WORLD CUP 2010 TRAFFIC SIMULATION

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ABSTRACT

The purpose of the paper is to describe how the use of tools like Geospatial Information technology and a traffic simulator, can determine the most efficient way to transport ticket holders from their accommodation to the match venue. The major focus is to determine the optimum number of Park ‘n Ride facilities to provide for the spectators from the Northern Suburbs of Johannesburg. Success is defined by providing a service, which alleviates congestion on the roads but still ensures less than two hours of travel. The simulations were designed with the aid of a Geographic Information System (ArcGIS). It is preliminarily concluded that the existing City of Joburg plan is inadequate as it does not cater for the key regions of Sandton and Midrand. It is recommended that additional Park ‘n Ride facilities, namely Innesfree Park and Megawatt Park should be added and further investigation is required into the amalgamation of other underutilised facilities.

1. INTRODUCTION

FIFA requirements emphasise the need for an excellent host country transport plan. The first and most enduring impression made by a host country on the teams, FIFA officials, the media and spectators is closely bound to the performance of the transport system [L D Beer, 2005]. Intensive planning and capital expenditure is required to ensure that Johannesburg (JHB), as the centre piece of the South Africa’s World Cup (WC) stage, will be able to provide a “quality, reliable, efficient and safe transport system” [2010 Bid doc, 2003].

On a match day at Soccer City (Nasrec), the transport network is required to move 95,000 people to Nasrec [L D Beer, 2005]. If the match begins at 8:00 pm, much of this traffic will coincide with the afternoon peak traffic.

Table 1 shows the number of additional vehicles that may be added to road network if every spectator used a single mode of transport.

Table 1: Increased traffic due to match ticket holders

Mode	People per vehicle [1, 3]	Number of vehicle
Private Car	2.3	41,305
Minibus Taxi	15	6,334
Bus	60	1,584
Train	500	190

It is thus clear that in order to minimise traffic on the roads, the traffic plan must encourage the use of trains and busses (public transport) and discourage the use of private cars.

This paper presents a design of a multi-modal high-level transport plan to deal with match day traffic. Success is defined if any match ticket holder, residing within the City of Joburg (CoJ) municipal area can travel to a match venue within two hours.

2. BACKGROUND

2.1 Mobility

The Victoria Transport Policy Institute defines mobility as “the movement of people…It assumes that any increase in travel mileage or speed benefits society” [Online TDM Encyclopedia, 2006]. Thus mobility can be improved through the increase of the motor vehicle system capacity and speed (which includes road and parking facility improvements, transit and ridesharing improvements, high-speed train, aviation and intermodal connections). Furthermore, the definition of urban mobility can be defined as “the mean time of the journey to work” [World Bank Report, 2006]. While discussing mobility it is imperative that a metric is defined to describe the number of people that can be transported. A Person Trip is defined as “a trip by one person in any mode of transportation” [SA National Household Travel Survey, 2001].

Mobility in JHB prior to and post 2010:

The city’s Integrated Transport Plan 2003 - 2008 [CoJ Report, 2003] vision for the city’s transportation system is “a safe and efficient transportation system, with a public transport focus” that “will support a world class city; connecting businesses, people and places in a sustainable and cost effective manner”. It states that currently urban mobility is rated as 48 minutes (i.e. it takes on average 48 minutes to travel to work) with more than 46 % of the public transport users spending more than 10 % of personal income on their travel to work.

Due to safety, reliability and time considerations, fewer people are choosing to use public transport [CoJ Report, 2003]. This is adding to the traffic on the roads and increasing the time required for ‘urban mobility’.

Due to the above mentioned mobility issues and also in order to improve the public transport services, the following measures are being undertaken:

- Development of the Strategic Public Transport Network (SPTN)
- The construction of the Gautrain Rapid Rail Link
- The upgrading of Metrorail infrastructure
- The taxi recapitalisation project

Mobility in JHB during WC 2010:
During a mega event, like the FIFA World Cup, the definition of mobility must be altered to include the mean travel time of spectators from main accommodation centres to match venues. The Local Organising Committee (LOC) has committed to providing "the highest quality and performance standards for the World Cup Family transport system" as well as a "quality, reliable, efficient and safe transport system for all supporters" [2010 Bid document, 2003].

This study focuses on the spectator traffic and ignores the impact of the FIFA family traffic as this impact has not yet been quantified [LD Beer, 2005].

Within keeping the specification of a 70-30 public private transport split [1], spectator traffic will be shared between the rail and road networks. The LOC aims to maximise the rail carrying capacity in order to keep the congestion on the roads to a minimum. The use of Park 'n Ride (P'n R) facilities will be used to encourage private car owners to use public transport. The spectator can safely park their cars at this facility and ride the bus to and from the game.

The following major projects should be completed before 2010:

- Upgrading key stations, particularly Ellis Park and Nasrec
- Upgrading all coaches used on World Cup routes
- North-South (N-S) flagship SPTN

Over and above the 95,000 match ticket holders, the transport system will have to cope with an estimated additional 100,000 non-ticket holding supporters that must be moved to and from fan festivals. A fan festival (called by some an exhibition site) is a large area where fans, without match tickets, can congregate to watch the soccer on large-screen television [L D Beer, 2005].

2.2 The Strategic Public Transport Network (SPTN)

The CoJ aims to transform the road network from a radial-focused to a nodal-focused transportation system by building the SPTN. The current system requires one to travel via the major node – the Central Business District (CBD), on all major journeys. The new proposed system will allow for direct travel between major residential and commercial nodes without passing through the CBD – i.e. a direct public transport route between Soweto and Sandton [CoJ Report, 2003]. By 2010, the CoJ hopes to have completed the flagship project - an N-S corridor between Soweto and Sandton. This existing route will be upgraded to have dedicated public transport and high-occupancy vehicle lanes (where possible) or other "public transport priority measures" [CoJ Annual Report, 2005].

2.3 Park 'n Ride

As the goal of the SPTN is to promote the use of public transport, one of the main features of the SPTN are P'n R facilities. P'n R facilities are public transport stations that allow commuters to leave their personal vehicles in a parking lot and transfer to a bus or rail system [10], thereby reducing the private traffic on the roads.

3. DESIGN OF THE HIGH LEVEL MODEL

The following data was supplied by CoJ:

- The Geographic Information System (GIS) maps of the road network, the SPTN and the municipal zones

- The projected 2010 AM (morning) peak traffic data
- High Level 2010 FIFA WC Transport Plan

In order to utilise the given data in a meaningful fashion within the given timeframe, a high level model was developed.

3.1 Geographic Information Systems

A Geographic Information System is a software application used for creation and management of spatial data and its associated attributes. All real-life features are represented in the GIS as one of three shapes: points, lines or polygons [Sher, 2006].

ArcGIS is ESRI's (Environmental Systems Research Institute) family of GIS products. This product is used by the CoJ for all their spatial data storage and analysis and was used by the authors to visualise the Johannesburg road network and metropolitan zones.

3.2 EMME/2

The traffic simulator used for this project is EMME/2. EMME/2 is capable of simulating multiple modes of transport, through finding the equilibrium between the supply (the road and/or rail network and the available public transport infrastructure) and the demand (the number of persons using the road and rail network). EMME/2 determines the number of person trips (a trip made by a single person in any mode of transport [User Manual, 1999]) that are made on each stretch of road over the defined simulation period. It does not display the dynamics of individual vehicles throughout the transport network (unlike other simulators). Refer to [User Manual, 1999] for further explanation regarding EMME/2.

In the preliminary stages of this project, the group investigated several (mostly open source) traffic simulators However, upon further research it was discovered that the CoJ already made use of a traffic simulator for which there is an existing database of JHB traffic and road network. The CoJ agreed that the students may make use of the simulator. This simulator is EMME/2. It was decided that it would be more productive for the students to rather simulate potential scenarios than to modify an existing traffic simulator.

3.3 Preparation of PM peak data

CoJ performs all its simulations on AM data as the morning peak traffic is more extreme than afternoon (PM) peak traffic. CoJ does not have the resources or the need to collect PM peak data as the AM peak is a worst case. The AM peak traffic includes all school trips (Generally scholars return from school before the start of the PM peak traffic). Furthermore, people arrive at work over a much shorter period of time than they depart from work [Msiya, 2006].

Although the AM peak traffic data provides the worst case traffic, nonetheless the traffic is flowing in the opposite direction than the required PM peak traffic. For example, during the AM peak there is more congestion on the N1 South than on the N1 North between Tshwane and Midrand. Therefore, when the WC traffic is superimposed onto the road network, it will be superimposed over the traffic which is actually travelling in the wrong direction. This would paint an inaccurate picture of the PM traffic.

It was therefore decided to reverse the AM traffic to create PM traffic as everyone who travelled from the Sandton to the CBD in the morning will be returning in the afternoon. MATLAB^{TM} was used to perform this complex data manipulation. In order to maintain simplicity, it was decided not to alter the number of person trips between metropolitan zones. This simplification can be justified as a worst case scenario is being modelled.

3.4 Preparation of a 2010 WC GIS Map

In order to gain a geospatial understanding of the transport requirements for the 2010 WC, the various important destinations were plotted on the GIS map. These destinations included Match Venues, potential sites for P'nR facilities and exhibition centres, train stations as well as various training venues [J Scheepers, 2006]. The zones which contain each of these destinations were recorded as important destination zones.

The High Level 2010 FIFA WC Transport Plan outlines a number of important origin (alternatively called departure) regions and the number of match ticket holders that will depart from each region. For example, one of the zones is Sandton, where there are expected to be 3,143 ticket holders residing.

The problem was simplified through the selection of several municipal zones to represent the key origin regions. Instead of altering every single Origin-Destination (O-D) pair, the problem has now been abstracted to roughly 16 origin and 20 destination zones.The justification for this simplification must be evaluated for each simulation scenario.

4. SCENARIO: OPTIMISING THE NUMBER OF PARK 'N RIDE SITES

CoJ has already performed many simulations in its High Level 2010 FIFA WC Transportation Plan [LD Beer, 2005]. These include the impact on the road network if every person in the vicinity of the train station used rail transport and the impact of an operational Gautrain on the WC transport. It was therefore decided to focus the research on an area that had not yet been formally investigated. One of the imperatives of transport planning for the FIFA WC 2010 is to encourage as many ticket holders as possible to use trains or busses as transport to the match venues (see Section 1).

On inspection of the CoJ GIS map, rail transport can easily provide for the requirements of the West and East Rand as well as the South. On the other hand, the Northern Suburbs currently do not have any rail infrastructure (as only the Gautrain link between O.R. Tambo International Airport and Sandton is on schedule to be completed by 2010 [van Olst, 2006]). It is assumed that there will be two types of ticket holder residing the Northern Suburbs: Middle to upper class locals (who own private cars) and international tourist who are residing in and around a central tourist region (Sandton and Rosebank – with their numerous hotels and shopping malls). In order to reduce the congestion on the road network all the private car owner should be encouraged to use P'nR facilities and the international guest will travel to the match on specially organised tour busses. One of the methods to encourage the use of P'nR facilities is to provide free safe parking and free bus rides to all match ticket holders. Alternatively, if the person chooses to drive, he will have to park far away and pay a very high parking fee. A similar system was implemented in FIFA WC Germany 2006 [Katz, 2006].

The High Level 2010 FIFA WC Transport Plan makes a number of suggestions towards potential P'nR facilities but does not give a number of required P'nR facilities or assign each facility with a catchment area.

It was hence decided that the key research question for the project would be: *To find the optimum number and spatial distribution of P'nR facilities* to ensure that every match ticket holder in CoJ will travel to the match venue in less than two hours.

4.1 Selection of Park ‘n Ride facilities

The following criteria were selected for choosing P’nR facilities:

- The P’nR facilities should be placed on the SPTN as these routes are conducive to public transport
- Each facility should have more parking capacity than the number of cars expected to use the facility during the busiest period of the tournament (day 15)
- A person should not have to travel further than 7 km to use a P’nR facility

Initially, the P’nR facilities suggested by [LD Beer, 2005] were plotted on the GIS map. All the important departure regions with 5 km radius were selected. (It is unlikely that a route along the road network will be longer than 7 km if it is within a 5 km radius). Each selected region was assigned to the relevant P’nR facility.

The regions in the West and East Rand and the South that were not assigned to P’nR facilities were all allocated to rail transport. The regions, in the Northern Suburbs, that were not allocated P’nR facilities were: Sandton, Alexandra and Midrand. (The Midrand region is called Midrand and Tshwane. Although Tshwane is distant from Midrand and not in CoJ, Tshwane’s traffic enters CoJ via the N1 which passes through the Midrand region. By increasing traffic on the border zones, one is able to include traffic from outside the CoJ Metropolitan.) These regions are highlighted in Figure 1 below:

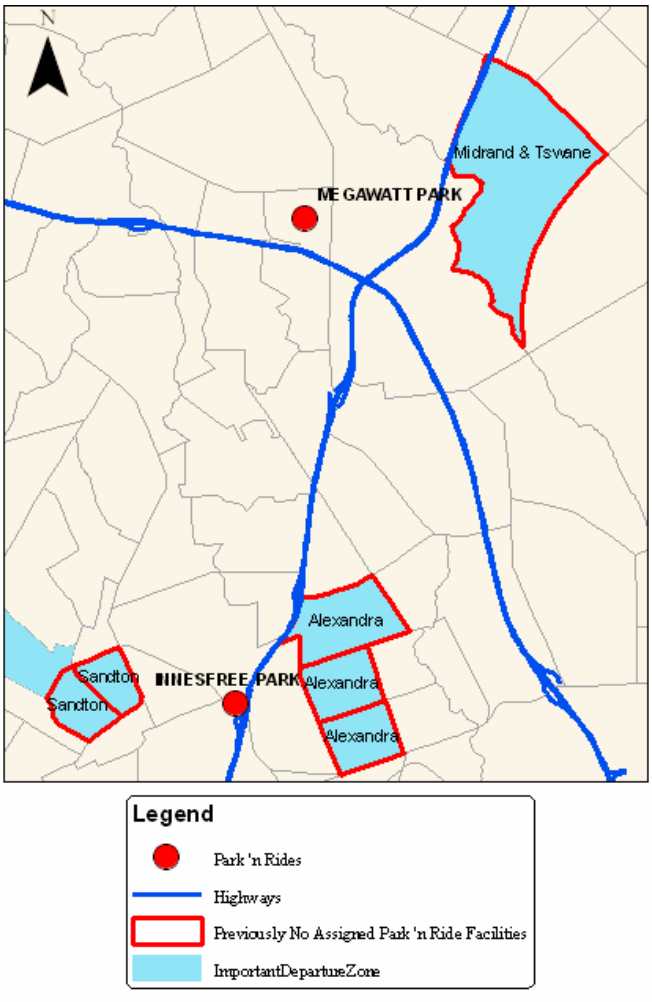

Figure 1: Assigning P'nR to the unassigned regions in the Northern Suburbs

Based upon a simple 7km circle area judgement it was decided to add two new P'nR facilities in the area: Innesfree Park to serve the Sandton and Alexandra origin zones and Megawatt Park to serve the Midrand origin zone. This can also be seen in Figure 1.

4.2 Manipulation of data for modelling

The problem of modelling the scenario was further simplified by focussing only on match ticket holder's transport and the use of P'nR facilities. This excludes transport of the FIFA family and transport of spectators to and from fan festivals. In terms of the private traffic model, it was assumed that roughly 80% of people will travel to the closest P'nR facility and remainder will travel directly to the match venue. In terms of the bus model, the changes were an increase in the number of people taking busses from the P'nR facilities and using the regular public transport system from the origin zones to the match venue.

Table 2 shows the additional traffic (in person trips and busses) that will have to be carried by the road network between the various P'nR facilities or origin zones and Soccer City. It must be noted that [2010 Bid doc, 2003] states that 60% of the traffic travels in the 2-3 hour period before kick off, and since the worst case scenario is being modelled, this period contains the majority of the WC traffic and also falls within the peak traffic period. Thus the calculated figures were altered accordingly.

Table 2: Changes required in the public transport data

Mode	P'nR Facility or Departure Zone	Destination: Soccer City	Bus Size	Number of Bus trips
Special busses from P'nR facilities	Bezuidenhout Park	1,149	60	20
	WITS	540	60	9
	Southgate	1,031	60	18
	Northgate	664	60	12
	Brightwater Commons	524	60	9
	Marks Park	1,550	60	26
	Montecasino	195	60	4
	Megawatt Park	383	60	7
	Innesfree Park	1,370	60	23
Regular Public Busses	Midrand & Tshwane	3,109	50	63
	Alexandra	1,327	50	27
	Central JHB	2,785	50	56
	Northcliff	1,367	50	28
	West (Northgate Area)	1,341	50	27
	Fourways	1,173	50	24
	Sandton	3,666	50	74
	Sandton	1,833	50	37
	Rosebank	1,833	50	37
Total		**25,840**		**501**

5. DISCUSSION

5.1 Key Findings

The outcome of the design is that CoJ should set up P'nR facilities in the following locations:

- Bezuidenhout Park
- WITS University
- Southgate
- Northgate
- Brightwater Commons
- Marks Park
- Montecasino
- Megawatt Park
- Innesfree Park

All of these facilities were proposed in High Level 2010 World Cup Transport Plan with the exception Megawatt Park and Innesfree Park. Figure 2 shows a graph of the total capacity of the various P'nR facilities in terms of the total number cars that it can hold as well as the number of cars expected at each venue.

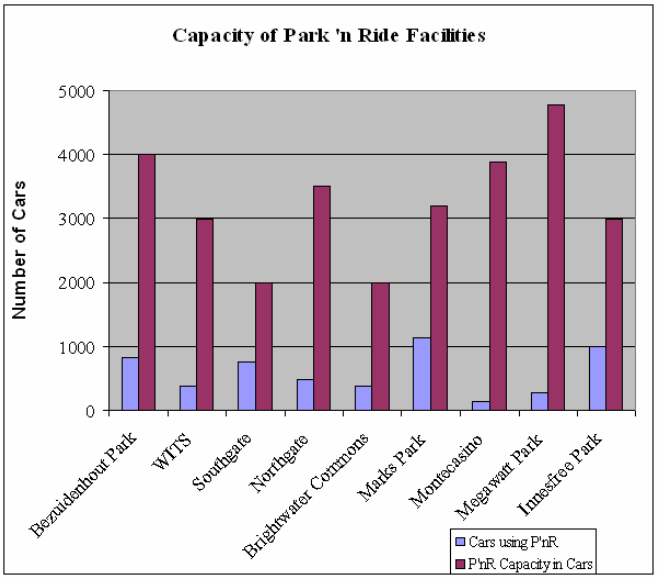

Figure 2: Capacity of Park 'n Ride Facilities

The graph shows that less than 50 % of the carrying capacity is used at all the facilities. The extent of this surplus should not be overestimated as often up to 30 % of available parking is taken up by busses and security at a P'nR facility [Bruce, 2006]. Some of the P'nR sites are not even reaching 20 % of their capacity. Although having more P'nR facilities than necessary is beneficial as it disperses the traffic on the way to these facilities, it is very expensive to set up and man them. Therefore, CoJ should consider combining a number of facilities. This should not be done until the simulations have been run to verify that this will not adversely affect the traffic.

The major obstacle with combining facilities is that it would require some people to travel more than 7 km to a P'nR facility. Following the results of a questionnaire [Sher, 2006], this assumption has been shown to be too restrictive as more than 60 % of the people interviewed were prepared to travel at least 10 km to the nearest Park 'n Ride Facility.

Further investigation is required into the combination of the following P'nR facilities as the number of expected cars may not be able to justify an efficient service from both facilities: Marks Park and WITS as well as Montecasino and Megawatt Park.

It should also be assessed how much parking will be required and cordon off the rest of the parking. Some shopping centres may prefer cordoning off an area for the WC P'nR and leaving the rest of the area open for regular shopping. Alternatively, different sections of the same P'nR facility can be used for match venue and fan festival transport. In general, this is not advisable as this may cause congestion and confusion.

5.2 Answers to Key Research Questions

Though not explicitly asked, the underlying question is: *Are people willing to make use of P'nR facilities?* In performing the survey, it was discovered that the majority of people who filled in the questionnaire after listening to the presentation, indicated that they would be willing to make use of P'nR facilities. Therefore, the answer to the underlying question is an emphatic yes - people only need limited convincing.
The answer to the posed research question is that it appears that nine P'nR facilities are needed throughout JHB to solve the problem. The specified design appears to be considered a success as it results in minimum congestion and promotes the use of public transport on a public transport orientated network. This allows for spectators to arrive at the match venue within the requisite time period. However, verification through simulation and analysis still needs to be performed.

5.3 Recommendation for further research

Once the simulation has been run and analysed, one can continue the research by devising other scenarios:

- Creating accurate PM peak traffic data
- Designing detailed layouts of each P'nR facility and the drop-off points at Soccer City
- Finding the optimum number of exhibition sites and the impact of their traffic on the road network
- Modelling effect of spectator traffic to training venues on the traffic
- Quantifying the effects of an accident on the N-S SPTN route and proposing emergency plans to the relevant parties

5.4 Cautionary note

In order to ensure that at least 80 % of match ticket holder from the Northern Suburbs make use of the P'nR facilities, it is imperative that an aggressive advertising campaign informing local residents of the advantages of P'n R is embarked upon. This campaign educating about required transport habit changes during the WC should begin well in advance.

6. CONCLUSION

This study used GIS tools and a traffic simulation tool to conclude that that the original plan proposed by CoJ for WC 2010 P'nR facilities is inadequate as it does not cater for the key area of Midrand and Sandton. It is suggested to add one or two P'nR facilities in the area and possibly amalgamate other facilities which are underutilised. This hypothesis requires verification through simulation before the recommendations can be finalised.

It is planned to re-run this student project in 2007 using a more up-to-date traffic simulator on the same City of Joburg data.

7. ACKNOWLEDGEMENT

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8. REFERENCES

[1] LD Beer, June 2005. "High Level 2010 FIFA World Cup Transport Plan", Axios Consulting Arcus Gibb, Working Draft,

[2] 2010 Bid Document, 2003. www.aveng.co.za/presentations/SAWorldCupSoccer2010.pdf, last accessed 16 July 2006

[3] C. Bruce, 2006. Personal Communication

[4] Online TDM Encyclopedia – Measuring Transportation, Victoria Transport Policy Institute, http://www.vtpi.org/tdm/tdm12.htm, last accessed 14 July 2006

[5] World Bank, http://www.worldbank.org/transport/learning/presentations/Results%20Measurement/roberts3_0503Headline%20indicators.pdf, last accessed 14 July 2006

[6] SA National Household Travel Survey, 2001. www.co.tompkins.ny.us/planning/Powerpoint/NHTS%202001_final.ppt, Last accessed 6 October 2006

[7] City of Joburg, "Integrated Transport Plan 2003/2008", Volume 1, May 2003

[8] D. Van der Walt, "SARCC Investment Plan World Cup 2010 – Gauteng", SARCC, July 2006

[9] City of Joburg, "2004/5 Annual Report: Annual Performance Reports", May 2005

[10] Wikipedia – Park 'n Ride, http://en.wikipedia.org/_wiki/Park_%27n%27_Ride, last accessed 18 October 2006

[11] W. E. Sher , W M Schay, Nov 2006. "Appendix A: Geographic Information Systems & ArcGIS", 4th Year Project Final Report 06P28, School of Electrical and Information Engineering, University of the Witwatersrand, South Africa

[12] B. Msiya, 2006. Personal Communication

[13] J Scheepers, "High Level 2010 FIFA World Cup Transport Plan for Ruimsig, Rand and Orlando Stadium Training Venues", Karabo Consulting (Pty) Ltd, Draft Copy, June 2006

[14] EMME/2 User Manual, INRO Consultants, 14 October 1999, Chapter 1

[15] R. Van Olst, 2006. Personal Communication

[16] G. Katz, 2006. Personal Communication

[17] W. E. Sher, Nov 2006. "Appendix D: Results of Open Day Questionnaire", 4th Year Project Final Report 06P28. Wits University.