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Modelling the Relationships Between Passenger Demand and Bus Delays at Busway Stations

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ABSTRACT
Bus dwell time is traditionally considered as a function of the number of alighting and boarding passengers plus an amount of time for door opening and closing. This approach describes the delays caused to a bus at any bus stop; however, these could be less accurate for busway stations where more than one loading area is available. This is because these traditional dwell time models do not account for the crowd phenomenon of the busway station platform.

This paper discusses the differences in boarding process at a bus stop and at a busway station. And based of these differences, a new methodology for estimation of bus dwell time at busway stations is proposed. For this study, data collection was performed at a busway station on the South East Busway in Brisbane, Australia and at suburban bus stops. Firstly, the sequence of activities performed by a passenger from viewing the desired bus to boarding the bus was divided into two parts: passenger – bus interface and passenger bus interaction. Later the effect of platform crowding on passenger – bus interface and passenger bus interaction was studied. Finally a dwell time model for buses at busway stations was developed.

Based on the analysis, this paper concluded that at a busway station where boarding is predominant, an increase in platform crowd increases the passenger – bus interface duration. This increase in passenger – bus interface duration then leads to lost time for buses and hence increases the bus dwell time.

Keywords: Busway platform, crowding, passenger – bus interface, lost time, dwell time.

INTRODUCTION
Traditionally, bus dwell time spent at a stop is considered to be a function of the number of alighting and boarding passengers plus the amount of time required for door opening and closing of a transit vehicle (1). This approach can describe the delays caused to a bus at an on-street bus stop (2) however this could be less accurate for busway (or bus rapid transit, BRT) station platform, where multiple linear loading areas are available. Traditional bus dwell time models do not specifically account for the effect of a large concentration of passengers (crowd phenomenon), which may occur at the busway station’s platform, upon the passenger – bus interface.

Crowding can be an unpleasant feeling that is experienced by an individual (3). Crowding influences each activity that occurs at the platform area. It can obstruct the passengers’ line of sight, making their vision and reaction to the incoming buses difficult. Platform crowding also compels the driver of the bus to slow down at the platform to check for any passengers hailing, even if there is none, as identifying the possible passenger(s) amongst the crowd can be difficult. Hence crowding leads to location specific congestion (4), to buses approaching the busway platform and to the passengers on the platform. This situation can result in extended dwell times for the buses and therefore delays to passengers using them.

Although any increase in bus dwell time presents a transit service reliability issue, there is a scarcity of research relating bus dwell time to the level of crowding at a busway station platform. This may be due to busways (or BRT) being a relatively recently adopted form of transit system.

This paper considers bus dwell time as a function of the passenger – bus interface, and passenger – bus interaction, and not just as a linear function of the number of boarding and alighting passengers plus a constant for door opening and closing. The paper defines the ‘passenger – bus interface’ (IF) as the phase where the first passenger and the bus driver were involved in a state when they both interact but perform their respective activities independently. The ‘passenger – bus interaction’ (IA) is defined as the phase where the first and subsequent passengers and bus driver were involved in a state when they both interact and perform their respective activities based on each other’s position or action.

This paper is an outcome of a broad research investigation into the impact of platform crowding on bus dwell time. A better understanding of how the crowd at a busway platform impacts bus dwell time may help in improving reliability.
Following this introduction, section two provides a brief survey of relevant literature. This is followed by a conceptualisation of the problem in section three. A brief description of the case study area and research design is provided in section four. Section five looks the difference in the passenger boarding process at bus stop and busway station. Section six presents the development of proposed dwell time form for busway stations. Section seven examines the implication of incorporating passenger – bus interface into the bus dwell time model in estimating busway station vehicle capacity and travel time reliability. The last section presents conclusions drawn from the results and future research scope.

**LITERATURE SURVEY**
This literature survey highlighted two very important points about current available bus dwell time models. Firstly, these models were developed considering bus stops as case studies, and secondly, the majority of these models considered the number of boarding and alighting passengers as two of the most significant variables. Although some studies associated bus dwell time with fare collection system, bus type (door size and number, floor type) and onboard passenger density; there is virtually no literature relating bus dwell times with crowding at a busway platform. A brief overview of the existing literature supporting the findings is given below.

Levinson (5) developed a bus dwell time model using a regression approach for bus stops across different United States cities. This study established the total number of boarding and alighting passengers as the determinant factors of bus dwell time. Guenthner and Sinha (2) showed that bus dwell time is sensitive to the total number of boarding and alighting passengers. They developed two bus dwell time models based on the number of boarding and alighting passengers; up to 24, and exceeding 24. Considering boarding and alighting passengers as separate variables, Kittelson and Associates (1) provided a multivariate linear regression model for dwell time estimation. Vuchic (6) suggested two different versions of a multivariate dwell time model depending on the number of doors available for boarding and alighting from the transit vehicle. To further increase the accuracy of bus dwell time estimation, some models have also accounted the effect of onboard standees (7); fare collection system (8); vehicle design (9); along with the numbers of boarding and alighting passengers.

**PROBLEM CONCEPTUALISATION**
In the previous section it was identified that the conventional dwell time models do not account for passengers beyond their boarding and alighting numbers. These models also do not consider the crowding phenomenon which can be observed at the busway platform. An attempt is made below to explain the effect of crowding by way of proposal of a model.

Crowd density at the platform has a manifold effect on the platform operation. Crowding at the platform not only reduces manœuvreing capabilities of passengers, but also causes occlusion to approaching buses. This results in increased passenger reaction time upon the arrival of their expected bus. This can be illustrated by considering the typical path of passengers at the platform from when they arrive until when they board their desired bus (Figure 1).

![FIGURE 1 Origin and destination of a trip segment at platform.](image-url)
The time spent by the passenger to walk between their wait point W and the bus front door (point D) influences the passenger service time for the bus. As the passenger density increases the walking speed is expected to decrease and therefore the time spent to increase. On the whole, the time spent, and so the dwell time, may vary in a manner somewhat proportional to the crowd encountered by the passenger on the way to the bus door.

Therefore the high dwell time consumed by some buses could be the outcome of the platform crowding (10). Not only can this affect an individual bus, but also other buses by delaying their ability to enter a loading area on the platform.

DATA COLLECTION AND OBSERVATION
The outbound platform of the Mater Hill busway station in Brisbane, Australia was chosen for data collection for this study. With the recent opening of the Inner Northern Busway, Mater Hill busway station is now the sixth station from the Brisbane central business district on the 16 km long South East Busway service corridor. Mater Hill Busway station has three signed and striped loading areas as shown in Figure 2. Occasionally some buses stop very close to the dwelling bus in front thereby creating a transient fourth loading area. The patronage to the station during the analysis period was general public including university students, hospital visitors, workers and high school students.

In Brisbane, a passenger can board the bus from front door only. However, an alighting passenger can use either the front or rear door. The fare collection system is such that a passenger may purchase their ticket on-board ticket by cash payment or can use a pre-paid ticket such as a daily, weekly or monthly ticket. Recently, a “smart card” electronic fare payment system was introduced as an alternative to on-board ticket purchasing.

Video footage was captured on Wednesday, 5 March 2008 with the assistance of the Translink Authority’s Busway Operations Centre in Brisbane. Passengers on the platform were unaffected by the video data collection as busway security cameras were used. These cameras, mounted on the ceiling of the busway platform awning, record the movements of passengers present on the platform on a 24hr / 7 day basis. Three distinct time periods of the analysis day – the morning off-peak period 10 am to 11 am; the evening peak period 3 pm to 4 pm; and the evening off peak period 7 pm to 8 pm – were subsequently analysed in a laboratory environment at QUT to obtain bus side and passenger side data. The bus side data included queuing time, dwell time, and door opening and closing time. The passenger side data included platform density, walking time from waiting position to bus door, and queuing time. For each one hour time period, 70 passengers randomly selected from the platform crowd were observed, from the time when they first reacted to their desired bus until the time when they boarded their bus.

FIGURE 2 Configuration of mater hill busway station.
Additionally, to understand how the boarding process at busway stations is different from the boarding process at bus stops, observations were made at three of Brisbane’s typical suburban bus stops during the morning peak period (7:45 am to 8:45 am). Figure 3 shows the observed concentration of platform crowding at a bus stop and a busway station.

FIGURE 3 Concentration of passenger crowding.

UNDERSTANDING THE BOARDING PROCESS

After observing passenger boarding activity at busway stations and bus stops, it was concluded that the boarding process can be divided into four distinct parts. The first part is the initial reaction of hailing when the passenger first sees the desired bus. The second part consists of walking to the bus entry door. The third part consists of queuing at the entry door. The fourth part is boarding the bus.

The first and second part comprises the passenger – bus interface stage. The passenger – bus interface starts when the passenger first sees the desired bus and hails it and/or starts walking towards a point by anticipating its stopping location. Similarly, the driver of the bus, after seeing the hailing passenger, prepares to stop the bus at the available loading area. During this course of action, both the bus driver and the passenger act independently but anticipate each other. The third and fourth parts comprise the passenger – bus interaction stage. However, when there are only one or two passengers boarding the bus, queuing may not occur and the passenger – bus interaction stage consists of only boarding.

At a typical bus stop, only one or two loading areas are provided, hence passengers know the stopping position of bus entry door with higher certainty and are generally positioned within a half a bus length of the front door. The waiting passengers, therefore, often, align themselves accordingly well before the bus stops. The passenger – bus interface plays a minimal role in the bus dwell time at bus stop. The dwell time of a bus at a bus stop can therefore be generally been defined as a function of passenger demand and service time per passenger, separately for alighting and boarding. However, more than one loading areas are provided at a busway station. This creates uncertainty in passengers’ mind about the loading area of the desired bus and hence passenger – bus interface comes into play.

Another important factor that differentiates a busway station from a bus stop is the number of bus routes servicing the station. In Brisbane, a typical bus stop serves between one and five bus routes. However, the Mater Hill busway station, being a mainline station, serves over 40 separate routes including a number of Bus Upgrade Zone (BUZ) high frequency spine services. Since the number of routes at a typical bus stop is far less, the passenger route groups are far less diverse. With more uniformity in passengers’ directional behaviour it is more likely that buses will arrive discretely and that passengers will be of a common route group. However, at a busway platform the number of bus routes is very high. Therefore the passenger route groups at the busway station are much higher, leading to crowding. Such platform crowding at the busway station platform acts as the obstruction to
the passenger’s walking path \((I)\) and also obstructs the passenger’s line of sight, resulting in a longer passenger – bus interface. Therefore the methodology to estimate the bus dwell time at busway station should take into account the passenger – bus interface.

**ANALYSIS AND MODEL DEVELOPMENT**

The existing dwell time models are not directly applicable to busway stations when boarding is predominant due to their unique characteristics as explained above. Hence a new model form, taking into account the crowd density and walking distance at busway stations, is proposed in this paper. The proposed dwell time model for predominant boarding combines additional variables of crowd density and walking distance along with the traditional variables of the number of boarding and alighting passengers. The model overview is given in Figure 4. Mathematically, the new model can be represented as

\[
Dwell Time = fn ( \text{passenger – bus interface, passenger – bus interaction, constant})
\]

\(1\)

**FIGURE 4  Overview of the proposed model form.**
Observations indicate that only the duration of passenger – bus interface of the first passenger impacted the bus dwell time. Because of the simultaneous interfaces of all boarding passengers with the desired bus, all boarding passengers except the first boarding passenger overlap their respective passenger – bus interface duration with that of first passenger’s interface. In addition to this, some part of the first passenger’s interface duration overlaps with the time taken by the bus to reach the loading area. The above observations can be better understood from a simple time-space diagram shown in Figure 5. The distance in space is represented on Y axis and the time is represented on X axis. The X – X axis, in space, represents the location of the bus entry door. P₁, P₂, ..., Pₙ are the position of first, second and nᵗʰ passenger at time t₀ when they first see the desired bus, B. In this case the dwell time for the bus is equal to sum of the lost time (LT) and passenger – bus interaction (IA). This paper defined ‘lost time’ as the time lapse between bus stopping time and the time of boarding of first passenger. In the above figure the door opening and door closing time are represented as constant (c).

The variables in Figure 5 are described as follows:

\[
\begin{align*}
DT &= \text{Bus dwell time} \\
LT &= \text{Bus lost time} \\
t₀ &= \text{Time when passenger(s) first see the desired bus (say at point B in space)} \\
IA &= \text{Duration of passenger – bus interaction} \\
P₁, P₂, ..., Pₙ &= \text{Location of 1ˢᵗ, 2ⁿᵈ, ..., nᵗʰ passenger in the space at time t₀. } IF₁, IF₂, ... , IFₙ \text{ represent their respective passenger – bus interface duration.} \\
c &= \text{Constant, for door opening and closing}
\end{align*}
\]

**Passenger – Bus Interface**

The amount of time taken by passengers to reach the bus entry door from the time when they first see their bus was analysed against the prevailing crowd density at the station platform. From Figure 6 it can be observed that the spread in the duration of passenger – bus interface was modest when the crowd at the platform was relatively small. As the crowding increased, the passenger – bus interface became non – uniform and the spread very large. This means, under the increased crowd condition, while some passengers have a reduced passenger – bus interface others have very high interface duration. Low interface duration occurs when the bus stops close to the passenger’s waiting position. That means passenger requires walking less distance. High duration of interface may occur because, as
the crowd density increases, a passenger’s walking speed decreases. The passenger can no longer use the straight path between the waiting point and the bus entry door, but is forced to undertake a zig-zag manoeuvre to complete the path. This zig-zag manoeuvring also increases the distance and thereby increases the walking time.

![Diagram showing the relationship between passenger bus interface and crowding](image)

**FIGURE 6** Variation in passenger – bus interface.

Therefore the duration of passenger – bus interface depends on the passenger’s walking distance to cover, speed and straightness of the waking path. The straightness of the passenger’s waking path, indeed, depends on the number of other passengers in the path. The higher passenger – bus interface proliferates the bus dwell time by increasing the bus’s lost time.

**Bus Lost Time versus Crowding**

The bus lost time as defined on Figure 5 depends on how late the passenger arrives at the bus entry door, which in turn depends on the passenger’s walking distance to cover and speed (i.e. the passenger bus interface) which in turn depends on the level of crowd on platform. Determining how each variable influences the bus lost time therefore becomes complex. Hence, the bus’s lost time was analysed using two models. In first model it was assumed that the platform crowd determines the bus’s lost time. However, the data spreads evident in Figure 7 suggests that there is no clear two dimensional relationship between bus’s lost time and crowd. We considered, then, that average and standard deviation of lost time, independent of crowd, could still provide useful insight into the generic effect of crowd on lost time. Table 1 shows the average and standard deviations lost times observed for each loading area. This information would be directly useful in the prediction of bus dwell times, and hence delays and capacities of loading areas, over say an hour-long analysis period. The standard deviation values provide the upper and lower limits of the bus lost times. The lost time of a bus could be towards the lower limits when it finds its passenger standing near to the loading area and vice-versa.

Qualitatively, for loading areas 1 and 2 some bus lost times were relatively high when the platform crowd was low. This is because under the low crowd condition passengers either prefer to sit
or stand keeping a large space between adjacent passengers and hence are spread along the platform. When the crowd increases the passengers start shifting toward to the loading areas, mainly towards loading area 2, and hence the bus lost time variation reduces. This means that the bus lost time does depend on the waiting position of the passenger. Therefore, a second model with modified assumption that the platform crowd effects bus lost time indirectly through variation in passenger – bus interface was investigated.

**TABLE 1  Descriptive Statistics for Bus Lost Time**

<table>
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<tr>
<th>Loading Area</th>
<th>Number of Passengers on platform (p)</th>
<th>Bus Lost Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>≤ 30</td>
<td>5.3</td>
</tr>
<tr>
<td>1</td>
<td>&gt; 30</td>
<td>2.7</td>
</tr>
<tr>
<td>2</td>
<td>≤ 30</td>
<td>3.1</td>
</tr>
<tr>
<td>2</td>
<td>&gt; 30</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>≤ 30</td>
<td>7.2</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 30</td>
<td>9.6</td>
</tr>
</tbody>
</table>

**FIGURE 7  Variation in bus lost time with increase in number of passengers.**

**Bus Lost Time versus Passenger – Bus Interface**

In the second model the bus lost time was analysis against the passenger – bus interface. Variations in individual bus’s lost time with passenger – bus interface, separately for each loading area, are shown in Figure 8. Here again the results failed to suggest any clear two dimensional relationship between...
bus’s lost time and passenger – bus interface. However the plots suggest some buses across all the loading areas experience increased lost time as the passenger – bus increased. Because of a lack of data representing passenger – bus interface above 25 seconds, it is hard to draw any conclusion when passenger – bus interface exceeds 25 seconds. The average and standard deviation of lost time based on the criteria duration of passenger – bus interface are provided in Table 2.

**TABLE 2 Descriptive Statistics for Bus Lost Time**

<table>
<thead>
<tr>
<th>Loading Area</th>
<th>Passenger – Bus Interface (s)</th>
<th>Bus Lost Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>≤ 20</td>
<td>3.7</td>
</tr>
<tr>
<td>1</td>
<td>20 to 25</td>
<td>7.1</td>
</tr>
<tr>
<td>2</td>
<td>≤ 20</td>
<td>3.1</td>
</tr>
<tr>
<td>2</td>
<td>20 to 25</td>
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<td>6.1</td>
</tr>
<tr>
<td>3</td>
<td>20 to 25</td>
<td>9.9</td>
</tr>
</tbody>
</table>

![Graph a) Loading Area 1](image)

![Graph b) Loading Area 2](image)

![Graph c) Loading Area 3](image)

**FIGURE 8 Variation in bus lost time with increase in passenger – bus interface.**

Both Tables 1 and 2 suggest that the loading area 2 is most efficient in terms of bus lost time (LT) amongst the all three available loading areas. Two reasons could be put forward to explain this. Firstly, it may be due to the behavioural pattern of passengers waiting on the busway platform (11) and secondly, due to the station configuration (Figure 2), the walking distance to loading area 2 from the center of the station platform is less compared to the other loading areas.
Passenger – Bus Interaction

In general, the passenger – bus interaction at a busway station can be estimated using number of boarding and alighting passengers and their respective service times (Equation 2). However, in most of the cases, alighting occurred from the rear door of the buses or occurred from the front door during the passenger bus interface time ($IF$), but prior to the lost time ($LT$). In these cases equation 2 reduced to equation 3. The duration of passenger – bus interaction ($IA$) was taken to be independent of the loading area since it is entirely depends on the through capacity of the bus entry door.

$$IA = P_b t_b + P_a t_a$$  \hspace{1cm} (2)

$$IA = P_b t_b$$  \hspace{1cm} (3)

Where,

- $P_b = $ Number of boarding passengers
- $t_b = $ Boarding time per passenger
- $P_a = $ Number of alighting passengers
- $t_a = $ Alighting time per passenger

The passenger – bus interaction was plotted against the number of boarding passengers. During the survey periods ticketing on boarding consisted of a relatively even mixture of drivers selling tickets with change given, magstripe card readers, and recently introduced smart card (electronic touch on / touch off) readers. From Figure 9 it can be observed that the duration of passenger – bus interaction increases with the demand for the bus. This observation is consistent with previous models where service time per bus is directly proportional to the number of boarding passengers ($I$, $6$).

![Figure 9](image-url)  
**FIGURE 9** Relationship between passenger – bus interface and boarding passengers.
Proposed Bus Dwell Time Model for Busway Stations

The proposed model estimates the dwell time based on the lost time acquired by the bus at the platform while waiting for passenger and the time it actually used in providing the service to the passenger(s). The bus dwell time at a platform is therefore equal to the sum of bus lost time \((LT)\) and duration of interaction \((IA)\) plus a constant for door opening and closing.

\[
DT = (LT) + (IA) + c
\]  

Where,

- \(DT\) = Bus dwell time at a busway station (s)
- \(LA\) = Lost time for bus while waiting for passenger to arrive at entry door (s)
- \(IA\) = Duration of passenger – bus interaction at the station (s)
- \(c\) = Constant, for door opening and closing

Example models for bus dwell time for each of loading areas 1, 2, and 3 at the Mater Hill busway station outbound platform during times when passenger boarding is predominant, assuming the measured average values of lost times and the relationships of Equation 4 and Table 1 for passenger bus interaction, are provided in Equation 5 to Equation 10. Door opening and closing values have not yet been gathered in this study, so for Equation 5 to Equation 10 a standard value of 3.5s from the TCQSM (1) has been used.

For loading area 1

\[
DT_{LA1} = 5.9P_b + 8.8 \quad NP \leq 30
\] 

\[
DT_{LA1} = 5.9P_b + 6.2 \quad NP > 30
\]

For loading area 2

\[
DT_{LA2} = 5.9P_b + 6.6 \quad NP \leq 30
\] 

\[
DT_{LA2} = 5.9P_b + 6.0 \quad NP > 30
\]

For loading area 3

\[
DT_{LA3} = 5.9P_b + 10.7 \quad NP \leq 30
\] 

\[
DT_{LA3} = 5.9P_b + 13.1 \quad NP > 30
\]

Where,

- \(NP\) = Number of passengers waiting on platform (p)

The above example illustrates that the effect of crowd varies across the loading areas. For a given number of boarding passengers, loading areas 1 and 2 actually have lower dwell times with increased crowding, while loading area 3 has an increased dwell time with increased crowding on the platform. It may be that crowding makes it more difficult for boarding passengers to make their way back to loading area 3, while this effect does not occur due to the proximity of the crowd to loading areas 1 and 2. Furthermore, boarding passengers may actually be more diligent in trying to reach their bus under the more crowded conditions. Current dwell time model (1, 6) do not account for these circumstances.

Table 3 gives the comparison of estimated dwell time by proposed dwell time estimation method and TCQSM method. A platform crowd of 25 passengers and a boarding load of 7 passengers per bus with no alighting load were considered for comparison. A boarding time of 4.8s per passenger (10) and the bus door opening and closing time of 3.5s (1) are used in TCQSM method. The TCQSM model estimates a single bus dwell time value irrelevant of the loading area; on the contrary the proposed model accounts for the variation in dwell time across the loading areas. From Table 3 the
TCQSM methodology substantially under predicts dwell time for the conditions on the Mater Hill busway station outbound platform, by between 26 and 29 percent depending on loading area.

**TABLE 3  Model Comparison**

<table>
<thead>
<tr>
<th>Loading area</th>
<th>Proposed Model</th>
<th>TCQSM, 2003</th>
</tr>
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<tr>
<td>1</td>
<td>50.1</td>
<td>37.1</td>
</tr>
<tr>
<td>2</td>
<td>47.1</td>
<td>37.1</td>
</tr>
<tr>
<td>3</td>
<td>52.0</td>
<td>37.1</td>
</tr>
</tbody>
</table>

**IMPLICATION OF PROPOSED MODEL**

The bus dwell time is a crucial factor in the design of bus rapid transit system. Along with some other factors, it determines the journey time and adherence of the bus service with its schedule. The station capacity and operational efficiency also depend on the bus dwell times. With the recent increase in emphasis of providing real time information, accurate estimation of bus dwell times at stations becomes more important. The new methodology for dwell time estimation revealed in this paper has, therefore, multiple implications while designing a bus rapid transit system.

The proposed methodology can facilitate real time calculation of station platform capacity based on the prevailing conditions. The real time capacity estimation could help in identifying and quantifying the delays to the buses caused by their queuing at the entry of the platform. Another important application of the proposed dwell time estimation methodology is in the area of development of bus arrival algorithms; for example, the real time information systems and bus priority signal design (12). The proposed dwell time methodology, when incorporated with the bus arrival algorithms could greatly improve the accuracy as the results will be based on the prevailing conditions of the upstream stations. Additionally, this new methodology can help transit planners in improving the scheduling of service timetable and this in turn could greatly enhance the travel time reliability. The proposed methodology would be specifically useful for design and improvement of bus rapid systems such as busways.

More work is to be performed on understanding the implications of the passenger bus interface model as it relates to the level of comfort and convenience experienced by passengers on the platform and the platform design itself.

**CONCLUSIONS**

This paper illustrates that the traditional approach of bus dwell time estimation could not be applied at the stations of bus rapid systems, such as busways. This is because of the significance of additional complex variables, such as the presence of large crowds, multiple bus services, bus queuing and lost times. This study establishes that the bus lost times at the platform increases due to the platform crowd which increases bus dwell times.

The paper highlights the complex relationships of bus lost time with platform crowd and passenger – bus interface. The former relationship can be particularly useful in station capacity estimation. The latter can be applied in better understanding the passenger movements in the platform area. However, further research is necessary to generalize the approach presented in this paper for other busway station configurations and modes of operation, and for the situation where passenger alighting predominates.

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REFERENCE