The Visualisation of the Public Transport System of Sydney

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Key words: visualisation, transport, planning

SUMMARY

The Sydney metropolitan area has the largest public transport system in Australia with over one million commuters using the CityRail network each day. Despite Sydney having one of the fastest growing population's in Australia, public transport usage is only slightly growing in Sydney compared to other major centres throughout Australia. The lack of growth in public transport patronage reflects the shortage in the delivery of public transport infrastructure projects within the Sydney metropolitan area. It is essential for the growth of Sydney that a sustainable, modern and cost effective transport system be established to cope with current transport patronage and to support future growth.

This paper assesses Sydney's current public transport system (including trains, buses and ferries), the strategic plans in place to cope with growth and a method for visualising these systems to provide an analytical view of the transport system. The main objective of this paper is to demonstrate a visualisation tool that is able to identify and highlight the problem areas within the transport system and offer input to test the capability of the proposed strategic plans for Sydney. This analysis has the ability to help improve Sydney's public transport for current and future residents.

The creation of the visualisation will use a dataset from a typical working day to identify the position of buses, trains and ferries within the Sydney public transport network. The visualisation will classify the different modes of transport and enable the analysis of these transit modes both individually and interacting together. The dataset of all of the public transport modes over Sydney for the typical day comprises of 1.3 million data entries. This paper will not only discuss methods deal with the large amounts of data but also look into the best methods to deal with data conversion, manipulation, analysis and presentation.

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1. INTRODUCTION

Sydney's population has been significantly increasing over the last 30 years with this growth predicted to continue. Population predictions indicate that there will be 655,000 new dwellings in the Sydney metropolitan area by the end of 2030 (NSW Government , 2005). Associated with the increased growth is the need to cater for the population with appropriate infrastructure including public transport facilities. Public transport is currently a contentious and strong political issue in NSW with a large amount of media attention. The Ministry of Transport stated that in some areas of Sydney there are more people leaving the public transport network and moving back to car-dependency because of the lack of public transport options available (Ministry of Transport, 2009). This is not a good signal for the public transport system.

With environmental issues becoming more of a concern in today's society the transition back to car dependency is not an ideal solution to these problems. With this onset, the state of the public transport system is likely to worsen due to traffic congestion resulting in further movement towards private transit, which then becomes a cyclic problem.

Public transport has long been an issue of concern for the Australian government. The 2009 Budget released in May 2009 has invested in this issue by placing initiatives in the national building infrastructure with $3.4 billion to be spent on roads and $4.6 billion for the metro rail projects (Ministry of Transport, 2009). This is a positive step towards creating an improved public transport system. However, due to political factors and elections previous plans such as these have either failed or have been indefinitely postponed.

2. BACKGROUND INFORMATION

2.1 NSW Metropolitan Strategy

The NSW Government established a Metropolitan Planning Authority to predict the future growth of Sydney and to develop a strategy to manage this growth. Sydney is a city that is restricted in many ways in terms of growth by the Pacific Ocean to the east, National Parks to the north and south and the Blue Mountains to the west. Therefore the only viable option to grow is the north west and south west of the existing centres. The Metro Strategy identified this as the most viable solution and location for growth over the next 30 years, with the majority of growth to be focused in the identified North West and South West Growth Centres.

The North West and South West Growth Centres (centered around Rouse Hill and Leppington respectively) are expected to house 60,000 and 100,000 people respectively and this will create approximately 180,000 jobs combined (NSW Government , 2005). This is a significant increase and a public transport network that can support this amount of patronage is necessary. It is therefore essential that a transport network be considered not only for the current patronage but also to plan for the future residents and businesses in this area.

2.2 Strategic Plans for Sydney

The poor performance of Sydney's public transport system reflects the shortage in the delivery of planned public transport infrastructure projects (Glazebrook, 2009). Figure 1 below shows the rate at which the patronage of public transport users is growing in the major centres of Australia. It is evident that Sydney has the lowest growth of these cities due to the issues that have plagued the transport network for many years. For a global city such as Sydney, a greater importance needs to be placed on the public transport system as 'fears of the decline of our global status are eminent' (Glazebrook, 2009).

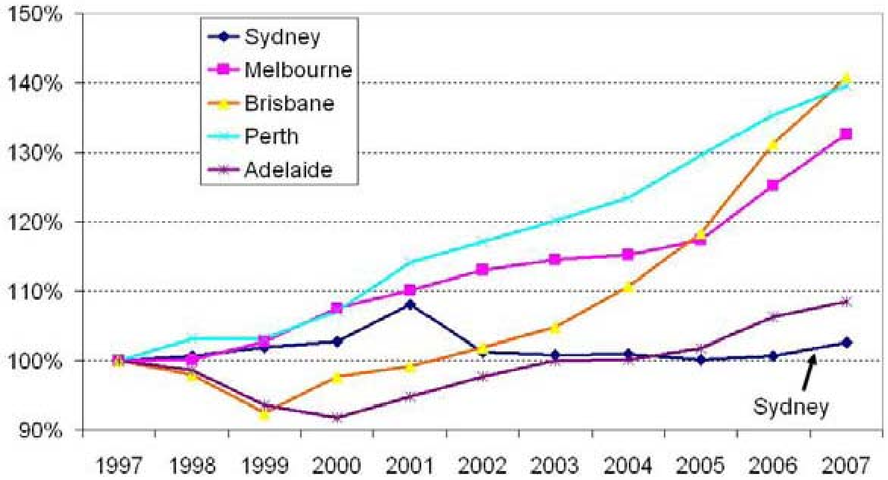

Figure 1: The Percentage in Public Transport Growth Patronages since 1997 (Glazebrook, 2009)

Glazebrook's (2009) Thirty Year Public Transport Plan for Sydney looks at the current transport system in Sydney and identifies solutions about how to cope with the transport systems over the next 30 years. It is estimated that $660 billion will be spent on car travel by Sydney-siders if the current transport system is not upgraded (Sydney Morning Herald, 2009). This is a significant amount of spending since the Thirty Year Public Transport Plan that Glazebrook has proposed will cost the government a mere $40 billion, averaged to $1.4 billion a year instead of the current $3.2 billion spent currently on public transport each year (Sydney Morning Herald, 2009).

Glazebrooks' proposal uses the concept of a double cobweb design. The current grid system is impractical for the future growth and expansion of the transport network. Instead, more cross regional links need to be created. Figure 2 illustrates the double cob-web network that has been proposed. This uses the CBD still at its centre but also uses a secondary centre which would be located at Parramatta (Glazebrook, 2009). The ring roads around the centres will later be seen appearing as the ring roads of Glazebrooks' proposals.

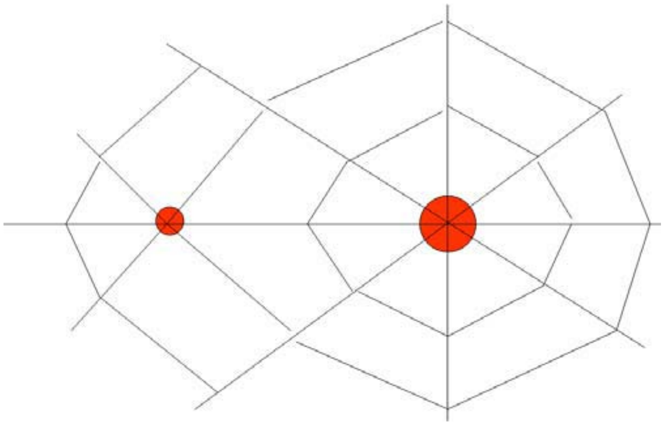

Figure 2: The Double "Cob-Web" Network Design (Glazebrook, 2009).

This Thirty Year plan is acclaimed by the Sydney Morning Herald to "link almost every home, office and university in Sydney to upgraded train, tram and bus services within 30 years" (Sydney Morning Herald, 2009). The proposal outlines the implementation of six new metro lines, a heavy rail link to the suburbs of South West Sydney (a region currently not well serviced by any public transport), and trams servicing the inner suburbs and Parramatta. Along with these infrastructure plans for heavy rail and metro rail are six major bus ring routes and light rail lines. The idea of these routes is to link the minor centres without commuters having to go through the major city hubs, i.e. encouraging Cross-regional linkages.

3. DATA PROCESSING

Creating a visualisation is a lengthy process with continual development and improvement to try and cater for the different development paths that become apparent during the process. The process of the continual development of this code involves many steps each one building on the successful completion of the previous step. Throughout the process of creating this visualisation many techniques were used in order to simplify the manipulation of the data. This process is shown in Figure 3 below.

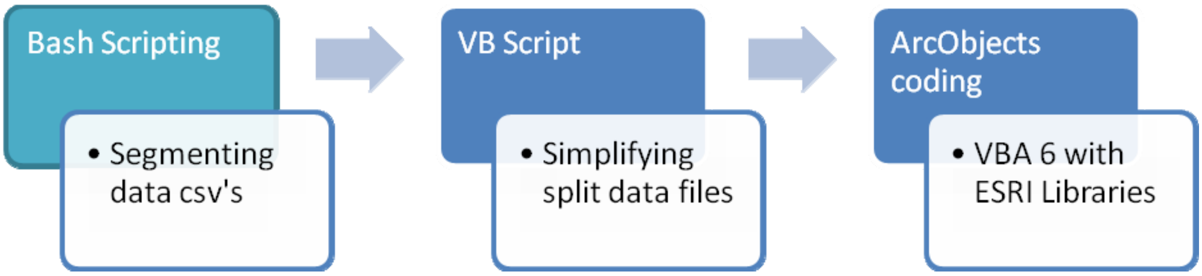

Figure 3: Data processing

4. RESULTS

After extensive programming and data processing, the end result effectively showed the movement of buses, trains and ferries over the Sydney metropolitan area. This visualisation has the ability to process exceedingly large tables in the format that was provided by the Ministry of Transport. One such implementation that is very effective within the code is the ability to accept all data types if given in the correct format. This visualisation is thus not limited to just the Sydney metropolitan region, but if any other data is implemented then the visualisation will also run.

One of the objectives of this study was to implement a method in which to visualise transport data through time. This objective was achieved and the results are very successful as the visualisation is able to be used and effectively shows the public transport networks. The visualisation in itself is extensive with large amounts of data available to be viewed at once. When zoomed out sufficiently as to see the whole of the transport data, the middle of Sydney looks like a blur of dots from the masses of bus routes that converge on the city. This of course is not useful at all for the analysis except to say that the city is overcrowded with public transport routes, as one would expect. When zoomed into particular areas, this is where the meaningful data can be found.

Upon review of Figure 4 with the pink dots representing the data entries at 9:00am on the Tuesday morning, it is clear that this method of visualisation is not useful at this scale. It is for this reason that test cases and smaller scales had to be implemented. The solution to this assumption however, is to view the areas of Sydney separately in a closer scale image such as the one below with the eastern suburbs, the CBD and stretching out to Parramatta (see Figure 5). This image is taken over the 3 minute interval of 9:00am to 9:03am.

This scale is very effective for viewing the visualisation as one can clearly see each route and its path that it traces out. This visualisation is very effective for viewing and analysing the bus routes. As one can see from the Sydney CBD area of the map, highlighted by the red circle, there is a vast amount of congestion in the CBD at 9:00am in the morning as well as along the arterial roads.

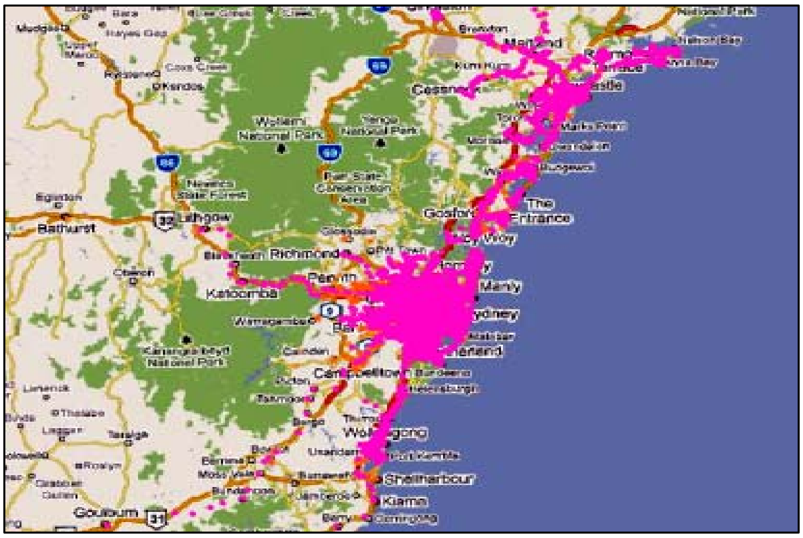

Figure 4: A screen shot from ArcGIS showing the pink dots to be all transport data entries at 9:00am.

Figure 5: Screen shot from ArcGIS of a closer scaled image with transport from 9:00am to 9:03AM

One result that showed a negative result within the visualisation was that some of the data tables were not complete. This was in terms of the minute by minute positions. Many buses take longer than 1 minute to go between 2 stops and thus there would be a gap of a minute where no data would be shown. In order to rectify this problem, interpolation of the data needs to be completed.

4.1 Test cases

4.1.1 Single route test case – 397 route

After reviewing the whole Sydney visualisation, the view of the extended Sydney makes the visualisation difficult to review and analyse the transport routes. It is for this reason that particular bus routes surrounding the University of New South Wales were chosen for a more detailed visualisation.

The route chosen for the single test case is the 397 bus route stretching from South Maroubra to Circular Quay. This bus is a regular bus within the Eastern suburbs leaving every 20-30 minutes from each end of the route. The 397 bus route was the first route that we chose to work on to make a detailed test case. For this case we completed a manual interpolation of all of the data along this route to achieve a true minute by minute route. This process involved manually determining the positions of each minute interval and creating new entries within the Bus_397 table.

The result of this manual interpolation was very effective with a smooth path being shown at each minute along the path. The interpolation was completed by manual interpolation. This process involved determining the position of the two stops next to each other and then if more than one minute is passed between stops, data entries would be added to that fall along the route to the approximate distance travelled.

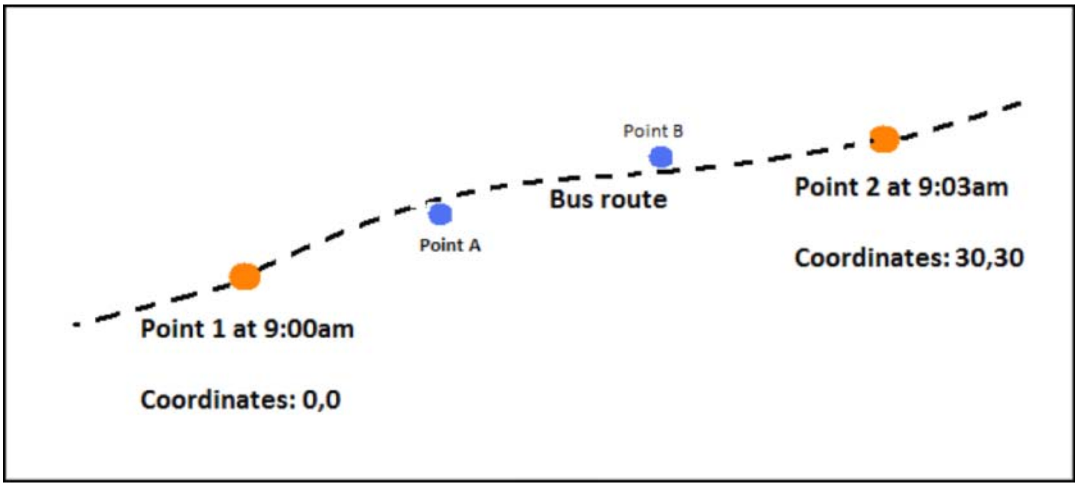

Figure 6: Simple explanation of manual interpolation

From Figure 6, one can see that there is a 3 minute difference between the two orange points which are the bus stops. The two pots (points A and B) are the approximate positions along the route that would be placed by manual interpolation. The coordinates placed for point A would be 10,10 whereas the position of Point B would be approximately 20,20. These would be given the respective times of 9:01am and 9:02 am respectively. This type of manual interpolation was very effective for showing the different smooth path along a route instead of the jolted paths between each different bus stop.

Figure 7: Screen shot from ArcGIS showing 397 bus route (blue) and the interpolated 397 route (pink).

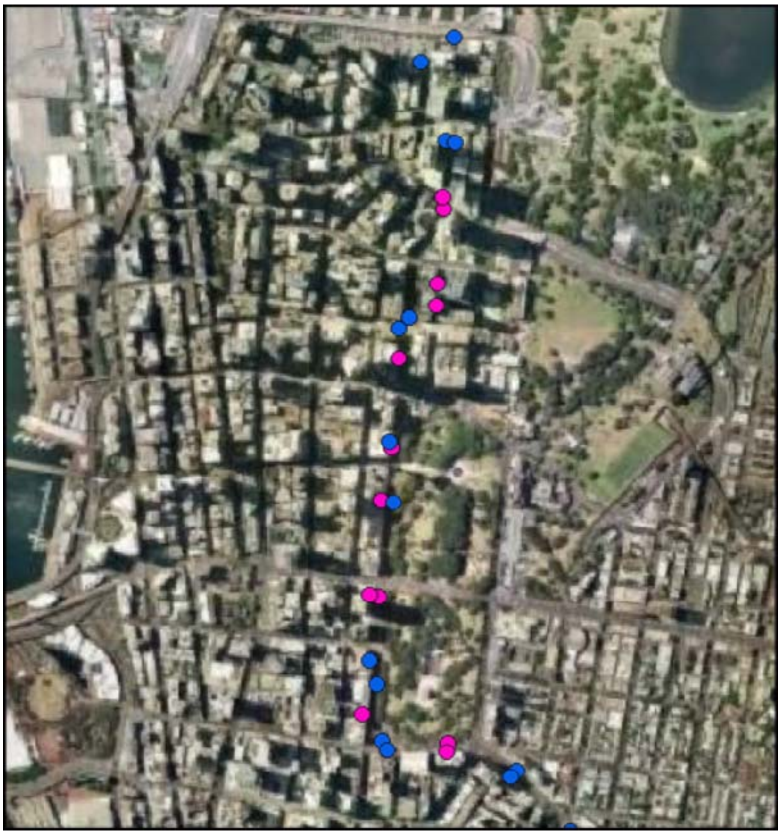

Figure 8: Screen shot showing small section of the 397 bus route (blue) and the interpolated route (pink).

Figures 7 and 8 show the route of the 397 bus stops in blue with the pink manual interpolation points superimposed. The first thing one would notice about these two images from ArcGIS is that it seems like some points are doubled up. This however is not true and the double ups are actually bus stops or either side of the road. Usually bus stops going both directions are placed relatively close to each other and thus the double ups seem to be displayed. The pink points or the manually interpolated points can be seen to be placed mid-ways between the blue bus stops. If we look closely at the position of these poi
nts, it is evident that they line up with the respective sides of the road however when placed together, the route looks rather confusing.

The background images used for this interpolation was sourced by SKM 2009 and Google Earth and used imagery taken on the 20^{th} of January 2007. This imagery was supplied by Parsons Brinkerhoff (PB) Australia. When running this Bus_397 route through the visualisation it is very clear to see each side of the route and when the buses pass each other. This visualisation of this particular route is very clear and outlines precisely the locations through time of the 397 bus.

4.1.2 Multiple route test case – Eastern Suburbs

A multiple route test case was then selected for further testing. As the last test case was within the Eastern Suburbs, it was chosen to do a multiple route test case of this area. This extent that the visualisation will run within stretches from La Perouse in the South West to Rosehill Racecourse in the Northeast. Areas included for this visualisation include the Sydney CBD, the Eastern Suburbs, the Inner West and areas extending from Parramatta to Bondi, La Perouse to Punchbowl.

This test case involves running the whole visualisation and just setting the zoom extend to be focused on these areas. By doing this, we were able to view all bus, trains and ferries within the area without having to use a different data set within the visualisation. The large scale integration is displayed very effectively with all of the different routes travelling along the roads with the aerial photography in the background. This multiple route test case also allows for future analysis of the congestion within the different areas of the Sydney area.

Figure 9 shows the buses, trains and ferries over this region through a snapshot of 3 minutes. One will notice how the tails (lighter coloured dots) help to understand the pathing as well as enable the major thoroughfares of transport routes to be properly highlighted.

Figure 9: A snapshot over 3 minutes of the multiple route test case.

5. FUTURE WORK

5.1 Improved interface

One of the most critical features of any program is its user interface. The quality of the user interface can make a program easy or difficult to use and is closely linked to the success of the program. Currently the user interface for this visualisation comprises of a series of prompts with requests for information or for a 'yes' or 'no' answer. This makes setting up a single run a long process and not very user friendly.

One of the most key improvements that could to be made to the visualisation is the user interface. Currently the visualisation only uses the basic input commands available through VBA. To improve the interface a custom form would need to be designed which gives the user access to all the data input variables. The simplest way to do this within ArcObjects is to create a custom form.

Custom forms allow a variety of methods for obtaining data to be implemented. This means that a combination of check boxes, dropdown menus and file browsing can be used to simply get the users input. However, if all the data is provided by the user in a single form then checking that the data provided is valid becomes an issue. As each piece of data is put into the form, code behind the form would need to check that it is suitable for visualizing and return an error message if it is not. This custom form would greatly aid the development of this visualisation into the key analytical tool that it could become.

5.2 Data interpolation

Data interpolation involves taking the data points given and constructing a simple approximation of position over time from them. The most basic approximation assumes that there is a straight line route between each stop. This style of approximation can be seen in Figure 10: A graphical solution of the interpolated data.below:

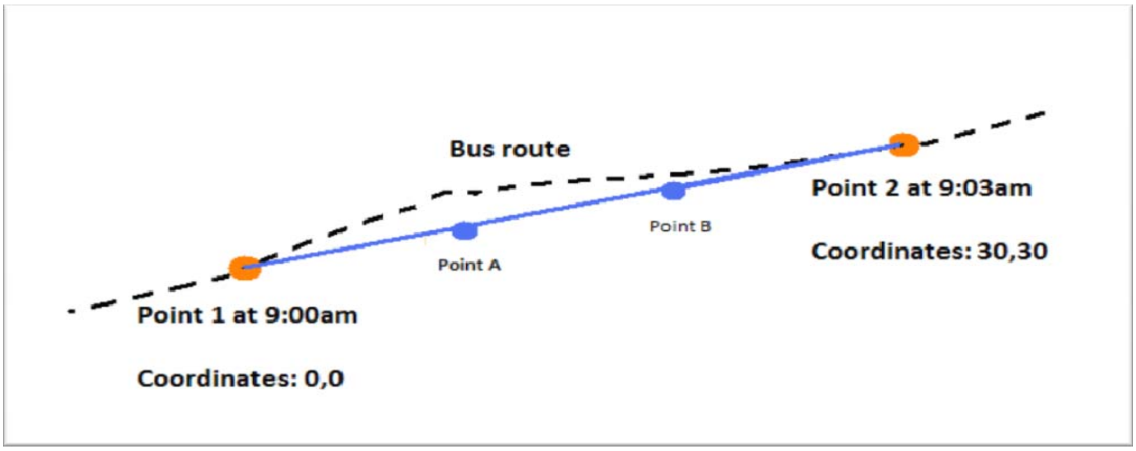

Figure 10: A graphical solution of the interpolated data.

As illustrated in Figure 10 this form of approximation may cause problems where it appears a bus has gone off the road or a ferry has gone through a headland. The ideal method of interpolation would be to get a full description of the paths which the transport systems follow. This may involve having a shape file that describes each route and could be used to trace a vehicles movement. This would require a large amount of data to complete but would give the most accurate description of the vehicle positions through time. As this data is currently not available, the only solution would be to draw the straight line.

The ferry transit data would be a good test case as currently the only stops recorded from the Ministry of Transport are the stops at each wharf. If people go between these wharfs, the straight line cuts through headlands, buildings and major sections of residential areas. The ferries do not do this, thus the ferries would be an initial test case.

Allowing data interpolation would be a great challenge for this visualisation. However, due to data constraints this function would have to be a future work. Currently, the transport data is missing the minutes that are not accounted for at the bus stops. Data Interpolation would solve this issue and make the visualisation run smoothly and without any gaps.

6. CONCLUDING REMARKS

This visualisation tool gives the ability to create detailed proposals for the future of the public transport system of Sydney. The public transport system of Sydney is facing constant issues with congestion, lack of services and an aging fleet. On top of these problems is the fact that many of the state government's planned projects have been delayed indefinitely or cancelled.

By analysing the working visualisation, the problem areas within Sydney became clear. This visualisation occurs over just one day yet all issues that have been within the media were apparent. Added to this is the fact that the Ministry of Transport provided the data for Tuesday, the most reliable day of the week. The fact that these problems are still able to be seen highlights the dire state of the current public transport system of Sydney.

The use of this GIS technology to make a visualisation tool such as the one we created will greatly aid in planning and decision making for future public transport networks. The aim of GIS in the commercial world is to value-add to your data and to give the non-spatial user the ability to view this data in a different method which can be easily understood. This visualisation captures this fundamental principle and allows the state of the public transport system of Sydney to be easily viewed and analysed.

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BIOGRAPHICAL NOTES

Sian Elliott is currently working within Parsons Brinkerhoff Australia (PB) as a graduate geospatial consultant with the Sydney offices of PB. Sian has completed her Bachelor of Engineering (Surveying and Spatial Information Systems), UNSW, in 2009.

Samsung Lim is teaching GIS and advanced estimation theory in the School of Surveying and Spatial Information Systems, UNSW. For the past fifteen years Samsung has been researching GNSS and GIS, especially network-based RTK and geo-information technologies to solve real-world problems. Samsung received his B.A. and M.A. in Mathematics from Seoul National University and his Ph.D. in Aerospace Engineering and Engineering Mechanics from the University of Texas at Austin.

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