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STILLORGAN QBC DWELL TIME ANALYSIS

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Abstract

Journey time surveys were carried out during spring 2013 as part of an analysis of dwell-time on the Stillorgan Quality Bus Corridor (QBC), a key arterial bus corridor accessing Dublin city centre from its suburbs. The focus of the study was to understand the pattern of dwell-time on the corridor and to identify potential areas, if any, where service levels may be enhanced. The study should provide a beneficial and detailed observation of in-journey bus operations. This in turn can help to understand the impact of ticketing, boarding/alighting and other aspects of journey dwell within a high-level of service bus corridor.

The Stillorgan QBC, between Foxrock Church and Leeson Street Bridge, comprises of 28 bus stops, 32 signalised junctions and measures approximately 9km. There are 60 locations, exclusive of running-time delays, where there is the potential for dwell to occur.

21 inbound journey time surveys were carried out in the morning commuter peak period over 7 days between the hours of 07:00 and 10:00, with 3 surveys carried out every day, one in each hour. Approximately 1,200 passenger boardings and 900 alightings were recorded. Individual fare transaction times were also surveyed.

Several key findings emerged from the study. Dwell at junctions accounts for 13% of total journey time, with boarding and alighting accounting for 23%. 59% of passengers surveyed alight at four individual stops, and 24% of those surveyed board at two individual stops.

Journey times are very variable, with a difference of 23 minutes between shortest and longest journeys (a variance of 110%). This has improved considerably since the last QBC Monitoring Report in 2010 when variances of 259% were recorded.

Pre-paid tickets are the most popular and fastest method of payment with 55% of those surveyed using this method. Pre-paid ticket users take on average 7 seconds to board. There is no time-saving for LEAP Card (e-purse) users, who take on average 10 seconds to board (being the same for cash payers).

The findings present evidence to support the implementation of off-board ticket purchase and/or the removal of both cash and e-purse ticket transactions from services. Service planning improvements, such as the consolidation of stops, multi-door entry/exit systems and measures to improve performance at junctions, are also suggested.

Introduction

Dwell is defined as 'the amount of time required to serve passengers at a transit stop and the time required to open and close the vehicle doors [1, 2]. One of the key variables in bus journey time is passengers boarding and alighting from the bus. With a stop call system in place a passenger must request the bus to stop either by ringing the on board bell or, at the stop, by raising his/her arm. This means that it is impossible to tell how many times the bus will be required to stop on its journey, and consequently how long the journey will be as each stop is a direct time cost. The numbers of people boarding the bus and the method of payment they use also contributes to the dwell time at each stop, with certain payment methods taking longer than others. The other significant variable for bus journeys is at junctions. These two variables combine to impose significant delays on journey time, making bus journey times variable from service to service and in turn reducing the certainty to the commuter. The unreliable nature of bus journey times has been shown to deter many would be users, both generally [3, 4] and specifically within the case-study area [5].

The focus of this paper is to establish where dwell occurs during a bus journey on a key quality bus corridor (QBC) in Dublin and analyse the nature of such dwell-time. This may help in identifying the extent to which "systems-based" improvements, such as the introduction of off-board ticketing, could result in improved journey time reliability. Running-time variance, also a factor in operational efficiency, is not in itself associated with dwell-time and was considered outside the scope of this study.

Car based commuting levels of 45-70% are typically displayed along the Stillorgan QBC and environs. The area around Foxrock Church displayed car commuting levels of 60- 70% in the 2011 Census [6]. Quality Bus Network Monitoring Reports have been produced by the NTA (and its predecessor, the DTO) between 1997 and 2010 [7]. Comparing the 1997 report to 2010 we can see that cars accessing the city centre have declined overall on the selected corridor by 28% and buses increased by 150%, with a 145% increase in passenger numbers. The most recently available report, in 2010, highlighted a year-on-year bus mode share decline, with 9% less buses crossing the canal and a 10% increase in car trips [7].

There has been much recent discussion around the development of higher quality bus systems. The concept of Bus Rapid Transit (BRT) has evolved over the years to establish itself as a strong and dynamic form of mass transit, featured in many of the world's leading cities [8, 9]. BRT systems have been identified as comprising of five main element, being: stations, vehicles, services, running ways and Information Technology Systems (ITS) [10, 11, 12]. Much of the discussion points towards the potential for a systems-based approach to service improvement, i.e. the programmatic improvement of any of the afore-mentioned system-components. Within the European sphere such a systems-based approach has been advocated as appropriate to the predominantly mid-sized category of cities [12].

Evidence suggests that systems-based improvements in bus priority can be both economic and effective. Toulouse has piloted a junction 'radio priority system' at signalised junctions which has yielded significantly positive results. The system involves equipping both bus and junctions with radio transmitters and the installation of a central control system to monitor performance, with a capital cost of €3m. The system has improved bus regularity and improved journey time by reducing the dwell time spent at signalised junctions. The average bus waiting time at signalised junctions has improved by 52%. This equates to a time saving of nine seconds per equipped traffic light. The system has also produced other gains for the bus operators, with a reduction in gasoline consumption which equates to a €2m saving in 2 years. The system is on course to reimburse the operators within 3-4 years of implementation. This case study highlights that for a small capital investment in bus priority measures there can be considerable gains to service quality [13, 14].

A review of policy indicates that government is committed to encouraging the use of more sustainable modes for commuter trips [15]. Implementing greater bus priority measures may provide greater value for money in times of reduced government expenditure. Given the adaptable nature and flexibility of bus based transit systems, any measure that can lead to service level improvement seems worthy of examination. It is also noted that the NTA are currently engaged in the design of a potential BRT network for Dublin which encompasses the study area corridor [16].

Methodology

The core of this study focuses on journey times on the Stillorgan QBC from Foxrock Church to Lower Leeson St. Using the same study area as the QBC Monitoring Reports allows comparison between data sets prepared between 1997 and 2010. A desk top study was undertaken of the proposed route using open-street mapping, to survey the number of stops along the route and the number of signalised junctions. Following on from this a detailed analysis of existing tickets and payment methods was undertaken using the Dublin Bus website. On-board observations were made while travelling on board services ensuring all payment methods were identified. The various payment methods were then categorised into four main categories Cash, Leap, Pre-paid, and Free Travel Pass.

Dwell Time data was collected through twenty-one on board surveys during the AM peak commuting period Monday to Friday, starting at 07:00 and concluding at 10:00, during March 2013. The aim was to start and conclude one journey within each hourly period thus achieving three peak trips a day, allowing the data to be collected within seven weekday mornings. Three daily survey periods identified were: -

- Survey period 1: 07:00 – 08:00
- Survey period 2: 08:00 – 09:00
- Survey period 3: 09:00 – 10:00

Timing of dwell time at stops commenced when the bus came to a complete stop. Timing was ceased when the bus began to move away from the stop. This included the time it took for the opening of the doors, alighting / boarding of passengers and the closing of the doors. The surveyor was positioned either in the wheelchair bay of the bus or in the central hallway of the bus with full view of the bus entrance. Care was taken not to disrupt the movement or behaviour of bus passengers. In general those boarding and alighting the bus are required to do so in single file, allowing the surveyor adequate time to properly enumerate each movement and transaction.

Figure 1 (left): Location of bus stops [Sn = stop] along the Stillorgan QBC

The surveys were carried out on board the 46A service starting at Springfield Park (Foxrock Church) and concluding at lower Leeson Street. The 46A operates one of the highest frequency services on the Dublin Bus Network with 8-minute headways during daytime. Surveys were carried out during school and college openings times. A sample size of 21 peak morning surveys and 2,000+ passenger movements produced robust data sets and it was noticed that identifiable patterns emerged towards the end of the study period.

The data collected included: -

- Time spent waiting for each service;
- Dwell time at each stop relating to boarding, alighting and any other factors;
- Dwell time at signalised junctions;
- The number of people boarding and alighting the bus at each stop;
- The method of payment used by each passenger boarding the bus;
- The total journey time from Foxrock Church to Lower Leeson St.;
- The location of key trip generators along the corridor e.g. Schools and Colleges.

Findings and Analysis

1. Schedule Adherence

Table 1 shows the wait time recorded for each of the 21 surveyed trips. For the entire survey period there was only one wait time (Survey 1 on Thurs 07/03/2013) that exceeded the reported operating frequency of 8 minutes. In the peak hour (08:00 – 09:00), as frequency increased, average wait times were only 3 minutes. At no time during the peak period did the bus wait time exceed 7 minutes.

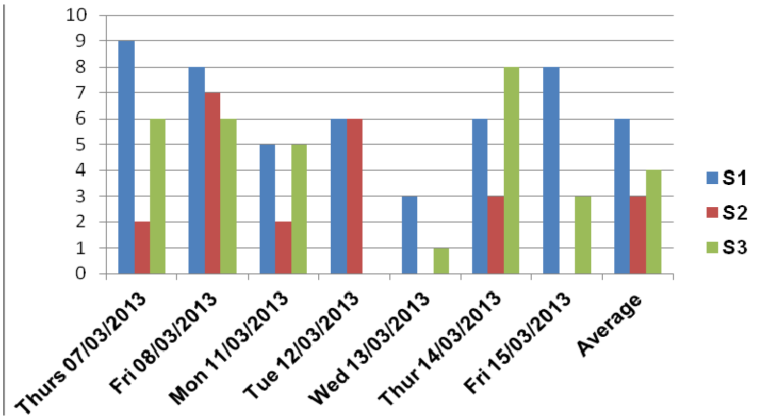


Table 1: Wait Times at Springfield Park (Foxrock Church)

2. Journey Time Reliability

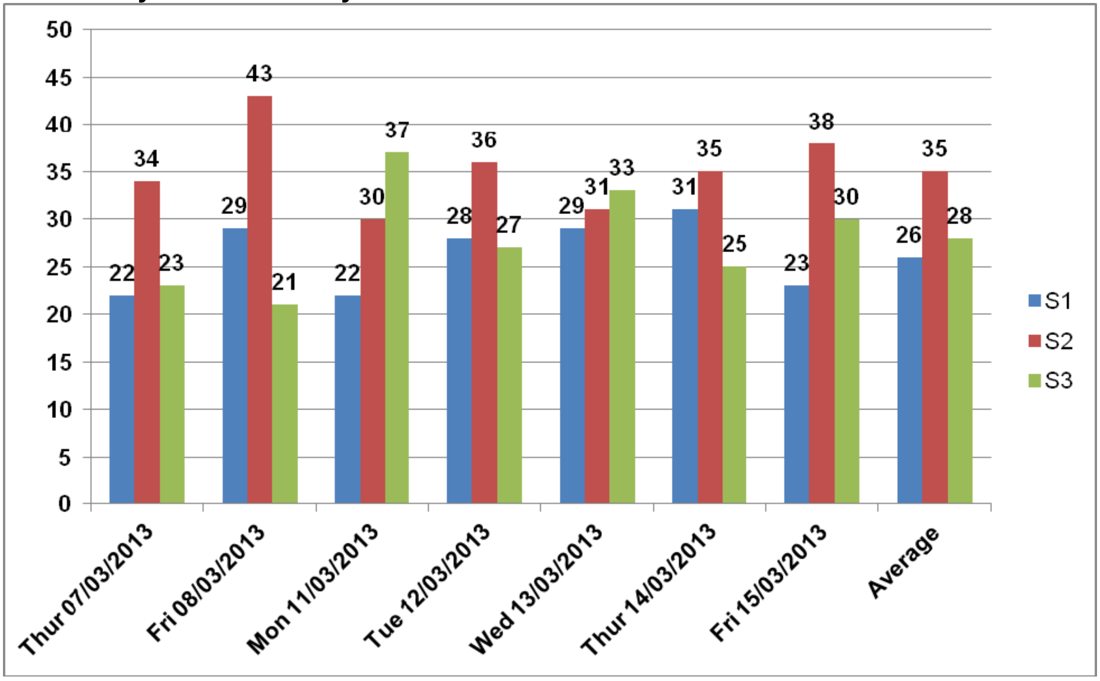


Table 2: Journey Times for each Surveyed Trip

Table 2 highlights the spread of journey times across the entire survey period. Survey period one has a difference of 9 minutes between the quickest and slowest journey time. Survey period 2 has a disparity of 23 minutes between the quickest and slowest journey time. And the final survey period has a difference of 16 minutes between quickest and slowest journey time. The average overall journey time was 30 minutes.

The peak period also has the highest average journey time at 35 minutes. This period accounted for 43% of all passengers surveyed. There was also increased traffic on the road network which may also have contributed to increased journey times.

The total journey-time variance [min-max variance as a percentage of minimum journey time] is 110%. This provides a useful comparison with the most recent of the QBC Monitoring Reports, carried out in 2010. The 2010 study measured a shortest journey time of 15:15, and a longest journey time of 59:19 [7]. The variance is 44:04 or 289%. Journey time variance appears to have reduced by 179%, a significant reduction over the course of three years. It is not clear what specifically may have contributed to this improvement. However, it is noted that a review of routes and timetables was carried out across the full network during this time. One of the aims of the *"Network Direct" project* (whose details remain unpublished) was to improve service reliability on strategic routes.

3. Method of Payment Choice

Table 3 shows how, during the survey, the Pre-paid Card was the most popular form of payment used, capturing 55% of user's surveyed. The second most popular form of payment method is Cash. The third most popular method of payment on the 46A service is the LEAP Card, a recently introduced electronic purse regime. The LEAP Card still requires the user to engage with the driver stating his/her destination and placing the card on the reader and the required fare is deducted by the driver. This form of payment is the most recent to the bus network and it was evident during the survey that many users were still unfamiliar as to the full benefits of its use. Some commuters appeared unsure of whether they should engage with the driver or use the smart reader, for example. The final form of payment used on the service was the Free Travel Pass. Only 3% of users surveyed used a Travel Pass as a method of payment. The Free Travel Pass is available to anyone aged over 66 and certain other people who may qualify under various criteria [17].

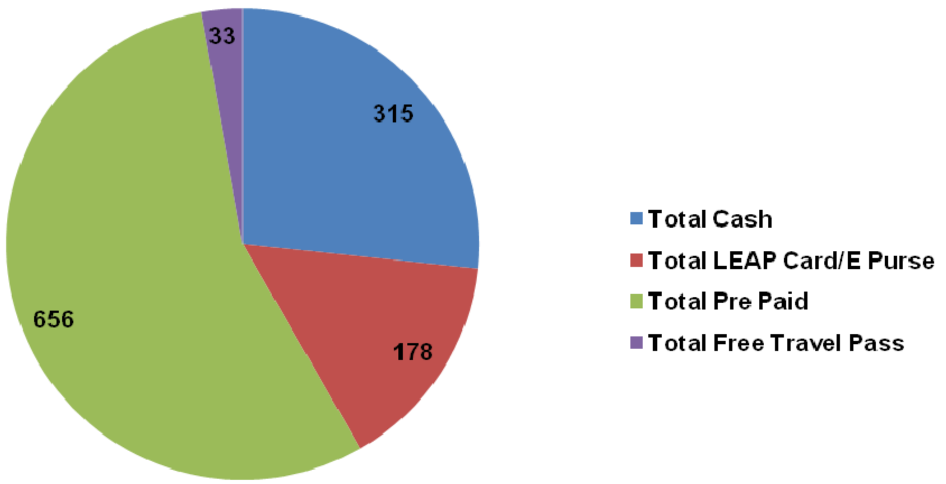


Table 3: Method of Payment

4. Average Time Cost per Method of Payment

In order to attribute an accurate time cost to each payment method a separate survey focused on the method of payment and the time cost associated with each. This was conducted during peak and off peak services. The survey timed a sample of individuals while boarding and this was then used to establish an average for each payment method.

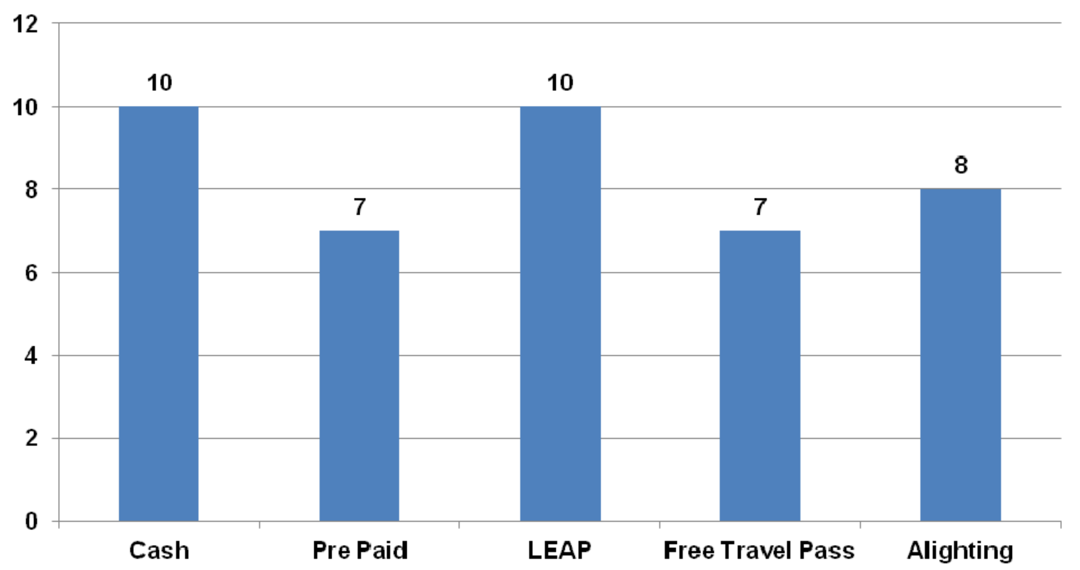


Table 4: Average Time cost per Method of Payment (seconds)

Table 4 shows the average time cost per method of payment. The Pre-paid card represents the fastest method of payment with transactions taking 7 seconds per person on average. Included in the Pre-Paid payment category are some LEAP card payments, as commuters travelling full fare can use the card reader provide to scan on. The Pre-Paid payment method requires the user to scan their card over a card reader without engaging with the driver.

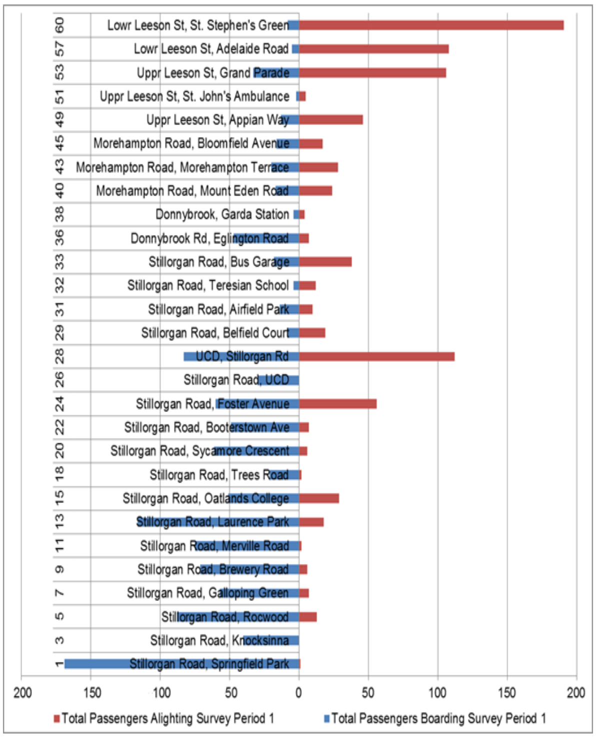
The Free Travel Pass was also shown to be a fast form of payment, taking on average 7 seconds. Timing can vary for this ticket type as many users are elderly and with restricted mobility. This is balanced by the ease with which users can simply display their ticket to the driver without any requirement for electronic validation.

A Cash transaction takes on average 10 seconds per person boarding the bus. Cash payments are made to the driver and no change is given meaning if a commuter does not have exact change a receipt is issued. Each LEAP Card transaction also takes on average 10 seconds. This is the same amount of time required for a cash transaction and both require the attention of the bus driver.

42% of payments were either by electronic purse or cash. These transactions take on average 40% longer to process than pre-payments or travel passes. Eliminating such payment types would yield a material reduction in overall dwell-time at stops. Calculated over the sampled period, a 5% reduction in total journey time for each and every trip would be yielded alone by the removal of cash / e-purse transactions. A similar, or likely greater, improvement in journey-time reliability should also be gained. Ticketing dwell could be reduced further by moving all payment infrastructures off the bus, placing it at bus stops instead or, more imaginatively, by reintroducing on-board ticket conductors.

5. Boarding and Alighting Pattern

Table 5 shows where boarding and alighting takes place along the Stillorgan QBC. A total of 1,180 people boarded and 874 people alighted during the 21 journeys surveyed, a total of 2,054 passenger movements. 43% of these were during the peak period.



Boarding is far more dispersed than alighting, probably indicative of the dispersed, suburban settlement pattern along the corridor. Boardings exceed alightings and this is due to the truncated case study area, which is cordoned at the edge of the city centre, the main trip attractor. This limitation was necessitated by the QBC Monitoring Report comparator study area, also by the high level of unreliability through the city centre journey segment.

Two stops (Springfield Park and Laurence Park) account for 24% of all those boarding the bus. Boarding begins to decline after the UCD stop with alighting becoming more prevalent.

Table 5: Total Passengers Boarding and Alighting by Stop

6. Analysis of Journey Time Components

This section highlights the contribution of (i) boarding & alighting and (ii) junction dwell to overall journey time during the surveyed journeys. Boarding and alighting dwell time accounts for 23% of all journey time in the survey sample. The average dwell time per stop is 15 seconds. With 28 stops along the QBC this makes an average total dwell time of 420 seconds or 7 minutes per journey attributed to boarding and alighting dwell along the QBC.

The QBN Monitoring reports feature dwell time surveys from 2002 which revealed dwell at stops to account for 19% of journey time. Another dwell time survey was carried out in 2007 which reported dwell time due to boarding and alighting to account for 21% of journey time. This highlights a steady and consistent increase in dwell time relating to boarding and alighting. Over an 11 year period dwell time has increased yearly by 0.36%.

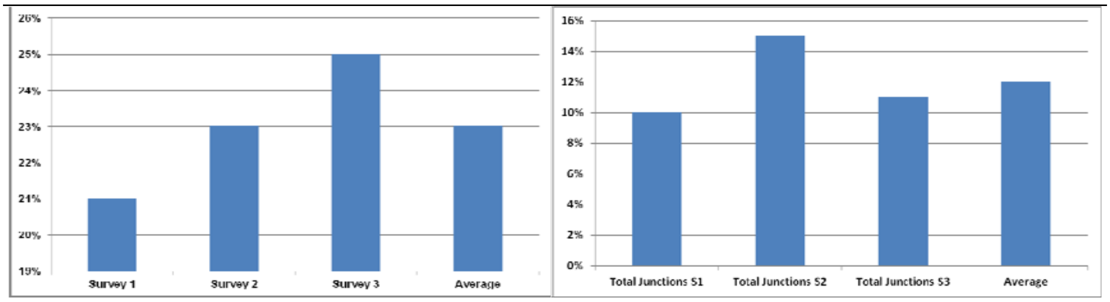


Table 6a (left): Boarding and Alighting Dwell as Percentage of Journey Time, and Table 6b (right): Junction Dwell as a Percentage of Journey Time

Junction dwell time accounts for 12% of all journey time in the survey. There are 32 signalised junctions along the Stillorgan QBC ranging from signalised junctions to pedestrian crossing. With the average dwell per junction 7 seconds this equates to an average junction dwell per journey of 224 seconds, or 3.25 minutes.

7. Journey Time Component Analysis

Table 7 illustrates the average breakdown of journey times for the seven day survey period. The average time spent in dwell for the survey period was 36% of journey time. This includes both junction dwell and boarding & alighting dwell.

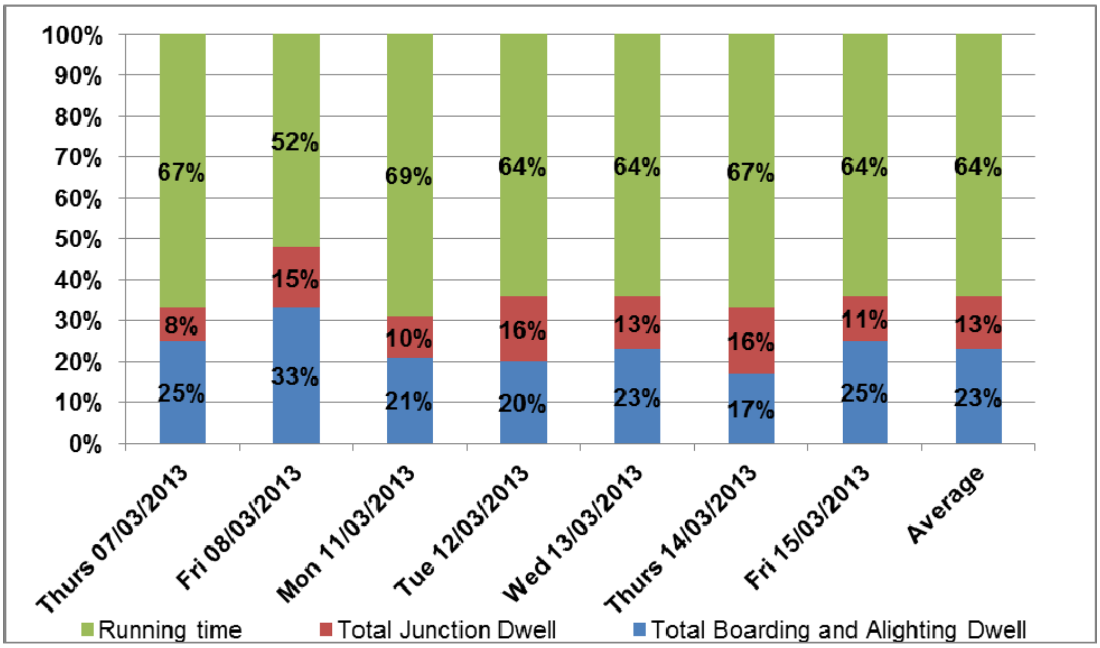


Table 7: Journey Time Components

Boarding & alighting is consistently the biggest contributor to bus dwell time, ranging from 17-33%. Junction dwell can also make a significant contribution to bus journey times, ranging from 8-15%.

Conclusions

Journey time surveys were conducted for 21 services on the 46A route between Foxrock Church and Leeson Street on the Stillorgan QBC, a key quality bus corridor accessing Dublin city centre. The analysis provides a detailed profile of factors contributing to dwell time and the relative impact of dwell on Quality of Service.

- Over the 21 journeys surveyed, journey times proved very variable with 110% variance between the shortest and longest trips.

- While journey time variability seems high, at 110%, this has improved significantly over the 2010 QBC study, which indicated variances of up to 259%. There appears to have been a significant improvement in journey-time reliability over a relatively short period in time. Investment has taken place, during this period, in a review of the network. While details of the latter remain unpublished, total bus numbers have reduced from 1,300 to under 800 with similar service coverage being offered.

- Approximately 1/3rd (36%) of all journey time is spent in dwell. The biggest contributor to dwell times is boarding and alighting time which comprises 23% of total journey time on average. Junction dwell also contributes significantly to the makeup of journey time, accounting for 13% of journey time.

- The Pre-Paid card is the quickest form of payment along with the free travel pass, with both methods requiring 7 seconds for one person to board using this method. The slowest methods of payment are Cash and LEAP Card which both require 10 seconds per person boarding on average.

- Boarding and alighting patterns are relatively concentrated with 24% of those surveyed boarding at two individual stops. 59% of passengers alighted at four individual stops. This points to a dispersed settlement pattern with clusters of key trip generators.

Some Implications of Key Results

Much of the focus of the study evidently falls on the ticketing regime and the boarding / alighting system. The survey data strongly suggests that efficiencies in both could be yielded. This could be achieved in a number of ways, e.g. by the reintroduction of a conductor who administers these types of fare payments. Ticketing dwell could be reduced by moving all payment infrastructures off the bus, placing it at bus stops instead. Multi door access would allow passengers board and alight at separate doors thus reducing dwell time further. There are a number of options in this regard such as a two door system or a three door system as deployed by Transport for London.

In addition to improvements at stops, the implementation of signal system improvements could reduce the amount of dwell-time at junctions which on average accounts for 13% of journey time. A smart signal control system could help reduce this dwell time considerably as seen in a Toulouse case study where this type of dwell was reduced by 52% and capital costs were recovered within 3-4 years due to increased patronage [14, 19].

While a full catchment analysis was outside the scope of this study, it was noted that a number of stops are spaced close together, sometimes less than 200m apart and have very low demand, suggesting overlapping catchments and redundancy. Rapid transit stops generally require a spacing of no less than 400m, with other commentators suggesting greater distances [20].

Some research limitations are noted, including the study area which is truncated at the edge of the city centre, but it was considered important to replicate the study area of the earlier QBC Monitoring Reports. Further, continuing the study into the inner urban zone would have exponentially increased the survey logistics beyond available resources.

Additional findings from the research are also available in the BSc Spatial Planning dissertation for which the initial research was conducted [21].

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