TURBO ROUNDABOUTS AS AN ALTERNATIVE TO TWO LANE ROUNDABOUTS

J.C. Engelsman and M. Uken

SSI, PO Box 1066, Pietermaritzburg, 3200, 033-8461000

ABSTRACT

The turbo roundabout is an innovative arrangement of the two lane roundabout that has revolutionised roundabout design in The Netherlands since 1998. Entering and exiting the previously applied two lane roundabout can be complicated for road users, which consequently leads to road safety problems. The turbo roundabout concept eliminates some of the most severe conflict points on the roundabout. A quick-scan evaluation model indicates that the capacity of the turbo roundabout is about 25 – 35% higher than a standard two lane roundabout.

The introduction of the turbo roundabout in South Africa can have a massive impact on the road safety situation in the country. The turbo roundabout is an ideal intersection solution for road accident hotspots. In addition, as South Africa is experiencing unprecedented traffic growth in the urban areas, the turbo roundabout could offer significant efficiency improvements to the transportation networks.

1. INTRODUCTION

The turbo roundabout is a specific kind of spiralling roundabout that was developed in The Netherlands by Mr. L.G.H. Fortuijn, a lecturer at the Delft University of Technology and member of the Board of Economy and Transport in the province of South Holland. Since the introduction of the turbo roundabout in the late 1990's, standard two lane roundabouts are no longer being realised in The Netherlands. The basic layout of a turbo roundabout is shown in figure 1.

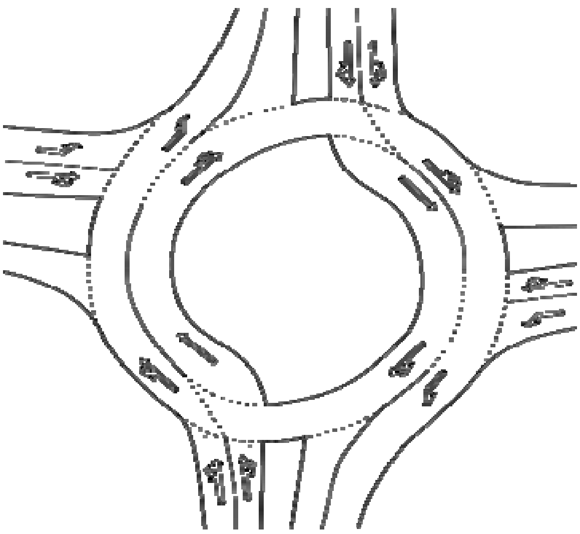


Figure 1: Typical lay out of a turbo roundabout

Proceedings of the 26th Southern African Transport Conference (SATC 2007) 9 - 12 July 2007
ISBN Number: 1-920-01702-X Pretoria, South Africa
Produced by: Document Transformation Technologies cc Conference organised by: Conference Planners

The turbo roundabout was primarily developed to deal with the entering and exiting conflicts that occur on two lane roundabouts of the type that is frequently in use in South Africa. The problems associated with two lane roundabouts are discussed in **Section 2** of this paper.

The entering and exiting conflicts are eliminated by directing motorists to the correct lanes before entering the roundabout and introducing spiral lines that guide motorists to the correct exit. The layout of a turbo roundabout can easily be adjusted to local traffic conditions. The elements of a turbo roundabout and alternative layout possibilities are discussed in **Section 3** of this paper.

The spiral lines reduce the number of conflict points from 16 on a standard two lane roundabout to 10 on a turbo roundabout. Besides the obvious road safety benefits, this also enhances the capacity of the roundabout. The evaluation of turbo roundabouts is discussed in **Section 4** of this paper, although, surprisingly little evaluation data is presently available.

Figure 2: Turbo roundabouts in The Netherlands

In this paper all the pictures showing traffic situations in The Netherlands, where traffic travels on the right-hand side of the road, have been mirrored to make them better understandable for traffic and transportation engineers in South Africa. Figure 2 shows two examples of turbo roundabouts in The Netherlands.

2. NEED FOR ADVANCED ROUNDABOUT DESIGN

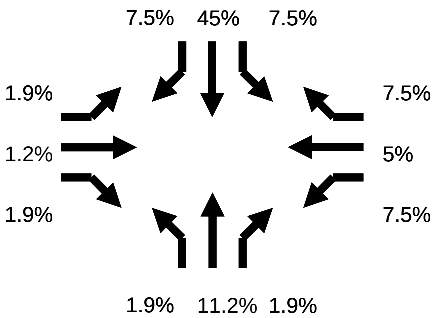
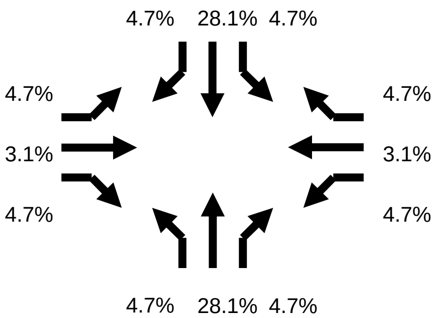
<u>2.1 Capacity of one and two lane roundabouts</u>

In general a roundabout is a very safe and efficient way to organise a traffic intersection. Delays are very low as long as the roundabout is not operating at or near capacity. Besides the geometric design, the capacity of roundabout depends on the balance of traffic volumes on the approaches, mainly the volumes on the conflicting flow.

Very little evaluation data is presently available about two-lane roundabouts. Even in the USA few two-lane high-capacity roundabouts exist to be analysed. Even fewer of those are operating at or near capacity (Stanek and Milam, 2004). For the purpose of this paper a quick-scan model developed by the Province of South Holland in The Netherlands (called the *Meerstrooksrotondeverkenner*) is used to compare the capacity of different kinds of roundabouts. This strategic macro model roughly indicates the capacity of alternative forms of roundabouts (Fortuijn and Carton, 2000). Besides one and two lane roundabouts, several kinds of spiralling roundabouts can be evaluated.

The quick-scan model shows that the capacity of a two lane roundabout is about 40% to 50% higher than the capacity of a one lane roundabout, depending on the balance of the traffic volumes on the approaches. The evaluation results for two situations with different balances of traffic volumes on the approaches are shown in table 1. These results are also dependent on the design of the roundabouts and on the driver behaviour factors used in the quick-scan model. For that reason, the results should mainly be interpreted as a comparison between the one and two lane roundabout and not as absolute conclusions about the capacity of the two roundabout options.

Table 1: Maximum entry capacity of standard one and two lane roundabouts*

Balance of traffic volumes on the approaches	Approximate maximum entry capacity** (in private car equivalents per hour)	
	One lane roundabout	Two lane roundabout
	1600	2300
	2150	3200

* Evaluation results of a quick-scan model developed by the Province of South Holland in The Netherlands (*Meerstrooksrotondeverkenner*)

** Maximum entry capacity is defined as the volumes corresponding with a v/c factor of 0.80 on the critical turn. The maximum entry capacity also depends on the geometric design of the roundabout.

2.2 Weaving and exiting conflicts on two lane roundabouts

The entering and exiting a two lane roundabout involves several conflict points. Entering requires giving way to traffic in the roundabout. In most situations this implies giving way to traffic on both lanes in the roundabout. Exiting the roundabout is complicated from the inner lane of the roundabout. One can either leave the roundabout directly from the inner lane or weave to the outer lane and subsequently leave the roundabout. In the first situation a so called exiting conflict can occur, as shown in figure 3. In the latter situation a so called weaving conflict can occur, as shown in figure 4.

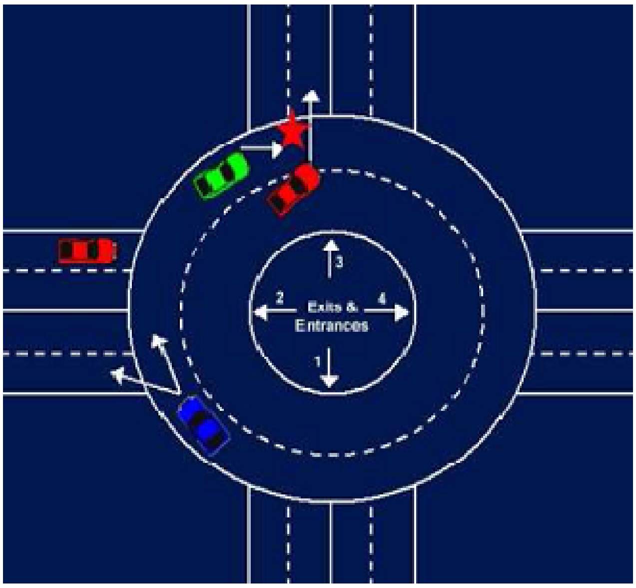


Figure 3: typical exiting conflict on a two lane roundabout

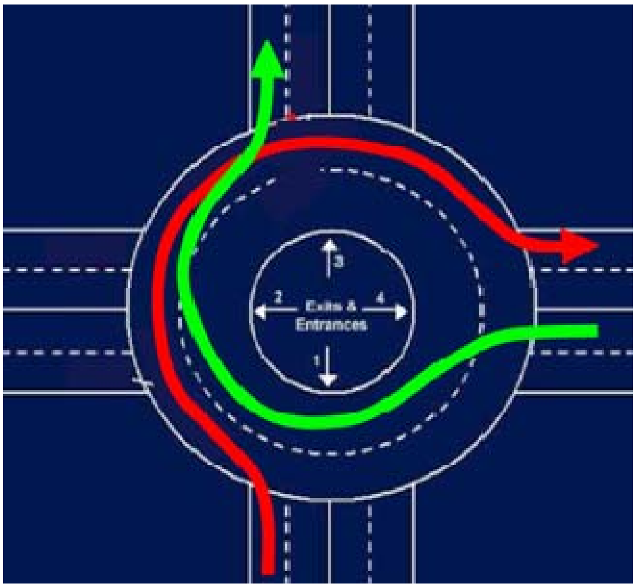


Figure 4: typical weaving conflict on a two lane roundabout

In The Netherlands practice has shown that not all road users appreciate the entering and exiting conflicts on two lane roundabouts (Fortuijn and Carton, 2000). The conflicts cause accidents and also lead to a less efficient flow of traffic. The latter is the result of both hesitant drivers on the inner lane as well as a relatively high number of drivers that only uses the outer lane. Because of entering and exiting conflicts at two-lane roundabouts, these roundabouts are no longer built in Germany, only single-lane roundabouts are constructed.

The situation in South Africa seems to be very similar, as unsafe traffic situations regularly occur on two lane roundabouts and the flow of traffic is often far from optimal.

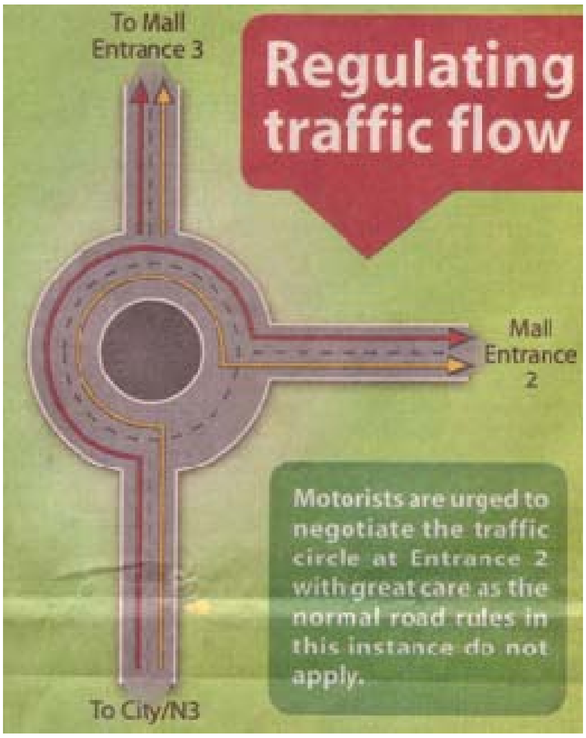


Figure 5: Publication concerning a roundabout in Pietermaritzburg (Natal Witness)

Figure 5 shows an example of confusion about the correct way to navigate through a two lane roundabout. The illustration was printed in the Natal Witness on 26 September 2006 after an interview with the manager of the Liberty Midlands Mall in Pietermaritzburg concerning the accessibility problems of the mall. In the accompanying text it was explained that, although turning right from the left entry lane is normally not allowed, an exception is being made for this roundabout. As the considered roundabout is part of the public road outside the mall premises, the 'normal' road rules would obviously apply.

3. THE TURBO ROUNDABOUT

3.1 Essential elements

The most important element of the turbo roundabout is the spiral lane marking to eliminate the necessity of weaving. This results in both an increase in road safety as well as an increase in the capacity of the roundabout. The turbo roundabout does not have two lanes throughout the whole roundabout, but only over the sections where two lanes are required. At least one of the exits should have two lanes, but in certain instances it may be necessary for all exits.

Figure 6 shows the layout of a typical turbo roundabout, including some access road variations. In this example the traffic from left to right (and back) is obviously the main traffic direction. The size of a turbo roundabout is in general comparable with the size of a standard two lane roundabout. The diameter of the roundabout is about 50 metres. Similar to standard roundabouts, traffic in a turbo roundabout has right of way.

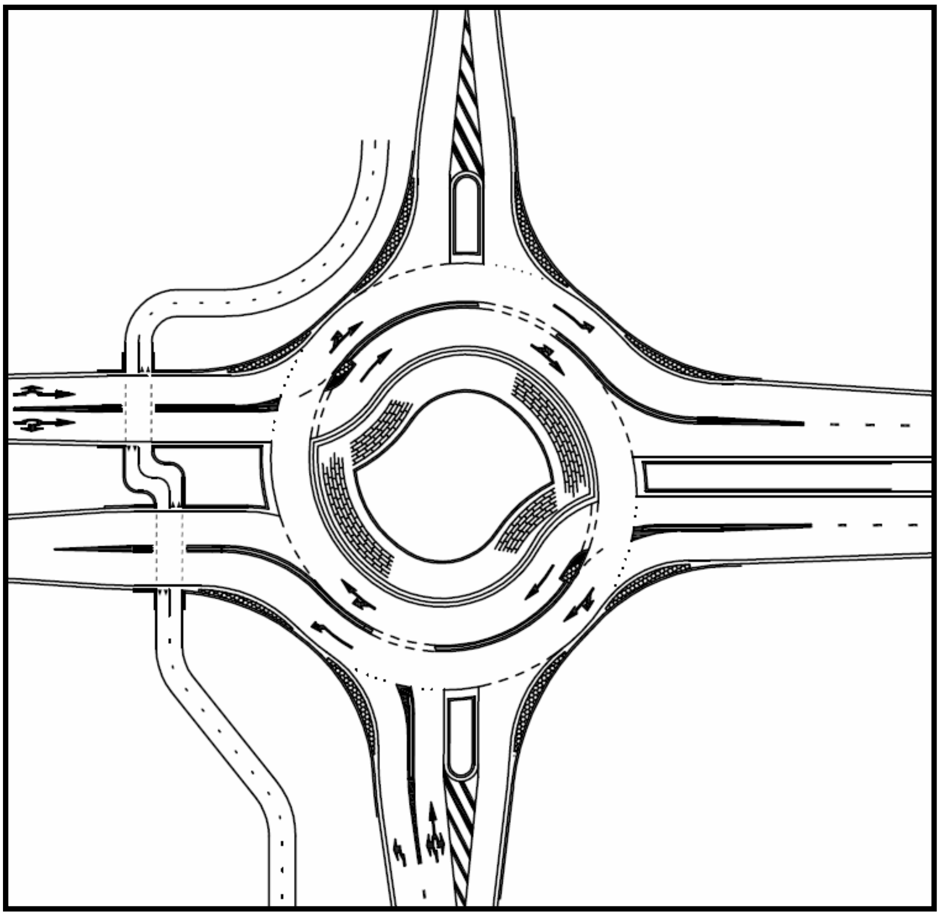


Figure 6: Layout of a typical turbo roundabout with different access road configurations

A typical turbo roundabout as shown in figure 6 reduces the number of potential conflict points from 16 to 10 (Fortuijn and Carton, 2000). This is mainly the result of the elimination of the weaving conflicts (reduction of 4 conflicts) in the roundabout. A further benefit is that traffic in the main direction only has to consider one lane before entering the roundabout (reduction of 2 conflicts).

Since weaving in the roundabout is no longer necessary, the delineator between the lanes can be slightly elevated (Fortuijn, 2003). Such a mountable lane divider induces traffic the traffic to keep its own lane, and this helps to prevent sideswipe collisions that can occur not only upon entering the roundabout, but also when exiting it. Heavy and oversized vehicles can traverse the lane dividers if necessary, as it is shown for the truck in figure 7.

Figure 7: Truck traversing elevated lane divider

As a result of the lane dividers, drivers will need to choose the correct lane before they enter the roundabout. Drivers should be assisted by clear signposting and lane marking. A special form of arrow marking has been developed for roundabouts, which makes for clearer lane selection (Fortuijn, 2003). An example of these lane markings is shown in figure 8. Similar lane markings have been used in the USA for some years.

Figure 8: Arrow lane markings especially developed for roundabouts

3.2 A variety of options

The turbo roundabout was primarily developed for situations that are typical of provincial roads, i.e. a major regional access road with heavy traffic volumes and intersecting roads with a lower volume of traffic. Subsequently different versions of the turbo roundabout were developed for specific combinations of traffic volumes. If the main traffic flow does not cross the roundabout but turns left or right, a so called ‘knee’ roundabout is the most suitable solution. This roundabout could very well be applied opposite the Liberty Midlands Mall in Pietermaritzburg, as shown in figure 5 above. An example of a knee roundabout is given in figure 9.

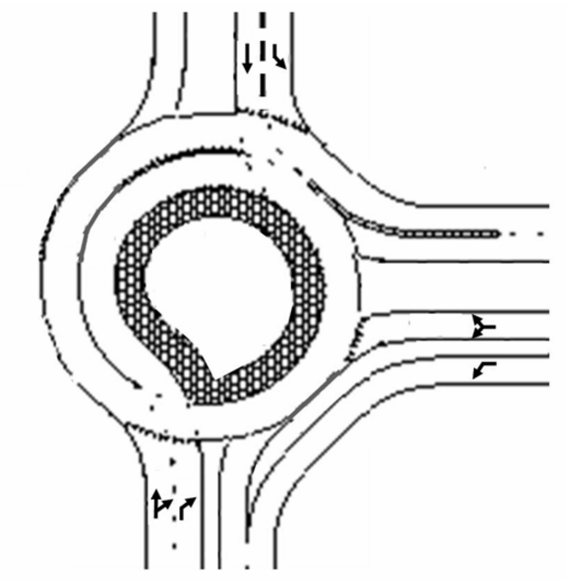


Figure 9: Knee roundabout

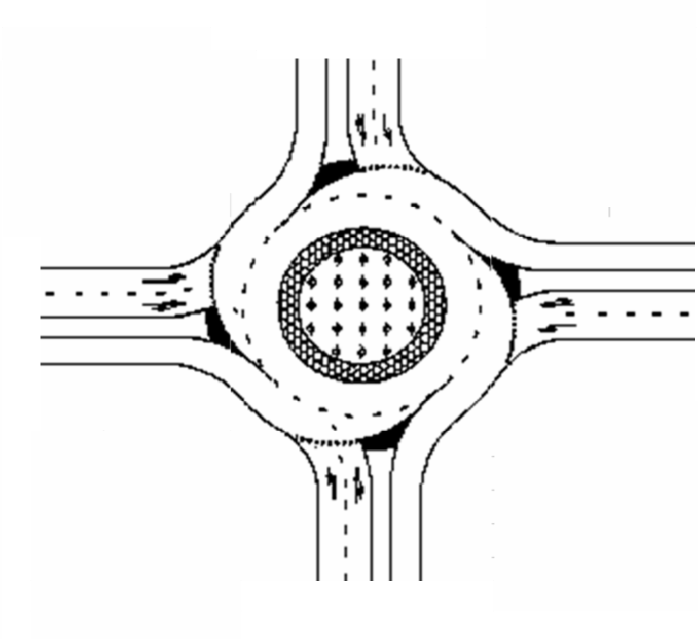


Figure 10: Spiral roundabout

A ‘spiral’ roundabout as shown in figure 10 would be appropriate in situations where all access roads have more or less the same traffic volumes. The same applies for the ‘rotor’ roundabout as shown in figure 11, but for higher volumes. These are just a few examples of the different turbo roundabout options.

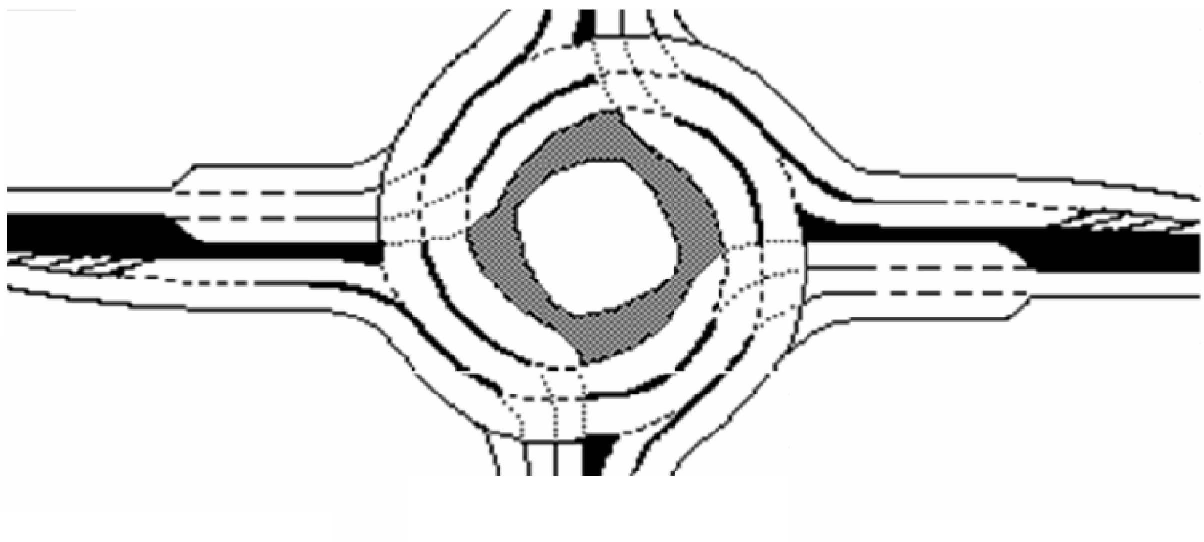


Figure 11: Rotor roundabout

4. EVALUATION OF TURBO ROUNDABOUTS

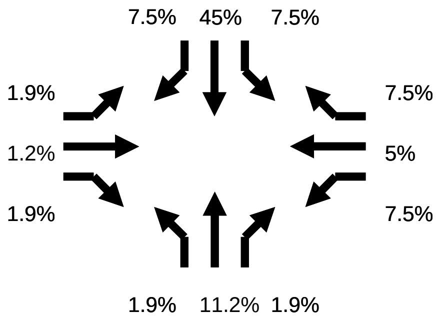
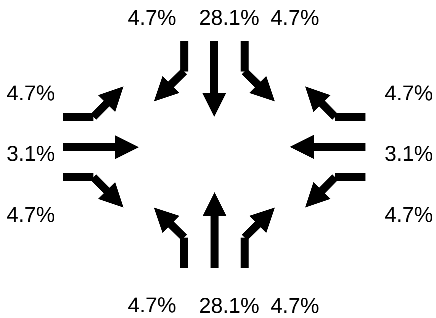
4.1 Capacity effects

Practical evaluation data is presently not available for turbo roundabouts, because only in The Netherlands a number of turbo roundabouts have been realised and very few of those are operating on or near capacity. For the purpose of this paper the quick-scan model, as it is introduced in section 2 of the paper, is used to compare the capacity of a turbo roundabout with a two lane roundabout. A variety of roundabout options can be evaluated in the model, including the turbo roundabout as shown in figure 6 and some variations as shown in figures 9, 10 and 11.

The quick-scan model shows that the capacity of a turbo roundabout is about 25% to 35% higher than the capacity of a two lane roundabout, depending on the balance of the traffic volumes on the approaches. The main reason for the higher capacity of the turbo roundabout is the reduction of conflict points for traffic entering and exiting the roundabout (Fortuijn and Carton, 2000).

The evaluation results for two situations with different balances of traffic volumes on the approaches are shown in table 2. These results are also dependent on the design of the roundabouts and on the driver behaviour factors used in the quick-scan model. For that reason, the results should mainly be interpreted as a comparison between the turbo and the two lane roundabout and not as absolute conclusions about the capacity of the two roundabout options.

Table 2: Maximum entry capacity of two lane roundabouts and turbo roundabouts*

Balance of traffic volumes on the approaches	Approximate maximum entry capacity** (in private car equivalents per hour)	
	Two lane roundabout	Turbo roundabout
	2300	3050
	3200	4050

* Evaluation results quick-scan model developed by the Province of South Holland in The Netherlands (*Meerstrooksrotondeverkenner*)

** Maximum entry capacity is defined as the volumes corresponding with a v/c factor of 0.80 on the critical turn. The maximum entry capacity also depends on the geometric design of the roundabout.

4.3 Road safety effects

On a turbo roundabout there are 10 conflict points for car traffic, while on a two lane roundabout with concentric lines there are 16 (as discussed in section 3). This represents 60% more conflict points, including four weaving conflicts and two exiting conflicts, which amount to a higher accident risk profile for the two lane roundabout (Fortuijn and Carton, 2000). The turbo roundabout is therefore a significantly safer option. Unfortunately, currently very little quantitative road safety data is available for accurate comparison of the two options.

Importantly, research from The Netherlands *does* make a comparison between turbo roundabouts and traffic lights or yield intersections. It shows that a 70% reduction of accidents resulting in serious injuries can be expected when introducing a turbo roundabout at such an intersection (Fortuijn, 2005). The same applies to the introduction of a one lane roundabout, but obviously this would result in a lower intersection capacity.

5. CONCLUSIONS

The introduction of the turbo roundabout concept in South Africa could have a major impact on the road safety situation in the country. While standard two lane roundabouts inherently have some crucial disadvantages, the turbo roundabout has solved these disadvantages and can be an ideal solution for many road accident hotspots.

Research from The Netherlands shows that the number of accidents resulting in serious injuries could drop by 70% where signalised and yield intersections are replaced with roundabouts. Because the capacity of a turbo roundabout is significantly higher than the capacity of a one or two lane roundabout, the opportunities to implement them are more extensive.

South Africa is experiencing unprecedented traffic growth in the urban areas and innovative solutions are needed to improve the efficiency of the transportation networks. As long as the total traffic volumes approaching an intersection do not exceed 3000 to 3500 vehicles per hour (depending on the balance of traffic volumes on the approaches), a turbo roundabout could offer significant efficiency improvements compared to one lane roundabouts, two lane roundabouts, traffic lights or yield intersections. However, more research would be desirable to show the benefits of the turbo roundabout concept for specific traffic situations.

Although road users would have to get used to the new roundabout design, there does not seem to be any serious obstacle to the introduction of the turbo roundabout in the South African situation. Initial investment requirements for road authorities may be compensated for by lower maintenance costs, energy consumption and road accident costs.

6. REFERENCES

[1] Fortuijn, LGH and Carton, PJ, 2000, Turbo Circuits: A Well-tried Concept in a New Guise, Province of South Holland, The Netherlands

[2] Fortuijn, LGH, 2003, Pedestrian and Bicycle-Friendly Roundabouts; Dilemma of Comfort and Safety, Delft University of Technology, The Netherlands

[3] Fortuijn, LGH, 2005, Veiligheidseffect turborotondes in vergelijking met enkelstrooksrotondes, Province of South Holland, The Netherlands

[4] Stanek, D and Milam, RT, 2004. High-capacity roundabout intersection analysis: going around in circles