BUS REAL-TIME PASSENGER INFORMATION
BUSINESS CASE RESEARCH

BY

L. Basford, C. Burke and M. Pickett

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EXECUTIVE SUMMARY

E1. The Government's White Paper on the Future of Transport (DETR, 1998) states its commitment to the creation of a better, more integrated transport system that will increase modal choice by improving public transport and will also provide sustainable mobility for all. Real Time Passenger Information (RTPI) is a way of providing the users of public transport 'real time' travel information from a variety of sources, including bus stops, stations, via telephone or Internet and on vehicles themselves. It is believed that Real Time Passenger Information Systems have the potential to bring a wide range of benefits to bus passengers, bus operators and Local Transport Authorities.

E2. The aim of the study was to determine whether there was likely to be a business case for introducing more bus Real Time Passenger Information systems. To establish whether there was a business case, an extensive literature review was carried out, referencing in excess of fifty texts. The review of literature extended to also include news items and articles from journals. Interviews were also carried out with key players in the public transport industry, including seventeen bus operators and twenty local authorities/PTEs.

E3. The review of evidence revealed a considerable number of research reports and other sources of information relevant to this study. The body of evidence was assessed and evaluated by the study team and presented in a series of summary tables for each recipient of potential benefits, including bus passengers, operators, and Local Transport Authorities

E4. However, it has been generally found that robust quantitative investigations into the effects of the implementation of a real-time passenger information system are rare. Statements supporting this finding were identified through out this document. For example, Bishop (1999) stated that '*investment in the integration of [real-time information systems] across agencies is very difficult to justify on a strictly commercial basis as little quantifiable data exists from which to assess the incremental costs and revenue associated*.'

E5. It was revealed in the review that a number of impacts were incurred across the range of recipients. These included

- Savings on journey times;
- Improved regularity of service; and
- Improved reliability of service.

E6. For a thorough business case to be made it is therefore essential that further research is carried out to justify in depth the impacts of RTI for the various recipients. In order to assist with this prioritisation, the study team has devised a priority search mechanism which analyses the recipient summary tables for further research requirements which would deliver maximum benefit to the business case. To do this the search focuses upon the impacts which have the highest scale but which have a requirement for further evidence, or in some cases no evidence at all.

E7. The study therefore revealed priority areas for further consideration. These were:

- Examination of the impact on the regularity and reliability of services, this would include the management of scheduling, avoidance of penalties from the Traffic Commissioners.
- Examination of the generation of new passenger trips through the provision of RTPI, including the impact on customer satisfaction, passenger pre planning activity and passenger diversionary activity.

E8. Both of these and other proposed areas of research outlined within the report should determine in more detail key areas of concern for the business case for the recipients of RTPI.

1. INTRODUCTION

1.1. In August 2002 TRL Limited was commissioned by the Department for Transport to undertake a *Bus real-time passenger information business case research* study. The project brief stated that the study should primarily present data that could assist in the development of a business case, rather than the actual development and presentation of a business case. Also, the project title directed the study to focus on the following stakeholder groups: the travelling public, service providers and supporting bodies, i.e. Local Transport Authorities and Passenger Transport Executives.

1.2. The research has consisted of a literature review (including reports and news items in the technical press) and the collection of unpublished information through interviews with and questionnaires completed by representatives from local authorities and public transport executives. Questionnaire responses were also collected from a sample of bus service operator representatives.

1.3. The review of evidence has revealed a considerable number of research reports and other sources of information relevant to this study. This body of evidence has been assessed and evaluated by the study team. The full evidence is produced in the Appendix: Literature Review Findings. It was necessary to summarise the key points of relevance, which are presented in a series of summary tables for each recipient of potential benefits, for example, passenger, operator, Local Transport Authority.

1.4. This report describes the results of the study and puts forward a series of recommendations for further research.

2. BACKGROUND TO THIS RESEARCH

2.1. The Government's White Paper on the Future of Transport (DETR, 1998) states its commitment to the creation of a better, more integrated transport system that will increase modal choice by improving public transport and will also provide sustainable mobility for all. Real Time Passenger Information Systems have the potential to bring a wide range of benefits to bus passengers, bus operators and Local Transport Authorities. However, the two organisations that provide them – operators and LTAs pursue different objectives. Operators are running commercial businesses and will only invest in RTI if it gives them a commercial return on their investment. Operator's also have to meet stringent criteria for schedule adherence that are set out by the Traffic Commissioners, who have the powers to impose financial and other penalties for non- compliance. The operator element of the business case will be focussed on these two issues.

2.2. LTAs have a wider range of objectives, which differ from area to area and are set out in their statutory Local Transport Plan. Achievement of higher level LTP objectives like reducing the environmental impact of transport, sustainable economic development of their areas and reducing social exclusion requires increased use of public transport. LTAs therefore can and do take a wider range of impacts into account in developing their business case for investment in RTI.

2.3. Experience so far in the UK has shown that neither operators nor LTAs alone can make the business case to justify the investment in RTI. Therefore partnerships have been developed with each partner contributing to the costs of systems.

2.4. The first application of the research reported here is therefore likely to be by individual partners identifying the benefits that their proposed system will bring to them and quantifying the impacts.

2.5. For this reason, the report does not set out the business case. What it does do is to:

- Identify the benefits that an RTI system can deliver – although not every system will deliver every benefit. These are categorised by benefit type and by recipient - passenger, operator, LTA.
- Examine the extent to which and how each benefit can be quantified
- Identify and summarise available evidence for quantifying each benefit
- Prioritise the areas for further research in terms of benefits and level of information that is required.

HOW TO USE THE REPORT

2.6. The following section of the report presents a series of summary tables designed for use by each recipient of benefits, e.g. operators, LTAs, passengers, in order to carry out a clear and easy assessment of the scope for RTPI.

2.7. Each summary report is based around five elements:

- The impacts of RTPI for the recipient.
- The significance of any given impact for each recipient. This has been summarised using the following scale to that recipient's business:
    1. High significance.
    2. Medium significance.
    3. Low significance.
- Whether the impact can be quantified

- The evidence that exists
- Whether the evidence had been quantified in research terms

2.8. The evidence displayed in the summary tables has been described as 'none', 'partial' or 'extensive', so that its quality is clear to the reader:

- None = No detailed evidence available
- Partial = Limited evidence available, further research is required
- Extensive = Substantive research evidence.

2.9. Using these five elements, the summary tables in this report are of two categories:

2.10. **A Recipient Summary Table**. One of these is provided for each of the three key recipients. For each of these the Summary table brings together all of the impacts relevant to that stakeholder group along with the assessment of the significance and the quality of the research. These tables are designed to allow the different types of stakeholder to quickly review how much is currently known about the implications of RTPI for their interests and the reliability of the available information.

2.11. **An Overall Summary table.** This brings together the benefits of RTPI, across all of the recipients

3. KEY FINDINGS – THE SUMMARY TABLES

3.1. The following summary tables have been laid out to clearly show the impacts that need to be taken into account in the development of a business case for RTI for

- Operators,
- Local Transport Authorities, and
- Passengers.

3.2. Each recipient has been given a unique scale for the evaluation of the impacts of RTI. This is because the values associated with RTI vary according to the recipient. For example, a passenger's key concerns are; increased reliability and regularity of service, their own satisfaction with the service and the journey experience. These are all rated as high whereas time savings are rated as medium and costs of RTI are low as the passenger is not essentially interested in the costs to the operator or to the LTA of the system.

3.3. The scale assigned to operator's impacts look to reflect their key concerns regarding monetary benefits (high) service benefits (medium) and administrative benefits (low).

3.4. The Local Transport Authority's scale relates closely to the passengers scales, particularly in terms of seeking benefits for users in order to enhance public transport and encourage modal shift.

3.5. This section concludes with a summary matrix which identifies shared impacts across all recipients of RTI.

Table 1: Assessment Of The Scale And Type Of Impacts Associated With Bus Service Operators With Regards To The Introduction Of Real Time Passenger Information

A scale value has been attributed to the impacts listed in relation to the importance of the impact to the bus service operators. 'High' relates to monetary benefits, 'Medium' relates to service benefits and 'Low' relates to operator administration benefits.

The quality of evidence has been described as either 'extensive', 'partial' or 'none'. 'Extensive' means that substantive research evidence was found, 'partial' indicates there was limited evidence available within the source and further research is required, and 'none' means that there was no detailed evidence available.

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
1	Savings on journey times	HIGH	Yes	DETR (2001) study indicates Bus SCOOT can reduce bus travel times by 2 to 4 mins on a 10 km route, with the variability of travel time improved by up to 16%. Time savings of 1 to 10 seconds per junction (with an average of 4 seconds), and travel time variability improvements of 0 to 20% (with an average of 12%) were achieved. (see Appendix paragraph: A39)	Extensive	YES
				DETR (2000) found number of buses being given priority is an important factor, particularly at higher degrees of saturation. Benefit per bus decreases as bus flow increases, due to competing / conflicting priority calls, but total passenger benefit remains substantial at bus flows as high as 120 buses/hr/junction. (see Appendix paragraph: A40)	Extensive	YES
				The SCOOT Version 3.1 and later includes facilities to provide priority to selected vehicles (e.g. bus priority). Trials in London have shown additional average reductions in delay to buses of 3 to 5 seconds per bus per junction. At particular sites much larger benefits can be found. A trial at one junction in Lances Hill in Southampton has shown reductions in delay of 34 seconds per bus in the PM peak period. (see Appendix paragraph: A41)	Extensive	YES
				If travel times are reduced by 2-4 minutes on a 10 km stretch, the value of time is estimated at £1.82-£3.64. If 4 seconds are saved at a junction, the value of time is estimated at £0.06. (see Appendix paragraph: A42)	Extensive	YES

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
				Lehtonen and Kulmala (2002) found that the RTPI system has the benefit of passenger time savings due to travel time reductions. (see Appendix paragraph: A29)	Partial	NO
2	Reduced number of buses needed to operate a service	HIGH	Yes, compare number of buses before and after RTPI deployment	Furth (2000) discusses benefits of automatically collected running time and punctuality data, including ability to perform statistically valid analyses of performance – guiding improvements in scheduling, operation control and traffic engineering. (see Appendix paragraph: A89)	Partial	NO
				Brandt (1996) discusses benefits of prioritisation at traffic signals for public transport, leading to a reduction in running time, bringing savings in terms of vehicles in operation while keeping the headway the same (source relates to trams rather than buses). (see Appendix paragraph: A47)	Partial	NO
				Wilkinson et al (1998) reported an 'anecdotal experience from Leicester [where] an operator using [telematics for fleet management] had been able to provide the same service on the same route with one less bus just by improving reaction times to problems on the network'. (see Appendix paragraph: A49)	Partial	NO
				Transit (15/11/02) highlights links between RTI and fleet and service management. (Media)	Partial	NO
3	Avoidance of penalties from Traffic Commissioners	HIGH	Yes, number and scale of fines imposed after deployment	Transit (18/10/02) highlights importance of compliance with reliability regulations (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
4	Improved regularity of service	MEDIUM	Yes, compare regularity.	Lehtonen and Kulmala (2002) review the HELMI system deployed in Helsinki – found that with the system there was an increase in regularity of service by 25 seconds, or an increase of 20%. (see Appendix paragraph: A69-A71)	Partial	YES
				Local Transport Today (LTT) (13/02/00) suggests frequency and regularity results in high patronage increases. (Media)	Partial	NO
5	Improved reliability of service	MEDIUM	Yes, compare running times with schedules	See Brandt (1996) in 2. (see Appendix paragraph: A49)	Partial	NO
				Schweiger (2003) found through a survey/telephone interviews that the main reason for deploying RTPI system is to improve customer service. (see Appendix paragraph: A76)	Partial	NO
				Horbury (1999) found that 'automatic vehicle location systems can help improve reliability by providing bus route controllers with more information in the face of non-recurrent congestion. (see Appendix paragraph: A50)	Partial	NO
				Transit (18/10/02) demonstrates new technology for satellite based AVL (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
6	More realistic schedules/better adherence to schedules	MEDIUM	Yes, compare running times with schedules	Okunieff (1997) discusses the monitoring benefits of RTI, which can influence the creation of better scheduling. (see Appendix paragraph: A53)	Partial	NO
				See Horbury (1999) in 5. (see Appendix paragraph: A50)	Partial	NO
				See Furth (2000) in 2. (see Appendix paragraph: A89)	Partial	NO
				LTT (08/06/00) bus scheduling software systems to facilitate assessment and management of schedules (Media)	Partial	NO
				Transit (15/11/02) satellite RTI system enables controllers to improve scheduling reliability. (Media)	Partial	NO
7	Fuel Cost Reductions	HIGH	Yes	If a bus is travelling at a steady speed as a result of bus priority measures, only stopping at scheduled stops, a reduction in fuel costs may be realised. It is estimated that a bus travelling at 29 km/h (average link speed from York, 1992) the fuel consumption will be 0.46 litres/km. (see Appendix paragraph: A42)	Partial	YES

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
8	Retaining existing passengers	MEDIUM	Yes, monitor passenger numbers and perform customer surveys	Estimates of increases in patronage as a result of the implementation of advanced traveller information systems (of which RTPI is a subset) are thought to be between 1 and 3% (Schweiger, 2003). It was noted that it is difficult to ascertain how much of this increase results solely from real time bus arrival information and not other measures. (see Appendix paragraph: A65)	Partial	YES
				Schweiger (2003) found through a survey/telephone interviews that the main reason for deploying RTPI system is to improve customer service and that RTPI was a way of maintaining patronage. (see Appendix paragraph: A76)	Partial	NO
				Harrison *et al* (1998) that the delivery of a whole package of measures (RTPI amongst other measures such as bus stops within reasonable walking distances, readily available information, safe environment etc) influences a passenger's selection or dismissal of bus travel. (see Appendix paragraph: A66)	Partial	NO
				LTT (06/09/07) and Transit (09/08/02) reports highlight link between providing passenger information and passenger retention. (Media)	Partial	NO
9	Increase in use by existing passengers	MEDIUM	Yes, monitor passenger numbers and perform customer surveys	See Schweiger (2003) in 7. (see Appendix paragraph: A76)	Partial	YES
				See Harrison et al (1998) in 7. (see Appendix paragraph: A66)	Partial	NO
				LTT (17/05/01) better information delivers patronage growth (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
10	Passenger generation	MEDIUM	Yes, monitor passenger numbers and perform customer surveys	See Schweiger (2003) in 7. (see Appendix paragraph: A75)	Partial	YES
				See Harrison et al (1998) in 7. (see Appendix paragraph: A65)	Partial	NO
				Holland (2000) reported on an online survey on journeys made using Superoute 66 as a result of the website. Estimated that 33 new bus passenger journeys had been generated. Approximations about the context surrounding this figure and estimated that approx 12% of these new journeys were trips that would not have previously been made. (see Appendix paragraph: A54-A58)	Partial	YES
				Wilkinson et al (1998) Bus company for Super Route 17 in Bournemouth reported a 5.6% increase along the route, as a result of RTPI, and possibly other measures. (see Appendix paragraph: A51)	Partial	YES
				LTT (14/02/02 'travel information holds the key to modal change' (Media)	Partial	NO
11	Increased passenger satisfaction	MEDIUM	Yes, subjective opinion surveys of passengers indicating level of satisfaction	Nakamura *et al* (1998) carried out research into customer frustration levels whilst waiting for buses. One group were provided with RTI and the other was not. The experiment found that the provision of real time information reduced the waiting passengers' level of frustration (except in cases where the system was unreliable and frustration levels rose again). (see Appendix paragraph: A78)	Partial	NO
				Schweiger (2003) reported on findings by London Buses that the Countdown RTPI service achieved an overall usefulness rating of 7.1 (on a scale of 0 to 10). (see Appendix paragraph: A77)	Partial	NO
				Transit (18/10/02) recognition of the importance of passenger satisfaction prompts Government Commission to study research relating to RTPI (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
12	Less unscheduled overtime	HIGH	Yes, frequency overtime is claimed and amount paid	Transit (29/11/02) information from RTPI capable system also used for managing schedules. (Media)	None	NO
13	Automatic updating of fare stages	HIGH	Yes	Transit (15/11/02) development of RTI technology to facilitate automatic fare management (Media)	None	NO
14	Cost of System	HIGH	Yes	Schweiger (2003) states that not enough is known about the operation and maintenance costs of real-time information systems. Research revealed that many of the survey respondents were unaware of how much it would cost to operate and maintain their systems. (see Appendix paragraph: A10)	None	NO
15	Improvements in bus service administration	LOW	Yes	Okunieff (1997) states that RTI systems can reduce amount of paperwork for dispatchers and service planning personnel – supervisors can therefore make better use of their time, no longer performing on-time performance checks (see Appendix paragraph: A86)	Extensive	NO
				See Furth (2000) in 2. (see Appendix paragraph: A89)	Extensive	NO
16	More effective supervision	LOW	Yes	Okunieff (1997) states how RTI linked to control software permits supervisory staff to closely monitor operator/driver behaviour – late/early departures, travelling off route, speeding and other work violations. As monitoring process can be automated, less supervision is required (see Appendix paragraph: A85)	Extensive	NO
				Transit (23/08/02) AVL technologies to support supervisors to deliver increased reliability (Media)	Extensive	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
17	Better information on vehicle performance	MEDIUM	Yes, quantify the number of inspectors required	Tillis (2003) – potential to incorporate RTI into monitoring and programming maintenance schedules - ensuring each bus is maintained to the safest possible standard, meeting relevant standards - early warning for remedial measures can reduce breakdown occurrences. (see Appendix paragraph: A90)	Partial	NO
				Transit (15/11/02) operational performance monitoring through RTI technologies. (Media)	Partial	NO
18	Quicker response to breakdowns	MEDIUM	Yes, measure response times	Wilkinson *et al* (1998) discuss the benefits of vehicle location information, suggesting that the occurrence and nature of breakdowns can be immediately reported (see Appendix paragraph: A79)	Partial	NO
				Transit (17/01/03) RTI system including AVL and voice data communications (Media)	Partial	NO
19	Better working conditions	LOW	Subjective – driver surveys may give an indication	Okunieff (1997) discusses how operator/driver behaviour can be closely monitored, and can be used to alert driver to early/late departures and documenting actual departure times, which can be compared against customer complaints (see Appendix paragraph: A85)	Extensive	NO
				LTT (08/06/00) bus scheduling software systems facilitate timing of driver breaks (Media)	Extensive	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
20	Reduced turnover of drivers	LOW	Yes, using recruitment and turnover statistics	No evidence in the literature review	None	NO
				Transit (20/09/02) report highlights importance of driver morale and satisfaction (Media)	None	NO
21	Better information on driver performance	LOW	Yes, information on fuel efficiency, maintenance costs and schedule adherence	See Okunieff (1997) in 19. (see Appendix paragraph: A85)	Extensive	NO
				O'Neill (2002) reports on TRB report *Predictive Diagnostics for Bus Maintenance* through the use of RTPI, which will help to reduce the maintenance turnaround time. (see Appendix paragraph: A91)	Partial	NO
				Transit (15/11/02) operational performance monitoring through RTI technologies (Media)	Extensive	NO

Table 2: Assessment of the Scale and type of impacts for local transport authorities with regards to the introduction of real time passenger information

A scale value has been attributed to the impacts listed in relation to the importance of the impact to local transport authorities. 'High' relates to network management benefits, 'Medium' relates to service benefits for passengers and 'Low' relates to policy development benefits.

The quality of evidence has been described as either 'extensive', 'partial' or 'none'. 'Extensive' means that substantive research evidence was found, 'partial' indicates there was limited evidence available within the source and further research is required, and 'none' means that there was no detailed evidence available.

	Impact	Scale	Can it be quantified?	Evidence	Quality of evidence	Was it quantified ?
1	Enhanced network management	HIGH	Yes	Wilkinson et al (1998) refer to anecdotal experience operators had been able to optimise services and reduce number of buses by improving reaction times to problems on the network (using RTI). (see Appendix paragraph: A102)	Partial	NO
				Brandt (1996) discusses benefits of prioritisation at traffic signals for public transport, leading to a reduction in running time, bringing savings in terms of vehicles in operation while keeping the headway the same (source relates to trams rather than buses). (see Appendix paragraph: A104)	Partial	NO
				LTT (14/09/00) satellite tracking system launched in Leicester to alter traffic signal timing to give priority to buses (Media)	Partial	NO
				LTT (17/01/02) (13/12/01) (11/04/02) Government provides £20m funding for LA development of RTPI for buses (Media)	Partial	NO
				Lehtonen and Kulmala (2002) review the HELMI system deployed in Helsinki – found that with the system there was an increase in regularity of service by 25 seconds, or an increase of 20%. (see Appendix paragraph: A43-46)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
				Schweiger (2003) found that the use of information can result in the modification of service frequency, an increase/decrease in the number of buses needed, and/or a better distribution of buses within the schedule to more closely meet the travel demand. (see Appendix paragraph: A103)	Partial	NO
				Local Transport Today (LTT) (13/02/00) suggests frequency and regularity results in high patronage increases (Media)	Partial	NO
2	Promotion of public transport through journey time savings	HIGH	Yes	DETR (2001) study indicates Bus SCOOT can reduce bus travel times by 2 to 4 mins on a 10 km route, with the variability of travel time improved by up to 16%. Time savings of 1 to 10 seconds per junction (with an average of 4 seconds), and travel time variability improvements of 0 to 20% (with an average of 12%) were achieved. (see Appendix paragraph: A39)	Extensive	YES
				DETR (2000) found number of buses being given priority is an important factor, particularly at higher degrees of saturation. Benefit per bus decreases as bus flow increases, due to competing / conflicting priority calls, but total passenger benefit remains substantial at bus flows as high as 120 buses/hr/junction. (see Appendix paragraph: A40)	Extensive	YES
				The SCOOT Version 3.1 and later includes facilities to provide priority to selected vehicles (e.g. bus priority). Trials in London have shown additional average reductions in delay to buses of 3 to 5 seconds per bus per junction. At particular sites much larger benefits can be found. A trial at one junction in Lances Hill in Southampton has shown reductions in delay of 34 seconds per bus in the PM peak period. (see Appendix paragraph: A41)	Extensive	YES
				If travel times are reduced by 2-4 minutes on a 10 km stretch, the value of time is estimated at £1.82-£3.64. If 4 seconds are saved at a junction, the value of time is estimated at £0.06. (see Appendix paragraph: A42)	Extensive	YES

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
3	Moving towards modal shift	HIGH	Yes, surveys of customers using service. Monitor use of service	Estimates of increases in patronage as a result of the implementation of advanced traveller information systems (of which RTPI is a subset) are thought to be between 1 and 3% (Schweiger, 2003). It was noted that it is difficult to ascertain how much of this increase results solely from real time bus arrival information and not other measures. (see Appendix paragraph: A65)	Partial	YES
				Schweiger (2003) found through a survey/telephone interviews that the main reason for deploying RTPI system is to improve customer service and that RTPI was a way of maintaining patronage. (see Appendix paragraph: A76)	Partial	NO
				Harrison *et al* (1998) that the delivery of a whole package of measures (RTPI amongst other measures such as bus stops within reasonable walking distances, readily available information, safe environment etc) influences a passenger's selection or dismissal of bus travel. (see Appendix paragraph: A66)	Partial	NO
				LTT (06/09/07) and Transit (09/08/02) reports highlight link between providing passenger information and passenger retention (Media)	Partial	NO
				LTT (17/05/01) better information delivers patronage growth (Media)	Partial	NO
				LTT (14/02/02 'travel information holds the key to modal change' (Media)	Partial	NO
4	Reduced in vehicle time for passengers	MEDIUM	Yes, surveys of time	See Wilkinson et al (1998) in 1. (see Appendix paragraph: A102)	Partial	NO
				LTT (06/09/02) increasing investment in significant priority schemes for buses to improve journey times (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
5	Improved regularity of services	MEDIUM	Yes, measure regularity	Lehtonen and Kulmala (2002) review the HELMI system deployed in Helsinki – found that wit the system there was an increase in regularity of service by 25 seconds, or an increase of 20%. (see Appendix paragraph: A45-46)	Partial	YES
				See Schweiger (2003) in 1. (see Appendix paragraph: A103)	Partial	NO
				Local Transport Today (LTT) (13/02/00) suggests frequency and regularity results in high patronage increases (Media)	Partial	NO
6	Improved reliability of services	MEDIUM	Yes, compare running time to schedules	See Brandt (1996) in 1. (see Appendix paragraph: A104)	Partial	NO
				See Schweiger (2003) in 1/3. (see Appendix paragraph:A103)	Partial	NO
				Transit (18/10/02) demonstrates new technology for satellite based AVL (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
7	More realistic schedules/better adherence to schedules	MEDIUM	Yes, compare running time to schedules	Okunieff (1997) discusses the monitoring benefits of RTI, which can influence the creation of better scheduling. (see Appendix paragraph: A53)	Partial	NO
				Horbury (1999) found that “automatic vehicle location systems can help improve reliability by providing bus route controllers with more information in the face of non-recurrent traffic congestion” (see Appendix paragraph: A50)	Partial	NO
				Furth (2000) discusses benefits of automatically collected running time and punctuality data, including ability to perform statistically valid analyses of performance – guiding improvements in scheduling, operation control and traffic engineering. (see Appendix paragraph: A89)	Partial	NO
				See Schweiger (2003) in 1. (see Appendix paragraph: A103)	Partial	NO
				LTT (08/06/00) bus scheduling software systems to facilitate assessment and management of schedules (Media)	Partial	NO
				Transit (15/11/02) satellite RTI system enables controllers to improve scheduling reliability (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
8	Better pre-journey planning capabilities	MEDIUM	Yes, customer surveys and monitoring of information sources – indicate how frequently /effectively pre-journey planning is carried out.	Stoeveken and Esters (1999) discuss a study conducted in Germany that found there was an immediate benefit to passengers who were provided with information directly to their mobile phone. (see Appendix paragraph: A132-133)	Partial	NO
				LTT (02/05/01) (13/04/00) Government and PTE sponsor studies of potential effects of access through Internet and WAP to multimodal information (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
9	Increased passenger satisfaction	MEDIUM	Subjective – opinion surveys of passengers indicating satisfaction	Nakamura *et al* (1998) carried out research into customer frustration levels whilst waiting for buses. One group were provided with RTI and the other was not. The experiment found that the provision of real time information reduced the waiting passengers' level of frustration (except in cases where the system was unreliable and frustration levels rose again). (see Appendix paragraph: A101)	Partial	NO
				Schweiger (2003) reported that London Buses found the Countdown RTPI service achieved an overall usefulness rating of 7.1 (on a scale of 0 to 10). (see Appendix paragraph: A77)	Partial	NO
				Schweiger (2003) found that the biggest overall benefit in deploying RTPI was improved customer service, followed by an increase in customer satisfaction. (see Appendix paragraph: A76)	Partial	NO
				Transit (18/10/02) recognition of the importance of passenger satisfaction prompts (Media)	Partial	NO
				Government Commission to study research relating to RTPI. (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
10	Reduced passenger waiting times at stops and improvements to waiting experience	MEDIUM	Yes, monitoring of passenger waiting times with customer satisfaction surveys	See Brandt (1996) in 1. (see Appendix paragraph: A104)	Partial	NO
				Study conducted by Backstrom (1998) found that passengers would like to know the time of buses approaching a stop and this may improve the waiting experience. (see Appendix paragraph: A131)	Partial	NO
				Schweiger (2003) looked at attitudes towards the 'Countdown system: 65% of passengers felt that they waited for a shorter period of time (from 11.9 minutes without Countdown, to 8.6 minutes with the system) (see Appendix paragraph: A137)	Partial	NO
				LTT (13/04/00) allocation of buses to stops using AVL with passenger direction capabilities (Media)	Partial	NO
				Transit (18/10/02) 'technologies will help passengers avoid waiting at the stop' (Media)	Partial	NO
11	Compliance with national policy	LOW		DETR (1998) required to make a difference for the public transport passenger "better information, before and when travelling; including a national public transport information system by 2000" and "more reliable buses through priority measures and reduced congestion" (see Appendix paragraph: A149).	None	NO
12	Compliance with Local Transport Plan Objectives	LOW		DETR (2000) Guidance on full LTPs offers supportive but not direct reference to bus networks and the provision of information. The need for networks to be considered both qualitatively and quantitatively is highlighted (see Appendix paragraph: A156).	None	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
13	Meeting local needs	LOW		DfT(not dated) – local authorities have an obligation to provide data to potential public transport users. One of the aims of Transport Direct is to "Advise the traveller about how their chosen travel option is performing in real time before they set off" (see Appendix paragraph: A156).	None	NO
14	Promotion of social inclusion	LOW		Bishop (1999) reports that a common complaint associated with the use of public transport is that total journey times (including the time to get to alighting point and waiting for vehicle) are much longer than that using private transport. (see Appendix paragraph: A164)	Partial	NO
15	Meeting environmental targets	LOW		The Government has set targets to reduce the impact of transport on the environment. By promoting modal shift to public transport and encouraging bus priority and smooth running of buses, environmental benefits can be gained. (see Appendix paragraph: A166)	None	NO
				Transport White Paper (DETR, 1998) aims to provide "*a multimodal response to the problems of congestion and pollution that threaten our quality of life and our future economic well being*". (see Appendix paragraph: A50)	None	NO
				The Government's Ten Year Plan (DETR, 2000a) sets out a long-term strategy for delivering a quicker, safer, more reliable transport system that has less of an impact on the environment. Part of the strategy to achieve these aims is to increase bus passenger numbers by 10%. (see Appendix paragraph: A167)	None	NO

Table 3: Assessment Of The Scale And Type Of Impacts For Passengers With Regards To The Introduction Of Real Time Passenger Information

A scale value has been attributed to the impacts listed in relation to the importance of the impact to bus passengers. 'High' relates to quality of service, 'Medium' relates to time savings (journey time and waiting time) and 'Low' relates to monetary costs for passengers.

The quality of evidence has been described as either 'extensive', 'partial' or 'none'. 'Extensive' means that substantive research evidence was found, 'partial' indicates there was limited evidence available within the source and further research is required, and 'none' means that there was no detailed evidence available.

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
1	Improved regularity of services	HIGH	Yes, compare regularity of services.	Lehtonen and Kulmala (2002) review the HELMI system deployed in Helsinki – found that with the system there was an increase in regularity of service by 25 seconds, or an increase of 20%. (see Appendix paragraph: A45-46)	Partial	YES
				Schweiger (2003) found that the use of information can result in the modification of service frequency, an increase/decrease in the number of buses needed, and/or a better distribution of buses within the schedule to more closely meet the travel demand. (see Appendix paragraph: A103)	Partial	NO
				Local Transport Today (LTT) (13/02/00) suggests frequency and regularity results in high patronage increases (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
2	Improved reliability of services	HIGH	Yes, compare running time to schedules	Brandt (1996) discusses benefits of prioritisation at traffic signals for public transport, leading to a reduction in running time, bringing savings in terms of vehicles in operation while keeping the headway the same (source relates to trams rather than buses). (see Appendix paragraph: A104)	Partial	NO
				Schweiger (2003) found through a survey/telephone interviews that the main reason for deploying RTPI system is to improve customer service. (see Appendix paragraph: A110)	Partial	NO
				See Schweiger (2003) in 1. (see Appendix paragraph: A103)	Partial	NO
				Transit (18/10/02) demonstrates new technology for satellite based AVL (Media)	Partial	NO
3	Increased passenger satisfaction	HIGH	Yes, subjective opinion surveys of passengers indicating level of satisfaction	Nakamura *et al* (1998) carried out research into customer frustration levels whilst waiting for buses. One group were provided with RTI and the other was not. The experiment found that the provision of real time information reduced the waiting passengers' level of frustration (except in cases where the system was unreliable and frustration levels rose again). (see Appendix paragraph: A101)	Partial	YES
				Lehtonen and Kulmala (2002) report on Helsinki's ELMI system: found that 68% of respondents agreed that the level of comfort experienced while travelling on this bus service has increased due to the provision of real-time passenger information (see Appendix paragraph: A69-72)	Partial	YES

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
				Schweiger (2003) reported that London Buses found the Countdown RTPI service achieved an overall usefulness rating of 7.1 (on a scale of 0 to 10). (see Appendix paragraph: A111)	Partial	NO
				Schweiger (2003) found that the biggest overall benefit in deploying RTPI was improved customer service, followed by an increase in customer satisfaction. (see Appendix paragraph: A110)	Partial	NO
				Transit (18/10/02) recognition of the importance of passenger satisfaction prompts Government Commission to study research relating to RTPI (Media)	Partial	NO
4	Enhanced journey experience	HIGH	Yes, based on quantifying journey times and carrying out subjective surveys on passengers	Horbury (1999) suggests that other locations, other than at bus stops, would benefit from RTPI, and could possibly result in passenger generation, attracting new users to the system. (see Appendix paragraph: A68)	Extensive	NO
				Transit (18/10/02) and Coach and Bus (20/02/02) satellite based RTPI provides next stop announcements on buses (Media)	Extensive	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
				DETR (2001) study indicates Bus SCOOT can reduce bus travel times by 2 to 4 mins on a 10 km route, with the variability of travel time improved by up to 16%. Time savings of 1 to 10 seconds per junction (with an average of 4 seconds), and travel time variability improvements of 0 to 20% (with an average of 12%) were achieved. (see Appendix paragraph: A39)	Extensive	YES
				DETR (2000) found number of buses being given priority is an important factor, particularly at higher degrees of saturation. Benefit per bus decreases as bus flow increases, due to competing / conflicting priority calls, but total passenger benefit remains substantial at bus flows as high as 120 buses/hr/junction. (see Appendix paragraph: A40)	Extensive	YES
				The SCOOT Version 3.1 and later includes facilities to provide priority to selected vehicles (e.g. bus priority). Trials in London have shown additional average reductions in delay to buses of 3 to 5 seconds per bus per junction. At particular sites much larger benefits can be found. A trial at one junction in Lances Hill in Southampton has shown reductions in delay of 34 seconds per bus in the PM peak period. (see Appendix paragraph: A41)	Extensive	YES
				If travel times are reduced by 2-4 minutes on a 10 km stretch, the value of time is estimated at £1.82-£3.64. If 4 seconds are saved at a junction, the value of time is estimated at £0.06. (see Appendix paragraph: A42)	Extensive	YES

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
5	Better pre-journey planning capabilities	HIGH	Subjective – customer surveys and monitoring of information sources indicating how frequently and effectively pre-journey planning is carried out	Stoeveken and Esters (1999) discuss a study conducted in Germany that found there was an immediate benefit to passengers who were provided with information directly to their mobile phone. (see Appendix paragraph: A132)	Partial	NO
				Nakagawa et al (1999) found that the effects of RTPI system appeared to be greater for those passengers who considered the bus service timetable prior to arrival at the bus stop 'since the information system is useful for enabling rational decision-making. (see Appendix paragraph: A136)	Partial	NO
				Horbury (1999) "if details about conditions that deviate from the norm are provided at the stop, then passengers will be able to make a much more informed choice about whether to travel by a particular bus on a given day" (see Appendix paragraph: A108)	Partial	NO
				LTT (02/05/01) (13/04/00) Government and PTE sponsor studies of potential effects of access through Internet and WAP to multimodal information (Media)	Partial	NO
6	Reduced passenger waiting times at stops and improvements to waiting experience	MEDIUM	Yes, monitoring before and after of waiting passengers, and customer surveys.	See Brandt (1996) in 2. (see Appendix paragraph: A104)	Extensive	NO
				Study conducted by Backstrom (1998) found that passengers would like to know the time of buses approaching a stop and this may improve the waiting experience. (see Appendix paragraph: A131)	Extensive	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
				Schweiger (2003) looked at attitudes towards the 'Countdown system: 65% of passengers felt that they waited for a shorter period of time (from 11.9 minutes without Countdown, to 8.6 minutes with the system). (see Appendix paragraph:)A137	Extensive	YES
				Wilkinson et al (1998) evaluated public responses to 'Timechecker' in Liverpool – found that 85% thought it made waiting more acceptable, 70% thought reliability of service had increased since its introduction, 50% thought journey times had been reduced, and 87% thought Timechecker gives a feeling of reassurance (see Appendix paragraph: A127-129)	Extensive	YES
				LTT (13/04/00) allocation of buses to stops using AVL with passenger direction capabilities (Media)	Extensive	NO
				Transit (18/10/02) 'technologies will help passengers avoid waiting at the stop' (Media)	Extensive	NO
				LTT (11/05/00) study establishes higher value of passenger's time (Media)	Extensive	NO
7	More bus priority/ Reduced delays at traffic signals	MEDIUM	Yes, before and after journey times compares, measure delays.	Wilkinson et al (1998) refer to anecdotal experience operators had been able to optimise services and reduce number of buses by improving reaction times to problems on the network (using RTI). (see Appendix paragraph: A49)	Partial	NO
				See Brandt (1996) in 2. (see Appendix paragraph: A104)	Partial	NO
				LTT (14/09/00) satellite tracking system launched in Leicester to alter traffic signal timing to give priority to buses (Media)	Partial	NO
				LTT (17/01/02) (13/12/01) (11/04/02) Government provides £20m funding for LA development of RTPI for buses (Media)	Partial	NO

	Impact	Scale	Can it be quantified?	Evidence	Quality of Evidence	Was it quantified?
8	Reduced in vehicle time	MEDIUM	Yes, surveys of time	See Wilkinson et al (1998) in 7. (see Appendix paragraph: A49)	Partial	NO
				LTT (06/09/02) increasing investment in significant priority schemes for buses to improve journey times (Media)	Partial	NO
9	Cost of information to passengers	LOW	Yes	Wilkinson et al (1998) found that telephone enquiry lines are often premium rate numbers, which will generate enough revenue to meet costs of service. However, to maximise the social inclusive nature of bus travel, information should be free to passengers (see Appendix paragraph: A12)	Partial	NO
				A study by Balcombe and Vance (1997) looked at customer's willingness to pay for information options. For real time information at a bus stop, 16% of respondents said they would be wiling to pay 20p on top of fare, 6% 30p on fare and only 4% or 50p on fare. (see Appendix paragraph: A143-146)	Partial	YES

SUMMARY OF THE IMPACTS OF RTI ON RECIPIENTS

3.6. The table below summarises the wide range of impacts of RPTI that have been revealed through out this study. There are a number of impacts that are incurred across the range of recipients, these are as follows:

- Savings on journey times
- Improved regularity of service and
- Improved reliability of services
- Reduced delay at traffic signals

3.7. It should be noted that this table includes all the impacts that have been claimed, but have yet to be verified.

3.8. A number of impacts are shared by passenger and bus operator and passenger and LTA , these are also shown in the table below.

Table 4: Summary of the Impacts of RTI on all recipients.

IMPACTS	Passengers	Bus Operators	Local Transport Authorities	IMPACTS COMMON TO ALL GROUPS
Savings on journey times	✓	✓	✓	✓
Reduced number of buses required to operate service		✓		
Avoidance of penalties from traffic commissioners		✓		
Improved regularity of service	✓	✓	✓	✓
Improved reliability of service	✓	✓	✓	✓
More realistic schedules/better adherence to schedules	✓	✓	✓	✓
Fuel cost reductions		✓		
Retaining existing passengers		✓	✓	
Increase in use by existing passengers		✓	✓	
Passenger generation		✓	✓	
Increased passenger satisfaction	✓	✓	✓	
Less unscheduled overtime (drivers)		✓		
Automatic updating of fare stages		✓		
Cost of system		✓	✓	
Improvement in bus service administration		✓	✓	
More effective supervision		✓		
Better information on vehicle performance		✓		
Quicker response to breakdowns		✓		
Better working conditions		✓		
Reduced turnover of drivers		✓		
Better information on driver performance		✓		

IMPACTS	Passengers	Bus Operators	Local Transport Authorities	IMPACTS COMMON TO ALL GROUPS
Reduced passenger waiting time at stops and improvements to waiting experience	✓			
More bus priority/reduced delay at traffic signals	✓	✓	✓	✓
Reduced in vehicle time	✓			
Cost of information to passengers	✓			
Promotion of public transport through journey time savings			✓	
Moving towards modal shift			✓	
Better pre-journey planning capabilities	✓		✓	
Compliance with national policy			✓	
Compliance with Local Transport Plan Objectives			✓	
Meeting local needs	✓		✓	
Promotion of social inclusion	✓		✓	
Meeting environmental targets			✓	

4. SUMMARY AND RECOMMENDATIONS FOR DETERMINING FURTHER RESEARCH REQUIREMENTS.

4.1. The review of evidence has revealed a considerable number of research reports and other sources of information relevant to this study, however, it has been generally found that robust quantitative investigations into the effects of the implementation of a real-time passenger information system are rare. Statements supporting this finding were identified through out this document. For example, Bishop (1999) stated that 'investment in the integration of [real-time information systems] across agencies is very difficult to justify on a strictly commercial basis as little quantifiable data exists from which to assess the incremental costs and revenue associated.'

4.2. Okunieff (1997) suggested that 'the major obstacles to performing benefit studies for [real-time information system] installations are:

- the lack of comparable cost information' (as, in most cases, real-time information 'systems cannot be readily compared'); and
- 'the lack of empirical evidence.'

4.3. 'Since the first demonstration tests, few studies have addressed the costs and benefits of installing [real-time information systems]. Moreover, successes related to intangible benefits such as faster emergency response times, increased integration of management information systems, improved internal communications, and better complaint handling procedures that affect staff and customer relationships, are not easily quantified.'

4.4. For a thorough business case to be made it is therefore essential that further research is carried out to justify in depth the impacts of RTI for the various recipients. In order to assist with this prioritisation, the study team has devised a priority search mechanism which has analysed the recipient summary tables for further research requirements which would deliver maximum benefit to the business case. To do this the search has focused upon the impacts which have the highest scale but which have a requirement for further evidence, or in some cases no evidence at all.

4.5. The search revealed the following priority areas for further consideration:

- Examination of the impact on the regularity and reliability of services, this would include the management of scheduling, avoidance of penalties for the Traffic Commissioners.
- Examination of the generation of new passenger trips through the provision of RTPI, including the impact on customer satisfaction, passenger pre planning activity and passenger diversionary activity.

4.6. Both of these proposed areas of research should determine in more detail key areas of concern for the business case for the recipients of RTPI.

4.7. Further to these priority areas, other proposals for research that could, if commissioned, be beneficial to central and local government as well as bus operators and academics are:

- Review, using costs etc. prepared at the planning stage, any differences with the costs actually incurred and benefits achieved by introducing and operating RTPI. A similar study of LRT worldwide found that there was a high incidence of underestimating costs and overestimating patronage.
- Retrospective examination of the costs and benefits of a system that has been operating for 3+ years. For example:

- How is the system being used and how does that differ from the original plan?
- What are the costs of operation for both operator and LA/PTE? Have they changed significantly?
- How accurate is the information provided to passengers and staff?
- How easy is the system to operate?
- What is the passengers' perception of the usefulness of the system? How has it affected travel behaviour?
- Has it generated increased revenue?
- What is the cost per passenger of operating the system?
- What are the benefits for the operators and are they as large as anticipated?
- Has the operator changed its modus operandii as a result of installing this system?
- Has the operator used any of the information in discussions with local authorities, Traffic Commissioners, disgruntled passengers etc.?
- Has the operator/local authority had to incur extra unanticipated costs to upgrade the hardware or software used to operate the system. If so, how much?
- What is the impact on the relationship between operator and LA/PTE?
- How have the systems been publicised and what was the impact?

- Undertake surveys to determine and quantify the effects of introducing RTPI as an isolated enhancement to a bus service (or set of bus services). Both Kent and Manchester have been cited as having routes appropriate to such a study.
- Produce a specialised cost model to study the capital and revenue requirements for the different types of RTPI such as radio station based systems and GPRS systems. There are some models in existence but they need reviewing in the light of recent changes in the mobile phone marketplace, government policy etc.
- Undertake an economic analysis to determine the proportion of total operating costs spent on installing and operating an RTPI system.

4.8. The study team, therefore recommends that further research funding is secured so that a thorough and robust investigation can be carried out on the issues outlined above. This will support the business case for RTPI which in turn will contribute to the government's commitment to the creation of a better, more integrated public transport system.

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APPENDIX: LITERATURE REVIEW FINDINGS

A1. This appendix provides the detailed information revealed through the comprehensive literature review undertaken by the study team. It also contains information obtained through consultation carried out with LTAs and bus operators for the purposes of this study.

A2. The format of this appendix supports the Summary tables to be found in section three of the main body of this report. The details of the impacts relevant to each of the recipients of RTPI are set out below. A detailed account of the references follows this appendix.

IMPACTS FOR BUS OPERATORS

A3. The main impacts for bus operations in relation to RTI are set out below:

Cost Considerations

A4. A business case for any investment should consider not only the initial cost but also the ongoing and likely future costs of operations, regular maintenance, emergency repairs and potential upgrades and expansions.

A5. This statement is supported by Horbury (1999) who reported on interviews conducted with project managers and bus operators who had been involved in the implementation of real-time passenger information systems in the United Kingdom. Respondents indicated the following elements of 'best practice':

- modular real-time information systems;
- inexpensive on-bus equipment;
- time-slot polling of standard operations and exception reporting, as needed (to minimise the costs of communication between buses and the control centre);
- broad and complete static information; and
- comprehensive maintenance policy with the information system manufacturer, with deferral of payment until specified accuracy is achieved.

A6. The 'RTI mapping and funding – survey summary' presented estimates of the amount of capital and revenue spending on real-time information systems that will have been committed in London and the whole of England by the end of 2003.

Provision by the end of 2003	Capital costs (£million)	Projected 15year revenue costs (£million)	Total costs (£million)
London	44.00	112.50	156.50
Non-London Public Transport Executives	11.10	19.43	30.53
Non-London Local Authorities	23.35	111.84	135.19
Total	**78.45**	**243.77**	**322.22**
Percentage breakdown of non-London spending		**Capital costs**	**Revenue costs**
On-bus kit		35%	21%
At-stop signage		31%	27%
Infrastructure		13%	25%
Miscellaneous		11%	12%
Communications		10%	15%

A7. The authors of the 'RTI mapping and funding – survey summary' note that, in comparison to capital costs, 'revenue costs (primarily maintenance and communication) are [currently] less well understood or in some instances not yet known.' Estimates of revenue costs may undervalue the historical spending as 'some revenue costs may have been capitalised as part of warranties or service agreements.'

A8. For a real-time passenger information system, the costs of data transmission may form a significant component of system operation costs. Therefore, consideration of Horbury (1999) suggests that this issue be investigated with respect to the possibilities of:

- adopting existing communication infrastructures; or
- sharing communication channels with other systems.

A9. Horbury (1999) also stated that 'computing costs are currently lower than communication costs, therefore, distributed real-time passenger information systems (which have minimal data transfer between components) are the most cost-effective.' (The specific source of this statement was not cited and it is noted that relative pricing between these elements may have altered since 1999, when the statement was made.)

A10. Schweiger (2003) found that, with regard to costs, "many agencies are not aware of the expense of operating and maintaining their real-time systems, because communication costs vary widely based on the type f communication and them way communication is charged…This issue highlights the need for determining all operation and maintenance costs very early in the deployment process (in the planning stage before procurement), and for providing transit agencies with better information on expected operations and maintenance costs.

A11. Wilkinson *et al* (1998) discussed *Timechecker*, Liverpool's real-time information system. It was reported that one of the flaws of this system 'is that each morning the bus company must enter the fleet number and running board for each bus into the system, otherwise the system does not know what buses are on the routes.' Although not quantified, this additional manpower requirement obviously increases the overall operating costs of the system. This cost (or automation of this type of process) should be included in the consideration of the business case for a real-time passenger information system.

A12. Wilkinson *et al* (1998) also presented a summary of the Berkshire County Council's piloting of a real-time passenger information system along Route 17, through Reading. 'A general point was made that introducing real-time systems along a bus corridor is expensive because all buses that operate along the route must be equipped with the on-board computers for the system to be effective.' These high initial costs may present a 'potential barrier against introduction for Local Transport Authorities', but it was noted that 'as the system expands the incremental costs go down.' It was reported that one Berkshire County Council member said that 'once you've bought into a [telematics] system it is not easy to get out without incurring a large financial loss.' The council was 'also concerned that to keep the system up to date they will need to up-grade software and equipment as it becomes available.' It was stated that such commitment to 'unknown future costs is unappealing to Local Transport Authorities.'

A13. Although lacking quantitative information, this case study presents the following points to consider researching and including within the compilation of a real-time passenger information system business case:

- the scale of initial costs, the system's potential for geographic/service/technical expansion and the scale of incremental costs;
- the scale of maintenance costs and necessary upgrade costs;and
- the extent of any contractual or technological dependency created.

A14. Also relevant to consideration of the operational costs of a real-time passenger information system is another finding of Wilkinson *et al* (1998). 'Installation of expensive telematics equipment on vehicles can only be justified if the vehicles will be used in the equipped area. Movement of vehicles between routes and possible changes to routes and services mean that operators may be unwilling to invest in telematics equipment.' As equipped vehicles should always be operating on equipped routes, it may be deduced that the installation of telematics equipment on a route or vehicle can limit the flexibility available to bus operators when organising their fleet.

A15. In addition to the capital and operational costs associated with the deployment of Real-Time Passenger Information, there are the system maintenance costs to consider. These include the maintenance of the physical system components and the maintenance of the system data.

A16. Arrangements for servicing should be considered within the full context of each individual implementation situation. A balance between initial outlay for quality, likely ongoing maintenance needs and the opportunity costs of system downtime should be investigated.

A17. Horbury (1999) suggested that 'keeping maintenance in-house may prove more cost-effective for a local authority or bus company if sufficiently skilled people are already available. However, to carry out in-house maintenance there needs to be easy access to components and available spare parts.' Horbury (1999) then provided the following advice regarding external maintenance contracts.

> *'The level of support and maintenance from [a system] supplier should be ascertained prior to purchasing the system. If a maintenance contract is to be awarded to the supplier then the guaranteed lifetime of components, replacement costs, lead time (which may depend on the location and availability of sub-contractors) and call out charges should be agreed upon prior to any contract being awarded (with appropriate penalty clauses for failure to comply with the terms and conditions of the contract). Keeping the number of contractors to a minimum may reduce the lead times for maintenance, as there are fewer channels to go through. Lead times can be quite significant in some cases. It is essential that the provision of spare parts is included in the specification for tender.'*

A18. Although the references for these statements were not explicitly cited, they are still considered valid issues for addressing within the development of a business case for a real-time passenger information system.

A19. System data and its maintenance is an important consideration for any bus operator as the information provided to customers should be accurate and reliable.

A20. Wilkinson *et al* (1998) reported on the real-time passenger information displays provided at bus stops along a bus corridor into the Newcastle Upon Tyne city centre, by the Tyne and Wear Public Transport Executive (NEXUS). 'It was commented that the system has not worked well. One of the main problems (apart from the [poor] accuracy of the displayed information) is that any changes to information on the timetable database is a lengthy and costly process.' It was also noted that the bus stop information display boards had been subject to a high level of vandalism and had required regular repair or replacement. Although the discussion of this real-time passenger information system did not include a quantitative summary of the associated costs and benefits, it still highlights a number of issues for inclusion within the consideration of a real-time passenger information system business case.

A21. Okunieff (1997) also stated that 'data integration expertise [was] key to deploying and maintaining a [real-time information] system. The system requires planned and unplanned updates of the map database, runs, route schedules, bus stops, and personnel.' It was reported that the expertise associated with this data management is 'needed over the long-run, and not just during implementation.

A22. System expansion and compatability will be a key consideration for bus operators. Horbury (1999) indicated that 'modular [real-time passenger information] systems that have standard interfaces and protocols are the preferred option as they can be expanded according to available resources and/or the results of a trial route. As [telematics] and communication technology is progressing at a rapid rate, upgrades of individual components in modular systems can be implemented as superior versions appear on the market, without replacing the whole system.'

A23. Horbury (1999) also identified the importance of providing a system with potential 'for easy modular expansion so that as and when funding is available for future expansion, all components of the current system can be utilised with the only additional cost being that of the extra components (with possibly an upgrade of the communication channel employed).'

A24. Horbury (1999) stated that 'once an automatic vehicle location system has been commissioned it may prove quite costly to 'add on' features that were not part of the original specification. Therefore, it is important to 'get it right' the first time.' Horbury (1999) also suggested that a 'breakdown of expansion costs should be included in the tender for telematics equipment.

A25. Despite these statements by Horbury being made in 1999 and the absence of explicit source referencing or quantitative support, they may still highlight issues that are valid for consideration within the development of a business case for a real-time information system.

A26. Wilkinson *et al* (1998) reported on anecdotal and research evidence that suggested operators should consider investment in telematics applications when specifying or purchasing new fleet vehicles. Thus, operators may avoid the potentially higher costs and inconveniences of retrofitting, which could be particularly significant if retrofitting also prevented the subject vehicle from fulfilling its regular service role.

A27. Anecdotal evidence was received during the consultation phase of this *Bus real-time passenger information business case research* project indicating the concerns held by a number of bus service operators about inter-system compatibility issues arising through regulatory body boundaries not necessarily aligning with bus service operating boundaries. It was reported that there was a need for greater harmonisation across the regions, possibly extending to national standardisation.

A28. Lehtonen and Kulmala (2002) discuss the *HELMI* project, referring to details of the economic evaluation and costs. Presentation of various aspects of their report is included here as it is considered that these will contribute to the building of a real-time passenger information business case.

A29. The system was evaluated in terms of its benefit/cost ratio. 'The system was estimated to have the following benefits that can be quantified in monetary terms:

- passenger time savings due to travel time reductions;
- vehicle cost savings due to more efficient public transport;
- fuel and exhaust emission cost reductions; and
- impacts on other traffic and its time and vehicle costs.'

A30. (It is noted that this list defined by Lehtonen and Kulmala as readily quantifiable aspects of the *HELMI* project outcomes does not include any of the benefits associated with the provision of real-time passenger information.)

A31. The impacts of the system were further evaluated against transport policy objectives relating to level of service and costs, safety and health, social sustainability, development of regions and communities and the environment.

A32. The project was also evaluated in terms of the private economy to estimate the economic impacts of the system to the public transport operator.

A33. Lehtonen and Kulmala (2002) also provided a percentage-based analysis of the system costs:

Element	Percentage of total system costs
Displays at bus stops	**22%**
In-vehicle systems	31%
Signal devices and priority systems	13%
management system, with a radio network	34%

A34. It is interesting to note the high proportion of investment directed towards the real-time passenger information displays at stops given the absence of readily quantifiable effects found to be attributable to this item.

A35. In 1999, the Department for Transport established four *Driver Vehicle Operator* agencies and the *Traffic Area Network*. These groups provide various services to motorists and have responsibility for setting standards, collecting excise duties, carrying out inspections and other matters relating to both drivers and their vehicles.

A36. The mission of the *Traffic Area Network* is 'to promote, through effective licensing and compliance services, a safe, fair and environmentally responsible commercial road industry.' A Traffic Commissioner is appointed for each traffic area and their responsibilities include regulation of the bus industry: establishing the principles and performance indicators with which bus service operators must comply.

A37. The Traffic Commissioners believe that the public's confidence in, and utilisation of, the public bus service can be improved through ensuring that services run punctually and reliably. To this end, Traffic Commissioners have expectations of the timetable-accuracy with which bus services should operate. For example, it may be expected that 95% of all services should arrive at their final destination no more than five minutes late. The *Traffic Area Network* publishes practice directions to bus and coach operators and advises operators that Traffic Commissioners 'have powers under the [Transport Act 1985] to take action against operators who fail to run their services in accordance with the registered particulars' and accepted service expectations.

A38. As a result of using RTI technology to increase bus priority throughout the network, bus operators are therefore more likely to meet the service provision expectations and avoid being issued with penalties by Traffic Commissioners.

A39. In a study conducted by DETR (2001) it is indicated that implementation of SCOOT can reduce bus travel times by 2 to 4 minutes on a 10 km route. The variability of bus travel time was also found to improve by up to 16%. It was also found that it was possible to achieve time savings of 1 to 10 seconds per junction (with an average of 4 seconds), and travel time variability improvements of 0 to 20% (with an average of 12%) were achieved.

A40. DETR (2000) found number of buses being given priority is an important factor, particularly at higher degrees of saturation. The expected benefit per bus decreases as bus flow increases, due to competing/conflicting priority calls, but the total passenger benefit remains substantial when bus flows are as high as 120 buses/hr/junction.

A41. The SCOOT Version 3.1 and later includes facilities to provide priority to selected vehicles (e.g. bus priority). Trials in London have shown that additional average reductions in delay to buses of 3 to 5 seconds per bus per junction can be achieved. At particular sites much larger benefits can be found. A trial at one junction in Lances Hill in Southampton revealed reductions in delay of 34 seconds per bus in the PM peak period.

A42. The Transport Economics Note (DETR, 1998) provides the latest values of time and vehicle operating costs recommended by the Department of the Environment, Transport and the Regions for use in economic appraisals of transport projects. All week average for non-work passengers can be calculated at 5469 pence per hour (91 pence per minute or 1.5 pence per second) [based on 'perceived values of time' in Transport Economics Note, DETR,1998]. If bus travel times are reduced by 2-4 minutes on a 10 kilometre stretch is equal to a £1.82 – £3.64 value of time per vehicle saving. An average of a 4 second time saving per junction is equal to a saving of £0.06 in terms of value of time per vehicle. Vehicle operating costs can also be calculated. By assuming that a bus will be travelling at a steady speed as a result of the introduction of RTI systems, and only stopping at scheduled stops, it is estimated that for a bus travelling 29km/h (average link speed from York, 1992) the fuel consumption will be 0.46 litres/km.

Service Benefits

A43. The value and practicality of service optimisation is illustrated by Lehtonen and Kulmala (2002) within their report on a comprehensive monitoring of the effects and economic evaluation of the *HELMI* system, implemented in Helsinki. This telematics-based system provided real-time passenger information to waiting and travelling passengers and bus priority capabilities at selected signalised junctions.

A44. The evaluations presented by Lehtonen and Kulmala (2002) do not allow for separation of those effects particularly attributable to the provision of the real-time passenger information from those effects attributable to the service optimisation measures. However, overall the scheme and study demonstrate the feasibility of sharing infrastructure between real-time passenger information systems and systems using real-time information for service optimisation purposes.

A45. The *HELMI* system included the following Intelligent Transport Systems services:

- Automatic Vehicle Location (AVL) systems based on satellite positioning and radio beacons;
- real-time passenger information in displays at stops and inside vehicles;
- priorities to vehicles behind schedule at signal controlled junctions; and
- a schedule monitoring system or Computer Aided Dispatch (CAD) for drivers.

The following table shows the changes in field study results from before to after the implementation of the *HELMI* system:

Result indicator	Change between before and after phases	
	Change	Percentage change
Cumulative number of passengers on-board, from visual estimations at strategic points along the route	+200 persons	**+10%**
Number of passengers boarding along route	+5 persons	**+12%**
Signal delays	-3min 18sec	**-48%**
Stop delays	+4sec	+2%
Other delays	-5sec	**-12%**
Travel time	-3min 18sec	**-11%**
Regularity of service	+25sec	**+20%**
Punctuality of service	+2min 4sec	**+58%**
Interviews and surveys with passengers		**Percentage of respondents agreeing**
I find the bus stop displays showing the real-time passenger information are **useful**		86%
The **level of comfort** I experience while travelling on this bus service has increased		53%
I **use the bus service more** due to the real-time passenger information display		17%
Simulation results		
Fuel consumption		**-3.6%**

A46. The cumulative benefits gained from the deployment of the system in terms of bus service optimisation therefore included an increase in the number of boarding passengers, improvements in the regularity and punctuality of services and a reduction in service delays (including delay from signals).

A47. Brandt (1996) reported on the effects of 'prioritisation of public transport at traffic signals' delivered through use of telematics systems in Linz, Austria. After linking vehicle location information with urban traffic control systems at 17 intersections along a tramway, 'reduction[s] in running time brought tangible savings in terms of vehicles in operation while keeping headway the same.' (It is noted that this statement refers to trams rather than bus services but the findings are still considered relevant and applicable.)

A48. A reduction in delay at junctions can also be gained by giving buses priority. The effects of installation of a SCOOT bus priority system at ten junctions in the London Borough of Camden were also discussed. The telematics system 'resulted in a 22 to 33 percent saving in bus delay per junction, giving a 7 to 8 percent saving in journey times and having no significant effect on the flow of general traffic.' Achieving reduction in delays adds to the reliability of a service.

A49. Many research sources assert that telematics systems that provide vehicle location information may be useful in the optimisation of bus services. Through the provision of Automatic Vehicle Location (AVL) technology, priority can be given to buses on the road network. For example, Wilkinson *et al* (1998) reported an 'anecdotal experience from Leicester [where] an operator using [telematics for fleet management] had been able to provide the same service on the same route with one less bus just by improving reaction times to problems on the network.'

A50. Reliability of bus services can be increased through the use of RTI technology. Horbury (1999) found that 'automatic vehicle location systems can help improve reliability by providing bus route controllers with more information in the face of non-recurrent traffic congestion (which can arise due to a combination of illegal parking, road works, accidents and inconsiderate driving, and which is, by its nature, impossible to predict) and can also help in identifying buses that are starting to bunch before bunching occurs. A reduction in bus bunching should provide a more regular service for passengers and improve the quality of service offered.' (Details of the foundations for these statements were not explicitly provided.)

A51. Wilkinson *et al* (1998) also provided evidence for the relationship between service frequency and reliability and the value of service information for passengers when they reported on monitoring of a real-time passenger information system installed along Bournemouth's *Super Route 17*. It was suggested that a high frequency of bus services could mean that bus passenger information can be superfluous to the user. (The foundations for this suggestion were not presented.)

A52. Another dimension of the effect of service frequency and reliability on passengers was presented when Wilkinson *et al* (1998) identified the high perceived penalty of missing an infrequent service compared to the inconvenience caused through missing a service that is offered at a high frequency. The scale of perceived penalty was proposed to be proportionate to a user's information requirements implying that the 'value' of information may increase as service frequency decreases. (Although this statement was made within a rail context, it is supposed to be equally applicable to travel by bus.)

A53. Okunieff (1997) discussed the impacts of real-time information and also included consideration of the influence of service reliability and frequency on the scale of the expected effects. It was found that 'the greater the difference between scheduled and actual running times, the greater the opportunity for savings' and positive impacts.

A54. Holland (2000), too, implied a relationship between service frequency and reliability and passenger valuation of information through reports on an Internet-based real-time passenger information service for Ipswich's *Superoute 66*. He noted that the *Superoute 66* was a well-marketed and frequent bus service and proposed that the increase in patronage attributed to the provision of real-time passenger information could be greater if applied to routes offering less frequent and less reliable bus services. (Unfortunately development and proof of this statement did not appear within Holland's article.)

A55. Increase in patronage can result in increase use of existing passengers, or the generation of new passengers from existing modes.

A56. Holland (2000) reported 'an online survey that was designed to gather data on the number of journeys that were made using *Superoute 66* as a result of the introduction of the web-site.' Holland stated that 233 respondents completed the online survey and one quarter of those indicated that they used *Superoute 66* more as a result of the real-time passenger information provided on the Internet. Using a weighting system where:

- journeys made on weekdays were factored by 100 percent;
- journeys made on some days were factored by 60 percent; and
- journeys made only occasionally were factored by 20 percent.

A57. It was estimated 'that the equivalent of 33 new [bus passenger] journeys had resulted from the provision of real-time passenger information via the Internet.' Critically, the unit for these 33 new bus passenger journeys was not stated, so it is unclear, but assumed, that the result represents 33 new bus passenger journeys on *Superoute 66* per weekday.

A58. Holland (2000) then made approximations about the context surrounding these 33 new bus passenger journeys. The following table shows the approximate percentage of new bus passenger journeys:

	Percentage of new bus passenger journeys
New bus passenger journeys generated through modal change from **private vehicles to the bus**	52
New bus passenger journeys generated through modal change from **other modes** (such as walking, cycling or taxi) **to the bus**	36
New trips that would not have previously been made	12

A59. Wilkinson *et al* (1998) reported on a passenger information system installed as part of the *Super Route 17* project in Bournemouth. The information system provides waiting passengers with an estimate of the arrival time of the next bus based on historical data. It was stated that the non-real-time information 'system has worked well in Bournemouth, and the bus company has recorded a 5.6 percent increase in patronage along the route.' The period over which this rise in patronage occurred and details of any simultaneous service improvements were not discussed.

A60. Wilkinson *et al* (1998) also reported on *Stopwatch*. *Stopwatch* is a real-time passenger information system that has also been used to provide priority for buses at some junctions, as part of Southampton and Winchester's *ROMANSE* project. After implementation of *Stopwatch*, monitoring 'found a 5 percent increase in bus patronage, but this was matched by a similar increase in patronage on [a] control corridor such that no overall effect could be attributed to the telematics system.'

A61. Wilkinson *et al* (1998) presented a discussion of Liverpool's real-time passenger information system project called *Timechecker*. The following table gives an overview of the Timechecker evaluation:

On routes where *Timechecker* had been installed, a **5 percent increase in patronage** had been recorded	
68 percent of passengers use *Timechecker* consistently	
	Percentage of respondents who agreed
Timechecker makes waiting more acceptable	85
The reliability of the bus service has increased since the introduction of *Timechecker*	70
The provision of *Timechecker* has reduced waiting times	50
Timechecker gives a feeling of reassurance	87
Real-time passenger information displays should be added to all bus stops	93

A62. It is noted that Wilkinson *et al* (1998) did not present the study methodology but it appears that the findings were based on passenger surveys. It is also unclear if any bus service improvements were introduced at the same time as the *Timechecker* system.

A63. Wilkinson *et al* (1998) also reported on the London Transport integrated travel telephone enquiry system called *ROUTES* (Rail Omnibus Underground Travel Enquiry System). This system was intended to 'provide callers with solutions to complicated travel queries within seconds and will enable customers to plan their journeys more easily as they will be aware of the range of travel options.' Although this is not a bus-specific or real-time information service, it is still considered interesting to note the information system's effects on public transport patronage. The following table (from Wilkinson et al, 1998) displays the results of the ROUTES Inquiries:

	Percentage of enquirers
Made a public transport journey as a result of their *ROUTES* enquiry	80%
Made a public transport journey after a *ROUTES* enquiry, who otherwise would **not have travelled**	8%
Made a public transport journey after a *ROUTES* enquiry, who otherwise would have used **private transport**	5%
Made a public transport journey after a *ROUTES* enquiry, who would have used public transport anyway	87%

A64. In more general terms, Wilkinson *et al* (1998) found that 'passengers appear to appreciate real-time devices which indicate how long they may have to wait for the next bus, tube or train (provided systems are reliable).' It is significant to note that 'it has yet to be demonstrated robustly that such [information] systems affect demand on buses'.

A65. In a study based on a survey into the deployment of RTPI by Schweiger (2003), it was reportedly estimated that 'ridership increases because the deployment of advanced traveller information systems, of which real time bus arrival information systems are a subset, range from 1% to 3%...However, many of the agencies contacted for the synthesis project indicated that it would be very difficult to ascertain if ridership increases did result solely from the real-time bus arrival information. Rather it is usually a combination of factors that lead to an increase in ridership after such a system has been deployed'.

A66. Through research and case studies, Harrison *et al* (1998) asserted that the basic elements influencing selection or dismissal of bus travel included:

- accurate and readily available information where and when buses operate;
- bus stops within a reasonable walking distance of their journey origin and destination;
- a secure, well-lit and sheltered waiting facility;
- a reliable and frequent service;
- helpful staff;
- a safe, warm, comfortable and easily accessible vehicle;
- minimal journey time that is comparable and competitive with the journey time provided by alternative transport modes; and
- optimised interchange with other transport modes, where necessary.

A67. Harrison et al (1998) enforces Schweiger's findings that it is often a combination of measures that may improve ridership and it is therefore difficult to ascertain what contribution the deployment of RTPI has to the reported increase.

A68. Horbury (1999) 'recommended that displays at locations other than at bus stops (such as supermarkets, train stations, etc.) should be encouraged as they may result in patronage generation by attracting new users to the bus system.' (Horbury (1999) indicated that this effect had been observed in Ipswich and Liverpool but specific details and referencing of relevant studies was not provided.)

A69. Lehtonen and Kulmala (2002) reported on Helsinki's ELMI and noted that this real-time passenger information system was part of a total transport telematics system package, including signal priorities, called HELMI. Lehtonen and Kulmala (2002) generally considered the effects of the combined HELMI system but some ELMI-specific findings were provided.

A70. Lehtonen and Kulmala (2002) reported on surveys distributed to and then returned (by post) by 445 bus passengers. The results of the surveys are displayed in the following table:

	Percentage of respondents
I do not check the time of arrival of the next bus before arriving at the stop	50%
I have **increased my use of the bus service** due to the provision of the real-time passenger information *	25%
The **level of comfort I experience while travelling of this bus service has increased** due to the provision of the real-time passenger information	68%
	Score out of optimum of 10
Usefulness of the real-time passenger information	7.9
Reliability of the real-time passenger information	7.3

*Note: (Lehtonen and Kulmala later noted that the actual recorded patronage increases are smaller that these reported by the passengers themselves.)

A71. Through interviews conducted with 528 bus passengers, Lehtonen and Kulmala (2002) found that:

	Percentage of respondents
I noticed the real-time passenger information display	83%
I **often** use the real-time passenger information display	60%
I **occasionally** use the real-time passenger information display	23%
I **never** use the real-time passenger information display	17%
I find the real-time passenger information display **useful** *	78%
I have **increased my use of the bus service** due to the provision of the real-time passenger information	15%
The **level of comfort I experience while travelling on this bus service has increased** due to the provision of the real-time passenger information	40%
	Score out of optimum of 10
Usefulness of the real-time passenger information	7.6
Reliability of the real-time passenger information	7.6

- Note: (Reasons provided for ‘usefulness’ of real-time passenger information:
  - informed intending passengers of the remaining waiting time;
  - provided the option to choose another line;
  - let intending passengers know if the expected vehicles had already passed the subject stop; and
  - encouraged the potential for effective utilisation of the remaining waiting time.

A72 Lehtonen and Kulmala (2002) noted that while approximately 75 percent of survey respondents and interviewees were in support of the expansion of the real-time information system, ‘passengers were reluctant to give up other services provided by the [bus service providers and regulators] in exchange for the extension of the studied system.’

A73. An abstract (written in English) for an article (written in Finnish) covering the effects of *ELMI* and *HELMI*, ‘soon after implementation’ and ‘a year after implementation’, was also obtained. Pesonen *et al* (2002) summarised their findings in the abstract.

- ‘the [real-time passenger information] system improves comfort, decreases experienced uncertainty, improves the choice of [service/route] and mode and enables better utilisation of waiting times;
- 88 percent of interviewed passengers evaluated the system as good or very good;
- 72 percent [or interviewed passengers were] in favour of the expansion of the system;
- a disadvantage of the [telematics] system has been that it binds fleet on certain [routes] and thus makes fleet arrangements more difficult;
- the value of passenger benefits [from the real-time passenger information system] has been evaluated in components on the basis of [passenger] interview[s] and passenger volume information; and
- the benefit-cost ratio of the system in its present scope (year 2002) was calculated [at] 1.3, hence the project has been socio-economically profitable.’

A74. It appears that the report referred to by this abstract focused on the effects of the *ELMI* real-time passenger information system although its combination with other telematics systems is discussed. It is also stated that ‘according to rough calculations the application of signal priorities with the *ELMI* [real-time passenger information] system seems to be socio-economically very profitable.’

A75. It is noted, and understandable, that as these statements reported from Pesonen *et al* (2002) were all extracted from the study report abstract, no quantification of effects has been presented. However, the abstract’s statements still appear to warrant further investigation and it is recommended that the full report be accessed (and translated).

A76. In a TRB report on Real Time Bus Arrival Information Systems (Schweiger, 2003), it is concluded that one of the main reasons for deployment of RTPI systems is to improve customer service. Benefits of deployment revealed in the study included improved customer service, increased customer satisfaction and convenience, and improved visibility of transit in the community.

A77. In the same study, Schweiger (2003) reviews a study conducted by London Buses to determine customer satisfaction of Countdown. The results of the survey, involving 1,125 interviews, found that on a scale of 0 to 10, Countdown achieved an overall usefulness rating of 7.1, with high frequency stops achieving the best overall rating for usefulness at 7.5.

A78. Nakagawa *et al* (1999) conducted experiments where participants indicated their level of frustration while watching videotapes that simulated the experience of waiting at a bus stop. Two video-scenarios were used, one scenario provided a real-time passenger information display for waiting passengers and the other scenario did not. Through comparison of the frustration levels reported during viewing of the two video-scenarios, it was found that the provision of a real-time passenger information system reduced the waiting passengers’ feelings of dissatisfaction. However, if the bus did not come at the time indicated by the system, that is if the real-time passenger information system proved unreliable, frustration levels rose again.

A79. Wilkinson *et al* (1998) highlighted the potential for inequitable distribution of benefits from investment in real-time information systems.

A80. *‘The implementation of electronic information systems will entail high hardware investment costs and will require investment by operators and/or Local Authorities and PTEs in the computerisation of data (which is only available in varied, often paper, formats in the bus industry). This investment will benefit a variety of stakeholders, not just the body who makes an investment. Some operators in the bus industry may be unable or unwilling to make such investments, but will still benefit from the investments made by their competitors, for example through general increases in patronage, revenue generation, reduced congestion and associated investment by the local authority in improved provision for buses. This means* *it is unlikely that an operator will agree to pay the full costs of such systems alone. In principle public bodies could take on the responsibility for collating and disseminating such information, charging operators a levy to cover part of the costs, as happens in the rail industry.'*

A81. (This paragraph from Wilkinson *et al* (1998) is quoted verbatim. This allows the reader to appreciate the absence of specific referencing of concepts.)

A82. Horbury (1999) reported on interviews that were conducted with project managers and bus operators who had been involved in the implementation of real-time passenger information systems in the United Kingdom. Information gathered from the interviews 'revealed that operators who have a financial stake in [a vehicle location information system] or real-time passenger information system are more likely to ensure that buses which are fitted with location equipment are assigned to the correct route and also encourage drivers to enter the correct information into the system.' It is recognised that these issues may be critical to the operational success of a real-time information system and so should be addressed within the business case for such a system.

A83. As part of this *Bus real-time passenger information business case research* project, consultation was undertaken with representatives from local authorities, public transport executives and bus service operators that had recently been involved in implementation or consideration of a real-time passenger information system. Throughout the completed surveys, a number of candidates representing bus service operators commented on their 'passive' role within the implementation and operation of their local real-time passenger information system. A number of respondents also recognised that the potential of existing telematics systems was not fully utilised due to the lack of co-operation and communication between stakeholder parties.

Administration Benefits

A84. The deployment of real-time passenger information systems and technologies is thought to have a number of administrative benefits for bus operators

A85. Okunieff (1997) states that real-time information linked to 'control software permits supervisory staff to closely monitor operator/driver behaviour. This includes checking for late/early departures from scheduled locations, travelling off route, speeding and other work rule violations.' The information could be 'used to benefit the driver [by] proactively alerting the driver to early/late departures and documenting actual departure times, which can then be compared against customer complaints.'

A86. Okunieff (1997) also reported on research that suggested that real-tine information systems may help improve the bus service administration and management efficiencies. Research found that 'in general, a [real-time information] system reduces the amount of paperwork for dispatchers and service planning personnel who collect data, and monitor schedule adherence and performance. Supervisors make better use of their time because they are no longer required to perform on-time performance checks.'

A87. Horbury (1999) stated that automatic vehicle location systems can be 'used to provide real-time passenger information at [bus] stops, which gives the expected number of minutes until the actual arrival time of the next few buses, thereby reducing the uncertainty of the wait time and improving the image of bus services. These systems also have the added benefit of allowing bus operators to reduce costs by reducing the number of roadside inspectors, since the automatic vehicle location system performs the same function as roadside inspectors at a fraction of the cost and continuously throughout the day.' (Individual references for these statements were not specifically provided.)

A88. Through full utilisation of the available RTI technologies, it should be possible to create more realistic scheduling, mainly by using the data monitoring capabilities.

A89. A potential operational advantage provided by use of real-time information was discussed by Furth (2000). 'Automated data collection holds the key to doing statistically valid analyses of running time and route-level schedule adherence. Most agencies are forced to rely on very small samples to estimate necessary running time and to monitor schedule adherence, and decisions made on these estimates are quite subjective. In contrast, agencies that automatically collect running time and punctuality data are able to perform statistically valid analyses of performance that guide improvements in scheduling, operations control, and traffic engineering. The large samples necessary for statistically valid analyses are impractical without automatic data collection.'

A90. Tillis (2003) reported on the potential for incorporating real-time information into monitoring and programming maintenance schedules. 'Every operator knows that good preventative maintenance reduces the frequency and costs of breakdowns and corrective maintenance.' Using fleet management software with the vehicle operational data available through real-time information systems 'can keep track of preventative maintenance schedules efficiently and effectively for all buses.' 'This control ensures that each bus is maintained to the safest possible standard, meeting all [relevant] regulations.'

A91. (It appears that substantial research into the potential benefits of applying real-time information within vehicle maintenance programmes is currently being developed. For example, the Transportation Research Board (USA) is commissioning a report titled *Predictive diagnostics for bus maintenance*. 'This project is designed to develop an efficient method to provide maintenance and operations managers with routine bus performance information to enhance the scheduling of maintenance, improve technician performance, and reduce maintenance turnaround time.' The study investigator, O'Neill (2002) predicts that 'by improving diagnostic tools available to the technician, it is logical to expect a reduction in both unscheduled maintenance and maintenance and support costs.')

A92. During consultation with representatives carried out as part of this study, local authorities, public transport executives and bus service operators, candidates were queried regarding the collection, analysis and use of the data from their real-time passenger information system. 14 respondents (from the total sample group of 33) could not provide a full indication of the parties involved in monitoring the data produced by a real-time passenger information system. This suggests that the 'monitoring of daily service performance', referred to within hypothesis three, may not be optimised within current practices. This may be a factor in the lack of evidence found relevant to this hypothesis.

A93. (It is noted that real-time operation of all aspects of the systems required to generate the data that may assist in 'establish[ing] the case for a wider range of investments in public transport measures' may not necessarily be required. For example, delayed communication of vehicle location information may provide sufficient data for use in periodic assessment and tailoring of bus service schedules.)

IMPACTS FOR BUS PASSENGERS

A94. A number of studies have been conducted to determine the aspects of a bus service that are particularly important to passengers and affect their perception of the quality of that service.

A95. Harrison *et al* (1998) found that the perceived quality of a transport service is affected by 'hard', more readily quantifiable, variables such as journey time and service reliability and also by 'soft' variables such as information provision, staff attitudes and vehicle condition and comfort. Harrison *et al* (1998) then reported that any effect enhancement of 'soft' variables had on the attractiveness of bus travel could diminish over time. Without ongoing improvement in the quality of the 'soft' attributes of the product and associated promotion of their virtues, consumers' concentration returned to the more quantifiable aspects of service quality, such as reliability, journey times and costs. These statements were based on reviews of research into the patronage effects of the Leeds *Superbus* project and a study of a guided busway in Essen. (Quantitative data from the reviewed research were not provided to support the conclusions drawn.)

A96. Research suggests that the information needs of passengers are affected by many external and internal/personal factors. For example, Sayeg (2001) recognised that a passenger's information needs depend upon:

- their **familiarity** with the public transport system;
- whether it is a peak or off-peak period and the associated **service frequency**;
- the **stage** they are at in their journey:
  - pre-trip (thirty minutes or longer before the planned departure time);
  - imminent trip (within thirty minutes);
  - during the trip; and
  - on alighting at the destination.
- whether an **exceptional event** has occurred, e.g. bus breakdown.'

A97. This is amplified by Bishop (1999) who reported that information for passengers can be categorised as:

- **strategic (used in trip planning)**
  - public transport journey time;
  - private transport journey time;
  - public versus private transport costs;
  - status of public transport system;
  - status of public transport services; and
  - summary of road congestion.
- **tactical (used during the trip to assess the services):**
  - identification/features of service;
  - departure/arrival times;
  - notification of cancellations/delays;
  - alternate available services;
  - boarding details and 'next stop' information; and
  - emergency incident instructions.

A98. The three broad concepts considered in this section to do with the passenger impacts of RTPI are quality of service, time savings and monetary costs for passengers.

Quality of Service

A99 A number of articles attempted to establish a relationship between the frequency and reliability of a bus service and the value, to passengers, of information about that service. The reviewed sources tended to suggest that the value of information is inversely proportionate to the frequency and reliability of a bus service.

A100. Another dimension of the effect of service frequency and reliability on passengers was presented when Wilkinson *et al* (1998) identified the high perceived penalty of missing an infrequent service compared to the inconvenience caused through missing a service that is offered at a high frequency. The scale of perceived penalty was proposed to be proportionate to a user's information requirements implying that the 'value' of information may increase as service frequency decreases. (Although this statement was made within a rail context, it is supposed to be equally applicable to travel by bus.)

A101. Nagakawa *et al* (1999) conducted experiments and computer simulations to monitor the effect of the provision of real-time passenger information on the frustrations and modal choice of waiting passengers. It was generally found that the effects of the real-time passenger information system were constant regardless of bus service frequency, except where low frequency was accompanied by poor punctuality of the bus service. In this case 'because the lower frequency is less convenient for passengers, there is greater possibility to improve these passenger decisions by implementation of the [real-time passenger] information system.'

A102. Many research sources assert that telematics systems that provide vehicle location information may be useful in the optimisation of bus services. Through the provision of Automatic Vehicle Location (AVL) technology, priority can be given to buses on the road network. For example, Wilkinson *et al* (1998) reported an 'anecdotal experience from Leicester [where] an operator using [telematics for fleet management] had been able to provide the same service on the same route with one less bus just by improving reaction times to problems on the network.'

A103. Schweiger's (2003) study on real time bus arrival information systems asked operators within a survey, how they used real time information. It was generally found from the respondents that 'information is used to optimise the transit service and operations. The use of the information can result in the modification of service frequency and increase or decrease in the number of buses needed, and/or a better distribution of transit vehicles within the schedule to more closely meet the travel demand'.

A104. Brandt (1996) reported on the effects of 'prioritisation of public transport at traffic signals' delivered through use of telematics systems in Linz, Austria. After linking vehicle location information with urban traffic control systems at 17 intersections along a tramway, 'reduction[s] in running time brought tangible savings in terms of vehicles in operation while keeping headway the same.' (It is noted that this statement refers to trams rather than bus services but the findings are still considered relevant and applicable.)

A105. Nakamura *et al* (1998) proposed that provision of information to passengers during the trip planning stage could allow travellers more choice and could possibly stimulate shift from private to public transport modes. 'This means that it will be important to provide pre-trip bus information at home and offices.'

A106. Experimental and simulated monitoring of the effects of provision of real-time passenger information on passenger behaviour were reported on by Nakagawa *et al* (1999). It was found that the effects of a real-time passenger information system appeared to be greater for those passengers who considered the bus service timetable prior to arrival at the bus stop 'since the information system is useful for enabling rational decision-making.'

A107. Cassidy *et al* (1996) also provided statements supporting this notion, reporting that passenger information systems that provide information for passenger behavioural decision making at the trip origin have the widest range of potential impacts on travel behaviour. 'Pre-trip information can affect the timing, destination, mode, route and frequency of travel, whereas on-route information is likely to mainly affect route and possibly destination choice (the mode, timing and frequency having already been established).'

A108. Horbury (1999) reported on the potential for improvement of the public's image of a bus operator through transparent service operation, including the provision of complete and accurate real-time information. 'If details about conditions that deviate from the norm are provided at the stop, then the passenger will be able to make a much more informed choice about whether to travel by a particular bus on a given day. Even though this may mean a lost trip for the operator on some occasions, the passenger will be more favourably disposed to use the bus on another occasion, which may result in an overall increase in trip frequency. As well as providing useful information, passengers may have a better opinion of the bus operator as they will be able to differentiate a bad service due to events outside the operator's control, such as traffic congestion, from a poor service due to undisciplined staff.' Qualitative or quantitative justification of the existence and scale of this effect on passenger perceptions and actions was not presented, but may warrant investigation.

A109. Service benefits, including customer satisfaction are described in detail in paragraphs A43 to A83.

A110. In a TRB report on Real Time Bus Arrival Information Systems (Schweiger, 2003), it is concluded that one of the main reasons for deployment of RTPI systems is to improve customer service. Benefits of deployment revealed in the study included improved customer service, increased customer satisfaction and convenience, and improved visibility of transit in the community.

A111. In the same study, Schweiger (2003) reviews a study conducted by London Buses to determine customer satisfaction of Countdown. The results of the survey, involving 1,125 interviews, found that on a scale of 0 to 10, Countdown achieved an overall usefulness rating of 7.1, with high frequency stops achieving the best overall rating for usefulness at 7.5.

A112. Wilkinson *et al* (1998) discussed the potential and Government-led requirement for all aspects of public transport to be socially inclusive. It was noted that as 'a significant proportion of today's public transport users are financially disadvantaged', for promotion and maintenance of social inclusion, 'investment by industry in telematics systems and information collection [must] not increase fares.' Further, 'public transport information should be available free of charge.'

A113. Within their discussion of public transport telephone enquiry services, Wilkinson *et al* (1998) stated that 'some enquiry lines are based on premium call lines. It [has been] claimed that this alone generates sufficient revenue to meet the cost of providing the service, irrespective of changes in fare revenue.' This suggests that a telephone passenger information system could be investigated as a feasible medium for provision of real-time information to passengers. However, it is noted, that Wilkinson *et al* (1998) also identified that 'public transport information should be available free of charge' in the interests of maximising the socially inclusive nature of bus travel.

A114. Wilkinson *et al* (1998) reported that 'in-vehicle information about forthcoming stops is welcomed by users and may help to reduce waiting times at stopping points. Advice on alternative routes in emergencies or during operational crises is also highly valued.' (The evidence for this statement was not presented.)

A115. Willis (1995b) found literature that indicated that 'new types of electronic information can be provided to passengers because of recent developments in the integration of real-time [passenger] information and next-stop announcements.' When focus group discussions were held with members of the travelling public, to determine the types of information desired by passengers when travelling on board a bus, 'participants were especially interested in next-stop, route number and name, and other transportation information.'

A116. Ristola (1999) reported that the in-vehicle information displays implemented as part of Madrid's 'Mobile' system had achieved a 'high satisfaction level from both travellers and drivers. Drivers do not need to inform the passengers about where to get off since this information is available in real-time. Travellers feel much more relaxed since they can find their destination even when they do not use a certain line regularly.' (The study methodology and quantitative results upon which these statements are based were not presented within the reviewed article.)

A117. Horbury (1999) reported that 'next stop displays on-board buses are only useful to a small fraction of bus passengers since most passengers are regular bus users and do not require the information as they are familiar with the route. In addition to the purchase and maintenance costs of these displays, if incorrect information is presented confidence in the whole system will be jeopardised. Therefore, next stop displays should only be used in areas with a high proportion of infrequent bus users, such as routes that pass through tourist areas, galleries, hospitals, etc.' (Specific sources or instances of evidence to support these statements were not provided.)

A118. During the consultation phase of this research project, one respondent representing a local authority/public transport executive indicated that customer surveys had revealed that the in-vehicle systems providing information about the location of the next scheduled bus stop were 'of no value'.

Journey Time Savings

A119. Horbury (1999) stated that automatic vehicle location systems can be 'used to provide real-time passenger information at [bus] stops, which gives the expected number of minutes until the actual arrival time of the next few buses, thereby reducing the uncertainty of the wait time and improving the image of bus services. These systems also have the added benefit of allowing bus operators to reduce costs by reducing the number of roadside inspectors, since the automatic vehicle location system performs the same function as roadside inspectors at a fraction of the cost and continuously throughout the day.' (Individual references for these statements were not specifically provided.)

A120. Mishalani *et al* (2000) proposed a model for evaluating the benefits of real-time information provision to travelling (and intending to travel) members of the public. A number of articles and studies of real-time passenger information systems were reviewed to determine appropriate variables and relationships to be used in the model's development. It was reported that:

A121 *'it has been empirically shown that passengers consider the time spent waiting for a bus to be significantly more disagreeable than the time spent travelling on a bus. This higher level of discomfort is partly attributed to the uncertainty associated with the arrival time of the upcoming bus. Therefore, real-time bus arrival information systems have the potential of reducing the disutility of waiting time. Bus arrival information can also allow passengers to use their waiting time more productively by engaging in other activities at the stop or at a location in the proximity of the stop. Moreover, real-time information on bus arrival times can allow passengers to make improved bus route choice decisions when multiple routes can satisfy their travel needs.*

A122. Although Mishalani *et al* (2000) were only reporting on research conducted by others, it is believed that as all sources are cited and given the complex and scientific nature and comprehensiveness of the presented model the base research methodology could be considered robust.

A123. Nakagawa *et al* (1999) conducted experiments and computer simulations to measure the effects of real-time passenger information on passengers' demand for buses. Participants watched videotapes, which showed the scene at a bus stop, and indicated their level of frustration while waiting and their intention to continue to wait for and use, or not to wait for and use, the bus service with respect to their original plans. The two video-scenarios used for the experiments showed a road, as it would be seen from a bus stop. One video-scenario included real-time passenger information signs at the bus stop and the other did not.

A124. Examinees were given information about the time limitations governing their arrival at their destination.

- half the sample were given a 'strong' arrival time limitation representing circumstances such as a commuter may face when arrival at a meeting is critical; and
- half the sample were given a 'weak' arrival time limitation, such as may operate on journeys for leisure purposes.

A125. It was found that these 'arrival time limitation' conditions, and therefore trip purpose, had a measurable effect on the rate of increase of waiting passengers' frustration. It was also found that the provision of a real-time passenger information system reduced the frustration levels experienced.

A126. This hypothesis appears to be supported by Stoeveken and Esters (1999) who reported that 'information on actual delays [to a bus service are] usually not available so that the passengers waiting at stops [for these services] do not know when the next bus is coming and delays result in connections being missed. Particularly in rural areas where the service is provided [less] frequently, this substantially reduces the attractiveness of the public transport, finally leading to a reduction in the number of passengers and a deterioration in efficiency.' (It is noted that no references were cited or statistics provided to validate these statements.)

A127. And also, Wilkinson *et al* (1998) evaluated public responses to *Timechecker*, a real-time passenger information system implemented in Liverpool and found:

	Percentage of respondents who agreed
Timechecker makes waiting more acceptable	85
The reliability of the bus service has increased since the introduction of *Timechecker*	70
The provision of *Timechecker* has reduced waiting times	50
Timechecker gives a feeling of reassurance	87

A128. It is noted that Wilkinson *et al* (1998) did not present the study methodology but it appears that the findings were based on passenger surveys. It is also unclear if any other bus service improvements were introduced at the same time as the *Timechecker* system.)

A129. Surveying of a sample of passengers using bus stops equipped with *Countdown*, London Buses' real-time passenger information system, was also conducted. 'A quarter of respondents perceived that they waited a shorter time for their bus since the introduction of *Countdown*. Only 7 percent believed they experienced longer waits.' However, another study of *Countdown* equipped bus stops found that 'analysis of the data by individual wait times indicated that *Countdown* had a positive effect on wait times the *longer* the passengers waited. However, the overall effect of *Countdown* on perceived wait times remained inconclusive; although there was evidence to suggest that perceived waits were lower at lower frequency stops.'

A130. Backstrom (1998) reported on *ELMI*, a passenger information system implemented in Finland that provides 'passengers at bus stops with timetable information based on the real-time movement of buses.' It was proposed that 'the effects of the system would be examined in three parts:

- before implementation;
- soon after [implementation]; and
- a year after implementation.'

A131. At the time of the article's publication, only the 'before implementation' study had been completed. Backstrom (1998) stated that 'the before study was done by interviewing passengers, video-taping their behaviour and by asking the opinions of bus drivers and traffic contractors.' It was found that:

- 'the majority of passengers coming to the bus stops find out what time the bus leaves ahead of time;
- passengers are more likely to come to bus stops without first verifying the time of departure if the bus stop in question is a busy transfer stop and if there are many alternative bus lines available;

- 37 percent of the people interviewed found the waiting time for buses to be long or very long;
- the waiting time felt shorter for people who use the bus daily and for people who had a choice of several alternative bus lines;
- the majority of passengers do nothing while waiting;
- almost one fifth of the people interviewed [indicated they] would use [a known] ten-minute waiting time to [engage in other activities]; and
- traffic contractors expect the [*ELMI*] system to mostly improve customer satisfaction and the image of bus transportation and to make timetable planning easier.'

(Although it is noted that the sample size is not stated, it is considered that the presented methodology appears robust and therefore the results of the complete study were sought.)

A132. Stoeveken and Esters (1999) proposed that 'real-time [passenger] information about expected [bus service] departure times should not only be obtainable at home or train/bus stations but also everywhere en-route. For this, the use of mobile phones is very practical. On the one hand, the existing hardware and data communication can be used, on the other hand the mobile phones [are becoming] more and more common.'

A133. Stoeveken and Esters (1999) then reported on a trial, conducted on behalf of Germany's Ministry of Transport, where 120 persons received mobile phones to access 'real-time information about the actual waiting and departure times of all local buses, regional buses and the trains' in their local area. The costs and benefits of the project were presented.

- the mobile phones will be able to use the existing public transport information platform so the system will only require investment in the equipment of the radio antenna and the mobile phones (hardware and software);
- since the communications network builds on the functions of the existing control centres and the radio and vehicle location systems of the individual operators, the investment costs are relatively low;
- alongside the one-off investment costs, running costs are incurred for the data transmission. It is one task of the field study to calculate the investment and operating costs for the system; and
- the immediate benefit for the passenger is the provision of updated departure times via mobile phones without any additional equipment. In this way, an improvement in the image and attractiveness of public transport and an increase in passenger volumes will be produced and therefore an improvement in economic performance.

A134. It is noted that these costs and benefits were purely hypothetical at the time of the article's publication as the trial and field study had, at that time, not been conducted. The presented survey methodology, including assessment of the mobile phones' effects on an individual's mobility, suggests that the completed study's findings may be worth investigating. Stoeveken (2000) also produced an independent report on this study. In this article, the before and after study methodologies to monitor the effects of providing real-time passenger information, on bus services, via mobile phones are set out. The reported monitoring approach appears robust and it is therefore again recommended that details of the results from this study could be pursued and reviewed.

A135. Nakamura *et al* (1998) analysed the effects of providing real-time bus service information via the Internet. The accuracy of the displayed real-time information was compared with the accuracy of the scheduled bus service timetable. It was found that the bus arrival time predicted by the real-time passenger information system was closer to the actual bus arrival time than the pre-determined scheduled bus arrival time was. Therefore the real-time passenger information system was found to be more reliable than the static information.

A136. Nakagawa *et al* (1999) conducted experiments where participants indicated their level of frustration while watching videotapes that simulated the experience of waiting at a bus stop. Two video-scenarios were used, one scenario provided a real-time passenger information display for waiting passengers and the other scenario did not. Through comparison of the frustration levels reported during viewing of the two video-scenarios, it was found that the provision of a real-time passenger information system reduced the waiting passengers' feelings of dissatisfaction. However, if the bus did not come at the time indicated by the system, that is if the real-time passenger information system proved unreliable, frustration levels rose again.

A137. Schweiger (2003) reviews passenger's attitudes and perceptions of the deployment of Countdown. Of the passengers interviewed, 65% felt that they waited for a shorter period of time when Countdown was present, with the perceived waiting time dropping from 11.9 minutes to 8.6 minutes.

A138. Harrison *et al* (1998) also stated that unless origin-to-destination journey times by bus are broadly comparable with those of alternative modes, the bus will not be considered voluntarily, and unless bus services are reasonably reliable they will not be considered by those people with a choice. This statement was based on interpretation of research into the effectiveness of a travel awareness campaign, however the details of the research methodology and results were not discussed.

A139. These findings indicate the value that passengers place on reliability and therefore the value that could be assigned to any system that improves bus service reliability.

A140. Video monitoring of a sample of bus stops equipped with the real-time passenger information system *Countdown* and a control set of bus stops without *Countdown* was undertaken. It was found that 'there was a slight, but not significant, increase in the proportion of passengers leaving the stop [aborting their wait or to pursue a time-filling diversionary activity] with the presence of Countdown. The 'opt out' rate at the Countdown stops was 6 percent compared with 4 percent at the control stops.' It was also reported that 'participation in diversionary activities was noted equally at stops with and without Countdown.'

Monetary Costs for Passengers

A141. It has been suggested that one method for funding of the implementation of a real-time passenger information system could involve passing a portion of the costs onto the bus service passengers themselves. Therefore, research to verify passengers' willingness to pay for the provision of such information was sought. Evidence from this section may inform the development of a business case for a real-time passenger information system.

A142. Adam and Vertsonis (2002) reported on a study that measured customer satisfaction with bus services in Sydney, Australia. 300 passengers were surveyed and indicated their general satisfaction with the provided level of service. The survey respondents then provided valuations of potential service improvement mechanisms.

A143. Balcombe and Vance (1997) reported on approximately 1,200 household and 800 on-street surveys conducted with bus users about bus service information use and preferred formats. Some significant conclusions were drawn concerning attitudes towards paying for bus service information.

> *'Passengers seem unwilling to pay higher fares in order to finance passenger information. However, some may be prepared to pay modest amounts for personal timetables or for occasional use of facilities like telephone enquiry services or publicly available computer terminals.''*

A144. The following table presents the survey statistics, percentage of respondents stating their willingness or unwillingness to pay for information options, upon which this statement is based:

Information option		Percentage of respondents stating their willingness to pay	unwillingness to pay
At home			
Personal timetables	£5.00	6%	74%
	£3.00	12%	58%
	£2.00	25%	45%
Enquiry terminal	50p	17%	59%
	30p	28%	44%
	20p	43%	34%
At bus stop			
Full timetable	25p on fare	10%	74%
	15p on fare	18%	62%
	10p on fare	29%	46%
Real-time passenger information display	50p on fare	**4%**	**87%**
	30p on fare	**6%**	**77%**
	20p on fare	**16%**	**56%**
At town centre			
Enquiry terminal	25p	15%	60%
	15p	27%	41%
	10p	47%	27%
(The percentage of undecided respondents is excluded.)			

A145. *'People seem to have developed an expectation that passenger information will be provided free, and do not therefore relish the prospect of having to pay for it. There was most resistance to the concept of a fare supplement in order to finance information at bus stops, whether conventional printed timetables or real-time bus arrival displays.' 'Furthermore, many bus users seem to be of the opinion that it is the responsibility of the business offering the service to inform the customer about the product, in the same way as they might expect to be informed about the attributes and proper method of using a particular detergent. Having paid their fare, [bus users] find it difficult to think in terms of any further investment, even hypothetically, because they see information as being the operator's contractual obligation and place little personal value on it.'*

A146. Balcombe and Vance (1997) compared their results, presented in, with studies of London's *Countdown* real-time information system. One study conducted by Smith, Sheldon and Atkins (1994) reported that bus users valued the provision of real-time passenger information at 26 pence per bus journey but a study by White and Brocklebank (1993) found that bus users were only willing to pay 6.5 pence, per bus journey, to use such a system with an accuracy of one minute.

IMPACTS FOR LOCAL TRANSPORT AUTHORITIES

A147. The main issues and impacts for LTA are discussed below.

Policy Development Benefits

A148. The Government's White Paper on the Future of Transport '*A New Deal for Transport: Better for Everyone*' (DETR, 1998) states its commitment to the creation of a better, more integrated transport system that will increase modal choice by improving public transport and will also provide sustainable mobility for all.

A149. It stresses the role of partnership with the private sector and local government in modernising the transport network. Amongst other things, the White Paper aims to provide "*a multimodal response to the problems of congestion and pollution that threaten our quality of life and our future economic well being*".

A150. Experience so far in the UK has shown that neither operators nor LTAs alone can make the business case to justify the investment in RTI. Therefore partnerships have been developed with each partner contributing to the costs of systems.

A151. The Government's Ten Year Plan (DETR, 2000a) sets out a long-term strategy for delivering a quicker, safer, more reliable transport system that has less of an impact on the environment. Part of the strategy to achieve this goal is to increase bus passenger numbers by 10%.

A152. DETR (2000a) states that "*for travel in towns and cities, our underlying objective is to create more attractive public transport alternatives. We want each town and city to have a high quality public transport system that is safe, integrated, efficient and affordable, that helps to reduce social exclusion and supports our wider vision of an urban renaissance*".

A153. The aim of the ten year plan is to provide the new transport investment needed to help achieve the urban goals of reduced traffic congestion, increased reliability and convenience of public transport, increase in safety and a reduction in air pollution (DETR, 2000a).

A154. It is understood that "improving our transport network represents an investment in this country's future, contributing to our sustainable development goals. Making full use of new technologies and encouraging innovation, we can create a modern, less polluting and more efficient transport system that will better meet the needs of business, motorists and all transport users", (DETR, 2000a).

A155. LTAs have a wide range of objectives, which differ from area to area and are set out in their statutory Local Transport Plan. Achievement of higher level LTP objectives like reducing the environmental impact of transport, sustainable economic development of their areas and reducing social exclusion requires increased use of public transport. LTAs therefore can and do take a wider range of impacts into account in developing their business case for investment in RTI.

A156. Local Authorities, through the Local Transport Plans (LTPs) process, and others such as Local Air Quality Management (LAQM) process, are encouraged to reduce car travel in order to reduce the impact of transport on the environment and to reduce congestion. Documents which support moves towards an increase in bus patronage as part of a strategy to achieve these goals include the Transport White Paper (DETR, 1998) and the Government's Ten Year Plan (DETR, 2000). The Government's guidance on full local transport plans (DETR, 2000b) also offers supportive, but not direct, reference to bus networks and the provision of information. The need for networks to be considered both quantitatively and qualitatively is highlighted. DfT (not dated) also states that local authorities have an obligation to provide data to potential public transport users. One of the aims of Transport Direct is to "advise the traveller about how their chosen travel option is performing in real time before they set off".

A157. DfT's progress report on delivering better transport (DfT, 2002) sets out further strategies to meeting the aims of the ten year transport plan. Tackling congestion is one of these key issues. The report states that rising traffic levels are a major factor in contributing to congestion within the UK (underlying growth in total motor vehicle traffic across Great Britain has increased by 1.3% between 2000 and 2001). One of the key measures stated within the strategy to reduce congestion is making improvements to public transport and alternatives to the private car.

A158. Local Authorities have a commitment to reduce congestion and the environmental impacts of traffic and transport. Through introduction of RTPI as a means of increasing bus patronage, there may be a reduction in the amount of traffic on the UK's roads. This decline in traffic could reduce the impacts of congestion and have a positive effect on the local environment.

A159. In a study conducted by DETR (2001) it is indicated that the implementation of the SCOOT system can reduce bus travel times by 2 to 4 mins on a 10 km route. There is a variability of travel time improved by up to 16%. It was also found that it was possible to achieve time savings of 1 to 10 seconds per junction (with an average of 4 seconds), and travel time variability improvements of 0 to 20% (with an average of 12%) were achieved.

A160. The SCOOT Version 3.1 and later includes facilities to provide priority to selected vehicles (e.g. bus priority). Trials in London have shown that additional average reductions in delay to buses of 3 to 5 seconds per bus per junction can be achieved. At particular sites much larger benefits can be found. A trial at one junction in Lances Hill in Southampton revealed reductions in delay of 34 seconds per bus in the PM peak period.

A161. Values of time can be attributed to the provision of bus travel time. The Transport Economics Note (DETR, 1998) provides the latest values of time and vehicle operating costs recommended by the Department of the Environment, Transport and the Regions for use in economic appraisals of transport projects. All week average for non-work passengers can be calculated at 5469 pence per hour (91 pence per minute or 1.5 pence per second) [based on 'perceived values of time' in Transport Economics Note, DETR,1998]. If bus travel times are reduced by 2-4 minutes on a 10 kilometre stretch is equal to a £1.82 – £3.64 value of time per vehicle saving. An average of a 4 second time saving per junction is equal to a saving of £0.06 in terms of value of time per vehicle. Local authorities should take this into account in reviewing the quantifiable benefits of bus service enhancements.

A162. Local Authorities have an obligation to meet the requirements set in Section 139 of the Transport Act 2000, which is reproduced here:

> *Bus services: provision of information*
>
> (1) Each local transport authority must from time to time determine, having regard to their local transport plan-
>
> > (a) what local bus information should be made available to the public ("the required information"), and
> >
> > (b) the way in which it should be made available ("the appropriate way").

A163. Leeder (2002) stated that 'the government has three broad transport goals. Firstly, decongestion, through modal shift. Secondly, greater social inclusion, by creating more journey opportunities, at affordable prices for the socially excluded. And thirdly, a better environment.' These 'transport goals' are discussed below.

A164. It is proposed that a socially inclusive transport system would equalise the advantages and disadvantages of using public or private transport and thereby promote equal opportunities for all community members. Bishop (1999) reported on aspects relevant to this issue within discussion of the South East Queensland *Real Time Passenger Information Project*. It was reported that 'a common complaint associated with the use of public transport is that total journey times (including the time to get to the alighting point and waiting for the vehicle) are much longer than that using private transport.' The reduction of public transport journey times, and any other measures that balance the costs and benefits of public transport use with those associated with travel by private modes, may advance equality between those society members with access to private transport means and those without. This may then increase the potential for achieving a more inclusive society overall.

A165. Within their discussion of public transport telephone enquiry services, Wilkinson *et al* (1998) stated that 'some enquiry lines are based on premium call lines. It [has been] claimed that this alone generates sufficient revenue to meet the cost of providing the service, irrespective of changes in fare revenue.' This suggests that a telephone passenger information system could be investigated as a feasible medium for provision of real-time information to passengers. However, it is noted, that Wilkinson *et al* (1998) also identified that 'public transport information should be available free of charge' in the interests of maximising the socially inclusive nature of bus travel.

A166 The Government has set targets to lessen the influence of transport on the environment. This could, in part, be delivered by increasing the efficiency and decreasing the emissions of various, and all, means of transport. With respect to a bus service, if a real-time information system can be used to monitor and optimise the performance of buses, both on an individual vehicle scale and as an entire fleet, then environmental impacts may be reduced. The guidance issued to LTA through the Government's Transport Economic Notes quantifies Vehicle Operating costs and fuel savings that should be accounted for in the cost benefit analysis of schemes.

A167. DEFRA (2001) are responsible for publishing 'Climate Change: The UK Programme' which sets out the climate change programme for the United Kingdom. Central to the programme is a strategy to reduce greenhouse gas emissions. It has been estimated that the proposals set out in the strategy may be possible to reduce greenhouse emissions to about 23% below 1990 levels in 2010, well beyond the Kyoto target. As the increase in road traffic is responsible for a large proportion of greenhouse gas emissions in the UK (third largest source), the strategy rightly points towards the policy measures being taken by the Government in producing the Transport White Paper (DETR, 1998) and the Ten Year Plan (DETR, 2000a). Both policy documents look to modal shift towards public transport use as an important part of the strategy to achieve these environmental aims. DEFRA's climate change strategy (2001) has identified the 10 Year Plan for Transport as a means of providing the resources to improve national and local transport and to bring on new technology in order to reduce emissions.

Network Management Benefits

A168. Horbury (1999) reported on the potential for improvement of the public's image of a bus operator through transparent service operation, including the provision of complete and accurate real-time information. 'If details about conditions that deviate from the norm are provided at the stop, then the passenger will be able to make a much more informed choice about whether to travel by a particular bus on a given day. Even though this may mean a lost trip for the operator on some occasions, the passenger will be more favourably disposed to use the bus on another occasion, which may result in an overall increase in trip frequency. As well as providing useful information, passengers may have a better opinion of the bus operator as they will be able to differentiate a bad service due to events outside the operator's control, such as traffic congestion, from a poor service due to undisciplined staff.' Qualitative or quantitative justification of the existence and scale of this effect on passenger perceptions and actions was not presented, but may warrant investigation.

A169. In a study based on a survey into the deployment of RTPI by Schweiger (2003), it was reportedly estimated that 'ridership increases because the deployment of advanced traveller information systems, of which real time bus arrival information systems are a subset, range from 1% to 3%...However, many of the agencies contacted for the synthesis project indicated that it would be very difficult to ascertain if ridership increases did result solely from the real-time bus arrival information. Rather it is usually a combination of factors that lead to an increase in ridership after such a system has been deployed'.

A170. Through research and case studies, Harrison *et al* (1998) asserted that the basic elements influencing selection or dismissal of bus travel included:

- accurate and readily available information where and when buses operate;
- bus stops within a reasonable walking distance of their journey origin and destination;
- a secure, well-lit and sheltered waiting facility;
- a reliable and frequent service;
- helpful staff;
- a safe, warm, comfortable and easily accessible vehicle;
- minimal journey time that is comparable and competitive with the journey time provided by alternative transport modes; and

- optimised interchange with other transport modes, where necessary.

A171. Harrison et al (1998) enforces Schweiger's findings that it is often a combination of measures that may improve ridership and it is therefore difficult to ascertain what contribution the deployment of RTPI has to the reported increase.

A172. Nakamura *et al* (1998) surveyed 192 residents about the effects of a real-time passenger information system that provided details of local bus services via the Internet. Approximately one quarter of respondents reported an increased use of the bus service and one quarter also reported instances of modal shift to bus after consultation of the Internet-based information. It is noted that these are reported passenger actions and not actual or measured patronage effects. (Attempts to measure the patronage effects were made using automatic passenger counters on buses within the experiment area but no relationship between patronage rates and the provision of the real-time passenger information on the Internet could be established, so this measurement is not presented within this summary of the research.)

Service Benefits

A173. Service benefits, including customer satisfaction are described in detail in paragraphs A43 to A83.

REFERENCES

Adam, W. and Vertsonis, H. 2002. Transit vehicles for 21st century roads. *Proceedings of the AITPM national conference,* Perth, 8-9 August 2002. Adelaide, Australia: AITPM Inc.

AGB McNair. 1997. *Market research on behalf of Queensland Rail between October 1992 and March 1997*, cited in Blythe, P. 2002. Can ITS satisfy the demands of the UK integrated transport white paper and subsequent 10 year transport plan: a SWOT analysis. *Presented at the 9th world congress on intelligent transport systems,* Chicago, 14-17 October 2002. Brussels, Belgium: ITS Congress Association.

Backstrom, J. 1998. Real-time information about waiting times at bus stops. *Proceedings of the 5th world congress on intelligent transport systems,* Seoul, 1998. Brussels, Belgium: ITS Congress Association.

Balcombe, R. & Vance, C. 1997. *TRL Report 330: Information for bus passengers: a study of needs and priorities*. Berkshire: Transport Research Laboratory.

Ben-Akiva, M. & Lerman, S. 1985. *Discrete choice analysis*. USA: MIT Press, cited in Mishalani, R., McCord, M. & Lee, S. 2000. The value of real-time bus arrival information under various supply and demand characteristics. *Presented at the 10th meeting of ITS America,* Washington DC, 2000. Ohio, USA: Ohio State University.

Bishop, M. 1999. A bold approach to the use and integration of real-time public transport passenger information in a multi-modal and multi-agency environment. *Presented at the 4th international conference of ITS Australia,* Adelaide, 1999. Canberra, Australia: ITS Australia.

Blythe, P. 2002. Can ITS satisfy the demands of the UK integrated transport white paper and subsequent 10 year transport plan: a SWOT analysis. *Presented at the 9th world congress on intelligent transport systems,* Chicago, 14-17 October 2002. Brussels, Belgium: ITS Congress Association.

Brandt, H. 1996. LIBE: The speed-up programme in Linz. *Public Transport International – Transport Public International – Der Offentliche Nahverkehr in der Welt,* 1996/4: 63-66.

Bus Industry Monitor team (Anderson, M., Cheek, C., Davis B., Davis M. & Huntley, P.) 2002. *Bus industry monitor: The market public spending and support investment and fleet analysis industry performance 2002.* North Yorkshire: TAS Publications and Events Limited.

BusinessCase.com 2002. *Make the case.* [Online] Available http://www.businesscase.com/ [May 2003]

Cartwright, M., Tilley, G. & Warman, P. 2002. *RTI programme: Quality of service and evaluation.* Draft 28 August 2002. [Unpublished report] Surrey: Curtis+Cartwright Consulting Limited.

Cassidy, S., Holvad, T. & Jones, P. 1996. *Socio-economic evaluation of the Hampshire County Council ROMANSE project: summary.* London: University of Westminster.

Counter Context Limited 2001. *Best Value Review: Passenger information.* July 2001. [Unpublished report] Manchester: Counter Context Limited.

Department for the Environment, Food and Rural Affairs, 2001, *Climate Change: The UK Programme,* The Stationery Office, UK.

Department of the Environment, Transport and the Regions, 2001, *Bus Priority*, Traffic Advisory Leaflet 6, DETR, UK.

Department of the Environment Transport and the Regions, 2000a, *Ten Year Plan for Transport*, The Stationery Office, UK

Department of the Environment, Transport and the Regions, 2000b, *Guidance on Full Local Transport Plans*, The Stationery Office, UK.

Department of the Environment, Transport and the Regions, 2000, *Bus Priority in SCOOT*, Traffic Advisory Leaflet 8, DETR, UK.

Department of the Environment, Transport and the Regions, 1998, “A New Deal for Transport: Better for Everyone”, The Stationery Office, UK

Department for Transport 2002. *Bus real-time passenger information business case research.* Project brief.

Department for Transport (2002) “Delivering Better Transport: Progress Report”, The Stationery Office, UK

Department for Transport (not dated) “Transport Direct” URL: www.dft.gov.uk/stellent/groups/dft_transstat/documents/page/dft_transstat_50391 [19/08/03]

Furth, P. 2000. *Synthesis of transit practice 34: Data analysis for bus planning and monitoring.* Washington DC, USA: National Academy Press.

Gallagher, M. 2002. Bits and business: a theoretical model for determining value in ATIS systems and its business implications for traveller information and in-vehicle devices. *Presented at the 9th world congress on intelligent transport systems,* Chicago, 14-17 October 2002. Brussels, Belgium: ITS Congress Association.

Harrison, S., Henderson, G., Humphreys, E. & Smyth, A. 1998 Quality bus corridors and green routes: can they achieve a public perception of ‘permanence’ of bus services? *Proceedings* of *seminar F, Public transport planning and operations, European transport conference,* Loughborough, 14-18 September 1998. London: PTRC Education and Research Serivces Ltd.

Holland, R. 2000. Superoute 66 Live! – the impact of providing real-time information on the Internet. *Proceedings of seminar E, The planning and management of public transport systems, European transport conference,* Cambridge, 11-13 September 2000. London: PTRC Education and Research Services Ltd.

Horbury, A. 1999. Guidelines for specifying automatic vehicle location and real-time passenger information systems using current best practice. *Transport Reviews*, 19 (4): 331-351, October-December.

Hounsell, N. & McLeod, F. 1998. Automatic vehicle location - implementation, application, and benefits in the United Kingdom. *Transportation Research Record,* 1618: 155-162.

Jack, R. 2003. Lockhead signals strong opposition to increases public subsidy for buses. *Transit,* 11 April 2003: 3

Leeder, D. 2002. What are the government’s bus priorities? *Transit*, 15 November 2002: 15.

Lehtonen, M. & Kulmala, R. 2002. The benefits of a pilot implementation of public transport signal priorities and real-time passenger information. *Presented at the 81st annual meeting of the Transportation Research Board,* Washington DC, 2002. Washington DC, USA: National Research Council (US), Transportation Research Board.

Lewis, M. & Mason, J. 2002. *National RTPI strategy.* Version 1.01 [Unpublished draft document] London: Real-Time Information Group.

Local Transport Today 2002. DTLR awards 19 projects a share in £20m of bus real-time awards. *Local Transport Today,* 11 April 2002: 4

London Buses, Accent Marketing and Research. 1994. *Countdown observational monitoring.* Reference RS94A3 [Research summary] Crowther, B.: Contact.

London Buses, Accent Marketing and Research. 1996. *Perceived waiting time at bus stops.* Reference RS96002 [Research summary] Crowther, B.: Contact.

London Buses, Accent Marketing and Research. 1994. *Uxbridge Road Countdown – bus user survey.* Reference RS94A1 [Research summary] Crowther, B.: Contact.

London Buses, Research and Auditing Services. 1997. *Countdown site location*. Reference RS97003 [Research summary] Crowther, B.: Contact.

Lowe, C. 1994. What the public wants to know. *Surveyor*, 181 (5303):14-15, August, cited in Balcombe, R. & Vance, C. 1997. *TRL Report 330: Information for bus passengers: a study of needs and priorities.* Berkshire: Transport Research Laboratory.

Mishalani, R., McCord, M. & Lee, S. 2000. The value of real-time bus arrival information under various supply and demand characteristics. *Presented at the 10th meeting of ITS America,* Washington DC, 2000. Ohio, USA: Ohio State University.

Nakagawa, D., Matsunaka, R. & Koide, Y. 1999. Effect of a bus location information system on the demand for buses. *Proceedings of seminar D, The AET European Transport Conference,* Cambridge, September 1999. London: PTRC Education and Research Services Ltd.

Nakamura, F., Babasaki, Y. & Konda, Y. 1998. Analysis on the effects of real time bus service information provision – Experimental evaluation of bus service information provision via Internet. *Proceedings of the 5th world congress on intelligent transport systems,* Seoul, 1998. Brussels, Belgium: ITS Congress Association.

Okunieff, P. 1997. *Synthesis of Transit Practice 24, AVL Systems for Bus Transit.* Washington DC, USA: National Academy Press.

O’Neill, G. 2002. *Research in progress: Predictive diagnostics for bus maintenance.* [Online] Available: http://rip.trb.org/browse/dproject.asp?n=7562 [April 2003].

Page, A. 2002. Key issues for successful integrated tracking and management systems. *Presented at Passenger transport solutions 2002,* London, 29 October 2002, cited in Stredwick, A. 2002. Technology to deliver a customer service revolution is showcased at PTS event. *Transit*, 15 November 2002: 12-13.

Pesonen, H., Laine, T., Backstrom, J., Granberg, M., Vehmas, A. & Niittymaki, J. 2002. *Assessment of impacts and socio-economical profitability of real-time passenger information system (ELMI).* [Abstract] Finland: Ministry of Transport and Communications.

Ristola, T. 1999. *Overview of current implementations of passenger information technology.* [Online] Available: http://www.ul.ie/~infopolis/pdf/berlin/overview.pdf [December 2002].

Sayeg, P. 2001. Forward thinking – Queensland’s real-time passenger information systems. *Traffic Technology International*, ?:52-3,55-8, February-March.

Smith, R., Atkins, S. & Sheldon, R. 1994. London Transport Buses: ATT in action and the London Countdown route 18 project. *Proceedings of the 1st world conference on applications of telematics and intelligent vehicle-highway systems,* Paris, 30 November-3 December 1994. Brussels, Belgium: ERTICO, cited in Balcombe, R. & Vance, C. 1997. TRL Report 330: Information for bus passengers: a study of needs and priorities. Berkshire: Transport Research Laboratory.

Stoeveken, P. 2000. Field study of real time passenger information via mobile phone. *Presented at the 7th world congress on intelligent transport systems,* Turin, 2000. Brussels, Belgium: ITS Congress Association.

Stoeveken, P. & Esters, D. 1999. Real-time passenger information via mobile phone. *Proceedings of the 6th world congress on intelligent transport systems (ITS),* Toronto, 8-12 November 1999. Washington DC, United States: ITS America.

Thompson, S., Sheat, D. & Holland, R. 1999. Using telecommunications to deliver real-time transport information; 'Superoute 66 Live' trial results. *Proceedings of the 6th world congress on intelligent transport systems,* Toronto, 1999. Brussels, Belgium: ITS Congress Association.

Tillis, L. 2003. *Diagnostic software improves maintenance (Bus Ride Magazine – March 2003).* [Online] Available: http://www.busride.com/2003/03/Diagnostic_software_improves_maintenance_productivity.asp [May 2003]

Traffic Area Network 2001. *TAN mission and objectives* and *What and who the traffic commissioners are.* [Online] Available http://www.tan.gov.uk/tanen/tancs/generalinfo/genweb3.asp [April 2003]

Vehicle Certification Agency 2003. *General VCA information.* [Online] Available: http://www.vca.gov.uk/general/dvo-information.shtm [April 2003]

White, P. & Brocklebank, P. 1993. The appropriate level of technology for urban bus operations. *Proceedings of seminar H, 21st PTRC summer annual meeting,* Manchester 1993. London: PTRC Education and Research Services Ltd., cited in Balcombe, R. & Vance, C. 1997. *TRL Report 330: Information for bus passengers: a study of needs and priorities.* Berkshire: Transport Research Laboratory.

Wilkinson, I., Perrett, K., Pickett, M., Wedlock, M. & Daugherty, G. 1998. *TRL Report 342: Review of telematics relevant to public transport.* Berkshire: Transport Research Laboratory.

Willis, P. 1995a. Electronic on vehicle passenger information displays (visual and audio) *Research Results Digest* (5), June, cited in Bishop, M. 1999. A bold approach to the use and integration of real-time public transport passenger information in a multi-modal and multi-agency environment. *Proceedings of the 4th international conference of ITS Australia,* Adelaide, 1999. Canberra, Australia: ITS Australia.

Willis, P. 1995b *Electronic on vehicle passenger information displays (visual and audio).* [Online] Available: http://gulliver.trb.org/publications/tcrp/tcrp_rrd_05.pdf [December 2002].

York, I 1992. *Potential travelling time improvements and changes associated with bus priority*, TRL Ltd, Unpublished Project Report.