

Understanding the On-Time Performance of Bus Services across Adelaide Using Ticketing Data

Presented to the 15th International Conference on
Computers in Urban Planning and Urban
Management

Abstract

Throughout the world, the reliability of public transport systems is constantly under review. Questions of reliability are particularly applicable to bus services, as they commonly share road space with other vehicles. This study used graphical and statistical approaches to assess the reliability of services in Adelaide across a typical month. Using smartcard boarding data in conjunction with the published timetables, bus reliability measures were developed. To check the validity of using this boarding data, comparisons were drawn to the results previously obtained using Automatic vehicle location along a handful of individual routes. The analysis suggests that passenger's boarding and alighting, as well as traffic congestion, are key contributors to on-time performance of buses at the stop level. However, it was found that boarding where a ticket sale was involved did not contribute much to travel time variability although it slows down vehicles considerably.

C. Sleep (Corresponding author)

Email: callum.sleep@unisa.edu.au

School of Natural and Built Environment, University of South Australia,
Adelaide, South Australia 5000

S. Somenahalli •

Email: sekhar.somenahalli@unisa.edu.au

M. Mosallanejad

Email: mona.mosallanejad@mymail.unisa.edu.au

1. Background

Throughout the world, the reliability of public transport systems is constantly under review. In recent years, the widespread prevalence of privately owned motor vehicles and people's quickening pace of life has increased the importance of public transport service reliability and on-time performance. This is of potential concern for bus services as buses share road space with a growing number of other vehicles. In Adelaide, the capital city of South Australia, the public transport system has been plagued by concerns of unreliable services (Kelton, 2012a).

The Department of Planning, Transport and Infrastructure (DPTI) is South Australia's main transport body. Adelaide Metro is a sub division of DPTI that manages Adelaide's public transport system consisting of predominantly bus routes. These bus routes are particularly prone to the effects of congestion on the roads immediately surrounding and within the central business district (CBD).

The South Australian community is encouraged, by the government, to use public transport especially for regular trips such as the daily commute. However, the South Australian public sector has found that many commuters are boycotting public bus services, reducing the total number of commuters using public transport (Kelton, 2012b). South Australia's initial boardings for metropolitan public transport rose each year incrementally between 2000 and 2009, reaching 52.4 million in the 2009–2010 financial year (DPTI, 2010). However, DPTI's Annual Report for 2010–2011 (Department of Transport Energy and Infrastructure, 2011) states that in 2010–2011, initial boardings reduced by 2.2 per cent to 51.25 million. One reason for this reduction is the perceived unreliability of services. (Nankervis, 2016) Often, buses do not meet the advertised service times, with many services running a quarter or even half an hour late—or, in some cases, not arriving at all (Kelton, 2012a).

South Australia's Public transport system is operating well below its full potential. According to the Australian Bureau of Statistics (Australian Bureau of Statistics, 2009), 14.4 per cent of adults across Australia were using public transport for their trip to work or study in 2006, while in Adelaide this figure was less than 10%. The use of public transport between 1996 and 2006 increased by only 18 per cent in Adelaide, dwarfed by

increases of 35 per cent and 22 per cent in Melbourne and Brisbane respectively (Australian Bureau of Statistics, 2009).

According to the Adelaide Metro website (Adelaide Metro, 2012), the quality of South Australian public transport needs minor improvement. DPTI monitors the performance of the bus contractors to make sure that the service quality (on-time running and reliability) meets community needs and demands. DPTI defines service as 'on-time' and 'reliable' if the vehicle departs no more than 59 seconds before and no more than 4:59 minutes (i.e., 4 minutes 59 seconds) after the time published in the timetable (Adelaide Metro, 2012). It must be noted that not all stops appear on the timetables; at these locations, estimated times are provided to the travelling public. Even with 6 minutes' flexibility, a large proportion of services are failing to meet targets. This lack of reliability for public transport services is a significant concern for the community.

In the past, several attempts have been made to improve the reliability of bus services in Adelaide, including: fining the contractors operating the bus services when they fail to meet targets (Bray & Wallis, 2008); continuously changing and reviewing timetables to suit changing road conditions; fitting buses with Global Positioning System (GPS) devices; and auditing buses to determine which bus routes require attention. Automated Vehicle Location (AVL) systems are helping public transport agencies all over the world to improve their performance. However there is a difference between the performance at the vehicle level and what the passenger experiences, often at the stop level (Chen et al., 2009) so it is important to collect and interpret the data accordingly. This study seeks to investigate travel time reliability as seen by the passenger using data collected automatically.

2. Methodology

Using boarding data to assess travel time has the advantage that these records directly relate to passenger experiences. Furthermore in Adelaide boarding data is recorded at the stop locations, as are the timetables, eliminating the need to process and compare the datasets geographically. Bus services were separated from other route services offered by Adelaide Metro for analysis primarily because they form the bulk of the network and are most affected by travel time variability.

In the Adelaide network, the bus driver is also the ticket salesman and therefore must wait until he/she is satisfied no further passengers need to buy a ticket before departing the stop. Compare this to the rail services where fare payment is collected by an on-board vending machine; a passenger could conceivably buy a ticket in transit and validate it as the vehicle is about to reach the next stop. Time spent selling tickets has been previously attributed exclusively to dwell time (time spent stationary at a stop) (Dorbritz et al., 2009), this helped shape the approach for the investigation, giving confidence that the last boarding would reflect bus departure time. As expected similarity was observed when the estimations of departure time from boarding data were compared to those obtained from Automatic Vehicle location records. These records were obtained previously covering a small selection of routes.

There are however some limitations of this method. Primarily, we only have data on a bus's location when a person, passenger or staff, boards and validates a ticket. This makes it difficult to track a bus's progress in the afternoon heading away from Adelaide and impossible to ascertain arrival time at terminals. A more detailed study to address these concerns could be undertaken with AVL data.

3. Data Processing

The busses true departure time was estimated from the last validation at a particular stop. This is deemed valid for assessing the lateness for bus services as there is only one boarding door at the front of the bus and the driver's presence helps enforce fare payment. For example, the records in Figure 1 below are those showing the progress of bus 1125 along route 503. Those records highlighted in the darkest grey will be retained for further processing.

The raw data as shown in Figure 1 has three distinct sections of information. Firstly there's the identifying information specific to each record in the form of an ID and a timestamp. Next there's the geographical information identifying the boarding location, and finally, there's the service information relating to the vehicle's operation.

1	VALIDATION_ID	VALIDATION Time	STOP_CODE	STOP_LABEL	STOP_LATITUDE	STOP_LONGITUDE	ROUTE_CODE	TRIP_DIRECTION	Vehicle_NUMBER
196028	1609919983	8:26:36	6931	Zone A Klemzig Interchange	-34.886524	138.639269	C1		2 1125
196029	1609919985	8:26:50	6931	Zone A Klemzig Interchange	-34.886524	138.639269	C1		2 1125
196030	1609920004	9:13:02	1217	Zone A Tea Tree Plaza Intercha	-34.831325	138.694308	503		2 1125
196031	1609920006	9:13:05	1217	Zone A Tea Tree Plaza Intercha	-34.831325	138.694308	503		2 1125
196032	1609920027	9:29:05	1656	34D Valiant Rd	-34.85004	138.67158	503		2 1125
196033	1609920029	9:29:08	1656	34D Valiant Rd	-34.85004	138.67158	503		2 1125
196034	1609920031	9:29:10	1656	34D Valiant Rd	-34.85004	138.67158	503		2 1125
196035	1609920034	9:30:01	1706	34C Valiant Rd	-34.853742	138.671835	503		2 1125
196036	1609920039	9:31:46	1762	34 Lyons Rd	-34.857462	138.667326	503		2 1125
196037	1609920041	9:31:48	1762	34 Lyons Rd	-34.857462	138.667326	503		2 1125
196038	1609920047	9:34:09	1869	29B Sudholz Rd	-34.861157	138.661002	503		2 1125
196039	1610698084	15:33:03	7735	School Urrbrae College Cross R	-34.964703	138.625472	990		1 1125
196040	1610698086	15:33:05	7735	School Urrbrae College Cross R	-34.964703	138.625472	990		1 1125

Figure 1: Initial boarding data structure

4. Analysis

The data was first aggregated by route, and while there was some inconsistency in average lateness observed across the three days individually, there is a clear trend observed towards consistency across days. On a scatter plot all the routes and their average likenesses were plotted for each day separately. Each route was treated equally spaced one unit apart along the X axis. Regardless of the order of the routes presented the trend lines for the two days are in high agreement both showing little to no variance across bus services. Statistically, the routes on Wednesday and Thursday have an almost standard distribution of lateness with mean and median values within 20 seconds. Their average lateness was within 21 seconds though the variance as measured by standard deviation was almost 40 seconds higher on Thursday. As might be expected bus services showed less variability on Saturday with an average lateness of 55 seconds and a standard deviation of less than two minutes. Figure depicts this difference between route lateness distributions on a weekday vs. a weekend.

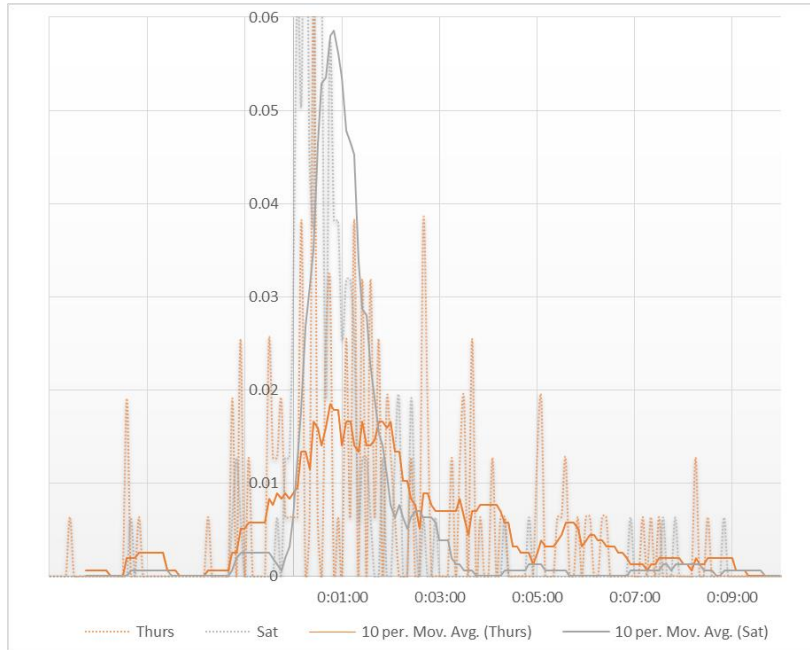


Figure 2: Comparison of weekday and weekend route lateness frequency distribution. Because there were not routes in every time category a moving average (Mov.Avg.) has been used to smooth the distribution curve.

Table 1: Descriptive statistics of route groupings
Times given as hh:mm:ss

	Wed	Thurs	Sat
Average	0:01:40	0:01:22	0:00:55
St dev	0:02:27	0:03:05	0:01:53
Median	0:01:21	0:01:10	0:00:30

The average observed lateness was calculated as well as the percentage of boarding locations where the service exceeded the five minute tolerance for lateness. The bus route 747 stood out here as being on average between 7.5 and 9.25 minutes late across both days. Furthermore, buses at 17% of boarding locations were reported as late by the Adelaide metro standard of arrival 5 minutes or more after the published time.

The 747 route is a feeder service linking the Seaford and Noarlunga interchanges in Adelaide's far south in a clockwise loop. Interestingly the 745 route which follows the same streets but in an anticlockwise direction showed much more variability with average lateness approaching 12 minutes on Wednesday and only 3.5 minutes on Thursday. Perhaps this is due to a disproportionate number of unsignalled right turns required across traffic for the 745 services.

When considering the whole dataset of passenger observations shown in Figure rather than route groups further differences were observed.

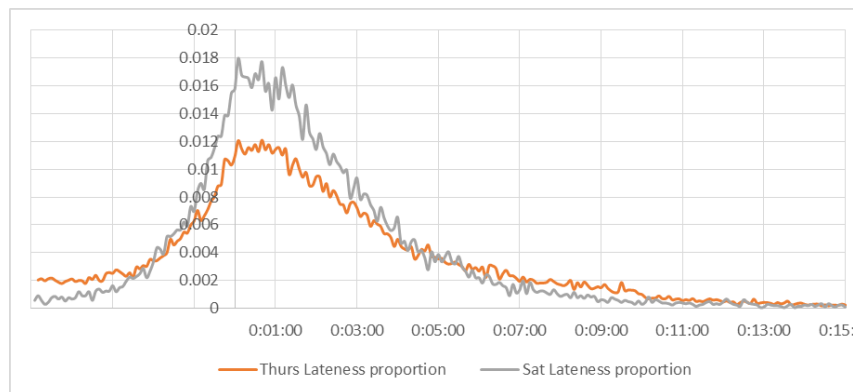


Figure 3: distribution of lateness at boarding stops

Table 2: Statistics for passenger observation data

	THURSDAY	SATURDAY
AVERAGE HR:MIN:SEC	0:00:36	0:02:13
MEDIAN HR:MIN:SEC	0:01:03	0:01:12
ST DEV HR:MIN:SEC	0:13:03	0:08:26
% ONTIME	56.332%	75.451%

Of the weekdays the services on Thursday performed considerably poorer with a standard deviation of 13 minutes. This higher spread means the buses were within the acceptable limits of +1 and -5 minutes for only 56% of observations compared with 75.5% of those on Saturday.

Where there were multiple boardings of a bus service at the same stop the time between boardings could be found. A Metrocard, smartcard, boarding took place on average 12 seconds after the previous boarding, whereas boarding with a magnetic ticket took twice as long at 24 seconds. It was also found that these magnetic ticket boardings were over-represented in the database of final boardings at each stop. Across a typical week, single trip tickets make up 8% of all boardings while these same tickets are the final boarding at a stop 17% of the time. This does confirm that the sales and validation process is prolonging the time that buses stand at some stops.

When the effect was investigated at a network level it was found that there is no relationship between the percentage of departures where the last recorded boarding was with a paper ticket and how late the buses became. This indicates that the sale of tickets is at most a minor cause of travel time unreliability. The presence of extra time taken by paper ticket purchase having no effect on reliability indicates that the distribution of such events either spatially or temporarily is captured in the timetable. This implies that there are travel time savings if not reliability improvements to be gained through off-board ticket sales or prepaid only services such as those used in Sydney (Byatt, Oscuro & Rookes, 2008)

5. Conclusion

The assumptions needed to use boarding data reduce the resolution but do not reduce the accuracy of travel time assessments when compared to automatic Vehicle location data for bus services in Adelaide.

Adelaide's bus services show less variability of lateness on the weekends although there is a lower percentage of prepaid tickets used.

Ticket sales are increasing the travel time of Adelaide's public transport bus services. However, they are not contributing to travel time unreliability. Removing the cash ticket sales from Adelaide's bus network will not improve reliability, however, travel time savings could be achieved

6. Acknowledgements

This paper would not have been possible without the Metrocard data owned by the Government of South Australia. Many thanks to everybody involved in granting my access to this data, particularly, Pete McKenna, Unit Manager of the Metrocard division of the South Australian Department of Planning Transport and Infrastructure (DPTI)

Adelaide Metro 2012, *Adelaide Metro Website*, Adelaide, <<https://www.adelaidemetro.com.au/>>.

Australian Bureau of Statistics 2009, *Public Transport use for work and study*, Australian Bureau of Statistics, viewed 15/08, <<http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Chapter10102008>>.

Bray, D & Wallis, I 2008, 'Adelaide bus service reform: Impacts, achievements and lessons', *Research in Transportation Economics*, vol. 22, no. 1, //, pp. 126-136.

Byatt, M, Oscuro, G & Rookes, M 2008, 'Improving efficiency: An evaluation of sydney buses "bondi bendy" prepay service'.

Chen, X, Yu, L, Zhang, Y & Guo, J 2009, 'Analyzing urban bus service reliability at the stop, route, and network levels', *Transportation Research Part A: Policy and Practice*, vol. 43, no. 8, 10//, pp. 722-734.

Department for Transport Energy and Infrastructure 2011, *Annual Report 2010-11*, Department for Transport Energy and Infrastructure (DPTI), Adelaide, <http://www.dpti.sa.gov.au/_data/assets/pdf_file/0020/75035/Annual_report_2010_2011_online.pdf>.

Dorbritz, R, Lüthi, M, Weidmann, U & Nash, A 2009, 'Effects of onboard ticket sales on public transport reliability', *Transportation Research Record: Journal of the Transportation Research Board*, no. 2110, pp. 112-119.

Kelton, S 2012a, *One in three Adelaide buses are running late, State Government data shows*, The Advertiser, Adelaide, viewed 1st August, <<http://www.adelaidenow.com.au/news/south-australia/one-in-three-buses-miss-deadlines/story-e6frea83-1226413857865>>.

Kelton, S 2012b, *More commuters avoiding Adelaide's buses* The Advertiser as Adelaide Now, Adelaide, viewed 21/8, <<http://www.adelaidenow.com.au/news/south-australia/more-commuters-avoiding-adelaides-buses/story-e6frea83-1226403572012>>.

Nankervis, D 2016, 'Adelaide Metro survey: Public transport users complain about frequency, reliability of bus, train and tram services', *The Advertiser*. <<http://www.adelaidenow.com.au/news/south-australia/adelaide-metro-survey-public-transport-users-complain-about-frequency-reliability-of-bus-train-and-tram-services/news-story/8ad8276a86f5b93aad9f8cc56d1fb3f9>>.

