorities and other stakeholders, including modellers and researchers, can enrich their database with the data fed by the operators. It should not restrict the data collection by each stakeholder on their own; however, such common platform for database and knowledgebase of travel behaviour has a significant value in that it enriches the data availability for the various stakeholders. In addition, such specialised association would also contribute to harmonisation of travel surveys. As harmonisation is not the main focus of the COMPASS project (if interested, please refer to deliverables from the OPTIMISM project), this is not elaborated in detail here, while it has to be pointed out that standardisation of the usage of ICT-based method as well as the collection methodologies of indicators through such specialised organisation would make it easy to handle the data from different parts of Europe in a harmonised manner. Such association would also have a value in terms of the survey cost, since there would be an economy of scale in the light of the fixed costs independent of the survey sample size.

Such % cansport data collection associations+ could be formed at different levels and scopes such as regional level and Europe-wide level that are responsible for its respective coverage. They would be able to cooperate vertically through a clear role-sharing so that the local-level association would be able to concentrate on short-distance trips and other modules about characteristics of respondents, vehicle possession as well as subjective evaluations of survey respondents within the region covered by the association, and the EU-wide and nationwide transport data collection associations would be able to concentrate on long-distance trips, while all bodies would exchange data between them. Both levels could utilise the data that can be provided from operators.

It has to be mentioned that the **%e**gional+travel data collection association does not mean domestic within a country: it is rather desirable to reflect actual travel behaviours among the citizens and thus it does not have to be limited within a nation. For example, some European regions such as Vienna-Bratislava-Sopron (Austria, Slovakia, and Hungary) or Copenhagen-Malmo (Denmark and Sweden) host much short-distance international trips and thus such association should operate across borders. With regard to the coverage by the regional association, the area of public transport associations (for example, Passenger Transport Executive in UK or *Verkehrsverbünde* in Germany, Switzerland and Austria) will probably be an optimal reference as it often reflects the area of actual local travel.

Concerning an EU-wide as well as nationwide associations, research within COMPASS as well as other research projects such as the ORIGAMI project highlights that there is a serious lack of data covering long-distance travel behaviour. EU-wide and nationwide travel data collection associations would be able to collect such long-distance travel data needed by various stakeholders. It is also to be particularly noted that the European countries that are not Member States of the EU such as



Switzerland, Norway, and Iceland have to be also integrated into such a survey and database platform, as the passenger movement of long-distance travel within Europe is not limited to EU Member States.

When it comes to the question which stakeholders should contribute to the survey cost, the travel survey association will enable such co-financing easily. The different interests by different user groups can be used as a guideline to determine the share of the cost to be covered by each group.

6.5 DATA AND PRIVACY PROTECTION AND CYBER SECURITY

Careful attention has to be paid to the data and privacy protection so that the travel surveys do not act against the European as well as national regulations with regard to this. At the moment, data and privacy protection laws vary slightly among European countries. In addition, particular attention has to be paid to the risk associated with cyber security issues to assure that the collected data will not be damaged by any sort of attacks as well as to protect the survey respondents from phishing scams.

As these require fairly sophisticated expertise on respective issues, the aforementioned transport data collection associations are advantageous in that they are able to employ specialised personnel so that the security and reliability as well as the transparency of travel surveys can be assured.

6.6 SUMMARY OF RECOMMENDATIONS

Summarising the findings as well as the discussion during the course of the research, the following list contains recommendations for conducting travel surveys as well as some research and development activities for the coming years.

- As more ICT-based methods will probably be available in the future, deployment of such techniques in the travel survey has to be sought. Further research and developments are needed to overcome barriers to employ ICTs in travel surveys. Deployment of ICTs can potentially make it possible to carry out travel surveys more frequently at lower costs.
- Among various ICT-based potential methodologies, as more internet-enabled consumer mobile devices, including smartphones, are expected to penetrate into the population, possibilities for cloud sourced ICT-based travel surveys using them need to be explored.
- As mobile device localisation techniques such as the Wi-Fi fingerprinting technique are foreseen to be developed and to spread in the next decade, combinations of GNSS (Global Navigation Satellite System: GPS is one of them) and such localisation techniques have to be investigated.
- Internet-enabled mobile devices including smartphones as well as any other web-based travel survey applications will be especially effective when they derive necessary geographical data from online databases. Such online GIS (geographic information system) will have to be made available. It will be desirable that such online GIS is provided in a harmonised manner throughout Europe.
- Public transport smartcards will also be able to provide mode-specific location data; thus integration of such smartcard logs to the travel survey data, if travel survey respondents permit, will have to be sought. If each card's data can be combined with the card owner's surveyed data, it will potentially be advantageous in that it provides accurate information about the travel mode as the mode imputation of public transport faces difficulties in terms of accuracy.
- Data mining by using administrative data as well as operator-collected data needs to be sought in the near future to realise an alternative cost-saving data collection to the travel survey. This will also potentially enrich the data about travel behaviour.
- ICT-based travel surveys to collect the basic travel behaviour indicators can potentially be carried out annually, or if budget permitting, more frequently. This will increase the data availability about travel behaviour.
- However, it is unlikely that such alternative methods are able to derive information about some important aspects such as non-motorised transport users, subjective evaluations, and the data about non-mobile population. Therefore, to fulfil the data needs by various important stakeholders such as policymakers, planners, and researchers, traditional travel surveys are still needed in the future.



- Furthermore, ICT-based methods will be inferior to the classical methods in terms of representativeness. There will be a potential trade-off between representativeness that is guaranteed more by the classical methods and frequency as well as reduced survey cost that will be realised by ICT-based methods. Therefore, combined employment of both ICT-based and classical survey methods to overcome this trade-off will have to be sought.
- Extended household travel surveys using the classical methods such as paper-and-pencil diary for more detailed data collection can potentially be carried out every five years.
- As there are different needs for detailed data analysis, surveyed data has to be stored and provided in a way that allows various ways of aggregation such as only for peak-hours, young generation, and so on.
- Privacy and data protection measures have to be fully implemented, especially when ICT-based travel surveys are carried out. Needless to add, all the travel surveys have to respect the data and privacy protection legislation. Travel surveys have to be designed so that, for example, the respondents can opt out the collection of PII (personally identifiable information) and they can retain the right to access to the data collected through travel surveys.
- In addition, in order to make the survey more reliable and to address the cyber security issues, measures such as data encryption for storage and transaction, and the strict data usage control as well as data anonymisation at the data collector side have to be implemented. The surveyors also have to be aware of any security holes of the server platforms such as on operating systems and programming platforms that could lead to cyber security problems.
- Finally, as various stakeholders tend to be interested in similar sets of indicators although the level of their interest are not necessarily same, in terms of data collection organisation, it is recommended that a specialised % bavel data collection association+comprising of the operators, authorities, practitioners, modellers, researchers is formed as an expert organisation that carries out travel behaviour data collection. This will eliminate the duality of data collection activities among the various stakeholders, while it will increase the data availability at one-stop. This will also reduce the survey respondentsq burden as similar surveys are not repeated by different organisations.



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

7.1 AIM OF THE HANDBOOK

One of the aims of the research undertaken in the COMPASS project is to recommend 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. 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 as a paper edition and online internet consultation at <u>http://www.fp7-compass.eu/</u>.

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

- 1) **Transportation management systems**, helping to plan and run 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 operation, as well as Vehicle- to-Vehicle (V2V) and Vehicle- to- infrastructure (V2I) communications;
- 5) **Demand-responsive transport (DRT) and shared mobility systems**, which include transport solutions enabled by ICT solutions to set up innovative transport services adjusted to demand.

Important enabling applications are represented by smart ticketing options combining tariff information of several transport modes (smartcards) and traveller information systems, informing transport users on timetables and travel time (multimodal traveller information systems). In particular, it must be stressed that in this latter category, the real-time co-modal traveller information systems are deemed to be the most promising ICT applications, to the extent that they can take into account of the dynamic context-related event, e.g. delays, traffic interruptions, etc., updating the travel planner and favouring seamless journeys.

The solutions in each of these categories that are contained within the Handbook are described in the following sections.

7.2 **TRANSPORTATION MANAGEMENT SYSTEMS**

7.2.1 Urban Transport Management

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 distributed 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).



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 major software functions.

Signal priority for bus and tram

This application is aimed at improving public transport by providing priority for buses and trams at signalised intersections through green lights. Signal priority 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, priority improvements can also reduce accidents and driver stress.

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 major disruptions occur in a public transport network, such disruptions lead to severe impacts on the timetable. The three mayor tasks in disruption management are timetable adjustment, rolling stock rescheduling and crew rescheduling (e.g. allocation of drivers).

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 prejourney (at bus stop, web, via SMS) and during the journey (in the vehicle).

7.2.2 Road Transport Management

Variable speed limits (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.

Smart lanes on hard shoulders

Temporary shoulder use is a congestion management strategy typically deployed in conjunction with speed harmonisation 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 flow breakdown.

Ramp metering

Ramp metering allows control of the flow of traffic entering 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 motorwaysqcapacity, even during rush hours and in case of incidents.



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.

Variable congestion charging systems

A road charge can be defined as a special fee that is paid by vehicles for entrance into a specific area. The level of the fee is usually dependent on the number of entries made by the vehicle into the area or time spent there, or according to vehicle type. Electronic road-pricing systems provide a targeted solution for congestion pricing by allowing the authorities to pin-point specific congested spots and vary the 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.

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.

Congestion monitoring based on probe vehicles and smartphones

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 than any other source. Real-time views of congestion on the road network is being provided by Google Maps since 2013 based information from Android phones travelling along the network.

Travel data collection based on twitter

Geolocated tweets have been used to find the most frequently travelled routes in selected US and European cities. This sort of data could be used to optimise transport systems. If the volume of geotagged 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.

Average speed checks for speed limit enforcement

In order to reduce the road accident rate, the Italian motorway infrastructure manager developed Tutor, a speed detector system based on a check ‰n road section+rather than a check ‰n time+. 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 the average speed between both sections and in case of maximum speed exceeded, enforcement procedures are activated.

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.



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 systems are capable of detecting incidents happening around the coverage area and help to prevent secondary accidents in favourable cases.

Vehicles miles travelled pricing

In a pay-per-use road pricing program, a meter is placed on the dashboard of cars, showing 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 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.

Vehicles miles travelled insurances

Vehicles miles travelled insurance 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 used by Jason Bordoff and Pascal Noel in their Brookings Institute paper is that of an allyou-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 regarded to be as absurd as paying a flat rate for petrol and filling up whenever you need to.

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.

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 smartphone apps for reporting the real-time traffic conditions and road infrastructure status such as congestion, roadworks, abandoned vehicles and potholes. Many local authorities have also developed smartphone 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.

7.2.3 Railway Traffic Management

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 on-going, 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.



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 ±rgent earthquake detection and alarm systemq (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.

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 <u>in</u>-cabqtrain 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.

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 communication 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.

7.2.4 Air Transport Management

SESAR (Single European Sky ATM Research)

In contrast 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 Europeas skies.

Enable air routes as the crow flies

Recent studies have demonstrated that air routes in Europe are not optimally designed. In 2009 a flight¢ 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, emissions and high costs to the industry. Since March 2011, 142 new direct routes are available in the airspace controlled by MUAC (Maastrich Upper Area Control Centre). These new direct routes will substantially contribute to reduced flight and engine running time, fuel consumption, gas emissions and costs in high-density European airspace. This development is the first step in the implementation of the Free Route Airspace Maastricht (FRAM) programme.

Accurate weather information for air navigation

Next Generation (NextGen) Network Enabled Weather (NNEW) is a project to develop a fourdimension (all points, lateral, vertical and time dimensions) weather data cube (4-D Wx Data Cube) from disparate contributors and locations. 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.



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 %dutter.+ 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 aircraft 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 skies

Airplane surface movement guidance and control system at airports (A-SMGCS)

Proper management of existing airside infrastructure at airports is key to optimising airport capacity, particularly in adverse weather conditions. 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. Operations on the airport airside are managed today manually+. A considerable amount of research effort is concentrated on the development of advanced surface movement guidance and control systems (A-SMGCS).

Radio frequency luggage identification at airports (RFID)

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. This can relate 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.

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 smartphone 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 smartphone over the electronic tag, and the app is then held over the electronic bag tag.

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: known travellerqlane, formalq lane, and fenhanced security 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.

7.2.5 Maritime Transport Management

Inland automatic identification system (AIS)

AIS stands for % automatic identification system+and enables identification of 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 % 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.

SERTICA

SERTICA is a widespread distributed computer system that supports shipts 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 mear-misses+, as a warning to all other ships of the fleet, as well as mon-conformities+.

7.3 **TRAVELLER INFORMATION SYSTEMS**

7.3.1 Passenger Orientation and Guidance

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.

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.

Bluetooth based queuing estimated time at transport terminals

This system automatically measures and displays the waiting time of queuing passengers in lines. Air 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 sales at train stations.

Augmented reality smartphone apps to locate closest public transport station

Augmented reality refers to the overlaying of geo-information data onto the <u>seal</u> worldqview, 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, overlaying guidance elements indicating closest stations and stops above the images of the streets taken from the smartphone camera.

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 vehicles 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.

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 communicated out to drivers via a variety of channels, permitting an optimisation of existing parking spaces.

Parking guidance for bicycles

An automatic bicycle parking detection system 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: 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.

7.3.2 Co-modal Travel Planners

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).

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.

Interurban traveller information system on personal computers (web based)

City-to-city traveller information systems on personal computers are software solutions for longdistance 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 *%*outeRANK+or *%*-U-Spirit+. These two examples are representing different approaches: the former being an integrative system, the latter a compilation of already existing information systems.

Route planners for bicycles

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.

7.3.3 Real-time Service Information Systems

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.



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.

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 increases user satisfaction. This information is very important especially when the passengers have any transfer during their trips, especially when the transfer times are very short.

Real-time public transport information based on social media

Twitter usage among public transport travellers is growing rapidly, with a flow of information that circulates between operators and passengers, and between the passengers of public transport themselves. 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.

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.

Vehicle tracking applications

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

7.3.4 Real-time Service Information Systems

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 Triplt. 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 Triplt 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 a flight.

Informed seat choice applications for airplanes

SeatGuru is an application for smartphones 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.

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 passengersq profile details and where there might be matches, allocating seats together.

Smartphone taxi apps

Smartphone 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.

7.4 SMART TICKETING AND TOLLING

7.4.1 Electronic Toll Collection (ETC)

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 quickly and easily. The intention is to have a unique payment system throughout Europe (whether it is a BroBizz, an AutoPASS or an AutoBizz).

National highways free-flow payment

There are many types of free-flow systems for 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 longer required to stop at plazas, but rather to pass through reserved lanes for automatic electronic payment (RFID traditional systems by OBUs), so that they simply continue their trip on the road.

Semi-automated payment at highways toll plazas

Electronic toll collection (ETC) systems were introduced in order to tackle the issue of increasing **%**Il gate congestion+. 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, for whom a manual payment option is still required.

7.4.2 Access Management

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. 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.

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 space; 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.



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¢ 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.

Biometric personal access control

Biometric personal access control means a method of identifying or verifying an individuals identity based on measurement of physical features or repeatable actions, which are unique to that individual. Biometrics can be used to % werify + or % dentify + a specific individual: verification (also called authentication) refers to the problem of confirming or denying a persons claimed identity, whereas identification refers to the problem of establishing or authenticating a subjects specific identity.

7.4.3 Automated Fare Collection Systems (AFC) - Ticketing Systems

Public transport smartcards

Smartcard 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 smartcard contains an embedded integrated circuit chip capable of storing information for identification, authentication, data storage and application processing. Most modern smartcards, 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 smartcards are London's Oyster card or ParisqNavigo.

SMS boarding passes

A mobile boarding pass refers to the delivery of an airline boarding pass direct to the passenger 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 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.

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.

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 systems are 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.



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 Syntigoqs AirRail system, Amadeusqs Global Rail Sales Platform and AccesRailqs Rail & Fly.

7.5 SMART VEHICLES AND INFRASTRUCTURE

7.5.1 Autonomous Driver Assistance Systems

Head-up display (HUD)

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. Other 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.

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 m. NIR systems use a light source with a wavelength of approximately 0.8 m 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 natural scene representation in the picture.

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. The system 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 driver**s** sleepiness from the images taken by in-vehicle cameras, based on the fact that the occurrence of sleepiness is reflected through the driver**s** face appearance and head/eyes activity.

Automatic car parking

Automatic parking uses computer processors which are tied to a number of sensors and imagerecognition technologies to enable the car to manoeuvre autonomously from a traffic lane into a parking space. 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.

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.

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 with the help of sensors. Nearly 46% of bus accidents across the United States each year occur on the left or right side of the bus.

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 whether the object is a pedestrian, a cyclist, a motorbike or anything else. Then, this system monitors the movement of the detected object and alerts the driver.

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 vehicles turn signal is not used to indicate the intention of lane change or departure, but nevertheless the vehicle is about to leave its lane.

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.

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 to 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.

Autonomous vehicles

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 become 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.

7.5.2 Cooperative Vehicle- to-Vehicle (V2V) Applications

Vehicular ad-hoc network

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 and



static road side units (RSUs). VANET¢ 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 within 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 expected that the first systems to fully integrate this technology will be police and fire vehicles to communicate with each other for safety purposes.

Enhanced driver awareness system

Enhanced driver awareness (EDA) is a cooperative safety application designed to keep the driver aware about their 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.

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 has been tested in a suburban area of Tokyo, in the prefecture of Saitama, Japan. The application is accessible via web browsers on PCs and smartphones.

Automatically driven car trains (SARTRE)

A car train consists of a manually driven lead vehcile, 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 avoidance, adaptive cruise control, lane departure warning and brake control systems to allow autonomous driving. 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.

7.5.3 Vehicle-to-infrastructure (V2I) Applications

Personal rapid transit (PODCars)

Personal rapid transit (PRT) is a form of public transport that uses small automated electric podcarsq 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 at Masdar City (United Arab Emirates).

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. A passive ISA warns the driver when the speed limit has been exceeded.

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 vehicles 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.

Weather detection by vehicles

Conventional weather monitoring with roadside and in-road sensors is 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.

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 also be generated manually by the occupants of the vehicle.

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 (from a driver perspective). On-board recorded vehicle data is transmitted in 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 and real-time assistance for drivers in rerouting to evade accidents and travel delays.

7.6 SHARED MOBILITY AND DEMAND-RESPONSIVE TRANSPORT

7.6.1 Public Transport Services in Low Demand Situations

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 have increasingly faced very strict budgetary pressures to deliver public passenger transport with reduced budgets, forcing the move towards route optimisation systems.

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 basedq 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.

7.6.2 Shared Mobility

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.

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 in 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 smartphone 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.

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 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.

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 include a planning function in which drivers and potential passengers are brought together. It is different from car sharing mainly in the fact that the latter typically provide access to vehicles alone, while in car pooling the driver and passengers share the ride.

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.

Shared car parking - WeSmartPark

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 in equal parts between the company and the owner of the car park.

7.7 STAKEHOLDER INTEREST IN KEY SOLUTIONS

During the final COMPASS conference the stakeholders present were asked to rank five solution families in order of their priority. These were:

- 1) <u>Variable road fees based on travel behaviour</u> rather than fixed toll fees: road fees depend on type of roads used, time of the day, vehicle occupancy, type of vehicleõ
- 2) <u>Smart road traffic management based on vehicle to vehicle and vehicle to infrastructure</u> <u>communications</u> (e.g. variable speed limits, congestion conditions included on GPS routing, accident warnings)
- 3) <u>Car sharing solutions</u> (e.g. car pooling platforms, car clubs, shared community vehicles in rural areas...)
- <u>Collaborative peer to peer applications</u> based on smart phones allowing increasing collaboration among public transport users (e.g. public transport disruptions warned via Twitterõ)



5) <u>Faster airport formalities</u> allowing passengers to arrive at airports 15 minutes before flight departure (e.g. self service check in, luggage drop, security controls, boarding)

Figure 7-1 shows that all of them were considered important, but that highest priority was given to smart road traffic management, with 64 % giving the very high or high priority. Variable road fees and car pooling / car sharing solutions were given the same average level of priority with 50% respectively 52% of respondents giving them very high or high priority. It was however interesting to note that variable road fees were given top priority by even more respondents than traffic management. Faster airport formalities were given the lowest priority, with only one respondent seeing them a top priority, while nearly 40% saw them as having very low priority.



Figure 7-1 Stakeholder interest in COMPASS solutions

7.8 **BUSINESS MODELS**

7.8.1 Overview of Business Models in COMPASS

The objective of this section is to illustrate the Business Models (BM) of the ICT applications which best contribute to the objectives of the COMPASS project of seamless co-modality for CO2 emissions reduction.

The illustration of the benefits of the selected solutions is among the purposes of business modelling in COMPASS. Here, a guide to the elements of success of the applications favouring seamless comodality under the business and decarbonisation points of view is presented. This section draws a set of **prototype business models** (BM)⁴, to be considered as reference for the business community and other stakeholders by the description of innovative configurations that organisations should aspire to become and that they can use to guide strategic transformation in organisations. Such models give the fundamental operational elements to help the promotion and use of the selected ICT solutions in co-modal passenger transport.

The methodology steps used for the business model analysis, and the COMPASS project tasks they relate to, are the following:

⁴ Conceptual business models that can represent a target model for business players in a real world situation (see also Osterwalder, 2004, pages 15 and 16).



- Assess the ICT applications;
- Review the assessment and identify a representative sample of innovative solutions for comodality and decarbonisation of transport;
- Select and involve the experts;
- > Desktop analysis and expert discussion to draw the prototype business models;
- SWOT analysis of the identified innovative solutions;
- Describe the methodology and the main results, highlighting the benefits of creating the conditions for the implementation of co-modality passenger transport services.

The set of innovative solutions identified to draw the prototype business models includes representative applications for long-distance, rural and urban mobility co-modality, which may effectively enable substantial greenhouse gases reduction in transport.

The strategic SWOT analysis for each solution aimed to provide the most effective representation of the benefits to the stakeholders to facilitate the take-up of identified models.

In this light, the business models in COMPASS were investigated and designed as % arototypes+ to illustrate 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 CO2 emissions in co-modal passenger transport. The COMPASS business models are conceived as % aroduct-oriented+ in the analysis of main business constituents of the ICT applications which better improve co-modality and reduce emissions: in such an 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 from a business and company-neutral point of view. Such an approach is expected to enlarge and maximise the impact of the research outputs to the audience of business community and policy makers in Europe.

7.8.2 Identification and Selection of ICT Solutions for Co-modality and Decarbonisation of Transport

Different methodologies were investigated in order to model the business of the most interesting solutions enabling co-modality and CO2 reduction, with the objective of ensuring the best results to the project audience and best scientific soundness. Osterwalder's approach was then selected for business modelling in COMPASS.

In this way, the following set of variables and scoring was chosen to extract a sample of applications for business modelling. These are divided into primaryqand secondaryqvariables according to the degree of their importance, which are part of a sound, verifiable and 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
 - CO2 reduction
 - Mobility
 - Direct business interest . drives the sampling, however public interest is considered
 - Overall qualitative rating
- Secondary variables
 - Door to door travel time
 - Door to door travel cost
 - Average score of the Solution from partners' assessment
 - Current and potential use of applications for long distance, urban and rural travels.



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.

- Bike-sharing systems. Urban applications with low/indirect business interest. Bike-sharing systems 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.
- Car parking management systems. These 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 information, payment, booking, site automation, etc. Particular attention is dedicated to the enforcement functions of such systems in the analysis.
- Shared taxis (or: collective taxi / Jitney / Blacktaxi / Taxibus). Urban and rural applications with direct business interest. Such services originated as an alternative (sometimes illegally) to state transport in the US, and quickly became common in Europe with a variety of business and technology configurations.
- Traveller information systems for mobile devices. Urban, rural and long-distance applications with direct business interest. Mobile traveller-information systems 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.

7.8.3 Business Model Conclusions

The analysis makes available structured knowledge about the target solutions and related business aspects 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. Nine elements that have been investigated with desk analysis and expert knowledge, describing the four pillars of the business model that shape the business model constituents. Each element was described by a set of open questions and reported in a worksheets where the business requirements to make money+have been detailed for each solution. The business models reports produced in the desk analysis were then shared with the experts for discussion and enrichment. Refinement and integration of information and evaluation proposed by the models is the output of this stage.

It is important to note 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 such business layer between strategy and operations are mostly qualitative.

All the solutions analysed highlight in fact the benefit of co-modality and present a fair degree of feasible innovation for decarbonisation of transport. 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 points 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.

Some of the ICT applications taken into analysis bring innovation to transport systems at maturity stage, while mobile traveller information systems represent a kind of solution generating entire new business too. The transport solutions considered can considerably enhance co-modality and reduce greenhouse gas emissions with the application of innovative technology; for this 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, but do not always show a successful track record; the prototype model and the SWOT investigate the main causes of failure and give operational and strategy suggestions for improvement.

Car parking management systems combine multiple technologies to enhance, in the view of the COMPASS approach, enforcement and payment; the model is investigated both from the point of view



of the solution provider and that of the public or private park operator, and shows how to improve the efficiency and effectiveness of such systems.

The business of shared taxis is another example of a 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. Important legal issues are also analysed.

Mobile traveller-information systems 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 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.

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 strategic evaluations of the internal and external factors influencing the competitive forces in the market of each solution and its strategic environment. 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 competitiveness of transport operators while creating the conditions for wider diffusion of co-modal transport services and helping to decarbonise the sector, while diffusion of the co-modal solutions described by COMPASS will also help to tackle the % inks and nodes+⁵ barriers against intermodality.

⁵ According to the HERMES European study, developed in the scope of FP7, +two fundamental types of barriers for improved intermodality were identified, accordingly with the nature of the problems they cause, being: problems in the link and problems in the nodes. The problems or issues in the links refer to problems related with the transport legs that prevent passengers to reach a given destination in a high quality intermodal service. The problems or issues in the nodes refer to problems in the terminal stations that make difficult for passengers transferring from one mode to another+(Macário, R., Viegas, J. M., Reis, V., Magalhães, L., 2012).

8 THE COMPASS CASE STUDIES

8.1 **OBJECTIVES**

The objective of the COMPASS case studies was testing ICT solutions in the context of real world situations in order to assess their real impact on the 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 applied allows for the discussion of the effects of different conditions existing at different urbanisation levels on proposed ICT solutions. Therefore the first COMPASS aim was to develop the methodology for the case studies selection process in order to choose well diversified case studies to be further researched in depth.

The first element of the selection process was the identification of ICT solutions to be applied in case studies according to the classification of solutions developed in COMPASS. It was decided to cover all categories of ICT solutions in case studies.

The next element of the selection process was the choice of regions. The differences between European regions led to a different reception of ICTs by local citizens, authorities, transport organisers and planners. For those reasons for COMPASS case studies practical tests of different ICT solutions were conducted in varied environments. Here the region selection process which ensures full social, economic and geographic coverage was based on the principle of selecting as many different region types as possible. Regional differentiation was 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 have been often perceived as serious barriers to the introduction of ICTs.

Geographic factors are 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 better handling of large numbers of passengers using transport in short periods of time. Different ICT tools are necessary for urban and rural areas. Here the differentiation should be even more detailed as metropolitan areas tend to create different demands on the transport system than smaller cities. A 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 contribute to differing needs for ICTs. Those special locations often add burden to the transport system and use of ICTs in them is more likely to occur than in other region types.

Cultural factors have a strong impact on the behaviour of users. Culture when it manifests itself by various national heritage sites or through historical landmarks impacts tourism. Areas which happen to be main touristic destinations require more ICTs and more advanced ICTs to handle increased traffic and very diverse needs of international travellers. The indicators representing the above mentioned factors were applied to the proposed case study locations and resulting analysis allowed for selection of the most differentiated setups for detailed study.

The resulting multilevel matrix allowed for the selection of best fitting case studies which have potential to cover most ICT applications and which are %esearchable+due to the partnersqknowledge, contacts and ability to collect data.

On this basis the final proposal of eleven case studies for detailed research was formulated.

Case studies had to build upon well researched data about user responses to proposed ICT solutions. To this effect within five case studies in-depth surveys were conducted in different setups across Europe. The survey methodologies depended on the needs of the particular case study. Surveys were based on questionnaires (field work, internet based, telephone based) and interviews (focus groups, telephone interviews). Both qualitative and quantitative approaches were utilised.



The surveys were designed to provide maximum missing information needed for each of the case studies. Hence there was a unequal number of surveys per case study. The most important information collected through surveys for each case study could be summarised as follows:

- For the case study on accessibility applications for disabled people: user acceptance, usage and problems which can be solved with the use of specific ICT solutions.
- For the case study on ITS solutions for Barcelonas local bus network: user opinions on positive and negative aspects of the TMB (Barcelonas bus operator) solutions and their willingness to pay for additional services provided through ICT.
- For the case study on future interurban public transport in Warminsko-Mazurskie voivodship: user acceptance of proposed ICT solutions, barriers to their introduction, possibilities for modal shift due to the introduction of ICTs, user willingness to pay for ICT applications, transferability potential of ICTs to rural areas.
- For the case study on bike-sharing in Vienna and the surrounding region: user acceptance of different ICTs used for bicycle traffic and especially for bike-sharing schemes, conditions for development of bike related ICTos and features of ICTos which might attract more users to bikesharing.
- For case study on grass-root cooperative smartphone-based car-sharing: advantages and disadvantages of solutions used alongside the car sharing schemes, user acceptance, interest to participate, impacts of employed solutions on user behaviours.

All data gathered through surveys has been used for the development of appropriate case studies. In the next sub-chapters the main results of the eleven COMPASS case studies are presented.

8.2 AN EU-WIDE MULTIMODAL TRAVEL PLANNER: ROUTERANK

routeRANK provides a software solution for travel planning. Unlike other solutions that consider only one means of transport at a time, routeRANK addresses the entire city to city travel route by integrating rail, road and air connections and their many multimodal combinations. In a single search, routeRANK's patent-pending technology finds and ranks the best possible travel routes, allowing users to sort them according to their priorities such as price, travel time and CO2 emissions. This is done by checking websites of unimodal transport providers, combining the findings to multimodal transport chains and then display these travel suggestions with their attributes (route, schedules, prices \tilde{o}) together with a link leading the user to the website(s) where a distinct travel solution then can be booked.

Custom developed versions of the proprietary software are offered to corporate customers and organisations, for their internal use or use on their own website, in both travel and logistics. Alternatively, corporate customers can easily sign up for the Standard Professional version or use the API to implement routeRANK functionality into their own system or portal. Website owners benefit from the routeRANK widget.

Another version illustrating the software is also publicly available on routeRANK's website. Although here the focus is on European travel, airports and flight connections worldwide and road connections in North America are also integrated.

From a user point of view, no special setup needs to be done to use routeRANK¢ web-based versions. Users only need an internet connection and a web browser. The documentation of how to use the basic public version of routeRANK is available in English, German, French, Spanish, Italian, and Dutch and can be found at http://www.routerank.com/en/faq/.

Business model

routeRANK provides a range of products based on its patent-pending technology to companies and organisations. Each version of the proprietary software solution addresses their respective requirements.



- Smaller institutions in particular can sign up for the Standard Professional version to optimise their travel planning with minimal effort.
- Custom developed versions of the proprietary software are offered to corporate customers and organisations, for their internal use or use on their own website. This might entail adapting the branding, integrating their own data sources and an existing online booking tool as well as additional features.
- Webmasters can easily integrate the widget on the 'contact us' or 'how to find us' pages of any website. Event organisers can use it on their dedicated event websites.
- Transport companies can benefit from the Logistics version for the optimal, end-to-end shipment of freight.

A detailed comparison of the features offered in different above versions, as well as a list of selected customers of routeRANK, can be found at the Business Applications page at http://www.routerank.com/en/business/

Capabilities

Compared to other projects on multimodal journey planners, routeRANK offers the widest coverage in terms of travel information at its deep level of integration and thus computes optimal travel plans based on relevant criteria.

Detailed coverage depends on the version in question, however, generally speaking there is worldwide air coverage, car routing for Europe, North America, Asia, train transportation information for most parts of Europe and increasingly North America. In addition, airport shuttle and transfers via buses, taxi, rental cars and car sharing are readily available. Diverse localisations are supported as well in currently six languages (English, German, French, Dutch, Spanish and Italian). This includes the localised booking information in the language of the relevant provider, e.g., not only is the routeRANK website supporting Spanish on the public version, but for booking a user will also be forwarded to the Spanish version of Expedia.es, say, typically a different commercial organisation from Expedia.fr.

routeRANK also developed and operates dozens customised versions of its journey planner, both own versions and customised ones for corporations. A wealth of additional features is available with them, including a meeting optimiser and an accommodation optimiser.

Limitations

The current limitation of routeRANK is in its lack of content (schedule and fare) coverage in some parts of world. While in general routeRANK provides world-wide coverage for flights, for other means of transportation the data is still not available for some countries, e.g. Asian train connections are not yet covered, car routes are not fully provided for Africa. routeRANK thus still provides an added value in these parts of the world over existing online travel agents or online booking tools, but does not yet fully exploit its potential there. In some cases train fares for international journeys cannot displayed exactly, but at least as an approximation, as railways companies often do not provide international rail fares on their own websites. Also some airlines (like Ryanair) prevent automatic data retrieval from their websites by using captchas, so that their flights cannot be incorporated into multimodal travel chains. Furthermore, on the public version there is only city to city information available and no door-to-door information, since local public transport is not covered at all.

User behaviour statistics

For the case study an extensive logging system was implemented and usage data from real users (randomised 100,000 searches from mid of February to end of May 2013) were retrieved to provide the statistics in the table below.

Results are shown for business travellers, that is by users of the standard professional or a customised version of routeRANK, and for users of the publicly available routeRANK services, assumed to be mainly non-business travellers.



	Business travellers	Non-business travellers
Users sorting travel solutions by emission travel criteria	23%	8%
Users who prefer economic travel options, i.e. sort travel solutions by price	46%	47%
Users who prefer shortest travel duration, i.e. sort travel solutions by time	38%	28%
Users who follow the CO2-emission offset links, i.e. pay for a CO2 compensation	3%	4%
Business travellers sorting travel solutions by their customised overall ranking (individually weighted time, cost, emissions, number of transfers, etc.)	18%	n/a
Short-distance (no flights) vs. long-distance searches (with flights)	26% vs. 74%.	53% vs. 47%

Table 8-1 Results from analysis of routeRANK user data

8.3 A REGIONAL MULTIMODAL TRAVEL PLANNER: MARCHE REGION OF ITALY

This case study⁶ addresses the potential for serving sustainable transport policies as a result of the use of regional traveller information systems, i.e. applications situated at an intermediate level between the urban scale and the national/international one. At the urban scale, the multimodal passenger travel information system essentially aims to favour short-distance trips through the utilisation of public transportation modes, e.g. primarily buses and metro, including options to reduce walking distance to the destination point. At the national/international level, the multimodal passenger travel information systems cover in general all transport modes, focusing on long-distance trips (e.g. including air and maritime transport means), for which the existence of effective interconnections (infrastructure, interchanges, etc.) between the trip legs can be considered as a necessary requirement (see, for details, INTERCONNECT, 2011).

More specifically, the objectives of the regional case study on the Marche region traveller information systems intend to address the following two issues:

- 1) An assessment of their environmental impacts, based on hypothesis on modal shift from car to public transport;
- 2) As assessment of their contribution to the improvement of mobility in general, and accessibility to remote areas in particular.

Pursuing the two objectives has been made possible due to the characteristics of the regional travel planners under examination:

- The Regione Marche Orari TPL, which provides information of the main public transport timetables and transfer times at interchanges from an origin to a destination point across the region. http://orari.trasporti.marche.it/prod2/default.asp
- The Mobilitami regional travel planner, which provides timetables, transfer time at interchanges and walking distance to the destination points of the regional public transport network (coaches, buses and regional trains). http://www.mobilitami.it/tp/mobilitami/home/index#

Data collection and analysis for the case study

Data collected from the analysis of the two data sets relates to the on-line access to the regional travel planners in 2012. Data analysis, after adjustments, has led to the following steps:

Identify the origin/destination paths through the usersq indication of public transport means in isolation or in combination (buses, train, coaches) to reach a given site or address.

⁶ A special thanks to Monica Giannini, Alessandro Pettinari and Silvia Magnalardo of the PLUSERVICE S.r.l. company based in Marzocca (AN), in the Marche Region, for their assistance and information provided.



Estimate the origin/destination paths by car, corresponding to the origin/destination paths for which the user has not indicated any public transport means among the available options.

The assessment of the potential environmental impacts (avoided transport external costs) are summarised in the following table. They are expressed in daily impacts at 2012 based on the assumption that 5% of the potential users would shift their daily car trips to public transport in the Marche Region. Congestion costs are not calculated, due to the non-availability of information on traffic flows (O/D matrix) in the regional network of road and rail links.

External costs	Urban	Extra urban	Total
Climate Change	1,148	6,077	7,225
Accidents	9,147	27,679	36,795
Total	10,295	33,725	44,020

Table 8.2 Marche region: Reduction in External costs from mode shift to public transport (€)

The reduced social costs from modal shift amount in total to about " 44,000 daily (of which about " 10,000 is in urban areas and about " 33,000 in extra-urban areas). The assessment is carried out under the assumption that the diverted demand from road transport (car) can be met by public transport without additional costs (spare capacity available). On an annual basis, the potentially avoided social costs amount to about " 16 million.

The improvement in mobility and accessibility emerges from the analysis of the access to the regional travel planners by month and destination.

Concerning mobility and accessibility, data analysis on the monthly access to the regional travel planners shows the higher peak in correspondence of bad weather conditions (February). In fact in Italy, during the winter of 2012, particularly in February, the weather was characterised by storms and heavy snow. The Marche region and in general the Central-Northern part of Italy, were mainly concerned, with transport activities strongly hampered by network disruption and service interruptions. During February the share of regional plannersq users in the most remote areas (mountainous municipalities) more than tripled compared to the average annual access, indicating that travel planners can make a particular contribution towards the improvement of mobility in prohibitive conditions and remote areas.

Conclusions and recommendations

- From CENSIS analysis (CENSIS, 2011), 37.9% of the Italian population using the internet regularly (53.1% of the total population age 14-80) use it as a means to query about ‰ads and destinations+.
- Based on the hypothesis on modal shift from car to public transport due to the information delivered by the regional travel planners, significant savings in car usersqvehicle operating costs and environmental costs (avoided external transport costs) may potentially accrue to users and society.
- Data analysis on access to the regional travel planners also allow infering improvement in accessibility to remote regional areas (mountainous municipalities) and increase of mobility in presence of adverse weather conditions.
- However, to fully exploit the potential of traveller information systems, the following issues must be considered:
 - Importance of the public sector. The public sector may play an important role, addressing several aspects. It is likely in fact that the public sector (i.e. the regional and local authorities in this case study) is an important shareholder, if not the principal stakeholder, in the portfolio of public transport operators (e.g. buses and coaches). Therefore, it can facilitate data collection, favouring the establishment of common standards for data exchange and overcoming administrative barriers, e.g. streamlining the process for the definition of objectives, services and characteristics of the application. Furthermore, the role of the public sector may be decisive in order to involve the private sector in the definition of the business



models of the application. Internet-based applications like travel planners may represent the basis for the provision of several services, e.g. commercial banners, involvement of touristic companies, subscriptions, etc. The public sector may encourage the involvement of the private sector through public procurements.

- The importance of shared procedures for data collection. Travel planners at regional/national level need data from several transport operators. Short and long-distance transport modes are involved (ferry, rail, air transport, road public transport). The issue of data collection from different platforms becomes therefore decisive. The experience of regional travel applications has stressed the need to harmonise the procedures for data collection from different data sets in order to ensure an efficient service.
- Data maintenance and renewal. How to ensure data maintenance and information updating in the long term is important aspect to be considered. This aspect must be dealt with in the context of the business model of the application. Travel plannersqdata need to be updated and this activity can represent a considerable barrier. A possible solution to overcome this barrier is to set up multiannual agreements with data providers and to support data collection/updating with new technologies and services.

8.4 ACCESSIBILITY APPLICATIONS FOR DISABLED PEOPLE

This case study looked 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. It is estimated that disabled people comprise approximately 15% of the population. Furthermore, it is widely observed that there is a strong link between ageing and impairment and that the proportion of older people in society is increasing over time.

Types of app

Apps are software applications designed to run on mobile devices such as smartphones and tablet computers. They are typically designed to offer a single service or task in a simple, direct, self-contained way, or to interact with a single service, task or website on the internet and, consequently, tend to be relatively simple to use. The apps considered in this case study target disabled car drivers, disabled car passengers, disabled public transport users and disabled pedestrians, and fall into three broad categories, as set out in Table 8-3.



Table 8-3	Overview of	f accessibility	apps for	disabled	people
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Type of app	Specific examples	Cost*
Apps which assist with navigation and way finding, particularly for visually impaired people	Navigon . this uses the mobile device 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 ±ake me homeqfunction, and links to the user contact list to provide directions to a selected contact.	£21.99
	Blind Square . uses the IOS device GPS capability to determine the user 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.	£16.99
	SeeingAssistant-Move - launched in 2013, this provides for route planning and route recording, advanced neighbourhood scanning with world directions, location search, <u>uvhere-am-lofunctionality</u> , input of sharing points and use of voice commands.	\$7.99
Apps which provide specific and tailored accessibility information, relevant to particular impairments	Jaccede - launched in 2012, this enables users to search for places that are accessible to those with a disability. Information, such as whether the entrance is step-free and accessibility of toilets, is displayed alongside photos, user comments and other relevant information. Users can contribute by adding accessible places anywhere in the world, or by editing existing listings.	Free
	GoGenie - this app aims to help disabled and deaf people find access information online for any location such as a shop, cinema, cultural event or town centre, based on the recommendations and comments of others. Specific features include access information, contact, maps, facilities to add reviews, photos and videos, and a <u>#eport-itqfeature enabling people to complain directly to inaccessible venues and organisations.</u>	Free
	Ldn Access - this app is designed to be used as a source of access-related information for places to eat, hotels, entertainment, attractions etc. throughout London. It is targeted slightly more broadly at disabled people (either physical or none physical or both), older people, families with young children, and visitors to London, and provides information on wheelchair access, disabled toilets, induction loops, baby changing facilities, customer parking etc.	(Still in development)
Apps which provide communication assistance between the disabled person and customer-facing transport staff.	Assist-Mi - this app can be used by disabled people to alert participating sites such as shopping centres, railway stations and airports know when they are on their way and when they have arrived, while conveying all their access needs so they can be met by staff and properly accommodated. In addition, the Parking Space Finder function can help locate nearby Blue Badge spaces and indicate how far away the space is, any special parking restrictions the space may have and what kind of parking it offers.	Free

* Costs sources: iTunes, Google Play, Nokia Store.

Data collection and analysis for the case study

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. From the results, the following conclusions can be derived:

- 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. Whilst less than a fifth of the sample (15%) reported that they always need assistance when going out, close to half of the sample (44%) stated that they do not go out as often as they would like to, and a similarly high proportion (41%) stated that they always had to plan their journeys really carefully.
- Nearly three quarters of the 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 the 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 demonstrates that some smartphone app attributes are indeed valued, whilst others are not. 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. The values obtained for these attributes can be thought of as being approximately equivalent to the value of saving 10-20 minutes travel time on a round trip.
- For the public transport users, the most useful attributes of the apps presented to them were those which 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. The values obtained for these attributes can be thought of as being in a range approximately equivalent to the value of saving 10-40 minutes travel time on a round trip.
- Interestingly, the values of the features of an app and the propensity to buy one are somewhat larger for public transport than car users. Given that the consequences of poor accessibility information and support are likely to be more problematic when travelling via public transport, this seems quite plausible.
- As they are focused on disabled people, many of whom are older, and as they are provided via smartphones, 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. Whilst it can be expected that as a greater proportion of the population becomes older and more familiar with technology this problem will subside, some further research into the barriers to take-up would be interesting.
- The survey assumed that smartphone apps would be most useful for trips of a less routine nature, and so was focused on respondentsq occasional or rare medium to long-distance trips, but it emerged that some 20% of the sample had, in fact, not made such a trip recently. Consequently, these respondents were screened out from taking part in the stated choice experiment. One useful area for future development, therefore, would be to conduct further work with this group, to understand the reasons for them not making any non-routine medium to long-distance trips and to test the assumption about the type of trip smartphone apps would be most useful for.

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 the COMPASS survey indicates that people do place value on particular aspects of these apps, their potential is, as yet, under-utilised, and so actions to improve take-up should be explored further.

8.5 **ITS SOLUTIONS FOR BARCELONA'S LOCAL BUS NETWORK**

With a decreasing trend in passenger ridership, Barcelonac 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 (internet, smartphones, on-vehicle, at bus stops); all in all to increase the attractiveness of the bus in relation to other competing modes, e.g. metro or tramway.

The headline initiative by TMB is the transformation of the current organic network onto a systematically structured orthogonal network making use of the particular structure of the Barcelona urban tissue. The Barcelona bus network today is in fact the result of the addition and adaptation of lines for more than 100 years. The resulting network is difficult to read and this discourages its use by non-frequent travellers who prefer clearer modes such as metro; simultaneously, the bus lines have overlapped itineraries with each other and today are operating at a below optimal level.

The operator is taking the opportunity of these structural changes to test new concepts for bus stations, which if successful, might be generalised at intersections of vertical and horizontal lines in the new orthogonal network. 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 sale of tickets (sells booths). At


the same time, TMB is enhancing its smartphone application with innovative features aiming at becoming increasingly useful to users.

An interesting initiative by TMB implemented since the 90s is the network of proximity buses within neighbourhoods envisaged for facilitating short-distance mobility e.g. of old people, or people with an impairment, but also acting as feeder services to other city-wide bus lines or to metro and tramway lines. With relatively low demands, especially on weekends, this case study explores the possibility to eventually increase the demand of these services by combing the classic operation with an adapted demand-responsive transport system (DRT) linked to weekend leisure mobility.

The technical solutions introduced and presented in this case study are in short the following:

- Smartphone Applications: the general functioning and the innovative features of the %MB on your mobile phone+smart app, and its level of awareness and use by citizens are analysed. The case study also surveyed the interest of citizens in other potential smartphone applications.
- Smart Bus Stops: the ITS equipment of new pilot bus stops is analysed: interactive multimodal 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 sales booths.
- Smart applications allowing for DRT services in Barcelona mountain neighbourhoods: the case study surveyed the potential interest of implementing DRT systems between the city of Barcelona and Collserola, a mountainous neighbourhood, and between other relevant metropolitan rail stations and the Collserola hinterland.

This case study was based on desk work and a user survey was carried out at different access points of Rasseig de les Aigües+ in the Collserola hills. The survey was held on the February 3rd 2013 (Sunday) from 8 am till 5 pm (9 hours in total) with a total number of 533 surveys obtained from 329 to pedestrians and 240 bikers.

The survey was specifically focused on gaining knowledge of:

- Citizensqawareness of the services that TMB offers today to improve the general bus services in Barcelona (orthogonal reorganisation of bus services, upgraded bus stops, TMB smartphone app)
- Citizensq awareness of the services that TMB (Barcelonage bus operator) offers to access the mountain neighbourhoods of Barcelona (proximity buses).
- > Willingness of citizens to pay for additional services provided with smartphone applications.

In synthesis, this case study has concluded the following points:

- Awareness of area inhabitants of the improvements TMB is performing on the Barcelona bus network and bus services are relatively high, with no major complaints linked to them. Area inhabitants showed relative high awareness of initiatives by TMB to improve bus services in Barcelona, especially regular and frequent users of the municipal public transport. In particular, three out of four respondents were aware of the reorganisation of the bus services in Barcelona, and two out of three were aware of the existence of neighbourhood proximity bus services providing access to the mountain neighbourhoods. Observations at new pilot bus stops (not based on user surveys) seem to indicate that new ITS equipment at bus stops has a fairly good public acceptance (time indicators, ticket booths), but the use of on-stop interactive travel planners seems low at this point, probably due to user unawareness.
- The TMB smartphone tool for user information is clear and easy-to-use, especially the travel planner, the atlas of bus lines and the module for querying expected times of arrival for services at stops; the augmented reality feature still has room for improvement, especially on the clarity of indications, user guidance to closest bus stops being a natural key dimension of the app. As a result, user acceptance of the app is high, it is deemed necessary and potentially very effective in increasing the quality of public transport services in Barcelona. The survey revealed that amongst those owning a smartphone and knowing of the existence of the app, more than one out of two used it regularly. With increasing user ownership of smartphones (one out of three does not own a smartphone yet), and awareness rising of the service (another one out of three does has not tried/does not know the app), the total number of users for such services still has a strong potential to increase (only 16% of survey respondents were today active users of the service).



Willingness of citizens to pay for additional services provided with smartphone applications is substantially lower. Applications attracting most interest by users are directly related to guidance, personal safety and emergency assistance (one out of two surveyed revealing they would pay for their acquisition). Other applications are less suggestive, like parking booking applications, and more complex proposals for services like DRT linked to smartphone applications (with around one out of five willing to pay for them; still 25% of bikers suggested they might be interested in such services). It also seems that user acceptance of services is rather linked to their level of clarity and simplicity.

8.6 FUTURE INTERURBAN PUBLIC TRANSPORT IN THE WARMINSKO-MAZURSKIE VOIVODSHIP

This case study uses a test bed approach for identification of possibilities and barriers for the introduction of some ITC solutions in rural areas. It is based on transport usersqresponse to the proposed ICTs as recorded through qualitative and quantitative surveys. Surveys were carried out in the Szczytno region in the Warminsko-Mazurskie voivodship in the north-eastern part of Poland. This is a low GDP rural area. Szcytno has about 28,000 inhabitants, while in the close vicinity of the Szczytno area (poviat) about 70,000 people live for whom Szczytno is the centre of gravity. ICT solutions tested in this setting were:

- 1) Internet based travel planners;
- 2) Electronic real time information at bus stops;
- 3) Ticket purchasing via mobile phones / internet;
- 4) Real time information on services via mobile phones / internet;
- 5) Real time information on estimated arrival times, stops, route on board of vehicles;
- 6) Demand responsive services possibility for direct pick-up/delivery of passengers in response to prior request.

The quantitative survey allowed for answers regarding acceptability of different ITC solutions among different user age groups and in regard to different distances travelled. Three different trip types have been taken into consideration: local (short-distance up to 40 km), medium (still rather short-distance - below 100km, however the purpose of the trip was not local . those were routes to/from the voivodship capital) and long-distance (more than 100 km routes to Warsaw and Gdansk). Five different user age classes have been established: 15-18 years old, 19-29, 30-45, 46-60 and 60+. This allowed for testing the acceptability as well as user willingness to pay for ICTs if introduced among different user segments. Also price elasticities have been tested. Again the responses were differentiated in regard to age and distance travelled. The main patterns emerging from the quantitative analysis were further researched in-depth using qualitative research . a focus groups approach in order to establish main factors responsible for identified user behaviour. Furthermore interviews with representatives of service providers were conducted to amend the overall picture with the opinions of the operator. Altogether this approach allowed formulating a complete opinion as to the barriers, opportunities and possibilities for transferability of ICTs into rural regions.

The overall result of the study is that ICTs are very much sought after by local transport users. Rurality and characteristics typical for remote locations do not reduce demand for a modern transport system. In the contrary, many ICTs are considered as essential, which might help to remedy typical failures of the 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 a rural setting than in urban high service frequency areas. User acceptance for the majority of tested ICTs is high or very high. 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. The lower acceptance among older users results from deep rooted behaviour, but could also be effect of fear of new technology and unwillingness to learn how to use it. Nevertheless overall a clear majority of all users are in favour of ICTs, although some solutions (especially those oriented at information provision) score better than others (the lowest score is noted for demand responsive services). This translates to more than 75% being 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 service with only 37% in favour of this measure. This also tells much about transferability . those ICTs which are most acceptable should be transferred to the rural areas first to allow users to familiarise with them and build a stronger acceptance base for ICTs.



Source: COMPASS Case Study Survey

Figure 8-1 User acceptance for ICT solutions in Warminsko-Mazurskie Voivodship

An 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 the main advantage is the possibility to plan their journey better. Also the psychological effect of better assurance that the particular service will be offered was important. The scores differ between age and distance groups. For example users who travel only locally (up to 40 km) rated this feature at 2.7 (adopted scale 1- definitely not useful, 5-definitely useful) while those travelling distances of 40-100 km considered it more useful with an average rating of 3.1. At the same time those who travel over 100 km attach to this type of application even higher value rating it at 3.3. The same numbers for the group of youngest users are considerably higher with age group of 15-18 years old real time information scored highest 3.7 points, for those of 19-29 years it was 3.6, 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 2.2 and those over 60 years of age at only 1.6.

Time savings on the user part for D2D travel are another factor which in theory should be crucial to users. The study shows that in local travel passengers expect to save about 15 minutes, the same holds true for long-distance travellers, while medium distance expectation is of about 12 minutes. It could be concluded that average time savings of about 14 minutes are certainly more valuable to those travelling short distances. At the same time it is obvious that the main reason of time saving results from the elimination of the need to be at the bus stop earlier than necessary. Yet lack of significant differentiation between values attached to time savings between short and long distance travellers indicates that this is secondary feature to them.

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 (younger 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 the financial means disposable to the local service providers. It is unlikely that without external support (e.g.



government sponsored projects) ICTs could be introduced by operators on their own. This unfavourable condition is reinforced by the fact that additional maintenance costs must be considered for operating ICTs and 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 reject the possibility for switching from private car to public transport even if it is ICT intensive. The rest declare 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 (the remaining percentage). At the same time higher operator costs cannot be compensated by ticket price increases 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 a three-fourth majority accepts only symbolic payments up to PLN 1 (approx. " 0.25).

The main conclusions and recommendations from this case study are:

- ICTs are useful for transport users in rural areas and they are well accepted. The rural features of the region actually cause even higher demand for ICTs than in well-developed regions. The acceptance levels vary in different user segments with the majority of supporters among younger users.
- There are no technical barriers preventing introduction of ICT c. The mobile phone density, even if it is rural area, is high and ICT technology available does not have to be extensively tailored to the needs of rural transport.
- There is a significant financial barrier resulting from high initial investment costs not likely to be compensated by increase in number of travellers due to low population density in the rural area. Moreover additional maintenance costs will not be compensated by ticket price increases due to high unwillingness to pay on the user part.
- There are certain operational barriers especially resulting from unfamiliarity of operators and their staff with ICT technology. Especially vehicle operators fear that they will not be able to operate ICT systems and prefer solutions which work without need for driver/operator staff input.
- The best reception is given to ICT which offer better information. This results from the rural region transport system characteristics . reduced frequency and increased possibility for delays and breakdowns. Any solution which provides the comfort of knowledge about delays and changes is important. Time savings, although noted by users, are not considered a primary benefit.

8.7 MOBILE APPLICATIONS FOR TAXI SERVICES

This case study considers the use of mobile applications (apps) applied to the taxi industry using the experienc of (different) apps in peer cities. The case study is motivated by the impacts that the taxi app may have on the industry. Four peer cities have been analysed: one on the east and one on the west coast of the USA, London and Edinburgh.

Apps have a demonstrable impact on the use of taxis and similar services served by taxi apps. They have been suggested to increase accessibility, ease of use and convenience of the taxi mode. The potential benefits of the taxi app extend to the (various) passenger(s) both current and intending; but should also be considered in terms of positive and negative impacts on the industry and on the regulating authorities.

App features

Taxi apps are based on a series of complementary ICT functions that vary across app generations. Functions and expectations of taxi apps are rapidly expanding in a competitive market that faces some conflicting controls reflecting the nature of legislation applied to the supply of taxis. The nature of this conflict varies between locations reflecting the local nature of taxi legislation and regulation, though the fundamental issues leading to conflict all fall into three areas in which control may be applied: quantity, quality and economic regulation.

Taxi app generations are broadly defined as:



- Seneration 1: Taxi Company Directories, providing broad listings and telephone numbers
- Generation 2: Taxi Company Booking, using existing infrastructure, typically existing taxi dispatch company systems. Examples include TaxiMagic.
- Generation 3: Taxi / FHV Direct Booking, using bespoke infrastructure to bypass existing taxi dispatch systems, typically engaging drivers directly, using a single vehicle type on a single platform. Examples include Hailo.
- Generation 4: Taxi / FHV and Car Sharing, offering a wider range of vehicle type on a common platform. Examples include Uber (UberX / UberSUV / UberTaxi / UberBlack).

Economic potential

There are four fundamental economic relationships which affect the success of an app. These can be defined as:

- 1) Passenger to app, linked to the willingness of a customer to accept any booking charge or additional costs associated with using an app-based taxi booking. This is a particular issue in terms of surge pricingq a policy adopted by some app providers and resulting in higher pricing at points of greater demand. This issue has created a disagreement in some jurisdictions between app supplier and licensing authority and is considered illegal in many. Despite the regulator view on illegality, the practice continues to be applied by some apps.
- 2) Driver to app. The majority of app suppliers consider drivers to be their customers as well as the passengers. This differs in apps to dispatch, see below. Not only does an app need to appeal to its passengers, it needs to provide a sufficiently broad range of taxi suppliers. Taxi apps require sufficient supply to be attractive to users in the long run, and sufficient passengers to be attractive to drivers. Absence of either reduces relevance and may exclude the app in some markets.
- 3) Dispatch to app. The third relationship relates to agreements between app manufacturers and dispatch companies where dispatch companies are involved in the app booking process. The involvement of traditional dispatch in app technologies is declining as it represents an avoidable process. Taxi company own label apps fit in this category.
- 4) App to Regulator. The most complex relationship exists between the app supplier and the regulator (if any relationship exists at all).

Peer city review

Three primary datasets are applied in addition to a review of local operating conditions: operational data obtained from a variety of sources from peer cities; taxi user data obtained through street surveys; and operator perception data obtained through focus groups and structured interviews. The main findings can be grouped as follows:

- Trip structure . market opportunities
 - Residential trips, particularly those from more distant suburbs, tended to be dominated by dispatched trips. This reflects the relative low densities of demand, which limit the commercial opportunity for cruising taxis, boosting the opportunity and benefits of app use.
 - City centre trips, including those from entertainment venues are more likely to be served by the taxi cruising and ranking markets. Concentrations of demand into defined areas, or at defined stances, are better suited to cruising and ranking taxis, reducing, but not excluding, opportunities for apps. Cities with lower levels of traditional taxi services appear to attract greater interest in app based services even in traditional cruising markets and in particular demographic groups.
 - Airport originating trips reflect a further pattern of engagement based on defined stances permitted by the airport. The relationships include an additional market participant, the airports, most of which derive economic gain in the form of airport concessions . the competitively tendered ±ight to operateq making entry of app operations problematic, and generally not welcomed by the airport authority.
- Operator and regulator response . barriers to entry



- The response of the taxi and private hire market to the development of mobile applications has been mixed, with a degree of hostility both on the part of the operator and the regulator, with a more muted response on the part of drivers. Apps are a new, and unknown, market participant.
- App based engagements are taking some market share from existing companies, both competitively (within the market) and, through attrition, to parallel markets.
- Taxi driver communities may also be less opposed than at first appears. The apps do, after all, offer new business, both focusing business, and growing the market. Logic suggests a desire not just to be tied to one app but to many, as each brings with it the opportunity for work.
- Regulators and industry operator communities appear the most opposed. The app has changed the market or will change the market, in a way not envisaged at the time of legislation. Few city codes/regulations fully accommodate the operation of apps, with many app developers seeking to sidestep traditional definitions to expand their market share.
- Financial viability
 - The viability of an app may rest upon the extent to which its legality is challenged, rather than the basic costs of operation itself. Costs and benefit ratios may be estimated in relation to the total numbers of trips and market take. In one of the case study locations, an estimated ±axiq market of 5,219,433 journeys is identified, of which app use represents 11%. An estimate of use based on public survey an individual app may receive around 150,000 bookings per annum (2012 figures), valued at circa \$2,400,000.
- Technical feasibility
 - Technical requirements include: the ability to locate a passenger vehicle; the ability to transmit and receive bookings; and the ability to facilitate payment. Additional features may develop from the set of information, such as the upward feed of information from app to regulator, itself a desirable requirement. Relatively few genuine technical barriers exist to the operation of taxi apps. The most significant challenge relates to the development of API links between apps and existing software. This challenge exists in relation to apps to dispatch, and is not applicable in apps to driver.

Overall impact of taxi apps

To the member of the public seeking reliability, speed and service, the taxi app is already a reality. The consumer may play between alternatives, taking a look at the latest or the most visible. This reflects the nature of the internet-type mentality underlying both the apps and their users. The need to make taxi bookings and the need to have a visible and reliable service will be understood far more than the legal framework under which such services are provided, and therefore the app market will probably expand despite the conflict with regulators. The taxi appears, and is likely to, contribute to better services and increasing mobility. The apps can make the service more attractive, but will be impacted by regulatory structures in place. The overall impact on traffic is not expected to be particularly relevant. However the taxi is, by its nature, a more environmentally friendly vehicle than a privately owned car. Any activity that diverts private car use to collective transport, such as taxis, will actively reduce carbon emission at point of use and life cycle carbon production. The taxi Apps contribute to this, as do any activities promoting taxi use.



8.8 BIKE SHARING IN VIENNA AND THE SURROUNDING REGION

This case study focuses 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 survey was carried out in Vienna, where Citybike is in operation, and in Lower Austria, where nextbike, also sometimes called as LEIHRADL-nextbike, is in operation. The survey conducted in Lower Austria was designed to be comparable to a survey in 2009 and thus the survey result is presented together with 2009 data where comparable, while the survey in Vienna was the first of its kind. The CATI survey in Lower Austria was carried out in small villages up to 2,500 inhabitants, (7 municipalities), towns up to 5,000 inhabitants (5 municipalities), regional centre up to 10,000 inhabitants (5 municipalities), large regional centres with more than 10,000 inhabitants (2 municipalities) as well as in a town in a suburb of Vienna (1 municipality), and in total 248 valid responses were collected. Distribution among the municipalities corresponds to the actual population based on the 2001 census, which was the latest available one at the time of the survey. The survey in Vienna was carried out in all districts in Vienna and 252 valid respondents are collected. The proportion of the respondents between Lower Austria and Vienna is also in line with the 2001 census.

The scheme in Vienna, Citybike, has been in operation since 2003 and currently served with about 100 stations with in approximately 3km radius from the city centre. The one in Lower Austria, nextbike, 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. Citybike has a terminal equipped with touch-panel screens at its stations and users operate this terminal to use the shared bicycle. On the contrary nextbike¢ stations do not have such terminal and users have to operate via mobile phones. Both systems require registrations of personal data and payment methods such as credit or debit card number in advance.



Source: nextbike, September 2013

Figure 8-2 Area served by Citybike and nextbike

In Vienna, the survey revealed that more than 90% of the people know about the bike-sharing scheme and 28% of the respondents have already used it. In Lower Austria, the awareness of the bike-sharing scheme is as low as 20%, while a comparison of the surveys revealed that there is an increase of bicycle use in general (including non-shared bicycle) while awareness of the bike sharing scheme that is employed in the region remains low. Meanwhile, awareness of the Viennese bike-sharing scheme has become higher over the four year period in Lower Austria. 17% of the respondents in Lower Austria have used the shared bike in Lower Austria at least once and 10% of the respondents have used the shared bicycle in Vienna.



Despite the high level of awareness in Vienna, the majority of the respondents have not yet used the bike sharing schemes. 28% of the Viennese respondents have used Citybike at least once, while 71% of the respondents have never used any bike-sharing schemes. The low rate of experience applies to the inhabitants to Lower Austria, too, with 10% of the respondents having used Viennese CityBike and 4% having used nextbike in Lower Austria. The most typical reason for not using shared bike is the ownership of an own bicycle. The data about the usage frequency shows that there are a certain proportion of the users in cities who use it regularly . 12% in Vienna use it weekly and 21% monthly, while 9% in Lower Austria use it monthly. 69% of the Viennese respondents and 56% of the Lower Austrian respondents indicate that they got to know about the bike-sharing on the street . either at the renting stations or by seeing shared bikes in use.

Among those who actually use it, the leisure activities in the same area are dominant as the main trip purpose when shared bikes are used (68% in Vienna and 60% in Lower Austria) and the leisure activities in other cities/regions (6% in Vienna, 21% in Lower Austria). 11 % of the people in Vienna uses it as an alternative transport mode for daily trips such as for commuting. As for the payment, the current system using debit or credit card appears to be well-accepted (43% in Vienna and 35% in Lower Austria preferring debit card/direct debit from bank account, and 15% in Vienna and 10% in Lower Austria preferring credit cards). However, a certain proportion of the respondents prefers the cash payment (31% in Vienna and 47% in Lower Austria), and thus inclusion of this payment method would improve the acceptance much. The preference for the identification method is not uniform and there are two groups . one that prefer phone-based identification (by SMS or calling) and another one that prefers card-based identification (dedicated bike-sharing card or debit/credit card).

Regarding ICT-relevant aspects asked in the survey, roughly two-thirds of the respondents recognise themselves as familiar with the ICT-based user interface in general. The survey results about potential further development show that the users find aspects such as the opportunity to report broken bicycles via e.g. apps, the app indicating conditions of bicycles to have this knowledge before going to renting stations, and the option for short-term reservation to hold a bicycle at a station fairly useful.

Main conclusions and recommendations

- Awareness of bike-sharing schemes in general is high in the surveyed region, especially of the one in Vienna that has been in operation for a decade. Meanwhile, the proportion of the people who uses the scheme regularly is fairly low, and among those who use it regularly, the leisure trips are dominant, although there are also some uses for commuting and other daily trips in the city.
- > The current pricing that is set to low appears to be well accepted.
- Making the stations denser and/or extended is an important development so that more population can be reached 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 ‰ard+ infrastructure for the bike-sharing will capture more potential users.
- Several ICT-based developments are recommended including short-term reservation to guarantee that a bike is available at a station for the user, diversifying identification methods especially with phone and own 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 report broken bikes.
- Regarding booking/identification system, it will have to be considered to integrate various schemesquser accounts so that one user account from a scheme can be recognised automatically by another schemes as bike-sharing schemes requires the users to create an account for it. Especially in light of the fact that a certain number of the 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 the people to use the bicycle in two places.
- The technologies used by bike-sharing schemes are becoming fairly mature and thus the bikesharing scheme is easily transferable.
- Initial investment cost is high with approximately "25,000 per station, if the one employing a docking station with touch-panel terminal is chosen. The maintenance cost per bicycle is between "1,500 and "2,500. This type is thus suitable for medium-sized to large cities. The one operated



fully by mobile phone is less expensive and it costs around " 5,000 with lower maintenance cost and thus it is suitable for small cities and also for rural areas.

8.9 CAR SHARING IN KARLSRUHE

Car sharing in Karlsruhe, when measured by cars per inhabitant, probably is the most successful system of this kind of mobility concept in the world. It is a system of classical car sharing (car club), where all cars have fixed locations i.e. when renting a car, the user has to pick it up at a distinct location and drop it off at the same point.

The case describes demand and supply structure, pointing out that strong demand occurs mainly in quarters of the town with a high population density, situated directly in or close to the city centre, while usage intensity of the system in remote districts of the area is more moderate.

A variation of demand applies concerning season, weekday and hour of the day, which must be considered by the fleet management, to assure a high availability of cars for the customers but in parallel an efficient usage of the vehicles to enable attractive costs for using the system and a financial viability to run this system economically successful.

The tariff system charges by time and mileage a car is rented, providing discounts for longer trips and in addition requires a monthly membership fee and a one-time charge for registration and a deposit resulting in average costs per kilometre of about " 0.40. This is not much higher than the full costs of owing a private car, but enables the customer to choose the right car for a specific purpose among fifty different types of cars.

An analysis of long-term booking behaviour showed that the annual mileage per user significantly decreases with the years to about 1,400 kilometres a year. Assuming a consistency in the number of ways undertaken per person, the conclusion can be drawn that car classical sharing causes a switch in mode choice towards public transport and bike usage. This is backed by results of a mobility survey undertaken in Karlsruhe in 2012.

Comparing this system of classical car sharing with dynamic or floating car sharing, as provided e.g. by Daimler motor company in Ulm since 2009 under the brand car2go, shows severe differences between these systems in user behaviour, efficiency and therefore also in financial viability. The system of dynamic car sharing focuses on a revitalisation of car usage in urban areas, where figures for car ownership and the mode share of car usage decreased in the last decade, especially among younger people, while it is not intended to replace existing car ownership by usage of dynamic car sharing. The existing tariff structure (making long-distance trips unattractive) and the uniform car fleet, consisting of just Smart 2-seater cars, supports this focus of dynamic car sharing towards a mode shift from public transport and bike usage to car driving in urban areas.

In Karlsruhe, the average mileage per car is at 28,000 kilometres, while this benchmark figure for car2go is about a just third of that value, resulting in a lack of profitability.

So classical car sharing can be considered as a mobility concept, which is sustainable, on the ecological as well as on the economical view, while this does not apply for dynamic car sharing, as performed by car2go.

8.10 GRASS-ROOT COOPERATIVE SMARTPHONE-BASED CAR SHARING IN AUSTRIA

This case study set its focus on newly-appearing grass-root cooperative car-sharing, called CARUSO, in Austria. It has several interesting features different from conventional car-sharing:

- > 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.
- > The users have to form a car-sharing group spontaneously based on their needs.



- The shared cars are provided by a group member (e.g. an individual, public organisation such as municipality, private companies, etc.) or procured cooperatively by the group and there is no carsharing company owning and offering vehicles.
- A special insurance policy package dedicated for CARUSO offered by a regional insurance company covers the mandatory insurance needed for this form of car-sharing.
- The reservation and usage-logging platforms on board are provided as an internet application by CARUSO.
- The user fee can be set in a flexible way and each group adopts different pricing models such as a linear per-km tariff with or without annual fee or just 6-month user fee divided based on the approximate usages by users.
- Some groups share EV(s).

There are three different stakeholders as shown in the table below. There is a system provider who provides a web-based reservation and logging system, smartphone-based on-board system, and organises an extra insurance with a regional insurance company. The second generation on-board system called CARUSO Box was under development at the timing of the research, as well as a smartphone app to enable reservations from this. The role of group organiser is to manage the cars and contract, as well as the accounting, and then there are the ordinary users.

Table 8-4	Stakeholders involved in	grass-root coo	perative car-shar	ing in Austria
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Stakeholders	System Provider	Group Organiser	Ordinary Users
Roles	Provision of on-board system, reservation system, drive log and insurance	Procurement of shared cars, Contract management, Accounting, Usage of shared car, Payment of user fee	Usages of shared car that belongs to the group, Payment of user fee
Who can be?	Developer of the system	Private person, municipal office, company, association, etc.	Anyone who is admitted to be a member

Data collection and analysis for the case study

In this case study, three different types of surveys were carried out, namely focus group interviews with the users, an online survey among the users, and a telephone survey among users and nonusers. The focus group interviews and online surveys were carried out in four municipalities where active grass-root cooperative car-sharing groups exist. The online survey was carried out with the users of Carsharing 24/7, another peer-to-peer car-sharing mainly used in Vienna and Graz.

With these three different types of survey, following the fact-finding research works at the very beginning, various key aspects are found as described below. It has to be noted however that these conclusions are mainly derived from the survey with a limited number of current users (ca. 30 people) and it may change if it expands largely in the future.

In terms of organisation, in addition to the basic features listed at the beginning of this subsection, the following two key points were found:

- > The largest challenge is probably 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 aspect is the national legal framework for renting a car which varies from country to country. For example, in Austria, car-sharing is seen as a commercial activity if it is considered as profit-generating (e.g. if the price for car-sharing is equal or higher than the government-set travel cost per kilometre). Thus, as long as CARUSO remains non-profitable, this problem does not arise, while once it becomes profitable, much complexity is expected.

As for the grass-root car-sharing basic characters, the following points were found as the main features.



- The closed group structure and the limited number of the members (up to 30 people) enable almost all members to know each other and it reduces the barriers to use the shared car through the grass-root cooperative car-sharing platform. In addition, this brings about the trust among the group members and thus each member feels higher responsibility to keep the conditions of the cars good.
- The high usability of the online reservation system seems a very important advantage for grassroot cooperative car-sharing: even people with little experience with the internet are able to book on their own.
- In rural areas, the grass-root car-sharing appears to work when it is also used as the official cars of the municipality.
- In cities, the system appears to work when it is employed within a housing complex or in a neighbourhood. This may also be applied in the rural areas; however, there is no working example existing as of yet.
- Typical users are both male and female and balancing. this is in contrast with the peer-to-peer car-sharing users, among which male users are the majority. The users of the grass-root car-sharing are in the age between 26 and 50 and they tend to be highly educated. This implies that the future challenge of the grass-root car-sharing will be how to make it usable for those who are older than 50 and especially than 60, who need more demand-responsive transport.

Conclusions from the case study

- The motivation for car-sharing differs from group to group while one 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 means 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 the second cars in their households. But the focus group interviews showed 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 shared car is for various purposes including shopping, short-term leisure, carrying heavy luggage, private trips such as visiting a doctor or friends. The usage is typically within a 30 km driving range, and the usage on weekdays and weekends balance well. This is in contrast with the peer-to-peer car-sharing, with which the leisure trips longer than 50km 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. Many users also recognise the easy user interface of the booking system as an important advantage. Most of the disadvantages that the respondents refer to are associated with the electric vehicle, especially the driving range of the car and the sparse battery charging infrastructure and are not directly associated with the grass-root cooperative car-sharing itself.
- After starting grass-root car-sharing, the users tend to get aware of their own mobility in various terms such as the idea to choose a suitable transport mode based on the trip purpose as well as the difference between the perceived cost that they are conscious of and the actual cost that they are paying for owning and/or driving cars.
- Survey respondents who do not own a car typically have access to the cars of their family members, relatives and/or friends, while most of them prefer the car-sharing vehicle to such other accessible vehicles.
- As for the experience with ICT, there seems no practical barrier as most of the users recognise themselves as fairly experienced with the internet or any other ICT-based services.
- The concept of car-sharing is well known among non-users in rural areas. Thus this type of carsharing appears to have a large potential to be employed in other rural areas with similar characteristics, where other car-sharing models have been considered unrealistic.



8.11 SANT CUGAT INTELLIGENT MOTORWAY TOLL SYSTEM

The motorway between Sant Cugat and Barcelona is a 13 km toll highway operating since 1991. This motorway, which includes a 2.5 km tunnel under the Collserola hills, had large impact on the attractiveness of Sant Cugat and the Vallès Occidental county as levels of accessibility increased dramatically, inducing an important migration flow of middle and upper class residents from Barcelona. The Sant Cugat population has increased dramnatically, by 60% only since the year 2000 reaching a population of 84.000 people in 2012. Prior to the existence of the motorway, a regular trip from Barcelona to Sant Cugat took approximately 40 minutes, whereas today a regular trip takes no more than 20 minutes during rush hours.

The motorway corridor is also served by a suburban rail line, with service frequencies of up to 3 minutes during peak hours, and allows reaching Barcelona city centre in 25 minutes. Rail and road modes are in direct competition, and the quality of service that each of the modes is able to provide is one of the key elements for users to choose between one or the other.

Tabasa, a public operator, has managed the motorway until December 2012, when it was sold to the Abertis Corporation. It has traditionally pioneered the implementation of smart infrastructure equipment, enabling semi-automatic free-flow toll payment already in the 90s, then introducing automatic incident detection systems inside the tunnel, environmental toll reductions for clean vehicles linked to OBU devices, and more recently a computer based HOV recognition system at tolls allowing for automatic vehicle occupancy detection and fare reduction.

The technical solutions introduced analysed in the Sant Cugat case study are aimed at improving safety, reducing congestion and increasingly becoming environmentally friendly. They are the following:

Automatic detection of high-occupancy vehicles and applications of discounts

Sant Cugat Motorway applies discounts for vehicles with three or more occupants. In order to be able to get the discount, drivers need to belong to the ViaT program, the OBU based system for semiautomated free-flow toll payment linked to a bank account. The client must go through the toll lane signalised as VAO3+; the user then stops the car at the toll and pushes the button to apply for the discount. The plate and the occupants are photographed. The camera recognises automatically the number of occupants. If the system can recognise three or more people, the discount is directly applied, otherwise the picture is validated manually by Tabasa personnel. Discounts are applied at the end of the month through the ViaT program. HOV get a 40% discount.

Environmental discounts for ecological vehicles

Sant Cugat Motorway has implemented discounts for low emissions cars since the 2000s. Users who own an environment friendly car must register on the website <u>www.ecoviat.com</u>, where they need to enter their personal details and their car registration details. Once the service documentation has been completed, users receive an SMS indicating the date from which the discount is activated. Having authorised the registration, when the vehicle passes through the toll a camera system reads the vehicle registration number and reads the ViaT number (DSRC electronic toll), authorising the discount.

The vehicles that can register on the ecoviat program are those with emission ratios under 120 gr/km for gasoline and 108 gr/km for diesel, and also vehicles run by hydrogen, GPL or electricity. ECO vehicles get a 30% discount.

ViaT electronic toll system

ViaT enables users making toll payments on Sant Cugat Motorway on the move, without having to stop. A wide-spread system in Europe today, the motorway was one of the first ones in Spain to implement such system already in the 90s. Once a user has registered the system, being linked to a bank account, an OBU device is sent to him which needs to be installed on the windshield of the vehicle. With the OBU receptor installed, for a vehicle travelling along an electronic toll lane the device is read by the antenna on the lane using a DSRC technology (Dedicated Short Range Communication). If the vehicle is authorised, the transaction is validated and the vehicle is allowed to



pass, and the system automatically charges the toll to the clientop account. The system also recognises recurrent users, who have a right for toll discounts to be applied; and it is also linked to the clean vehicles and the HOV programmes.

The discount for recurrent users is only applied for those travelling off-peak hours balancing the traffic along the day and optimising the capacity of the highway. Recurrent vehicles can get up to a 20% discount for more than 31 trips per month.

Discounts for the toll fare are cumulative, therefore one user can cash up to 90% discount in case of being ECO, HOV and recurrent user.

Automatic incident detection system

The Sant Cugat motorway is equipped with technology in order to automatically manage incidents inside the tunnel, increasing the overall levels of safety. The tunnel is equipped with cameras linked to incident recognition algorithms, which, in case of emergency or of heavy congestion, activate a red traffic light located at the entrance of the tunnel not allowing more vehicles in.

Conclusions from the case study

The analysis of these applications allows for the following final considerations:

- Misaligned interests between the private and public sector. The Sant Cugat motorway has pioneered many initiatives to enforce civic behaviour on the road mode, e.g. increasing average vehicle occupancy and promoting fleets of environmentally friendly vehicles. Being these objectives of general interest, the framework of a public operator managing the motorway was an element facilitating the implementation of these experiences in the corridor, even when at stages where technologies were not yet mature. One year after the sale of the operator to the private sector, discounts are still applied, subsidised by the public administration. However, the general HOV strategy aims at promoting lower vehicle flows, an element that a priori may conflict with the operators legitimate objective of maximising toll income, provided that congestion levels are low enough to maintain traffic flow under capacity limits. It will be interesting to follow the evolution of these programs in the mid and long term.
- Discount linked to frequent users. Discounts for recurrent travellers were introduced by the public administration on motorways to compensate drivers %orced+ to use the motorway for everyday mobility. This initiative is to be understood in a context of high levels of citizen concern about toll systems in Catalonia, mainly motivated by the fact that toll policies in the Spanish motorway network are not harmonised; the existence of tolls, and eventually the level of fares applied, respond more to financing mechanisms and needs, rather than to integrated traffic management criteria. This policy is in conflict with congestion charging initiatives applied in the 2000s in cities like London and Stockholm, having had clear success in reducing congestion and promoting public transport. However, discounts being only available to those travelling off-peak, it can be considered that the system has a management dimension aiming at moving travellers from peak to off-peak periods.
- Complex procedures for obtaining discounts. The impact of behavioural incentives in the Sant Cugat motorway is relatively limited compared to what one would expect (only 36% of users that have the right to apply for an HOV discount are currently doing so, according to surveys by the operator and they represent just 5.74% of the total traffic). A possible explanation to this observation is the fact that discounts can only be applied to users engaged in the ViaT program. The engagement into this program requires a certain number of formalities (e.g. linking it to a bank account), and it has a yearly cost of 12 euros plus a one-time payment of 34 euros for the acquisition of OBU receptor (50% of the highway vehicles use the ViaT paying system, above the average of 40% of the Catalan motorways).



8.12 LATIS: ICT MODELLING IN SCOTLAND REGION 2007 TO 2027

This case study uses the existing transport model for Scotland which is owned by Transport Scotland (The Scottish Government) to produce quantitative estimates for traffic and emission reductions resulting from the potential implementation of two general ICT solutions.

The ICT measures assessed in the case studies generally have a broad range of impacts, the relative impacts of which have been assessed against the COMPASS assessment matrix. This case study aims to quantify some of the potential impacts relative to reduction in CO2 emissions and traffic congestion levels. This quantification is made feasible by the existence of the LATIS model (Land Use and Transport Integration in Scotland) which is an integrated land-use and transport model for strategic assessment across the full Scotland region. The nature of the model is such that the relative impact of possible ICT scenario effects could be assessed across different sub-regions; specifically urban regions, interurban and rural.

The first solution assesses the impact of a **reduction in in-vehicle travel time** on road-based public transport which may be the result of smart ticketing measures. (Other ICT measures such as improved traveller information and bus signal priority may also contribute to the reduction in overall/in-vehicle public transport journey time).

The second solution assesses the impact of increased car occupancy levels which may be achieved by lift-sharing initiatives.





Data collection and analysis for the case study

Model data outputs were extracted from the TMfS07 2007 Base Year, 2027 Do Minimum Forecast year scenario and each 2027 Option Test scenario. The following scenarios were appraised and analysed:

- Test 1 PT: 5% reduction in urban bus journey times (Glasgow, Edinburgh, Aberdeen & Dundee). all journey purposes and time periods. The in-vehicle time (IVT) factor for urban buses was reduced from 1.2 to 1.15;
- Test 2 PT: 10% reduction in urban bus journey times (Glasgow, Edinburgh, Aberdeen & Dundee)
 all journey purposes and time periods. The in-vehicle time (IVT) factor for urban buses was reduced from 1.2 to 1.1;
- Test 3 Car: 5% increase in car occupancy subsequent reduction in AM & PM Peak commuter matrices (Car occupancy increased from 1.03 to 1.08);



- Test 4 Car: 5% increase in car occupancy for *±*ityqorigins . subsequent reduction in AM & PM Peak commuter matrices (Car occupancy increased from 1.03 to 1.08);
- 5) Test 5 Car: 5% increase in car occupancy for <u>±non-cityqorigins</u>. subsequent reduction in AM & PM Peak commuter matrices (Car occupancy increased from 1.03 to 1.08)

Generally, the impacts of each of the tests is relatively marginal (when compared to major schemes such as infrastructure schemes), but some of the measures do start to make an impact with the higher-end assumptions in place. The relatively marginal impacts are likely to stem from some of the test assumptions, whereby the aspects that are changed/appraised here only make up one specific component of travel time. This illustrates some of the challenges of encouraging greater use of public transport or car sharing, but whilst reductions are not large relative to major strategic assessment, the carbon reductions are apparent and in some cases could be quite significant.

First solution: reduction in urban bus journey times as a result of ICT

The change to in-vehicle time (IVT) for urban buses to represent smart ticketing has little effect at a 5% level but the trend associated with decreasing IVT becomes more apparent in the 10% test, where small but consistent percentage decreases may be observed across carbon and CO2 emissions (tonnes) and total v-km. As might be expected, the effects of reduction in PT journey times in the urban regions show some spill over into the adjacent interurban regions and negligible impact into the rural regions. The city of Glasgow would benefit most from a 10% decrease in PT-IVT with a reduction of 108 tonnes of CO2 (equivalent per annum) and a reduction in 1.06 million veh-kms (per annum). Emission/congestion maps (from the model-base year 2007) show that the rural areas are generally uncongested and that reductions are most beneficial within the central belt.

For a 10% decrease in PT-IVT in city regions, v-km driven reduce across all regions ranging from 0% to 0.06% reduction and the annualised CO2 (equivalent) emissions reduce across all regions ranging from 0% to 0.06% reduction. This gives average reductions by region of:

	Urban(City)	0.48 mill-v-km/annum	38 tonnes;
۶	Interurban	0.15 mill-v-km/annum	18 tonnes;
\triangleright	Rural	0.05 mill-v-km/annum	4 tonnes.

Second solution: mobile technology to encourage car sharing

The change to car occupancy levels to represent increased lift-sharing presents much more promising results in terms of quantifiable carbon reduction. If average car occupancy levels were increased from 1.03 to 1.08 across the entire Scotland region, an annualised equivalent CO2 saving of 17,897 tonnes could be made. The modelling suggests that regional effects would produce regional benefits and that the percentage benefits are slightly more favourable in interurban/rural regions than in urban regions, which supports the introduction of lift-sharing schemes in rural areas. The change in both congestion and emissions for a 5% increase in vehicle occupancy caused by lift-sharing is much more significant than for reducing public transport in-vehicle journey time.

	v-km (10 ⁶)			CO2 (tonnes)		
	All	Urban-origins	Non-urban origins	All	Urban-origins	Non-urban origins
Urban	-5.00	-3.82	-1.27	-552	-444	-97
Interurban	-5.20	-1.21	-3.94	-660	-179	-470
Rural	-5.13	-0.45	-4.65	-606	-57	-550

Table 8-5 CO2 savings through car sharing: LATIS model

Significant reductions in overall CO2 emissions could be achieved if national car occupancy increases could be made. Any scheme to promote this objective would be expected to perform well on emission reduction measures. Local schemes however would be expected to benefit the local area, and whilst detailed local schemes have not been specifically tested it, is clear that the location of the origin where the increase in occupancy occurs will produce a strong local effect.



- The effects of this measure were significant for all tests and approximately an order of magnitude greater than for the PT journey reduction of 10%.
- The regional effects were strongly apparent suggesting that local-lift sharing schemes with high take up could produce significant carbon reductions at a local level
- > City based lift sharing schemes would have little impact in rural areas.

8.13 TRANSFERABILITY OF CASE STUDY RESULTS

8.13.1 Method

In the COMPASS project the transferability assessment of each solution analysed within case studies is performed in order to inform on the transferability potential of the experiences investigated as well as to provide a basis for the discussion on the potential barriers which might hamper the diffusion of such kind of solutions. The definition of the COMPASS transferability assessment framework started with a review of transferability approaches recently developed in other European research projects (INTERCONNECT, ORIGAMI, NICHE+). In the approach proposed by COMPASS three main dimensions are considered for the transferability assessment:

- The applicability of the solution;
- The interest for the solution;
- > The feasibility of the solution.

Within the dimension of *applicability*, the spatial area and the demand segment addressed by the solution are the two main components to be investigated. Co-modality refers to solutions that can be implemented in an urban area, in a rural one or at a regional or corridor level and that can intercept different demand segments (i.e. short-distance or long-distance, the latter being also national or international). Within the dimension of *interest* three different groups of stakeholders are considered: the traveller, the operator and the government. The *dimension of feasibility* is investigated in relation to the following sets of stakeholders: financier, regulator, technology supplier and non-users. An excerpt from the COMPASS transferability framework, for applicability and interest, is shown in Table 8-6.

Research question: Is the solution applicable in a different context? VARIABLE VARIABLE				
Urban areas	APPLICABILITY			
Rural areas	APPLICABILITY			
Regions	APPLICABILITY			
Corridors	APPLICABILITY			
Short distance travel	APPLICABILITY			
Long distance travel/National	APPLICABILITY			
Long distance travel/International	APPLICABILITY			
n <u>interesting</u> enough to be useful for other users in a c	different context?			
General Public	INTEREST			
Business travellers	INTEREST			
Leisure travellers/Tourists	INTEREST			
Commuter/Students	INTEREST			
Users of Public Transport	INTEREST			
Car drivers	INTEREST			
Younger people (< 50 years old)	INTEREST			
Senior people (> 50 years old)	INTEREST			
Male	INTEREST			
Female	INTEREST			
Disabled	INTEREST			
Low to medium education (below secondary school)	INTEREST			
High education (above secondary education)	INTEREST			
Low income level	INTEREST			
Medium income level	INTEREST			
High income level	INTEREST			
People with specific interests/preferences/values	INTEREST			
(environment-friendly thinking people, people with				
cooperative values, etc)				
	applicable in a different context? Urban areas Rural areas Regions Corridors Short distance travel Long distance travel/National Long distance travel/International <u>interesting enough to be useful for other users in a of</u> General Public Business travellers Leisure travellers/Tourists Commuter/Students Users of Public Transport Car drivers Younger people (< 50 years old) Senior people (> 50 years old) Senior people (> 50 years old) Male Female Disabled Low to medium education (below secondary school) High education (above secondary education) Low income level High income level High income level People with specific interests/preferences/values (environment-friendly thinking people, people with cooperative values, etc)			

Table 8-6 COMPASS transferability framework



· · · · · · · · · · · · · · · · · · ·					
What is the overall magnitude of	Decreased travel time	BENEFIT			
benefits to users?	Decreased travel costs	BENEFIT			
	Increased reliability	BENEFIT			
	Increased comfort	BENEFIT			
	Increased frequency	BENEFIT			
	Increased quality of information	BENEFIT			
	Improved personal carbon footprint	BENEFIT			
	Increased safety/security	BENEFIT			
	Increased accessibility	BENEFIT			
Stakeholder: Operators					
Research question: Is the solution	n <u>attractive</u> enough for other operators to consider in	another context?			
What is the targeted operator?	Local authorities/district planning managers	ATTRACTIVENESS			
	PT operators	ATTRACTIVENESS			
	Taxi operators	ATTRACTIVENESS			
	Rail operators	ATTRACTIVENESS			
	Road managers	ATTRACTIVENESS			
	Air traffic operators	ATTRACTIVENESS			
	Bike sharing operators	ATTRACTIVENESS			
	Departments of travel (at companies/institutions)	ATTRACTIVENESS			
	Tourist boards / organisations	ATTRACTIVENESS			
	(online) Travel agencies	ATTRACTIVENESS			
	Car clubs operators	ATTRACTIVENESS			
What is the overall magnitude of	Optimised routes	BENEFIT			
benefits to operators?	Optimised use of capacity (vehicles and roads)	BENEFIT			
	Optimised frequency	BENEFIT			
	Increase sales / revenues / number of customersõ	BENEFIT			
	Decrease operating costs	BENEFIT			
What is the organisational	Staff number	REQUIREMENT			
requirement?	Skills and training	REQUIREMENT			
	Space (dedicated areas/warehouses/garages etc.)	REQUIREMENT			
	Administrative structure	REQUIREMENT			
Stakeholder: Government					
Is the solution strategic enough for other governments to consider?					
What are the policies targeted by	Accessibility policies	INTEREST			
the solution?	Public Transport policies	INTEREST			
	Traffic management policies	INTEREST			
	Pollution reduction policies	INTEREST			
	Sustainability (modal shift) policies	INTEREST			

In order to make a cross-cutting analysis the 21 solutions have been clustered according to the categories of ICTs solutions identified in the COMPASS Handbook. 10 clusters were identified:

- > CLUSTER 1 Passenger orientation and guidance
- > CLUSTER 2 Automated fare collection systems (AFC) Ticketing systems
- CLUSTER 3 Access management
- CLUSTER 4 Shared mobility
- CLUSTER 5 Co-modal travel planners
- > CLUSTER 6 Strategic transport management for corridors and network
- > CLUSTER 7 Real time travel information services
- CLUSTER 8 Electronic toll collection
- CLUSTER 9 Demand Responsive Transport (DRT)
- CLUSTER 10 Collective Taxis

Conclusions for specific transferability dimensions (applicability, interest and feasibility) are presented below.

8.13.2 Applicability

ICT solutions were in the case studies investigated in a specific local context, but they can be replicated in different contexts or geographic scales, and for some of them the analysis already provided evidence of their high transferability, as in the case of co-modal travel planners which have been tested from European to urban scales.



It is well-known that the complexity of ICTs architecture inevitably increases with the number of transport modes covered and operators to be integrated, thus making large scale applications more challenging and therefore reducing their ease of transferability. On the other side it should be considered that also the benefits potentially achievable from complex ICTs architectures are higher.

Indeed the analysis performed revealed that most of the investigated ICT solutions can be combined together in order to provide with highly advanced ICT architectures which are capable to combine and amplify the benefits arising from each of them. It is for example the case of integrated real-time information systems that can be built upon a bundle of solutions (e.g. live travel time information at local public transport terminals, live travel time information inside vehicles, live travel time information on mobile phone / internet etc.).

These kinds of architectures are expected to be highly beneficial to transport systems that operate in a great network synergy since they support the management and distribution of any type of information (schedules, infotainment, security etc.), to any transport mode (metro, rail, trams, ferries, buses) making them truly integrated multi-functional information management platforms.

Thus the increased complexity of ICTs architectures is also accompanied by increased potential benefits and this relationship should be further investigated by research projects and real-life applications in order to clearly identify the related cost-benefit dynamics and potential.

8.13.3 Interest for Travellers

As far as the interest for travellers is concerned, the analysis showed that some solutions are expected to be of more general interest for travellers than the others.

It is for example the case of co-modal travel planners whose interest is quite widespread among all travellers, regardless of personal peculiarities. The interest in co-modal travel planners appears to be higher when they cover a larger geographic area since they are expected to provide a higher contribution to the planning of the trip than local applications. Indeed, the planning of shorter distance trips might require less information and information might be also collected from alternative sources (e.g. travellersqinformation points at terminals) or for more regular trips even already known.

Other solutions instead appear to be more specifically dedicated to enhance mobility for some transport modes and/or demand segment (e.g. biometric personal access control or mobile applications for taxi services) and therefore their interest to the general public might be lower.

Car sharing and bike sharing schemes perform generally well as far as concerns their interest from travellersqperspective, even though they appear to be of higher relevance for people with specific preference and values (e.g. environment-friendly thinking people, people with cooperative values etc.). In particular it can be expected that some solutions of shared mobility (e.g. lift sharing and grass-root cooperative car sharing schemes) might be more transferable to those environments characterised by persons with higher cooperative values and more oriented to innovative solutions.

When looking at personal peculiarities, the analysis disclosed that gender seems to be not an issue of preferences for ICTs applied to transport. A certain preference might be instead observed towards the different transport modes supported by these ICTs. It is for example the case of bike-sharing which was quoted to have a higher interest for male users, being this preference apparently not linked to the technology behind, but mainly on the specific transport mode covered and on different inclination to sport activities.

As far as the age of users is concerned, interest for ICT solutions appears to decrease with increasing age. This evidence is more or less widespread amongst all investigated situations, confirming that the digital divide is a general issue all over European countries and zones. Nevertheless the barrier which prevents elderly people to fruitfully access ICTs applied to transport is expected to gradually being removed in the future where the generation of elderly will have higher digital skills and be more used to web services and information.

Generally the benefits for disabled people deriving from ICTs applied to transport are strongly related to the channel of information and to the transport mode supported by the ICTs. It is evident that the nature of impairment plays a fundamental role in both these aspects.



If the information is provided only by visual channels (no audio information) the ICT technology would be useless for blind people. Similarly, if it is provided only through audio channels deaf persons would not profit from it.

In the same way, people with mobility impairment might not benefit from ICTs solutions applied to all the schemes of shared mobility which imply sharing a vehicle (and not a trip). It should be considered that persons with this kind of physical impairment might need specific vehicles customised with equipment able to compensate for their specific impairment. These kinds of vehicles are generally not available in car or bike sharing fleets.

But this is supposed to change in the future. As already pointed out by the COMPASS project in other places, the ageing of the European population will impose new challenges on the development of the European transport systems and the future European economy. Supporting the mobility of physically impaired persons is expected to become a cornerstone of future policies at several levels, and it can be argued that ICT applications and transport solutions specifically devoted to this challenge will gain a significant relevance in the near future.

When discussing solutions and income levels, a distinction should be made about the interest of different income level groups towards ICTs and towards the transport solutions supported by these ICTs. It is obvious that ICTs applied to improve local public transport might be considered of lower relevance for high income people, who are generally less interested in public transport (since they might prefer private mobility). But their interest might radically change when the same ICT solution is applied to long-distance transport modes (e.g. high-speed rail services or flights). It is for example the case of %ive travel time information inside vehicles+ or %ive travel time information at transport terminals+, which might be considered of low relevance for high income people when applied to local PT, but they might be of high relevance when applied to high-speed vehicles and related terminals. Additionally, it can be argued that high income people might be more demanding with regard to the quality and level of information during their journey than medium-lower income people.

The level of interest of travellers for ICTs is strongly related to the perceived benefits deriving from their exploitation: most of them are related to the quality level and to the timing at which the information is delivered to final users. Indeed, information is a high perishable good that should be provided to travellers at the right time and in the right place, otherwise it might be useless. Only information collected before the trip starts can really help improving the planning of the journey (increased reliability of trips by establishing appropriate departure and arrival times). Information received during the journey must be delivered in due time and place to allow travellers to change their journey plan in case of delays or services disruptions. In such a case benefits provided by ICTs are mainly on time savings.

8.13.4 Interest for Operators

The interest of operators towards the diffusion of ICTs applications to transport is strongly influenced by the benefits achievable from their implementation and by the balance between the organisational requirements and the expected benefits. If this balance is not so favourable due to higher organisational requirements, it can be expected that ICTs solutions perform poorly in this respect and therefore the potential for transferability is lower.

The analysis performed showed that mobile applications for taxi services might appear to be of high interest to certain taxi operators (or at least to the share of them supporting the diffusion of these apps) since they are expected to strongly increase their business with minor organisational requirements.

The analysis also disclosed that, despite the organisational requirements, this balance appears to be also favourable for car sharing schemes which might represent an interesting business for dedicated operators as witnessed by the Karlsruhe case, or for DRT in rural areas which is expected to highly reduce operational costs for public transport provision in low density demand zones.

It might be concluded that, under the assumption of reasonable organisational requirements, the higher the benefits in terms of increased revenues, reduction of operational costs, better fleet management and optimised capacity of routes and services, the higher is the interest for operators.

Under the perspective of the balance between benefits and requirements, some ICTs applications might be perceived of less strategic relevance by operators (or at least might be considered not so relevant in all contexts). It might be the case of ICTs applications providing live travel time information to users in those contexts where the information provided has a lower potential to efficiently manage services disruptions (i.e. providing benefits to operators). It is for example the case of live travel time information inside buses or at bus stops in rural areas, where the benefits arising from the delivered live time information to users could be rather limited for operators when no alternative public transport option is in place. In such cases the interest for operators could be mainly justified by the potential of such ICTs in attracting more customers by providing the users with higher quality information. Nevertheless these applications might reveal to not increase per se the number of customers in absence of increased quality of services.

On the contrary, live travel time information provided by automatic incident detection might be of high relevance for road transport operators since they could effectively contribute to traffic management and rerouting for avoiding serious services disruptions.

Smart ticketing is another case where the interest for operators might be strongly limited by the organisational requirements, whose complexity is expected to increase considerably with the number of modes and operators involved thus reducing the level of perceived benefits.

8.13.5 Interest for Government

As far as the general interest of the government is concerned, the analysis of individual solutions disclosed that several of them are supposed to contribute to a different degree in fulfilling the most common strategic transport policies. In particular co-modal travel planners and the most common schemes of shared mobility (i.e. car and bike sharing) are supposed to perform better than the other solutions, since they are expected to contribute to modal shift policies, to pollution reduction policies as well as to the promotion of public transport services and to increase the territorial accessibility.

The cross-cutting analysis also revealed that investigated ICT solutions have a high potential to operate in great synergy; therefore for those situations where the contribution of some of these individual ICT solutions to pursuing specific transport policy objectives might be not substantial when applied individually, their potential in actively supporting the most common transport strategic objectives exponentially increases when they are framed into a more complete information technology framework for transport systems. It can therefore be argued that the interest of the government towards ICTs deployment in transport might strongly increase in the case of more complete technology frameworks.

8.13.6 Feasibility for Financiers

From a financing point of view it emerged that the profitability - evaluated in terms of additional revenues compared with the overall magnitude of costs for the implementation of the solution - for most of the investigated ICTs is low and it is further accompanied by a generally low potential of benefiting from international and also national funding.

Profitability appears to be higher for some emerging applications (i.e. accessibility applications for disabled people, European co-modal travel planners like routeRANK and mobile applications for taxi services) while it is almost zero for live travel time information applications and for those applications targeted at improving road traffic access and management (e.g. incident automatic detection and biometric access control).

This evidence seems to confirm that a central role in the deployment of ICTs by private transport operators is played by the direct benefits achievable by the operators, and this makes many solutions only financially viable, if they are implemented within a more general overall framework of network and fleet management.

8.13.7 Feasibility for Regulators

When looking at the regulatorsqperspective, very different situations emerge from the analysis. Some emerging applications, like the mobile applications for taxi services, have a clear potential to



revolutionise traditional transport markets, while posing problems with respect to established national legal frameworks and consolidated lobby interests.

In some other cases ICTs solutions might pose problems with respect to privacy protection laws. It is for example the case of applications dealing with biometric access control that can raise serious privacy concerns about the ultimate use of the collected information.

In such complex situations the opportunity might be explored to assess the compliance (or not) of these applications at a higher level (e.g. European Union) and to establish common guidelines for their diffusion rather than leaving their regulation at Member Statesq level which might determine a patchwork of different situations across the Union.

Besides these particular situations which might deserve more attention, other solutions appear to be generally feasible. Some solutions are considered to be more demanding in terms of partnership agreements, especially in those cases involving more operators (e.g. smart ticketing); other solutions are instead more demanding in terms of contracts and licenses (e.g. insurance contracts for shared vehicles); others appear of no general complexity from the regulatorsqperspective. But in all of them no insurmountable barriers are ultimately envisaged.

8.13.8 Feasibility for Technology Suppliers

As far as concerns the technology supply, the analysis disclosed that the level of technology to be made available by the end-user for investigated solutions is different. Indeed, several solutions are generally accessible through a smartphone or a PC connected with the web; others require the installation of on-board units or the possession of smart-cards; some others require no devices from the end-user side (e.g. live travel time information inside vehicles or at transport terminals, biometric personal access control, etc.).

In general terms, higher transferability potential can be expected for those solutions requiring no or limited provision of technology equipment by end-users. Nevertheless the diffusion of smart-phones keeps growing in almost all European countries and their cost is expected to be no longer a barrier. But the availability of PCs and smart-phones is not a guarantee of accessibility to transport solutions when these devices are not connected to the web.

Solutions requiring the availability of internet connection might have low transferability to those zones where internet coverage is low (e.g. rural areas). Additionally their accessibility might be reduced when a traveller is in a foreign country and roaming charges may be prohibitive.

When focusing on the operatorsqperspective, the analysis disclosed that some solutions are more demanding in terms of information to be collected, processed and delivered to end-users. It is for example the case for co-modal travel planners, which often require the combination and harmonisation of information provided by different operators.

The quality and nature of existing in-house data sets of different operators might not be compatible as such for a cross-exchange of data and this situation might require further processing and common standards identification, thus limiting the potential of creating multi-modal platforms also in restricted and low budget situations (e.g. rural areas).

Furthermore the analysis disclosed that skills and expertise to develop and/or manage such kind of ICTs applications might be not so commonly available in some zones, thus limiting the transferability potential in these areas.

9 A EUROPEAN ASSESSMENT OF ICT SOLUTIONS

9.1 **OBJECTIVES**

Based on the findings at local scale from case studies and on knowledge gained from the analysis of ICT transport solutions in the COMPASS Handbook, quantitative modelling has then been used to assess the potential impact of ICT solutions at European scale. The assessment of long-distance ICT solutions is based on quantitative modelling using MOSAIC, the European-wide model developed in the INTERCONNECT FP7 research project, a modal choice and assignment module originally programmed to investigate how upgrading the interconnections between transport networks in Europe impacted on the European transport system.

From a demand side, ICT impacts both on trip substitution (e.g. teleworking, teleconferencing) and on induced demand for trips (e.g. enlarged personal and business relations supported by ICT inducing trip demand increases). The net impact of ICT in travel induction and substitution is difficult to assess isolated from other social, economic and technologic drivers. What can be stated, however, is that ICT allows for better real-time management of user needs, transport conditions and externalities, creating incentives for more informed user choices and leading to a more efficient transport system. Increase in demand or decrease due to ICTs has not been considered in the COMPASS modelling.

From a supply side, ICT implementation on transport systems results in: efficiency improvements, mainly through more reliable transport services and vehicles and more efficient traffic management leading to travel time reductions; more efficient infrastructure management, leading to operating cost savings; to the extent infrastructure managers transfer these savings to users, also to travel fees and user cost reduction; and more information to users, increased comfort and convenience, leading to a change in the value of the time perceived by users when travelling⁷.

ICT impacts have been modelled mostly from a supply-side point of view, since these impacts are to some extent specific to ICT implementation, even if they can be promoted or restricted by adequate market regulation.

User behaviour, policies and technologies such as ICT can be translated into four main sets of input variables:

- Commercial and free-flow speeds on road, rail, airport and ferry links,
- Transport fees for rail, air and ferry links,
- Values of time for different types of users,
- > Interconnectivity costs and times between modes.

The most interesting use of a modelling exercise is to investigate the sensitivity of key indicators at the European level (e.g. total costs reduction, total vehicle-kilometre increases, modal shares, emissions...) in relation to assumptions on the input variables defined according to different scenarios.

Three aggregated scenarios of ICT implementation have been defined: low ICT implementation, medium ICT implementation and intensive ICT implementation. Each of the scenarios is defined with a particular set of changes in travel times, travellersqvalue of time, operating costs, and fees applied by modes and by modal interconnections and connections to cities, grouped in four main areas:

- ICT impact on infrastructure managers and service operators,
 - optimised infrastructure and service management,
 - optimised intermodality,
 - optimised traffic management.
- > ICT impact on enhanced user comfort and convenience.

⁷ It has been analysed in the literature how the value users place on travel time varies depending on trip type, people**q** preferences, and travel conditions. The impact of **%**oft-factors+addressing user comfort and convenience is assessed in COMPASS by testing how the model responds to reductions in usersqualue of travel time.



For modelling purposes, seven scenarios are modelled: mid/high/very high ICT implementation impacts on infrastructure managers and service operators, and mid/high/very high ICT implementation impacts on users, as well as a reference baseline scenario.

The extent to which ICT will affect travel times, travellersqvalue of time, operating costs, and fees for long-distance travel depends on the specific ICT system being used and the specific place where it is implemented. ORIGAMI, and previously INTERCONNECT, have reviewed a number of cases in order to get a reference of the magnitudes of impacts, even though these magnitudes are often rough general expectations. Values for the potential ICT impacts have been estimated based on these cases.

9.2 **DEFINITION OF SCENARIOS**

The translation of changes in ICT into models input values is based on the expert judgment of modellers and the COMPASS partnership. In the case of the ICT analysis, the empirical evidence to support this judgment is mostly based on the COMPASS and ORIGAMI case studies and user surveys.

- Optimised infrastructure and service management: road mode benefits most (-2.5%, -7.5%, -12.5% cost reduction) due to better vehicle performance and more efficient driving regimes via semi or fully-autonomous vehicles (it is estimated that more efficient driving regimes can reduce fuel consumption and costs associated to vehicle parts up to 25%)⁸ as well as less congestion (e.g. more intelligent GPS routing avoiding congestion, traffic jam assistants)⁹. Air mode and long-distance rail have moderate improvements (-2.5%, -7.5%, -12.5%) due to more efficient fleet management. Improvements in urban and regional rail from ITS technologies will be dedicated to reduce rail subsidies, so impact on fees paid by users will be limited.
- Optimised intermodality: all road interconnections improve in cost by -5%, -10%, -15% just like general road infrastructure. City-rail interconnections improve like short distance rail, while airportrail interconnections improve like long-distance rail. Time for formalities in airports (e.g. check-in, security, boarding, transits) improves in line with ACARE vision 2020.
- Optimised traffic management: for air mode 5%, 10%, 15% speed increase obtained from more direct routing and better management of take-off and landing operations (e.g. FRAM, A-SMGCS, optimised queue-management software). For rail gains in speed are lower, 0%, 5%, 10%, due to more difficult implementation of ERTMS all over Europe. The road mode has speed increases of 2.5%, 7.5%, 12.5% due to better management of congestion (e.g. ramp metering, HOV/HOT lanes, variable speeds) and more autonomous vehicle driving (e.g. SARTRE platooning, advanced cruise control). Limited ferry speed improvements are linked to better information protocols between ships and ports.
- In relation to enhanced traveller comfort and convenience: reduction of the perception of travel time costs by 5%, 10% and 15% for all trip purposes, 10%, 20% and 30% for business trips because it is expected there will be more intensive technology implementation in more expensive travel services.

Based on the previous discussion, the values of parameters for baseline and the relative variation of the three scenarios are presented in the next table. The baseline is considered to be a scenario with low ICT implementation.

The selected horizon of analysis is 2030. The base of the modelling exercise is the TEN-CONNECT transport matrix OD for 2030, produced with TRANS-TOOLS, and already used in the ORIGAMI FP7 project.

http://www.racq.com.au/__data/assets/pdf_file/0005/4973/FactA4_EcoDriving.pdf

⁸ ‰co-driving easily saves 10-15% fuel reduction on average+according to FIA: <u>http://ec.europa.eu/transport/road_safety/pdf/ersd2012/gabriel-simcic.pdf</u> ‰co-driving allows for average savings in fuel consumption up to 20% without reducing average speed+

according to RACC foundation: <u>http://w3.racc.es/index.php?mod=paginas&mem=detalle&id=100013&relmenu=1174</u> %Rlanning your route can avoid delay and diversion. Ten minutes of unnecessary driving in a one-hour trip results in a 14% increase in fuel consumption+according to Australian Automobile Association



Table 9-1 Quantitative definition of scenarios mid, high and very high ICT implementation impacts on users

		units	Baseline	Mid ICT	High ICT	Very High ICT
	Road direct costs paid by the user (tolls and vehicle operation)	" /km	0.15	-2.5%	-7.5%	-12.5%
Optimised	Rail interNUTS3 SD user-fees	" /km	0.09	0%	0%	-5%
infrastructure	Rail interNUTS3 MD user-fees	" /km	0.15	0%	0%	-5%
and service management	Rail interNUTS3 LD user-fees	"/km	Baseline Mid ICT High ICT Vertig ICT 0.15 -2.5% -7.5% -12. 0.09 0% 0% -5 0.15 0% 0% -5 0.15 0% 0% -5 0.15 0% 0% -5 0.15 0% 0% -5 0.2 -2.5% -7.5% -12. Variable -2.5% -7.5% -12. Variable 0% 0% -5 Variable -5% -10% -15 Variable -5% -10% -15 Variable 0% 0% -5 Variable -5% -10% -15 Variable -2.5% -7.5% -12. 90 70 50 3 Variable 2.5% 7.5% 12. Variable 0% 5% 10 Variable 0% 5% 10	-12.5%		
U U	Air user-fees	"/km	Variable	-2.5%	-7.5%	-12.5%
	Ferry fees	" /km	Variable	0%	0%	-5%
	City-road local connection speed	km/h	Variable	-5%	-10%	-15%
	City-rail local connection speed	km/h	Variable	-5%	-10%	-15%
	Airport-road local connection speed	km/h	Variable	0%	0%	-5%
Optimised intermodality	Rail-road local connection speed	km/h	Variable	ICT ICT ICT H 5 -2.5% -7.5% -12 6 0% 0% -4 7 0% 0% -4 7 0% 0% -4 7 0% 0% -4 7 0% 0% -4 10 -2.5% -7.5% -12 10 -2.5% -7.5% -12 10 0% 0% -4 10 -2.5% -7.5% -12 10 -5% -10% -1 10 -5% -10% -1 10 -5% -10% -1 10 -2.5% -7.5% -12 10 -2.5% -7.5% -12 10 -2.5% -7.5% -12 10 -2.5% 7.5% 12 10 0% 5% 1 10 0% 5% 1 <t< td=""><td>-15%</td></t<>	-15%	
interneticality	Airport-rail local connection speed	km/h	Variable	-2.5%	-7.5%	-12.5%
	Time spent at airport terminals (check- in and security formalities; transits between consecutive flights)	minutes	90	70	50	30
	road speed	km/h	Variable	2.5%	7.5%	12.5%
Optimised traffic	rail speed	km/h	Variable	0%	5%	10%
management	air speed	km/h	Variable	5%	10%	15%
	ferry speed	km/h	Variable	0%	0%	5%

		units	Baseline	Mid ICT	High ICT	Very High ICT
	Commuter VOT	" /h	10	-5%	-10%	-15%
Enhanced	Private VOT	" /h	10	-5%	-10%	-15%
traveller comfort and convenience	Holiday VOT	" /h	7.5	-5%	-10%	-15%
	Business VOT	" /h	25	-10%	-20%	-30%
	Car occupation	users	1.5	1.75	2.0	2.25

9.2.1 Impacts Resulting from Optimised Service and Infrastructure Management with ITS

Road modal share increases in each consecutive scenario

The increased intensity of ICT solutions on the transport system in the COMPASS scenarios results on the road modal share increasing from 69.8% in the Baseline to 71.2% in the *very high ICT* scenario.

The reason behind this increase is the higher decrease in the cost of interconnections involving the road, as the decrease in travel costs and fees is assumed to be the same for all modes simultaneously. Higher performing interconnections between the road mode and all others imply allowing easier access to the road mode. This fact, in combination with a relatively high increase in speed makes roads more competitive, gaining modal share.

The improvement of road interconnections with other transport modes is mostly related to the decreasing congestion levels of metropolitan motorways, represented in COMPASS by *city to road*, *rail to road* and *air to road* connectors. This can be achieved via a number of different ITS solutions applied to urban and metropolitan motorways, such as the implementation of dynamic speed limits,



active hard-shoulder management, or ramp meters in accesses (infrastructure management dimension). It can also be addressed with smarter on-board route assistants for vehicles that consider real-time congestion on the network, advanced driver assistance systems (ADAS) that allow for more stable traffic flows, or with traffic jam assistants that allow quicker dilution of congestion waves (service management dimension).



Figure 9-9-1 Modal Split variation between COMPASS scenarios. Scenarios impacting on service and infrastructure management

Rail modal share decreases initially but then recovers between mid and high/very high ICT scenarios

It is observed that while the rail modal share decreases from 6.2% to 5.8% between the baseline scenario and the *mid ICT* Scenario, it is then able to recover its initial share of 6.2% between the *mid ICT* Scenario and the *very high ICT* Scenario.

The reason behind this behaviour is the different speed increases on each of the transport modes in the long-distance segments of the network (e.g. in the HSR, motorways, air flights and ferries). Whereas between the baseline and the *mid ICT* scenario, the road mode increases network speed on a 2.5% and the air mode in 5.0%, the rail mode is assumed not to increase. Then, between the *mid ICT* and the *high ICT* Scenarios, the rail mode begins increasing speed, up to 5% in the *mid ICT* scenario (7.5% for road and 10% for air) and 10% in the *very high ICT* Scenario (12.5% for road and 15% for air).

When rail gains operational speed, it also gains competitiveness against other modes in a much faster proportion, allowing it to recover initial modal share. The air mode, by comparison, is not able to materialise the greater increase in average operational speeds, and keeps losing modal share from 23.0% in the baseline to 22.7% in the *mid ICT* scenario to 21.8% in the *very high ICT* scenario.

The speed increases in the air mode are assumed to derive from more direct routing of flights facilitated by more integrated air space management (already tested by EUROCONTROL¢ FRAM pilot initiative above the skies of Maastricht); it is also assumed that planes can fly closer to each other due to more accurate radars (satellite based ADS-B successor to radar); and that take-off and landings are faster at airports as surface movements become optimally managed with new initiatives such as A-SMGCS. Ensuring better punctuality of flights allows for faster terminal transits during plane connections, which can be reduced from 90 to 30 minutes (according to ACARE¢ ‰lightpath 2050+the goal is to reach that all flights arrive within 1 minute of the planned arrival time regardless of weather conditions).

Speed increases in the rail and road modes derive from technologies ensuring safety at higher speeds. In the case of rail, ERTMS is to allow for greater operating speeds (as trains are able to



autonomously regulate operating speeds and automatically break in case of emergency with lower reaction times) and services can operate closer to each other (more service frequencies in busiest corridors). For cars, many devices aimed at increasingly autonomous driving regimes (e.g. ADAS, car platooning like in SARTRE, robotically driven cars such as Audios TT trial or Googles) allow for increased driving speeds at motorways without compromising safety, vehicle-to-vehicle communications on VANET platforms (Vehicular Ad-hoc NETworks) allow anticipation of incidents on the road before vehicles reach hot spots, or even vehicle-to-infrastructure communications allow for vehicles anticipating bad road conditions or eventual traffic speed restrictions.

More vehicles on the network, more emissions and fuel consumption, but less overall network usage in passenger kilometres and particulates

The increase in use of road mode results in up to 1.8% increase in the number of vehicles in the network. This seems contrary to the fact that passenger-kilometres decrease a little, but is explained due to the modal shift from air, rail and maritime to the road, as these modes use high occupancy vehicles and a large number of cars are needed to substitute them.

Road vehicle kilometres increasing implies an overall increase in fuel consumption, up to 4.5% respect to baseline, and CO2 emissions, up to 4.3%. The increase in road is greater than the decrease in air and maritime fuel consumption (under the hypothesis that engine efficiencies are not relatively altered between scenarios and modes). Vehicle kilometres increase in the road mode are driven by the attraction of passengers in a mode where vehicles have less capacity (road is less occupancy-efficiency). Also, speed increases on the road, air and maritime modes increase the overall levels of fuel consumption.

An overall decrease on particulates emissions is registered simultaneously, up to almost 7%, due mainly to reduction of maritime and air traffic. These modes are the highest particulate emitters.

Despite the fact of having more vehicles on the network and greater volumes of vehicle kilometres, there is a total decrease of -0.25% passenger kilometres for higher ICT Scenarios. This suggests that moving traffic from air and rail modes to the road results in slightly shorter trips per passenger, even though transport is less efficient as it moves fewer passengers per vehicle on average.



CO2 (Mtons)

Figure 9-2 CO2 emissions: different ICT Scenarios impacting on service and infrastructure management



9.2.2 Impacts Resulting from Changing Travellers Behaviour and Perceptions of Travel Time Cost Driven by ITS

Decreased travel time costs perception as a result of better information and comfort favours road preferentially

According to the literature, the value users place on travel time varies depending on the type of trip, peoplec preferences, and travel conditions. The impact of &oft-factor+ solutions addressing user comfort and convenience is assessed in COMPASS by testing how the model responds to reductions in the value of travel time of users. In particular, the value of travel time is lowered evenly for all passengers alike (business, private and tourists) and in all modes of transport, a total of -5%, -10% and -15% in relation to baseline for the *mid ICT*, *high ICT* and *very high ICT* scenarios respectively.

The presumed impact is the increase of road modal share, from 69.8% in Baseline to 71.1% in *very high ICT* scenario. ICTs, provided that they are able to impact evenly on the perception of travel time costs on users in all modes to the same extent, increase the attractiveness of the road mode more than others.



Modal split

Figure 9-3 Modal split variations among COMPASS scenarios. Scenarios impacting on user perception of travel time costs

It can be discussed to what extent ICTs can impact on all modes alike:

On public transport modes (i.e. air, rail and ferry), there are many &oft factor+ solutions which have an impact on the way users perceive travel time. Real-time information to users on service operation reduces the uncertainty of passengers when waiting at stops. Collaborative P2P information networks on public transport service operation and eventual service disruptions allow passengers to seek alternatives, or to handle exceptional situations with lower levels of stress. Travel planners on smartphones allow users to seek routing assistance at all times, reducing the possibilities of using wrong travel choices or getting lost. Increased amenities in vehicles (e.g. WiFi internet) or allowing more informed pre-trip seat choices (e.g. seat allocation in planes based on social network profiles, or on collaborative P2P aircraft information as in SeatGuru) allow more convenient and comfortable journeys, especially on very long trips.



- On the other hand, Litman (2011) points out that the road mode seems to be the mode that better understands the willingness of passengers to maximise their comfort and convenience. In fact, the basic engine and safety performance of vehicles these days is ensured by all makes alike provided that drivers respect road regulation (e.g. speed limitations, minimum resting during longer trips, no drug use, no drinking). The vehicle industry is therefore constantly working on increasing the comfort of cars to provide added value to car owners, through:
 - More spacious interiors, better materials, less noise from the engine, more performing entertainment systems (e.g. music, DVD) increases the comfort of users and passengers.
 - Having pioneered in route planning applications with early GPS devices, new vehicles now increase the information to users by considering real time congestion when proposing routes, and with many new possibilities arising from upcoming systems such as VANET.
 - Semi-automation solutions for certain driving operations are in constant development, such as automatic vehicle parking assistants, traffic jam assistants and smarter cruise control devices
 - New ICTs to ensure that vehicles are safer in all traffic and weather conditions (e.g. head-up display, night vision, automatic pedestrian detectors, pre-crash systems), reducing the levels of stress for drivers.

In its clearly user-targeted strategy, the car industry is successful in constantly reducing the perception of travel time cost by users. All these **%**oft-factors+not having direct impacts on travel time may result in a given journey being perceived as shorter for a car compared to other modes, especially for trips under a certain range threshold. For longer trips, the rail mode is most likely to take the same approach to compete better with the air mode.



10 FINAL CONCLUSIONS AND RECOMMENDATIONS

10.1 **OVERVIEW**

The conclusions and recommendations of COMPASS have been developed with reference to the projector general objectives formulated as:

- 1) The provision an overall picture of the future travellers needs in the light of the key socioeconomic trends;
- 2) The analysis how ICT and ITS applications can meet the new demands, favouring the integration of multimodal transport solutions;
- 3) The assessment how these solutions can contribute to the de-carbonisation of transport activities.

In such a framework, the following collateral and important objectives were also addressed:

- 4) The potentials of the ICT and ITS applications to provide behavioural data and information to improve travel surveys and fostering harmonisation;
- 5) The validation of the ICT solutions with stakeholders rooted in the national contexts, due to the involvement in the project of TTS Italia, member of the ERTICO National Network of ITS Associations.

The fundamental research questions of COMPASS are whether, and to what extent ICT and ITS solutions can influence de-carbonisation of transport activities. This main focus of COMPASS research is based on the analysis of factors and challenges determining the shape of future mobility. Project results can be viewed from two perspectives: external factors in wider society, and internal factors in the transport sector. The external perspective consists of a complex analysis of factors determining trends on mobility, while the internal perspective covers evaluation of solutions in the light of traveller needs. There are two domains of COMPASS research in that area:

- Main research studying the contribution of ICTs to reduced CO2 emissions;
- Supplementary research studying the problem of providing behavioural data through widespread use of ICTs.

The contribution of ICTs to reduced CO2 emissions has been analysed in COMPASS on three different levels:

- > Elaboration of a *Handbook of ICT Solutions* improving co-modality,
- > Realisation of 11 case studies covering various ICT solutions in different European regions,
- European assessment of ICT solutions through scenarios analysis.

Finally, some conclusions are presented regarding the problem of strengthening the potential and opportunities for positive influence of ICT solutions. Firstly, a wide dissemination and validation of the ICT solutions with stakeholders is necessary and this was one of the specific COMPASS tasks. Secondly, a transferability assessment of ICT applications was performed in order to analyse the transferability potential of the solutions investigated as well as to provide a basis for the discussion on the potential barriers which might hamper the adoption of these solutions. Thirdly, business models have been elaborated in COMPASS in order to present a way to promote implementation of ICT solutions.

The main conclusions for the above mentioned areas, drawn from the previous chapters of this report, are highlighted in the following subchapters.

10.2 WHAT ARE THE KEY TRENDS INFLUENCING MOBILITY PATTERNS IN THE FUTURE?

10.2.1 Problem Statement

Transport demand is generally examined by placing the sector itself at the centre of the analysis, and investigating variables that influence the changes to mobility and transport patterns. However,



transport demand is also generated by wider societal factors that are exogenous to the transport sector and these are the subject of the investigations in COMPASS.

10.2.2 Main conclusions

The analysis framework in COMPASS was based on the four defined domains - social, technical, environmental and economic - in order to identify the main drivers potentially impacting on future mobility. Each domain could play an important role in reshaping future mobility; each domain has relevant driving forces that, on their own or in combination with others, could substantially impact on transport demand. In most cases it is difficult, if not impossible, to predict the scale and timing of such impacts. The speed by which environmental and technological shifts could take place is difficult to predict, and thus their impacts on the planning and development of the future transport system remain uncertain. As witnessed by the current European situation, it is also difficult to predict the secondary impacts of this on the overall mobility of people and goods. Less challenging could be the prediction of the impacts deriving from demographic factors whose dynamics, unless there will be disruptive events, can be more easily understood and forecast.

10.2.3 Recommendations

Future planning and policy making in the transport sector increasingly need to take into account the potential alternative developments of mobility patterns and traveller needs arising from the evolving dynamics outside the sector.

Under a wider perspective it could be also envisaged for policy makers active in all the investigated domains to work in a more cross-sectoral way and to develop joint policy frameworks capable to exploit the full potential of driversq interactions for influencing the future changes on a more sustainable track.

Nevertheless, COMPASS research pointed out that it is very hard to identify and clearly outline the dynamics of key drivers interactions and potential magnitude of effects and therefore more research is needed in this respect.

Also, data gaps should be addressed by more focused research on the travel behaviour and needs of specific user groups (older, mobility-impaired, migrant groups etc.) which will make up increasing numbers of future European travellers.

Indeed, the need of major investigations on key drivers and future travellers needs appears as one of the cornerstones of the future research framework HORIZON 2020.

In parallel with research on drivers and travellers behaviour, innovative system-dynamics modelling tools could (and should) be developed in order to support the development of European alternative, long-term and wide-vision scenarios capable to explore the complexity of the transport system and its interactions with all the domains of human activities.

10.2.4 Further Reading

- > COMPASS D3.2 Key Trends and Emerging Traveller Needs
- Roadmap for future mobility and transport available on-line: http://www.fp7-compass-keytrends.eu/
- Library for key drivers available on-line: http://www.fp7-compass-keytrends.eu/index.php?Itemid=132



10.3 WHAT ARE THE TRAVELLER NEEDS FOR URBAN, METROPOLITAN AND RURAL TRAVEL?

10.3.1 Problem Statement

According to the 2001 Transport White Paper (CEC, 2001) users are at the heart of transport policy. In a review of Common Transport Policy (CEC, 2009) the EC stressed <u>the need to focus future</u> *European transport policy on the pursuit of an integrated, technology-based and user-friendly transport system ...whilst ensuring that users, with their needs and rights are always kept at the centre of policy making*.q In the context of the COMPASS project, traveller needs are an important factor determining the implementation of ICT solutions allowing the integration of multimodal transport solutions.

10.3.2 Main Conclusions

A total of 16 key user needs for short-distance intermodal journeys have been identified and described. These key user needs are identical to those identified for long-distance intermodal journeys, which suggests these needs are generic for all intermodal journeys, irrespective of distances involved. These traveller needs concern both physical and psychological aspects, covering network characteristics, interchange and baggage handling facilities, information and ticketing issues, and more subjective needs such as environmental concerns or comfort.

In addition to the identification of usersqneeds, where personal and situational factors are known to influence the relative importance of each need, this is also highlighted. The relative importance attached to each user need, as well as specific attributes of these broad user requirements is shown to be dependent on both personal factors (age, mobility-impairment, gender and migrant status) and situational factors (trip purpose).

10.3.3 Recommendations

Further research is needed in order to establish the relative importance of user needs to each other. Additionally, there is also considerable evidence that if £ertainquser needs are unmet, this can prevent people from making certain journeys. However, the relationship between user requirements and modal choice decisions is complex and also dependent of the personal attributes of travellers as well as their trip purpose, and prevailing conditions (service provision, costs) according to location. To fully understand this complexity, further research is also needed.

10.3.4 Further Reading

> COMPASS D3.2 Key Trends and Emerging Traveller Needs

10.4 CAN ICT SOLUTIONS MEET NEW DEMANDS AND CONTRIBUTE TO DE-CARBONISATION?

10.4.1 Introduction

The decarbonisation policy is becoming more and more important concern for EU citizens and as such has been given primary attention by the EU policy makers. Transport is one of the areas where substantial contributions to the decarbonisation of EU economy could be made. ICTs are perceived as one of the possible tools allowing to meet this goal. In COMPASS the impact that ICT solutions could have on de-carbonisation is discussed in:

- > COMPASS D5.1 Handbook of ICT Solutions for Improving Co-modality in Passenger Transport
- COMPASS case studies
- European assessment of ICT solutions through scenarios analysis.



10.4.2 COMPASS Handbook of ICT Solutions

Problem Statement

Many ICT examples reviewed within COMPASS provide valuable insights as to the way ICTs work in different settings, and are contained within an extensive database of ICTs that are shown to work well. These successful applications of ICT solutions result in optimised, more accessible and less resource consuming transport which is less emission intensive. The COMPASS Handbook is designed as a tool to allow for dissemination of these good practice examples. The COMPASS Handbook of ICT solutions brings together a set of 92 examples including those that apply to urban and metropolitan mobility and long-distance passenger transport, and also those that provide innovative ICT solutions aimed at increasing the quality of transport services in areas where demand levels are low, like rural or sparsely-populated regions.

Main conclusions

All identified ITC solutions were grouped into a number of broad categories:

- Transportation management systems . covering ICTs which aim is to help planning and running the transport system in efficient manner;
- Traveller information systems . solutions designed in order to provide travellers with information (travel time, routes, traffic conditions, etc.);
- Smart ticketing and tolling applications ICTs addressing ways to get tickets and to pay for using transport services;
- Smart vehicles and infrastructure . including:
 - ICTs aimed at improving vehicle operation,
 - Vehicle- to-Vehicle (V2V),
 - Vehicle- to- infrastructure (V2I) communications,
- Demand-responsive transport (DRT) and shared mobility systems . covering ICTs fostering transport services adjusted to demand.

Several sub-themes within those main groups were further established and solutions within these groupings were identified and described. For transport management systems sub-themes include ICTs designed for urban traffic control, road transport management, strategic transport management for corridors and networks, public transport management, railway traffic management, air transport management and maritime transport management. For traveller information systems sub-themes include passenger orientation and guidance, co-modal travel planners, real-time travel time information services, vehicle positioning information systems, and parking-management systems. Smart ticketing and tolling applications encompass ICTs useful in electronic toll collection, access management and automated fare collection systems. Smart vehicle and infrastructure solutions range from ICT¢ for autonomous driver-assistance systems through cooperative vehicle-to-vehicle applications to vehicle-to-infrastructure applications. Demand-responsive transport solutions include ICTs useful for public transport services in low-demand situations and shared-mobility schemes.

All specific solutions have been evaluated against major factors determining their performance. These factors were grouped in four divisions:

- Feasibility, which covers investment costs, operational and maintenance costs, financial viability, technical feasibility, organisational feasibility, administrative burden, legal feasibility, user acceptance, public acceptance;
- Interest to travellers, which covers door-to-door travel time, door-to-door travel cost, comfort and convenience, safety, security, accessibility for mobility impaired;
- Impact on modal change, which covers car usage, bus and coach usage, rail usage, ferry usage, aeroplane usage and;
- Other impacts, which covers mobility, congestion, CO2 emissions, contribution to user pays principle, contribution to European economic progress.

Recommendations

The practical assessment of real-life ICT solutions through performance factors analysis is a useful tool for the selection of the optimal ICT solution for a particular set of circumstances. The COMPASS Handbook should therefore be used as a reference case database by all those willing to introduce ICTs. The Handbook helps to analyse whether a particular solution fits well into particular conditions. Having certain characteristics and being able to compare to the scores for relevant real life cases from the Handbook makes it an efficient policy support tool.

Further reading

- COMPASS Handbook website <u>http://81.47.175.201/compass/</u>
- > COMPASS D5.1 Handbook of ICT Solutions for Improving Co-modality in Passenger Transport

10.4.3 Case Studies

Problem statement

The objective of the COMPASS case studies was to 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. A balanced set of case studies was necessary in order to provide answers for variety of possible setups. The applicability of ICT solutions in different thematic topics and geographical coverage, varied urbanisation levels as well as diversity of ICT solutions themselves were crucial to this problem.

Main conclusions

The conclusions of the case studies are case dependent and cannot be treated as one EU-wide response to the ICTs. Certain trends are however visible regardless of regional differences.

Firstly, there is relatively high acceptability among users. Users generally welcome introduction of ICTs. This is however very dependent on user age with older users more often rejecting ICTs than younger. Secondly it is visible that user acceptance is combination of many sub factors of which most important are D2D travel time, D2D travel costs, comfort and convenience. Most ICTs - as case studies confirm - contribute to travel time reduction and comfort increase. While travel cost can increase or decrease in response to ICTs an increase in punctuality and reliability and a reduction in delays are often first visible effects of ICTs. The major barrier for ICTs application revealed by case studies is that of financial nature. Users are generally unwilling to pay extra for ICTs. Only limited profits for operators could result from increased demand or optimised use of resources gained through ICTs. From the society point of view ICTs could contribute to achievement of CO2 emissions reduction or increased territorial cohesion or they may facilitate economic progress. Accordingly to case studies reduction in CO2 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.

Recommendations

Detailed recommendations are case specific but some general advice to policymakers might be formulated. ICT solutions could be introduced into transport system without much opposition from users and with no substantial legal or organisational barriers. There are however high financial barriers resulting from high initial investment needs accompanied by moderate maintenance costs. This is reinforced by user general unwillingness to pay. ICTs are most useful when they are created on the lower level as response to particular transport problem that local community or particular transport provider faces. Then financial efficiency is more likely to follow. Those ICTs are however introduced with comfort and travel time reduction goals in mind. More general societal goals like CO2 emissions reduction are by-product and are not main intention of developers of ICTs. If governments would like to support ICTs and treat them as a tool helping combat emissions (or to achieve any other general transport policy goal) it would require their financial involvement as economic validity of large ICT schemes for operators is questionable.



Further reading

> COMPASS D6.1 User Response to Suggested ICT Solutions

10.4.4 EU Assessment

Problem area

The case studies provide local scale ICT impact analysis while the Handbook gives insights into the variety of possible tools which can be used in ICT role. The aim of EU assessment was to combine those findings into scenarios representing possible futures of EU transport on a large scale.

The net impact of ICT in travel induction and substitution and resulting decarbonisation effect is difficult to assess isolated from other social, economic and technologic drivers. ICT allows for optimisation of transport use - better real-time management of user needs, more efficient provision and management of services, creation of incentives for more informed user choices, all leading to a more efficient transport system.

Main conclusions

Three possible situations in regard to ICT intensity have been defined: low ICT implementation, medium ICT implementation and intensive ICT implementation. Each of the scenarios is defined with a particular set of changes in travel times, travellersqvalue of time, operating costs, and fees applied by modes, as well as by a network of modal interconnections and connections to cities. This has specific (and different) impacts on user and operator sides. Through modelling, these base scenarios are extended to follow different paths providing seven possible futures: mid/high/very high ICT implementation on infrastructure managers and service operators, and mid/high/very high ICT implementation impacts on users, as well as a reference baseline scenario.

The results show that the extent to which ICTs will affect travel times, travellersq value of time, operating costs, and fees for long-distance travel as well as total CO2 emissions depends on the specific ICT system being used and the specific place where it is implemented. Detailed results show, for instance, that if optimised infrastructure and service management is the main effect of ICTs introduction into the transport system then it is road mode which benefits most. For mid/high/very high ICT intensity scenarios figures are: -2,5%, -7,5%, -12,5% cost reduction while air mode and long-distance rail have moderate improvements (-2,5%, -7,5%, -12,5%). If optimised traffic management is the main result of ICTs then figures are: for air mode - 5%, 10%, 15% speed increase while for rail gains in speed are lower - 0%, 5%, 10% and road mode has speed increases of 2,5%, 7,5%, 12,5%. If enhanced traveller comfort and convenience is the main ICT contribution then reduction of the perception of travel time costs by 5%, 10% and 15% for all trip purposes is expected and of 10%, 20% and 30% for business trips. The scenarios allow for exploration of those alternate macro-level futures.

Recommendations

Regardless of the scenario adopted there is a general road use increase. ICTs, provided that they are able to impact evenly on the perception of travel time costs on users in all modes the same, increase the attractiveness of the road mode more than others. It is therefore impossible to reduce road use without severe government intervention, which will decrease positive effects of ICTs on comfort and convenience. But the overall negative effects for sustainable development could be reduced due to ICT simpact on reduction of congestion and resulting decrease in emissions. Thus, efforts should be concentrated on city congestion-reducing ICTs in order to achieve CO2 emission decreases. Also rail modal share decreases initially after widespread introduction of ICTs into the transport system but then recovers between mid and high/very high ICT scenarios. When rail gains operational speed, it also gains competitiveness against other modes in a much faster proportion, allowing it to recover from initial low modal share. Thus, those ICTs which promote seamless rail travel should be of primary importance. All scenarios predict more vehicles on the network, more emissions and fuel consumption, but less overall network usage in passenger kilometres. Despite that fact of having more vehicles on the network and greater volumes of vehicle-kilometres, there is a total decrease of -0.25% passenger kilometres for higher ICT scenarios. This suggests that moving traffic from air and rail modes to the road results in slightly shorter trips per passenger.



Further reading

COMPASS D6.2 An Assessment of the Potential Impact of ICT Solutions on a Co-modal Transport System

10.5 CAN ICT SOLUTIONS IMPROVE PROVISION OF BEHAVIOURAL DATA?

10.5.1 Problem Statement

Behavioural data is a key in transport planning as it will allow forecasts of future travel demand with models, which enables decision making in transport policy, especially investments into the infrastructure, to be made more rationally. Here ICT solutions could contribute to carrying out travel surveys in more digitalised manner putting less burden on the respondents, and eventually to harmonising various national travel surveys throughout Europe through a standardised technique. However, the matching and/or gaps between such newly appearing survey techniques and the needs for data, as well as the limitation of such new technology have not been well understood. This led to the formulation of the three key issues: 1) Which indicators are needed by the travel demand forecast method? 2) Which information/indicators are needed by which stakeholder? 3) What types of method with/without ICT solutions can be best used to collect the data for each indicator?

10.5.2 Main Conclusions

Overall, ICT technologies are still not widely used for travel surveys at the time of this research, although a number of experimental ICT-based travel surveys have been carried out in different countries. GPS-enabled mobile devices such as smartphones appear to be the most promising, but also data mining from other data sources such as smartcards used for fare payment has to be sought more in the future. The experimental ICT-based travel surveys have shown that it is basic indicators that tend to be collected with ICT-based methods. However, among the indicators required by models to forecast the future travel demand and the ones of interest to various stakeholders, some are not able to be collected with the ICT-based travel methods, unless the respondents are asked to put this information in manually, such as car occupancy. Imputation of travel mode and trip purpose still remains challenging. The current rapid development of ICT-based travel survey will be carried out more, especially when necessary components for ICT-based travel surveys such as a detailed point-of-interest databases covering wide areas on a GIS system exist. The difficulty might however arise from the issue of privacy protection and this has to be addressed.

10.5.3 Recommendations

Since ICT-based travel survey methods have a possibility to transmit and process the data quickly at lower costs, it is recommended that the ICT-based travel surveys are used to collect basic travel behaviour indicators on a regular basis more frequently than the conventional methods - for example, annually. However, the indicators that can be collected by them are limited and there are several ICT-peculiar underrepresented groups, and therefore questionnaire-based surveys are recommended to be kept as an alternative surveys means, but that they are carried out less frequently than the ICT-based surveys, such as every five years, to cover a wide range of representative respondents for more in-depth behaviour analysis. Here, *%* additional+ methods include field work methods and telephone-based surveys (CATI: computer-assisted telephone interview) as well as web-based surveys. In this way, the gaps between the ICT-based data collection and the data requirements by transport professionals are filled.

Public transport smartcards will also be able to provide mode-specific location data; thus integration of such smartcard logs to the travel survey data will have to be sought. If each card's data can be combined with the card owner's surveyed data (which would require permission from the travel survey respondents), this will potentially be advantageous in that it provides accurate information about the travel mode as the mode imputation of public transport faces difficulty in terms of accuracy.

Organisationally, as various stakeholders tend to be interested in similar sets of indicators, it is recommended that a specialised % bavel data collection association+ comprising of the operators, authorities, practitioners, modellers, researchers, and so on is formed as an expert organisation that carries out travel behaviour data collection. This will eliminate the duality of data collection activities



among the various stakeholders, while it will increase the data availability at one-stop. This will also reduce the survey respondentsquarden as similar surveys are not repeated by different organisations.

10.5.4 Further Reading

> COMPASS D4.2 The Role of ICT in Travel Data Collection

10.6 How Can the Influence of ICT Solutions be Strengthened?

10.6.1 Introduction

The identification and analysis of ICT solutions favouring the integration of multimodal passenger transport is not an end in itself. Specific solutions identified in case studies and described in a handbook remain still in their separate environment. Therefore the question is how to extend and promote the application of these solutions and strengthen the positive impact on de-carbonisation.

In COMPASS project three types of activities have been carried out:

- Dissemination and validation of ICTs with stakeholders . with the aim of disseminate information regarding applications and experiences of its implementation and use as well as validate ICTs with stakeholders.
- Transferability analysis . with the aim to assess transferability potential and to provide a basis for the discussion on the potential barriers.
- Business modelling . with the aim of promoting ICTs implementation.

10.6.2 Dissemination and Validation of ICT Solutions with Stakeholders

Key dissemination areas were the following:

- The COMPASS website;
- COMPASS final conference.

According to web statistics gathered between March 2012 and October 2013, the COMPASS website was visited by an average of 270 unique visitors per month, with a very marked peak of 635 unique visitors in October 2013 at the time when all project partners were making a great effort to promote the work of the project in connection with the COMPASS final conference.

The COMPASS final conference took place on 13 November 2013, in Rome. The conference was open to all relevant stakeholders and more in general to the actors who showed interest in the COMPASS project during the lifetime of the project. Presentations were given both by consortium partners and invited speakers. More than 80 people participated, among them researchers, transport and technology industry representatives, automotive representatives, associations active in the field of transport and technologies; public administration and EC representatives. Participants were invited to fill in a questionnaire to provide their views on the priorities related to ICT deployment.

Further dissemination activities were:

- The COMPASS newsletter;
- Publications;
- Papers at the conferences.

Further reading

- Project presentation leaflets
- > COMPASS D7.3 Final dissemination and use plan (publishable sections)


10.6.3 Transferability of Solutions

Problem statement

The objective of this part of COMPASS was to assess the potential transferability of the solutions analysed within the case studies. Such analysis enables to inform on the transferability potential of the experiences investigated as well as to provide a basis for the discussion on the potential barriers which might hamper the diffusion of such kind of solutions.

Main conclusions

Based on the cross-cutting analysis for all 21 solutions investigated by COMPASS case studies it could be concluded that different types of barriers are more or less important for different solutions. The most significant and difficult barriers to overcome are low interest for operators and low viability for financiers for those solutions that depend on private finance. Profitability - evaluated in terms of additional revenues compared with the overall magnitude of costs for the implementation of the solution . was for several of the investigated ICT solutions regarded as low. This was in particular the case for the various kinds of traveller information in rural Poland. In such cases the interest for operators could be mainly justified by the potential of such ICTs in attracting more customers by providing the users with higher quality information, but this cannot always be guaranteed.

Interest for governments is conditioned by the role of ICT in fulfilling policy objectives. Governments are more likely to promote and support those ICTs which contribute to the achievement of specific policy goals (e.g. reduction of CO2 emissions) as compared to ICTs which only contribute to user comfort.

General applicability of the ICT solutions tested shows that it is usually high regardless of region and context. Several of investigated ICTs can be replicated in different contexts or geographic scales. Moreover it seems that ICTs bundled together, while more complex than single use solutions, offer more benefits to the users due to the synergy effects and are still well transferable. Interest for travellers is varied and more solution than location dependent. The level of interest of travellers in ICTs is strongly related to the perceived benefits deriving from their use: the quality level and the timing for the information delivered to final users are crucial. Information is a highly perishable good that should be provided to travellers at the right time and in the right place.

Further reading

COMPASS D6.2 An Assessment of the Potential Impact of ICT Solutions on a Co-modal Transport System

10.6.4 Business Modelling as Instrument for Promoting ICT Implementation

Problem statement

A necessary condition for successful implementation of ICT solutions is to show to stakeholders the benefits of co-modality and opportunities generated by ICT solutions. Adoption of the business models can enhance competitiveness of transport operators through creating the conditions for wider diffusion of co-modal transport services and helping to de-carbonise the sector. Diffusion of the co-modal solutions described in business models can also help to tackle the **%** inks and nodes+ barriers against intermodality.

Main conclusions

The modelling of business configurations makes available structured knowledge to the target audience about the target solutions and the related business aspects, with an innovative approach to learn how to create and capture customer value in the business of co-modal transport systems.

All four solutions analysed (bike sharing, car parking management, shared taxis, and traveller information for mobile devices) highlight the benefit of co-modality and present a fair degree of feasible innovation for decarbonisation of transport. The technology behind the modelled solutions is a mix of innovative and of legacy (although improved) ITS applications. In the analysis of the business elements, both the points 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.

Some of the ICT applications taken into analysis bring innovation to transport systems at maturity stage while others, such as mobile traveller information systems or example, represent a kind of solution generating entire new business too. All the transport solutions considered can considerably enhance co-modality and reduce greenhouse gas emissions with the application of innovative technology; the business models delivered by COMPASS help organisations to plan and introduce and/or change elements for business success.

Recommendations

The key recommendation is to promote the use of business models as instruments that in turn promote ICT implementation.

Participants at the COMPASS conference were asked whether they use business models in their institutions, but only one third of those declaring to use and/or have used business modelling in their organisations show the adoption of a structured approach. This demonstrates that actual knowledge on business modelling seems insufficient and further dissemination about business modelling, its value for profit and or non. profit organisations, and about proper methodologies to implement it appropriately is needed.

The dissemination of knowledge on ICT to enhance co-modality and decarbonise the transport sector necessarily requires explaining how these goals can be achieved and which business models should be adopted to realise them. The COMPASS business models are a first example of such strategy, and their approach deserves to be replicated and expanded with further research and dissemination.

Further reading

- COMPASS Handbook website <u>http://81.47.175.201/compass/</u>
- > COMPASS D5.1 Handbook of ICT Solutions for Improving Co-modality in Passenger Transport

10.7 FUTURE OUTLOOK

The future of passenger transport and the transport system are shaped by many often contradictory influences. While COMPASS could not make any quantitative predictions as to the detail of transport technology evolution or behavioural shifts, visible trends could be identified, which will be strengthened in the possible futures which COMPASS looks into through the analysed scenarios. There is certainly the changing age structure of society and progressing urbanisation. Future transport planners will have to take into account increasing scarcity of fossil fuels and address the emerging culture of sustainable mobility. At the same time demand for mobility will increase and users will be more and more satisfied only by % puality+mobility . connectible, fast and easy to access. The COMPASS research indicates that the relationship between user requirements and modal choice decisions is not a simple one, being also dependent on the personal attributes of travellers as well as their trip purpose, and prevailing conditions (service provision, costs). More research is needed to fully understand user behaviour. One aspect of the COMPASS analyses of ICT in transport applications is the question whether the ICT solutions could also improve provision of behavioural data. The prospects for this are promising. ICTs could be used to collect behavioural data, especially travel behaviour indicators, for frequent and quick capture of user actions. They are also very resource efficient but limited to the evaluation of behaviours of those who use ICT solutions and can therefore not replace traditional data collection methods altogether. However, with the spreading of ICT into transport systems their usefulness in data acquisition will be increasing.

COMPASS also attempted to answer the question whether ICT solutions could contribute to meeting diverse and fragmented user needs in urban and rural travels. COMPASS reviewed many working solutions and provides valuable insights as to the way they could be optimised in different settings. In particular, ICT has a positive role to play in contributing to de-carbonisation. While they cannot be considered the panacea capable of fully solving the CO2 problem, they produce more accessible and less resource consuming transport, which is also less emission intensive. ICT is also relatively easy to introduce. The potential for transferability of identified successful applications to other locations in



Europe is crucial, if ICTs are to grow. COMPASS shows that transferability between EU regions is generally high. Many technologies already exist or are in development, user acceptance is high and there are no significant legal or organisational barriers preventing ICT introduction into the transport system throughout Europe. The most significant barrier is that of finance . many ICT solutions are expensive to implement. In order to convince transport operators and planners to introduce ICT solutions, business models have to be prepared. COMPASS addresses this issue by looking into solutions behind success stories where ICTs were a source of profit for private enterprises and a source of efficiency for public operators.

For the time being ICT implementation is still fragmented and location specific, but its deployment in various transport modes and locations is more and more visible. ICT is gaining momentum and has the potential to become a key feature of future transport systems, because it promises to contribute to solving some of the most urgent transport problems of Europe . demand for increased mobility, better accessibility and ease of use of transport system while at the same time reducing transport emissions.



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