Abstract

The great demand for just in time and emergency services as well as the massive programs to relieve congestion in order to improve mobility and accessibility in urban areas have force the great interest for transportation system reliability and road network vulnerability study. Based on the literature, previous studies appraise road network vulnerability by measuring the increase of travel time, travel cost as well as accessibility index reduce. However, there is a left study about the individual lost (accessibility to participate in activity as well as the environmental consequences) due to the impacts of the travel time variability and reliability. This study will assess the South Road corridors in Adelaide metropolitan area road networks and measure the travel time variability in terms of finding out the travel time reliability.

This paper review the integration of the GPS probe vehicle survey and GIS application by looking into the speed-time profile and the speed-distance profile in terms of measuring travel time reliability. As this is a part of the PhD project, some findings based on the current data analysis is also presented. This paper also review a further work in order to assess the community lost based on the differences of some accessibility index and the fuel consumption.

Key words: travel time variability, travel time reliability, road network vulnerability, gaseous emission, GPS probe vehicle survey, GIS application
I. INTRODUCTION

According to previous study, there is some evidence that travel time reliability may become more important than travel time savings. Based on some literature (Small et al., 1999, Lomax et al., 2003), road users prefer to choose reliable route rather than unreliable one. By recognizing the trip pattern through their past experiences, road users will identify that for different time of day, different days of week and different weather condition, they will face different traffic conditions. Then in order to tackle that difference, they will plan their trip by choosing the reliable routes. However, traffic incidents, either short term (e.g. road crashes) or the long term (e.g. road works) can happen at any time and the effect of incidents will lead to higher travel time variability.

The impact of incidents as well as the duration of incidents has already become an important research topic in terms of having more robust and reliable transportation systems. Previous studies have discussed and proposed some techniques to measure the adverse impacts of the incidents to the community either by calculating the increases in travel time and travel cost or the reductions in accessibility (usually in terms of changes in an accessibility index) (D’Este and Taylor, 2003). However, due to the lack of data and the massive data analysis required for real world networks, previous studies have tended to focus on simple networks, and not many studies have been conducted at the real network (Jenelius, 2007b).

Some of previous studies used the loop detector data to analyse the travel time reliability and some others use the microsimulation technique to model the travel time variability then used the output to obtain the travel time reliability. In line with some previous studies (Tu et al., 2007, Hollander and Yiu, 2008), this study will try to integrate the GPS probe vehicle travel time survey and the microsimulation model to get the travel time data. GPS data can give not only the position of the probe vehicle but also the speed profile. Speed distance and speed time profile might be a useful input for further congestion study, by assessing the different type of speed-distance and speed time-profile might give better view of the travel time variability and reliability. Indeed, since the vehicle will be equipped by a vehicle emission and fuel consumption technology, then the speed profile could also be used to measure the fuel consumption as well as the level of the gaseous emission.

This study will focus on the South Road corridor in Adelaide metropolitan road network which was identified as the busiest corridor in the network. In addition, in order to improve the network performance, the South Australian government is presently undertaking some improvement schemes, including the South Road and Anzac Highway underpass and the Tram line flyover. Those two road works take at the same area and will finish at the end of 2009. Due to that fact, this study has been developed based on the idea that there will be much increase of travel time variability during road works. Then a depth study of the South Road Corridor will be interesting.

The next section will review some travel time reliability measurement and its application in road user’s trip planning and route choice. In order to get the idea of community lost during the incident, the third section discusses the concept and the current road network vulnerability study. Fourth section will review the application of a vehicle emission and fuel consumption technologies based on previous studies. As this paper is a part of my PhD research, the fifth section tells about research methodology including the study area, the proposed methodology as well as some preliminary findings. The last section considers the future works and future research.
II. TRAVEL TIME RELIABILITY

Travel time reliability can be denoted as the probability of successfully completing a trip within specified time interval (Iida, 1999). Therefore, the increase of travel time will lead to the unreliability and variability of travel time (Recker et al., 2005). The better understanding of travel time reliability and variability might assist transport planner to select proper transport policy in conjunction with reduction congestion problems as well as lessening the impact of different type of incidents (Recker et al., 2005). It can be said that, the more reliable the transportation system, the more stable is the performance. In addition, lower travel time fluctuation also contributes to less fuel consumption as well as less emissions due to a reduced amount of acceleration and deceleration by vehicles (Vlieger et al., 2000). Moreover, from a transport user’s point of view, more reliable travel times mean more predictable journey times and improved activity schedules. In accordance with just in time services, reliable travel time will significantly increase the freight industry’s performances to deliver goods (Recker et al., 2005).

As travel time reliability considers the distribution of travel time probability and its variation at road network, the higher travel time variance the lower travel time reliability (Nicholson et al., 2003). It can be also said that under ideal conditions travel time reliability would have a variance equal to zero. Indeed, the increase of its variance will therefore significantly reduce its reliability. However, the relationship between travel time variance and its reliability is not linear, so that, it cannot be generally accepted that a double of travel time variance will lead to a half of its reliability. To conclude, the greater travel time fluctuations will have significant impacts on transport network reliability.

According to different purposes of travel time reliability study, there are several travel time reliability surveys. By comparing different aspect of the travel time study and by considering the complexity of data collection as well the data analysis, Lomax et al. (2003) has reviewed the suitable assessment of travel time reliability. Based on the scope and the limitation of each method this work suggested the different study in terms of measurement travel time variability and travel time reliability. The analysis of the archive traffic data is not proper in measuring the travel time reliability due to the lack of data constant and the lack of other attribute related with the traffic condition. However, the data is easy to obtain. In addition, the micro simulation techniques have been used extensively, however according to Lin et al (2005) there are some deficiencies in travel time microsimulation modeling in terms of the high need for data calibration. In order to gain real life traffic conditions, some travel time reliability research used the probe vehicle methods. Since this method requires extensive labour and only covers some of the study area or some of the road segments, it cannot be applied in terms of assessing the travel time reliability on large road networks.

Indeed, Lomax et al also recommended some reliability measurements by examining the reliability and variability percentage (e.g., 5%, 10% and 15%). Those approaches take into account the effect of irregular conditions in the forms of the amount of extra time that must be allowed for travelers. The first measurement is the percent variation which expresses the relationship between the amount of variation and the average travel time in a percentage measure. The second is the misery index that calculates the amount of time exceeded the average slowest time by subtracting the average travel time with the upper 10%, 15% and 20% of average travel rates and the last is travel time buffer which add the extra travel time of 95% trips in order to arrive on time.
In addition, since reliable travel time is the key indicator of user’s route choice there are many recent research works which investigated the traveler’s behaviour under unreliable travel time. According to traveller’s behavior in route choice survey, the greater the variance of travel time of selected links the less attractive it is (Tannabe et al., 2007). Additionally, Bogers and Lint (2007) investigated traveller behaviour on three different road types in The Netherlands under uncertainty conditions, as well as the impact of providing traveller information on route choice. They conclude that providing traveler information has significant impact on effecting traveler’s decision, in addition, based on traveler’s experience they will choose the route with minimal travel time variance. It means that the routes that have high travel time reliability are not attractive for users. Indeed, according to Lomax et al’s review that the best alternative to measure the travel time variability and route choice behaviour under uncertainty condition is by using probe vehicles. Though this method was highly labourious and expensive, it is more realistic (Lomax et al., 2003). Then Tannabe et al (2007) undertook an integrated GPS and web diary in Nara, Japan. This study found that travellers might change their route to reduce the uncertainty in travel time. In addition, there was a positive correlation between coefficients of variation (CV) of the commuting routes. It is found that the appropriate functional hierarchy of road may be disturbed by the uncertainty of travel time. These findings suggest that a reliability index of travel time is very useful and important for evaluating both actual level of service (LOS) and functional hierarchy of road network.

Recent travel time reliability research investigated the relationship between the traveller behavior and their response to the provision of travel information system while they experience high travel time variability. Asakura (1999) concluded that the Stochastic User Equilibrium model can generate the user route choice behavior based on the different levels of information provision. This study analysed two different groups, the first group being the well informed users and the second the uninformed users. He concluded that providing better information can improve the transportation network reliability.

In order to find out the different perspectives of travel time reliability for different persons with different purposes, Lo et al (2006) studied the notion of the travel time budget, in which each traveller seeks to minimize their own individual travel time budget (the amount of time that the individual is prepared to devote to travelling), which means the total travel time of the individual should not exceed their allocation of time to travel.

To evaluate the link between the presence of ramps on motorways and travel time reliability, recent reliability network research has been undertaken in The Netherlands. This study analysed whether the geometry of road network also affected the travel time reliability (Tu et al., 2007) by investigating the presence of ramps on six major. This study concluded that the presence of ramps in the road network has reduced the travel time reliability.

Since road network reliability considers the probability of transportation system failures in how to meet performance parameters such as reasonable travel time and travel cost, level of service and the probability of connectivity of the transport network and lack of measuring the consequences of link failure to the community, the concept of road network vulnerability might be an alternative way to fill some of road network reliability deficiency, particularly in assessing the adverse socio-economic impact to community (Taylor et al. 2006). The next section will discuss road network vulnerability.
III. ROAD NETWORK VULNERABILITY

Due to the potential socio-economic cost of degraded transport network to community, the concept of road vulnerability has been developed by researchers under transport network reliability umbrella. The definition of vulnerability has not yet been generally agreed. Several authors’ notion of the vulnerability focused on the negative events that significantly reduced the road network performance. Berdica (2002) defined the vulnerability as “a susceptibility to incident that can result in a considerable in road network serviceability”. The link /route/road serviceability described the possibility to use that link/route/road during a given period of time. Furthermore, since accessibility depend on the quality of the function of the transportation system, this concept relate to the adverse of the vulnerability in terms of reducing accessibility that occurs because of the different reasons. As the idea of network vulnerability relates to the consequences of link failure and the potential for adverse socio-economic impacts on the community (Taylor et al., 2006, Jenelius, 2007a), thus vulnerability can be defined in the following terms:

1. A node is vulnerable if loss (or substantial degradation) of a small number of links significantly diminishes the accessibility of the node, as measured by standard index of accessibility.
2. A network link is critical if loss (or substantial degradation) of the links significantly diminishes the accessibility of the network or of particular nodes, as measured by standard index of accessibility.

Therefore, it can be concluded that road vulnerability assesses the weakness of road network to incidents as well as adverse impacts of the degraded road network serviceability on the community.

In relation with the road network vulnerability definition which focuses on two different aspects; selecting critical road network elements and consequences of measurements, Jenelius (2007a) has identified that road network vulnerability assessment can be distinguished into two stages. The first stage is to select a critical link by identifying the road network likelihood and by quick scanning of wide road transport and the second one is measuring the consequences of link disruption to community. Based on previous works, different approach has been applied in order to scan wide road network. Jenelius et al (et al., 2006) selected particular major arterial road which connect the district at the Northern Sweden to be the worst case scenario and selected road links randomly as the average case scenarios. Scott et al (2006) has also introduced topology index and the relation between capacity and volume then select the critical link. Indeed, Jenelius (2007a) has suggested that conducting comprehensive assessment of road network will be helpful for identifying roads that are probably affected by the traffic accident, flood and landslides.

Berdica et al (2003) undertake a comprehensive study in order to test 3 types of software to model road network interruptions. This study simulated the short duration of incidents on University of Canterbury networks by using SATURN, TRACKS and Paramics. They modelled a total block of one link on the small network then run the model at the macroscopic level by using TRACKS, at mesoscopic level by using SATURN and at the microscopic level by using Paramics. Based on the simulation, the different packages gave different result in terms of their responsiveness to model the short incidents, for instance, Paramics might be considered as a suitable software package for short duration incidents
because it is more responsive than other softwares. SATURN which is more detail in its formulation than TRACKS has less responsiveness than TRACKS.

Given the lack of generally recognised measurement of road vulnerability, it has been common practice to consider measures such as the increase of the generalised travel cost, the changes of the accessibility index or the link volume/capacity ratio when one or more links were closed or degraded as road vulnerability measurement. Taylor et al (2006) studied the network vulnerability at the level of Australian national road network and the socio economic impact of degradable links in order to identify critical links within the road network, by using three different accessibility approaches. The study introduced the three indices for vulnerability. The first method was the measurement of the change of the generalised travel cost between the full network and the degraded one. This method has concluded that by degrading one particular link the generalised travel cost will increase, and then the links which gave the highest travel cost was determined as the most important link. The second method used the changes of the Hansen integral accessibility index (Hansen, 1959) in order to seek the critical links. It was assumed that the larger the changes were after cutting one link, the more critical that link was on the basis of the adverse socio-economic impacts on the community. The last approach considered the changes of the Accessibility/Remoteness index of Australia (DHAC, 2001). This method was similar to the second method which sought the critical link depending on the difference between the ARIA indices in the full network and the ARIA indices in degraded network. Moreover, Taylor et al (2006) also studied the application of the third approach at the regional level in the state of Western Australia. This study concluded that removing a link gave different impacts for the cities, for example, by cutting one link, the impacts on the several cities were only local, in contrast, other cities where they were available similarly alternative road performance did not give significant changes of the ARIA indices.

Due to the importance of a particular link within the wide road network, Jenelius et al (2006) introduced a similar approach to Taylor et al (2006). They studied the link importance and the site exposure by measuring the increase in generalised travel cost in the road network of the Northern Sweden where the road networks were sparse and the traffic volumes were low. By assuming the incident was a single link being completely disrupted or closed so the generalised cost increases, then the most critical link of the operation of the whole system and the most vulnerable cities because of the link disruptions were determined. The study concluded that the effect of closing a link was quite local and the worst effect was in the region where the road network was sparser with fewer good alternative roads. This research suggests that the road network vulnerability assessment can be applied in road network planning and maintenance, to provide guidance to the road administration for road prioritisation and maintenance.

In addition, Taylor (2007) studied the road network vulnerability in South Australia road network which included all the freeways, highways and major main roads. This research used a large complex road network and evaluated the ARIA indices changes for about 161 locality centers with populations exceeding 200 people. This study found the top ten critical links in the South Australia regional road network.

Moreover, in relation with vulnerability approach in D’ Este and Taylor (2003), Chen et al (2007) tries to assess the vulnerability of degradable networks by using the network based accessibility and by combining with a travel demand model. Their study concluded that the
model can consider both demand and supply changes under abnormal conditions. Thus the vulnerability network assessment can be measured by considering the duration of the disruption (increase the travel time) and modeling the user equilibrium both the cases when there are alternative roads or the case when there are not alternative roads (Jenelius, 2007b). Indeed, Scott (2005) introduced the measurement of the Network Robustness Index by considering the ratio between the link capacity and link volume and assigning topology index for each link then test whether the particular links can cope with the changes of the traffic demand when one or more links were closed or degraded (Scott et al., 2005).

Jenelius (2007b) introduced the new method in order to incorporate dynamic road condition and information by assessing the increase travel time using the extended of the user equilibrium model. This study assumed that there was no congestion and there was at least one alternative route between the origin and destination. Further, this study also assumed that the road users have perfect road information about the length of road closure so that they can decide whether they need either to take a detour or to go back to their origin and wait until the road reopened. This method calculated the additional travel time which is calculated since the road users were informed about the road closure, the waiting time until the road reopened. The difference between the normal travel time and the additional travel time due to road closure was assigned as the increase travel time. However, this study did not take into consideration the change of the travel flow at the alternative routes. This assumed that the mix of the current and diverted traffic can flow at the free flow.

In order to assess the increase of the flow when the diverted traffic mix at the current traffic which already meet the capacity or are already congested, the study which conducted by Lam et al (2007) can be considered. This method introduced the path preference index which is the sum of the path travel time reliability index and the path travel time index. To examine road network vulnerability in an urban area, Berdica et al. (2007) studied the vulnerability of the Stockholm road network by examining 12 scenarios involving partial and total closure of selected links, including bridge failure. Also, it assessed the road network degradation in three different times of day, morning peak hour, middle of day and afternoon peak hour. This study concluded that by closing one link or all links as well as bridge failure would increase the total travel time and total trip length (on the assumption that travellers chose their minimum time route based on user equilibrium method). The model of different scenarios at different times gave different results but the most vulnerable links were the Essinge route and the failure of Western bridge scenario. To conclude this study calculated the increase of total travel time a day and then multiply that by 250 days to obtain the total increase travel time for yearly basis. Though the highest total travel time increase in only 8% per day, however if it is calculated by 35 SEK (travel cost per hour) it gave significant impact of total travel cost increase. However, it did not take into account the duration of the closure and left some discussion of link disruption impacted such as the effect of noise and pollution during the road closure.

Moreover, Knoop and Hoogendoon (2007) assess the spillback simulation in dynamic route choice in order to examine the spillback effects then evaluated the road network robustness and the vulnerability of links. This study concluded that it is necessary to assess the spillback effect in order to identify the most vulnerable link within the wide road network. Tampere (2007) investigated the vulnerability of highway sections in Brussels and Ghent. This work was quite challenging, it tried to consider the different aspect of the road network vulnerability criteria related to the amount of vehicle hours lost due to major incidents. This
work compromised of two steps; the first one is the quick scanning of the most vulnerable link from the long list into short list by considering the several aspects and then by obtaining the short list links then the vulnerability measure was conducted. Since this method used the dynamic traffic assignment, there are some drawbacks during the model run such as the lack of traffic distribution after the occurrence of the incident which resulted an illogical of travellers route choice. In general this method has successfully measured the vulnerability by not only considering the traffic condition but also taking into account the different road networks. Though this method has not considered traffic assignment criteria, it is still considered as a refinement over similar studies.

IV. GASEOUS EMISSIONS

There is a great need and interest in the development of sustainable transport due to the recent environmental concerns on the global warming issues and fuel crises. It has been proven that transportation contributes more than 15% of greenhouse gas emissions which catalyse the negative effects of global warming. With regards to assessment of different environmental consequences of the automobile, one scheme for identifying the environmental impact of a transportation system on the community is to measure the gaseous emissions of vehicles. Vlieger et al (1994) introduced a vehicle emission and fuel consumption analysis method which estimates the emission values within the cost effectiveness evaluation by using vehicle fleet, mobility and emission factors as input parameters. Moreover, Vlieger et al (2000) undertook a complete study to investigate Vito's on-board fuel consumption and emissions measuring system on the ring roads of Brussels and Antwerp. This study developed the method to measure the effect of congestion, driving behaviour (calm, normal and aggressive driving) and traffic condition on gaseous emissions by using nine different types of cars based on car technology and fuel type (petrol and diesel). This study was conducted at three different traffic conditions (morning and afternoon rush hour and normal condition). To conclude, the aggressive driving, the congestion at the rush hour and the slow speed due to the congestion significantly increased vehicle emission; the petrol car arise higher gas emission than diesel and the traveling time on the ring roads is lower than the short cut. Also, it concluded that, using ring road was much better than the main roads and rural roads in reducing the emissions due to the free flow traffic on ring roads (vehicle can maintain the speed at 50km/h).

There are now alternative ways to reduce greenhouse gas emissions such as the ‘green car’ which use greener fuel (e.g. diesel, CNG and biofuels) (Banister, 2005) as well as the implementation of different travel demand management (TDM) schemes. The rapid growth of the automobile has also worsened the environment. Kitamura et al (1998) conducted a study in Kyoto which aimed to measure the outcome of implementation of new TDM policies in relation to the gas emissions (Kitamura et al., 1998). This work investigated three different TDM schemes and measure gas emissions based on three scenarios; introduction of a loop light-rail transit (LRT) line surrounding the central parts of Kyoto, introduction of parking surcharges in the CBD, and auto traffic restriction in the CBD. This study concluded that the automobile ban in the city centre had significantly reduced the gas emission in city centre.

Similar to Kitamura et al research, Taylor et al modeled freight vehicle greenhouse gas emission impacts along the freight routes in Sydney with the purpose of testing several policies to reduce greenhouse gas emissions (Taylor et al., 2005). By combining travel demand, traffic network and emission model, this study suggested that reducing vehicle load
factors might be the best policy. Also this model is suitable for assessing private vehicle’s gas emission. Since most of the emission modeling was based on the acceleration and deceleration as well as driver’s behaviour, Panis et al (2006) concluded that there needs to be a complex study to measure the environmental impacts of traffic managements and policy controls in relation to data requirements. Indeed, it suggested that understanding the second-by-second speed and acceleration of individual vehicles travelling in a road network based on their individual driving style is required to give a proper picture of the traffic emission. This method can be used for long term forecasting as well.

Three sections above discussed some methods and techniques to measure the travel time reliability and variability, the concept and current research about road network vulnerability and the development of a vehicle emission and fuel consumption technology. The next section will focus on the propose methodology in order to study the Adelaide urban road networks travel time reliability

V. THE METHODOLOGY

This section briefly discusses the characteristic of the study area, the propose methodology and the data collection techniques. Since this is a first part of the PhD research, this paper will not come up with findings and conclusions, however based on the current data analysis, this section can provide some preliminary findings.

5.1 The road network performance data analysis

The South Australian Department for Transport, Energy and Infrastructure (DTEI) has been collected the travel time data for selected corridors as a part of the road network performance measurement project. Travel time data was collected by using the GPS probe vehicle survey for three different time of day, AM peak, off peak and PM peak. This data has been collected annually since 1999. In order to get different data collection for different season of year, this survey was conducted for two different times, during March and July for each year.

In accordance with the travel time distribution for each corridor, it has been identified that the busiest and the highest travel time variability is for the South Road Corridor. This corridor starts from the South Road and Panalatinga Road intersection then continue to the South Road and Anzac Highway intersection as shown in Figure 1.
By analysing the AM peak and PM peak data for that corridor, the highest travel time variability is that for the AM peak northbound traffic as shown in Figure 2. This figure represents the AM peak average travel time for South Road corridor which was collected in the month of March in each of the survey years. From this figure, the highest travel time variations on South Road are for the section from Marion Road to the Southern Expressway and the section from Daws Road to Edward Street. Furthermore, the other interesting finding is that the AM peak congestion index for some adjacent links of the Southern Expressway is much higher than rest of links. The range of the CI is from 0.03 to 5.52. The biggest one is for the Marion Road-Southern Expressway section. Table 1. below illustrates the variability of the congestion index for each link based on the AM peak travel time data.
Figure 2 The AM peak average travel time

<table>
<thead>
<tr>
<th>Links</th>
<th>Length</th>
<th>CI 99</th>
<th>CI 00</th>
<th>CI 01</th>
<th>CI 02</th>
<th>CI 03</th>
<th>CI 04</th>
<th>CI 05</th>
<th>CI 06</th>
<th>FF</th>
<th>Speed</th>
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<tr>
<td>Panalatinga Road - Chandlers Hill Road</td>
<td>0.13544</td>
<td>0.309</td>
<td>0.033</td>
<td>0.368</td>
<td>0.447</td>
<td>0.476</td>
<td>0.398</td>
<td>0.476</td>
<td>0.476</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Chandlers Hill Road - Black Road</td>
<td>2.71007</td>
<td>0.14</td>
<td>0.129</td>
<td>0.221</td>
<td>0.46</td>
<td>0.136</td>
<td>0.202</td>
<td>0.534</td>
<td>0.405</td>
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<td></td>
</tr>
<tr>
<td>Black Road - Majors Road</td>
<td>0.594913</td>
<td>0.419</td>
<td>0.226</td>
<td>0.338</td>
<td>0.625</td>
<td>0.86</td>
<td>0.499</td>
<td>0.771</td>
<td>0.867</td>
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<tr>
<td>Majors Road - Seacombe Road</td>
<td>3.096485</td>
<td>0.292</td>
<td>0.198</td>
<td>0.181</td>
<td>0.045</td>
<td>0.051</td>
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<td>0.201</td>
<td>0.041</td>
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<td>Seacombe Road - Marion Road</td>
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<td>1.932</td>
<td>1.012</td>
<td>3.567</td>
<td>2.768</td>
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<td>1.207</td>
<td>2.184</td>
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<td>3.249</td>
<td>1.217</td>
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<td>4.518</td>
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<td>5.523</td>
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<tr>
<td>Southern Expressway - Flinders Drive</td>
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<td>1.581</td>
<td>3.541</td>
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<td>Sturt Road - Ayliffes Road</td>
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<td>0.059</td>
<td>0.358</td>
<td>0.251</td>
<td>0.159</td>
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<td>2.036678</td>
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<td>1.579</td>
<td>0.913</td>
<td>1.397</td>
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<tr>
<td>Daws Road - Edward Street</td>
<td>1.62536</td>
<td>0.477</td>
<td>0.193</td>
<td>0.672</td>
<td>0.875</td>
<td>0.883</td>
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<td>Edward Street - Cross Road</td>
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<td>0.158</td>
<td>0.453</td>
<td>0.267</td>
<td>0.582</td>
<td>0.935</td>
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<td>0.85</td>
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<tr>
<td>Cross Road - Anzac Highway</td>
<td>1.590398</td>
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<td>2.009</td>
<td>2.659</td>
<td>3.295</td>
<td>2.737</td>
<td>1.73</td>
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</tbody>
</table>

Table 1 Congestion Index

5.2 The study area

With regard to preliminary findings, this study will focus on the AM northbound traffic of the South Road corridor. This corridor starts form the intersection of Seaford Road and South Road and continues to the South Road-Anzac Highway intersection. This corridor serves the traffic from the southern suburbs and is also an assigned freight corridor. In addition, there
are currently two major road works projects which are taking place at the same area. One is the South Road underpass at Anzac Highway, which started in June 2007 and the other one is the Tramline Fly over which will start early in 2009. This circumstance might affect the current traffic conditions and lead to higher travel time variability.

5.3 The data collection

There are some techniques to do the travel time reliability measurements. The main concern before selecting the proper techniques is the data availability. The more complete the data collection, the more reliable and the deeper the data analysis. As the data from the DTEI only cover some parts of the study areas and that was not a continual data, new travel time data collection needs to be conducted. A GPS probe vehicle survey has been designed and the longitudinal travel time study will be conducted next year. The two day pilot survey was conducted in 2008, along a route which started from the second stage of the Southern Expressway and continued to Adelaide CBD.

5.4 The travel time variability and reliability analysis

In accordance with the travel time reliability study, the longitudinal and continual data are required. Since this is a beginning part of the PhD research, the data is not ready to analyse yet. It requires a minimum 6 months continual data collecting to get the better picture of the travel time variability and reliability. According to Faouzi and Maurin (2007), the distribution of the travel time data variability could be expected to follow the log normal distribution, then the depth analysis of how the log normal distribution works in travel time reliability measurement will be studied as well.

5.5 The speed - time and speed - distance profile

Since the GPS probe vehicle survey can collect not only the vehicle position but also the vehicle speed, further speed–time profile as well as the speed-distance profile analysis will be undertaken. The speed–time profile might represent the duration of queues for particular links, especially for those been identified as the busiest links. Moreover, by integrating the GPS data and GIS application, the speed-distance and speed-time profile will be overlaid with GIS format road network data, and then the duration and the distribution of delay at the most congested links can also be obtained. Figure 3 and Figure 4 below show the speed – time profile and the speed – distance profile for GPS data collected in the pilot survey.
In order to examine in detail any discrepancy between different speed–distance profiles, Figure 5 below illustrates how two sets of travel time data were overlaid with the Google image, from which any differences can be ascertained.
VI. FUTURE WORKS

The previous section discussed the opportunity to use the integration of GPS probe survey data and the GIS application to measure travel time variability by analyzing the speed-time and speed-distance data. Since this is an early stage of the PhD project, the next stage of this project is to measure the community lost due increases in travel time. The community lost due to the travel time variability can be quantified either by measuring the increase of travel time as well as the increase of the generalised cost or by looking into the fuel consumption and the gaseous emission.

As the travel time has been generally accepted as the road network performance particularly in assessing the mobility and accessibility in urban areas, the decrease of an accessibility index due to the travel time variability can be another measurement to evaluate the community lost. The 95th percentile of the travel time variability distribution has been used to predict the probability for the morning commuter to be late. By considering the additional travel time as the input for the accessibility index measurement, the new accessibility index measure. The differences between the accessibility index before the road works and during the road works might be useful to measure the amount community lost particularly in participating in one activity.

Fuel consumption and gaseous emission are also excess costs of the congestion and travel time variability. ‘Stop and go’ traffic consumes more fuel than smooth and high speed trips. Based on the speed profile data, the further fuel consumption as well as the gaseous emission can be quantified.
References


