USER BEHAVIOUR AT A FOUR WAY STOP

C. Liebenberg and M Sinclair

Department of Civil Engineering, Stellenbosch University, Private Bag X1, Matieland, 7602. ph 021 8083838; Email Author 1: 15114767@sun.ac.za
Email Author 2: msinclair@sun.ac.za

ABSTRACT

This study examines the behaviour of vehicles at a four way stop in close proximity to the University, along one of the principal roads through the town of Stellenbosch. Four way stops are simple concepts founded on relatively simple rules of engagement. However a series of observations conducted in 2010 evidenced significant levels of conflict between vehicles, and between vehicles and other road users. The study identified a high level of contravention of the yielding rules associated with a four way stop configuration, suggesting either that drivers are unaware of the yielding convention or are operating wilfully. The behaviour of pedestrians and cyclists was also examined but has been omitted from this paper because of space constraints.

1 INTRODUCTION

Four way stops are fairly common forms of junction control in South Africa. The advantages of this type of junction are that they reduce the speed of vehicles which is thought to enhance safety (*Elvik et al ,2009*). They also ensure equal opportunity for users from all directions. For them to work successfully and safely, it is imperative that all users understand the user protocols which are based exclusively on the democratic principle that the first vehicle to the line has right of way. In addition, safe passage requires clear visibility for all vehicles, consideration for other road users (such as pedestrians) and a high level of driver obedience. If any of those elements are jeopardised then the potential for conflict – and collision – occurs. International experience of stop street junctions, and four way stops in particular, show that motor-vehicle collisions at such intersections are a considerable source of injuries and property damage (*Retting et al, 2003*). Using the conflict studies technique developed by Swedish experts in the 1990s, the project set out to determine the patterns of vehicle behaviour at this junction and to investigate whether the requirements for safe passage were met.

Road safety in South Africa has long been a concern among traffic engineers and transportation planners. The country has an extremely high traffic fatality rate; almost double the international average and higher even than the average for the African continent (World Health Organisation, 2009). Around 39% of fatalities in South African annually are pedestrians (Road Traffic Management Corporation, 2009) and so environments which incorporate high levels of pedestrian-vehicular interaction are of particular concern. The research project offered an opportunity to examine not only the possible engagements between vehicles at a four way stop but also an opportunity to examine patterns of engagement that may be evident between different types of users in this particular junction configuration.

Proceedings of the 30th Southern African Transport Conference (SATC 2011) 11 - 14 July 2011
Proceedings ISBN Number: 978-1-920017-51-4 Pretoria, South Africa
Produced by: Document Transformation Technologies cc Conference organised by: Conference Planners

Merriman is a major road that runs from the north to the south of the town. In contrast, the minor Bosman road is essentially a linking road within the local University area. Merriman road is used daily by people living in the northern suburbs of Stellenbosch or in towns to the north and who work in other parts of town or out of town. Bosman road is mainly used by students and lecturers to travel from the one side of campus to the other. This junction is not just an intersection between two roads but is a dynamic crossing environment which serves a wide variety of users, from cars, buses, trucks and taxis to high concentrations of non-motorised transportation types, particularly pedestrians but also cyclists.

Traffic volume data obtained from Stellenbosch municipality indicated that the peak traffic flows occurred between 07:45 and 09:00, and again between 16:45 and 18:00. An average of 1,383 vehicles per hour moved through this junction during the morning peak, and 1,639 crossed per hour during the afternoon peak. Queue lengths along Merriman peaked at 13 vehicles in both morning and evening peaks, with 6 vehicles in the queue along Bosman during the same periods.

Average pedestrian numbers were 1, 601 per hour during the morning peak and 452 per hour during the evening peak.

As the pedestrian numbers show, the junction carries a very high number of students from the residential areas and student housing to the west of the camps into the central area. This is the only four way stop in the area which carries this volume of pedestrians, and so represents an interesting opportunity to examine not only vehicle-vehicle behaviour but also the interaction between pedestrians, cyclists and vehicles at this location.

2 COLLISION DATA

Collision data for the Merriman and Bosman roads junction was obtained from the regional traffic department .The data captured was from 2005 until June 2010. Sixty four collisions were reported at this junction during the five years. The collision data was analysed under the following categories: date; day of week; time; number of participants involved; driver age; driver gender; the severity of injury and type of vehicle. Events precipitating each collision were poorly recorded, if at all, and unfortunately a causation analysis could not be carried out. This was particularly unfortunate as it meant that subsequent correlation with observed behaviours was not possible. The lack of causation information on collision reporting forms has long been recognised to be a problem with collision reporting across South Africa.

A summary of the key features of the collision database follows.

2.1 Collisions by vehicle type

The relative breakdown of vehicle type for this junction was calculated to be 96% motor cars; 0.2% buses; 3.2% bakkies, LDVs and taxis. Heavy goods vehicles constituted 0.9% of traffic, motorbikes less than 0.1% and bicycles 0.1%. As indicated in Figure 1, the vast majority of collisions – 81% - involved a motor car, followed by collisions involving light delivery vehicles (‘bakkie/truck’) and taxis at 13% percent. Motor cycles were involved in 1% of the collisions, and bicycles were involved in 3% of the collisions. In other words, LDVs/bakkies and taxis, motorbikes and bicycles were overrepresented in collisions.

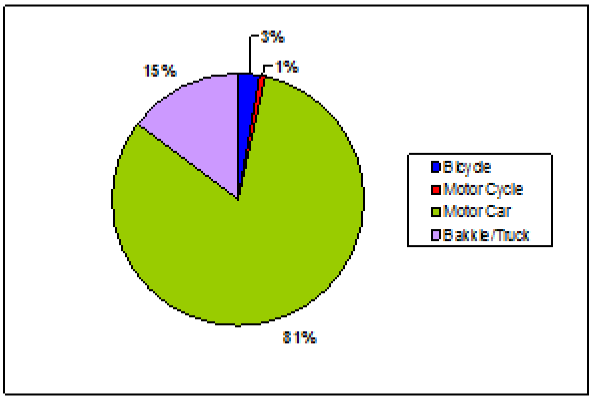

Figure 1. Collisions by vehicle type

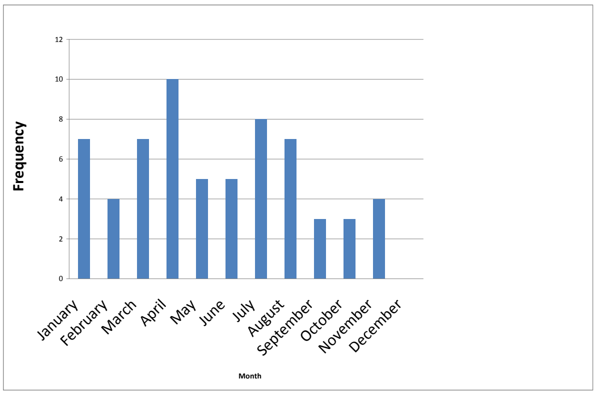

Figure 2. Cumulative collisions by month

The sixty-four collisions resulted in eighty-eight injuries, eight percent of which (7 in total) were recorded as ‘serious’. No detail of the nature of the injuries sustained was recorded on the police forms. Of these serious injury records, seven motor cars and two bicycles had been involved.

2.2 Collisions by month for 2005-2010

As can be seen in Figure 2 the month of December had no recorded collisions, while the highest number of collisions occurred during the month of April. The fluctuation of collisions roughly follows the student working calendar; e.g. when students are more likely to be present. December is a month when most of the students and local residents are on summer vacation. This would contribute to the junction being less congested and the driving environment consequentially being less complex. No conclusions could be drawn to why the month of April had so many collisions, apart from the fact that a number of public holidays occur in April which may affect traffic volumes. Stellenbosch falls within a winter rainfall region. During July and August the number of collisions was relatively high.

2.3 Cumulative collisions by day of week for 2005-2010

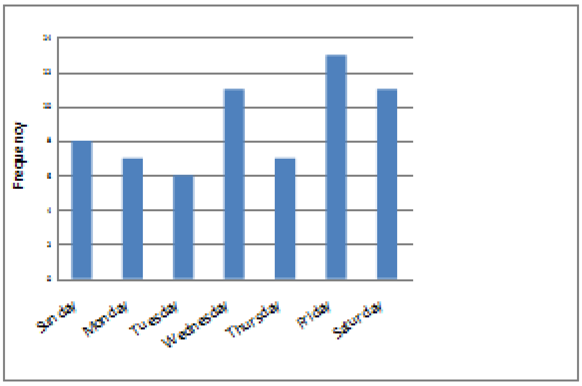

Figure 3: Collisions by day of week

Figure 3 indicates that the frequency of collisions increases notably over the weekend and also reflects a Wednesday peak, with a lowest incidence on a Tuesday.

Both weekend evenings and Wednesdays are associated with students socialising and the consumption of alcohol. These may well be factors in this collision pattern.

2.4 Cumulative collision times for 2005 - 2010

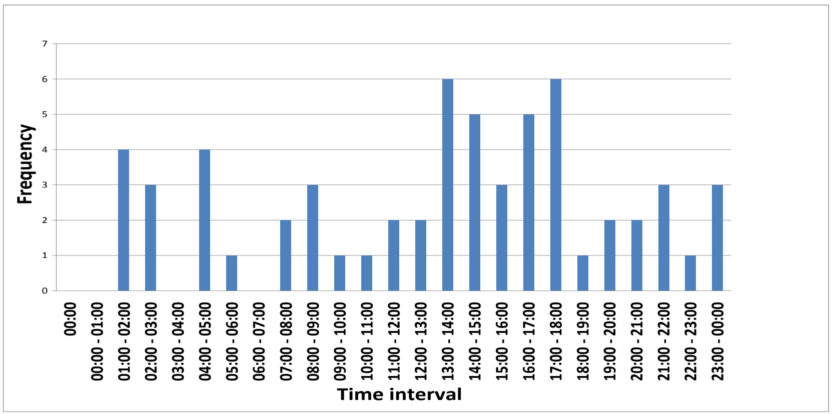

Figure 4. Cumulative collision times

As mentioned previously, the Merriman and Bosman roads junction is situated at the heart of a student campus and dominated by student activities at night. During peak volume periods the frequency of collisions tends to increase. This could be the result of the increase in the volume of information that needs to be processed in a short time by the first user at the stop line.

2.5 Cumulative collisions by age of driver

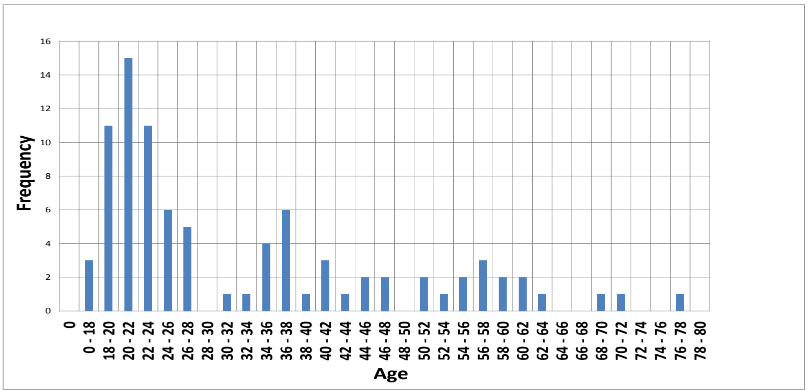

Figure 5: Cumulative collisions by age of driver

Figure 5 is an example of a statistical graph that is skewed to the left, i.e. to younger drivers. It clearly illustrates that young drivers are disproportionately involved in collisions at this particular junction. It must be noted that this junction is situated at the heart of a student campus and is not necessarily a true reflection of normal situations on roads in South Africa. That said, however, the observation of traffic identified a balanced mix of young and middle aged drivers using this junction through the day (with a significantly lower incidence of elderly drivers). The relative high proportion of young drivers in the collision database thus does potentially reflect a higher collision risk amongst this group.

3 RESEARCH METHODOLOGY

Observation of the junction was carried out to identify patterns in road user behaviour, looking at how vehicles behave, at how drivers interact with each other and at the potential conflicts that arise from the interaction around yielding decisions at the junction. Observation took place at strategic and specific times of the day and week when traffic volume was at a peak, and/or when casualty records indicated an elevated risk of collisions. In all, 26 hours of observation were carried out.

An ‘event’ was defined as the improper use of the junction or a near conflict that was caused by user error. A total of 943 events were noted. For each record, fifteen categories of information were recorded, including information about the vehicle, the driver, the vehicle occupancy, the dominant manoeuvre of the vehicle and the behaviour of each vehicle approaching, and arriving at, the stop line.

4 RESULTS

Twenty-three (2.5%) of the 943 events recorded were categorised as ‘close conflicts’, representing near miss situations which very nearly resulted in a collision. Twenty-two percent of these involved a close conflict between a motorist and a pedestrian. 43% of these close conflicts involved an out of sequence manoeuvre, and a further 43% were associated with a turning vehicle. The breakdown of all events by type is details below.

4.1 Types of events

The observation enabled the identification of six distinct types of events, all of which had the potential to generate conflict and cause possible collisions. The events fell into two categories; events that arose from **driver misbehaviour** (Distraction; Aggression; Not stopping; Out-of-sequence events), or events that were the consequence of **driver caution** (Holding back; Visual obstruction). The incidence of the six types of events is illustrated in Figure 6 below:

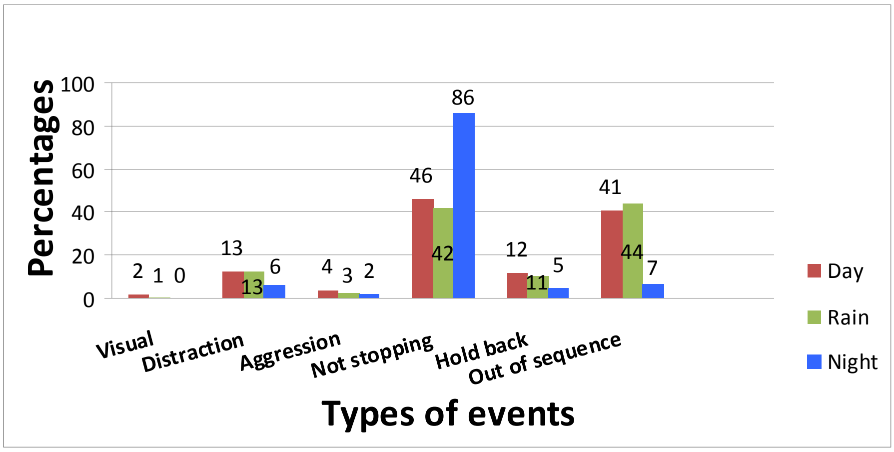

Figure 6: Events – all causes

4.1.1 Not stopping. The most common type of event was not stopping at the stop line. Not stopping was particularly common at night, and increased in likelihood with the lateness of the evening. Not stopping appeared to be directly related to weather – the frequency of not stopping decreased sharply during rain or when the roads were wet. Figure 6 indicates the average incidence of not stopping during the day and night, and during wet conditions. There is significant variation across these different circumstances.

4.1.2 Out of sequence. The second highest reason for events was out of sequence events. Out of sequence events occurred when users proceeded through the junction before their turn, mostly as a consequence of driver impatience or drivers opportunistically taking advantage of the hesitation of other drivers. The frequency of this type of event remained the same during all weather conditions but decreased at night. This could possibly be because there are fewer vehicles at night and also fewer vehicles that are stopping at the same time at the junction. As a result, the probability of an out of sequence event is lower during this time.

4.1.3 Holding back. Holding back was the third highest reason for an event taking place. Holding back was defined as when the user was noticeably hesitating, which often led in turn to an out of sequence event.

4.1.4 Distraction. This was evidenced primarily in the use of cell phones but was also witnessed in the interactions between drivers and passengers. Distraction did not appear to be affected by time of day or weather – it was equally common at different observation times. It often gave way to out of sequence events, or to aggression (see below).

4.1.5 Aggression. Aggression by the driver was a fifth type of event, evidenced in the observation of rude gestures or angry retorts between drivers; in the aggressive acceleration of a vehicle as it waited in the queue of traffic, and in the general behaviour of the driver towards other vehicles and drivers in the queue. Twelve percent of the aggressive actions were observed to take place in vehicles that had experienced a fairly long delay in getting to the front of the queue.

4.1.6 Visual obstruction. The final and least common type of event was that associated with visual obstruction. This occurred when traffic sequence was interrupted because a vehicle was unable to see whether its way was clear, and so was forced to allow others to move out of sequence until visibility had been restored.

<u>4.2 Events by driver gender</u>

It is clear from Figure 7 that male drivers exhibited higher levels of aggression than female drivers. Indeed aggression as a category showed a distinct gender bias. Visual obstruction, on the other hand, was apparently gender-neutral, suggesting that gender did not play a significant role in how drivers responded to a visual obstruction. For the rest, males were significantly more likely to cause out of sequence events than females, and to fail to stop at the stop street. They were also more likely to hold back, which was unexpected given the high levels of aggression, and also to exhibit distraction.

<u>4.3. Events by driver age</u>

Figure 8 illustrates that young and middle-aged drivers shared responsibility for the events at a fairly balanced level. Elderly drivers were observed in the categories of ‘aggression’ (6%) and ‘out of sequence’ (7%) but otherwise the field was almost equally shared by the young and middle aged. This is probably a consequence of the demographic of the town, rather than a reflection of elder drivers in general.

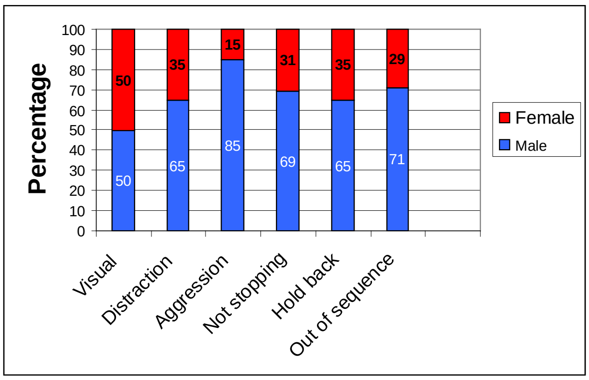

Figure 7: Events by driver gender

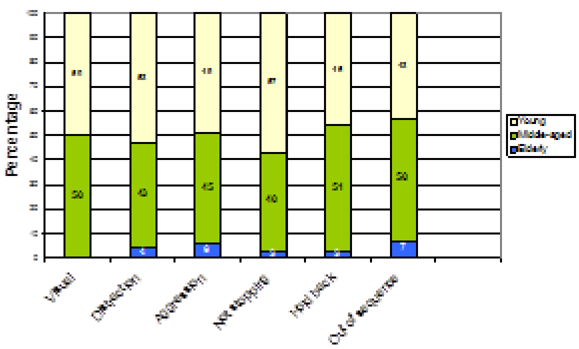

Figure 8: Events by driver age

Young drivers had a greater tendency not to stop than middle aged drivers, and middle aged drivers were most likely to move ahead into the junction when it was not their turn (‘out of sequence’). Young drivers showed a higher propensity for distraction than middle aged or elderly drivers, but displayed similar levels of aggression.

4.4 Events by vehicle type

It is clear from Figure 9 that the vehicle type responsible for triggering the majority of events was the motor car. Eighty three percent of all events caused by visual obstruction were cars. The bakkie/truck was the second highest vehicle type that triggered events – in this case mostly distraction events. Taxis exhibited a high level of aggression. Motorbikes did not trigger any distraction, visual events or aggression.

4.5 Events by vehicle occupancy

Figure 10 illustrates that drivers who were alone triggered more events, with the exception of visual events. This finding suggests strongly that solitary drivers are more prone to active disregard for traffic regulations and to negative behaviour than drivers accompanied by other people.

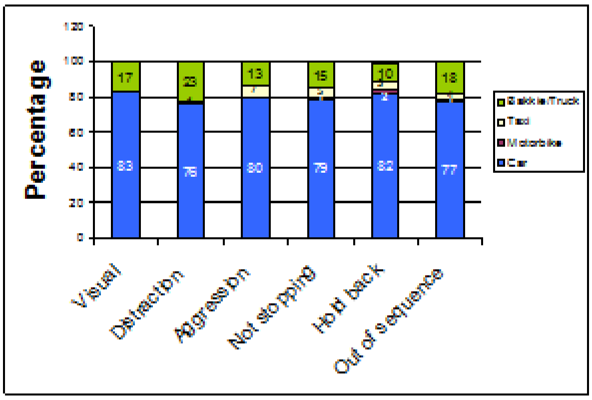

Figure 9: Events by vehicle type

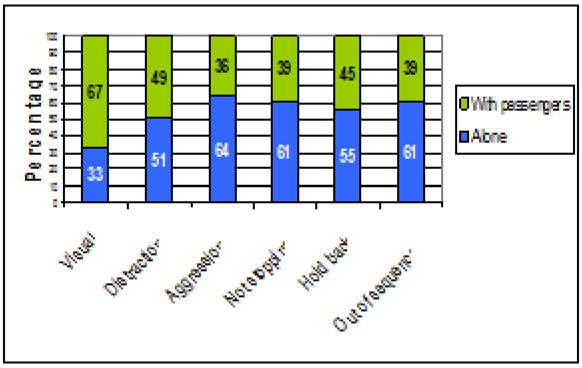

Figure 10: Events by vehicle occupancy

4.6 Events by time of day

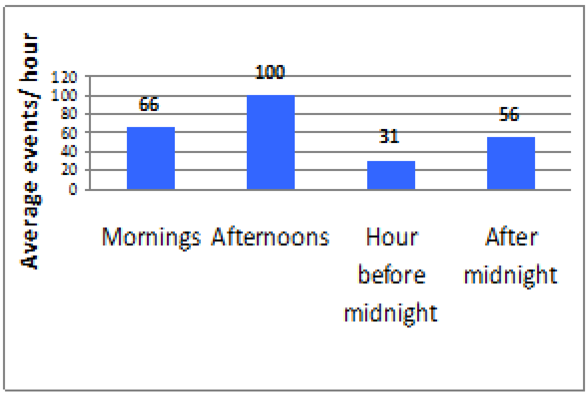

Figure 11. Events per hour recorded

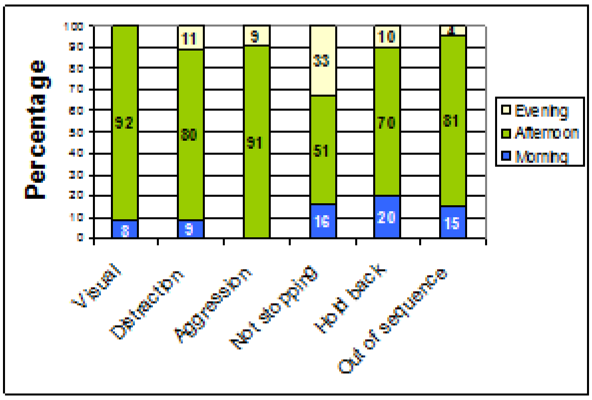

Figure 12. Type of events through day

As is evident from Figure 11, most events recorded were triggered during the afternoons. It is interesting to note from Figure 12 that aggression was particularly common during the afternoons, and that out of sequence events were also mostly triggered during these times. A high number of not stopping events occurred during the night. No visual events were triggered at night.

4.8 Events and conflict points

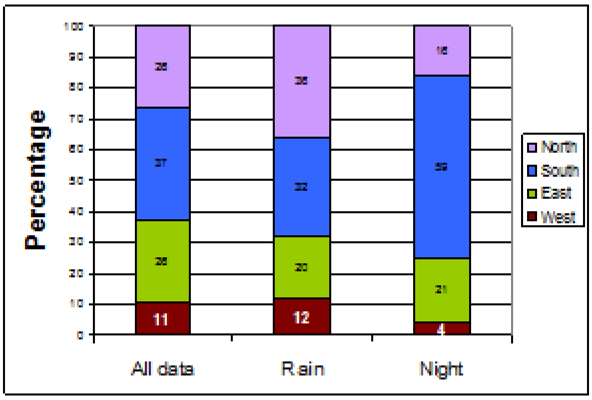

Figure 13: Conflict points

Figure 14: Distribution of conflict points by quadrant

The highest number of events were recorded on the southern side of the junction (37%) followed by the northern side (26%) and eastern side (26%) of the junction. The side with the lowest number of recorded events was the western side (11%). During rainy conditions, however, most events were recorded on the northern side (36%). This may be because the weather forced people approaching the junction from the south to drive with more care.

5 DISCUSSION

5.1 General behaviour

During peak-hour periods the movement of road users through this junction could be best described as 'organised chaos'. Vehicles displayed a very mixed level of compliance with traffic regulations and consideration for other users. The hours of observation identified over 900 incidences of events and indicate a high potential for conflict between road users. The biggest problem for users seems to be the behaviour that resulted from frustrations of drivers tired of waiting for their turn. A high percentage of users were witnessed not stopping at the junction and misuse of the lanes provided also generated potential conflicts.

Many of the observed discrepancies in expected behaviour were the result of intentional wrong doing or driver hesitation because of visual obstruction or uncertainty. This latter type of hesitation was witnessed on a regular basis, suggesting either unfamiliarity with the rules of engagement in the junction or a fear of other drivers operating out of sequence.

It is important to note that the junction does become extremely congested at times. The over-congested junction leads to complex information about vehicle priorities which needs to be processed by the next user in the queue within a limited span of time.

5.2 User behaviour at different times of the day

In the mornings users were observed to be more relaxed and in less in a hurry than in the afternoons. Afternoon users gave the impression of being preoccupied or more harried. There was more evidence of cellphone use in the afternoons.

As was evident from the collision data there were no collisions very early in the mornings compared with a few hours later. Through observations at different times through the night and early mornings the following explanations for this are suggested:

5.2.1Traffic volume differences. Between 11 pm and midnight there was almost twice the volume of traffic compared with the hour between 1.30 am and 2.30 am. A total of 585 vehicles per hour were recorded before midnight, compared with 251 vehicles per hour between 1.30 am and 2.30 am. This data was obtained for a typical Wednesday night and Thursday morning. Between 4 am and five am only 88 vehicles per hour were recorded.

5.2.2 User profile differences. Young drivers (87%) were more frequently observed during the early hours compared with a wider variety of drivers around midnight. The majority of drivers (70%) observed during the early hours were male. It was also observed that if the driver was female during this time then they would be less likely to stop at the stop street - 92% of the female drivers that were observed during the early hours of the morning did not stop (compared to 83% of the male drivers who did not stop).

5.2.3 Recklessness. During the hour before midnight the users of the road were observed to be more compliant with the rules of the stop junction than during other times of the day. The increase in compliance may be because there are mostly vehicle users using the junction at this time, and the junction is congested enough that users must still be vigilant and observable. A noticeable change in driver behaviour was observed a few hours later. Traffic offences - such as speeding, not stopping or stopping on the side of the road near the junction, not looking to see if junction is clear of traffic - were noted. One event of racing was observed and a number of events were noted where the vehicle speed exceeded the limit while taking a turn at the junction. Driving while under the influence of alcohol at this time of the morning may play a part in the behaviour changes that was noted. This was obviously not possible to confirm through simple observation.

5.2.4 Driver-passenger relationship. The probability that there were passengers with the driver of the vehicle increased in the very early mornings (refer to Figure 15 below).

Fifty-seven percent of the drivers had passengers during the night compared to 36% during the day. There were also interesting behavioural similarities between the driver and the passengers, e.g. if the driver seemed exuberant so did the passengers.

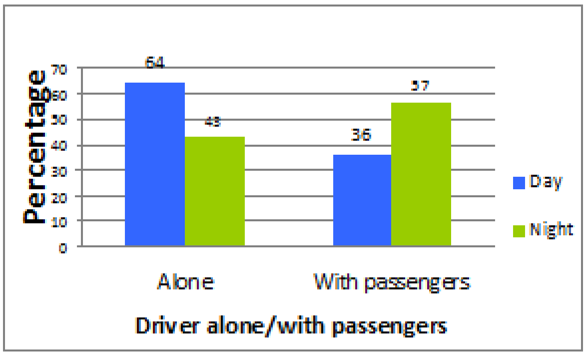

Figure 15. Occupancy of vehicles

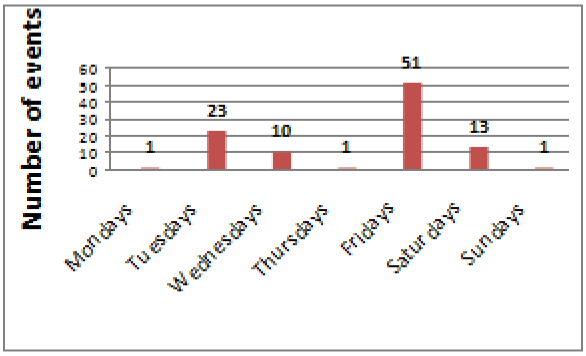

Figure 16. Cellphone use by weekday

5.3 Cell phone usage

Cellphone usage was observed to be the main means for distraction by various users. While no discernable patterns of cell phone use was evident during the mornings, cell phones were observed to be used more frequently during the afternoons by the middle age group users coming from work. Thirty-six percent of the total cellphone distractions were caused by middle age drivers during this time. Figure 16 illustrates that cellphones were also observed to be more frequently used during weekends, and particularly on Friday afternoons. The increase in usage was apparent in driver, passengers and also pedestrians.

5.4 Driving environment

It was observed that users who were driving in the minor road, Bosman road, were more likely to stop at the junction behind the stop line and obey the general rules of a four way stop than users in Merriman road. It was also observed that users approaching from the Western side of Bosman road had the lowest number of misbehaviour type events.

It is evident that the driving environment leading up to the four way stop junction may play a key role in the behaviour of users at the stop junction.

The western side of Bosman road before the four way stop has many hindrances. These hindrances include another four way stop only a few metres away, a side street linking up to Bosman street, a speed bump close to the observed junction and parked vehicles on either sides of the road which makes the road narrower. All these reduce the possibility for speeding and demand more attention from the driver. At the stop line, the width of lane restricts access to only one vehicle. Finally, a clear sight distance for the whole junction is only possible for the first vehicle at the stop line.

On the other hand, the eastern side of Bosman road experiences a free flowing driving environment leading up to the junction. This increases the likelihood of speeding towards the junction. The lane width at this stop line is wide enough for two vehicles to stop next to each other. Users turning left into Merriman from this side of Bosman road are thus more likely not to stop, or not to wait for their appropriate turn to continue into Merriman.

The driving environment leading to the junction from both the north and south side of Merriman is free flowing. The road consists of wide lanes with sufficient sight distance and almost no hindrances. Speeding and not stopping at the junction were observed more frequently at off-peak hours. Fortunately, Merriman is a major road with a high volume of users that decreases this possibility of speeding at peak hour.

The presence of the right-turning lane on the southern junction created a number of issues. When it was being used correctly by vehicles it created a potential visual obstruction for vehicles in the outside lane, causing them to creep into the junction space to check for clear passage. This created conflict with pedestrian and cyclists using the designated pedestrian crossing, and often forced them to weave in between vehicles at this crossing. The turning lane was also used illegally by vehicles, particularly taxis, seeking to overtake other vehicles across the junction itself.

6 CONCLUSION

The junction of Merriman and Bosman streets is a busy one, and high levels of interaction between vehicles other road users occur, leading to a crossing environment that is complex and where crossing decisions are not always predictable. The high number of events recorded, including a ‘near miss’ with a pedestrian, indicates that the potential for conflict here is very high. Driver error, through wilful intent and also as a consequence of excessive caution, generates opportunities for collisions. Drivers and other road users were observed exhibiting aggression, distraction and opportunism on a regular basis. Pedestrian behaviour, though not detailed in this paper, also indicated pedestrian discomfort in the use of this junction.

The physical layout of the junction certainly plays some role in the observed patterns of behaviour, but in the main the majority of the causes of conflict are derived from the behaviour of drivers. The safe utilisation of this particular junction is frequently undermined by behavioural patterns that pose risks for all road users.

The study allowed us to begin to determine the most common forms of such errant behaviour, and is a step towards better understanding the nature of the opportunities for conflict between vehicle, and between vehicles and pedestrian and other non-motorists forms of transport. This type of analysis is important if we are to make inroads into reducing potential for conflict between users in the future. Of course this study related to a single junction in a single town, but even so it has begun the process of developing a typology of junction-related vehicle/user events. More research at other similar junctions will add immeasurably to its value in the future.

References

World Health Organisation, 2009. Global Status Report. Geneva.

Road Traffic Management Corporation (SA), 2009. Road Traffic Report, 31 March 2009. Pretoria.

Elvik, R. Hoye, A, Vaa, T and Sorensen, M; 2009. Handbook of road safety measures. London, Emerald Group.

Retting, RA, Weinstein, HB and Solomon, MG,; 2003. Analysis of motor-vehicle crashes at stop signs in four U.S. cities. Journal of Safety Research 34 (2003) 485– 489