# The Application of the Transit Capacity and Quality of Service Manual on a Bus Corridor in Dublin

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**ABSTRACT**

The introduction of eleven Quality Bus Corridors (QBC) has been a success story in the provision of public transport in Dublin over the past few years.  In a city where the main mode of public transport is bus, the QBC initiative has resulted in decreased commute times and increased passenger numbers.  QBCs operate on dedicated traffic lanes between the hours of 7:00am – 7:00pm and in certain instances on a 24-hour basis.

This paper will examine the performance of the Malahide QBC, which extends 4.7miles/7.5 km from the city centre to the north east of the city. Performance will be measured by examining service coverage, headway and transit/auto comparison. The Transit Capacity Quality of Service Manual (TCQSM) is used to provide quality of service measurements on the corridor to evaluate its performance.  The data for the TCQSM analysis has been taken from an automatic licence plate recognition system that was installed on the Malahide QBC in 2003. The paper will look at the future plans for the QBC network, concluding with an examination of how QBCs play their role in providing a more efficient public transport system in Dublin.

**INTRODUCTION**

The Greater Dublin Area (GDA) consists of the capital city, Dublin, and the counties of Dublin, Kildare, Wicklow and Meath and is located on the eastern side of the country. In 2002 the GDA had a population of 1.5 million. The population of the GDA is growing at a significant rate and by 2016 is expected to reach 1.75 million (1). In the past decade traffic congestion has become a major problem with private car ownership rates at 342 per 1,000 and this is predicted to rise to 480 per 1,000 by 2016 (1). It is from the need to reduce congestion that the Irish government has looked into finding new ways to make public transport a more attractive transport option.

The Dublin Transportation Initiative (DTI) Final Report was published in 1995 (2). This report was commissioned by the Irish Government to ascertain the best way forward in providing Dublin with an effective transportation strategy. With regard to the provision of public transport infrastructure the main recommendations of the DTI were to introduce eleven, Quality Bus Corridors (QBC) and to construct a light rail transit system.

In 2001, the eleven QBCs, outlined in the DTI, were operational in Dublin. Due to the flexibility characteristics of bus services they have been relatively quick and cost effective to implement. QBCs operate on dedicated lanes between 7:00am – 7:00pm and in some cases on a 24-hour basis. QBCs have been implemented on a radial basis from the city centre, as can be seen in Figure 1.

This paper examines the QBC concept and reports on its success to date in Dublin. Quality of service (QOS) is measured using the Transit Capacity and Quality of Service Manual (TCQSM) (3). The data for some of the measurements has been taken from Automatic Licence Plate Recognition system that Dublin City Council (DCC) introduced on the Malahide QBC in 2003. With these data the paper will outline TCQSM requirements in relation to headway, hours of service, transit/auto time comparison, accessibility and service coverage.

The paper concludes by examining the importance of QBCs and the role they will play in providing a more efficient public transport system in Dublin. Access facilities such as park & ride and Real-Time Passenger Information (RTPI) should also be examined. RTPI is a system that provides passengers at the bus stop with up-to-date information on the estimated arrival time of their service via a system of Global Positioning System (GPS). The role that these facilities could play in improving the attractiveness of the QBC as a viable public transport option is also examined.

The first section looks at the concept of bus corridor/lanes drawing on the experiences in the United States (US) and the United Kingdom (UK). The following section examines the TCQSM measures as a means to evaluate the performance of the corridor. The final sections describe the means of data collection, which is then used in the last section to detail the TCQSM in a case study of the Malahide QBC. The paper concludes by considering the future direction of QBCs in Dublin and how with improved facilities, the bus could be seen as a rival to rail based options.

## BUS PRIORITY CORRIDORS/LANES

In the US the concept of bus priority corridors as a viable alternative to rail based solutions is seen as an increasingly attractive alternative. Federal incentives have been used to implement Bus Rapid Transit (BRT) corridors, due to the costs in implementing rail based public transport systems (4,5). The following section examines the situation with regard to bus corridors in the US, London and in Dublin.

**Bus Rapid Transit (BRT)**
The aim of the BRT, projects as funded by the US Federal Transit Administration (FTA) is to demonstrate how the bus may be seen as an attractive alternative to rail based solutions. "BRT is a flexible, rubber tired rapid transit mode that combined stations, vehicles, services running ways, and intelligent transport systems (ITS) elements into an integrated system with a strong positive image and identity" (4).

It is using this concept of having bus corridors acting as viable alternatives to rail and private car that the BRT initiative is based. BRTs utilise the following to achieve this:

- Signal priority.
- Bus-lanes; bus only roads, and tunnels.
- Low-floored, electronic and compressed natural gas vehicles.
- Automatic Vehicle Location (AVL), RTPI and prepaid ticketing systems.
- Park & Ride facilities.

In Los Angeles, the Wilshire BRT demonstrates the benefits of implementing a bus priority corridor. In 2000 the overall investment in the Wilshire BRT was $235 million. The Wilshire BRT is an improvement over the previous Metro Rapid bus line #720 extending 13.7miles/22km from Wilshire in Los Angeles to Downtown Santa Monica. These improvements include high capacity vehicles, enhanced stations on the route, signal priority and dedicated bus-lane and smart card prepayment systems. Since the introduction of the Wilshire BRT there has been a 27% reduction in travel times and a 50% increase in vehicle capacity. It is anticipated that the introduction of a smart card prepayment, will decrease boarding times, and therefore decrease dwell time by 50-65% (6).

An innovative example of the BRT initiative is the New Britain to Hartford Busway. In 1999 it was decided after an investment study to construct a busway to New Britain and Hartford in Connecticut. This is a 9.4mile/15.1km bus-way with 12 stations situated on the route (7). The unique feature on this route is that it has been constructed on an abandoned railway between the two cities. The analysis of the system looked at constructing a light rail, heavy rail or a bus service along this corridor. On economical and congestion-reducing grounds the bus was the chosen mode.

The ethos of the BRT is to provide passengers with a service equivalent to that of rail based services. In Washington D.C. a stated preference evaluation was conducted, comparing the Metro with a bus based service with equivalent service standards. When comparing express busways and Metro services the results found

that a high performance bus service could be a substitute for rail service (8).   The results of this analysis demonstrate that when evaluating enhanced bus services and rail based light rail or Metro, one should evaluate the modal alternatives on a level playing field, providing Levels of Service (LOS) are comparable.

**London Bus Initiative**
London Buses is a division of Transport for London; it manages, plans routes, specifies service standards and monitors these standards in London. London Buses co-ordinates one of the largest bus networks in the world.  Operating a fleet of 6,000 buses, providing 4.5 million passenger trips each weekday (9).  Since 1994 London buses has introduced over 400 sections of bus-lane and signal priority at over 500 traffic junctions.  The London Bus Initiative  (LBI) is a programme aimed at realising comprehensive improvements in bus services with high levels of bus priority on all major intersections.  The LBI makes provisions for the bus-lanes to be operated on a 24-hour basis with access for buses and emergency vehicles. From the initial stages of the introduction of the LBI a 10% reduction in bus journey times has been realised, and a 40% improvement in schedule reliability (10).

In line with providing a more efficient bus network, the LBI also makes provisions for the introduction of improved access facilities on bus corridors. These include the following:

- Improved shelters, seating, lighting, maps and timetables at London's 17,000 bus stops.
- Low-floored buses to improve access, with 3,000 wheel chair accessible buses.
- LBI details the provision of RTPI services at 4,000 stops; reaching 60% of passengers.
- Increased Closed Circuit Television (CCTV) surveillance on buses to improve safety.
- Lower emission buses operating on ultra low sulphur diesel buses, and a pilot project assessing fuel cell buses.
- Bus information is to be fully integrated between buses, underground, national rail and the Dockhands light rail.
- Increased curbside boarding space to increase the ease of entry and exit.

These service improvements coupled with the planned increase in the number of bus-lanes will provide Londoners with an improved bus service with access facilities comparable to that of rail services (10).

**The Quality Bus Corridor Programme in Dublin**
From 1996 to 2001 the eleven QBCs outlined in the DTI (2) were implemented in Dublin. They operate in a radial pattern originating in the city centre to mainly residential and industrial areas (see Figure 1).  The services operating on the QBCs are predominately provided by Bus Átha Cliath (BAC). BAC is a state owned company and is the principal provider of bus services in Dublin operating a fleet of 1,100 buses and provided 146.6 million passenger journeys in 2002 (11).  Essential to the success of the QBC is the strict management of traffic on the QBC, whereby the

Garda Síochána (police force) in conjunction with the DCC ensure free flowing traffic on the QBC.  The Garda impose an on the spot fine of $28 for violations of the regulations of the QBC.

The characteristics of the QBCs that have been implemented are as follows:
- Dedicated road space between the hours of 7:00am and 7:00pm and some operating on a 24-hour basis adjacent to the curb.
- High frequency service and increased capacity.
- Strict enforcement of QBC regulations.
- Taxis, cyclists and emergency vehicles have access to the QBC.
- Capacity of 5,000 passengers per direction per hour.

The capacity of buses compared to private vehicles has been central to the justification of taking traffic lanes and dedicating them to public transport. The average car occupancy rate on a peak hour journey in the GDA is 1.4 persons, whereas bus capacity is 54 persons.  Therefore bus capacity is 38 times greater (12). It has been calculated that if bus headway were increased to one every two minutes it would increase the capacity of the QBCs by 250% (12).

Initial passenger growth figures show an average increase in passenger growth of 50% and an average time saving of 10 minutes across the QBC network  (13) (see Table 1). The results show that the QBC with the best performance was the Stillorgan QBC.  The Stillorgan QBC extends 8miles/12.9km from the city centre to one of the most affluent residential areas to the south of the city and has been evaluated before by (14).  This QBC has realised a 232% increase in patronage (although it is recognised this was from a comparatively low base compared with the other routes – see Table 1) and average timesavings of 11 minutes (13).

BAC has carried out extensive market research on the Stillorgan QBC.  This market research undertaken in 1999 showed that of the passengers surveyed 70% had an alternative mode of transport available and 72% of passengers were satisfied with the QBC.  With regard to travel time, 73% of passengers indicated that the QBC was quicker than their previous mode of transport and 60% of the new customers had previously travelled by car (15).

## TRANSIT CAPACITY QUALITY OF SERVICE MEASUREMENTS

The TCQSM defines measures for QOS along transport corridors.   These measurements are defined with regard to both the levels and quality of service the mode provides. The manual also details the physical infrastructure along the route with regard to access to stops and the facilities that are provided at the stop, and how improved access facilities can improve the overall QOS.

The Department of Transport in Florida in 2001 required that all transit services with fixed route public transport services undertake a TCQSM. This was the first statewide application of the TCQSM in the US. When gathering the data required for the TCQSM, the data collection relied on the use of ITS applications such as AVL and Automatic Passenger Counting (APC) (16). Using ITS applications has enabled the evaluation to keep costs to a minimum.  The results when compiled for Florida

provided the Department of Transport with information on the performance of public transport in the state. State officials have used this evaluation as a means to justify increased investment in public transport in the state.

**Dublin Bus (BAC) Quality of Service Measurements**
In Dublin the operator in this case, BAC, defines a quality of service (QOS). BAC has a passenger charter defining LOS that BAC has committed to provide to its passengers. The charter defines levels of reliability whereby 92% of services will operate within five minutes of schedule, all buses will be cleaned every day with a complete valet service at least once every four weeks and all BAC properties cleaned daily, accurate passenger information and regular vehicle inspections to ensure lighting and heating standards are maintained (16).

BAC in conjunction with the introduction of QBCs initiated extensive market research from October 2000 to March 2001. This research was conducted with a mixture of door-to-door interviews, on bus interviews, spot checks on levels of service and observed departure times. Over the observed period the survey measured approximately half a million observations. The overall results of the survey indicated that 65-70% of passengers were satisfied with the service BAC provided (15).

**AUTOMATIC LICENCE PLATE RECOGNITION SYSTEM**

Automatic Licence Plate Recognition (ALPR) is a technology used for the purposes of automatic vehicle identification. ALPR systems operate with the use of infrared cameras, and high-resolution digital cameras situated in the same manner as CCTV cameras along the corridor. The cameras record vehicle licence plates as they pass. Data is then sent to a control unit where the information is analysed.

One of the most recent applications of an ALPR system has been in London, to enforce the recent congestion charges. The scheme utilises ALPR cameras, which have been placed at 230 locations, monitoring all access points to the congestion cordon at a cost of $325million. To date this system has managed to account for 90% of all traffic passing through the cordon each day (17).

In Finland the Finnish Roads Administration implemented a system of traffic information (private car) via a variable message signs (VMS) system along a stretch of highway extending 17miles/28km from Lahti (just outside Helsinki) to Heinola (a popular Finnish weekend resort). Due to the attraction of this resort there is heavy congestion on this route over the weekend. Along the highway at four positions ALPR cameras have been installed and data from these cameras is relayed to a control centre, which in turn relays information to the VMS displays situated on the corridor. The displays give information on the estimated time of arrival in Heinola (18).

A similar system was installed on a highway between Orlando and Orange County in Florida. This system utilises data from E-PASS toll transponders that collect data on vehicle movements on the highway, which is an equivalent technology to ALPR. The data is used to calculate real-time travel times across the 55mile/90km stretch of highway. The system has been in operation since 2001 and provides the roads authority with real-time traffic speeds along the highway. (19).

**ALPR System on the Malahide QBC**
In January 2003, the Office of the Director of Traffic in the DCC installed an ALPR system at eight locations on the Malahide QBC, four inbound and four outbound, as seen in Figure 2. The system was implemented to provide the DCC with real-time vehicle travel time over three stretches, sections 1, 2 and 3 (as shown in Figure 2) of the Malahide QBC. The system uses infrared imaging to recognise the vehicle licence plates.

The system has the ability to differentiate between all other vehicles and BAC vehicles, as the system is cross-referenced with the BAC licence plate database. Therefore the system can identify buses that travel along the QBC. This enables the DCC to analyse how the two modes of transport compare in relation to travel times and average speed. Some of the TCQSM measures in the case study on the Malahide QBC are based on measurements using the ALPR.

**CASE STUDY OF THE MALAHIDE QBC**

The Malahide QBC was completed in December 1998, and extends 4.7 miles/7.5km to the north east of the city as seen in Figure 1. Since its inception it has realised an average time saving of 8 minutes for passengers on the corridor, and a 27% increase in patronage from 22,018 to 28,105 (13). The following TCQSM levels of service were measured: service frequency, hours of service and transit/auto travel time.

**Hours of Service LOS**
This is defined as the hours during the day when the transit service is being provided along the route. Table 2 details the LOS on the Malahide QBC, taken from bus operating schedules (20). The results show a LOS A during weekdays on both inbound and outbound services and on Saturdays inbound. There is a lower LOS C on Sundays and LOS B outbound on Saturdays. The service provided by BAC on the QBC extends from the earliest services at 5:15am on weekdays to the latest services 'Nitelink' operating until 2:00am on Monday – Wednesday and Thursday – Saturday until 4:30am.

**Transit/Auto Travel Time LOS**
The data for this performance indicator is based on the average time taken to travel between two points on each of sections 1 and 2. Section number 3 as indicated on Figure 2 was not used in this analysis because some of buses take a detour and enter a residential area in section 3 and others do not. The data used is the hourly average observed from April and May 2003, between 07:00 and 19:00. This LOS measures the difference between time taken to travel the route between two points by bus and car. From Table 3 the differences between the two modes was 1.7 minutes on average inbound and 3.65 minutes on average outbound, where the car was faster on both inbound and outbound routes. LOS B was therefore observed, which is defined as 'about as fast by transit as by automobile' (3). LOS A defined as 'faster by transit

than auto' was observed for 10:00-11:00 inbound and the 16:00-17:00 and 18:00-19:00 outbound services, for sections 1 and 2 of the QBC.

The ALPR system measures the travel times of the buses that travel between two points on the corridor as detailed above. The services that join the corridor feed passengers in from the surrounding areas and circulating passengers on to the QBC.

From the analysis over the twelve-hour observed period the average speed of both bus and car was calculated. Figure 3 illustrates the average speed over the observed time period. The graph shows the bus is able to maintain a steady average speed throughout the day, whereas the average speed of the other traffic is less stable. During the day the car is quicker but in the morning peak the average speed is the same for bus and car at 8.6miles/14km per hour in both directions.

The transit/auto LOS in Table 3 only accounts for the in-vehicle time. Time penalties such as the walk time to and from both modes, the wait time for public transport and the transfer time from transit and auto to destination and the time required to park ones car were not applied. The TCQSM assumes a transfer time of 11 minutes for transit users and 3 minutes for auto users (3). For a transit user there is an assumed walk of 0.4km (0.25miles) to and from the appropriate mode of transport, and 5 minute wait time for transit. The time penalty for auto users is 3 minutes which is the assumed time to park a car and walk to the destination. This equates to a 9 minute modal penalty on transit users. If this modal penalty were applied to the results in Table 3 it would affect the LOS resulting in a LOS B for all the transit/auto LOS, with the exception of a LOS C inbound between 08:00am – 09:00am.

**Accessibility**

In 2000 BAC introduced low-floor fully accessible buses. These low-floored buses are fitted with kneeling suspension to reduce entry step height with a retractable ramp that allows access to the bus. On-board wheel chair passengers have dedicated space with grip bars and palm activated bells to stop the bus.

These new vehicles also have lower engine exhaust emissions. In 2002 BAC operated 359 of these buses amounting to 34% of the fleet (11). On the Malahide QBC seven of the routes use these fully accessible buses. The buses have a scheduled frequency from 7:00am to 11:00am of on average 5.5 vehicles per hour both inbound and outbound on the QBC (20).

**Service Frequency LOS**

Service frequency is defined as the headway that is observed on the route. The TCQSM defines this either by the number of vehicles per hour or the headway in minutes. The APLR system was used to measure the average weekday LOS on the corridor. The data used for the analysis is hourly average from the first three weeks in June 2003. The results in Table 4 show an average LOS A defined as, 'passengers do not need schedules' (3). The LOS was completed for all three sections of the QBC inbound and outbound. The results should be examined for each section as the numbers of buses on each segment of the corridor increases as the corridor approaches the city centre as more services join the QBC. A high degree of

variability exists on each section over the day and in some cases there is no noticeable increase in the LOS for peak periods. Although there exists a greater number of buses per hour generally on section 1, the standard deviation over the day is 8.4 compared with 4.2 and 4.78 for the other two sections.

**System Coverage LOS**
This LOS measures the area within walking distance of a transit service. This was calculated using Geographic Information System (GIS) technology (Dublin Transportation Office system). The TCQSM defines the coverage area as the air distance within 400m (0.25miles) of the area served by a fixed route bus stop (3); therefore any area under this 400m is covered by the service. Along the Malahide QBC this was done on section 1 inbound and outbound. The results in Figure 4 show the transport capture area for an inbound transit stop. The GIS analysis of the area showed that 295 residential units on the inbound route and 225 residential units on the outbound route were within 400m walk of the stop. The residents are displayed with dark blue circles are within walking distance and those in white are not. Under the assumptions of the GIS land use model (Dublin Transportation Office) it assumes 2.7 persons inhabit each residential zone. This computes to 608 persons outbound and 797 inbound are within 400m walk of the stop.

       In conclusion, the LOS provided on the Malahide QBC has been shown to be quite high. All of the LOS measures were between A and C, demonstrating a high QOS on the QBC. In the results that use the ALPR system, one must take into account that this data system captures 80% of all vehicles. Not always does a bus recognised by the system have passengers on-board as it may be returning to the depot, therefore the number of buses in service may be overestimated.

       As already mentioned, passenger growth between 1998 and 2001 grew by 27%. Recent figures comparing passenger numbers in November 2001 (31625) and 2002 showed a 0.06% increase (13). The next section details some improvements to the service and access facilities that if provided could result in increased patronage.

**FUTURE OF QBCS IN DUBLIN**

The Malahide case study and the results in Table 1 detail the success and benefits of the QBC programme. However there are still some shortcomings in the QBC network. To realise the full potential of the QBCs the future direction of the programme should take a similar direction to that of the BRT in the US and the LBI in London and provide improved access facilities and make bus travel as comfortable and convenient as rail based travel. To this end there are plans to increase the number of QBCs, and the introduction of park & ride facilities, prepaid smart card ticketing and RTPI to improve the QBC network.

**Increased Network**
With regard to QBCs, the aim is to increase the capacity of the bus network, provide orbital and local routes, increase fleet, additional bus priority measures and additional

QBC routes. These improvements to the network and the increased fleet size are estimated to cost $930million (1). The improvements include the ITS applications and park & ride facilities detailed below.

**Smart card prepaid ticketing**
Integrated ticketing using contact-less smart card technology is planned in the medium term for the GDA. This system will integrate fare structures, modes and operators with the use of a single ticket. One of the main advantages of this system will be to reduce the dwell time at stops, due to more efficient boarding. As seen in the BRT in Los Angeles, dwell times are expected to be reduced by 50-65% with the introduction of a similar system (6).

**Real Time Passenger Information (RTPI)**
Real time passenger information (RTPI) exists on three QBCs in Dublin, to provide expected time of arrival and different route variants at stops on the Lucan, Clondalkin and Ballyfermot QBCs all located to the south west of the city see Figure 1.
        This is the first stage of Q-time, which is a pilot programme by BAC to test the introduction of RTPI on these corridors. The project started in 2000, and as a three-year programme it is nearing completion. It is planned to achieve system wide RTPI covering all modes by 2010. The extension of this system has been justified in the 'Platform for Change' as a means to integrate the transportation network between modes and operators (1). To date no research has been published on the success of the pilot Q-time project.

**Park & Ride**
The DTO has examined placing park & ride facilities in proximity to the city centre near QBCs (21). The initial analysis has looked at 22 potential sites, and analysed their performance with regard to estimated passengers and revenue per annum. These sites were chosen due to their proximity to QBCs and national primary roads. From the potential sites they ranked sites on the following QBCs as those with the most potential for park & ride sites, Lucan QBC (Fonthill Road), Blanchardstown QBC (Castleknock) and Stillorgan QBC (Cornelscourt) (22) these locations are on the south side of the city. The ridership levels were estimated on the basis of applying an incremental intercept rate to the traffic flow level past the location of the site. This was done using a value of 0.86% which was found to represent the reduction in cars for every 1 minute saving in relative bus and car journey times following completion of the QBC schemes in Dublin (0.86% transfer to bus per 1 minute change in relative but and car journey times).

**CONCLUSIONS**

The conclusions of the study are as follows:

1.     The TCQSM carried out on the Malahide QBC showed the corridor to provide an efficient service. All of the measures had results between LOS A and LOS C, but are mainly in the range LOS A and B.

2.    The transit/auto comparison demonstrates how the bus service provided in the majority of instances is as fast as the car. However this LOS does not take into account the different modal penalties inherent to public and private transport.

3.    The hours of service on the corridor are extensive. The 'Nitelink' service BAC extends the operating hours of the corridor and passengers may use the service up to 20 hours a day.

4.    If Dublin were to employ the same strategy for TCQSM as in Florida, it would provide a useful comparison of quality of service of modes and operators in the city. The evaluation, if done on a regular basis to a strict set of guidelines, could provide transport planners with comparable results that could demonstrate how improvements in the system have impacted upon the QOS.

5.    The use of ITS applications, such as the automatic licence plate recognition system would result in a lower cost of monitoring and provide a much more comprehensive set of results as shown by the results in the Malahide QBC case study.

6.    If the system of ALPR were installed on the other eleven QBCs, it would provide transport planners with a comprehensive database with regard to the performance of the QBCs.

**FUTURE WORK**

It would be interesting to extend this analysis to compare bus and rail based corridors in Dublin using the same criteria i.e. TCQSM, particularly when the new light rail corridors commence in 2004.

Providing high quality public transport corridors from outside the greater Dublin area has also been considered e.g. to Navan to the north west of the city. An interesting analysis would be to review this in a similar way to the BRT initiative in New Britain in Hartford where an analysis looked at constructing a light rail, heavy rail or a bus service along the corridor in terms of the LOS that might be achieved.

**REFERENCES**

1. Dublin Transportation Office, A Platform for Change, Dublin, Ireland. Sept. 2000
2. Steer Davies Gleave, Dublin Transportation Initiative Final Report, Department of the Environment, Dublin, Ireland, 1995.
3. Transportation Cooperative Research Programme, Transit Capacity and Quality of Service Manual, Transportation Research Board, Washington D.C., 1999
4. Levinson, H., Zimmerman S., Clinger J. and Gast J. "Bus Rapid Transit, Synthesis of Case Studies" (CD-ROM). 82nd Annual Meeting of the Transportation Research Board. Washington DC, January 2003
5. Baltes R. "Statistical Estimation of the Importance Place on Specific Elements of Bus Rapid Transit by Customers".  (CD-ROM). 82nd Annual Meeting of the Transportation Research Board. Washington DC, January 2003
6. Papandreou N., Wilshire Bus Rapid Transit, More than Just a Dedicated Bus Lane, (CD-ROM). (CD-ROM) 82nd Annual Meeting of the Transportation Research Board. Washington DC, January 2003

7. Watkins K., Sorenson T. and Garrick N. Platform Layout for the New Britian to Hartford Busway, (CD-ROM) 81st Annual Meeting of the Transportation Research Board. Washington DC, January 2002

8. Akiva B. and Takayuki M. Comparing ridership attraction of rail and bus. Transport Policy 9 (2002) 107-116

9. Transport for London, The Mayors Transport Strategy, London, England, July 2001

10. Transport for London, Bus Priority and Traffic Unit Annual Review, London, England, 1998

11. Córas Iompair Éireann (2002), CIE Group Annual Report and Financial Statements 2002, Dublin, Ireland

12. Dublin Transportation Office, Traffic Management Guidelines, Dublin Ireland, May 2003

13. Dublin Transportation Office, QBC Report to QBC Committee/ Steering Committee, Dublin, Ireland, Sept. 2002

14. O' Mahony, M. Quality Bus Corridors in Dublin. (CD-ROM) 81st Annual Meeting of the Transportation Research Board. Washington DC, January 2002

15. Bus Átha Cliath, http://www.dublinbus.ie/home/market_research.asp Accessed 30th of June 2003

16. Bus Átha Cliath, http://www.dublinbus.ie/home/customer_charter.asp Accessed 14th of July 2003

17. Road Traffic Technology, http://www.roadtraffic-echnology.com/projects/congestion/.   Accessed 4th June 2003

18. European Commission, SERTI Project. European Workshop: Travel Time Estimation, Avignon November 2001.

19. Ciccarelli A., Griffin L. and D'Angelo M, The Orlando-Orange County Express Authority's Traffic Data Collection Pilot Project, CD-ROM, Proceedings from the 9th World Congress on ITS, Chicago 2002

20. Bus Átha Cliath, http://www.dublinbus.ie/your_journey/search_by_map.asp?map=dublin_north. Accessed 30th of June 2003

21. Dublin Transportation Office, Bus Based Park & Ride – A Pilot Scheme, A Report by: The TAS Partnership, To the Dublin Transportation Office, Dublin, Ireland, October 2002

22. Dublin Transportation Office, http://www.dto.ie/qbc.pdf Accessed 21st July 2003

**TABLES AND FIGURES**

**TABLES**
Table 1 Performance of the QBCs

Table 2 Hours of Service LOS

Table 3 Transit/Auto LOS

Table 4 Service Frequency LOS


**FIGURES**
Figure 1 Quality Bus Corridors in Dublin

Figure 2 Map of Malahide QBC

Figure 3 Transit/Auto Speed Comparisons

Figure 4 GIS Map of Section One

**TABLE 1. Performance of QBCs since Launch (13)**

| QBC | Launch Date | QBC Length | | Time Savings (Min) | Bus Patronage | | Increase in Patronage |
|---|---|---|---|---|---|---|---|
| | | Miles | Km | | Pre QBC | Post QBC* | |
| Lucan QBC | July 1996 | 7.5 | 12.1 | 9 | 16328 | 22243 | 36% |
| Malahide QBC | Dec. 1998 | 4.7 | 7.5 | 8 | 22018 | 28105 | 27% |
| Stillorgan QBC | Aug. 1999 | 8 | 12.9 | 11 | 9768 | 32425 | 232% |
| Finglas QBC | July 2000 | 3.7 | 6 | 3 | 8928 | 8974 | 0.5% |
| Clondalkin QBC | Feb. 2001 | 7.5 | 12.1 | 8 | 14723 | 14405 | -2% |
| Rrathfarnham QBC | March 2001 | 4.4 | 7.1 | 30 | 10786 | 14786 | 37% |
| Swords QBC | April 2001 | 1.8 | 2.9 | 4 | 16829 | 19666 | 17% |
| Tallaght QBC | April 2001 | 7.5 | 12.2 | 6 | 18916 | 22570 | 19% |
| Blanchardstown QBC | Sept. 2001 | 10 | 16.4 | - | 20383 | 28272 | 39% |
| Swords (Airport) 2001 | Nov. 2001 | 7.2 | 11.7 | - | - | - | |
| **Average** | | | | **10min** | | | **50%** |

* Based on BAC patronage for November 2002

**TABLE 2. Hours of Service LOS**

| Direction | Hours of Service* | LOS | TCQSM Comments** |
|---|---|---|---|
| **Inbound** | | | |
| Weekdays | 20 | A | Night owl service provided |
| Saturday | 23 | A | Night owl service provided |
| Sunday | 16 | C | Early evening service provided |
| **Outbound** | | | |
| Weekdays | 20 | A | Night owl service provided |
| Saturday | 18 | B | Late evening service is provided |
| Sunday | 16 | C | Early evening service provided |

* BAC timetables (21)

** TCQSM (3)

**TABLE 3. Transit/Auto LOS**

| Time | Weekdays | | | | Weekends | | | |
|---|---|---|---|---|---|---|---|---|
| | Inbound | | Outbound | | Inbound | | Outbound | |
| | Time min:sec | LOS | Time min:sec | LOS | Time min:sec | LOS | Time min:sec | LOS |
| 07:00-08:00 | 02:10 | B | 04:20 | B | * | * | * | * |
| 08:00-09:00 | 06:45 | B | 04:18 | B | * | * | * | * |
| 09:00-10:00 | 02:10 | B | 05:19 | B | * | * | * | * |
| 10:00-11:00 | (01:23) | A | 03:01 | B | 00:40 | B | 01:05 | B |
| 11:00-12:00 | 01:06 | B | 04:13 | B | 02:16 | B | 00:30 | B |
| 12:00-13:00 | 00:33 | B | 02:05 | B | 01:17 | B | 03:04 | B |
| 13:00-14:00 | 00:50 | B | 03:49 | B | 01:32 | B | 04:27 | B |
| 14:00-15:00 | 00:45 | B | 04:52 | B | 00:49 | B | 04:14 | B |
| 15:00-16:00 | 00:18 | B | 02:46 | B | (00:54) | A | 01:52 | B |
| 16:00-17:00 | 01:01 | B | (00:50) | A | 01:12 | B | 00:44 | B |
| 17:00-18:00 | 01:05 | B | 02:20 | B | 00:23 | B | 03:02 | B |
| 18:00-19:00 | 01:04 | B | (01:04) | A | 00:42 | B | 00:27 | B |
| 19:00-20:00 | 01:18 | B | 00:58 | B | 01:10 | B | 01:06 | B |
| Average Difference | 01:37 | B | 03:39 | B | 04:19 | B | 02:03 | B |

* Data not available

**TABLE 4. Service frequency LOS**

| Sections | 1 | | 2 | | 3 | |
|----------|---|---|---|---|---|---|
| Time | Bus/per hour | LOS | Bus/per hour | LOS | Bus/per hour | LOS |
| **Inbound** | | | | | | |
| 07:00-08:00 | 4 | C | 1 | E | 1 | E |
| 08:00-09:00 | 18 | A | 10 | A | 10 | A |
| 09:00-10:00 | 41 | A | 15 | A | 15 | A |
| 10:00-11:00 | 23 | A | 14 | A | 10 | A |
| 11:00-12:00 | 20 | A | 15 | A | 14 | A |
| 12:00-13:00 | 24 | A | 11 | A | 6 | A |
| 13:00-14:00 | 26 | A | 11 | A | 6 | A |
| 14:00-15:00 | 18 | A | 11 | A | 7 | A |
| 15:00-16:00 | 18 | A | 12 | A | 7 | A |
| 16:00-17:00 | 23 | A | 7 | A | 3 | C |
| 17:00-18:00 | 28 | A | 19 | A | 11 | A |
| 18:00-19:00 | 23 | A | 12 | A | 10 | A |
| 19:00-20:00 | 18 | A | 11 | A | 18 | A |
| **Average** | **21** | **A** | **8** | **A** | **11** | **A** |
| **Outbound** | | | | | | |
| 07:00-08:00 | 1 | F | 2 | D | 0 | F |
| 08:00-09:00 | 16 | A | 8 | A | 4 | C |
| 09:00-10:00 | 20 | A | 16 | A | 8 | A |
| 10:00-11:00 | 29 | A | 11 | A | 2 | D |
| 11:00-12:00 | 11 | A | 11 | A | 8 | A |
| 12:00-13:00 | 12 | A | 11 | A | 5 | B |
| 13:00-14:00 | 8 | A | 7 | A | 9 | A |
| 14:00-15:00 | 18 | A | 11 | A | 8 | A |
| 15:00-16:00 | 9 | A | 9 | A | 5 | B |
| 16:00-17:00 | 12 | A | 10 | A | 6 | A |
| 17:00-18:00 | 18 | A | 17 | A | 11 | A |
| 18:00-19:00 | 30 | A | 16 | A | 11 | A |
| 19:00-20:00 | 33 | A | 15 | A | 9 | A |
| **Average** | **16** | **A** | **11** | **A** | **6** | **A** |
| | **Sections of Malahide QBC** | | | | | |
| **1** | Amien Street/Buckingham Street – Fairview Pedestrian Bridge | | | | | |
| **2** | Fairview/Pedestrian Bridge – Malahide Road/Elm Mount Road | | | | | |
| **3** | Malahide Road/Elm Mount Road – Malahide Road/Darndale Roundabout | | | | | |

**FIGURE 1. Quality bus corridors in Dublin (25)**



Position as of June 2003
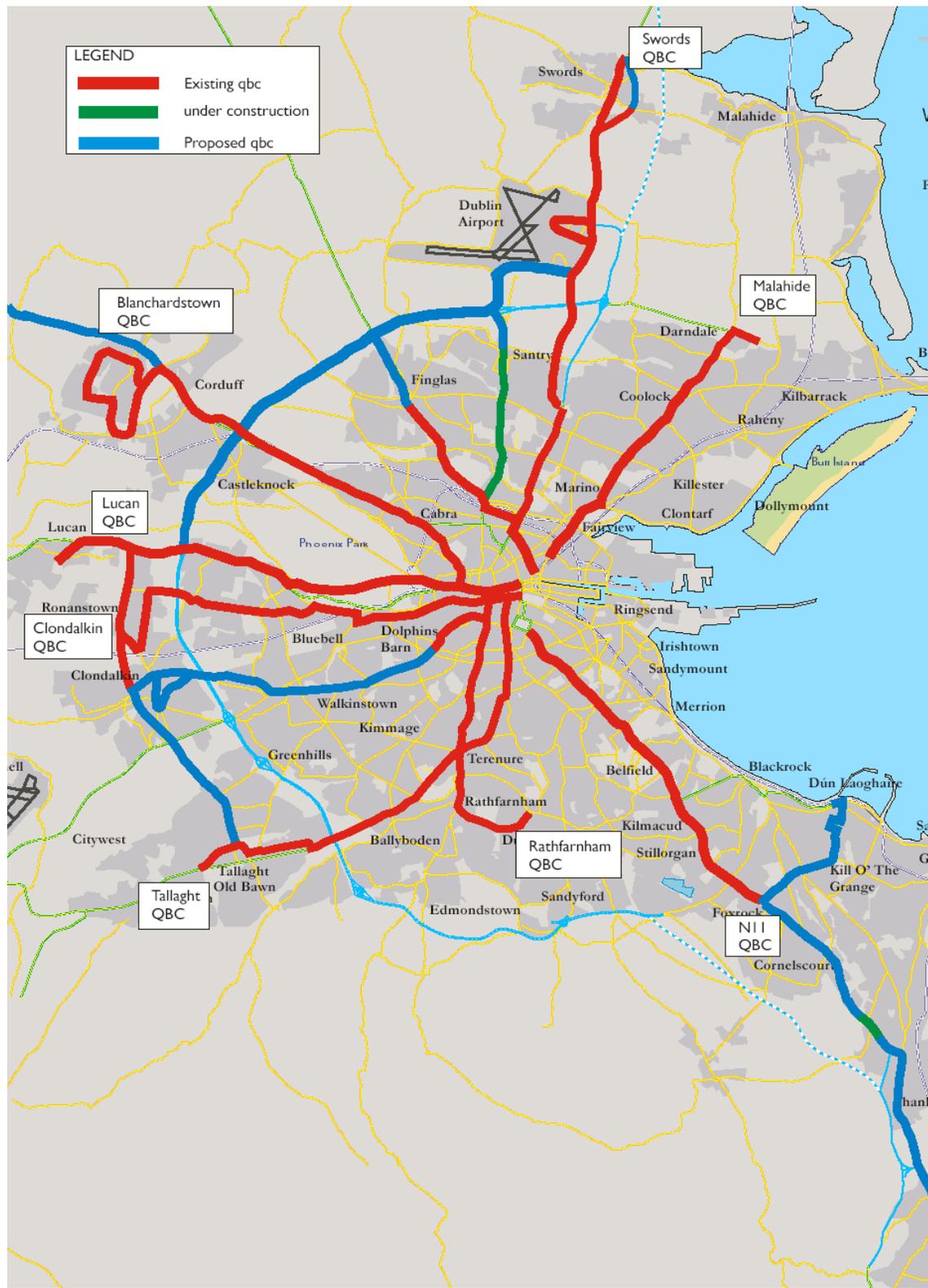
**FIGURE 2. Map of Malahide QBC**
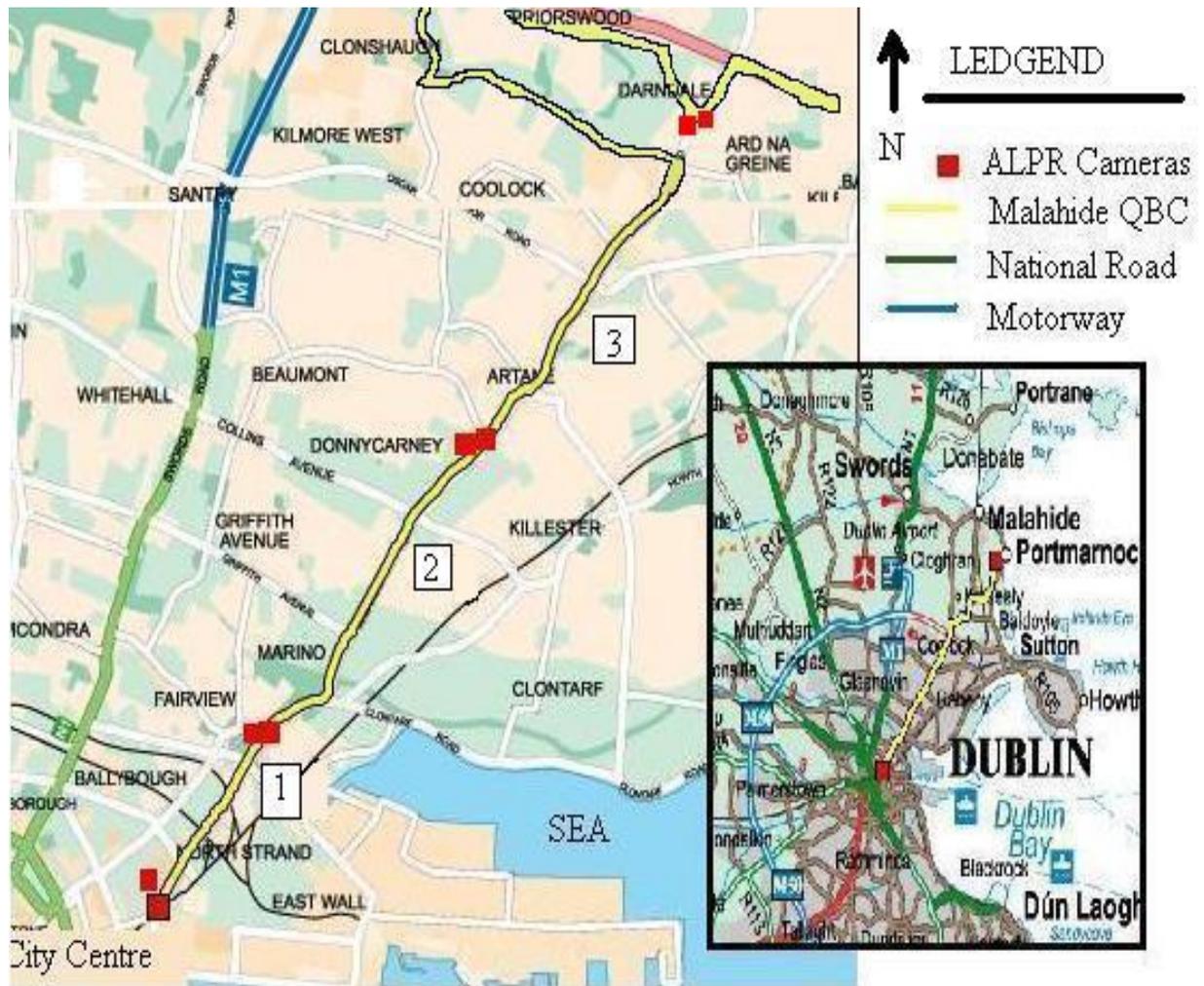


| | Segment of Malahide QBC |
|---|---|
| 1 | Amien Street/Buckingham Street – Fairview Pedestrian Bridge |
| 2 | Fairview/Pedestrian Bridge – Malahide Road/Elm Mount Road |
| 3 | Malahide Road/Elm Mount Road – Malahide Road/Darndale Roundabout |

**FIGURE 3. Transit/Auto Speed comparison**
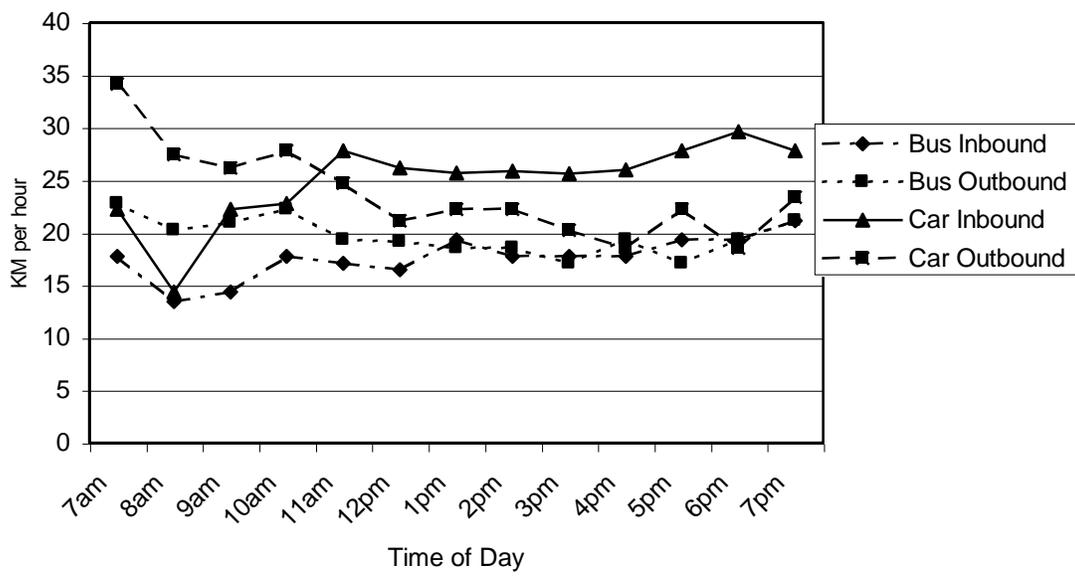
**FIGURE 4. GIS Map of Section One Inbound (DTO)**