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FACULTY OF ENGINEERING AND THE ENVIRONMENT

<u>An Appraisal of QR Code Use to Deliver Bus Arrival Time Information at Bus Stops in Southampton</u>

by

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Abstract

The provision of at-stop bus arrival time information has numerous potential benefits to bus users. With real-time passenger information well established in the UK the challenge is relaying accurate bus arrival times to passengers in a cost effective manner. Display screens are costly to install and maintain, rendering placement at all bus stops economically undesirable. QR codes represent an inexpensive alternative to delivering this information, usually at zero marginal cost to users.

QR codes linking to a webpage displaying the arrival times of the next nine buses servicing a given stop were placed in the display cases of 44 bus stops in six distinct areas of Southampton. Scanning the QR code using a smartphone linked automatically to bus arrival information, the majority of which was in real-time. Arrival data was skimmed from the ROMANSE Traffic Control Centre website and adapted for convenient, smartphone friendly display.

The project was split into two broad areas of investigation; QR code uptake and the effects of QR code use. QR code uptake examined usage trends over the project life and variations in usage by time of day, day of the week, stop location, stop characteristics and whether system explanation and promotion was displayed. Users had the option of obtaining the same information through typing the URL into a mobile browser rather that scanning the QR code, the use of which was also explored. The results of this section are anticipated to be useful for information providers in allocating resources, detailing where, when and under what circumstances there was greatest demand for QR code provision. The necessary data such as the time, date and location of scans was collected automatically over the life of the project.

The second area investigated possible positive psychological factors, adjusted travel behaviour, effects on patronage, perceived information accuracy and easy of system use. Data was collected through the use of a smartphone friendly survey optionally completed by system users and a face to face survey conducted at trial bus stops.

Results saw a trend of increasing use over the life of the project but remarkably little variation in use by the day of the week or between peak and inter-peak times. Virtually all users scanned the QR code rather than typing the URL. Surprisingly neither the stop having a shelter or display screen had a significant effect on usage, nor did promotion and explanation of the trial. There was however substantial variation in use by geographical area.

Survey results were encouraging with the vast majority of users finding the system easy to use, although a significantly higher proportion of older users found it more challenging. QR code use increased wait time acceptability for over two thirds of respondents and over a third felt safer. Potential patronage increases were also very positive, however results should be treated with caution. Adjustments to users' travel behaviour were present although limited and perceived system accuracy was considered acceptable. The study concluded that given the low cost of implementation and the clear current, and potentially greater future benefits, the system should be employed wherever mobile internet connection and real-time information render it viable.

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Contents

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Glossary

App - A mobile phone application

AVL - Automatic Vehicle Location

CSS - Cascading Style Sheet

DfT - Department for Transport

GIS - Geographic Information System

GPS - Global Positioning System

HTML - Hypertext Markup Language

IMTI - Integrated Multimodal Travel Information

PDA - Personal Digital Assistant

QR code – Quick Response Code

ROMANSE – Road Management System for Europe

RTI - Real-Time Information

RTPI - Real-Time Passenger Information

SMS - Short Message Service

TfL - Transport for London

URL – Uniform Resource Locator

WAP - Wireless Application Protocol

χ^2 – Chi-square

1. Introduction

1.1 Project Outline and Report Structure

The purpose of this project was to trial the use of QR codes to provide bus arrival time information. QR code posters were placed in the display cases of 44 bus stops in distinct locations around the study area of the city of Southampton, including the transport interchange of Southampton railway station, Southampton general hospital, Southampton University, an urban centre and two suburban centres. Please see Figure 5.5 in the Results and Discussion section below for a map displaying all stop locations. A QR code specific to each bus stop was generated which, with the users' permission, linked automatically to stop specific bus arrival times for all routes servicing a given stop; please see section 3.2 for a detailed description of QR codes. The arrival time data was skimmed from the existing ROMANSE Traffic and Travel Information website and adapted to be mobile friendly. Users received either timetable or, in the majority of cases, real-time information for all buses servicing a given stop via a mobile-friendly webpage.

The intention was that passengers use a smartphone to scan the QR code and obtain the relevant information. Virtually all mobile phones with internet access and an in-built camera have this capability and software or applications (apps) facilitating the scanning of QR codes are free, although access and downloading information may not be depending on the users mobile contract.

The report begins by examining current at-stop information provision in general and in Southampton specifically. It moves on to a literature review of relevant research to date, centred around current QR code use and the effects of arrival time information provision, with a summery detailing which areas have been selected for further study. A methodology is included detailing data collection of both hits data and the effects of QR code use. Finally, results are displayed and discussed, summarised by a key finding section and conclusions are drawn.

1.2 Aims and Objectives

The aim of this study is to assess QR code uptake at bus stops, the factors affecting uptake and the results and effectiveness of the QR code trial. The project objectives can therefore be split into two broad categories:

1.2.1 QR Code Uptake

- Frequency of QR code use:
  - To obtain counts, known as hits, of the overall number of passengers who use the QR code link where available
  - To adjust hits data to account for passenger boarding numbers (footfall) at stops and facilitate comparison of the factors effecting uptake

- Factors effecting uptake:
  - The difference in uptake between basic and full poster design; revealing the importance of explanation and promotion
  - Stop characteristics: The presence of a bus shelter, the effect of an at-stop display giving arrival information
  - Stop location: Variations in uptake between a transport interchange, hospital, university, urban and suburban areas
  - Variations in use related to the time of day and day of the week
  - If users prefer to type the URL linking to bus arrival information into a mobile browser or scan a QR code

1.2.2 Effects of QR Code Use

- The effects of obtaining bus arrival time information through QR code use; the aim is to acquire a broad understanding of the following:
    - Positive psychological factors such as reduced uncertainty, reduced effort and greater feelings of safety
    - Adjusted travel behaviour in the form utilisation of wait time or more efficient route or mode choice
    - Possible effect on bus patronage
    - Perceived accuracy of the information provided; that is the perceived disparity between the estimated and actual bus arrival times
    - Easy of system use

2. At-Stop Information Provision

2.1 General At-Stop Information Provision

There is currently a range of options for passengers to obtain bus arrival information on site at the bus stop. The traditional paper timetable is often displayed; however methods now stretch far beyond this. Firstly, a method that has gained popularity over the last decade is the at-stop telematic display. This is a screen or display generally mounted on or near to the bus stop giving passengers arrival times of the next buses. The times displayed are either timetable information, usually given as a time of day, or, where available, real-time information (RTI), usually displayed as a countdown. Real-time arrival information is generated by continually locating a vehicle, generally using GPS (Global Positioning System). An algorithm is then employed, incorporating the distance the bus has to travel between it's present location and the bus stop, if the bus is behind or ahead of schedule and the current traffic conditions and speeds to produce an arrival time estimate (Clowes, 1996).

At the end of 2010, 21,414 buses, 48% of the total UK bus fleet, were fitted with on board tracking units and 3.2 billion bus passenger journeys occurred on equipped buses, equating to 61% of all UK bus trips (Knoop & Eames, 2011). There were 10,292 real-time information-enabled physical displays in the UK, 8,196 bus stops fitted with 3-line or multi-line LED signs and a further 2,096 fitted with full screen, LCD or plasma displays (Knoop & Eames, 2011). As can be seen in figure 2.1 below the total number of at-stop displays has been relatively stagnant since the end of 2008, although there has been some growth in full screen displays. There may be a number of reasons for this, not least recent public spending constraints, however, it may also suggest the number of stops with sufficient passenger boarding numbers or footfall to render installation and maintenance of a display viable and cost effective may have been reached. This implies other methods of information dissemination need to be explored for the remaining UK bus stops.

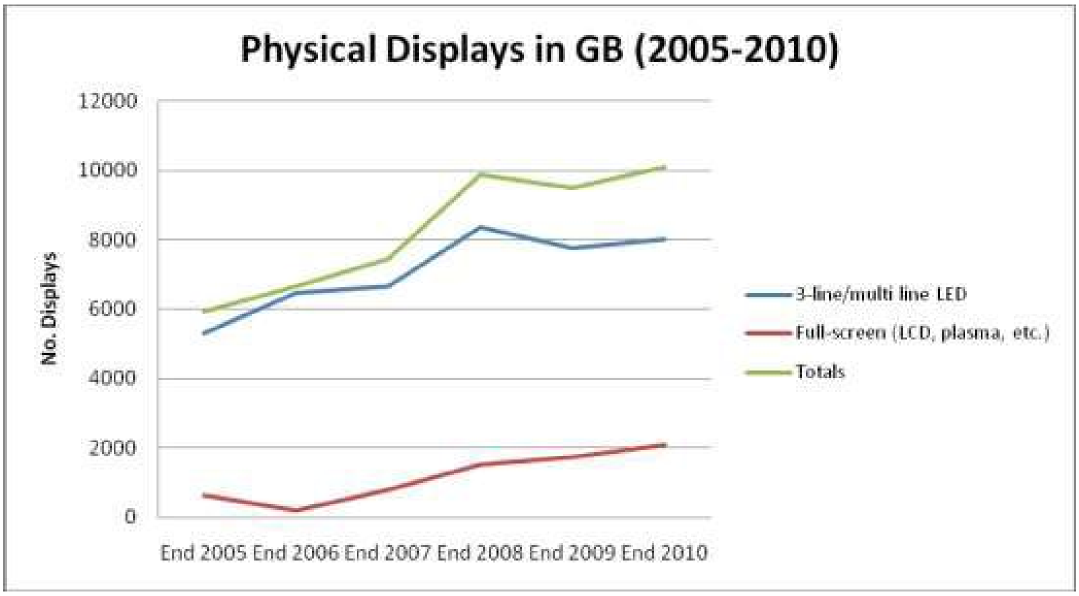

Figure 2.1: Time trend of physical display use in Great Britain (Source: Knoop & Eames, 2011)

Virtual information dissemination is now widely used and stops covered substantially outnumber those with physical displays. Receiving bus arrival time information by SMS (Short Message Service) has been in widespread operation for over a decade and covers the largest number of stops, over 100,000 currently in the UK (Knoop & Eames, 2011). SMS is a form of communication available on virtually all mobile phones and allows users to send and receive text messages. The user texts a specific, usually short number the unique bus stop code displayed at the stop. Upon receiving the text, the service provider sends an automated reply containing the arrival times of the next buses for the given bus stop (TfL, 2011). There is often a charge for this service over the standard network cost of a text message; for example TfL currently charge 12p pence per text message.

There are a number of further dissemination methods included under the title of virtual information. WAP (Wireless Application Protocol) is in effect standard webpages adapted for mobile use. Ordinary web pages often contain too much information to display satisfactorily on mobile phones' small screens. WAP takes existing pages and rewrites them in a special, simplified language (Stucken, 2011). There were a number of successful WAP trials involving public transport information during the early 2000's (Maclean and Dailey, 2001) and WAP use continues to grow as can be seen in figure 2.2 below. For example in October 2008 Traveline introduced a national bus departures service on mobile internet, believing it is now established as a convenient, fast growing and cost effective way for travellers to access transport information (Travelinedata, 2008).

It is worth noting the term 'WAP' is often used loosely as an equivalent to 'mobile internet', but in fact refers to a particular technology. Many smartphones and PDAs (Personal Digital Assistant) access websites using traditional HTML, although websites are more convenient to use when adjusted for mobile use, for example through adjusted resolution. Therefore Local Authority and centrally administered national websites (e.g. Transport Direct Portal), even if not mobile friendly, can potentially be used at a bus stop, with varying degrees of success, to obtain bus arrival times.

The more traditional method of phone hotlines covers many bus stops in the UK. The user calls a dedicated number and speaks to a call handler to gain bus information, including arrival time. There is generally a charge for making such calls, for example Traveline currently costs 10p per minute from a landline and more if using a mobile at the stop (Traveline(2), 2011). Phone hotlines, Local Authority websites and WAP are the largest virtual dissemination technologies after SMS, all covering between 80,000 and 90,000 stops (Knoop & Eames, 2011). Many stops are covered by more than one dissemination mechanism.

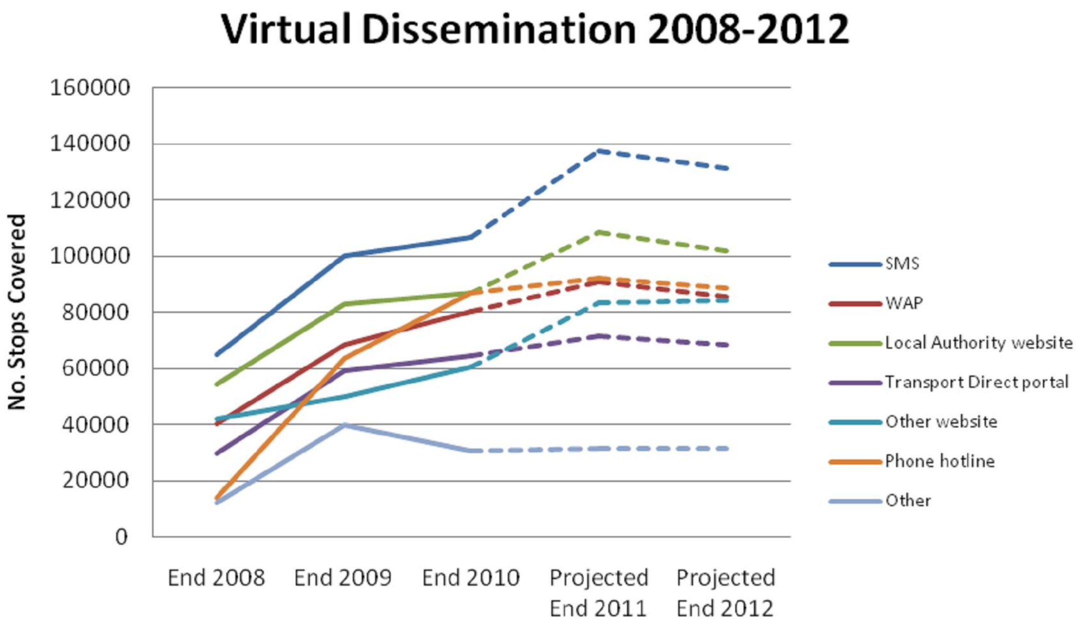

Figure 2.2: Stops covered by various virtual information dissemination methods (Source: Knoop & Eames, 2011)

The ‘other’ category in figure 2.2 above includes the use of mobile phone applications (apps). There are currently a wide variety of apps world-wide providing bus arrival information, which essentially operate under the same principles. Users enter one or more of the following pieces of information: the bus route, start location, stop or destination. The app will then advise the user which bus to catch and the arrival time. This is similar in operation to WAP or mobile friendly websites - the app’s aim is to simplify the process and possibly provide additional features. For example many apps take advantage of most smartphones’ GPS capability to establish the users location and can give directions to a suitable bus stop (Nextbus, 2011). One of the most popular in the UK currently is an app called ‘Catch That Bus’. Reviews are positive about its usability, coverage and accuracy (data is taken from Traveline’s Nextbuses); however battery usage is high (McFerran, 2010) and arrival times are timetabled, not real-time information (Farrow, 2011). However the advent and popularity of smartphones has lead to increasing information provision through WAP, mobile friendly sites (e.g. Nextbuses) and apps.

It is worth noting that the QR code trial scrutinised in this paper combines the use of an app and mobile friendly webpages. To allow QR code use the smartphone must have an app installed to scan the QR code symbol which links to an adapted, mobile friendly webpage giving the bus arrival times.

A comprehensive study was conducted by Caulfield & O'Mahony (2007) into passenger preferences for receiving public transport information. The provision of real-time information was shown to be the most important method of information provision and RTI displays were found to be the most popular method of acquiring real-time information followed by SMS and call centres. It would appear providing a substitute for the at-stop RTI display, such as through the QR code link, potentially has value.

The above survey also asked respondents about the provision of information via mobile phones. The provision of real-time information via mobile devices was rated as important or very important by 85% of respondents. The cost of information provided via mobile phones was also found to be key with 84% of respondents stating that this characteristic was either very important or important. (Caulfield & O'Mahony, 2007).

2.2 Current At-Stop Information Provision in Southampton

Many bus stops in Southampton display a paper timetable, though not for all stop and not for all routes servicing a particular stop. An important source of information in Southampton for bus arrival times is the Stopwatch Bus Information System operated by the ROMANSE Traffic Control Centre. Stopwatch is a county-wide Real-Time Passenger Information (RTPI) system that provides up-to-the-minute bus arrival times directly to selected bus stops around Hampshire (ROMANSE, 2011) using GPS Automatic Vehicle Location (AVL) technology as described above. Currently 95 First Group and all 25 Unilink buses are equipped, covering the majority of trips in Southampton (Chapman, 2011).

Real time arrival information in Southampton is currently available in three ways. Firstly, it is shown on displays at 175 of a total of just under 900 bus stops in Southampton and on 17 displays (all of the full screen type), in locations remote from bus stops such as Southampton high street (Chapman, 2011).

Secondly, the ROMANSE website covers all bus stops in Southampton including accurate service descriptions and real-time information from Stopwatch if available. Any stop can be selected and bus arrival times for the next nine arrivals up to an hour in the future are shown. However accessing this at a stop from a smartphone is technically difficult and slow, if possible at all, as the site is not mobile friendly.

The final option is a solution developed by the University of Southampton's Open Data Service called Sotonbus, available as an app on the iphone. The user's location can be determined through the smartphone's GPS or a postcode can be entered. This then displays a list of bus stops in the area. Clicking on a bus stop gives a map of the stop location and bus arrival times in real-time where available (Sotonbus, 2011). This data is skimmed from the ROMANSE website and is displayed in the same format as when using the QR code link in this trial. The difficulty is knowing the stop required, some search time may be needed checking various stops before a user finds the most suitable stop or service. Furthermore it is only available on the iphone, excluding all other smartphone owners and there is currently no promotion at stops meaning passengers are unlikely be aware of the service.

The mobile friendly website Nextbus from Traveline can also be used at stops to obtain bus arrival times. The map showing stops around a given location is clear and easy to understand. However clicking on a stop and receiving bus times has two disadvantages. Firstly, services names are incomplete when displayed, for example the Unilink U1 service has two routes, the U1A and the U1C; these are not distinguished. Secondly, bus arrival times are taken from Traveline are not real-time but from timetable information. Therefore if a bus is not running to schedule the information will be incorrect. Smartphone apps are available to give a better experience obtaining this information such as Catch That Bus and TransiCast UK (Nextbus, 2011). However, as the data is supplied by Traveline, the issues described above persist.

Through Traveline all stops in Southampton are covered by a well promoted but chargeable SMS service (Chapman, 2011). Although in general Traveline provides real-time information through it's SMS services - never through the website or telephone enquiries (Farrow, 2011) - Southampton stops are set up only to receive timetable information via SMS (Chapman, 2011). Also using the SMS service can be time consuming as its necessary to enter the number to text, enter the bus stop code and then wait for the reply, although it will be under a minute to receive this in most cases (Traveline, 2011). Arrival of the next three buses only is returned, however it is possible to add the service number if known and receive the next three arrivals for that specific service. It is also possible to call Traveline, but as highlighted above issues with service specificity, no real-time information and cost are present. Using the Transport Direct website or a number of apps are other possible options, however all these methods again take information directly form Traveline and as such suffer the problems identified above.

It is beneficial to briefly considering the accuracy of Southampton's RTI system. Firstly, the actual accuracy required is not immediately obvious. If the time quoted is too precise it becomes meaningless and alternatively if the imprecision is too large the passenger cannot place any credibility on the message (Clowes, 1996). In Southampton as with virtually all RTI displays, time until arrival is counted down in whole minutes.

Bus arrival time prediction accuracy in Southampton can be seen in table 2.3 below. Reasons for the inaccuracy include faulty equipment, faulty bus calibrations leading to inaccurate time or distance estimates and interruptions to data transmissions (Warman, 2003). Southampton bus arrival predictions appear to be sufficiently accurate to be acted upon. Warman (2003) in an evaluation of London's Countdown system found users were willing to tolerate some lapses in either the amount or accuracy of the information provided. However tolerance dropped off rapidly if the next bus was more than five minutes later than shown on the display.

Variance (Mins)	% Achieved
0.5	75%
1	87%
2	94%
5	98%

Table 2.3: Southampton Bus Arrival Time Predication Accuracy (Source: Adapted from Clowes, 1996)

It seems logical that RTI provision is more beneficial the lower actual bus punctuality. The latest data on bus punctuality in Southampton shows only 63% of buses are on time at both start, finish and intermediate points (Southampton City Council, 2008). The average excess waiting time for frequent services in Southampton during 2009/10 was 1.4 minutes (DfT, 2011).

3. Literature Review

3.1 Buses in the UK

The UK bus market in terms of patronage has been in decline since 1950 (House of Commons Transport Committee, 2006) as can be seen in figure 3.1. below. There are two explanatory vicious cycles acting here. Firstly, as explained by DfT (2009) falling demand and rising costs force operators to raise fares and cut services leading to further patronage decline. A second vicious cycle is as congestion worsens, the bus services slows therefore encouraging bus passenger to buy cars, leading to increased congestion and further slowing of bus services (House of Commons Transport Committee, 2006).

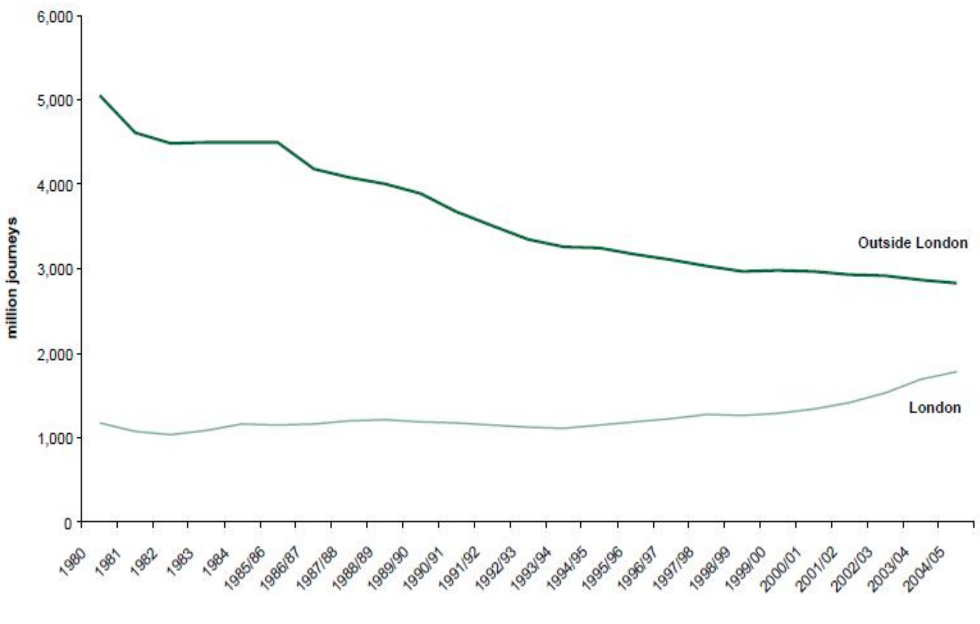

Figure 3.1: Time trend of UK bus patronage (Source: House of Commons Transport Committee, 2006)

The largest single change to the UK bus industry came in the form of deregulation under the 1985 Transport Act. Prior to 1985 increasing car ownership lead to falling demand. Fare regulation was supported by subsidy and the budget burden of this system had been steadily increasing prior to deregulation to unsustainable levels (Gwilliam, 2008). As Nash (1993) details, the main measure was the removal of route licensing. The result was that, subject to some relatively easily achievable conditions, any operator could offer any service they wished. Majority ownership was quickly transferred to the private sector.

It was hoped deregulation would not only greatly reduce the budget burden of subsidising unprofitable routes but that an increase in patronage on some routes would occur as a result of the potential lower fares and improved services due to the introduction of, or threat of, competition. This was largely proved inaccurate and in most areas deregulation reduced service levels, promoted unreliable and unstable services and reduced integration leading to a fall in patronage (Pickup et al., 1991). Although costs to operators declined, the cost to users increased in excess of the rate of inflation (Davison & Knowles, 2006). The disparity of services and bus operators inevitably increased the need for coherent and reliable passenger information, available in different and easy to use fashions (Clowes, 1996).

Despite more than 50 years of declining use, buses are still the main form of local public transport outside central London (Davison & Knowles, 2006). Local buses are the most used form of public transport in Great Britain representing around two-thirds of all public transport journeys (Stradling, 2007); during 2009/10 a total of 5188 million passenger journeys on local bus services were undertaken (DfT(3), 2011). In Southampton specifically 19,046,387 passenger journeys were made in 2009/10 (DfT(2), 2011). Bus travel nationally and in the city of Southampton is clearly still vitally important economically and socially. The Department for Transport (DfT) is committed to improving access to jobs and services in ways that are sustainable and reduce the problems of congestion and pollution (DfT (4), 2011); increased bus use is a key component to achieving this and in turn information provision, especially given the disjointed, deregulated bus industry, could be of vital assistance.

3.2 QR Codes - Background and Current Usage

The Quick Response (QR) Code is a successor to the traditional bar code – a one dimensional series of horizontal strips. QR codes are a type of two dimensional bar code, with information stored in both the horizontal and vertical directions. QR codes were created by Denso Wave in 1994 to track parts in vehicle manufacturing (QRme, 2011).

While conventional bar codes are capable of storing a maximum of approximately 20 digits, up to 7,089 characters can be encoded in one QR code symbol (Qrcode.com, 2011). Furthermore a host of other information can be stored such as mobile telephone numbers, contact cards (e.g. VCards), geographic information and, imperative to this study, URL's linking directly, with the users permission, to a webpage (QRme, 2011). A further useful property is a QR Code possesses an error correction capability; data can be restored even if the symbol is partially obscured or damaged with a tolerance of up to approximately 30% of image unavailability (QRcode.com, 2011).

Despite being in existence for well over a decade QR codes were only introduced to the UK in any mainstream form in 2008 (QRme, 2011). There is overwhelming anecdotal evidence that use is growing in the UK with QR codes becoming increasingly visible in a variety of locations. A recent British consumer survey found that 36% of respondents knew the purpose of a QR code, 11% had used them and 48% of respondents had the technical capability to scan a QR code (Charlton, 2011). There does not appear to be any comprehensive national UK QR code usage statistics; however US data may give an indication of usage patterns. Scanlife (2011) in their annual trend report found a growth of 810% in the total number of scans in the US in 2011 compared to 2010. The report also stated some interesting demographics; most scans were undertaken by the age range 25-34 (27%) closely followed by 35-44 (22%) and 18-24 (19%) and males (73%) scanned substantially more than females (27%).

The above results are supported by a University of Bath study investigating the introduction of QR codes for various functions in libraries. Two surveys were conducted in 2009 and 2010; the latter showing 39.8% of respondents were aware of QR codes in comparison to 13.8% the previous year. Furthermore, awareness was higher among younger age groups with 42% of respondents aged 18-22 being aware of what a QR code was, dropping to 29% for the over 40 age group (Ramsden, 2010).

To facilitate QR code use it is necessary to have a smartphone, defined as a cellular telephone with built-in applications, internet access and camera (PCmag, 2011). Smartphones have grown in popularity at a rapid rate with the latest statistics from Ofcom showing 27% of UK adults and 47% of teenagers now own a smartphone, with 58% of adult owners being male and 42% female (Ofcom, 2011). To scan a QR code it is necessary to download a scanning app or reader; smartphones currently are not sold with this pre-installed. There are a variety of QR code readers that are free and widely available, although users may incur a marginal cost to download and use the scanner due to data usage charges. This is dependent on an individual's contract with their service provider.

QR codes have been employed in a huge variety of ways. The sports brand Umbro recently included a QR Code on the inside of the latest England football shirt, linking to a secret mobile website. QR codes have been printed and sewn onto clothing, created from safety barriers by New York artists. They have been used to give information about exhibits in museums, galleries and libraries, about youth hostel facilities, Macdonald's nutritional information and generally anywhere a bit-size piece of information is required (QRme (2011), Linkedin (2011)).

In terms of public transport use, as with QR code use in general, the USA and Japan are leading the way. For example the Chicago Transport Authority have placed QR codes at bus stops linking to their travel information website, which gives bus and rail information and utilises GIS (Geographic Information System) mapping with the aim of enabling unfamiliar travellers to make the most efficient or convenient public transport choices (Edmonds, 2011). Also LYNX bus services, operating in three Florida counties and with 300 buses servicing 65 routes, have introduced a trial similar to the one described in this paper. A selected number of bus stops will have

QR Codes placed on them which, when scanned with a smartphone, will link to a schedule and map for every bus servicing that stop. Initially arrival times will not be real-time; however there are plans to show users how far away their next bus is and how long it will take to arrive (O' Sullivan, 2011). In the UK at the time of writing QR codes have been introduced into the transport market and appear at some bus stops, however they are currently are only used for marketing purposes, for example linking to a bus company's Twitter or Facebook pages.

Information on factors affecting QR code use generally are scant on a disaggregate level. It seems the majority of current QR code use is based around information provision; Ciabaton (2011) finds 87% of people scan QR codes to get additional product information. QR code uptake can be varied. For example at New Haven, Connecticut arts festival, 1000 poster placed around the city and in total only 10.2% were scanned (Joecasscio, 2011). QR codes were placed at the SxSW Interactive Motor Show and an estimated 2% of attendees scanned one (Elkin, 2010). Mountain Dew ran a campaign where a QR code was placed on a drinks cup linking to a site where free music could be downloaded. This was a nation wide US campaign and therefore it is difficult to draw comparisons, however there were between five and six thousand hits per day (Cerreta, 2011). Success is varied however; Frito Lay, a US snack manufacturer, ran a nation-wide sweepstake facilitated by on pack QR code scanning; a maximum of 65 hits per day were recorded and there were often zero hits per day (Cerreta, 2011). It seems technology and knowledge is now sufficient for successful QR code rollout in the USA at least but users must have sufficient incentive to scan.

Evidence of time trends in uptake is also varied. The mountain Dew campaign saw initial increasing uptake over time, possible as products with QR codes on the packaging infiltrated the market, and thereafter reasonably consistent daily hits. The Frito Lay campaign saw fluctuating daily use with no visible trend (Cerreta, 2011) and the trial of QR code use in four UK university libraries demonstrated slightly decreasing use over the year long project (Ramsden, 2010).

In terms of users reaction to QR codes, Ramsden (2010) in the university library trials found 62% described the experience of QR code use as positive while 32% as negative; the key terms used to describe QR code use were ‘easy’, ‘simple’ and ‘interesting’. The same study found students saw a benefit from scanning as a means of accessing information compared to manual text entry on phones - only 16% of respondents stated entering a URL into their mobile browser was more appealing than scanning.

3.3 Effects of Bus Arrival Time Information Provision

3.3.1 Introduction

The basis of this project is providing at stop bus arrival times, predominantly in real time. As such this section examines the possible effects of arrival time, and largely real-time, information provision. Figure 3.2 below summarises the possible effects.

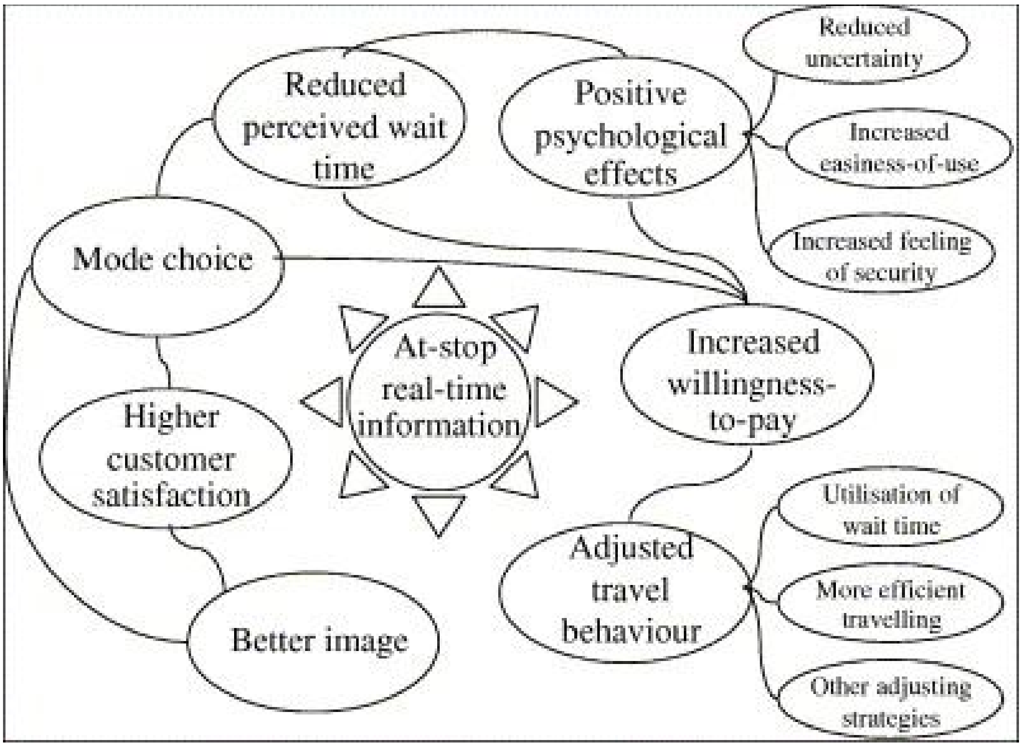

Figure 3.2: Mind map on possible effects of at-stop real-time information displays (Source: Dziekan & Kottenhoff, 2007)

3.3.2 Perceived Wait Time

It has been shown arrival time information provision can affect the perception of at-stop wait time, and hence users perception of punctuality and reliability of services. This can in principle be investigated by asking passengers at stops and stations to estimate how long they have been waiting. These estimations can then either be compared to estimations made without the system or to observed wait times (Clowes, 1996).

In general public transport users traditionally tend to overestimate their waiting time at stops or stations (Caulfield & O'Mahony, 2009). Warman (2003) agrees, stating that time perception studies have repeatedly shown passengers have a tendency to exaggerate the length of time spent waiting for a bus, and that the level of inaccuracy increases as wait time lengthens. There are ordinarily three elements of time involved in public transport trips: walking, at-stop wait time and in vehicle time. Of these at-stop wait time is generally considered of highest value in a generalised cost function (Waterson, 2009). Real-time information provision has the potential to shorten the perceived wait time (Dziekan & Vermeulen, 2006) and therefore substantially reduce the cost of the journey. That is reducing actual, or decreasing perceived wait time can make public transport more attractive as wait time holds a negative quality for users (Dziekan & Vermeulen, 2006).

Many studies in this area have reported a reduced perceived wait time as an effect of at-stop RTI displays (Dziekan & Kottenhoff, 2007). When evaluating the London Countdown system Warman (2003) reported a substantial fall in the perceived mean wait time of 26%, from 11.9 to 8.8 minutes after system installation. In reality, wait times had not improved over this period.

A case study of Leicester StarTrak (DfT, 2010), where RTI was introduced on displays at bus stops, reported 53% of survey participants believed the real-time information had reduced waiting times. Similarly a survey conducted on the Timechecker system in Liverpool concluded 57% of respondents believed display installation resulted in decreased wait time (Dziekan, 2004).

The concept of reduced waiting due to RTI provision extends to all forms of public transport. A good example is a study of newly implemented traveller information on tramline 15 in The Hague, The Netherlands. Dziekan & Vermeulen (2006) conducted a before and after evaluation study. The main result was that the perceived wait time decreased significantly by 20% after the installation of displays. This perceived reduction possessed longevity as more than a year after installation passengers still stated a remarkable reduction in perceived wait time.

It follows that if the time spent waiting for a bus is perceived to be longer than reality, then the level of service and reliability will probably be judged as worse than reality. This is likely to lead to a downgrading of the status of the bus journey experience itself (Warman, 2003). This is supported by the StarTrak case study where 62% of users believed that bus services had increased in reliability due to RTI provision; the actual change in service reliability was negligible (DfT, 2010).

It is worth noting that although there is substantial evidence that RTI provision reduces perceived wait time, it is generally still greater than actual wait time. For example study of larger public transport terminals in Sweden showed that with real-time information, the traveller overestimated the waiting time by 9-13% compared with 24-30% without it (Dziekan 2004).

Dziekan & Vermeulen (2006) suggest a psychological explanation for the reduction in perceived wait time. Improved predictability through reliable information enhances the experience of being in control of the situation, positively influencing the travellers' mood and a good mood allows subjective time to pass faster. The increased feeling of control stems from a reduced feeling of uncertainty which, alongside other psychological factors, is explored further below. Wardman (2003) supports the finding that a tendency to overestimate wait time is exacerbated by both feelings of anxiety and futility at the sense of wasted time.

It is worth noting that real-time information may also reduce the actual wait time. As Dziekan & Vermeulen (2006) explain, passengers may simply walk by the stop, see that there are still several minutes until departure and decide to use the remaining time to do something else; the concept of modified behaviour is examined below.

Furthermore, if real time arrival information is available remotely, for example online, passengers can make more informed choices regarding when to set off for their stop hence reducing actual waiting time.

3.3.3 Psychological Effects

The psychological effects resulting from the introduction of real-time arrival information can only be studied by asking questions since they are related to the feelings and experiences of individuals (Dziekan & Kottenhoff, 2007). Three broad areas of psychological effect are outlined by Dziekan & Kottenhoff (2007), defined as: increased feelings of safety, reduced uncertainty and increased easy of use (also know as reduced effort).

There is evidence to suggest traveller information systems contribute to an increased feeling of personal security and reduced anxiety at public transport stops in general and especially after dark (Schweiger, 2003). A case study was carried out examining the Leicester StarTrak RTI system, where at bus stops with no RTI display passenger can receive an estimated arrival time of the next bus via SMS. Before and after surveys on the scheme showed 80% of respondents felt StarTrak increased their sense of personal security when waiting for a bus after dark, compared with 68% saying this at times during the day (DfT, 2010). A greater proportion of females stated that RTI provision enhance feelings of personal safety at any time whilst waiting for a bus - 82% in contrast to 61% of male respondents.

A study examining the introduction of London’s Countdown system concluded that an important ancillary benefit of the system’s introduction was a reduction in passengers' anxieties regarding bus travel at night. Of the three bus routes covered by the study one showed 52% and another 40% of those interviewed said that they felt 'more safe' at the bus stop at night since the introduction of Countdown (Warman, 2003).

A survey carried out on the Timechecker system in Liverpool also supports the above findings; 87% felt that Timechecker gave a feeling of reassurance. Some 73% of respondents found the availability of RTI enhanced feeling of personal security when waiting for a bus after dark (Dziekan, 2004).

However not all research indicates RTI displays increase feelings of safety. In a before and after study of such a scheme by Dziekan & Vermeulen (2006) the perceived security at boarding stops was rated on a scale from 1 (very bad) to 10 (very good). The total average security experience in the before study was 7.9. In the after study, post installation of new displays at stops, the average perceived security rating worsened to 7.6. However, no significant differences between the security experiences could be calculated. This unexpected result was, according to the authors, in part at least explained by flaws the studies' methodology leading to possible bias.

Considering the second psychological effect, reduced uncertainty, simply knowing time remaining until departure removes uncertainty, increases feelings of control and could reduce stress (Schweiger, 2003). In this context, various terms are used such as 'stress reduction', 'increased feeling of control' or 'reduced frustration' in a number of studies. Nevertheless, the overall category can be labelled with the term 'reduced uncertainty' (Dziekan & Kottenhoff, 2007).

During a study by Caulfield & O'Mahony (2007) individuals were asked if the lack of information on the whereabouts of their service caused them frustration; 72% agreed it did. Frustration with not knowing if their bus or train had already passed was also examined and 55% of public transport users found this frustrating. As such Caulfield & O'Mahony (2007) believe one of the main reasons individuals access real-time information is to remove the uncertainty when using public transport and one of the main purposes for providing real-time public transport information to individuals is to reduce levels of frustration.

Dziekan & Vermeulen (2006) share the opinion that systems displaying the next train or bus departure time at stops or stations can greatly reduce anxiety. The paper goes further, suggesting that just the existence of such a system creates trust in the whole public transport network and may improve its image.

The third potential psychological effect is increased ease-of-use, that is reduced effort when making a journey (Dziekan & Kottenhoff, 2007). Effort can be of a physical, affective or cognitive nature. Stradling (2002) defines these as physical effort being the physical activity on a journey, cognitive effort is expended on a journey via information gathering and processing for route planning, navigation, progress monitoring, and error correction. Affective effort is the emotional energy expended on a journey in dealing with uncertainty regarding safe, comfortable travel and timely arrival at destinations; therefore it is strongly related to reduced uncertainty described above.

Dziekan & Vermeulen (2006) found that those people who trust at-stop RTI displays perceived a high reliability of the information provided and had an easier journey, although establishing a satisfactory method of measuring ease-of-use was not trivial meaning results should be treated with caution. This does however suggest system accuracy is important for achieving increased easy-of-use.

Stradling (2002) conducted a study of interchanging bus travellers in Edinburgh. When asked to rate the acceptability of the amount of physical, cognitive and affective effort expended on their journey, it was affective effort ('uncertainty') that proved the most taxing. While 27% rated the amount of physical and mental effort involved as 'More than I would like', 46% rated the uncertainty involved with the journey, and hence affective effort, as excessive. Evidence above regarding reduced uncertainty and reduced anxiety can in turn be applied to reduced affective effort as these are its root cause.

A useful benchmark of all the psychological effects is if passengers find an improvement in the acceptability of wait time as a result of the introduction of RTI. The case study of Leicester StarTrak (DfT, 2010) found 68% of all respondents stated their wait was more acceptable post scheme introduction, while 26% said it made no difference. The survey results on Liverpool's Timechecker RTI system supported this as 85% of users believed using Timechecker made waiting more acceptable (Dziekan, 2004).

3.3.4 Willingness to Pay

An indication of the value of real-time arrival information provision and of interest to information system providers is passengers' willingness to pay for the service. Willingness to pay can be measured using stated preference experiments (Dziekan & Kottenhoff, 2007). Evidence on this subject is not conclusive as some studies found some willingness to pay for at-stop RTI displays while others claim that travellers are not willing to pay for such a service as the expectation is the public transport provider should supply this information free of charge (Dziekan, 2004).

Wardman et al. (2001) reported that passenger's value RTI at interchange terminals equal to 1.4 minutes of in-vehicle-time, which in monetary terms was approximately 5p per journey at the time of writing.

Warman (2003) undertook extensive work obtaining valuations of passengers willingness-to-pay for the Countdown system in London. The average willingness to pay on different routes spanned a range from 0.9 pence to 26 pence per trip. The disparity in valuations was attributed to a number of factors including differing methodologies, the reliability of Countdown (passengers' valuations are likely to be higher when the system is working well), differing route characteristics and increased expectations over time eroding customers willingness to pay. The work concluded that as passengers' expectations increased, as bus routes operated at higher frequencies and as services were perceived as more reliable, customers' willingness to pay declined.

In terms of mobile provision Warman (2003), investigating a RTI trial in Margate, found of the 56% of the sample who used mobile phones, half of them would not expect to pay for real time information. Of the remainder, most would expect to pay less than 10 pence per enquiry.

In a stated preference survey examining providing RTI at public transit interchange points, Molin et al (2007) find the price of receiving RTI was one of the most important attributes of system introduction to potential users, demonstrating that respondents were highly price-sensitive. Caulfield & O'Mahony (2009) also conclude the empirical evidence demonstrates individuals are very price-sensitive when it comes to paying for RTI but that individuals derive a benefit from RTI provision and are willing to pay for it, although no estimate of suitable charges was given.

3.3.5 Adjusted Travel Behaviour

Adjusted travel behaviour is the concept that due to receiving their bus arrival time a passenger amends their travel plan in some way. Dziekan & Kottenhoff (2007) suggest three possible adjustment strategies due to receiving at-stop RTI; utilisation of wait time, more efficient travel and other adjusting strategies.

Firstly, knowledge of the remaining wait time until bus arrival frees users to pursue alternative activities away from the bus stop, such as last minute shopping, banking or sustenance. This utilisation of wait time rather than simply remaining at the stop implies a reduction in the disutility or cost of the wait period. (Dziekan & Kottenhoff, 2007).

A number of studies have investigated utilisation of wait time. One such study in Birmingham found 20% of people who left the stop after checking the display stated they use the time for shopping or going to the bank (Nijkamp et al, 1996). A more thorough stated preference survey conducted by Caulfield & O'Mahony (2004) attempted to ascertain what passengers would do if they arrived at the stop and found they had a 15 minute wait time, given that they had confidence in the arrival time estimate. The results can be seen in table 3.3 below; while waiting at the stop is still the most popular choice a substantial proportion stated they would adjust their behaviour. The options here are severely limited, however, as utilisation of waiting time is the only effect examined and respondents were not given the option of adjusting their mode or route of travel.

Activity	Frequency	Percent
Waiting	150	58.3
Shopping	99	38.6
Other	8	3.1
Total	257	100

Table 3.3: Use of wait time (Source: Adapted from Caulfield & O'Mahony, 2004)

Utilisation of wait time is most likely to occur when passengers have gained full confidence in the information on display and where diversionary activities are available to passengers, for example nearby shops and amenities (Warman, 2003).

In an analysis of Southampton's installation of the real-time bus information system Stopwatch, when users were informed of a 'long wait' by the display 12.6% of users left the bus stop (Brown, 1997); a breakdown of their actions is shown in table 3.4 below.

Walked the whole trip	38.1%
Walked to the next stop	30.0%
Went to a shop or bank	18.1%
Hailed a taxi or shared a lift in a car	5.7%
Did something else	7.1%

Table 3.4: Reported actions of passengers opting-out of waiting at the bus stop (Source: Brown, 1997)

Approximately one fifth (18.1%) of passengers leaving the stop utilised their wait time, which is a relatively small proportion (2.3%) of all passengers. This introduces the second possible adjustment to travel behaviour, more efficient travel. Real-time at-stop bus arrival times can be used by travellers to make travel decisions that lead to more efficient travelling (Dziekan & Kottenhoff,2007). Table 3.4 above reports a much larger proportion of travellers chose to adjust the way they travelled, at least 73.8% of passengers leaving the stop did this (10.8% of all passengers).

Nijkamp et al (1996) reports similar results again from examination of Stopwatch implementation in Southampton. When a long wait time is indicated by a display, of the people who leave the stop, roughly 39% walked all the way, 30% walked to other stop and 7% hailed a taxi or shared a lift.

Warman (2003) finds substantial evidence of adjusted travel behaviour when examining the introduction of London's countdown system. One of the three routes studied showed 6% of passengers at Countdown stops opted out (left the stop), after an average wait of 1.6 minutes. At control stops, without Countdown information, 4% opted out after an average wait of 3.1 minutes. On the second route considered the same proportion of passengers (4%) opted out from both Countdown and non-Countdown-served stops. However, passengers leaving Countdown stops had waited for much less time than those leaving non-Countdown stops: the average waiting times were 1.4 minutes and 9 minutes, respectively. This suggests that Countdown information is allowing passengers to make informed choices about whether or not to wait for a bus. The most common reason given for leaving the stop was to walk to the destination. This will be offset to some extent by people who substitute a walk for a bus journey because they see from the RTI display that a bus is due shortly.

Studies described above, however, do not include assessment of passengers remaining at their stop and adjusting their behaviour, for example through a change of route. A before-and-after study conducted of a real-time bus information trial in Glasgow included this. Results revealed that 56% would wait for a bus that suited them better rather than taking the first possible bus (Duke, 1998).

The idea of the hyperpath is a possible effect of RTI provision related to more efficient travel. If a waiting passenger finds a bus on another line that could take them close to the desired destination, the passenger would probably take that bus. But if the information system informs the passenger that the bus on the original line was expected to arrive shortly after the alternative bus, the passenger may decide not to board the bus arriving soonest on the original line, therefore leading to a change in travel path (Mascia, 2003). Clowes (1996) believes with real time forecasting there is the potential for significant journey time savings on longer journeys by changing route and using the most efficient path to the final destination.

Other adjusting strategies such as not boarding a crowded bus if the display shows another will be arriving shortly have not been sufficiently investigated. However, unstructured observation on the Stockholm Metro indicated that few people wait for the next train when a crowded train arrives, even when the real-time displays show a second train arriving in 1–2 minutes (Dziekan & Kottenhoff, 2007). This is contradictory to the findings of Warman (2003) where approximately half of passengers surveyed on two routes - 51 % and 47% - said that they caught the second bus 'often/sometimes' if the first bus was overcrowded. Another potential ‘other’ adjustment strategy is travellers changing destination as a result of receiving at-stop information. There is no evidence regarding this as it appears to not have been investigated.

3.3.6 Customer Satisfaction

Arrival time information provision is likely to affect customer satisfaction of bus travel and have possible knock-on effects for bus patronage. Satisfaction is generally understood to be based on direct experiences, that is a direct response to encounters with a product or service (Dziekan & Kottenhoff, 2007). As such, customer satisfaction is less important than attitude - a predisposition to at product or service - to bus travel in terms of achieving modal shift. Attitudes are mainly influenced by cognitive processes, affective processes, personal behaviour or social influences. However, satisfaction can have some influence on attitude over time and is therefore still valuable (Dziekan & Kottenhoff, 2007).

In general real-time at-stop information tends to increase customer satisfaction. A before and after study was conducted of a real time bus information trial in Glasgow. The overall impression expressed at the discussion groups was favourable; all said that they wanted the pilot project to not only continue but be extended. Of those who were aware of the system, 90% found it either fairly or very helpful (Duke, 1998).

An evaluation of electronic displays at a number of public transport stops in Dresden, Germany showed that three months after installation 82% of the sampled population knew about the displays and rated them as very reasonable. The follow-up investigation two years later showed a 90% approval rating (Dziekan, 2004) indicating satisfaction longevity with RTI displays.

A review of Seattle's Transit Watch RTI system showed it was widely used and useful. Real-time bus departure times were the feature found most useful by users (Schweiger, 2003). This is supported by a survey conducted by Portland Tri-Met of its Transit Tracker service; respondents stated what they liked most about the display was that 'they know how many minutes until the bus comes' (Schweiger, 2003).

Passengers were asked about the importance of having London's Countdown system at high street bus stops and local residential stops. Whilst 24% said that it was very important to have Countdown at high street bus stops served by 'lots of buses', 39% felt that Countdown was a very important addition at stops near where they lived (Warman, 2003) indicating a desire for widespread RTI provision. Furthermore, Warman (2003) found support for the Countdown system has also translated into an improvement in attitudes to bus travel in general, important for both sustaining patronage due to existing users and potentially increasing patronage through modal shift.

3.3.7 Increased Bus Use

Personal freedom offered by the car has enhanced personal mobility for many years leading to an unsustainable transport system (Davison & Knowles, 2006). Therefore, arguably the most important question is, does at-stop RTI provision increase bus travel? Mode shift is plausible if the attractiveness of one mode increases (Dziekan & Kottenhoff, 2007). The effects described above – improved attitudes, increased safety, reduced anxiety and affective effort, journey modification, shorter perception of, and increased opportunity to utilise wait time – all seemingly have the potential to increase the attractiveness of bus travel and therefore influence bus patronage. It is a question of whether these effects have sufficient strength to influencing travellers' behaviour.

There are three elements to the effect on bus patronage to consider; existing regular bus users choosing to travel more frequently by bus, modal shift by current non-bus users and maintaining bus patronage at current levels. Given the steady decline of bus use outside London over the last few decades (House of Commons Transport

Committee, 2006) simply maintaining patronage it seems requires effort. Passenger information could assist in this goal; Geoff (1998) states easy access to reliable, accurate information about public transport services is an important determinant in attracting and retaining passengers.

There is evidence to suggest RTI provision is an important factor in modal shift towards bus use. Within the Infopolis2 project, people in Birmingham were asked which soft measure would be useful in achieving mode shift from the private car to bus use. Real-time information on public transportation was considered the best measure on offer - even more important than improved bus shelters or low-floor vehicles (Dziekan & Kottenhoff, 2007). A study by Grotenhuisa et al (2007) showed the most desired wayside Integrated Multimodal Travel Information (IMTI) type was real-time information delays, with over 90% of respondents expressing a need for this.

When answering stated preference surveys it appears both bus and non-bus users tend to be very positive about increasing bus use due to RTI provision. For example a survey was undertaken before the introduction of a real time bus information trial in Glasgow (Dziekan, 2004). The responses were promising; 59% said they would be more inclined to wait for a bus than use an alternative mode such as taxis, and 46% said the system would affect how often they would use a bus - of these, 77% would increase a little and 20% would increase a lot.

In research by Caulfield & O'Mahony (2007) respondents were asked if the lack of information deterred them from using public transport; 21% of respondents either strongly agreed or agreed with this statement. The authors believe this sizeable proportion of respondents demonstrates that RTI provision may attract more passengers.

In reality it appears optimistic estimates of patronage increases are unrealistic. It is worth noting that effects of RTI displays are often challenging to separate and quantify because introduction is often combined with others measures, such as marketing initiatives and the introduction of new routes, shelters or buses (Dziekan & Kottenhoff, 2007). An advantage of the study described in this paper is QR code introduction is the only measure introduced.

Considering the Glasgow trial study mentioned above, the stated preference survey results anticipate a large increase in patronage due to the introduction of RTI provision. In reality there was a 9% increase in patronage. This is less than the initially survey would have lead us to believe but nevertheless substantial. However the RTI scheme was introduced in conjunction with bus priority and low floor buses therefore the effect of RTI while uncertain, were likely to be small. The Leicester StarTrak case study (DfT, 2010) reported bus operators found an increase in passenger numbers with selected routes recording a 20% expansion in patronage since the introduction of the scheme. However this result should be treated with caution as these routes may have had infrastructure improvements and new vehicles.

Warman (2003) also investigating StarTrak highlights that 2% of each sample, both before and after system installation were first-time users. It appears that in Leicester's case at least the new passenger information system (or the infrastructure improvements) had no effect on attracting new users. There is however some evidence that RTI encourages more frequent travel by existing bus users. Dziekan (2004) summarises results from a number of schemes; in Brussels the use of public transport lines equipped with RTI displays had increased by 6%. In Liverpool routes where Timechecker had been installed led to a 5% increase in patronage.

Examination of London's countdown system by Warman (2003) was based on changes in revenue, which can be a good indicator of patronage change. Analyses of two London routes suggested revenue increases of 4.5% and 1.8% as a result of the introduction of Countdown. However the results are highly sensitive to the control route chosen and should be treated with caution.

A possible reason for the over-optimism of stated preference surveys on patronage increases is these, and related techniques used to explore decision making structures, operate on the basis of perfect information. In reality bus users may not have all the information or have complete trust in the reliability of the RTI system and therefore on street decisions are likely to be different to the results of stated preference surveys.

Closely related to the phenomenon to over-optimistic stated preference survey results, it would also seem that describing RTI provision leads to more enthusiastic responses from people than post experiencing it in operation. Brown (1997) conducted an analysis of Southampton's initial installation of real-time bus information. When asked what effect the system would have on their use of buses respondents replied as shown in table 3.5 below (the 'before study' was conducted before installation and 'after study' was post installation). As can be seen, when participants had experienced the system in action there was a large fall in expected bus usage increases.

	No effect	Increase usage	Not sure
Before study	73.5	16.3	10.2
After study	95.1	3.7	1.2

Table 3.5: The reported effect of displays on the use of buses in Southampton (Source: Brown, 1997)

It is useful to compare the effectiveness of RTI provision against other 'soft' measures. Again using revenue as the basis for assessing effectiveness Currie & Wallis (2008) examine this in comparison to cost of various 'soft measures' and find RTI provision the least cost effective measure in terms of revenue increases as can be seen in figure 3.6 below. This is likely to be partly due to the high cost of installation and upkeep of at-stop displays.

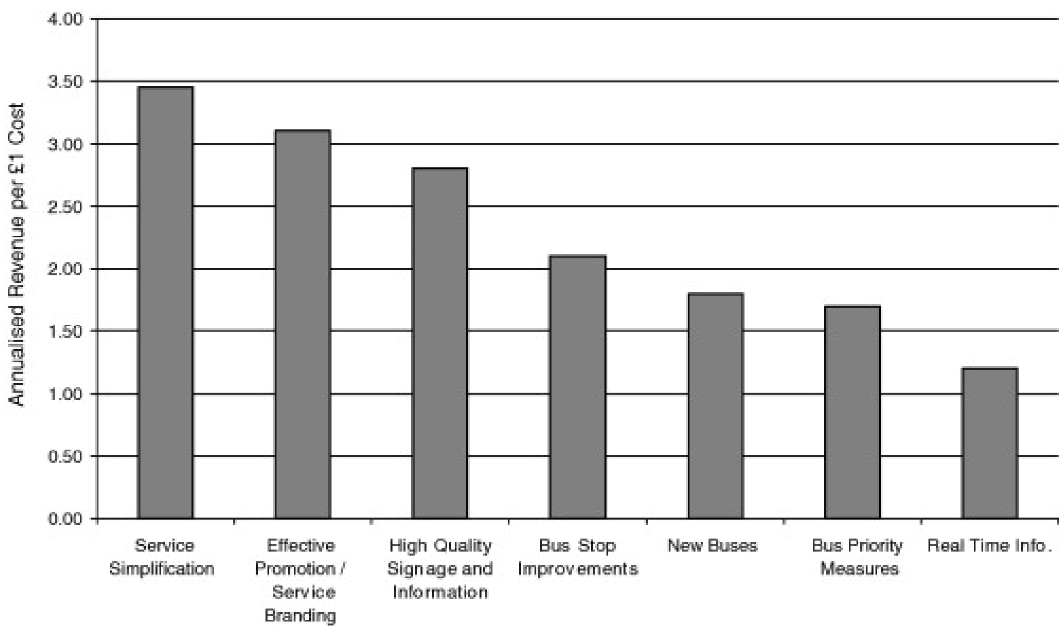

Figure 3.6: Cost-effectiveness of bus improvements – UK (Source: TAS Partnership, 2002)

Broadly speaking in terms of patronage Currie & Wallis (2008) suggest the following rank order of bus improvements in terms of patronage impacts: service reliability-based measures (busways, bus lanes, junction priority), frequency of service and finally passenger information based measures.

There are a number of reasons for the comparatively small influence on of RTI on bus patronage. Research by Kenyon & Lyons (2003) illustrates that the majority of travellers do not consider their modal choice for the majority of journeys. Rather, this choice is automatic and habitual, based upon subconscious perceptions of the viability and desirability of travel by modes other than the dominant mode. That is, a developed habit or script (e.g. of choosing to drive) is generalised to many situations so that it is triggered by the goal of travel from one place to another (Garling & Axhausen, 2003). Switching to another mode has an initially high generalised cost as it is necessary to learn new routines. Furthermore, habit may actually prevent the user seeking the information about alternative modes which would facilitate a rational choice of mode (Kenyon & Lyons, 2003).

Habit aside, Kenyon & Lyons (2003) in a study using focus groups found many participants who were not regular public transport users, perceived public transport to be inconvenient, unreliable, uncertain, risky, unsafe; time consuming, costly and incompatible with their lifestyle. Whilst RTI provision assists in alleviating some of these it clearly has a limited effect on mode choice when challenged with such formidable barriers.

There is also the possibility bus arrival time information will have a negative effect on patronage as knowledge of wait time means passengers will decide not to use the bus on some occasions when they otherwise would have done so. However, Warman (2003) argues that for specific journeys this may be true, but passengers experiencing the same long wait without information will be deterred from making similar journeys in the future. In fact, providing passengers with information about waits, even if they are a long period of time, will produce benefits to passengers and over time additional patronage by improving passengers' confidence in bus travel.

It is worth noting an observation by Grotenhuisa et al (2007), distinguishing between familiar travellers, who frequently use public transport, and unfamiliar travellers, who occasionally or never use public transport. During their research they were surprised to find familiar travellers expressed more need for wayside Integrated Multimodal Travel Information (IMTI) than non-frequent travellers. This could be due to frequent traveller's familiarity with and knowledge of the public transport systems therefore at stop information facilitates inform route and mode choices allowing users to get through the network as quickly as possible. Infrequent travellers conversely may be more wary and not wish to deviate from their planned route. While RTI provision is still useful in terms of utilisation of wait time and increased feelings of security it often does not assist with the more desirable goal of reduced travel time. This may assist in the explanation of finding by Warman (2003) that RTI at stops appears to not attract new users, with patronage increases largely resulting from increased use by existing frequent bus users.

Grotenhuisa et al (2007) reach the same conclusion as this study based on the above literature review:

Information provision in itself does not have the capability to persuade people to switch modes, though in various studies this service has been indicated as important, and hence it can substantially contribute to the overall satisfaction with public transport quality.

3.4 Summary

The evidence relating to factors effecting QR code uptake is scant and it appears no research has been undertaken regarding QR code use on public transport either at bus stops or in general. As such the affect of stops' characteristics, location and promotion and explanation of QR codes for obtaining bus arrival times will be investigated. The literature review shows conflicting uptake trends over time; total daily usage over the life of the project will be considered as will variations in use by time of day and day of the week. Also, following the stated preference survey work of Ramsden (2010) users typing the URL into a mobile browser as opposed to scanning the QR code will be recorded. Furthermore, smartphone ownership among Southampton bus users will be investigated in conjunction with demographic information.

The effects on perceived wait time whilst interesting are not practical to investigate during this project as a before and after study would be necessary and data would be difficult to obtain as it is anticipated only a small proportion of passengers boarding at any one stop use the QR code. The investigation of perceived increased reliability of bus services due to RTI provision suffers from similar practical problems and again will not be considered during this study.

Psychological effects resulting from the introduction of real-time arrival information can only be studied by asking questions since they are related to the feelings and experiences of individuals (Dziekan & Kottenhoff, 2007); it is therefore possible and desirable to include scrutiny of such factors in this study. This includes gauging if passenger's uncertainty, and therefore associated frustration, stress and anxiety were reduced by the introduction of the QR code link. Feelings of safety are deemed important enough to warrant individual attention in their own right but also as one study (Dziekan & Vermeulen, 2006) demonstrated a surprising reduction in feelings of personal security due to RTI provision.

Passengers' willingness to pay would be interesting to investigate in terms of valuing QR code introduction and for benefit-cost analysis of the system. However, as information provision in this case is effectively usually at zero marginal cost to users, and implementation would be very inexpensive for operators, examination of willingness to pay is not crucial to the introduction of the scheme and due to limited survey space it will not be included.

Adjusted travel behaviour will be investigated further, both in terms of amended route and mode choice and use of wait time. Studies testing adjusted travel behaviour are in practise sparse (Dziekan & Kottenhoff, 2007) and these effects have the potential to substantially reduce the cost of public transport use. Observations of changes in the proportion of passengers leaving stops after obtaining bus arrival information and the time taken to make the decision to leave, as with Warman (2003), will not be carried out. This would again require a before and after study and observations would be extremely time consuming given the expected low proportion of passengers using the QR code system.

Customer satisfaction is somewhat abstract and difficult to effectively evaluate. Also, it's generally best observed in experienced, regular users, of which there will be none as this trial is a new concept. Therefore customer satisfaction will not be included in this research beyond a basic examination of the system's ease of use.

Enquiry into patronage effects will centre on whether QR code introduction reduces the cost of wait time, and hence increases the attractiveness of bus travel sufficiently to encourage existing users to travel. There is insufficient time and resources during this project to conduct the before and after study required to accurately gain an estimate of patronage change. Stated preference surveys have been shown to lead to over optimistic results however they are believe to be beneficial for two purposes if the results are treated with caution. Firstly, as a gauge of the potential for QR codes to incite increased bus use, but also to give an idea of which traveller demographics are likely to be most influenced by the introduction of QR codes. As such patronage effects will be briefly included, although only in relation to existing bus users; no direct examination of modal shift will be undertaken.

4.Methodology

4.1 Introduction

The QR code system used in this project was essentially very simple. When a user scanned the at-stop QR Code poster it automatically, with the users permission, linked to an existing web page set up by Southampton University Open Data Source giving mobile-friendly bus arrival time information for that stop. All buses arriving at the specific stop within the next hour were displayed up to a maximum of nine arrival times. Bus times were given in ascending order with the next bus to arrive at the top of the screen and the bus furthest in the future at the bottom, as can be seen in figure 4.1 below. Arrival times were given as a countdown where real time information was available and as a time of day where the arrival time was from timetable information.

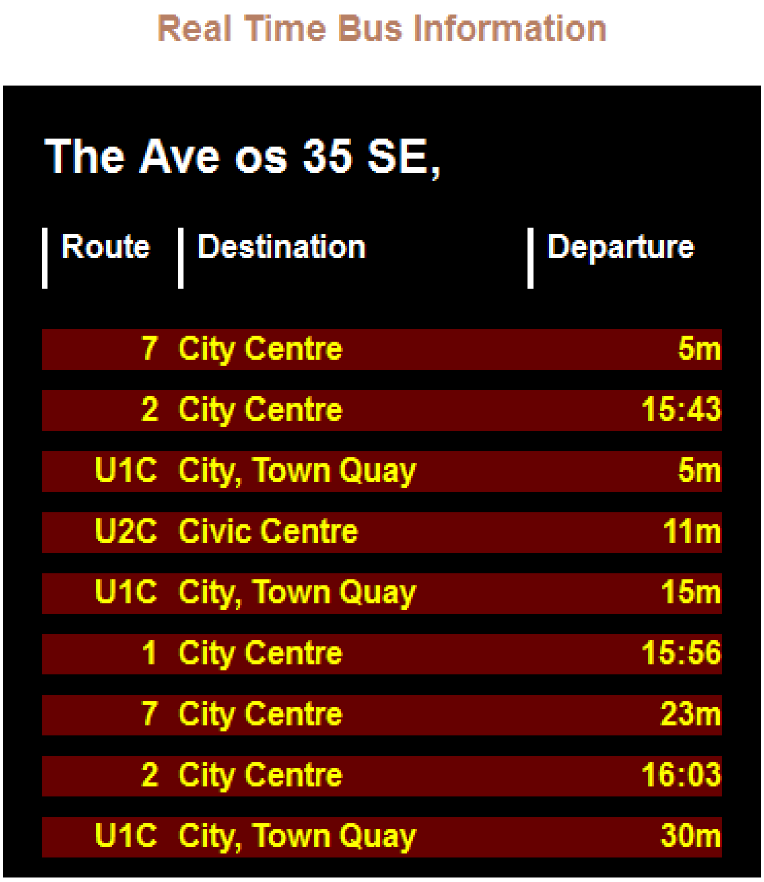

Figure 4.1: Example of bus arrival time QR code output (Source: ROMANSE Traffic Control Centre)

Arrival time data was skimmed from the ROMANSE Traffic Control Centre website by Southampton Universities Open Data Source and is also used in the pre-existing iphone application, isoton. Linking directly to the ROMANSE site was considered however upon investigation various smartphones demonstrated issues with resolution; that is the ROMANSE information is not mobile-friendly. Although isoton's conversion to mobile friendly arrival time webpages was designed for the iphone, testing revealed it worked well on a variety of smartphones.

The aim of this project was to analysis two distinct areas. The first was to examine QR code usage through hits data with the aim of showing where, when and under what circumstances QR codes are in highest demand. This section is likely to be of greatest interest to ROMANSE traffic control centre and First Group involved in the project, and bus information providers in general, as it would inform where to best allocate resources dedicated to QR code rollout. The second area is a more general and qualitative analysis of consumer reaction to the trial and the effects of receiving bus arrival time information through the QR code link upon passengers' psyche and behaviour.

4.1.1 QR Code Usage

Trend data will be examined in terms of the change of QR code use over the life of the project and variations in use by time of day and day of the week. A one-way ANOVA test will be used to examine if there is a significant difference in usage by day of the week. Also, the number of users scanning QR codes will be compared to passengers typing the URL to obtain the arrival information.

The second stage of QR code usage investigation is to examine the effect of bus stop and poster characteristics on QR code use. To do this in a meaningful manner QR code use needs to be adjusted at each stop for footfall where possible. Initially descriptive statistics will be utilised to compare differing usage at bus stops displaying the full and basic posters, stops with and without a shelter and with and without a functioning telematic display. Also differing usage in the areas of Southampton University, railway station, hospital, urban and suburban centres will be displayed.

T-tests will be conducted to examine if there are significant differences in uptake due to poster or stop characteristics.

4.1.2 Survey Data

It was initially hoped to gather data through a mobile survey; however due to a poor initial response rate this was supplemented with street surveying. Both surveys had numerous objectives. It was hoped to gain a basic understanding of how user friendly participants found the trial and to understand the psychological effects upon wait time and safety of receiving bus arrival times in this way. A further aim was to examine how participants adjust their travel behaviour as a result of receiving this information and in light of the remaining wait time for their bus. Perception of arrival time prediction accuracy was also investigated.

Furthermore, demographic data was collected from respondents and results from the above areas of interest can be broken down into and examined by a range of factors such as stop characteristics, frequency of use, trip purpose, length of wait, smartphone ownership, age and gender. Results from survey questions are displayed and discussed below, with a number of more precise relationships scrutinised in greater detail. The below questions were evaluated for statistical significance using a Chi-Squared test.

- *Are QR codes more useful at stops without displays? That is, is there a difference in the change of acceptability of wait time when at a stop with a display and without a display?*

- *Does arrival time provision through the QR code link have a greater effect on the acceptability of wait time for frequent or infrequent travellers? That is, do occasional travellers display a greater change in acceptability of wait time than frequent travellers, vice versa of no difference?*

- *Does receiving information in this way reduce the cost of wait time more when the wait is long or short? That is, is there a more positive change in acceptability of wait time for a long wait, a short wait or is there no significant difference?*

- *Which user group is likely to be most affected in terms of increased patronage? That is, will non-commuters increase bus use due to QR code introduction more than commuters?*

- *Are changes in feelings of safety due to arrival time knowledge greater in females than males?*

- *Do older people find the technical aspect of obtaining arrival times through QR code use more challenging?*

- *Do smartphone owners find the technical aspect of obtaining arrival times through QR code use less challenging?*

It was hoped to investigate two further questions, firstly: *Are passengers more likely to adjust their behaviour given a longer wait time?* Unfortunately due to a lack of data this could not be done quantitatively but only anecdotally. Secondly*: are changes in feelings of safety affected by the time of day?* The mobile survey software did not record the time of day correctly and all street surveys were undertaken only during daylight so this was not possible to test.

4.2 Stop Choice

The project aimed to examine the effect of stop type and location on QR code uptake. As such a reasonable spread of stops were chosen covering a variety of locations and included major and minor stops. Stops with existing information displays were selected (all display stop included had a three line LED screen) as were stops with and without shelters where appropriate, although only three stops without shelters were finally included.

The first step in stop selection was discussing appropriate areas with First Group, the operator responsibly for information provision at the majority of stops in Southampton, and ROMANSE Traffic Control Centre. In an attempt to capture a wide variety traveller types, journey purposes and interchanging passengers' stops at the interchange of Southampton railway station and around the hospital were included. It was hoped to include the Town Quay interchange at the exit of the Red Funnel ferry terminal however this was not possible due to lack of access to the display cases.

The difference between urban and suburban uptake was thought important and therefore stops were selected in Portswood (urban), Shirley and Bitterne (suburban). It was hoped to include the industrial area of Millbrook adjacent to Southampton docks but this was not viable, again due to lack of display case access. Finally the area in and around the University of Southampton was included to assess the likely QR code uptake and effects on Southampton's large student population and also as it is likely a higher proportion of bus users in the area would have smartphones. Please see figure 5.5 in the Results & Discussion section below for a map of all stop locations.

Subsequently a number of stops were selected in these areas based on location and the number of routes servicing the stop. These were then checked and agreed by First Group for footfall, accessibility of the display case and general appropriateness. High footfall was not an absolute prerequisite of stop selection as the project adjusted hits data giving uptake as a proportion of footfall where appropriate for analysis. However, in order to maximise data collection, stops with a high footfall were given priority.

Initially 54 stops were chosen for inclusion in this trial. However, it was agreed with First Group that only stops where there was sufficient space for the QR code poster, without impeding timetable or other relevant information, could be included. In order to maximise the number of stops the full poster was produced in A5 rather than the originally intended A4 size.

Where possible stops displaying the full and basic posters were grouped into clusters. It is likely passengers will regularly use one stop, or a collection of stops close to each other. The reasoning for this was to try and minimise passengers reading and learning how to use QR codes and their purpose at a stop with a full poster and transferring that knowledge to another stop with a basic poster. It was felt this could devalue the results from the explanation and promotion verses the no explanation or promotion effect on uptake.

The first round of placing posters at stops was carried out on 26th July 2011 with 35 posters put in place. Nineteen could not be placed due to stops not having display cases, insufficient display space or being unable to gain access to the display case. It was felt covering 35 stops was inadequate to achieve the project goals and a further 9 stops were selected. These posters were all placed at stops on the 29th July 2011 giving a total of 44 stops covered in the trial. It is thought one of these, stop number 40, was removed shortly after being placed in the display case. In total 41 stops had a shelter, 3 without, 18 had displays, 26 did not and 25 had full posters displayed leaving 19 with the basic poster. Please see appendix F for a detailed breakdown of stop numbers, locations and characteristics.

4.3 Poster Generation

Two types of QR code poster were placed at bus stops as described above. The first basic poster had only the QR code, the URL of the link to bus information and the stop location description. The second full poster also included a title – 'How Long Until Your Bus Arrives' and brief instructions describing how to use the QR code.

Web pages were developed to automatically generate both the basic and full QR code posters. The QR code link, stop information and URL all automatically update when the stop code was changed in the automatic poster generator URL. All posters generated included the unique stop code, stop description and a map, via a link to Google Maps, showing the stop location; these measures were to avoid location errors when placing posters at stops. It was imperative the QR code linked to arrival information for the correct stop. As a failsafe measure the information link was also checked for accuracy against at stop timetables or route information when the posters were placed. All QR code posters were correctly placed at stops. Links to each poster generator are given below and should remain active indefinitely.

Basic layout:
http://data.southampton.ac.uk/bus-stop/SN120257.html?view=qrlite

Full layout:
http://data.southampton.ac.uk/bus-stop/SN120257.html?view=qr

The full poster was designed in conjunction with marketing department at First Group. Small amendments to the initial poster design were made in order to give it the appropriate corporate image and to include logos for the groups involved: First Group, University of Southampton and Southampton City Council. Please see appendix A for an example of the basic poster, appendix B for the full poster and appendix C for a photo of a full poster place at a bus stop.

4.4 QR Code Hits Data

4.4.1 Data Collection

Data on QR code use was collected automatically over the life of the project. Each time a QR code poster was used a hit was record containing the time, date, unique bus stop code and if the users scanned the QR code or typed in the URL. This data was fed automatically into an excel spreadsheet. The link to this spreadsheet is:

http://data.southampton.ac.uk/qr/b.csv

It is worth noting that if a user book-marked the bus arrival time webpage and re-accessed the book-marked page this was not recorded.

QR code posters were initially placed at selected stops Tuesday 26th July 2011; as it took the majority of the day to place QR code posters and test scans were conducted the trial was deemed to start Wednesday 27th July 2011. The trial ended with the last full day being Monday 17th October 2011, running for a total of 83 days. This was also the final day any mobile surveys, described below, were accepted.

The hits data collected was in the first instance used to examine patterns in QR code uptake. The trend of total use over the life of the project for all stops is displayed and discussed below. Varying usage by day of the week is investigated and a One-Way ANOVA test conduced to assess if there is any significant difference between usage on different weekdays. QR code use by time of day is displayed graphically and discussed as is scanning against users typing the URL into their mobile browser.

Secondly, the data collected is used to assess the factors effecting QR code use, initially analysing the data unadjusted for footfall and subsequently footfall adjusted data as described below. Stop location, stops with full and basic posters, with and without a shelter and with and without a display screen are displayed and analysed. Two sample t-tests are employed to test if there is a significant difference in uptake due to these stop characteristics.

4.4.2 Footfall at Stops

In order to compare the effectiveness of QR code posters and examine usage given differing stop characteristics and locations it is desirable to adjust the absolute hits data to account for footfall. A stop with high footfall is likely to receive more hits due the volume of passengers than one with low footfall regardless of the stop characteristics. The adjusted hits figure used for comparison was calculated as follows:

$$\text{Adjusted hits} = \frac{\text{total QR code hits for stop X over the life of the project}}{\text{daily number of passengers boarding at stop X}}$$

The resulting output is therefore not meaningful in itself but only for comparison of QR code use at stops. The higher the figure the greater the proportion of passengers at that stop used the QR code.

It proved very challenging to obtain data for passenger boarding numbers at stops. It is believe bus operators have reasonably accurate passenger boarding numbers at individual stops, or groups of stops with the same fare bracket, from ticketing data. However due to the commercially sensitive nature of this information no operator was willing to release this data.

A survey conducted by MVA Consultancy commissioned by Transport for South Hampshire (TfSH) offered the only credible data on passenger boarding numbers (Fenwick et al, 2010). However there were some issues; firstly the survey was conducted in July during university holidays meaning passenger numbers travelling from the university would be unrepresentative of term time passenger patterns. However as the project spanned both school and university holidays and term time any single footfall data survey would be unrepresentative and the only way of obtaining an accurate estimate would be to average footfall from a number of counts over term time and holidays. More importantly, of the 44 stops covered in this trial only 23 had footfall data available. For this reason, all comparative analysis using adjusted hits data excluded stops for which footfall data was unavailable and therefore is based on a sample of 23, not 44 bus stops.

4.5 Mobile Survey

4.5.1 Mobile Survey Set Up

The basic hits data collection described above was invaluable for examining overall uptake and poster type, location, stop type and time of day effects. However to investigate the other areas of interest such as psychological effects, adjusted travel behaviour and perceived accuracy of arrival times further information from users was required. This was achieved through the use of a mobile survey and an on-street survey.

The mobile survey operated as follows; a link was placed below the arrival time information passengers received from scanning the QR code saying ‘please help us out by taking our Survey’ with the word ‘Survey’ larger, in blue and acting as the link to the mobile survey. This linked to a short survey to be conducted on the user’s smartphone. It was initially hoped to develop this mobile friendly survey within Southampton University’s dedicated survey building software, isurvey, adapting the existing webpages for use on a smartphone by implementing a new CSS (Cascading Style Sheet) for the mobile applications to correct for resolution and the need to scroll horizontally; however this was not possible. Tests of the available survey building software showed Survey Monkey (Survey monkey, 2011) gave the best results in terms of usability and resolution on a variety of smartphones. It also provided adequate survey building potential and data collection for the relatively simple mobile survey.

In order to encourage participation the mobile survey was restricted to be very concise, with ten closed ended, multiple choice questions. It was felt that with no incentive to complete the survey provided anything longer than this would be too discouraging. The survey also included three optional open ended questions. While providing very useful data these were optional rather than mandatory as survey pilots demonstrated entering text was found to be generally slow, cumbersome and discouraging to users. Again for simplicity there was no routing in the survey, that is all participants were asked all questions with no need to change the path of the survey depending on previous answers.

A web-based survey was chosen as a potentially large amount of data could be collected from QR code users without interviews and processed without data entry (Caulfield & O’Mahony, 2007). Web-based surveys, especially conducted on a smartphone will inevitably create biases as not all individuals have access to the internet through a smartphone. However, as participating in the trial itself requires these two prerequisites this bias is not an issue here. Due to the nature of the survey the sample was self selecting as there was no control over participant selection.

4.5.2 Mobile Survey Question Choice

A number of pilot interviews were conducted before the question set and order was finalised. The motivation behind each question is briefly described below. The full mobile questionnaire is given in appendix D including answer options.

How days per week do you usually use a bus?
Included due to a general interest in the proportion of user type at test stops but more importantly to distinguish and test the effects of QR code use on regular and infrequent users and validate the findings of Grotenhuisa et al (2007) that frequent travellers express a greater need for RTI.

What is the purpose of this trip?
Again included due to general interest in proportion of user type at test stops but more importantly to distinguish and test the effects of QR code use on commuter and leisure users.

How easy was it to get your bus arrival time?
Included to examine the easy of technical or practical use of the QR code link; potential factors affecting ease of use could be downloading the scanning application, scanning the QR code itself and viewing the webpage (screen resolution problems in particular). A comments box for respondents to detail any difficulties, or include general comments was included with this question but was not compulsory.

Did receiving the information make waiting for your bus more acceptable?
The aim was to investigating any psychological effects in one all encompassing question. Again due to length restrictions it was felt individual questions regarding unique psychological factors could not be included and this question forms a suitable all encompassing substitute. It is very similar to questions asked during research of both StarTrak (DfT, 2010) and Timechecker (Dziekan, 2004).

Did the information provided make you feel safer while waiting for your bus?
While an element of changing feelings of safety would be included in the question above it was felt this is a sufficiently important psychological factor to merited individual attention. A similar question was asked during research into London's Countdown system (Warman, 2003). It was hoped the effects of gender and time of day could be examined in relation to changes in perceived safety due to bus arrival time information. The former is analysed below, the latter could not be explored due to insufficient surveys completed outside day light hours.

What did you do as a result of receiving your bus arrival time:

- ❑ *Waited at the stop for your planned bus*
- ❑ *Waited at stop but took a different bus*
- ❑ *Went to a different bus stop and took your planned bus*
- ❑ *Went to a different bus stop and took a different bus*
- ❑ *Went away from the stop (e.g. shopping, bank, café) and returned*
- ❑ *Used an alternative form of transport (e.g. walking, taxi, lift)*
- ❑ *Other […..]*

This is an ambitious question to investigate users behavioural modification; both in terms of utilisation of wait time and adapted travel including mode choice, as a result of receiving bus arrival time information. An open ended 'Other' category was included but again was not compulsory. The hope was to investigate if different categories of passengers reacted to or utilize the information provided in different ways. Due to a poor response rate to this question this was not possible.

Does receiving bus arrival times in this way make you more or less likely to use a bus?
This is a crude attempt at gauging the possible effects on patronage of receiving bus arrival times. As this question is being asked of bus passengers it is unlikely to give any idea of modal shift from car use but only of increased patronage through more frequent travel by existing bus users. An accurate estimate of increased patronage would require a before and after study of a route or area where arrival time information is introduced. However the question was included as it was believed there is value in understanding passengers feelings towards bus use resulting from this

information provision and to assess which demographic groups any likely change in patronage would arise from.

How much difference would you estimate there was between the predicted and actual bus arrival times?

The question aim was to test users perceived accuracy of the system. This is interesting as the system has a greater value the more accurate and therefore trustworthy it is. To gain the beneficial psychological effects and for passengers to modify their behaviour users must perceive the estimated arrival times as accurate. The option ‘don’t know’ was reluctantly included in this question as users were likely to be completing the survey whilst awaiting the arrival of their bus and therefore would not know how accurate the predicted arrival time was. Although ‘don’t know’ is not a useful response to this question it was felt better to have this option than discourage survey participants.

Please select the age range you fall in:

To examine the effect of age upon answers to survey questions.

Are you: Male/Female

To examine the effect of gender upon answers to survey questions.

Any other comments?

An open ended question where participants can raise any points, suggestions or feelings not covered in the survey.

4.6 Street Survey

4.6.1 Street Survey Set up

The mobile survey demonstrated an initial poor response rate. It was therefore decided to supplement this with a face to face street survey. The premise was to ask the same, or very similar question to the mobile survey to boost the data set and also add a number of additional questions excluded from the mobile survey. It was felt the street survey could be more comprehensive as it involved less participant effort as respondents were guided through and encouraged to complete the survey by the interviewer. Data from the street and mobile surveys was amalgamated where the same or very similar questions were asked.

The street survey included a demonstration of QR code use. The motivation for this was two fold; firstly, it was the most effective way of allowing respondent to understand and be able to assess the system. Secondly, respondents tend to be overly optimistic before seeing RTI in operation (Brown, 1997) therefore by demonstrating the system over optimistic stated preference responses could be somewhat mitigated.

A task performed in conjunction with the street survey was checking the QR code poster for vandalism; there was concern third parties may generate QR codes linking to inappropriate websites and replace the arrival time link. This is likely to be more of an issue with widespread introduction of standard sized QR codes however if vandalism did occur at this test stage it was considered a good indication that preventative measures would be required if wider introduction was to take place. All posters were checked at least once over the trial period.

The sample population resulted from interviewing random passengers at a variety of trial bus stops over a number of days. No particular stops were selected as the hope was to get responses from stops at a variety of locations and with various characteristics. While checking posters for vandalism any passengers waiting at the stop were asked to take part in the survey. No targets were set for a number of interviews from particular stops. However, interviewing was particularly intensive around the university as it was felt most useful to gather responses from areas where waiting passengers were more likely to own a smartphone.

4.6.2 Street Survey Question Choice

Questions that were either very similar or identical to the street survey are not included below. The questions described below are either additions to the mobile survey or where the mobile survey question was sufficiently amended to warrant explanation. There was some basic routing in the street survey. A number of pilot interviews were conducted before the question set and order was finalised. Please see appendix E for the full street survey.

Date:
Day:
Time:
Bus Stop Name/Number:
The above was used in analysis but also to remove demonstration QR code use from the hits data.

Do you know what time your bus is expected to arrive at this stop?
Included to obtain an estimate of the proportion of passengers knowing their bus arrival time and as a prerequisite to the following question.

IF YES: Which method did you use to obtain your bus arrival time information?

- ❑ *Internet – at home/office*
- ❑ *Internet – mobile*
- ❑ *RTI display*
- ❑ *Previous knowledge*
- ❑ *Paper timetable*
- ❑ *SMS*

To build a general picture of the popularity of each bus arrival time method in Southampton.

At this point an explanation of the QR Code trial in Southampton was given.

Do you have a smartphone - a mobile telephone that has a camera, internet access and the ability to download and install applications (apps)?
To estimate the proportion and of bus users travelling with a smartphone in Southampton as this would effect the potential scope of the QR code system.

IF YES: What make of phone is this?
Popular phone makes in the area could be important as information providers could target usability tests towards certain models' mobile operating systems.

A demonstration of the QR code system was given at this point to showing the respondent their bus arrival time: open app. ⇒ scan ⇒ show respondent bus arrival times webpage on smartphone.

Establish and record wait time until respondent's bus:
Included in order to obtain an average wait time estimate at QR code stops and to examine how varying wait times effect behaviour and psychological effects, specifically the change in acceptability of wait time.

If you were not doing this survey, what would you do as a result of receiving your bus arrival time?

- ❑ *Wait at the stop for your planned bus*
- ❑ *Wait at stop but take a different bus*
- ❑ *Go to a different bus stop*
- ❑ *Go away from the stop (e.g. shopping, bank, café) and return*
- ❑ *Change your destination*
- ❑ *Walk the whole journey*
- ❑ *Get a taxi or lift*
- ❑ *Other […….…]*

The above question is very similar to the mobile survey question. However as the wait time until a respondent's bus was recorded the motivation was to investigate answers in relation to this. There is an addition to this question from the mobile survey; the ‘change of destination’ option was added. The literature review reveals this has not been investigated in relation to bus arrival time information. It is worth noting the question has changed from a revealed preference question in the mobile survey to a stated preference question in the street survey. This is because respondents are obliged to remain at the stop to complete the survey.

How much difference would you estimate there was between the predicted and actual bus arrival time?

This question was removed from the street survey as it was necessary to complete the survey before the arrival of the respondent’s bus.

SMARTPHONE USERS: Does receiving bus arrival times in this way make you more or less likely to use a bus?

The above question was only put to smartphone owners this as it was considered excessively hypothetical asking non-smartphone owners.

SMARTPHONE USERS: If this were available on a regular route would you scan the poster every time or bookmark the page?

Arrival time web pages accessed through book-marking were not recorded in the hits data. This question was to gain an estimate of passengers accessing through book-marking and therefore the extent of hits under-recording. A ‘not applicable’ category was included for respondents who thought they would not use the services or did not travel a regular route.

Under what circumstances would you be most likely to use this service [assuming you had a smartphone and] if available?

- ❑ *When catching a bus I regularly take*
- ❑ *When catching an unfamiliar bus*
- ❑ *I’d be unlikely to use it*

Grotenhuisa et al (2007) somewhat counter intuitively found frequent travellers on regular routes had a greater need for real-time information. This was included as an attempt to test this.

Do you know what the difference is between receiving a countdown to bus arrival (that is the number of minutes until the bus arrives) and the arrival time as a time of day?

Leading on to the question below.

IF YES: What is the difference?

Is the answer given correct:

The two questions above were included to test the proportion of passengers that know when they are receiving timetable as opposed to real-time information in Southampton. ROMANSE were interested in this as they felt it was a possible cause of confusion to passengers. The study also has an interest as confusion and lack of confidence in the accuracy of arrival times massively reduces the benefits of real-time provision.

4.7 Statistical Analysis

Results for both QR code hits data and survey results are displayed through descriptive statistics where appropriate such as scatter plots, pie charts and bar charts as well as frequency tables.

The proportion of passengers waiting at trial bus stops who accessed arrival times through the trial was estimated by first calculating the total average daily hits for all footfall stops and dividing this by the total daily footfall these stops:

$$\frac{\Sigma \text{ total hits at QR code stops with footfall available / Life of the project in days}}{\Sigma \text{ daily total footfall}}$$

The effect of stop characteristics on QR code usage is explored through two sample t-tests to determine if there was a statistically significant higher mean average hit rate at stops with a given characteristic than those without. Two sample t-tests were performed using SPSS.

The test statistic used was:

$$t = [\ (x_1 - x_2) - d\ ]\ /\ \sqrt{[(s_1{}^2/n_1) + (s_2{}^2/n_2)]}$$

Where x_1 is the mean of sample 1, x_2 is the mean of sample 2, d is the hypothesised difference between population means, s_1 is the standard deviation of sample 1, s_2 is the standard deviation of sample 2, n_1 is the size of sample 1 and n_2 is the size of sample 2 (Stattrek, 2011(1)).

Sample populations are assumed to be independent and distributions were tested for normality using a Kolmogorov-Smirnoff test. The degrees of freedom were calculated as follows:

$$DF = (s_1{}^2/\ n_1 + s_2{}^2/\ n_2)2\ /\ \{\ [\ (s_1{}^2\ /\ n_1)2\ /\ (n_1 - 1)\ ] + [\ (s_2{}^2\ /\ n_2)2\ /\ (n_2 - 1)\ ]\ \}$$

Results were given as a p-value defined as the probability of observing a sample statistic as extreme as the test statistic (Stattrek, 2011(1)). The evaluation involves comparing the p-value to the significance level, chosen as 5% in all cases and rejecting the null hypothesis when the p-value is less than the significance level, that is less that 0.05.

A one-way ANOVA test was performed to test if there was a significant difference in the QR code use between days of the week. This is a way to test the equality of three or more means at one time. The test statistic is based on sample means and variances. The following assumptions are required to conduct a one-way ANOVA: sample populations are normally or approximately normally distributed, samples are independent and the variances of the populations are equal (Jones, 2011). This test was also conducted in SPSS.

Chi-square (χ^2) tests for homogeneity were employed to investigate the specific relationships detailed above in the categorical data generated by the mobile and street surveys. Calculations were carried out manually. The Chi-square test of homogeneity was applied to a single categorical variable. The test is used to compare the distribution of frequency counts across different populations and test if they are identically distributed. It was necessary to collapse some categories so the observed value of each cell was not zero and the expected value was greater than five.

The expected frequency for each cell was calculated using the following formula:

$$E_{r,c} = (n_r * n_c) / n$$

Where $E_{r,c}$ is the expected frequency count for population r at level c of the categorical variable, n_r is the total number of observations from population r, n_c is the total number of observations at treatment level c, and n is the total sample size (Stattrek, 2011(2)).

The test statistic is a chi-square random variable (χ^2) defined by the following equation:

$$\chi^2 = \Sigma \left[(O_{r,c} - E_{r,c})^2 / E_{r,c} \right]$$

Where $O_{r,c}$ is the observed frequency count in population r for level c of the categorical variable, and $E_{r,c}$ is the expected frequency count in population r for level c of the categorical variable (Stattrek, 2011(2)).

The degrees of freedom (DF) is equal to:

$$DF = (r - 1) * (c - 1)$$

Where r is the number of populations, and c is the number of levels for the categorical variable (Stattrek, 2011(2)).

The rejection region was calculated using a table of percentage points of Chi-square distributions and a 5% significance level was used in all cases.

5. Results & Discussion

This section displays the results of the QR code trial and simultaneously discusses their validity and implications. The section is broken into two broad areas, firstly examining hits data and then the survey results. However there are areas of overlap between these and some survey results are used to support discussion in the QR Code Hits Data section.

5.1 QR Codes Hits Data

5.1.1 Project Lifetime Trends

The QR code trial appeared to be successful in terms of overall usage with an average usage of 21.37 hits per day. A rough estimate of the percentage of passengers using footfall data, calculated below, shows only approximately one in every 650 passengers used the link. This initially appears a poor usage rate; however, the literature review suggests this is reasonably satisfactory, certainly when compared to the US national campaign by Frito Lay (Cerreta, 2011) which exhibited a much poorer response rate. Also almost all QR posters were scanned - only two were not used at all over the project life - which is considerable better than the 10.2% scanned at the Connecticut Arts Festival (Joecasscio, 2011) although this trial ran for considerably longer.

$$\text{Proportion of passengers using QR codes} = \frac{945 / 83}{7441} = 0.00153 = 0.15\%$$

Figure 5.1 below plots the total QR code hits for each day the trial was in operation. There appears to have been a reasonably consistent increase in QR code use over the life of the project with the trial steadily gaining popularity and attracting increasing numbers of users or hits per day.

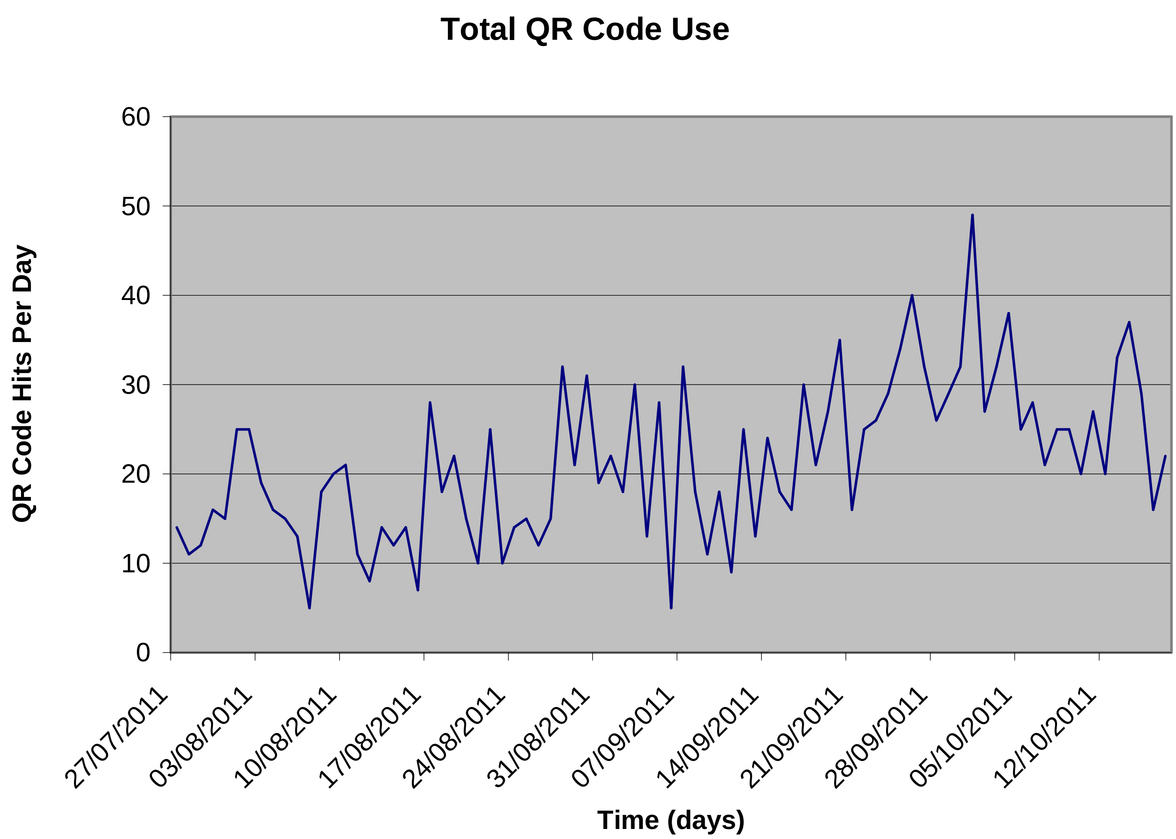

Figure 5.1: QR code hits per day over the life of the project life

There are two points to note however; firstly there were additional posters added two days after the trial started giving very early figures a boost. Of greater importance, Southampton has a substantial, heavily bus dependant student population, therefore an increase in QR code scans due to increased patronage would be expected towards the end of September as students returned.

The above effects may exaggerate the trend in increasing uptake over time to some extent; however, there is an important opposing factor dampening the trial's reported uptake. It was not possible to record those accessing bus times through book-marking the webpage displaying arrival times after the initial scan. During the street survey smartphones owners were asked, if they were to use this service regularly, would they book-mark the webpage displaying their bus times or scan every time they were at a stop. Of the 23 people who responded to the question 15 (65%) said they would book-mark the page. It is difficult to estimate the extent of usage under-recording as the accuracy of the book-marking estimate cannot be relied upon from such a small sample. Also, the frequency of bus use generally by QR code users, the repeat use of book-marked stops and the desire to know arrival times when at a book-marked stop (that is the frequency of repeat use through book-marking) are all unknown. However it is likely access to bus times facilitated through the at stop QR code link are substantially under represented here. It is believed usage results would have demonstrated a greater increase in uptake, and possibly in a more exponential as opposed to linear manner over time, had it been possible to record access through book-marked pages.

5.1.2 Daily Trends

Figure 5.2 below displays QR code usage over days of the week. Monday was the most popular day with average total hits on all Mondays during the trial period being 24.75; this compares to 18.25 on Sundays, the day with least QR code scans.

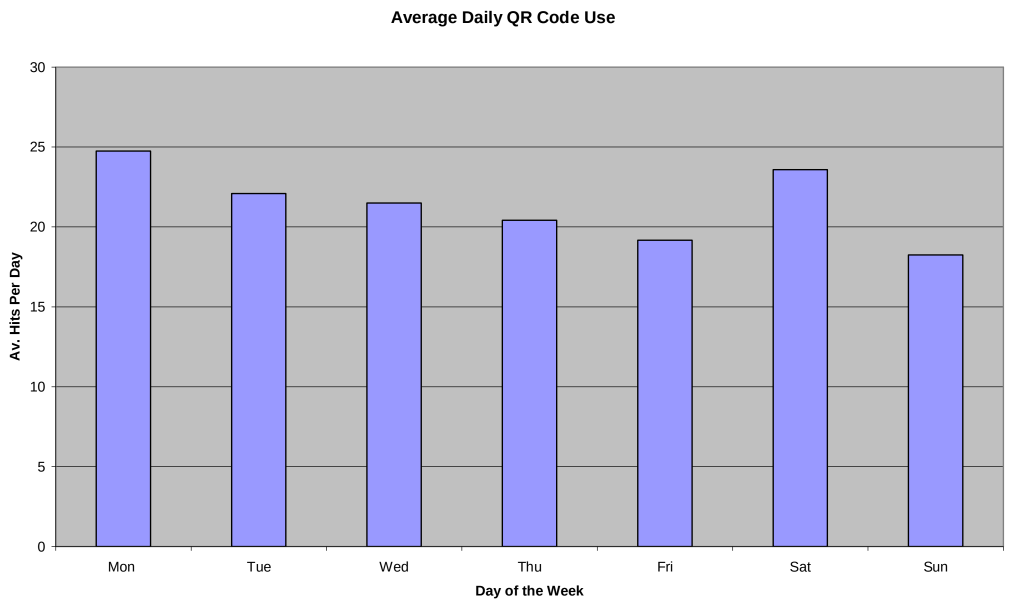

Figure 5.2: Average QR code hits per day

A one -way ANOVA test was conducted to investigate any significant difference between QR code hits on days of the week.

H_0: Average daily Monday hits = Average daily Tuesday hits = Average daily Wednesday hits = Average daily Thursday hits = Average daily Friday hits = Average daily Saturday hits = Average daily Sunday hits

H_1: At least one population mean is different

Each of the sample populations is considered independent and can be assumed normally distributed. A one-way ANOVA test p-value of 0.542 is greater than the critical value of 0.05 required, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no significant difference between average QR usage on different days of the week.

It is somewhat surprising QR code use is unaffected by the day of the week. It was anticipated weekdays, with high commuter flows and greater total patronage would demonstrate higher hits. In fact Saturdays exhibited the second highest number of hits of any day. This suggests substantial use by leisure or infrequent travellers rather than regular commuters.

The most popular time of day for scanning QR code posters was the evening peak, between 17:00 to 18:00 with a total of 145 scans taking place over the life of the trial. However, as can be seen in Figure 5.3 below use is reasonably consistent during peak and inter-peak times. There was in fact a greater number of scans per hour between 12:00 and 14:00 than at the height of the morning peak 08:00 to 09:00.

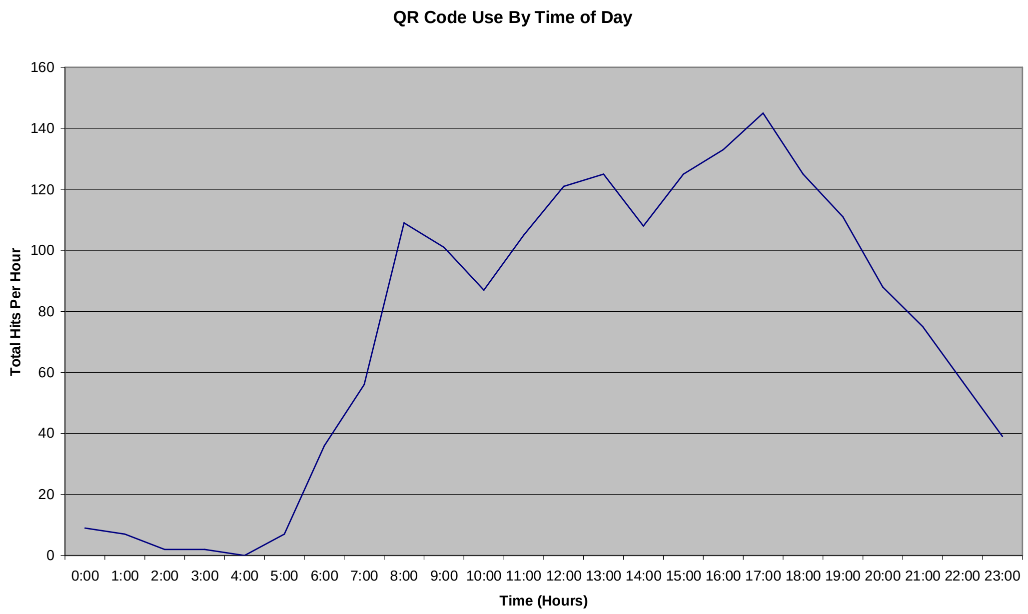

Figure 5.3: Total QR code hits per hour over the project life

Causes of the daily usage pattern seen above could be varied. Possibly as commuters tend to be regular, habitual travellers who know their bus times and therefore have less incentive to check them, where as less familiar, irregular travellers require more reassurance. This would lead to a greater proportion of unfamiliar travellers using the system which is likely to correlate to the high inter-peak and weekend hit rates observed. It maybe that in the PM peak there are greater numbers of unfamiliar travellers, combining with the high commuter flows to produce the highest overall hourly hit rate, where as the AM peak consists of mainly commuters. There could also be some correlation with smartphone ownership; initially this seems unlikely as commuters, often working full time are likely to be wealthier and therefore could be assumed more likely to own a smartphone. However, it is possible a large proportion of daytime use is the result of travellers accessing education (classed as commuters), who fit the demographic of a smartphone owner well.

It is possible to carry out a crude test of the argument for substantial non-commuter use causing the high inter-peak hit rates, as opposed to education commuters or another unknown reason causing this. This is by examining the difference between trip purpose results from the street survey, where participants were chosen at random while waiting at a bus stop, and the mobile survey, where participants chose to use the

QR code. If the above conjecture were true then it is reasonable to expect a greater proportion of street survey participants, chosen at random, to be commuters and fewer commuters would be found in the mobile survey sample. While this is the case there is not a large disparity with 67% and 59% of respondents respectively being commuters. It seems the trial was slightly more useful to less regular leisure travellers but used consistently by both groups. It is worth noting this result appears to be in contradiction to Grotenhuisa et al (2007) who found frequent travellers expressed a greater need for real-time information. However, if the high inter-peak usage were caused by education commuters this could still be the case.

Survey results assist in determining which group used QR codes more. The circumstances under which respondents would be most likely to use the QR code service, that is on a familiar or unfamiliar bus route, was not included in the mobile survey, therefore responses are solely from the street survey. As can be seen in table 5.4 below the majority of respondents, 69%, would be unlikely to use the service at all; not surprising as the actual QR code usage rate was in the region of one hit for every 650 trips made. However of the remaining respondents 12 (57%) said they would be more likely to use the service on a regular route and 9 (43%) an unfamiliar one. It is unwise to rely heavily on these results coming from a small sample; regardless, it is unclear which traveller type benefits most from the QR code link. This is also reflected in the assessment of likely commuter and non-commuter patronage changes examined below, with no significant difference between groups. Further research is required to reliably establish which group uses and benefits more from the QR code link.

QR Code Use Circumstances	Frequency
When catching a bus I regularly take	12
When catching an unfamiliar bus	9
I'd be unlikely to use it	46
Total	67

Table 5.4: Responses to the question ‘Under what circumstances would you be most likely to use this service?’

Results clearly show QR code scanning was the preferred option for mobile access of the bus arrival times webpage. Of the 1775 hits recorded only 11 (0.6%) were due to users typing the URL into a browser, the remaining 1764 resulted from QR code scans.

It is interesting that very few users, just over half a percent, chose to type the URL into their mobile device. His can either be seen as evidence for the easy of use of the QR code scanning system or alternatively that it is unhelpful and fruitless providing URLs to mobile users. It is difficult to distinguish which is the case without further research.

5.2 Factors Affecting Usage

5.2.1 Unadjusted Data

Due to limited footfall data availability an initial inspection of raw, unadjusted data in relation to the factors affecting QR code use is valuable. Firstly, examining the effect of poster type, the full poster including promotion and instructions had an average number of hits per stop over the life of the trial of 38.21. The basic poster had a higher average of 47.16 hits per stop.

In testing if usage is significantly higher with a minimal poster, the following hypotheses are defined:

H_0: Average hits per stop with a minimal poster displayed = Average hits per stop with a full poster displayed

H_1: Average hits per with a minimal poster displayed > Average hits per stop with a full poster displayed

Both distributions can be considered normal; equal variances cannot be assumed. A one sided two sample t-test p-value of 0.151 is greater than the critical value of 0.05 required, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no significant difference between QR use resulting from displaying minimal and full posters. This suggests there is no value in promoting and explaining the QR code link, which is discussed further after assessment of the footfall adjusted data.

Figure 5.5 below displays all stop locations, stop numbers (which correlate to the breakdown of stop characteristics, footfall, hits and adjusted hits shown in appendix F) and colour coding denoting the total number of hits individual stops received over the project life. As can be seen there is considerable variation in use by area. Please note that stop number 40 was found to have no QR code poster in place and received not hits over the trial; it was therefore excluded from all results.

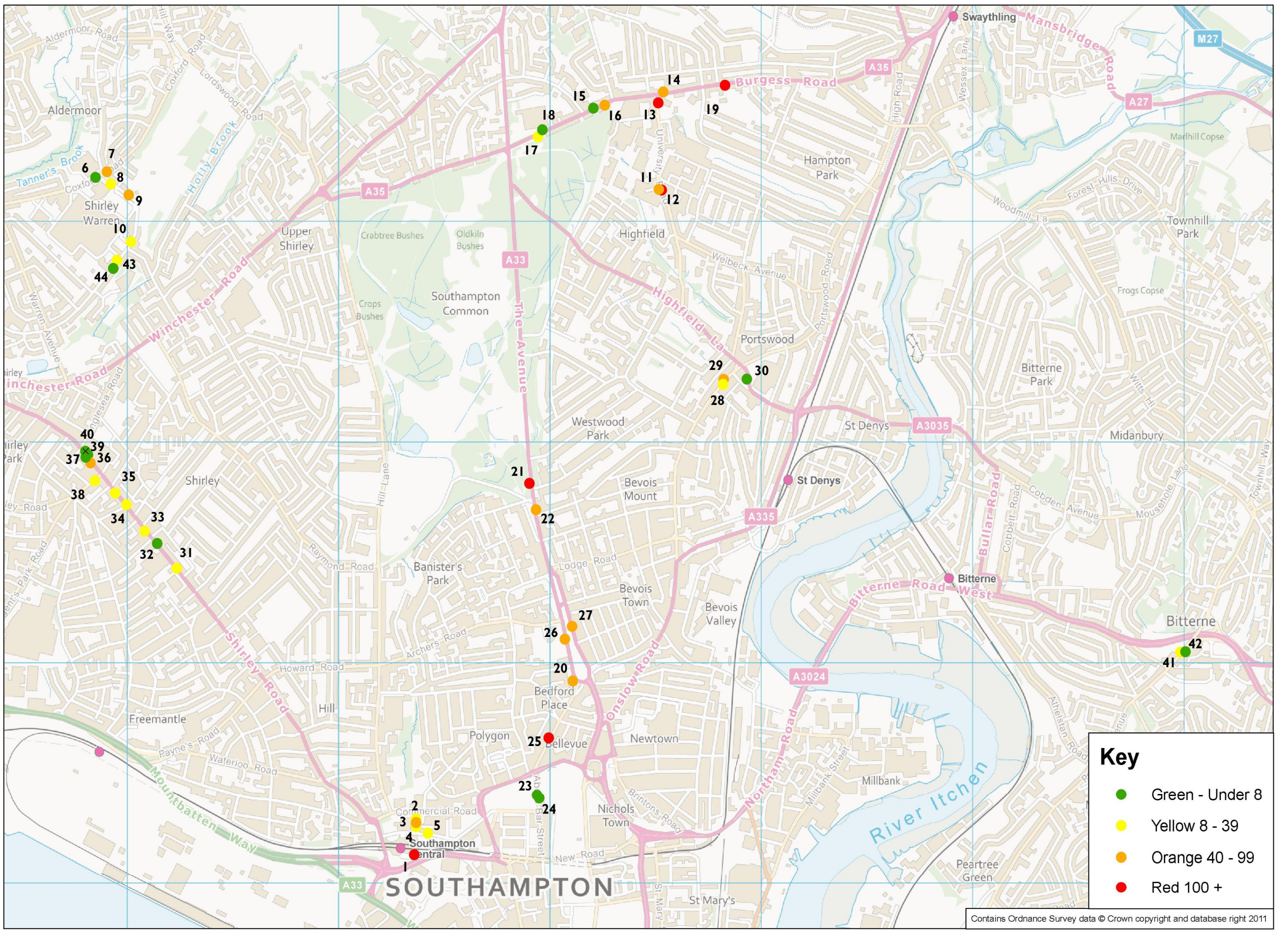

Figure 5.5: Map displaying all stops colour coded for total hits

Table 5.6 below displays the average hits per stop by geographical area over the life of the trial. As with figure 5.5 above, it is clear usage varies substantially by area. This is again discussed further after adjusting for footfall.

Area	Average Hits Per Stop
Railway Station	50.4
Southampton General Hospital	28.43
Southampton University	61.33
Portswood	54.91
Shirley	17.5
Bitterne	14

Table 5.6: Average unadjusted hits per stop by geographical area

In terms of the stop type, stops with a shelter had a total average per stop hit rate of 41.44 while stops without a shelter showed an average of 53.00 hits per stop. There were however only three stops in the sample without a shelter therefore testing a significant difference in the average QR code usage between these stop types was not conducted due to insufficient data. However the above does suggest stop type has an effect on QR code use. This is intuitively correct as waiting at a stop with no shelter is likely to be less comfortable, with a higher associated disutility of wait time. This suggests passengers would benefit more from using the QR code to obtain their remaining wait time, reducing its uncertainty and therefore disutility or cost.

This result is heavily dependent upon footfall at stops, as shelters are likely to be provided at stops with high footfall and therefore are likely to demonstrate greater QR code use meaning the result is likely to be more pronounced when accounting for footfall. Disappointingly it was not possible to obtain footfall data for any stops without a shelter therefore substantially higher QR code use proportional to the number of passengers using stops without a shelter, while appearing likely, cannot be substantiated.

Finally, unadjusted hit rates at stops with and without a functioning telematic display were very similar. Average hits per stop with a display were 42.38 and without were 42.19. Implications are again discussed further upon adjusting for footfall.

5.2.2 Adjusting for Footfall

It is important to examine the above results with QR code use adjusted for the number of passengers boarding at each stop. As discussed above there were issues obtaining footfall data at stops therefore only stops for which accurate data was obtained were included. The higher the usage figure adjusted for footfall, the greater the proportion of passengers at that stop used the QR code. The above factors affecting uptake are re-examined below using the comparative rather than absolute, unadjusted data.

5.2.3 Poster Type

Adjusting for footfall continued to demonstrate higher use at stops with a minimal poster in comparison to a full poster; the average footfall adjusted usage figure for minimal stops is 0.193 compared to 0.147 for full poster stops; 31% greater use.

In testing if uptake as a proportion of footfall is significantly higher with a minimal poster the following hypotheses are defined:

H_0: Average hits per stop adjusted for footfall with a minimal poster displayed = Average hits per stop adjusted for footfall with a full poster displayed

H_1: Average hits per stop adjusted for footfall with a minimal poster displayed > Average hits per stop adjusted for footfall with a full poster displayed

Both distributions can be considered normal; equal variances cannot be assumed. A one sided a two sample t-test p-value of 0.243 is greater than the critical value of 0.05 required, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no significant difference between QR use adjusted for footfall resulting from displaying minimal and full posters.

It appears promotion and providing instructions has no impact on QR code use. The absolute average hits per stop was actually substantially higher for the basic poster compared to its full counterpart (47.16 compared to 38.21 respectively). When adjusting for footfall average hits per stop were 31% greater at stops displaying a minimal poster. This was however not statistically significant as the null hypothesis of equal means could not be rejected, therefore it appears poster type has no effect on usage. This result is of particular interest to bus operators and those publishing literature incorporating QR codes generally, demonstrating there is no benefit in using resources and display space providing instructions or promoting use.

5.2.4 Geographical Disparity

Table 5.9 below displays the average hits per stop adjusted for footfall by geographical area over the life of the trial. Figure 5.7 and 5.8 graphically display hits by area unadjusted and adjusted for footfall for comparison.

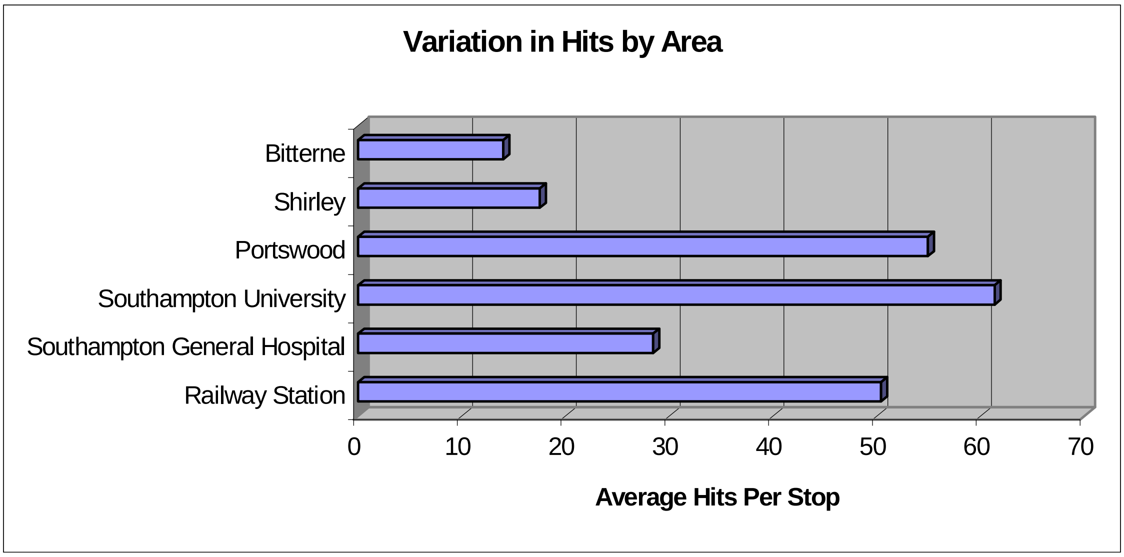

Figure 5.7: Unadjusted hits by geographical area

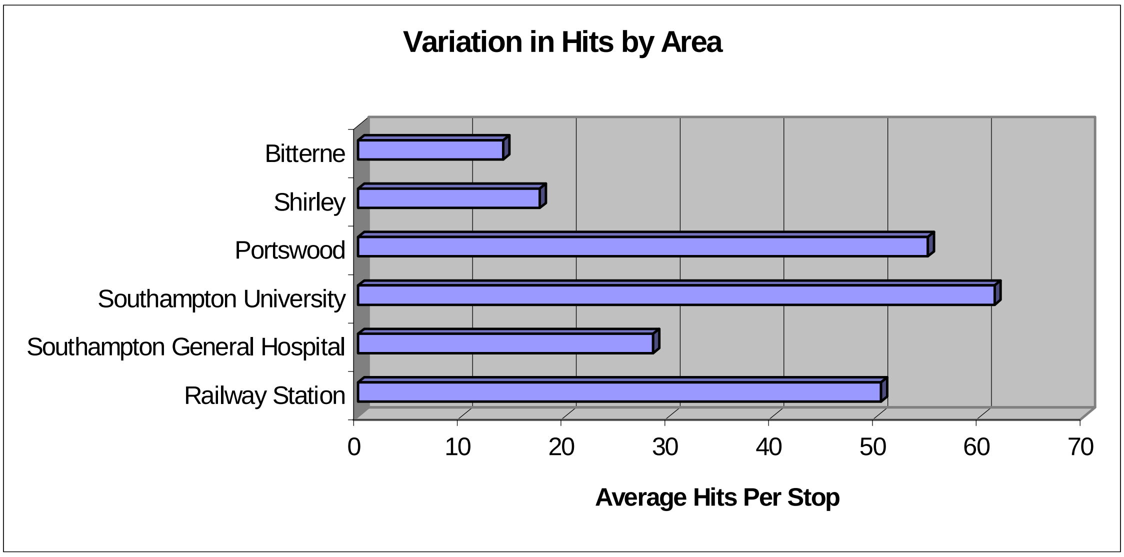

Figure 5.8: Adjusted hits by geographical area

Area	Average Adjusted Hits Per Stop
Railway Station	0.168
Southampton General Hospital	0.190
Southampton University	0.359
Portswood	0.215
Shirley	0.099
Bitterne	0.024

Table 5.9: Average adjusted hits per stop by geographical area

In terms geographic area there appears to be a large location disparity in QR code use with low uptake in the suburban areas of Shirley and Bitterene and much higher use in the urban area, the transport hub of Southampton railway station and Southampton University. Taking account of footfall leaves the rank order of uptake by area virtually unchanged. The University continues to demonstrate the greatest use per passenger and Bitterne (suburban) still the least. However the disparity of use is far more striking when accounting for footfall. For example there was approximately four times the use in terms of absolute hits around the university compared to the suburban areas; when accounting for footfall there is up to 15 times the use around the university. The hospital, station and urban areas also display much greater usage when accounting for footfall compared to Shirley and Bitterne.

It is worth noting the footfall survey was conducted during university holidays and a proportion of this trial, although the minority was conducted during term time. The result being the university area footfall figures used to adjust the hits data are likely to be lower than the actual footfall over this trial giving an artificially high adjusted hits per stop figure.

Nevertheless the difference in use by area is undoubtedly large with various potential causes. It is possible age and affluence of the local population affect smartphone ownership and therefore QR code use. Education levels leading to the desire to experiment with a new system could also be a factor. A further possibility is highlighted by Wardman et al. (2001); real time information at transfer points was found to be very important, especially for occasional users. This could explain the high QR code use in Portswood and especially at the transport hub of Southampton railway station where a reasonably high proportion of passengers are likely to interchange. Further research is required to define and separate the underlying factors causing such disparity of use.

The geographic disparity highlighted by this study could be of interest to information providers with limited resources wishing to direct spending in the most effective way. If QR code posters (more likely as an additional feature on the stop timetable) could not be provided for all stops it is more efficient to target urban, education and interchange points rather than suburban centres. These results suffer from lack of locational variety, being clearly geographically specific to the medium sized urban setting of Southampton. Research into other cities or areas would be required to validate the relationship and allow extrapolation of results with confidence.

An important point related to geographical location is rural areas, where system use is likely to be seriously impeded if not completely inoperable due to mobile internet access. The amount of data downloaded when accessing arrival times is small; however access could still be slow if the connection is poor and, as in many rural areas, if there is no mobile internet access the system will not work. However, this is mitigated somewhat as real-time information provision (and bus use generally) tends to be concentrate in urban and suburban areas, therefore the QR code system would be less beneficial in rural areas anyway.

5.2.5 Display Presence

When accounting for footfall, average hits were higher for stops without a display at 0.186, although not substantially so as stops with a display yielded an average of 0.155.

Testing if QR code use at stops without a display was significantly greater than stop with a display:

H_0: Average hits per stop adjusted for footfall with no display = Average hits per stop adjusted for footfall with a display
H_1: Average hits per stop adjusted for footfall with no display > Average hits per stop adjusted for footfall with a display

Both distributions can be considered normal; equal variances can be assumed. A one sided two sample t-test p-value of 0.160 is greater than the value of 0.05 required, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no significant difference between QR use adjusted for footfall resulting from the presence of a telematic display.

Initial inspection suggests the presence of a functioning telematic display made no difference to QR code use. Average hits per stop with a display present were 42.38 and without a display were a very similar 42.19. However, as with shelters above, it is more likely a display will be installed at a stop with high footfall therefore presumably rendering results sensitive to footfall. When accounting for footfall as expected average hits were higher for stops without a display. However, there was no significant difference between average QR use per stop adjusted for footfall relating to the presence of a telematic display; this suggests QR codes are just as advantageous at stops with a display present as those without. This is surprising as with a display present bus arrival times are readily available. There are however more times available through the QR code link and it is possible passengers expected to obtain different or possible better information through using the link. There may also have been an element of users experimenting with the new technology.

The result above is also supported by the street survey results through examination of the following question:

Are QR codes more useful at stops without displays? That is, is there a difference in the change of acceptability of wait time when at a stop with a display and without a display?

H_0: There is no association between a display being present and the change in acceptability of wait time.

H_1: There is an association between a display being present and the change in acceptability of wait time.

Does receiving this information make waiting for your bus more acceptable?				
[Observed]	Much More	A Little More	Do Difference/A Little Less/Much Less	Total
Display	11	16	13	40
No Display	6	13	8	27
Total	17	29	21	67
[Expected]	Much More	A Little More	Do Difference/A Little Less/Much Less	Total
Display	10.2	17.3	12.5	40
No Display	6.9	11.7	8.5	27.1
Total	17.1	29	21	67.1

Table 5.10 Changes in acceptability of wait time due to display presence; observed and expected values

Z = 0.470; degrees of freedom 2; α = 5%

Using the Chi-Square distribution table, the critical value of χ^2 is 5.99

The χ^2 test statistic value (0.470) is not in the critical rejection region, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no significant difference in the proportions of answers relating to the increased acceptability of wait time between respondents undertaking the survey at a stop with a display and those without a display. That is, respondents did not find waiting time significantly more acceptable due to QR code use when a display was not available.

This suggests the incentive to use the QR code link at such a stop is no greater than at a stop with a display, and may explain why use at without display stops is not significantly greater. This is surprising as it seems logical to expect passengers waiting at a stop with no real-time display to have more incentive to expend the effort required to obtain them. The test statistic value was close to the rejection region and with more data it is possible there would have been a significant difference in changes in the acceptability of wait time and also possibly significantly greater hits at without display stops also.

5.3 Survey Data

5.3.1 Demographics

The total number of complete surveys collected was 32 mobile surveys and 67 street surveys giving a total data set of 99 surveys. Data from the street and mobile surveys was amalgamated where the same or very similar questions were asked.

In demographic terms the sample was reasonably evenly split between male and female participants with 51 female and 48 male respondents. The sample age was heavily skewed towards younger generations as can be seen in table 5.11 below, with 80% of the sample population being under 40 years of age. This is partly due to smartphone ownership being predominantly with younger generations (Ofcom, 2011) and therefore the mobile survey being more likely to attract younger participants. Also, around one third of the surveys were carried out at the university as it was felt more smartphone users and would be found in this location; this has an obvious correlation to younger participants. The weighting to younger respondents did not cause any analytical problems.

Age Group	**Frequency**
Under 18	6
18-24	42
25-39	31
40-60	10
60+	10
Total	99

Table 5.11: Frequency of sample age groups

The sample displayed a weighting towards frequent bus users with 80% of respondents usually using a bus more than once a week (table 5.12 below). This skewness is not surprising as there is natural selection at work in that a regular bus users are more likely to be found at a bus stop and therefore more likely to complete a survey.

Usual days per week of bus use	Frequency
5-7 Days	31
4-5 Days	24
2-3 Days	24
1 Day	6
Less than one day	14
Total	99

Table 5.12: Frequency of sample bus use

The majority of respondents (64%) appear to be commuters travelling for either work or education; this supports the high frequency of travel observations above and can be seen in figure 5.13 below. The ‘other’ trips category was largely respondents travelling for hospital appointments interviewed at stops around the hospital.

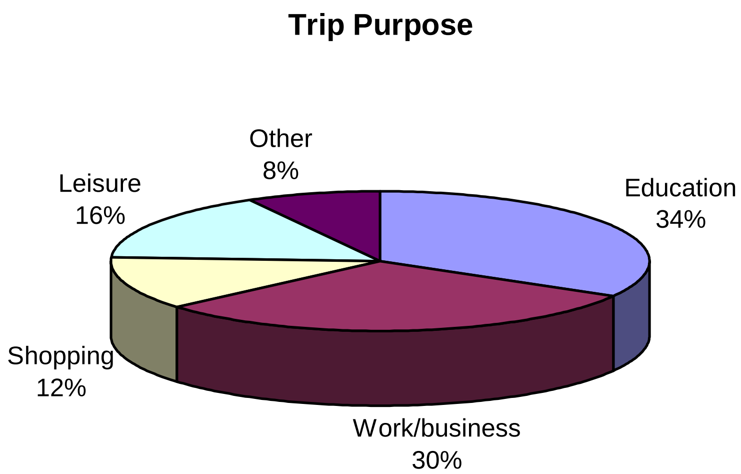

Figure 5.13: Trip purpose

Turning to smartphone ownership, 45% percent of the 67 street survey interviewees owned a smartphone; the makes of which can be seen in figure 5.14 below.

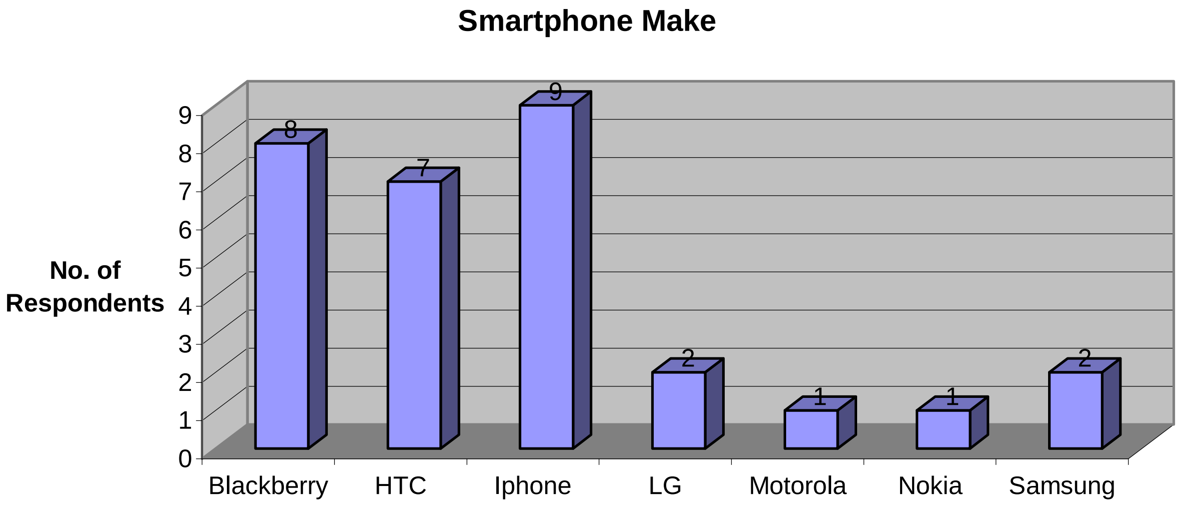

Figure 5.14: Respondents' smartphone brands

The proportion of respondents participating in the street survey who owned a smartphone was higher than the national average - 45% to 27% respectively (Ofcom, 2011). This is almost certainly due to the street survey locations being chosen to target smartphone users. The results suggest Blackberry, HTC and Iphone are most popular makes owned in the Southampton area so those wishing to provide mobile web-base information should create or adapt sites to perform optimally on the operating systems of these phones. The sample size was relatively small, however, so these results only provide a rough guide to phone ownership in the area.

5.3.2 Current Arrival Time Knowledge

Seventy two percent of respondents, that is 48 of the 67 street survey respondents, knew the arrival time, not necessarily in real-time, of their bus. The methods used to gain bus arrival times information can be seen in Figure 5.15 below.

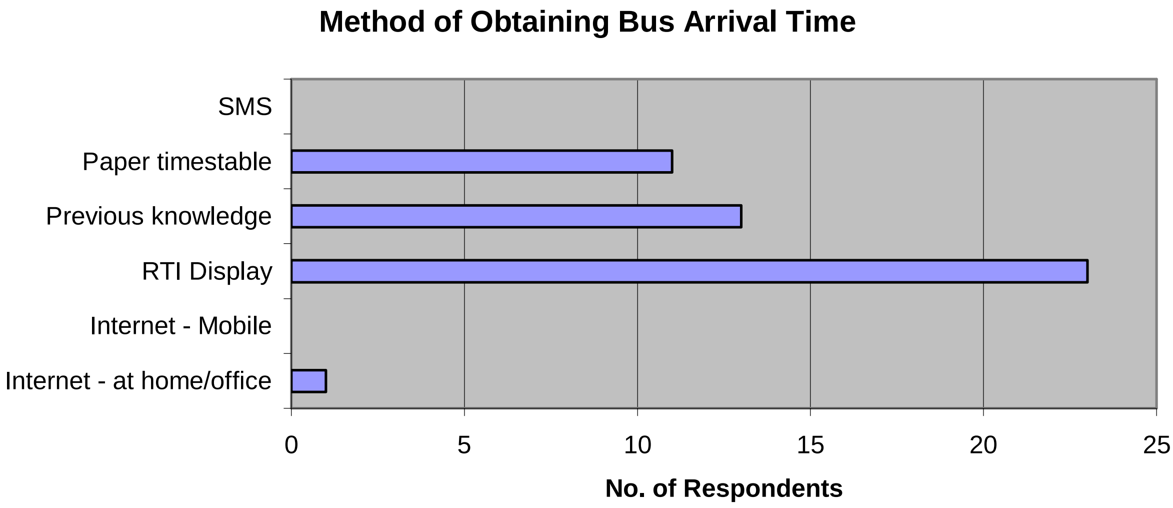

Figure 5.15: Methods respondents used to obtain bus arrival time

The most popular method was at stop real-time information displays with 48% of respondents who knew their bus's arrival time gaining it through this method.
Less than 34% of all respondents knew the expected arrival time of their bus in real-time – all from RTI displays as no passengers interviewed used mobile internet to obtain their bus's arrival time. This is 'less that 34% percent' as some display times are not real-time but from timetable information. The low level of real-time arrival information knowledge supports the introduction of arrival time provision through QR code use as an alternative method of providing passengers with real-time information.
It was also surprising to find no respondents of the 67 questioned during street surveys used the SMS service. QR code links could potentially replace this service and surpass its popularity giving not only essentially free but often real-time information.

5.3.3 Ease of System Use

Respondents were asked to rate how easy it was to obtain their bus arrival time through use of the QR code system. Results are an amalgamation of responses from the mobile survey and the street survey, which included a demonstration. Eighty one percent of respondents thought the system either very or quite easy to use.

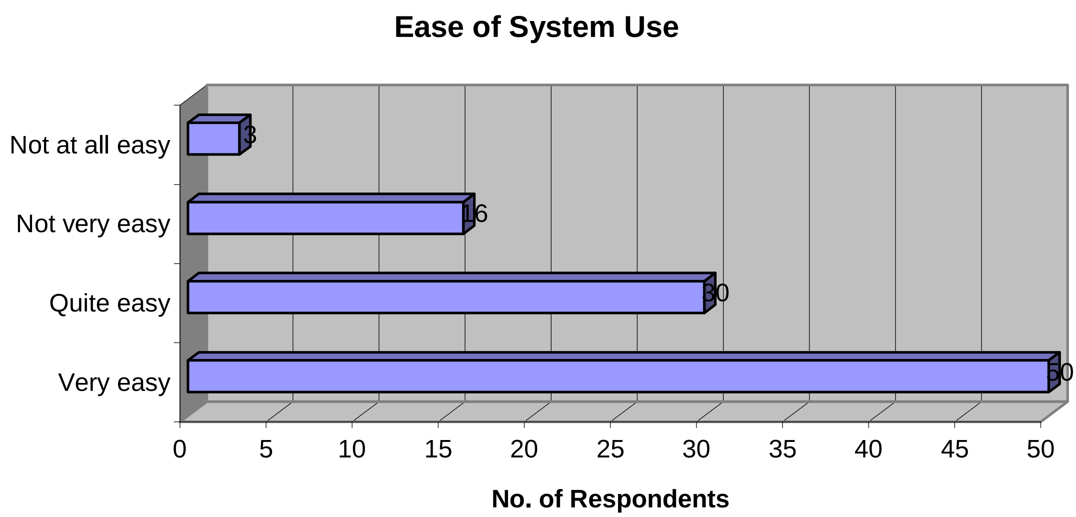

Figure 5.16: Ease of obtaining bus arrival time through QR code use

In terms of easy of use of the QR code system the response was clearly very positive. Over four-fifths of respondents stated the system was either very or quite easy to use; this was higher than expected as 37% of the whole sample population did not own a smartphone and it was thought they find the system difficult to grasp. This is supported by statistical analysis outlined below finding no significant association between easy of obtaining arrival information through QR code use and smartphone ownership. However, non-smartphone owners did find system use significantly more difficult to use at the 10% significance level suggesting in reality some may find it challenging. This does not have implications for QR code rollout as only smartphone users would be able to access the system.

Do smartphone owners find the technical aspect of obtaining arrival times through QR code use less challenging?

H_0: There is no association between ease of obtaining bus arrival times and owning a smartphone.

H_1: There is an association between ease of obtaining bus arrival times and owning a smartphone.

How easy was it to get the estimated bus arrival time?				
[Observed]	Very Easy	Quite Easy	Not Easy	Total
Smartphone	36	18	8	62
No Smartphone	14	12	11	37
Total	50	30	19	99
[Expected]	Very Easy	Quite Easy	Not Easy	Total
Smartphone	31.3	18.8	11.9	62
No Smartphone	18.7	11.2	7.1	37
Total	50	30	19	99

Table 5.17: Easy of system use in relation to smartphone ownership; observed and expected values

Z = 5.398; degrees of freedom 2; α = 5%

Using the Chi-Square distribution table, the critical value of χ^2 = 5.99

The χ^2 test statistic value (5.398) is not within the critical rejection region, therefore there is sufficient evidence at the 5% significance level to reject the null hypothesis. There is no significant association between easy of obtaining arrival information through QR code use and smartphone ownership.

Do older people find the technical aspect of obtaining arrival times through QR code use more challenging?

H_0: There is no association between ease of obtaining bus arrival times and being aged forty and over

H_1: There is an association between ease of obtaining bus arrival times and being aged forty and over

How easy was it to get the estimated bus arrival time?				
[Observed]	Very Easy	Quite Easy	Not Easy	Total
40+	6	5	9	20
<40	44	25	10	79
Total	50	30	19	99
[Expected]	Very Easy	Quite Easy	Not Easy	Total
40+	10.1	6.1	3.8	20
<40	39.9	23.9	15.2	79
Total	50	30	19	99

Table 5.18: Easy of system use in relation to age; observed and expected values

Z = 11.225; degrees of freedom 2; α = 5%

Using the Chi-Square distribution table, the critical value of χ^2 = 5.99

The χ^2 test statistic value (11.225) is in the critical rejection region, therefore there is sufficient evidence at the 5% significance level to reject the null hypothesis. There is an association between easy of obtaining arrival information through QR code use and age. Examining the difference between the expected and observed values it seems there is a significantly higher proportion of 40 and over participants believing the system is not easy to use.

It could be assumed that age is correlated to not owning a smartphone which would lead to potential difficulty in use, however the above result found no significant correlation between smartphone ownership and easy of use. Again this should not affect QR code implementation as there are a number of alternative methods of obtaining bus arrival times which the QR code link would complement. Hence it would not be necessary to provide access for all bus travellers, which is not possible by the nature of the system. Those providing QR codes may, however, wish to think about strategies to make them more accessible to older generations who do own a smartphone, for example clear, simple signing and instructions. This would, however, be challenging because, as stated above it, appears promotion and explanation have no effect on overall usage, although there is the possibility it would have an affect for specific demographics.

5.3.4 Behavioural Change

Table 5.19 below gives respondents' responses to receiving their bus arrival time. Results from the revealed preference mobile survey and the stated preference street survey have been combined.

Response to Receiving Bus Arrival Time	**Frequency**
Wait at the stop for your planned bus	91
Go away from the stop (e.g. shopping, bank, café) and return	5
Go to a different bus stop	3
Wait at stop but take a different bus	0
Change your destination	0
Walk the whole journey	0
Get a taxi or lift	0
Other	0
Total	99

Table 5.19: Respondents' responses to receiving their bus arrival time

Behavioural change due to respondents receiving their bus arrival time was limited. Only 8% of respondents in total either modified their behaviour (in the mobile survey) or stated they would do so (in the street survey). This is lower than the 12.6% found by Brown's (1997) observations. There is a valid reason for this in that respondents who arrived at a stop checked the RTI display or paper timetable and modified their behaviour by leaving the stop were much less likely to be interviewed in the street survey as they would be present at the stop for a much shorter time. Mobile survey respondents could suffer from the same issue as users are less likely to complete the mobile survey when changing behaviour than simply waiting at the stop.

Furthermore, studies conducted by Caulfield & O'Mahony (2004) and Brown (1997) examined passengers faced with a 'long wait', of approximately 15 minutes; the average wait of Southampton users is substantially shorter. The estimated wait time from the QR code demonstration of each respondent participating in the street survey was recorded. The average expected wait time of respondents was 5 minutes 16 seconds, reducing the incentive and opportunity for passengers to modify their behaviour.

It is logical to assume QR codes placed at stops with less frequent services would be of greater benefit to users in terms of affording them the opportunity to modify their behaviour. The possibility of users receiving the arrival time of their bus being more valuable when in conjunction with a longer wait was also investigated as can be seen below. There was no significant association between the length of wait time and the change in its acceptability due to QR code use. However, this is not surprising as the relatively small proportion of participants changing their behaviour was unlike to be picked up in the Chi-squared test even if there was a positive effect on the acceptability of wait time.

Warman (2003) suggests a further explanation for the low use of wait time. Utilisation of wait time is most likely to occur when passengers have learnt to have full confidence in the information on display. It may be the case that had the trial been run for longer and been more comprehensive bus users would gain confidence in it and in the longer term a higher rate of utilisation of wait time may have been observed.

Does receiving information in this way reduce the cost of wait time more when the wait is long or short? That is, is there a more positive change in acceptability of wait time for a long wait, a short wait or no significant difference?

A short wait is defined as five minutes or less and a long wait as six minutes and over.

H_0: There is no association between the length of wait time and the change in acceptability of wait time

H_1: There is an association between the length of wait time and the change in acceptability of wait time

Does receiving this information make waiting for your bus more acceptable?				
[Observed]	Much More	A Little More	Do Difference/A Little Less/Much Less	Total
Short Wait	13	9	14	36
Long Wait	8	15	8	31
Total	21	24	22	67
[Expected]	Much More	A Little More	Do Difference/A Little Less/Much Less	Total
Short Wait	11.3	12.9	11.8	36
Long Wait	9.7	11.1	10.2	31
Total	21	24	22	67

Table 5.20: Change in acceptability of wait time in relation to length of wait; observed and expected values

Z = 3.989; degrees of freedom 2; α= 5%

Using the Chi-Square distribution table, the critical value of χ^2 = 5.99

The χ^2 test statistic value (3.989) is not in the critical rejection region, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no association between the length of wait time and the change in acceptability of wait time due to QR code use.

Respondents stating they did or would change their behaviour all chose one of two options; five leaving the stop and returning and three going to a different stop. This is broadly consistent with the findings of previous studies (Brown, 1997, Caulfield & O'Mahony, 2004) however, to gain a full picture of the effect of arrival time provision through QR code use much more data would be required, ideally through time consuming observation rather than stated preference surveying. It is reasonable to assume any modification to bus users' planned journey facilitated through QR code use are positive and beneficial in reducing the disutility or cost of wait time, therefore reducing the generalised cost of bus use and making bus travel more attractive. Although observed changes in behaviour were limited it is believed that if introduced on a large scale QR codes could have valuable advantages to travellers making better use of wait time or journey modifications (route, destination or mode).

5.3.5 System Accuracy and Reliability

For passengers to change their behaviour based on the predicted bus arrival time they must have confidence in the accuracy and reliability of the system. Respondents to the mobile survey were asked to estimate the difference between the predicted and actual arrival time of their bus; results of this are shown in table 5.21 below. It was impractical to include this question in the street survey as it would have been necessary to continue the interview until the respondent's bus arrived. The response rate to this question was good (81%) considering respondents could easily have completed the survey waiting at the stop before their bus arrive and therefore would not be able to make the estimate.

Disparity of predicted and actual arrival time	Frequency	% Exc. DK
Under 1	11	42
1-2	7	27
2-5	5	19
Over 5	3	12
Don't know	6	N/A
Total	32	100

Table 5.21: Disparity between predicted and actual arrival times of respondents buses

The sample is however small and not a good representation of how accurately the Stopwatch algorithms predict bus arrival time in Southampton as it is highly likely to include results from passengers catching a bus where timetable information, rather than real-time, is provided through the QR code link. It does however give some idea of how the system as it stands functions in term of accuracy. Warman (2003) finds passengers have a reasonably high tolerance when the disparity between produced and actual arrival time is under 5 minutes and as 88% of predicted times were under this it suggests the system is accurate enough to be valuable. This is well below the 98% Stopwatch accuracy level reported by Clowes (1996). In fact, given the poor timekeeping of buses in Southampton (63% on time record, (Southampton City Council, 2008)) the result suggests Stopwatch is performing well, compensating for any timetable information in the results and leading to the reasonable level of perceived accuracy shown.

Functional reliability of the QR code system itself appears high with no system failures during the street survey demonstration scans and only one reported failure from the mobile survey stating ‘no time displayed’ which would have been a fault with Stopwatch rather than the QR code link. This is somewhat misleading, however, as any users having difficulty with the system are much less likely to reach the webpage with the mobile survey link and as such the problem would remain unreported. It is also worth noting no vandalism occurred; there was a concern others may generate QR codes linking to inappropriate websites and place them over the trial QR codes. This appears not to have happened and would be very obvious if placed on the outside of the timetable case.

5.3.6 Psychological Effects

Figure 5.22 below shows the change in acceptability of wait time due to respondents receiving bus arrival times.

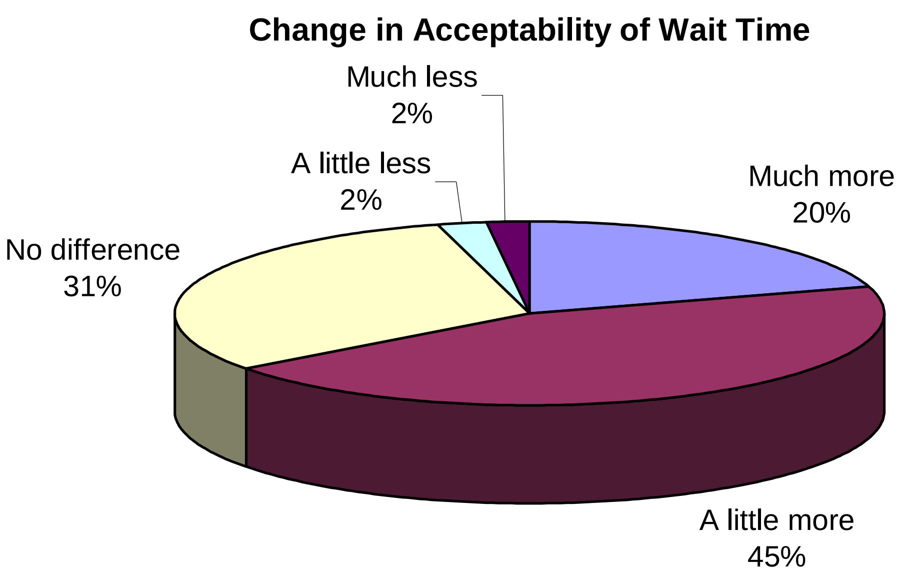

Figure 5.22: Change in how acceptable respondents find wait time due to receiving bus arrival times

Results regarding the change in acceptability of wait time due to arrival time provision were very positive with over two thirds of respondents feeling this made their wait more acceptable; this is very similar to the research into StarTrak (DfT, 2010) where 68% felt waiting was made more acceptable. Only 4% of respondents to the QR code surveys stated that knowing their wait time made waiting for their bus less acceptable. The increased acceptability stems from the positive psychological factors of increased feelings of security, reduced uncertainty and reduced effort (Dziekan & Kottenhoff, 2007). As the question was designed to encompass all the above it is not possible to distinguish which factor contributed most heavily to the increase in acceptability. While being of interest the important point is acceptability of wait time seems to have been substantially improved.

It was thought it might be the case that either regular, familiar travellers or infrequent, less familiar travellers may benefit more from QR code use in terms of improving acceptability of wait time; infrequent travellers due to easing the anxiety of not knowing when an unfamiliar bus is due to arrive and frequent travellers as warnings of delays may be more useful to those on a schedule and with a good knowledge of the local transport network. As can be seen below there was, however, no association between frequency of travel and the change in acceptability of waiting time due to QR code use. It seems both groups valued the change and valued it in statistical terms equally. This supports the findings above relating to day and time of QR code use suggesting the system is used and valued by both groups of travellers.

Does arrival time prevision through the QR code link have a greater effect on the acceptability of wait time for frequent or infrequent travellers? That is, do occasional travellers display a greater change in acceptability of wait time than frequent traveller, vice versa of no difference?

A frequent traveller defined as a respondent who usually uses a bus four days per week or more.

H_0: There is no association between a frequency of travel and the change in acceptability of wait time.

H_1: There is an association between a frequency of travel and the change in acceptability of wait time.

Does receiving this information make waiting for your bus more acceptable?				
[Observed]	Much More	A Little More	Do Difference/A Little Less/Much Less	Total
Frequent	15	26	13	54
Infrequent	16	18	11	45
Total	31	44	24	99
[Expected]	Much More	A Little More	Do Difference/A Little Less/Much Less	Total
Frequent	16.9	24	13.1	54
Infrequent	14.1	20	10.9	45
Total	31	44	24	99

Table 5.23: Change in acceptability of wait time in relation to frequency of bus use; observed and expected values

Z = 0.837; degrees of freedom 2; α = 5%

Using the Chi-Square distribution table, the critical value of χ^2 = 5.99

The χ^2 test statistic value (0.837) is not in the critical rejection region, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis; there is no association between a frequency of travel and the change in acceptability of waiting time due to QR code use.

Figure 5.24 below displays the stated change in respondents' feelings of safety upon receiving their bus arrival time through QR code use.

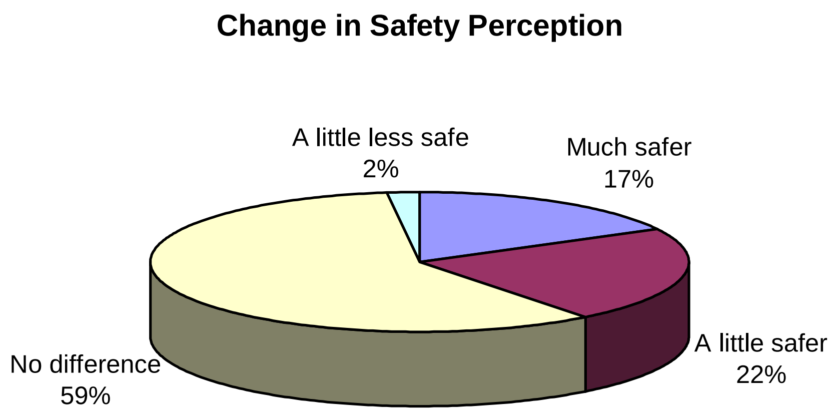

Figure 5.24 Change in feelings of safety due to receiving bus arrival information

The psychological effects of increased security or safety were deemed sufficiently important to merit individual scrutiny. Upon initial inspection results again appear positive with a total of 39% of respondents feeling either a little or much safer, 2% feeling a little less safe and no respondents feeling much less safe as a result of arrival time provision.

A greater proportion of females stated that receiving arrival times enhance feelings safety whilst waiting for their bus; 53% in contrast to 25% of male respondents. However when compared to the StarTrak study investigating the installation of RTI displays (DfT, 2010) 82% of female and 61% of males stated increased feelings of safety. This suggests the QR code link has less impact on feelings of safety in comparison to a display, although results from London's Countdown system (Warman, 2003) were more in line with this study.

Possible reasons for the comparatively low change in feelings of safety could be passengers have less faith in the accuracy of the QR code link, feel safer in Southampton than other cities initially or possibly the methodology or phrasing of the question had an effect. Also the majority of surveys were undertaken during daylight hours which is likely to have a substantial effect of responses. The study did showed feelings of safety increased, which was not the case in the study by Dziekan & Vermeulen (2006).

As with Warman (2003) and DfT (2010) it was the case that females benefited more from the system and a Chi-squared test revealed a significantly higher proportion of female respondents exhibited positive changes in feelings of safety compared to males as can be seen below.

Are changes in feelings of safety due to arrival time knowledge greater in females than males?

H_0: There is no association between the change in feelings of safety and gender

H_1: There is an association between the change in feelings of safety and gender

Does the information provided make you feel safer while waiting for your bus?				
[Observed]	Much Safer	A Little Safer	No Difference/Less Safe	Total
Male	5	7	36	48
Female	12	15	24	51
Total	17	22	60	99
[Expected]	Much Safer	A Little Safer	No Difference/Less Safe	Total
Male	8.2	10.7	29.1	48
Female	8.8	11.3	30.9	51
Total	17	22	60	99

Table 5.25: Change in feelings of safety in relation to gender; observed and expected values

Please note one male and one female felt a little less safe, no participants felt much less safe.

Z = 8.081; degrees of freedom 2; α = 5%

Using the Chi-Square distribution table, the critical value of χ^2 = 5.99

The χ^2 test statistic value (8.081) is in the critical rejection region, therefore there is sufficient evidence at the 5% significance level to reject the null hypothesis. There is an association between changes in feelings of safety due to QR code use and gender. Examining the difference between the expected and observed values it is clear females experienced a greater heightening of feelings of safety than males.

The changes in the acceptability of wait time and feelings of safety, possibly in conjunction with other positive effects such as better use of wait time or modified travel to some extent reduce the cost of bus travel. As the generalised cost function of a mode of travel falls it follows that demand for that mode should increase, either through more frequent use by existing travellers or modal shift. The implication is for patronage increases or at least helping to stem declining bus use.

5.3.7 Patronage Effects

A total of 55% of respondents stated they were either a little or a lot more likely to use a bus due to receiving bus arrival times through the QR code link, with almost a quarter being a lot more likely. Forty four percent of respondents felt it would make no difference to their bus use while no users felt it would make them either a lot or a little less likely to use a bus.

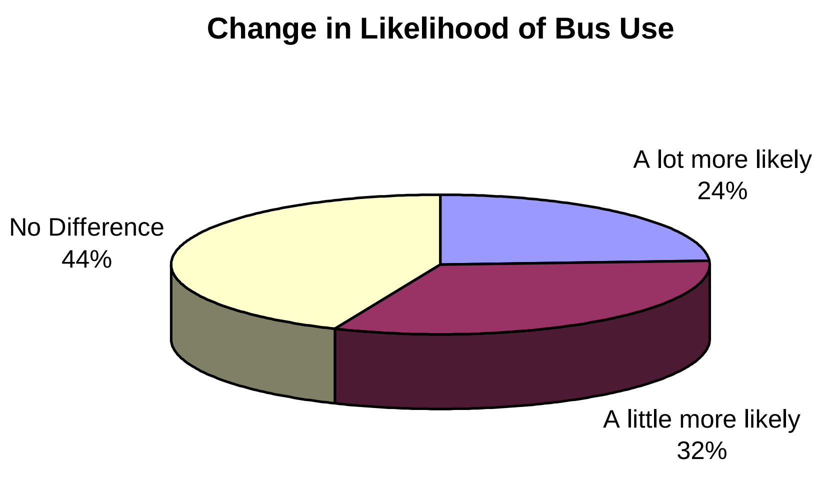

Figure 5.26: Respondents stated change in the likelihood of using a bus due to receiving arrival times

The results suggest QR code scheme introduction may produce a substantial increase in passenger numbers. Previous studies, however, advise this result should be treated with extreme caution. Stated preference surveys in this area (Dziekan & Kottenhoff (2007), Grotenhuisa et al (2007), Dziekan (2004)) get very positive results such as this but comparable before and after studies show RTI provision has a small, if not negligible effect on patronage (Dziekan (2004) Warman (2003), Brown (1997)). Furthermore, as non bus users did not feature in the study it is impossible to say what effect, if any, QR Code introduction would have on mode shift. Experience again suggests that in the short term at least mode shift effects are very limited, however information provision may contribute to positive longer term changes in attitude towards bus use (Grotenhuisa et al, 2007).

A possible reason, beyond general over optimism of responses, for the unrealistically high potential effects on patronage is the problem of acquiescence. That is the interviewee telling the interviewer what they believe they want to hear. In the case of the street survey this problem may be especially salient for two reasons. Firstly, it was fairly obvious this was a small scale trial and the interviewer was likely to have an interest in the projects success and secondly, it was easy to distinguish a positive and negative answer for a number of questions. The problem of acquiescence is likely to have occurred to varying degrees with questions regarding easy of use, wait time acceptability, safety and increased bus use.

Regardless of the above caveats it is clear the QR code system was warmly received by the majority of respondents. An attempt was made to explore which group any patronage increases would stem from should they occur; commuters or leisure travellers. This is shown below. The test for homogeneity found no significant difference in the proportions of the responses and therefore any patronage increase is equally likely to come from both groups.

Which user group is likely to be most affected in terms of increased patronage? That is, will non-commuters increase bus use due to QR code introduction more than commuters?

H_0: There is no association between trip purpose and the likely change in future bus use

H_1: There is an association between trip purpose and the likely change in future bus use.

Does receiving bus arrival times in this way make you more or less likely to use a bus?				
[Observed]	A Lot More	A Little More	No Difference	Total
Commuting	12	11	18	41
Non-commuting	3	9	9	21
Total	15	20	27	62
[Expected]	A Lot More	A Little More	No Difference	Total
Commuting	9.9	13.2	17.9	41
Non-commuting	5.1	6.8	9.1	21
Total	15	20	27	62

Table 5.27: Change in likely bus use in relation to journey purpose; observed and expected values

Please note the total number of respondents is correct at 62 (32 mobile survey respondents and 30 smartphone owners from the street survey).

Z = 2.390; degrees of freedom 2; α = 5%

Using the Chi-Square distribution table, the critical value of χ^2 = 5.99

The χ^2 test statistic value (2.390) is not in the critical rejection region, therefore there is insufficient evidence at the 5% significance level to reject the null hypothesis. There is no association between trip purpose and the likely change in future bus use due to QR code use.

5.3.8 Knowledge of Real-Time Provision and Respondent Comments

Twenty one percent of those interviewed during the street survey believed they knew the difference between bus arrival times displayed as a time of day and those displayed as a countdown. Of these half, that is 7 respondents from a total of 67 (10%), correctly stated the difference. There is clearly very poor knowledge of where arrival times are real-time and where they originate from timetable information. Explanation of this by providers is likely to be beneficial as users would be able to establish which arrival times can be relied upon and confidence in the system generally, whether through the QR code link or displays, should increase, especially given the reasonable poor timekeeping of Southampton buses. As described above confidence in the accuracy of arrival time predictions is a vital prerequisite for achieving the beneficial effects associated with bus arrival information provision.

Finally, comments boxes were included on both the mobile and street survey. The majority of comments actually came from the mobile survey and most were positive including:

- *Brilliant system. Well done. Used the scanner and, bingo!*
- *Put qr codes at every bus stop.*
- *[Buses] never come on time. I think the code thing is amazing idea and should be carried on and should be on every bus stop in Southampton!*
- *QR code worked. Really impressed with this and will be using in the future.*
- *Shame it's not at every bus stop*
- *Very Cool, you should integrate the ferries too.*

There were three negative comments left in total:

- *Told me my bus was due in 6mins, I'm still waiting 34 mins later!!! Ridiculous, should give u updates if bus is going to be late, said 6 min ended being 42 min*
- *No time displayed*
- *Same as timetable, not much use*

6. Key Findings

The QR code trial was successful with increasing use over the life of the project.
Unprompted respondent comments were largely positive. The time trend of daily hit counts shows the project gained popularity over the time it was in operation, especially given book-marked hits were not recorded.

QR Code use was unaffected by the day of the week
There was little variation in average daily use and a One-Way ANOVA test confirmed no significant difference in average daily hits.

The QR code system was likely to have been beneficial to both regular, familiar, commuters and irregular, unfamiliar leisure travellers
Use was very consistent between weekdays/weekends and peak/inter-peak times. Also, survey results asking respondents whether they would be more likely to use the service on a familiar or unfamiliar route were reasonably evenly split (57% to 43% respectively). Furthermore, there was no significant difference in the change of acceptability of wait time between the two groups.

Scanning as opposed to entering the URL in a mobile browser was the preferred access method
Only 0.6% of hits recorded were through typing a URL

It is not beneficial to provide instructions on, or promotion of QR code use as there is no effect on uptake
Use of basic posters was higher in terms of absolute hits and footfall adjusted hits, however t-tests revealed not significantly greater for either data set.

It appears QR code posters placed at stops without a shelter receive higher QR code use

The average hit rate at stops without a shelter was substantially higher (28% greater usage) however due to insufficient without shelter stop numbers and footfall data this could not be formally tested.

There is substantial variation in use by area with the urban, university and interchange areas displaying much greater use that suburban areas.

This is true for absolute average hits per stop in given areas and even more pronounced when data is adjusted for footfall.

The presence of a display does not effect QR code use

Surprisingly the average footfall adjusted hit rate was not significantly higher for stops without a functioning display giving bus arrival times. This is supported by street survey data as respondents did not find wait time significantly more acceptable due to QR code use when a display was not available.

Use of the existing SMS arrival time service is low and could be redundant

None of the 67 street survey respondents used this service suggesting potential for replacement by essentially free and often real-time QR code provision.

The QR code system was easy to use

Eighty one percent of respondents found the system either very or quite easy to use. Easy of use was not significantly influenced by smartphone ownership, however a significantly higher proportion of respondents aged over 40 found it more challenging.

Observed behavioural change was limited; the majority was in the form of utilisation of wait time.

Due to the methodology and high service frequencies the observed behavioural change was lower than previous studies. The only observed modifications were utilisation of wait time or going to a different stop. Further research is required.

System accuracy and reliability was adequate

Eighty eight percent of respondents believed the difference between their estimated and actual bus arrival times were less than the crucial 5 minutes. There were no system errors during demonstrations or from mobile survey comments and no vandalism occurred.

Arrival time provision through QR code use substantially improved the acceptability of wait time

Sixty five percent of respondents stated receiving wait times make their wait either much or a little more acceptable. There was no significant difference in the change of acceptability of wait time between respondents at stops with and without a display, frequent and infrequent travellers or passengers faced with a short and long wait.

QR code use lead to a valuable increase in feelings of safety

Thirty nine percent of respondents, mostly interviewed during daylight hours, felt safer after receiving wait times. A significantly higher proportion of female respondents exhibited positive changes in feelings of safety.

Potential patronage increases appear large although should be treated with caution

Fifty six percent of respondents stated they would be either a little or a lot more likely to use a bus as a result of QR code use. Previous studies reveal this is likely to substantially over-represent any resulting patronage change.

Knowledge of the difference between real-time and timetable arrival information is very poor and there could be substantial benefits from improving this knowledge

Only 10% of respondents knew the difference between timetable and real-time arrival times. Confidence in the system could potentially be greatly improved by informing passengers which times can be relied upon; confidence is an essential prerequisite for reaping the benefits RTI provision.

7. Conclusions

The QR code trial can be considered a success in many ways. Uptake was reasonably high and increased over the life of the trial, even given the under-recording of book-marked hits, showing potential for much greater use. Future potential arises not only through increased awareness of the Southampton system but also, assuming current trends continue, through increasing smartphone ownership and general QR code recognition and uptake. Both are gaining popularity at a rapid rate suggesting future system usage and benefits could be large in comparison to this trial. Also, the system showed no technical errors, was widely considered easy to use, even by non-smartphone owners and no vandalism occurred. Furthermore, the trial was accurate enough to facilitate the substantial psychological benefits, increasing the acceptability of wait time and feelings of safety for many participants. Benefits arising from modified behaviour were less clear, although they could be substantial to some users over time.

QR codes potentially represent an extremely cost effective alternative to bus stop displays which involve a large capital outlay on equipment, planning permission and cable laying and also ongoing costly maintenance. The cost of QR code implementation to provide arrival times is very low; QR codes could be printed on timetables or other promotional material which is already placed at the vast majority of bus stops. The potential to replace bus stop displays with a QR code system is currently limited however. This could be viable at stops where a very high proportion of users own a smartphone, for example universities, however caution would have to be taken not to exclude or alienate travellers.

QR codes have a number of advantages over some other information dissemination methods. The webpage, displaying the next nine arrivals, often provides more information than the widely used three line, next five arrivals LED displays. QR code use could enhance access for visually impaired users as it is possible to zoom in on areas of the arrival times web page; this does however assume sufficient vision to initially complete the scan. Also, users can book-mark the webpage showing times from their regular stop or stops and access this information remotely, potentially reducing the high cost actual at stop wait time. A further potential benefit could be that scans provide optional links to other websites, not only bus times, supplying information on local amenities, a message board for travellers or a virtually infinite range of web based information sources and services.

Currently QR code implementation is a realistic, viable and desirable as an addition to, rather than replacement for bus arrival time provision methods already available. This is with the possible exception of SMS services where immediate replacement with QR code services is reasonable. QR codes are superior to SMS as receiving information is essentially free, bus arrivals are real-time where available and are automatically updated every 30 seconds. Furthermore there are less exclusion issues than complete replacement of displays as SMS users are currently required to own a mobile telephone. In the future, given continued increasing smartphone ownership and QR code use, complete replacement of displays with a system of this type could be considered.

Given the scheme’s clear current and potentially greater future benefits coupled with low implementation costs this study recommends QR code systems be implemented alongside existing information provision wherever viable; that is, any location with reliable mobile internet coverage and a substantial number of equipped buses providing real-time information availability. Should resources be limited the results suggest the areas of highest usage proportional to footfall are stops around education facilities, transport interchanges and urban centres and these areas should be targeted for the most efficient allocation of resources.

8. References

Brown S. (1997) *ROMANSE Public Transport, Information Systems (Hampshire County Council ROMANSE Project)*, Journal of Navigation (1997), 50: 14-26

Cairnsa S., Slomanb L., Newsonb C., Anablec J., Kirkbrided A. & Goodwine P. (2008) *Smarter Choices: Assessing the Potential to Achieve Traffic Reduction Using 'Soft Measures'* Transport Reviews, Volume 28, Issue 5, 2008

Caulfield B. & O'Mahony M. (2004) *The provision of on Street Passenger Information Via Real Time Passenger Information; A Case Study of Dublin*, Centre for Transport Research, Trinity College, Dublin

Caulfield B. & O'Mahony M. (2007) *An Examination of the Public Transport Information Requirements of Users*, IEEE Transactions on Intelligent Transportation Systems, Vol. 8 No. 1, March 2007

Caulfield B. & O'Mahony M. (2009) *A Stated Preference Analysis of Real-Time Public Transit Stop Information*, Journal of Public Transportation, Volume 12, No. 3, 2009

Cerreta A. (2011) *2011 Mountain Dew, Taco Bell & Frito Lay QR Code Case Studies & Campaign Statistics*, http://anthonycerreta.com/2011/05/2011-mountain-dew-taco-bell-frito-lay-qr-code-case-studies-campaign-statistics/ [Last Accessed 20.11.2011]

Chapman, S (2011) Email responding to Southampton information provision questions received 21.09.2011

Charlton G. (2011) *Two thirds of consumers don't know what QR codes are: survey*, Econsultancy Digital Marketers United, http://econsultancy.com/uk/blog/7959-two-thirds-of-consumers-don-t-know-what-qr-codes-are-survey [Last accessed 27.09.2011]

Ciabaton B. (2011) *The Direct Mail Man, Marketers here are the QR Code Statistic You've Been Looking For,* http://www.thedirectmailman.com/direct_mail_answers_for_p/2011/03/marketers-here-are-the-qr-code-statistics-youve-been-looking-for.html [Last accessed 19.11.2011]

Clowes, D. (1996) *Public Transport Electronic Systems,* W.S. Atkins Consultants Ltd, 1996 International Conference, page(s): 64 – 68

Currie G. & Wallis I. (2008), *Effective ways to grow urban bus markets – a synthesis of evidence*, Journal of Transport Geography, Volume 16, Issue 6, November 2008, Pages 419-429

Davison L. & Knowles R. (2006) *Bus quality partnerships, modal shift and traffic decongestion*, Journal of Transport Geography, Volume 14, Issue 3, May 2006, Pages 177-194

DfT (2009), *Kickstart Bus Funding Competition 2009: Guidance on the Application Process.* http://webarchive.nationalarchives.gov.uk/+/http:/www.dft.gov.uk/pgr/regional/buses/busgrants/kickstart/funding2009guid.pdf [Last Accessed 21.09.2011]

DfT (2010) *Case Study - Leicester StarTrak* http://www.dft.gov.uk/itstoolkit/CaseStudies/leicester-star-trak.htm [Last Accessed 13.8.2011]

DfT (2011) *Average excess waiting time for frequent services by local authority: England 2004/05 to 2009/10,* Department for Transport Bus Statistics, http://www2.dft.gov.uk/pgr/statistics/datatablespublications/public/bus/index.html [last accessed 25.09.2011]

DfT(2) (2011) *Local bus and light rail passenger journeys originating in the authority area by local authority: England 2004/05 to 2009/10,* Department for Transport Bus Statistics, http://www2.dft.gov.uk/pgr/statistics/datatablespublications/public/bus/index.html [last accessed 25.09.2011]

DfT(3) (2011) *Annual passenger journeys on local bus services by region: Great Britain 1970 to 2009/10,* Department for Transport Bus Statistics, http://www2.dft.gov.uk/pgr/statistics/datatablespublications/public/bus/index.html [last accessed 25.09.2011]

DfT(4) (2011) *Regional and Local Transport,* Department for Transport, http://www2.dft.gov.uk/pgr/regional/index.html [Last accessed 02.10.2011]

Duke G. (1998) *Creating the Superbus with ITS: Real Time Passenger Information,* Strathclyde Passenger Transport

Dziekan K. (2004) *Customer perceptions and behavioural responses to IT based public transport information—Literature review and what the experts say,* Royal Institute of Technology, Stockholm

Dziekan K. & Kottenhoff K. (2007) *Dynamic at-stop real-time information displays for public transport: effects on customers,* Transportation Research Part A: Policy and Practice, Volume 41, Issue 6, July 2007, Pages 489-501

Dziekan K. & Vermeulen A. (2006) *Psychological Effects of and Design Preferences for Real-Time Information Displays,* Journal of Public Transportation, Vol. 9, No. 1, 2006

Edmonds, E (2011) *QR Code GIS solutions for Mapping Technologies,* http://www.geo-jobe.com/blog/2011/09/13/qr-code-gis-solutions-for-mapping-technologies/ [Last accessed 27.09.2011]

Elkin T. (2010) *Emarketer, Chevy Case Study: Using Mobile, Location and QR Codes to InspireBrand Engagement*, http://www.emarketer.com/blog/index.php/chevy-case-study-qr-codes-mobile-location-inspire-brand-engagement/ [Last Accessed 19.11.2011]

Farrow, M (2011) Email responding to Traveline questions received 21.09.2011

Fenwick A., Wilkinson I. and Brewer M. (2010) *Transport for South Hampshire Evidence Base,* MVA Consultancy

Garling T. & Axhausen K. (2003) *Introduction: Habitual travel choice,* Transportation 30: 1–11, Kluwer Academic Publishers.

Grotenhuisa J., Wiegmansa B. & Rietveld P. (2007), *The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings,* Transport Policy, Volume 14, Issue 1, January 2007, Pages 27-38

Gwilliam, K. (2008) *Bus Transport. Is there a regulatory Cycle?* Transportation Research A, 42, 9, 1183-1194

House of Commons Transport Committee (2006) *Bus Services Across the UK*, Eleventh Report of Sessions 2005-06.

Joecascio (2011) *The AdTraqr Blog, QR Code usage statistics from a city-wide arts festival,*
http://blog.adtraqr.com/index.php/2011/08/19/qr-code-usage-statistics-from-a-city-wide-arts-festival/ [Last Accessed 19.11.2011]

Jones, J. (2011) *Stats – One-Way ANOVA* Richland Community College, http://people.richland.edu/james/lecture/m170/ch13-1wy.html [Last Accessed 26.11.2011]

Jones P. & Sloman L. (2003) *Encouraging behavioural change through marketing and management: what can be achieved?* Paper presented at the 10th International Conference on Travel Behaviour Research, Lucerne, August 2003.

Kenyon S. & Lyons G. (2003) *The value of integrated multimodal traveller information and its potential contribution to modal change*, Transportation Research Part F: Traffic Psychology and Behaviour Volume 6, Issue 1, March 2003, Pages 1-21

Knoop L. & Eames T. (2011) *Public transport technology in the United Kingdom: Annual Survey 2010,* Centaur Consulting Ltd

Linkedin (2011), *QR code – Great Ideas* (group) http://www.linkedin.com/groups/QR-Codes-Great-Ideas-1788244?gid=1788244&mostPopular=&trk=tyah [Last accessed 20.09.2011]

Maclean S. & Dailey D. *Real-time Bus Information on Mobile Devices*, 2001 IEEE Intelligent Transportation Systems Conference Proceedings - Oakland (CA) USA, August 25-29, 2001

Mascia, M. (2003) *Effects of traveller information systems on model-choice.* Paper presented at the EIRASS workshop Behavioural response to ITS, Eindhoven, The Netherlands

McFerran D. (2010), *Catch That Bus UK Review,* Know Your Mobile http://www.knowyourmobile.com/smartphones/smartphoneapps/androidapplications/575708/catch_that_bus_uk_review.html [Last accessed 24.8.2011]

Molin E. (2007) *Need for Advanced Public Transport Information Services When Making Transfers,* Transportation Research Board Annual Meeting 2007 Paper 07-0549

Nash C. (1993) *British Bus Deregulation*, The Economic Journal, Vol. 103, 419, 1042-1049

Nextbus (2011) *Smart Phones* http://news.nextbus.com/find-your-nextbus/smart-phones/ [Last accessed 18.09.2011]

Nextbus (2011), *Traveline – Bus Arrival Times* http://mytraveline.mobi/ [Last accessed 19.09.2011]

Nijkamp P., Pepping G. & Banister D. (1996) *Telematics and Transport Behaviour. Chapter 7: Public Transport Information Systems: An English Case Study,* Springer, Heidelberg (1996)

O' Sullivan C. (2011) *Mobile barcodes for buses: LYNX adopts QR Codes,* GoMo News, http://www.gomonews.com/mobile-barcodes-for-buses-lynx-adopts-qr-codes/ [Last accessed 27.08.2011]

Ofcom (2011) *A Nation Addicted to Smartphones*, Ofcom http://consumers.ofcom.org.uk/2011/08/a-nation-addicted-to-smartphones/ [Last accessed 02.10.2011]

PCmag (2011) *Definition of Smartphone* http://www.pcmag.com/encyclopedia_term/0,2542,t=Smartphone&i=51537,00.asp#fbid=zaFVhyGoD-i [Last accessed 02.10.2011]

Pickup L., Stokes G., Meadowsroft S., Tyson W. & Kenny F. (1991*) Bus deregulation in the metropolitan areas*, Oxford Studies in Transport, Aldershot, U.K. Avebury

QRcode.com (2011), *QR Code features*, Densowave Inc. http://www.denso-wave.com/qrcode/qrfeature-e.html [Last Accessed 20.09.2011]

QRme (2011), *Introduction to Bar Codes* http://www.qrme.co.uk/qr-codes-explained.html [last accessed 20.09.2011]

Ramsden A. (2010) *The level of student engagement with QR Codes: Findings from a cross institutional survey.* Working paper. University of Bath

ROMANSE (2011), *Stopwatch Bus Information* http://www.romanse.org.uk/about.htm [Last accessed 18.09.2011]

Scanlife (2011) *Scanlife Trend Report: Infograph* http://blog.scanlife.com/2011/04/trend-reportinfographic/ [last accessed 20.09.2011]

Schweiger C. (2003) *Real-time bus arrival information systems,* Federal Transit Administration, Transit Cooperative Research Program, Transit Development Corporation, National Research Council (U.S.), Transportation Research Board

Sotonbus (2011) *Southampton Mobile Bus Stop Finder,* http://data.southampton.ac.uk/bus.html?lat=&long= [Last accessed 19.09.2011]

Southampton City Council (2008) *City of Southampton Local Transport Plan 2006-2011* - Annual Monitoring Report 2008 http://www.southampton.gov.uk/Images/LTP2%20Annual%20Monitoring%20Report%202008_tcm46-221814.pdf [Last Accessed 10.09.2011]

Stattrek (2011(1)) *Statistics and Probability Glossary – Two Sample t-Test,* http://stattrek.com/help/glossary.aspx?target=two-sample_t-test [Last accessed 19.11.2011]

Stattrek (2011(2)) *Statistics and Probability Glossary – Chi-Square Test for Homogeneity,* http://stattrek.com/Help/Glossary.aspx?Target=Significance+level [Last accessed 19.11.2011]

Stradling S. (2002) *Transport user needs and marketing public transport*, Proceedings of the ICE - Municipal Engineer, Volume 151, Issue 1, pages 23 –28

Stradling S., Carrenoa M., Ryea T. & Noble A. (2007) *Passenger perceptions and the ideal urban bus journey experience,* Transport Policy, Volume 14, Issue 4, July 2007, Pages 283-292

Stucken A. (2011) *BBC Webwise* - *What is WAP* http://www.bbc.co.uk/webwise/guides/about-wap [Last Accessed 14.09.2011]

Survey Monkey (2011) Smartphone survey building and data collection software, http://www.surveymonkey.com/ [Last Accessed 2.12.2011]

TfL (2011) *Bus Arrival Information by SMS*, Transport for London, http://www.tfl.gov.uk/termsandconditions/20914.aspx [Last accessed 17.09.2011]

Traveline (2011) *Mobile Phone Services* http://traveline.info/mobile.html [Last accessed 19.09.2011]

Traveline(2) (2011) *Telephone Support* http://traveline.info/support.html [Last accessed 20.09.2011]

Travelinedata (2008) *Traveline Bus Information on the Mobile Internet* http://www.travelinedata.org.uk/mobilei.htm [Last accessed 16.09.2011]

Wardman M., Hine J. & Stradling S. (2001) *Interchange and travel choice.* Vol. 1. Edinburgh: Scottish Executive Central Research Unit

Warman P. (2003) *Measured Impacts of Real-time Control and Information Systems for Bus Services*, Prepared for Transport Direct, Department for Transport

Waterson B (2009) *Transport Planning: Policy and Methods – Trip Distribution.* Lecture given at the University of Southampton November 2009

9. Appendices

Appendix A

http://data.southampton.ac.uk/qr/b/SN120519

Blechynden Ter opp Station E

Appendix B

How long until your bus arrives?

Scan for bus arrival times

Use any Smart phone to scan the QR code above for arrival times of all buses that stop here

A QR code reader app can usually be downloaded for free and you may already have one (e.g. RedLaser). This is a trial so please complete the survey via the link under the bus times to let us know what you think.

Thank you - University of Southampton Transport Research Group.
For more information about this project please email ngg1g09@soton.ac.uk

SN120256+

First

SOUTHAMPTON CITY COUNCIL®

UNIVERSITY OF Southampton

Appendix C


Bevois Town, The Avenue
uni-link
How long until
your bus arrives?
Scan for bus arrival times
First
Southampton

Appendix D

Mobile Survey

This survey will take about 2 minutes. All information given is anonymous. No personal information about you or your phone will be recorded. The results of this survey are for academic use.

How many days per week do you usually use a bus?

- 5-7 days per week
- 4-5 days per week
- 2-3 days per week
- 1 day per week
- Less than once a week

What was the main purpose of this (most recent) trip?

- Education
- Work/business
- Shopping
- Leisure
- Other

How easy was it to get your estimated bus arrival time?

- Very easy
- Quite easy
- Not very easy
- Not at all easy
- Any comment [……….]

Did receiving the information make waiting for your bus more acceptable?

- o Much more
- o A little more
- o No difference
- o A little less
- o A much less
- o Not Applicable (did not wait for bus)

Did the information provided make you feel safer while waiting for your bus?

- o Much safer
- o A little safer
- o No difference
- o A little less safe
- o A much less safe
- o Not Applicable (did not wait for bus)

What did you do as a result of receiving your bus arrival time?

Tick all that apply!

- o Waited at the stop for your planned bus
- o Waited at stop but took a different bus
- o Went to a different bus stop and took your planned bus
- o Went to a different bus stop and took a different bus
- o Went away from the stop (e.g. shopping, bank, café) and returned
- o Used an alternative form of transport (e.g. walking, taxi, lift)
- o Other […..]

Does receiving bus arrival times in this way make you more or less likely to use a bus?

- o A lot more likely
- o A little more likely
- o No difference
- o A little less likely
- o A lot less likely

How much difference would you estimate there was between the predicted and actual bus arrival time?

- Under 1 minute
- 1m-2m
- 2m-5m
- Over 5m
- Don't know

Please select the age range you fall in:

- Under 18
- 18-24
- 25-39
- 40-60
- 60+

Are you:

- Male
- Female

Any other comments?

[………..]

Appendix E

Street Survey

Sorry to bother you but please could you spare about 3 minutes to take part in a survey about your travel and bus arrival information. All information given is anonymous and the results will only be for academic use.

Date:

Day:

Time:

Bus Stop Name/Number:

1) How many days per week do you usually use a bus?

- ❑ 5-7 days per week
- ❑ 4-5 days per week
- ❑ 2-3 days per week
- ❑ 1 day per week
- ❑ Less than once a week

2) What is the main purpose of this (most recent) trip?

- ❑ Education
- ❑ Work/business
- ❑ Shopping
- ❑ Leisure
- ❑ Other

3) Do you know what time your bus is expected to arrive at this stop?

- ❑ Yes
- ❑ No

4) IF YES TO Q3: Which method did you use to obtain your bus arrival time information?

- ❑ Internet – at home/office
- ❑ Internet – mobile
- ❑ RTI display
- ❑ Previous knowledge
- ❑ Paper timetable
- ❑ SMS

There has recently been a trial at selected bus stops in Southampton giving passengers the option to use a smartphone to scan a QR code and get arrival times for all buses servicing that stop.

5) Do you have a smartphone - a mobile telephone that has a camera, internet access and the ability to download and install applications (apps)?

- ❑ Yes
- ❑ No

6) IF YES TO Q5: What make of phone is this?

Demonstrate QR code use at this point: Open app. => scan => show respondent bus arrival time.

Record wait time until respondent's bus:

7) How easy do you think it was get the estimated bus arrival time?

- ❑ Very easy
- ❑ Quite easy
- ❑ Not very easy
- ❑ Not at all easy
- ❑ Any Comment […………………………………………………………………..]

8) If you were not doing this survey, what would you do as a result of receiving your bus arrival time?

- ❑ Waited at the stop for your planned bus
- ❑ Waited at stop but take a different bus
- ❑ Go to a different bus stop
- ❑ Go away from the stop (e.g. shopping, bank, café) and return
- ❑ Change your destination
- ❑ Walk the whole journey
- ❑ Get a taxi or lift
- ❑ Other […………………………………………………………………………..]

9) Does receiving this information make waiting for your bus more acceptable?

- ❑ Much more
- ❑ A little more
- ❑ No difference
- ❑ A little less
- ❑ A much less
- ❑ Not Applicable (did not wait for bus)

10) Does the information provided make you feel safer while waiting for your bus?

- ❑ Much safer
- ❑ A little safer
- ❑ No difference
- ❑ A little less safe
- ❑ A much less safe
- ❑ Not Applicable (did not wait for bus)

11) SMARTPHONE USERS: Does receiving bus arrival times in this way make you more or less likely to use a bus?

- ❑ A lot more likely
- ❑ A little more likely
- ❑ No difference
- ❑ A little less likely
- ❑ A lot less likely

12) SMARTPHONE USERS: If this were available on a regular route would you scan the poster every time or bookmark the page?

- Scan
- Bookmark
- Not applicable (would not use, no regular route, etc)

13) Under what circumstances would you be most likely to use this service [assuming you had a smartphone and] if available?

- When catching a bus I regularly take
- When catching an unfamiliar bus
- I'd be unlikely to use it

14) Do you know what the difference is between a receiving a countdown to bus arrival (that is the number of minutes until the bus arrives) and the arrival time as a time of day?

- Yes
- No

15) IF YES: What is the difference?

Is the answer given correct:

- Yes
- No

16) Please tell me the age range you are in:

- Under 18
- 18-24
- 25-39
- 40-60
- 60+

17) Respondent is:

- Male
- Female

18) Any other comments about this trial:

Many thanks for taking part in this survey.

Appendix F

Breakdown of Stop Details, Footfall, Hits and Adjusted Hits

Stop No.	Stop ID	Stop Description	Poster Type	Shelter Present	Display Present	Footfall	QR Code Hits	Adjusted Hits
	Railway Station							
1	SN120520	Southampton Station South Forscourt E	Basic	Yes	No	1140	108	0.095
2	SNA09196	Wyndham PI3 N	Full	Yes	No	170	16	0.094
3	SN12518A	Wyndham PI2 N	Full	Yes	No	170	61	0.359
4	SN120518	Wyndham PI1 N	Full	Yes	No	170	31	0.182
5	SN120519	Blechynden Ter Opp Station E	Full	Yes	No	325	36	0.111
	Southampton General Hospital							
6	SN120979	Coxford Rd os Princess Anne Hospital	Basic	Yes	Yes	161	0	0.000
7	SN120083	Coxford Rd opp 247 SW	Basic	Yes	Yes	485	79	0.163
8	SN120082	Tremona Rd opp 216 NW	Basic	Yes	Yes	102	9	0.088
9	SN120084	Tromona Rd nr 198 SE	Full	Yes	Yes	162	87	0.537
10	SN120221	Tromona Rd opp 154 NE	Full	Yes	Yes	86	14	0.163
43	SN120218	Tromona Rd opp 130 NE	Full	Yes	Yes	n/a	9	
44	SN120219	Tromona Rd os 120-122 SW	Full	No	No	n/a	1	
	Southampton University							
11	SN120257	University Rd os Sports Centre NW	Basic	Yes	No	158	63	0.399
12	SN120256	University Rd os Sports Centre SE	Basic	Yes	Yes	464	123	0.265
13	SN120134	University Rd oppStile ph S	Basic	Yes	No	244	101	0.414
14	SN120131	Burgess Rd nr Library E	Basic	Yes	No	n/a	49	
15	SN120127	Burgess Rd os Holmwood Ct NE	Full	No	No	n/a	1	
16	SN120128	Burgess Rd opp 189 SW	Full	Yes	Yes	n/a	40	
17	SN120120	Burgess Rd nr Bassett Ave SW	Full	Yes	No	n/a	11	
18	SN120121	Burgess Rd nr Bassett Ave NE	Full	Yes	No	n/a	7	
19	SN120140	Burgess Rd opp 202 W	Full	No	No	n/a	157	

Stop No.	Stop ID	Stop Description	Poster Type	Shelter Present	Display Present	Footfall	QR Code Hits	Adjusted Hits
	Urban - Portswood							
20	SN120535	London Rd os Law Courts N	Basic	Yes	Yes	n/a	69	
21	SN120401	The Ave os 69A SE	Basic	Yes	No	n/a	101	
22	SN120404	The Ave os 35 SE	Basic	Yes	Yes	n/a	50	
23	SN120525	Above Bar St nr 200 S	Full	Yes	No	n/a	7	
24	SN12524B	Above Bar St os Cenotaph N	Full	Yes	No	n/a	4	
25	SN120522	London Rd os Natwest N	Full	Yes	No	n/a	107	
26	SN120405	The Ave nr Archers Rd NW	Full	Yes	Yes	n/a	95	
27	SN120406	The Ave os 15-16 TGWU office SE	Full	Yes	No	n/a	99	
28	SN12275A	Portswood Rd os 170 Superdrug SW	Basic	Yes	Yes	542	13	0.024
29	SN12272A	Portswood Rd os 241 nr Somerfield NE	Basic	Yes	Yes	143	58	0.406
30	SN120274	St Denys Rd os Mitre Ph NW	Basic	Yes	No	n/a	1	
	Suburban - Shirley							
31	SN12367B	Shirley Rd nr McDonald SE	Basic	Yes	No	n/a	21	
32	SN120376	Shirley Rd os 411 SE	Basic	Yes	No	n/a	1	
33	SN120377	Shirley Rd os police station NW	Basic	Yes	No	148	29	0.196
34	SN120372	Shirley High St oppEmsworth Rd SE	Basic	Yes	No	66	8	0.121
35	SN120371	Shirley High St os 50 KFC NW	Basic	Yes	No	87	13	0.149
36	SN12368A	Shirley High St os 104a NE	Full	Yes	No	550	29	0.053
37	SN12368B	Shirley High St os Iceland NE	Full	Yes	Yes	n/a	0	
38	SN12370A	Park St os 2 SW	Full	Yes	No	585	35	0.060
39	SN120367	Shirley High St os precinct 2 SE	Full	Yes	Yes	333	4	0.012
40	SN12367A	Shirley High St os precinct 1 SE	Full	Yes	Yes	n/a	0	
	Suburban - Bitterne							
41	SN12921A	West End Rd, opp Sainsbury NE	Full	Yes	Yes	602	24	0.040
42	SNA90798	West End Rd os Sainsbury SW	Full	Yes	Yes	548	4	0.007