Understanding the On-Time Performance of Bus Services Across Adelaide from a Passengers Viewpoint.

Callum SLEEP [a], Mona MOSALLANEJAD [b], Sekhar SOMENAHALLI [c]

[a,b,c] *School of Natural and Built Environment, University of South Australia, Adelaide, South Australia 5000*

[a] *E-mail: callum.sleep@unisa.edu.au*
[b] *E-mail: mona.mosallanejad@mymail.unisa.edu.au*

[c] *E-mail: sekhar.somenahalli@unisa.edu.au*

Abstract: Throughout the world, the reliability of public transport systems is constantly under review.(Chen, Yu, Zhang, & Guo, 2009; Liu & Sinha, 2007) Questions of reliability are particularly applicable to bus services, as they commonly share road space with other vehicles unlike rail services for example, with a dedicated right of way (Liu & Sinha, 2007). 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 with results previously obtained using Automatic vehicle location along a handful of individual routes. The analysis suggests that as traditionally expected services on the weekends are more reliable than their weekday brothers. This is most likely due to lower traffic volumes and fewer boardings. It was also noted that there was significant difference between the reliability measures currently used by the service provider and those observed by passengers due to differing levels of aggregation.

Keywords: Bus, Punctuality, Public Transport, Passengers, Smartcard, Adelaide

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 increasing numbers of other vehicles. In Adelaide, the capital city of South Australia, the public transport system has been plagued by concerns of unreliable services (Kelton, 2012b).

The Department of Planning, Transport and Infrastructure (DPTI) is South Australia’s main transport body. Within DPTI is Adelaide Metro, the body that manages Adelaide’s public transport system, in turn run by the Public Transport Services (PTS) division. Buses, trams and trains run on PTS routes across Adelaide. These bus routes are particularly prone to the effects of congestion across city links and suburban arterial roads near the central business district (CBD). This is the key reason why the bus routes were singled out for this analysis.
Adelaide’s tram line has significant on road sections with similar potential issues however this was not included for simplicity. The small sample size (1 route) and different operating conditions would have unnecessarily complicated the data preparation process.

The South Australian community is encouraged 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, 2012a). South Australia's initial boardings for metropolitan public transport rose incrementally each year 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 for 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, 2012b).

South Australia's Public transport system is operating well below its full potential. According to the Australian Bureau of Statistics (Austrailan Beaurau 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 (Austrailan Beaurau 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, as recently installed in Adelaide are helping public transport agencies all over the world to improve their performance. There is however a difference between the performance at the vehicle level and what the passenger experiences (Chen et al., 2009)and so it is important to collect and interpret the data accordingly. This paper seeks to use ticketing data to assess the scale of this discrepancy

Adelaide Metro consistently reports that over 90% of busses are on time achieving up to 97% for some weeks, however the community is not satisfied by this (Nankervis, 2016). This aggregation gives equal weight to every bus service across a whole week while the levels of passenger use are far from uniform. It is known that the majority of passengers travel in the morning and evening peak periods coinciding with increased congestion and the potential for delays. Interestingly the levels of congestion also change across different route types (Ma, Ferreira, Mesbah, & Hojati, 2015). This paper hopes to determine if such aggregation may explain why the passenger's perspective of reliability differs so drastically from the service providers.

2. METHODOLOGY

Using boarding data to assess travel time has the advantage that the records directly relate to passenger experiences. Furthermore, in Adelaide, unlike Vehicle Location data which consists of a vehicles recorded position every 20 seconds, boarding data is recorded at the stop locations, as are the timetables. 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 undertakes multiple roles including; ticket salesman and fare enforcement, 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. Others have likewise attributed the time spent selling ticket exclusively to dwell time (time spent stationary at a stop) (Dorbritz, Lüthi, Weidmann, & Nash, 2009), this helped shape the approach for the investigation, giving confidence that the last boarding would reflect bus departure time.

2.1 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 1 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 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

2.2 Validation

Aggregate data is available from the Adelaide metro website however there are differences in data collection methodology. Validation was undertaken by visually comparing our timetable matching results with those for a single corridor produced from AVL data. Callum with the help of his colleagues, Jack Bruce, Jonas Magiera and Masoud Lotfi analysed this vehicle location data previously though this work remains unpublished to date. (Sleep, Somenahalli, Magiera, Lotfi, & Bruce, 2013) This Validation should ensure that the findings, using data across a wide area, are as accurate as possible.

Firstly, the data for busses traveling the previously studied corridor along Henley Beach Road to the west and The Parade to the East of Adelaide was identified. The progression of these busses was plotted against their assumed timetable to check the data matching process. This plot, Figure 2, identified very few errors in the data matching process and provided a very similar plot, to that of the first study 3 years ago, Figure 3, in terms of bus progress and timetable variance. Due to the recording of a single departure time the waiting behaviour appears differently but is still observed. Busses consistently enter the Adelaide CBD ahead of the schedule and leave slightly behind. Satisfied with the validity of the matching process the lateness was studied across the region. Across 3 full days of operation, one Wednesday, one Thursday and one Saturday. With this done a direct comparison to the figures published by Adelaide Metro was attempted. It soon became apparent that due to differences in methods of data collection and the arrival time limitation this was not practical.

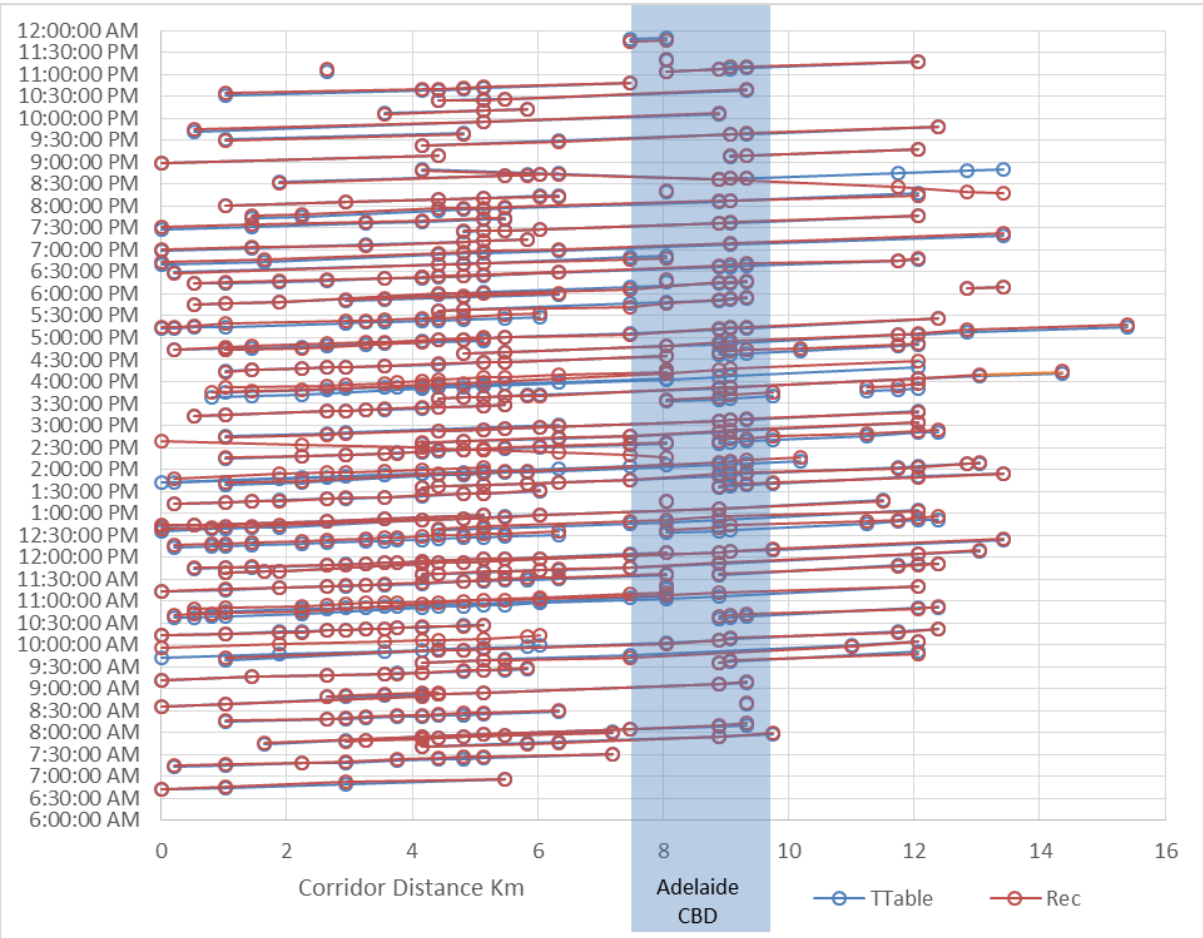

Figure 2: progression of bus services along Henley Beach Rd and the Parade corridor from

boarding data

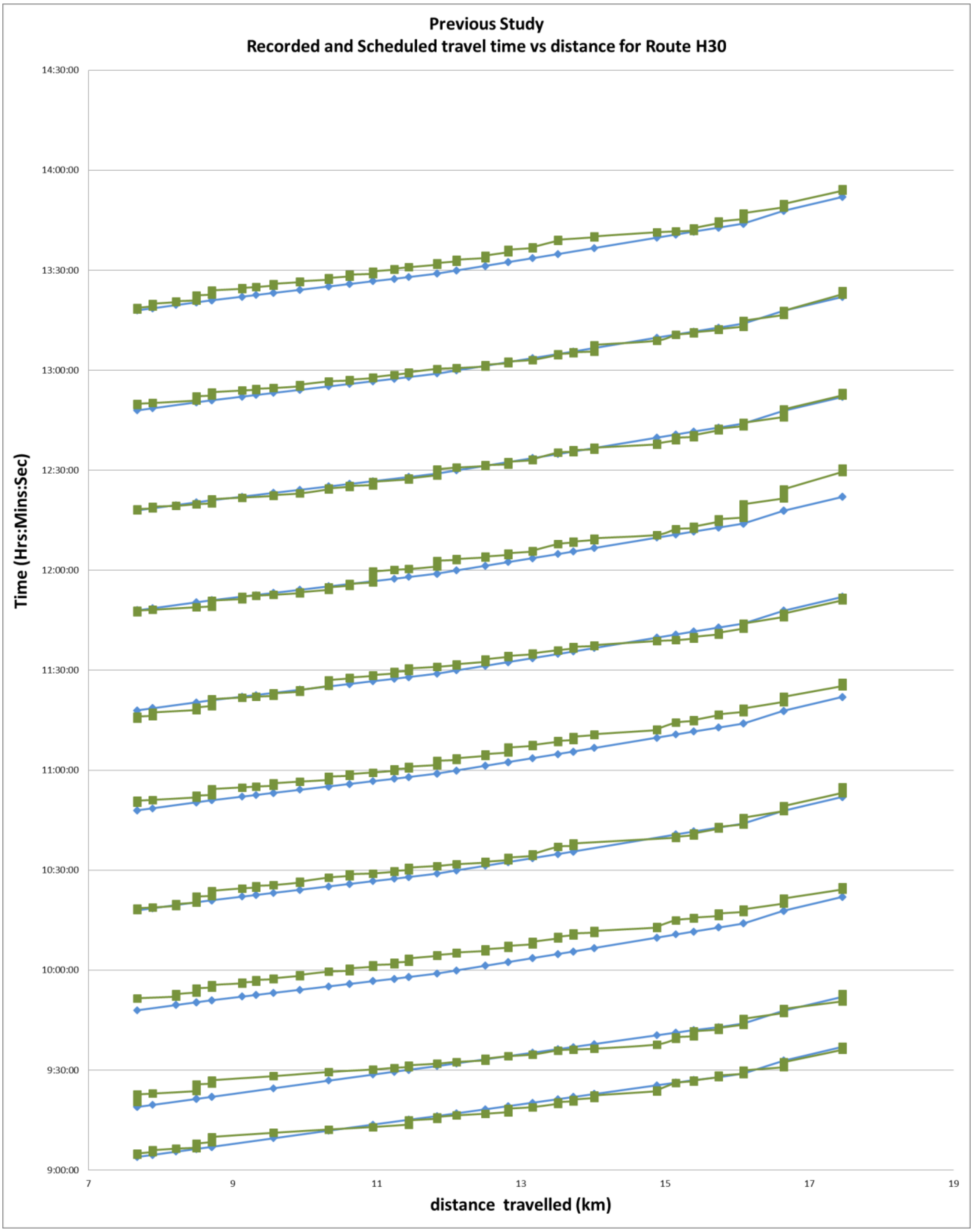

Figure 3: Previous progression study using AVL data

2.3 Limitations

Working with boarding data it is not possible to positively identify departures from all timed locations. Only if passenger arrives immediately before the bus departs will the departure time be recorded accurately. Further the disutility of missing a bus service will tend to cause passengers to arrive early to these stops. Similarly, there will not be passengers boarding every bus service at every stop so any plots of progression produced will be approximate across these points. Finally, there were a few assumptions made when joining these two datasets to find the lateness. Primarily an assumption was made that at the first boarding point a bus would not be more than 15 minutes late or 5 minutes early. This bounded search improved the efficiency of the matching process. That is finding an entry in the published timetable for each bus service. Another limitation is the inability to determine arrival times. It is assumed that for the majority of stops departure and arrival are very close separated by just enough time for passengers to board. However, it is also acknowledged that at stops listed on the published timetable this may not be the case. Busses arriving early to these locations will wait for their scheduled departure time. Furthermore, at the destination terminal there is an arrival time but no departure and no possibility of boarding passengers.

3. RESULTS

The data was first aggregated by route and while there was some inconsistency in average lateness observed across the same routes on different days there is a clear trend observed towards consistency across days. On a scatter plot all the routes and their average latenesses were plotted for each day separately. Each route was treated equally spaced by 1 along the X axis. Regardless of the order of the routes presented the trend lines for the two days are in great 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 4 depicts this difference between route lateness distributions on a weekday vs a weekend.

From Table 1 it can be seen that all the routes are on average performing with a reliability of over 87%. This number does not suggest there is any cause for mass complaint by passengers.

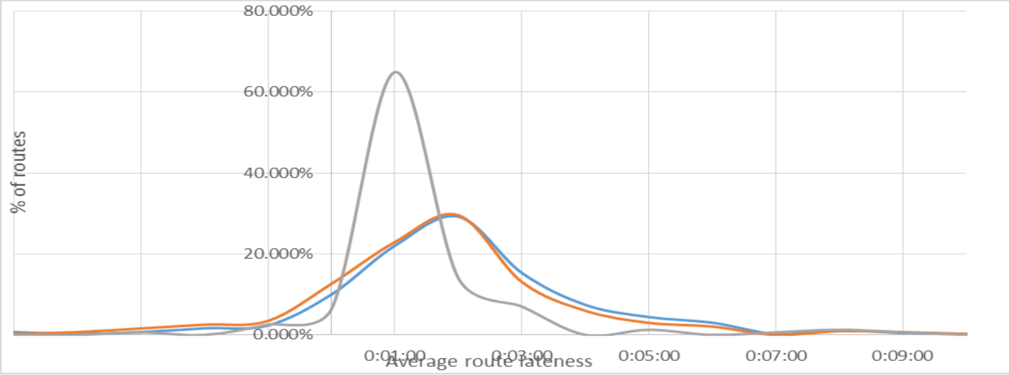

Figure 4: comparison of weekday and weekend route lateness frequency distribution

Table 1: descriptive statistics of route groupings

	WEDNESDAY	THURSDAY	SATURDAY
Average	0:01:40	0:01:22	0:00:55
Median	0:01:21	0:01:10	0:00:30
St Dev	0:02:27	0:03:05	0:01:53
% routes within bounds	88.40%	87.16%	93.63%

When considering the whole dataset of passenger observations, shown in Figure 5, rather than route groups stark differences were observed.

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

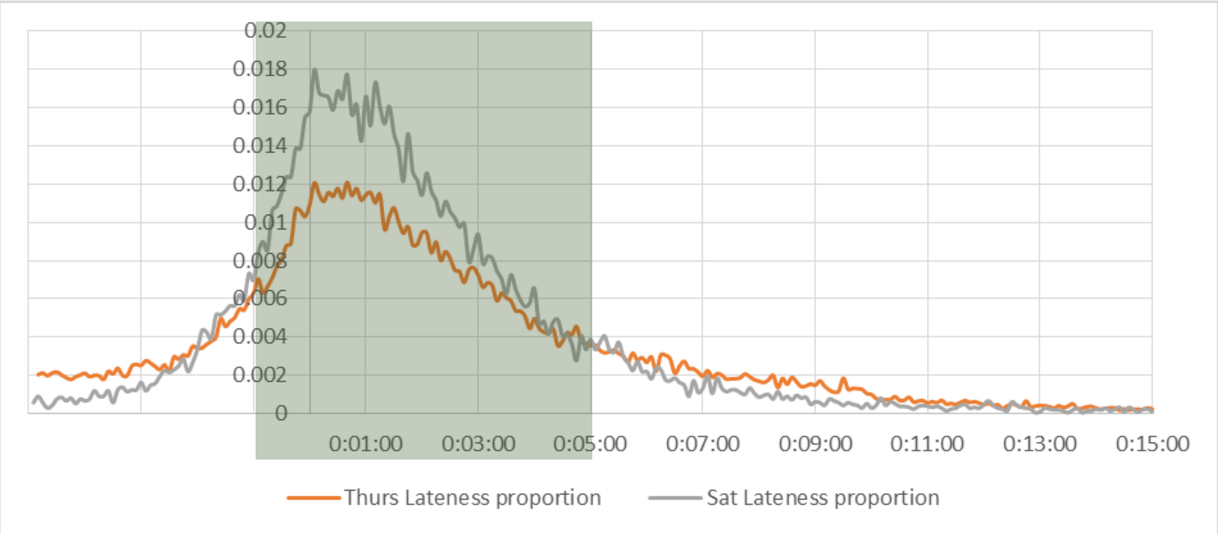

Figure 5: distribution of lateness at boarding stops

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
On time %	56.332%	75.451%

This analysis shows that even when 94% of average bus routes are punctual (as stated by Adelaide Metro), as on Saturday, the passengers see a delay at 24.5% of boarding locations. This is an example of how the aggregation of data published by Adelaide Metro could be improved by adding information from newer data sources, for example a compensation for bus loading.

While measuring network reliability using the traditional methods is valid it is clear that measuring the performance as observed by the passenger is valuable in understanding satisfaction. With the modern data sources available and ever improving computing power we can better understand the drivers of behavior and act effectively to achieve desired outcomes such as a mode shift to public transit.

4. CONCLUSION

There seems to be a great discrepancy between the reliability figures published by the service provider, Adelaide Metro, and the public consciousness (Nankervis, 2016). While psychological effects may play a role it is clear that their effect is overstated. The population is not reacting badly to a service operating reliably 95% of the time. What users see is a service that’s within the specified tolerances just over half, 56%, of the time. While this appears to suggest passengers are attracted to late services it is more likely that the reverse is true and a high demand induces delays. It has been seen here that grouping, in this case by route, reduces the reported average lateness and spread considerably. The Adelaide example demonstrates the importance of performance metrics that align to what the passengers’ experience, highlighting a barrier to increased public transport use that can be removed.

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