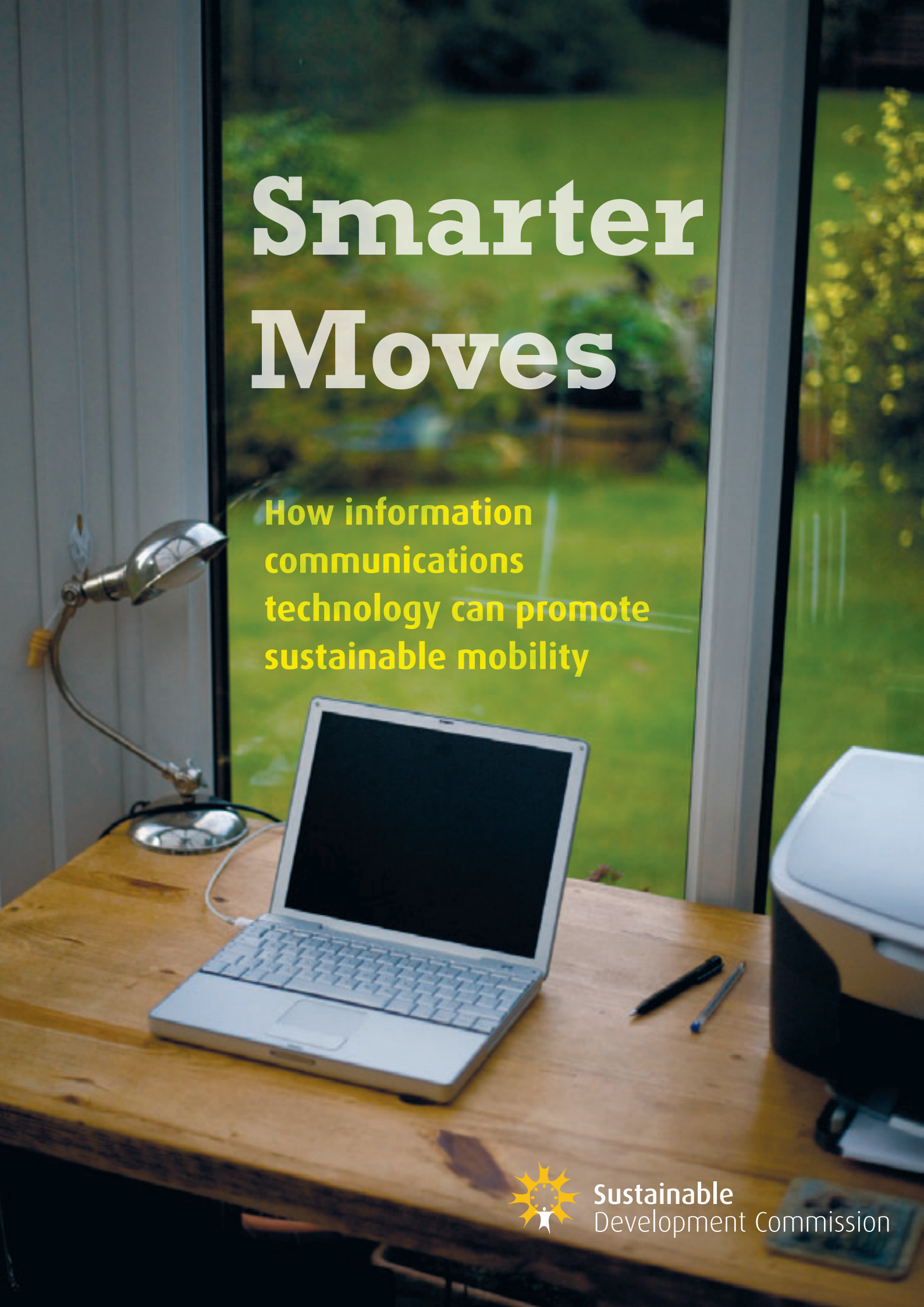

Smarter Moves

How information communications technology can promote sustainable mobility

Sustainable Development Commission

Acknowledgements

The Sustainable Development Commission (SDC) gratefully acknowledges the work of Jeremy Green in researching, analysing and presenting this work during a secondment from Ovum Europe Ltd in January 2009. Jeremy wrote the technologies appendix for this report and maintains a blog about how ICT can help to make personal transport more sustainable: http://smartermobility.blogspot.com/.

The SDC also extends its thanks to ARUP for hosting the seminar event held on February 23rd 2009 as part of this work, as well as the many stakeholders who contributed their knowledge and support during the research. Thanks in particular go to Nick Illsley of Transport Direct, Michael Stephenson of IBM, Simon Willis of Cisco Systems, and Theo Quick of Logica who formed the panel at the seminar and to Stewart Davies who chaired the event.

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Executive Summary

Transport accounts for 29% of the UK's total carbon dioxide emissions.[1]

It is also the only major sector in which CO_2 emissions continue to rise. Almost 70% of UK transport emissions come from road transport and more than half of that is from cars.

The Climate Change Act commits Government to legally binding carbon budgets and an overall emissions reduction of 34% by 2020. Transport must therefore play its part in achieving this reduction. The Department for Transport's *Low Carbon Transport: A Greener Future*[2] sets out how a 14% reduction might be achieved. Although this strategy recognises there can be opportunities for reducing the need to travel through the use of information technology, it does not identify any specific policies to achieve this or to contribute to the 14% reduction identified.

Making mobility sustainable is not only about reducing CO_2 emissions though. It can also help reduce congestion, improve health including reducing obesity levels, improve air quality, reduce noise, and increase wellbeing and social cohesion.

The Sustainable Development Commission's Mobility 2020 project aims to show how the UK could achieve a major cut in carbon emissions from land-based personal mobility using 'in-reach' technologies. One element of this is the role that information communication technology (ICT) can play in bringing a vision for convenient, joined up, multimodal sustainable mobility to reality. There are many ways in which ICT has been proposed to make mobility more sustainable, from avoiding travel altogether, to driverless, automated, personal rapid transit systems. In this study, the SDC has explored ICT's scope to:

- Reduce the need for travel
- Influence travel mode choice
- Change driver behaviour
- Change vehicle behaviour
- Increase vehicle loading factor
- Improve the efficiency of transport networks

This report reviews existing initiatives in each area and explores the opportunities and risks. For each area, it makes policy recommendations to government.

The report is based on the work that Jeremy Green, Practice Leader Mobile for Ovum, undertook whilst on secondment to the SDC in January 2009, and on discussions at a stakeholder seminar held on February 23rd 2009.

Key Findings

ICT can support a range of ways to make mobility and our lifestyles more sustainable. It can allow people to work without commuting, hold international meetings without flying and identify the most sustainable way of making a journey. It can promote more efficient use of vehicles and make the vehicles themselves more efficient. It can also ensure that the transport networks for those vehicles are used as efficiently as possible.

The research for this report indicates that the following applications appear to have the most significant potential for improving overall sustainability:

- enabling home working and travel avoidance

- speed limit enforcement - particularly through the use of intelligent speed adaptation
- delivering congestion charging and road pricing
- reducing barriers to the use of public transport and improving the journey experience
- facilitating car sharing; car clubs; and eco-driving.

(Note that these are not necessarily listed in order of effectiveness).

However our research also identified a number of significant challenges.

- We found relatively little conclusive evidence of ICT being successfully used to improve overall sustainability within transport. This is partly due to the difficulties in assessing whole lifecycle impacts, and what would have happened had the technology not been introduced. Accurate assessments of likely sustainability benefits require detailed full lifecycle analysis of proposed interventions compared against an agreed set of baseline assumptions.
- Travel behaviours tend to be habitual for the vast majority of journeys - 84% of trips are under 10 miles and in locations where travellers have already adopted, and become accustomed to, preferred travel modes. In such circumstances the provision of ICT to provide journey information is unlikely to significantly improve the sustainability of mobility. It is most useful when a longer, unfamiliar journey is being undertaken or when someone has moved residence to a new and unfamiliar area.
- The requirement for revenue funding is a further challenge to increasing use of ICT. Initial capital investment for ICT interventions may be relatively small (in comparison to road building for example). However ICT systems require funding for software and hardware support and maintenance, running costs, regular software updates, computer hardware updates, and roadside hardware replacement. A typical computer's working lifetime may be as little as five to ten years, while roadside hardware may have a lifetime of 10-20 years. Given the current limitations on revenue funding allocation, increasing use of ICT may require new arrangements for local authority transport funding.
- Public transport service information is not always available and accessible in a form which can be utilised by third parties to provide accurate travel tools and assist people in making convenient, joined-up, door-to-door journeys. There is a need for government to take a lead in ensuring that such information is freely available and accessible.
- There is also a need to ensure that increasing the use of ICT does not lead to increased inequalities in the UK transport system. It is important to bear in mind that 30% of UK households do not have internet access[3] and 16% of the population do not own a mobile phone,[4]

although these figures are likely to reduce over time.

Thus, the application of ICT to make mobility more sustainable will require careful consideration. Decisions need to take into account whole lifecycle impacts of the production, use and disposal of new technologies, and an understanding of human behaviour to ensure its use is effective. We therefore conclude that ICT must be seen as an enabling tool within a wider sustainable transport policy framework designed to create sustainable travel behaviours. If this is not the case, it may simply encourage increased unsustainable travel.

Recommendations

Better Government and business collaboration would enhance the development of UK businesses in the cross-over area between ICT and Mobility, and contribute to the development of a low carbon economy. We recommend:

1. The Department for Transport, Department for Business, Innovation and Skills, and the Department for Culture, Media and Sport to sponsor an ICT-Enabled Sustainable Mobility Innovation and Growth Team.

The following 18 recommendations relate to the six areas examined in the report:

Reduce the demand for travel

2. All government departments to lead by example in the use of ICT to improve the sustainability of their operational travel. Utilisation rates of video conferencing facilities and number of days employees work from home to be reported as part of the Business Travel and Employee Commuting Information recommended to be collated by Defra.

   All departments should also ensure national and public sector policies encourage other organisations to use ICT to reduce the impact and improve the sustainability of their staff travel and the travel of their customers and clients.

3. The Department for Transport, Department for Business, Innovation and Skills, and the Department for Culture, Media and Sport to work together to investigate the potential to reduce the need to travel through the creation of a UK network of high quality video conferencing facilities.

Recommendations to the Department for Transport to:

4. Work with UK businesses and the National Business Travel Network to increase the number of organisations allowing and promoting home working.

Influence travel mode choice

5. Ensure that all public transport service information is freely available and accessible in a form which can be utilised by third parties to provide accurate travel tools.

Change driver behaviour

6. Work with the Highways Agency to enforce motorway speed limits through the use of average speed camera technology

7. Encourage the use of average speed camera technology to better enforce urban speed limits

8. Accelerate actions to enable the widespread introduction of voluntary Intelligent Speed Adaptation technology, setting out a clear timetable for implementation of the recommendations made in the joint Commission for Integrated Transport / Motorists' Forum report.

9. Consider further trials of Intelligent Speed Adaptation, fitting units to ministerial and other Government Car and Despatch Agency vehicles. If successful, the technology should be rolled out to all government, public sector and public transport operator's vehicles.

10. Monitor and report on the level of public awareness of the benefits of eco-driving and further raise awareness through the "Act on CO_2" campaign.

11. Ensure all public sector employees who drive a vehicle as part of their job are given eco-driver training.

12. Put in place actions to accelerate the growth of car clubs, working with Carplus and local authorities to identify and overcome barriers to growth.

Change vehicle behaviour

13. Promote further investment in public transport to ensure that improvements in sustainability keep pace with or exceed those of private vehicles.

Increase vehicle loading factor

14. Fully integrate car sharing options into the TransportDirect journey planner and further promote car sharing through the Act on CO_2 campaign.

15. Develop and publish metrics such that numbers of people car sharing and an estimate of the resulting reduction in vehicle mileage can be published in future editions of Transport Statistics Great Britain.

16. Investigate how latest technology can be deployed to improve enforcement of high occupancy vehicle lanes, update guidance to reflect this, and encourage their increased implementation.

17. Run a large scale demonstration pilot of Demand Responsive Transport (DRT) as previously recommended by the Commission for Integrated Transport.

Improve the efficiency of transport networks

18. Encourage more efficient road network utilisation through better use of parking controls, tolls and road pricing.

19. Revise transport funding arrangements to allow local authorities increased flexibility between revenue and capital funding.

1. Background

Transport accounts for 29% of the UK's total carbon dioxide emissions.[5] It is also the only major sector in which CO_2 emissions continue to rise. Almost 70% of UK transport emissions come from road transport and more than half of that is from cars.

The Climate Change Act commits Government to legally binding carbon budgets and an overall emissions reduction of 34% by 2020. Transport must therefore play its part in achieving this reduction. The Department for Transport's *Low Carbon Transport: A Greener Future*[6] sets out how a 14% reduction might be achieved. While this recognises that there can be opportunities for reducing the amount we need to travel through the use of information technology, it does not identify any policies to achieve this. Information technology does not specifically contribute to the 14% reduction identified.

Making mobility sustainable is not only about reducing CO_2 emissions though. It can also help reduce congestion, improve health including reducing obesity levels, improve air quality, reduce noise, and increase wellbeing and social cohesion.

In 2007 the UK Government's Business Taskforce on Sustainable Consumption and Production investigated sustainable mobility. The result was the Mobility 2020 project led by the SDC's Business Commissioner, Stewart Davies. The project's aim was to show how, by enhancing the collaboration of business and government, the UK could achieve a major reduction in carbon emissions from land-based personal mobility by 2020 using "in-reach" technologies. The first phase of the project was an analysis of existing market forces and customer perceptions around personal mobility.

Analysis showed that currently private car travel (with low average occupancy) dominates personal mobility due primarily to the public perception of the necessity of car ownership coupled with low awareness of running costs. This situation has been exacerbated by the fact that the real cost of motoring has declined over the last 30 years while the real cost of public transport has increased. For many people, having invested in buying a car, insuring and taxing it, there is an inevitable incentive to use it.

In addition the business models associated with private motoring are not aligned with sustainability. Maximising profits in an industry which often has very small margins requires high sales volumes. This has involved aggressive marketing, often based on promoting additional power, safety features which have increased vehicle weight and extras such as air conditioning that are detrimental to vehicle efficiency. The recession has illustrated how new car sales can fall dramatically in the face of an economic downturn, indicating that new car purchases are to an extent discretionary.

The one area of personal mobility in which the business model appears to align better with sustainability is that of the provision of 'mobility as a service'. A good example of this is the growth of 'pay as you go' car clubs. Members are able to use a car for a fixed price per hour which includes fuel, insurance and all other costs. This discourages unnecessary journeys and encourages car sharing. Meanwhile car club operators use the most fuel efficient and reliable models available in order to minimise their costs. Similar dynamics apply in the case of public transport, and to a lesser extent mainstream vehicle hire services and more recent innovations such as bike hire schemes.

The SDC's Mobility 2020 Project

In 2008 the next phase of the project, developing business-led solutions to sustainable mobility was led by the Sustainable Development Commission.

The project team engaged with key stakeholders from business, government, academia and civil society with the aim of creating space for a new market in the next five to ten years. The market would provide consumers and business users with low-carbon mobility products and services and accelerate the pull-through of the technologies and infrastructure needed to transform mobility in the decades beyond.

In the course of research for the project, it became clear that information communications technology (ICT) could play a vital role in bringing the vision for convenient, joined up, multi-modal sustainable mobility to reality. In order for the Mobility 2020 vision to be achieved, ICT would be needed to ensure that people could easily find accurate and up to date information on how they could make their journey, how long it would take and how much it would cost. Having chosen their preferred option, it would allow them to make reservations, book tickets or simply know where to go. It could also ensure they were able to get the best price and pay for their journey quickly and conveniently. Once travelling, ICT could help ensure the journey was made as efficiently as possible, that any delays were minimised and even that the journey time itself could be productively used. Of course ICT could also reduce the need to travel altogether. It was therefore decided to explore the potential for ICT to support sustainable mobility.

Jeremy Green, Practice Leader Mobile for Ovum, spent one month on secondment to the SDC researching the role that ICT can play in making mobility more sustainable. He conducted stakeholder interviews with a range of people from across the industry as well as extensive desk based research. This report is based on his work, and his presentation at a stakeholder seminar held on February 23rd 2009.

2. Approach

The SDC advocates a hierarchical approach to transport which was first proposed in our response to the Department for Transport's *Delivering a Sustainable Transport System* consultation. This classifies transport interventions in the order in which they should be considered, to achieve a truly sustainable transport system. Since then, the thinking around the hierarchical approach has developed. A fuller explanation of this hierarchy is given here:

1. **Demand Reduction**

   Aiming to reduce the need for *powered* transport. Increased demand for 'active travel' (cycling and walking) should be viewed positively. Demand reduction should be achieved through the widest possible application of spatial planning, fiscal interventions, behavioural change and technological measures (e.g. teleconferencing / ICT, working from home, home shopping, travel planning).

2. **Modal shift to more sustainable and space efficient modes**

   Focusing on four areas:

   i. Shifting away from motorised modes to cycling and walking due to the multitude of benefits this creates (congestion reduction, health and air quality improvements, noise reduction, and greater social cohesion). This can include a range of measures including reducing speed limits, restricting motorised transport volumes and creating high quality, safe and attractive routes for cyclists and pedestrians.

   ii. Shifting from private motor vehicles to public transport. Increasing passenger numbers on existing public transport improves efficiency (in per passenger kilometre terms), improves viability and may lead to improved quality of service. Regular public transport users also tend to have higher levels of walking and cycling. This category should include measures to improve inter-modality between different forms of public transport and active travel.

   iii. Measures to shift freight from road to rail.

   iv. Measures to shift away from unsustainable air travel.

3. **Efficiency Improvements to existing modes**

   This covers a wide range of possible options including vehicle efficiency improvements; encouraging higher occupancy rates; promotion of car clubs; eco-driving; measures to spread demand peaks on public transport; and measures to improve the efficiency of transport networks.

4. **Capacity increases for motorised transport**

   This should only be considered once the full potential impacts of 1-3 have been appraised, an explicit delivery programme determined, and the full effects of that programme included in assessing the residual role for 4. Any capacity increases that are required should be prioritised to the most efficient and sustainable modes.

Research work conducted for the SDC's report "Building Houses or Creating Communities" (2007) indicates that much new development practice is far from this hierarchical approach. Interviews with the residents of Cambourne (a new town which started construction in 1998) found that there were only limited opportunities for local employment, that they were heavily reliant on their cars, that bus services were unreliable and inconvenient and that although cycle lanes had been built for the estate, towns beyond the development were considered too far for travel by bicycle.

In each of the first three priorities identified in the hierarchy, ICT can play an important role. It can provide alternatives to travel and thus reduce transport demand. It can encourage a shift to more sustainable modes of transport and it can improve the efficiency of how we use existing modes.

3. Context

The use of ICT in transport is a large and diverse subject and covers a much broader scope than purely improving the sustainability of transport. The IT industry has claimed for some time that it could reduce global emissions by as much as 15 per cent by 2020 – a volume of CO_2 five times its own footprint.[7] Transport and logistics are among the areas where it is claimed that the most significant contributions could be made. Large numbers of projects have been running over many years including projects focusing on such areas as improving the driver experience; safety; reducing congestion; and making public transport more attractive. Some have been repositioned in light of the increasing focus on sustainability.

Initiatives have come from various different organisations:

- Local and national government departments
- Inter-governmental bodies and standards organisations
- Transport operators
- Technology providers from the mobile industry, ICT hardware and software vendors
- IT service providers and systems integrators
- Applications developers and providers
- Content providers, aggregators and portals.

In particular the European Union has funded numerous transport related ICT projects through CORDIS – the Community Research and Development Information Service. This has included initiatives such as the Transport Sector of the Telematics Applications Programme (4th Framework programme 1994-1998[8]).

The 7th Framework Programme for CORDIS (2007-2013) continues to support work on ICT, identifying "modernisation of public services, such as health, education and transport" as one of three key areas. It calls for projects looking at "*ICT for safe, clean and smart mobility*" and offers €80 million in funding.

More recently, in December 2008, the European Commission launched an action plan on the use of Intelligent Transport Systems (ITS) in road transport. The Action Plan suggests a number of targeted measures and a proposal for a Directive laying down the framework for their implementation: http://ec.europa.eu/transport/its/road/action_plan_en.htm

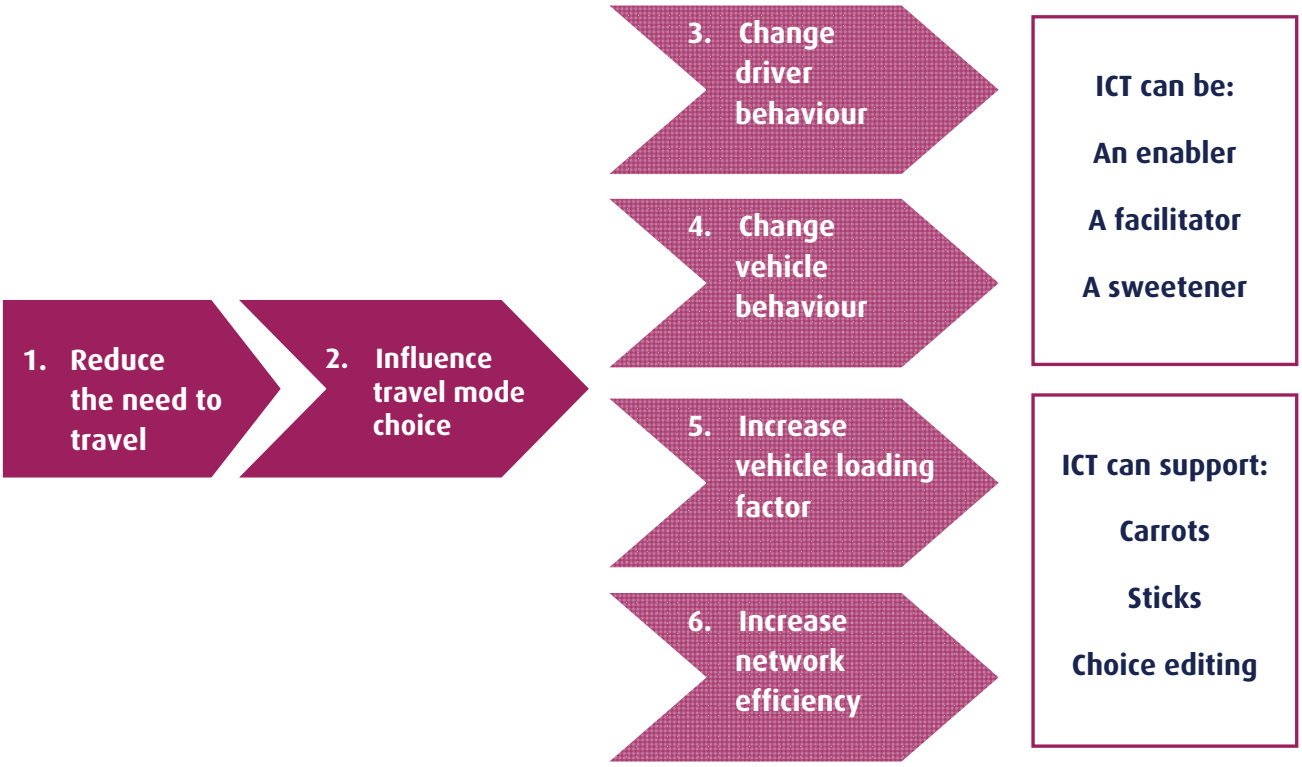
The EU is also coordinating the "Intelligent Car Initiative": http://ec.europa.eu/information_society/activities/intelligentcar/index_en.htm

In the USA, Research and Innovative Technology Administration (RITA)[9] is looking at intelligent transportation systems.

It is difficult to identify the outcomes and results of some of the projects that have been funded by these various initiatives. Many of the associated websites are still live, but have not been updated for years.

4. Opportunities: Where ICT can help

Given the sheer scope and diversity of ICT Mobility projects it is helpful to have some way of categorizing them. For the purpose of this report, these have been grouped into the following six categories:



ICT can play various roles within these categories. It can act as:

- **an enabler -** providing the travel information needed to make a journey
- **a facilitator** - allowing online booking and payment or perhaps even facilitating travel avoidance through video conferencing
- **a sweetener** – providing wireless internet coverage while travelling on bus, coach or train, or enabling queues to be avoided through ticketless payment systems
- **a carrot** - pay as you go schemes that reward travelling at off-peak or lower risk times, or travel carbon footprint monitoring. This is an area that could be developed further with concepts such as 'green miles'

rewards operating in a similar way to air miles, but rewarding low carbon travel choices

- **a stick** - congestion charging, safety cameras, high occupancy vehicle lane monitoring
- **a choice editor** - journey planning tools which are configured only to provide the lowest carbon options, or to highlight them.

The role that ICT can play within these six categories is examined in more detail in the following chapters.

An appendix of the technologies which form the building blocks for ICT solutions for sustainable transport is included at the end of the report.

5

Reduce the need for travel

5. Reduce the need for travel

ICT can facilitate travel demand reduction through video-conferencing and tele-presence systems, net meetings, voice over internet protocol (VoIP) systems such as Skype and Hotmail messenger which now include video facilities, facilities to enable home or remote working (including work hubs), shopping ordered from and delivered to homes, and even via synthetic environments such as 'Second Life'.

5.1 Home Working

In the UK, the daily commute to work accounts for 28% of CO_2 emissions from surface transport with a further 10% associated with "employer's business".[10] In Japan the government has declared an aim of doubling the number of telecommuters to 20% of the workforce by 2010.[11] In 2005 it was estimated that only about 11% of the UK workforce work from home, of which 8.3% were teleworkers.[12] If this could be increased, there may be significant savings in CO_2 emissions, congestion and pollution. A UK survey found a third of workers would like the option to work more frequently from home or other locations in order to reduce the time they spend commuting. Just under half of respondents said that their employers would not allow them to work from home or undertake flexible hours to help avoid lengthy commutes.[13] Workwise UK estimate that 50% of the UK workforce could work from home.[14]

According to the Smith Institute's report *Can Homeworking Save the Planet?* the necessary equipment to turn an office worker into a homeworker is a high speed broadband connection, a telephone line and a laptop.[15] The report reviews the available evidence for carbon reductions attributable to homeworking and concludes that "It is highly likely that, in most circumstances, homeworking is positive in carbon terms, and often considerably so." The likely net reductions in travel would also reduce accidents, air pollution and noise.

However there are limitations to the potential benefits of home working with some home workers reporting dissatisfaction due to lack of social interaction with their colleagues. There is some evidence that while the daily commute may be avoided, home workers make additional journeys during the working day.[16] Overall though, the evidence indicates a net reduction in travel is likely. A study found that British Telecom (BT) teleworkers reduced their car travel by 193km per week on average despite making additional trips that they would not have made if working from the office.[17] The conclusions of this report into the sustainability of teleworking were mainly positive. BT also recorded a 55% improvement in job satisfaction amongst homeworkers in their annual attitude survey.

Recommendations:

- All government departments to lead by example in the use of ICT to improve the sustainability of their operational travel. Utilisation rates of video conferencing facilities and numbers of days employees work from home to be reported on.
- This should be part of the business travel and employee commuting information recommended to be collated by Defra. (See recommendation 21 of the SUSTAINABLE TRAVEL ENGAGING THE PUBLIC SECTOR project report 'A Review of Government Travel').
- All departments should also ensure national and public sector policies encourage other organisations to use ICT to reduce the impact and improve the sustainability of their staff travel and the travel of those taking up their products and services.
- The Department for Transport to work with UK businesses and the National Business Travel Network to increase the number of organisations allowing and promoting home working.

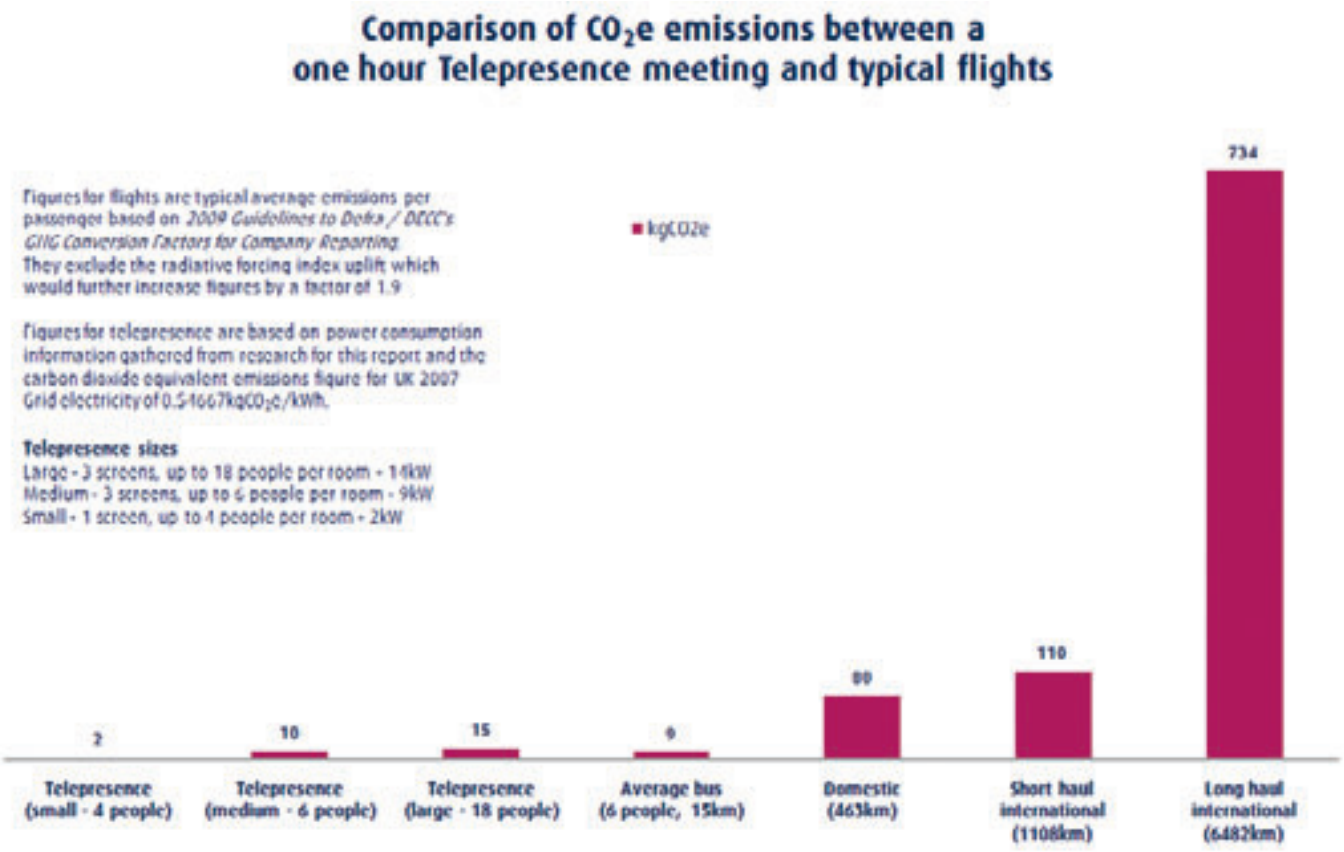
5.2 Video Conferencing

Video conferencing can be used to hold meetings with participants from anywhere across the globe. Video conferencing technology has improved significantly since its original introduction and now provides a vivid and reliable way of holding meetings, with participants seeing and conversing with each other from different physical locations.

It is difficult however to measure the true impact of this technology. It is not always clear when video conferencing has genuinely eliminated physical travel, and when an additional meeting has taken place due to the increased convenience of video-conferencing. Some even consider that video-conferencing simply increases the number of meetings and exchanges of ideas and information across geographical locations, while simultaneously reducing the time needed. This, it is argued, can lead to overall increases in levels of travel. Certainly, the technology on its own cannot guarantee a reduction in travel. However, an academic study[18] has shown that where companies have introduced wider policies to limit or reduce travel, ICT offers a realistic alternative to physical meetings. In other words, if reduced travel is an aim, video-conferencing is a powerful tool to help achieve it, provided that the policy context is right. This finding at the company level should apply equally at the national level.

More sophisticated forms of video conferencing exist such as telepresence which utilises large video screens to create life-size images of meeting attendees giving the illusion that everyone is sitting around the same table in the same room. This enables participants to interact in a more natural way. However, it should be noted that the energy consumption of such systems is not insignificant. Anecdotal evidence received in the course of research for this project indicates that a telepresence meeting between offices in the same city might use more energy than travelling to meet face to face.[19] Estimates received from one source suggested that telepresence units use between 0.4kW and 14.2kW per room depending on the size of the facility

(and including extra air conditioning and lighting requirements). A WWF report suggests that the carbon footprint of video conferencing is approximately 2% of flying if 'rebound' effects are excluded.[20] In a demonstration of Cisco's Telepresence system, SDC was told the energy consumption of the system was approximately 3kW per room.[21]



It should be noted that a comparison of energy use between video conferencing and travelling to a meeting does not take into account the additional sustainability benefits of not travelling which include reduced congestion, air and noise pollution, and risk of accidents. Not travelling also offers significant time savings which may have social benefits - allowing people to spend more time with their families.

Last year Tata Communications launched a worldwide network of both public and private telepresence rooms. By offering 'hosted' rooms that can be booked by the hour, they enable smaller businesses who may not be able to invest in the technology

for themselves the chance to benefit from this technology.[22]

Recommendation:

- The Department for Transport, Department for Business, Innovation and Skills, and the Department for Culture, Media and Sport to work together to investigate the potential to reduce the need to travel through the creation of a UK network of high quality video conferencing facilities.

5.3 Synthetic Environments

Perhaps the most extreme or unusual use of ICT for travel avoidance is through the use of synthetic environments such as "Second Life". Here users create 'avatars' – fictional characters which inhabit a virtual world via the internet. Users can meet, converse, give presentations and hold workshops within this virtual world. Universal Music Group held its 2008 annual Pan-European company conference in Second Life.[23] The event lasted two days and involved more than 100 delegates holding meetings and seminars.

To encourage the adoption of smarter working practices, The Department of Business Enterprise and Regulatory Reform (BERR, now the Department for Business, Innovation and Skills) set up the organisation Workwise UK (www.workwiseuk.org), a not-for-profit initiative. It advises companies on introducing flexible and remote working practices.

eWorking Solutions is an example of a commercial company set up to advise on these issues. They are part of Coventry University Enterprises. In 2000 Coventry University Enterprises (CUE) Ltd. ran out of office space. They therefore examined possibilities and decided to expand using e-working solutions, allowing employees to work from home. Now 70% of CUE's staff work away from CUE's facilities. Rates of sickness absence have dropped by 30% and they estimate they are saving an additional £135,000 a year from reduced office space requirements. They also calculate approximately 1 tonne of CO_2 saved for every person that utilises "location independent working" practices.

The Department for Transport commissioned research into the potential for synthetic environments in transport which concluded "there are considerable opportunities for wider application of synthetic environments in transport and few insurmountable barriers to their use."[24] However, the focus of this research appears to have been looking at how synthetic environments could help with transport design and planning, rather than the avoidance of travel altogether.

There are many other examples of the potential for ICT to reduce the need to travel. Internet shopping with home delivery is increasingly popular. Ocado, the online supermarket, commissioned an independent carbon footprint audit which demonstrates that a typical Ocado delivery has a lower carbon footprint than even walking to a local supermarket.[25] Their delivery fleet is managed by state-of-the-art algorithmic 'routing' software which ensures that the delivery routes created for their drivers are as efficient as possible. Online banking, rated as the second most useful online activity[26] has reduced the need to visit a local branch. Other examples include direct streaming of films and music via high speed broadband; transactions such as vehicle

excise duty payment online; and the post office's website allowing payment and home printing of stamps for parcels. Indeed the growth area now is expected to be the move of services such as online banking to mobile phones.

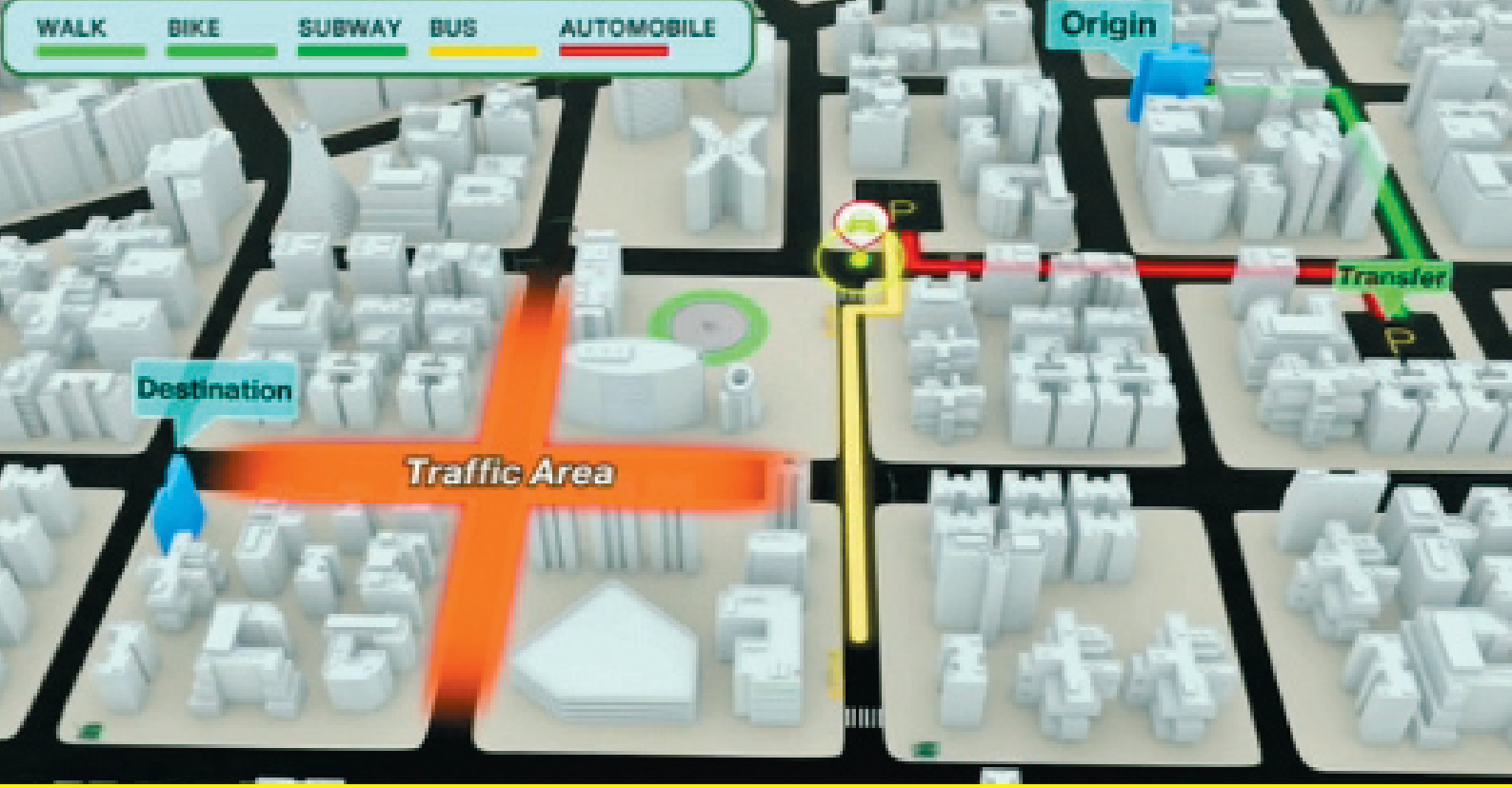
5.4 Challenges

There are potential risks to many of these travel avoidance solutions. Increasing access to goods and services through ICT can lead to a reduction in the number of jobs in these areas. A sedentary lifestyle in which it is hardly ever necessary to leave the house can result in both physical and mental health problems and many would argue that even the most sophisticated video and audio conferencing techniques are no substitute for meeting people face to face.

A paper published in 2009 indicates that not travelling to meet people can mean losing out on developing trust and cohesion in relations.[27] It also points out that going to visit people results not just in a greater awareness of their situation and surroundings but also helps understanding of how one's situation and home location is perceived - so called 'reflected knowledge'. This can help create a different kind of mutual trust. Organisations need to consider these potential impacts when encouraging increased use of ICT for travel avoidance. One approach would be to encourage face to face meetings when establishing new relationships but transitioning to ICT solutions to reduce travel once participants know each other.

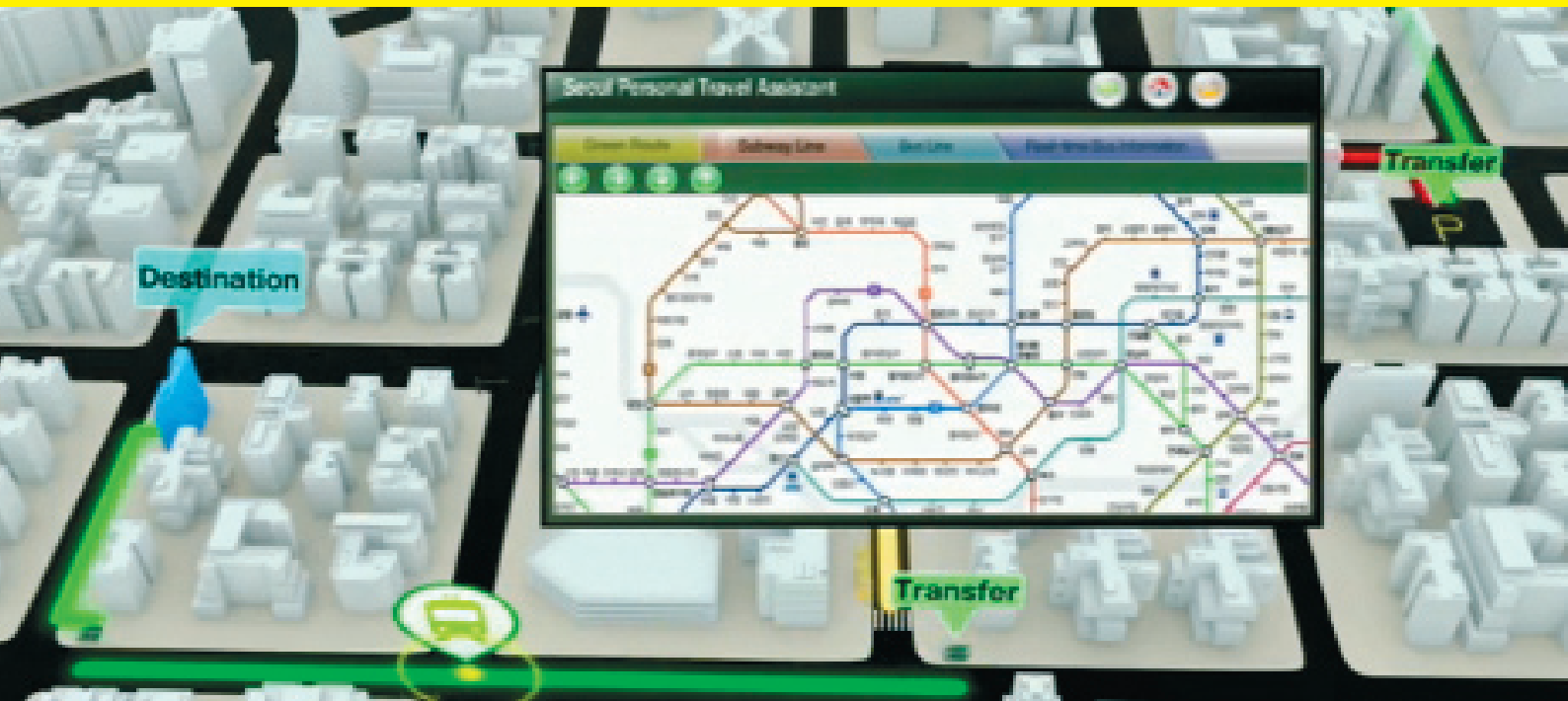
There are social issues concerning the adoption of teleworking and flexi-working practices. Different management styles may be required and older generations may not be comfortable with these changes. Equally companies must be aware when recruiting that many young people, having grown up using ICT to stay connected wherever they are, may expect or demand employers to make these practices available.

Another question is whether many of these solutions do lead to an overall decrease in travel. Banking or shopping on line may simply lead to increased time spent on leisure travel. Societies in which ICT technologies are used most frequently are often also those with higher levels of mobility. ICT can offer alternatives to travelling but it must operate within a wider policy framework to ensure that society moves towards sustainability.



6

Influence travel mode choice



6. Influence Travel Mode Choice

Once the decision has been made that a journey is necessary, the next area in which ICT can help promote sustainable travel is by influencing the choice of the mode of travel. This can be done in a number of ways:

- Mode specific journey planning: Offering advice on the best way to travel by a particular mode
- Multi-modal journey planning: Planning routes and comparing alternative modes of travel for a journey (price, time, environmental impact)
- Improving the travel experience: Providing updates on traffic conditions, service cancellations or delays; making sustainable modes of travel more convenient and attractive

6.1 Mode specific journey planning

There are various journey planning tools available which are tailored to specific modes for example bus, train, car, bicycle or walking. The website www.WalkIt.com provides users with recommended walking routes in UK cities. The site provides information on the time the journey will take, the number of calories burnt and the CO_2 emissions savings through avoiding motorised transport. According to the website's developers, surveys of their users show almost 80% have been encouraged to switch away from a motorised mode to walking at least once.[28]

In order to ease overcrowding on London's public transport system, Transport for London is now aiming to reduce peak time pressures by encouraging increased levels of walking and cycling. Its project "Legible London" [29] features a series of maps which clearly show how short journeys can easily and conveniently be made by foot, highlighting how little time it can take.

One of the problems for visitors to London is that referring to the tube map can often make short journeys look longer than they are in reality since the map is not geographically accurate. There have been suggestions that the original map may even have been designed to encourage use of the underground in this way.[30] More recently a version of the tube map has been published showing how many steps it takes to walk between tube stations.[31]

Web sites are becoming available offering specific advice on cycle routes and many local authorities provide online cycle route maps for their areas. There is even a global cycle routes mapping project with open source software allowing anyone to make updates or corrections.[32] Transport for London has introduced an online cycle route planner and in Cambridge, which has the highest levels of cycling of any town or city in the UK, the local cycle campaign group has implemented a similar concept.[33] This has details of all known cycle paths and enables users to choose between fast and quiet routes.

Meanwhile sites such as www.nationalrail.co.uk, www.thetrainline.com and www.raileasy.co.uk specialise in offering journey planning advice and ticket sales for train journeys and www.seat61.com offers advice on making longer journeys by train thus avoiding air travel.

6.2 Multi-modal Journey Planning

Websites such as www.transportdirect.info and www.traveline.info allow users to plan their journey by choosing between different modes and by examining the price, time taken and, in the case of TransportDirect, an estimate of the carbon dioxide emissions resulting from their choices. TransportDirect is currently working to include cycle route planning into their journey planner.

Transport for London's www.tfl.gov.uk/journeyplanner allows users to plan journeys in a similar manner within London. Transport for London is also working on a project called iBus which provides audiovisual journey information to passengers while they are on the bus.[34] The system relies on satellite tracking of all bus locations and allows users to get real time information regarding bus arrival times via the internet, mobile phone and on street displays.[35]

Globally there are many more examples of travel and trip planning information being made available through websites and mobile phones.

Google's "Transit" pages allow users to plan journeys using public transport in over 260 towns and cities across the world. In the UK at the time of writing, the East Midlands and the South East are covered while coverage of London is limited to maps of the tube and rail lines. The system can be access via the Google Maps "Get Directions" facility which also offers directions for driving and walking.

Helsinki city's travel planner includes a cycle journey planner with details of cycle specific routes and bike parking facilities, as well as public transport information.[36] A website shows real-time locations of all buses and trams.[37]

Stockholm's planner also has real-time information on buses and trains and is available via mobile phones.[38]

In Switzerland, the movements of all trains on the entire rail network can be tracked on the http://www.swisstrains.ch website an unofficial "mash-up" of Google maps and timetable information (rather than actual train positions).

In Japan, the travel planning site http://www.hyperdia.com/cgi-english/hyperWeb.cgi offers information on both high speed and normal train services and allows cost and time comparisons to airline services.

Nokia has integrated its phone-based map service more closely with its PC-based "Ovi" service. Users can plan the route on a PC then synchronise it with their phone. This makes it easier for the user and also means that the route processing doesn't have to be done on the phone itself.

The website www.travelfootprint.org focuses solely on providing information on the environmental footprint of your journey and transport choices enabling users to compare the carbon dioxide, nitrogen oxides and particulates emissions associated not just with the journey itself, but the fuel and vehicle production.

Another project "Carbon Diem"[39] aims to use GPS-enabled mobile phones to track users' movements and automatically generate their travel carbon footprint.

There are several projects that look at providing more sophisticated "personal travel assistants".[40] This can be done through the use of Intelligent Agent technology or integration with Unified Communications and presence applications. These projects attempt to provide intelligent real time,

continuously updated travel information using GPS technology to track an individual's current location and potentially those of colleagues or friends.

Examples include a system which is being trialled by Cisco's Connected Urban Development project in Amsterdam and Seoul with a pilot running in summer 2009,[41] and "Journey Angel" - an avatar based mobile (Symbian) application to provide users with real time travel information in London.[42]

6.3 Improving the travel experience

ICT can influence travel mode choice in less direct ways, for example through the use of ICT to make a mode more attractive. Examples of this include the provision of wi-fi internet connections on trains, buses, coaches and even ferries. The ability to stay connected and turn travel time into productive work time can be a significant attraction for business travellers. A survey conducted by Accent in 2007 indicated that 64% of travellers think wi-fi availability influences mode choice, with 19% of wi-fi users anticipating making extra journeys by train rather than flying because of wi-fi availability.[43] In the UK mobile phone coverage of the rail network is inconsistent with many lines suffering from intermittent coverage due to tunnels and cuttings. Coverage on the central London underground is almost non-existent. Availability of wireless broadband internet is also limited to certain rail lines. These issues have been recognised in the *Digital Britain* report which proposes that Government may in future require provision of high-speed broadband services as part of the rail franchise requirements. The report also suggests that mobile network operators should work with the Mayor of London to provide broadband and mobile phone coverage for the tube network, commenting: "If regulatory or other similar constraints turn out to be a barrier the Government is willing to address these."[44]

ICT can also help make travel more convenient. The internet is increasingly being used to book tickets in advance of travel which can then be picked up at automated ticket machines often avoiding queues. In London, the introduction of the Oyster card offering the convenience of ticketless travel, in conjunction with significant cost savings, has been a major success. Smart card operated barriers also benefit public transport operators. Fare evasion on the London underground is reported to be down from 17% to less than 3% since the introduction of the Oyster card.[45]

Innovations such as Barclaycard's integrated Oyster and credit card[46] further improve convenience by allowing users to make cashless transactions up to £10.

Indeed public transport is now seen as the main driver for take-up of contactless card payment with Transport for London stating that they may be ready to accept bank-issued cards for payments at ticket barriers on the London underground by 2011.[47] The sQuid eMoney contactless payment card has now been launched in Bolton and is compatible with transport smartcard applications including ITSO (originally standing for Integrated Transport Smartcard Organisation) enabling users to pay for bus travel.[48]

Services are now available to try to reduce the inconvenience of congestion, cancellations and delays. For motorists, the Highways Agency's traffic website allows

users to check real-time traffic information[49] and also to review predicted traffic conditions at different times of day[50] for a specific journey they are thinking of making. Predictions are based on historical data. This service can be more useful than real-time congestion information which is often too late for the traveller to take action. Predicted data allows people to make changes to their travel plans to take account of likely congestion and could help to make more efficient use of the road network.

www.frixo.com is an example of a similar website providing live UK traffic reports, but also including the facility to access updates through a version of their website designed specifically for mobile phones.

Google Maps includes a "Traffic" feature which uses traffic information from the Highways Agency for the UK, and at the time of writing also covers large parts of France and America. The system enables users to view "live" traffic conditions as well as the predicted conditions at any given time and day of the week. However many drivers do not check road conditions before travelling - 62% say they never do.[51]

Google Map's 'Streetview' system which offers a pedestrian's eye view of roads may also help with travel planning, enabling users to 'see' where a bus stop, train station, taxi rank or bike hire location is before setting off on the journey.

Many satellite navigation systems now offer route planning that can take into account both real-time and/or expected traffic conditions. TomTom's IQ Routes system[52]uses historic information based on data sent by all TomTom units and tagged to routes, dates and times. TomTom's High Definition (HD) service uses modelled real time information based on data sourced from Vodafone relating to the number and velocity of mobile phones on specific roads.

The UK government is promoting the adoption of digital radios in cars to enable access to more sophisticated traffic information.[53]

For public transport users, services such as Transport for London's automated text service alerts travellers to delays or cancellations on London underground services. The service can be customised to provide alerts only for specific routes. National Rail has introduced a similar service.

6.4 Challenges

For many people, simply having access to improved information about more sustainable modes of transport is not sufficient to change travel behaviours. Many of the journeys people make are regular, habitual ones: daily commuting; taking children to school; and shopping trips. 68% of trips are less than five miles, 84% are under 10 miles.[54] For these journeys people are unlikely to consider alternatives once they are accustomed to a routine. It often takes a change in circumstances - for instance a new job, new school, or moving house - before the range of possible mode options are reconsidered. However, specific situations in which the habitual travel strategy may not work (e.g. road works, service disruption) may lead to alternatives being sought.

The second major issue is that, even for those journeys where a journey planning tool might be consulted, it is difficult to provide accurate, relevant information. There are a range of factors that may affect people's requirements in any given journey:

luggage; preparedness to walk or cycle for a portion of the journey and to what extent this is dependent on the weather and the distance; whether there are multiple destinations or passengers involved. It is possible to design a journey planner which takes all of these factors into account but the resulting complexity can make using it off-putting.

The data required for journey planning tools is often fragmented, making end-to-end trip planning difficult and, if information is inaccurate or out of date, then people are unlikely to make use of the travel planner again, mistrusting any future results. The Department for Transport has created a number of standards designed to ensure that there are common formats for the exchange of public transport information. Journeyweb[55] is a protocol that allows independent journey planning systems to send enquiries to each other, and to receive and understand the responses. The "Transport Exchange Standard" named TransXChange[56] is a nationwide standard designed to allow for the exchange of bus routes and timetable information with other computer systems such as journey planners and vehicle real-time tracking systems. Details of other standards can be found here: http://www.public-transport.org.uk/

One of the findings from the stakeholder interviews held as part of this research was that information owners (typically transport operators, but also government agencies) are often unwilling to share timetable information with those best placed to provide it to end-users. For example, while TransportDirect has access to timetable information, it has found that transport operators are unwilling to let them share information with other transport providers or third parties providing journey planning tools, perhaps believing that it may affect their competitive position. This may also be because they perceive it has a market value.

The issue was reported in the national press when several free iPhone applications providing National Rail Enquiries information found they could no longer access the necessary raw data when National Rail Enquiries itself started selling a similar application.[57]

The difficulties in creating a satellite navigation based travel assistant that integrates all forms of transport have also been highlighted.[58] The need for a government initiative to "force public sector organisations such as Highways Agencies, Transport for London, and local authorities to collaborate" being emphasised.

Recommendation:

- The Department for Transport to ensure that all public transport service information is freely available and accessible in a form which can be utilised by third parties to provide accurate travel tools.

A further problem is that a comparison of different travel modes does not necessarily encourage users to make the most sustainable choice. For instance if the results indicate that flying or driving is not only quicker but also substantially cheaper than taking public transport then it is unlikely that many people will choose the latter, even if the information suggests it is more sustainable.

In addition many current journey planners are either difficult or impossible to access via a mobile phone so in-trip information and updates based on real-time information are

not possible. Many of these frustrations are likely to be addressed in the near future as technology improves.

Finally it must be remembered that improving availability of travel information may lead to additional journeys being made. If it becomes easier to find out how to make a journey, people may be encouraged to travel more and to more varied locations.

7

Change driver behaviour

7. Change Driver Behaviour

There are many ways that ICT can be used to influence driver behaviour. The most significant potential for improving sustainability in this area, due to the number of vehicles, is influencing car drivers to drive in a more fuel efficient and safer manner. Drivers of public transport buses and trains and freight operators can also benefit from this technology.

There are a number of specific technologies to cover in this area:

- Enforcement technologies
- Intelligent Speed Adaptation
- Satellite navigation
- Eco-driving
- Pay-as-you-drive insurance schemes
- Pay-as-you-drive car clubs

7.1 Enforcement technologies

Perhaps the most well-known example of ICT influencing driver behaviour is the use of cameras to enforce speed limits. Although controversial, Department for Transport evidence is clear that their use reduces speeds, accidents, deaths and injuries.[59] Enforcing the speed limit has also been shown to be a very cost effective way of reducing CO_2 emissions from road transport with estimates of a reduction of 1.4 million tonnes of carbon dioxide simply by enforcing the 70mph speed limit.[60] DfT data shows 52% of cars exceed the motorway speed limit.

Cameras which measure average speed over a distance are becoming widely used on motorways. These have the advantage that it is not possible to slow down briefly to avoid detection, and also avoid instances of dangerous sudden braking as can happen with traditional speed cameras.

In 2009 the Home Office approved average speed cameras to enforce speed limits in urban areas. Cameras are networked together and can be placed at entry and exit points to an area with a fixed speed limit, for example 20 or 30mph. By measuring the time between a vehicle entering and leaving the zone and knowing the shortest route between the entry and exit points, the system is able to calculate if the driver exceeded the average speed limit.

Better enforcement of urban speed limits and the adoption of 20mph speed limits in residential areas could have very significant sustainability benefits. Currently 49% of vehicles exceed the 30mph limit. Higher levels of compliance would reduce accidents, deaths and injuries. If drivers adopted slower, smoother driving styles then it would also reduce fuel consumption. By creating a safer urban environment, it would also encourage more people to walk and cycle for short journeys.

Recommendations:

- The Department for Transport and the Highways Agency to enforce motorway speed limits through the use of average speed camera technology
- The Department for Transport to encourage the use of average speed camera technology to better enforce urban speed limits

7.2 Intelligent Speed Adaptation

Another technology that is currently being examined is the use of 'intelligent speed adaption' (ISA). ISA allows the speed of a vehicle to be automatically limited according to the speed limit of the road on which it is driven.

The technology was first investigated by the Department of Environment, Transport and the Regions between 1997-2000. Between 2001-2006 the Department for Transport conducted the ISA-UK project with extensive field trials involving 79 drivers. The report on this work looked primarily at the safety benefits and concluded that "substantial reductions in excessive speed and thereby considerable benefits in terms of safety" could result, with, interestingly "56% of participants approving of compulsory fitting of ISA to all new vehicles." [61]

A more recent report by the Commission for Integrated Transport looked at the wider environmental benefits. This suggested that mandatory fitment of ISA to all cars over a 60 year period could result in savings of 25 million tonnes of carbon as well as improving safety.[62]

It identified four types of ISA:

- **Advisory** - in which the driver is simply made aware of the current speed limit and warned when it is exceeded
- **Voluntary** - in which the system is linked to the vehicle drivetrain (engine management and possibly braking system) and controls the vehicles' speed to ensure it does not exceed the current speed limit, the system being over-rideable by the driver
- **Mandatory** - as per a voluntary system, however there is no option to override
- **Dynamic** - a system which in addition to knowing fixed speed limits can also acquire information about variable speed limits such as those used on motorways during bad weather or congestion

A survey conducted as part of the research identified strong public support for ISA with approximately one third of drivers saying they would buy a mandatory system, one third opting for a voluntary system and one third not liking either option.

It went on to calculate that the introduction of voluntary ISA would result in benefits from reductions in accidents, fuel use and carbon dioxide emissions that would outweigh costs by a factor of over five to one.[63]

This figure does not include any expected further cost savings from reduced expenditure on the policing and enforcement of speed limits. This might include reducing the need for speed humps and other road features designed to reduce vehicle speeds. Nor does it include any estimate of the potential for the technology to create modal shift to cycling and walking by creating a safer road environment.

ISA systems require robust digital mapping of the road network and corresponding speed limits. This has been completed within the M25 area and the technology is currently being trialled by Transport for London. The system has been fitted to a bus, taxi and 20 TfL vehicles driven by road engineers, traffic managers and highway inspectors. The results are expected to be published in Spring 2010.[64]

A further trial is being conducted in Lancashire with ISA units being fitted to 550 volunteers' cars.[65]

Various trials across Europe also indicate that public acceptance of the technology is relatively high with 60-75% of users accepting having ISA in their own cars.[66]

The Swedish Road Administration announced in 2005 that it would introduce 'support systems for speed compliance or similar systems' in its own vehicles and in those it leases as new ones are acquired. It also committed to other parties such as city municipalities, transport purchasers and transport providers participating in the scheme.[67] It identified ISA as a major component of its strategy and to date 60-80 organisations have implemented speed alert systems; in total 2000-3000 units.[68]

Given that 28% of all business and commuting journeys by household cars are carried out by public sector workers there is tremendous scope for this technology to help reduce deaths and injuries, carbon emissions and fuel costs within the public sector.

Recommendations:

- Accelerate actions to enable the widespread introduction of voluntary Intelligent Speed Adaptation technology, setting out a clear timetable for implementation of the recommendations made in the joint Commission for Integrated Transport / Motorists' Forum report.

Recommendations:

- Consider further trials of Intelligent Speed Adaptation, fitting units to ministerial and other Government Car and Despatch Agency vehicles. If successful the technology should be rolled out to all government, public sector and public transport operator's vehicles.

7.3 Satellite Navigation

In addition to influencing behaviour prior to the start of the journey in the route planning stage, satellite navigation can also change driver behaviour during the journey. Research commissioned by TomTom69 suggests that drivers using satellite navigation travel fewer miles and for less time. The study also measured a reduction in driver workload when using Satnav devices allowing drivers to give more attention to the road and potentially improving safety and reducing accidents.

A further study conducted by NuStats and funded by Navteq found drivers in Dusseldorf and Munich using satellite navigation benefitted from a 12% reduction in fuel consumption compared to those without.[70]

Some satellite navigation systems also display the speed limit on the road currently being used and allow the user to set an audible alarm to warn them not to exceed it.

Garmin's Ecoroute system allows the user to choose the route which will use the minimum amount of fuel and can provide fuel and mileage reports.[71] A new Eco-Satnav range was unveiled by Vexia which will advise the driver on how to drive to

minimise fuel, indicating what gear to use, and the optimum acceleration and speed.[72]

7.4 Eco-driving

Eco-driving - driving in a style to minimise fuel consumption and improve safety - has generated much interest. It is often discussed in conjunction with the use of gear shift indicators, a visual display to the driver indicating the optimum time to change gear in order to maximise fuel economy. More sophisticated displays indicate the actual gear number that should be used.

Studies indicate that fuel consumption can be reduced by between 5-25% depending on previous driving style and ability to adopt the new techniques. Longer term evidence suggests these improvements are reduced as some drivers revert to inefficient driving styles, however a 4.5% long term fuel consumption reduction has still been reported for eco-driving in combination with a gear shift indicator.[73]

There have been a number of initiatives to help drivers learn eco-driving techniques. Fiat's "Eco:drive" system, developed in conjunction with Microsoft, allows a USB memory stick to be plugged into the dashboard to record information from the engine management system while driving. This can then be downloaded and analysed using supplied software which then calculates an 'eco:drive' score (on a range of 1-100) and offers tailored advice on how to improve.

Nissan's Carwings system,[74] launched in Japan, is a similar system to Eco:drive but includes historical analysis and comparison to other drivers.

One factor which may increase adoption of eco-driving techniques is market penetration of hybrid and electric vehicles. Many of these have large displays showing fuel economy which can help drivers adapt their driving style to maximise efficiency. Battery electric vehicles' range is much more sensitive to driving style. Lower speeds and smoother driving result in longer distances between recharging. During research for this report, one manufacturer estimated that real world range may vary by a factor of three or more.

Fleet managers have been using GPS tracking devices for a number of years to monitor driver behaviour. Speed limit violation and heavy acceleration and braking can be notified to both the driver and the fleet manager. Significant savings can be realised through the use of such systems, not just in fuel economy improvements and accident reductions but also through reduced insurance premiums and curtailment of unauthorized vehicle use.[75]

Some insurance companies are now offering private customers schemes using similar technology. Royal Sun Alliance has introduced an insurance scheme through their MoreThan brand, named "Greenwheels".[76] Customers' cars are fitted with a GPS tracking device which monitors car use and driving style. Customers can check their green rating on a scale of A to G in comparison to other Greenwheels customers via a website.

Eco-driving techniques are also being introduced into driver training by public transport operators alongside software monitoring to reduce fuel costs.[77] One of the most cost-effective measures announced in the Department for Transport's Low Carbon Transport Strategy was to extend their existing 'Safe and Fuel Efficient Driving'

(SAFED) programme for van and HGV drivers to include bus drivers.

Rail operators also see the benefits of eco-driving techniques. Eurostar use a data logger fitted to one of their trains to monitor energy consumption and analyse ways of reducing energy usage. Initial tests of the extremes of efficient and non-efficient driving styles suggest that there could be the potential to save of the order of 5% of energy consumption. As a result, Eurostar driver training now includes training on economical driving techniques and an energy efficiency package will be installed on their driver simulator which will then become an integral part of their regular driver training programme.

Virgin Trains also monitor energy consumption on their trains. The company employs a system which measures and displays to the driver overall energy consumption at the end of the journey. It is intended this will encourage drivers to compare energy consumption 'scores' and discuss ways of reducing it.

Deutsche Bahn (Germany's national railway company) is the country's biggest energy consumer and has had commitments in place to reduce energy consumption through eco-driving techniques since 2002. In three years (2002-2005) savings of €32M were achieved through energy efficient driving.[78] The company uses a programme of education with feedback talks for drivers who are identified as having very high or very low energy consumption and a competition for the title of most energy efficient driver on a training simulator.

Recommendations:

- The Department for Transport monitor and report on the level of public awareness of the benefits of eco-driving and further raise awareness through the "Act on CO_2" campaign.
- All public sector employees who drive a vehicle as part of their job to be given eco-driver training.

We also endorse the Committee on Climate Change's recommendation that eco driving is included in the practical part of the driving test.

7.5 Pay-as-you-Drive Insurance Schemes

The introduction of GPS tracking units to privately owned vehicles enables new business models for vehicle insurance. A number of companies have trialled 'pay-as-you-drive' insurance.

Norwich Union were the first to offer this product to the private motorist in the UK[79] but withdrew it in mid-2008, citing low customer uptake and blaming car makers for not fitting the necessary telematics[80] equipment during manufacture.[81] The scheme is still available to business drivers. Norwich Union's parent company, Aviva, is now marketing the product in France claiming two key advantages from their experience in the UK: an average 30% reduction in insurance premium for drivers and a 20% fall in the number of road accidents for those insured with the scheme.[82]

In the UK, Coverbox now offers a similar product,[83] claiming up to 25% savings on fuel costs as the system discourages unnecessary trips. Coverbox's system also connects into the vehicle's onboard computer and management system allowing detailed information to be captured which the driver can use to improve their driving style. A personal online portal allows users to access their data and compare to other drivers with the same car.[84]

Similar products are also offered in Australia, South Africa, Japan, Canada and ten other countries. Real Insurance, who offer pay-as-you-drive insurance in Australia, include a summary of the various pay-as-you-drive insurance products on offer globally on their website.[85]

7.6 Pay-as-you-drive Car Clubs

Extending the idea of pay-as-you-drive further, the other growing area in which ICT is helping to make car utilisation more efficient is through the use of pay-as-you-go car-clubs. Members pay an annual fee and have access to a car by booking it in advance and paying per hour of use.

Companies such as Streetcar, City Car Club, Zipcar and more recently the vehicle rental company Hertz's "Connect by Hertz" [86] scheme offer a web based system for car booking. Vehicles are generally accessed using a smart card to unlock the door via a reader mounted inside the windscreen. The ignition keys are then unlocked from the glove box using a PIN code. Vehicle movements are normally tracked with GPS units fitted in the cars. Streetcar has now expanded to include a service for per hour hire of vans.[87]

The vehicles used are normally amongst the most fuel efficient available as the service is offered on a pay per hour basis including fuel, tax and insurance. Note however that since members are not paying directly for fuel costs, there is no eco-driving incentive.

Commonwheels is a not-for-profit community interest company which promotes and runs car clubs, specifically trying to "establish an accessible and affordable integrated network of car clubs across the UK through a combination of direct operations and through supporting individuals, community groups and other organisations to set up schemes in their locality."[88]

Carplus is an umbrella organisation representing the majority of car club companies. Its 2008 survey of car club members indicated that one car club car takes at least 14 private cars off the road and that the CO_2 emissions of the average car club car are only 64% of those of the private cars they replace.[89] The 2007 survey also found that on average members reduce their car mileage by 54% on joining.[90]

Currently there is no 'roaming' policy whereby members of one car club company can access vehicles of another company. There is no technical reason why this is not feasible, but currently the companies involved do not see a business case to do this. Smartcards used by car clubs could also be used for bike rental schemes or public transport payments in a similar way to the Oyster card in London.

The 'car club' business model has been taken one stage further by Car2go.[91] This is a pilot project run by Daimler corporate research and currently based in Ulm, Germany but also planned to expand to

Austin, Texas. It utilises Smart Fortwo diesel vehicles (with fuel economy of 3.3 litres per 100 km and combined CO_2 emissions of 88 g/km) which can be used without pre-booking by registered Car2go users. The vehicles can be used as long as the customer likes and can be returned to any public parking space within the area of operation. The cost of 19 Euro cents (€0.19) per minute includes tax, insurance and fuel. Low per hour or per day rates are also available. Each registered driver is allowed to cover up to 2000km a month. The system works using a chip fixed to the users driving licence which then provides access to the vehicle.

Recommendation:

- The Department for Transport to put in place actions to accelerate the growth of car clubs, working with Carplus and local authorities to identify and overcome barriers to growth.

7.7 Challenges

Influencing driver behaviour to be more fuel efficient and safer, and hence more sustainable is an attractive policy option. Eco-driving training, especially when done as part of learning to drive, is low cost and can have significant benefits but the long term impacts need further research.

Technologies that successfully enforce speed limits can also have significant environmental and sustainability benefits. However there has been much public opposition to the use of speed cameras and concerns have been raised regarding liability issues with technologies that control vehicle speed.

There have also been concerns with the potential infringement of privacy through the use of technologies which may track vehicle location.

An additional potential drawback to these policies is that technologies which reduce the cost of motoring could lead to so called 'rebound effects' of increased car use.

8

Change vehicle behaviour

8. Change Vehicle Behaviour

There are various ways in which ICT can be used to ensure vehicles operate more sustainably.

Automated reminders for routine servicing, tyre pressure monitors[92] and engine management system self diagnostics can help ensure that vehicles run at optimum efficiency. One survey indicated that 95% of vehicles have at least one underinflated tyre.[93]

Adaptive cruise control, with automated braking systems to maintain safe stopping distances, has been on the market for many years. A GPS-based database of speed limits can be linked into a vehicle's cruise control system to automatically set cruise speeds.

More recently technologies such as collision avoidance, lane keeping, blind spot radar, night vision systems and even driver alertness monitors and speed limit sign reading have become available. These technologies are primarily aimed at improving the safety of drivers though some also improve vehicle efficiency. There are also examples of ICT being used to improve safety through providing advanced warning of hazards such as obstacles or other vehicles, the presence of emergency vehicles, or reduced surface grip.[94]

Research is ongoing into more advanced ways of automating vehicles to improve safety and efficiency. For example the engineering company Ricardo have used internet-enabled mobile phone communications, GPS and advanced mapping data in their Sentience project to "see" beyond the immediate horizon of the driver. This data is integrated with the vehicle's hybrid control system and an advanced form of adaptive cruise control to determine an optimal driving strategy, taking into account vehicle speed, acceleration, deceleration, speed limits, traffic conditions, road gradient, bends and even speed bumps. The strategy also optimises the recharging strategy for the hybrid system's batteries. Track-based tests have demonstrated fuel savings of between 5 and 24%.

Another example is the concept of "vehicle platooning" whereby technologies such as radar and radio communication are used to control vehicles and allow them to travel safely much closer together than would normally be possible. This can provide improved fuel efficiency through reduced drag as well as potentially reducing congestion. Although the technology has been demonstrated as far back as 1997[95] it has never been commercialised. However, the European Commission's Framework 7 research plan is funding a new project, Safe Road Trains for the Environment (SARTRE) which aims to reduce fuel consumption as well as journey times and congestion.[96]

Other research is focusing on optimising recharging strategies for electric vehicles. Concerns have been raised over the ability of the grid to cope with the additional load of a large scale shift to electric vehicles. Mitigation strategies are being developed whereby vehicles 'talk' to the grid via smart meter connections to optimise recharging and synchronise it to off-peak periods. Electric vehicles' battery storage could even prove to be a valuable resource to help smooth the intermittent nature of some renewable electricity generation.

Project Betterplace[97] is working in partnership with an electric vehicle manufacturer and electricity supply companies to create a recharging network, and to market electric vehicles in leasing

arrangements using a business model similar to that of contract mobile phones. Denmark is one of a number of countries that have an agreement with Project Betterplace to utilise the renewable electricity that it generates off-peak to recharge vehicles rather than exporting at very low prices.

Possibly the ultimate in changing vehicle behaviour is the concept of personal rapid transit (PRT). This covers a range of different designs, the unifying theme being driverless operation, fixed tracks and non-stop operation. The vehicles themselves are small (typically seating 2-6 people) and tend to be very lightweight resulting in very low energy use per passenger kilometer.

The most well known example in the UK is probably the ULTra system under construction at Heathrow airport's terminal 5, due to be operational in autumn 2009. This utilizes PRT to transport staff and passengers from car parks to the central terminal area. The system is capable of running at speeds up to 25mph and is claimed to reduce carbon emissions by 70% in comparison to cars and 50% compared to trains and buses (rising to a 90% benefit in comparison to congested traffic).[98] Further systems are being investigated in Daventry[99] and Derby.[100]

8.1 Challenges

Much of the ICT technology directed at private vehicles is aimed at making them safer, more comfortable, easier to use and generally more attractive to buy and run. The downside in terms of sustainability is the continued growth of private vehicle ownership and use which can outstrip efficiency improvements of newer vehicles leading to an overall increase in carbon emissions from road transport.

A further challenge is to ensure that improvements in public transport vehicles keep pace with efficiency improvements of private vehicles. Some cars now available have lower CO_2 emissions per passenger kilometer with only the driver on board than an underutilised bus service. In-use CO_2 per passenger kilometer is not a measure of overall sustainability as it does not take into account reduced congestion, improved safety, lower overall noise pollution and reduced space and parking requirements. However, it weakens the argument that public transport should be prioritized over private vehicles. To assess sustainability, whole lifecycle analysis must also be used so that resource use and environmental effects of vehicle production and disposal are taken into account.

The Department for Transport's announcement of a Green Bus fund is a welcome initiative in this respect.[101]

Recommendation:

- The Department for Transport to further promote investment in public transport to ensure that improvements in sustainability keep pace with or exceed those of private vehicles.

9

Increase vehicle utilisation

9. Increase Vehicle Utilisation

9.1 Car sharing

As car ownership has continued to increase, with over three quarters of all households now having access to a car, so car occupancy levels have decreased. In the early 1960s the average was over two people per vehicle; these days, for commuting and business journeys, it is less than 1.2.[102]

Due to the sheer number of vehicle miles travelled in the UK, even a 1% improvement in car occupancy levels would equate to a reduction of over one billion vehicle miles.

One of the easiest ways of improving vehicle efficiency measured on a per passenger kilometer basis is to increase the number of passengers in each vehicle. An economical family car with 4 people on board can have lower CO_2 emissions per passenger kilometer (pkm) than a bus or train. For instance a car with CO_2 emissions of 160g/km divided by 4 = 40g/pkm.

In comparison Defra's Greenhouse Gas Reporting Guidelines[103] include the following per person emissions levels which are based on average "loading factors" (numbers of passengers):

Average Bus:	104g/pkm
National rail:	58g/pkm
Coach:	30g/pkm

(Note: as mentioned in the previous chapter, CO_2 emissions per passenger kilometer are in no way a measure of overall sustainability).

Sites such as www.liftshare.com, which is one of the largest car sharing (or car pooling) websites, allows users to enter details of the journey they wish to make and either look for people offering a lift or offer a lift themselves.

Some car sharing websites use route planning software to predict routes and enable users to offer lifts 'en-route' rather than only finding matches based on start and end points of the journey; however, the single biggest success factor seems to be a large database of users to provide the best chance of finding a good match.

The most commonly shared journeys are those which are made regularly and for which it is easy to establish a routine of sharing. The other commonly shared journey is when many people are attending the same specific event e.g. music festivals, football matches etc.

Recommendations:

- The Department for Transport to fully integrate car sharing options into the TransportDirect journey planner and further promote car sharing through the Act on CO_2 campaign.
- The Department for Transport to develop and publish metrics such that numbers of people car sharing and an estimate of the resulting reduction in vehicle mileage can be published in future editions of Transport Statistics Great Britain.

9.2 Dynamic Ride Sharing

ICT may also be able to help with more diverse journeys. Dynamic ride sharing is defined as "a system that facilitates the ability of drivers and passengers to make one-time ride matches close to their departure time. Hallmarks of a dynamic service are flexibility and convenience."[104] Most of the thinking around this idea incorporates the use of mobile phones and GPS to enable drivers and riders to connect to each other. In a trial scheme running in Brescia in Italy, users wear hi-tech bracelets with built in breathalysers and use social networking tools to offer and request lifts from friends.[105]

Another initiative is Avego - a 'real time carpooling' system using an iPhone application. They are currently seeking partners to run a pilot programme in America.[106]

As with many applications of ICT to transport there is a huge amount of information available on proposed schemes, but the concept of dynamic ride sharing has yet to make a significant impact. However if transport costs rise and systems to facilitate dynamic ride sharing are well executed, this may be a growth area.

9.3 High Occupancy Vehicle (HOV) Lane Enforcement

Provision of high occupancy vehicle lanes can be a strong incentive to encourage car sharing. In the UK the introduction of a high occupancy vehicle lane on the A467 in 1998 achieved an increase in average vehicle occupancy from 1.35 to 1.51 in four years and journey times reduced for all vehicles (a 1.5 minute reduction for single occupancy vehicles, and a four minute reduction for high occupancy vehicles).

This can lead to attempts by single occupancy vehicle drivers to use the lane using a dummy to give the impression of carrying a passenger. ICT can play a role in enforcing high occupancy vehicle lanes using cameras and software able to detect the number of vehicle occupants. A system has been developed in the UK which is capable of recognising human skin to ensure that only genuine passengers are counted.[107]

Recommendation:

- The Department for Transport to investigate how latest technology can be deployed to improve enforcement of high occupancy vehicle lanes, update guidance to reflect this, and encourage their increased implementation.

9.4 Demand Responsive Transport (DRT)

According to the Commission for Integrated Transport, demand responsive transport (DRT) refers to any form of transport where day-to-day service provision is influenced by the demands of users.[108] Although not widespread there are several examples of DRT within the UK. In Europe it is more common. Systems normally operate using a combination of a call centre and a web booking system to allow users to pre-book travel requirements.

DRT is particularly useful in regions where the density of population means that more traditional public transport such as scheduled train and bus services are uneconomic to

run. It represents a cost effective way of reducing transport related social exclusion.

In Wiltshire a "Wigglybus" service was run successfully for several years. The service combined a pre-defined circular bus route with a booking service allowing requests for the bus to "wiggle" away from the route to pick up or drop off passengers within a wider defined operating area. Bookings were made through a call centre where specialised software was used. A GSM communication link enabled the call centre to communicate to the bus driver.[109] This has now been replaced by the county's "Connect2" service which uses a combination of buses, taxis and community transport, but still relying on a demand-responsive software system to co-ordinate bookings.

The Commission for Integrated Transport's report *A New Approach to Rural Public Transport* recommended the adoption of a "Taxiplus" concept. This is described as a large-scale taxi-based operation which provides bookable, shared, demand-responsive public transport. Having examined activities across UK and Europe they concluded that by operating services across a larger geographical area, European operators were able to achieve economies of scale. They recommended a county-wide pilot study to investigate the benefits in the UK.

Recommendation:

- The Department for Transport to run a large scale demonstration pilot of Demand Responsive Transport (DRT) as previously recommended by Commission for Integrated Transport.

9.5 Dynamic Pricing

Using ICT to enable travellers to book discounted tickets in advance either by internet or phone can help transport providers maximise utilisation rates. Easyjet is widely recognised as one of the pioneers of this approach and has sophisticated demand models to set prices. There are potential benefits for travellers through the availability of discount prices, but also to transport operators by maximising profits, gaining a level of certainty regarding demand as well as a better understanding of the price/demand relationship of their customer base.

There is potential for these dynamic pricing systems to be more widely used by other transport service providers.

9.6 Challenges

There do not appear to be any serious drawbacks in relation to the more efficient use of vehicles other than the ever present danger that success in reducing congestion through policies to promote more efficient vehicle usage may induce further traffic. However this is an issue which must always be considered.

Concern about travelling with strangers is often raised as a barrier to encouraging car sharing. Organisations promoting car sharing take safety very seriously and publish guidelines to minimise any risks. Events can be held to promote car sharing at which potential car sharers can meet prior to starting to share lifts. *Lift*share.com has been operating for 11 years and estimate that their members currently share around 10 million trips per year. They state that there has not been a single member reporting a personal safety issue.[110] Some car sharers

feel it gives them increased personal security while walking to and from the car or in the event of a breakdown. Evidence also suggests that car sharers are half as likely to be involved in an accident as those driving solo.[111]

10

Improve network efficiency

10. Improve Network Efficiency

The final area in which ICT can help improve the sustainability of mobility is in the efficient use of transport networks. By making real-time traffic management more efficient, ICT can obviate the need to build more infrastructure or purchase more public transport equipment. This can improve both cost-efficiency and environmental performance.

IBM's "Smart Planet" report points out that as of 2007, for the first time in history, the majority of the human population lives in cities.[112] The report emphasises the fact that although our vehicles have become a lot smarter, our roads need to do the same.

ICT can help achieve optimum infrastructure utilisation through:

- Parking management
- Congestion charging/road pricing
- Real-time traffic management (including active traffic management on motorways)
- Automated tolls

Within these categories there are two broad kinds of application:

- Those aimed at making road traffic, including private cars, flow more freely
- Those aimed at making public transport more efficient

Currently ICT is mainly used in transport networks to collect and process data on traffic flows and speeds to provide better information to the traveller. The same information can also be used to optimise use of the infrastructure though this is comparatively under-developed. The technology is available, but so far has only rarely been deployed.

As sensor technology improves and becomes cheaper there is significant potential for all vehicles to act as mobile data acquisition units, monitoring traffic speeds, densities and perhaps even air quality. Intelligent network management techniques similar to those currently used in battlefield scenarios can allow network optimisation.

The European Cooperative Vehicle-Infrastructure Systems (CVIS) project launched in March 2006 aims to design, develop and test the technologies needed to allow cars to communicate with each other and the nearby roadside infrastructure. The project claims creating a wireless network between vehicles and infrastructure will increase efficiency and safety, while offering business opportunities for stakeholders and delivering essential benefits for users and society. However, it cautions that this will demand "unprecedented cooperation amongst leaders from automotive and traffic systems industry, road and telecom operators, service providers and governments."[113]

10.1 Parking Management

Research has shown that the availability of parking is one of the most important determinants of car use.[114] This is the case even in a city like Hong Kong in which public transport is widely available and there are relatively low levels of car use.[115] Another survey in Sydney showed that amongst those surveyed, the primary reason for using public transport was to avoid parking problems.[116]

The search for a parking space wastes time and fuel. Research suggests that up to 30% of the traffic in cities is due to such "search traffic".[117] ICT could enable checking of parking availability before making a journey and pre-booking of a space to avoid unnecessary extra mileage looking for somewhere to park. For example the Cooperative Vehicle-Infrastructure Systems (CVIS) project aims to make it possible for drivers to find and pay for parking more easily thus reducing emissions. The system will be demonstrated in one of London's busiest roads in Camden town.[118]

However making parking easier and more convenient through pre-booking systems needs to be done in conjunction with policies to ensure the number of parking spaces available do not encourage further unsustainable car use. Copenhagen is a good example of a city in which parking policy has been used to successfully influence transport choices. Parking spaces have been reduced by 2-3% a year over a period of 35 years in order to make public spaces available for other uses. According to Living Streets, the result has been "a four-fold increase in public life since the 1960s".[119] Living Streets also state that UK car parking consumes a land area twice the size of Birmingham, [120] much of which could be put to better use.

10.2 Congestion Charging and Road Pricing

There are comparatively few examples worldwide of congestion charging. Singapore introduced the first scheme in 1975. In the UK the first scheme was in Durham (2002), but the most well known example is the London Congestion Charge (2003). The London scheme uses number plate recognition cameras positioned around the perimeter and within the congestion charging zone.

Despite many predictions that the London scheme would not work, five years after implementation traffic levels entering the congestion charge zone are still 21% lower than pre-charge levels and levels of bus use and cycling have increased.[121] Actual congestion levels have risen back to pre-charge levels but this is primarily due to a reduction in road space for motor vehicles in favour of pedestrians, cyclists and public transport.

In Seoul, South Korea, a Smart Transportation Pricing scheme is currently being trialled to reduce traffic and parking congestion using time, location, and distance-based flexible pricing. The technology makes use of GPS and wireless broadband.[122] Between 1996 and 2005 Seoul had seen a slight increase in public transport use (which was already high) but also increasing use of private cars. To combat this, policies of reducing road space for motor vehicles in favour of pedestrians and cycle paths are being followed in combination with the smart pricing strategy.

Stockholm also introduced a congestion tax system in 2007 after a seven month trial period. The system uses wireless RFID technology and drivers who regularly enter the zone are encouraged to fit in-vehicle transponders allowing direct debit payment of the tax.[123] This has led to significantly lower operating costs than the London scheme and also makes it easier to vary the charge according to time of day. Number plate recognition cameras are used to identify vehicles without transponders. Despite initial public opposition, following the trial the residents of the municipality of

Stockholm voted in favour of the system by a small majority.[124]

For several years the concept of widespread road pricing has been put forward as the most economically efficient way of addressing congestion on our roads. A sophisticated system which was able to charge according to geographical location, time of day and vehicle type could be used to incentivise drivers to avoid roads during peak congestion times where possible. By linking the charge to the vehicle's CO_2 emissions rating the system would also incentivise purchase of fuel efficient vehicles. Three countries appear to have actively considered a national road pricing scheme: Sweden, the UK and the Netherlands. The Swedish Road Authority announced in 2005 that it would make it possible to collect road charges and kilometer taxes via an electronic system by 2009 at the latest.[125]

In the UK strong resistance has been voiced to the possible introduction of such a scheme. 1.7 million people signed a petition to the Prime Minister citing concerns regarding the necessary tracking of all vehicle locations and the affect of increased costs on poorer people and those who live apart from their families. However the Netherlands plans to introduce a scheme in 2012-2017 with variable pricing based on time, location and environmental factors (vehicle size and emissions). The scheme will use GPS-based vehicle tracking and aims to be revenue neutral as the road pricing payments would replace existing transportation taxes and fees. The primary justification for the scheme is cited as improving equity and fairness by "addressing the insufficient link between the costs and benefits to road users under the existing taxes" and "charging those users who create congestion".[126] Improving accessibility, managing congestion, economic and environmental reasons are also given. In November 2009, the scheme was put forward to the Dutch parliament and is currently being considered.[127]

In a report on road pricing in 2006,[128] the Commission for Integrated Transport advised that while the primary focus in the UK has been tackling congestion, it may be wise to aim for a wider range of objectives with future plans.

Recommendation:

- Department for Transport to encourage more efficient road network utilisation through better use of parking controls, tolls and road pricing.

10.3 Active Traffic Management on Motorways

In the UK after initial trials on the M42, the expansion of active traffic management for other motorways has been announced. This involves allowing vehicles to use the hard shoulder during peak periods, with refuges provided in case of breakdowns. The system utilises traffic sensors and CCTV cameras to monitor traffic speed and density, and large gantries with electronic signs to relay information to motorists.

The trials on the M42 regulated traffic speeds to a maximum of 50mph. This was reported to result in a 4% reduction in CO_2 emissions as well as reducing NOx (-5%) and particulate (-10%) emissions.[129] However further implementation will be accompanied by an increase in the speed

limit to 60mph which may reduce or negate any carbon savings.

10.4 Automated tolls

ICT can also be used to automate road tolls, sometimes known as electronic toll collection. Norway has pioneered widespread use of this technology with Trondheim first introducing an electronic toll system with no requirement to slow down in 1991. The system used a small transponder fitted inside the windscreen and enabled tolls to be paid by direct debit from users bank accounts. The toll plazas formed a ring around the city centre. The scheme was considered a success, winning public support as the funds raised were committed to local transport improvements. However the tolls were discontinued at the end of 2005. A four month study comparing traffic before and after indicated that overall growth was insignificant, but that more journeys were made during the hours when tolls had previously applied (6am-6pm). Interestingly the study also concluded that the possibility of getting a parking place seemed to be a more important restriction on traffic than the payment of the toll.[130]

10.5 Challenges

Proposals for congestion charging and road pricing schemes are often unpopular. The public referendum in Manchester illustrated this with 79% of people voting against a package of public transport improvements linked to the introduction of a congestion charge zone. This makes it politically difficult to introduce such measures.

Despite this, where schemes such as those in Stockholm and London have been introduced, public opinion has often been seen to change once the benefits are realised. In Stockholm following the seven month trial of the scheme, the residents voted in favour of making it permanent. In London support for the scheme went from 39% before charging was introduced to an average of 54% in the eight months after introduction.[131]

ICT based transport interventions often have much lower capital costs than measures to increase capacity such as building new roads or railways. However ICT does tend to need higher revenue funding to maintain and upgrade systems once in place. Systems will have continuous running costs and may need regular software updates. Computer hardware can have a working lifetime of as little as five to ten years, while roadside hardware may have a lifetime of 10-20 years.

This can be an issue due to local authority transport funding arrangements. Capital funding is often more readily available and schemes which require higher revenue funding may be discouraged even in situations where the overall result is likely to be lower cost and increased sustainability.

Recommendation:

- The Department for Transport to revise transport funding arrangements to allow local authorities increased flexibility between revenue and capital funding.

11. Conclusion

The research for this report demonstrates that there are many ways in which ICT can help to make mobility and our lifestyles more sustainable. Whether it be through enabling us to avoid the need to travel at all, or by making public transport easier to use and more attractive, through helping us to make more efficient use of cars or by optimising the use of our transport networks.

To investigate the opportunities for ICT-enabled sustainable mobility further, we recommend that a Government sponsored Innovation and Growth Team is set up. In addition we make 18 further specific recommendations.

We also recognise there are challenges. In pursuing these recommendations, care must be taken to ensure that the overall full life cycle impacts of the use of ICT are taken into account, and the necessary funding is provided for hardware and software support, maintenance and updates.

It is also important to be realistic in assessing the extent to which travel behaviours can be influenced, and to be sure that encouraging ICT based solutions doesn't lead to increased social exclusion.

Overall, we conclude that ICT must be seen as an enabling tool within a wider sustainable transport policy framework designed to create sustainable travel behaviours. If this is not the case, it may simply encourage increased unsustainable travel.

Annex 1: Technologies Appendix

A number of technologies form the building blocks for ICT solutions for sustainable transport. Not all of these are new, but miniaturisation and cost reduction has made them more generally applicable and brought them within range for some sustainable transport applications. Here is a brief overview of some of the key technologies:

Mobile networks and devices

Cellular mobile networks have become much more powerful in the last ten years. Originally optimised for voice calls, internet-like data capability was first introduced with the launch of the General Packet Radio System (GPRS) in 1999. They now have the capability of carrying high-speed data. The HSDPA upgrades to the 3G networks in the UK make their carrying capacity comparable to fixed broadband networks. The increased capacity of the networks has also resulted in a sharp decline in data service pricing, with all-you-can-eat (unlimited) price plans increasingly common.

Mobile handsets are also much more powerful than their predecessors, with better screens and easier-to-use input methods including touchscreens. This makes it possible to use them as personal navigation devices, accessing high-quality maps and real-time transport information online.

Mobile web frameworks

Smartphone platforms (device operating systems, like Symbian, Windows Mobile, and Android) make it easier to use web services on a mobile device, as if it were a PC. When every phone has its own proprietary operating system designing a useful web page to display properly requires a lot of effort for each individual device; making sure that the device only 'sees' the right kind of page is very difficult.

New software tools (Rich Internet Application Frameworks) are also being created which will make it easier for developers to make modularised applications for mobile devices. This will make web-based information services, such as personal transport planners, easier to develop and easier to use.

Positioning technologies

Originally developed for the US military, the Global Positioning System (GPS) is now part of everyday life. The main elements are the constellation of satellites maintained by the US government, and the individual receivers which pick up the satellite signals and then use the information that these contain to calculate their latitude, longitude and height. GPS receivers, already familiar in car-mounted satnav devices, are becoming more common in mobile phones and will reach the mid-range within three years. Improvements to the software are helping to reduce the impact on the phone's battery. Many products and services combine GPS receivers with mobile data networks to allow devices to send information about their position to a database or other application.

Location from public WiFi access points is emerging as a useful complement to GPS in urban areas, where the signal is often blocked by buildings. Phones which do not have in-built GPS, or where there is no signal, can use an alternative technology which uses signal strength measurements from the mobile network itself (because the

positions of the network's masts are known).

Positioning technologies are an important enabler of transport and travel solutions, including navigation assistants and vehicle monitoring systems.

Web 2.0

Web 2.0 is a family of approaches which have made new kinds of internet content and business models possible, with the emphasis very much on communication and sharing of user-generated content rather than one-way publishing and selling. Most of the underlying technology is not new or is not specific to Web 2.0; it is the context of deployment that is innovative.

Because users are much more involved with Web 2.0 content and applications there is potential to use it both as an agent of behaviour change and as a source of travel information – for example, by allowing users to post their own real-time updates to transport or traffic information.

Imaging and cameras

Cameras and image processing are central to several ICT transport solutions. Their primary use is in applications which involve some kind of enforcement, like speed limit enforcement and road pricing. For example, the capture and analysis of car number plates is the basis of the London (and other) congestion charging schemes. The miniaturisation and connectivity of the cameras is important, but so too is the speed of optical character recognition which allows the images of number plates to be turned into numbers, and the speed of database look-up, which allows the payment records to be checked and compared.

Cameras can also be used in bus lane, parking and high occupancy vehicle lane enforcement, all of which can be used to reduce traffic congestion. There is potential for further use in travel information systems and dynamic traffic management systems. For example, the Trafficmaster traffic information system uses information from cameras to record the movement of individual vehicles and thus to estimate the speed of traffic flows.

RFID

Radio Frequency Identification is the use of a programmed chip to identify an object, which can be a vehicle, a container, or a tag or card. Chips may be either active (with a battery), which allows for reading at a greater distance, or passive (no battery), which requires closer proximity to read the chip.

RFID tags can be as an identity token in goods tracking, payment cards (like TFL's Oyster Card), or in road tolls, to allow for automated payment.

RFID technology itself is not new; it was used during WWII to identify returning aircraft so as to distinguish them from enemy planes. The technology has generated some fears about privacy and about security from hackers.

WiFi

WiFi is a family of technologies and standards which allows radio to be used instead of cables – e.g. in local area networks (LANs). Unlike mobile cellular networks it is intended to be used over relatively short distances at very low power levels. The family includes the 802.11p

standard for Wireless Access in the Vehicular Environment (WAVE) – a series of projects to develop dedicated short range communications for vehicle-vehicle and vehicle-infrastructure communications. Already in use for in-vehicle entertainment systems, there are plans to use this for information and safety systems, and tolls (to replace or supplement RFID).

Sensors and sensor networks

Sensors are widely deployed in intelligent transport systems. Most applications are aimed at improving safety or driver experience rather than sustainability. There are lots of different types of sensors, including optical, mechanical, radar and even chemical. They can be used to provide information to the driver (for example, in automated parking systems), to the vehicle (as in collision prevention and automatic braking systems), or to traffic managers (as in traffic flow measurements). There are even projects that aim to measure car exhaust emissions in real time.

Endnotes

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