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# The Application of Traffic Conflict Technique as a Road Safety Evaluation Method: a Case Study of Hasselt Intersection

FARDZANELA Suwarto[1, a *], KAMI Hari Basuki[2,b]

[1]Engineering faculty – University of Diponegoro, Semarang 50275, Indonesia

[2] Engineering faculty – University of Diponegoro, Semarang 50275, Indonesia

[a]fardzanela@gmail.com [b]basuki.kh@gmail.com

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**Abstract.** The majority of traffic safety evaluations in the world generally have been conducted by colecting historical accident data. The data will then being analyzed using risk prediction models or before-after study that required an exact and reliable data. Meanwhile, the availability of accident data is rare where the rest actually consist of near-crashes and abnormal behaviour, which is mostly underreporting and lack of detail concerning the behavioural and situational of the event. Therefore, traffic conflict technique, is needed to assess traffic safety as another approach rather than waiting for several years until a number of accidents happen in a certain area. Hence the aim of this study is to make a safety evaluation towards a specific intersection in Hasselt Belgium using traffic conflict technique. The observation of conflict (near crashes) was carried out in intersection of Manteliusstraat – Dorpsstraat – Thonissenlaan in the Hasselt, Belgium. In order to differentiate slight conflict and serious conflict, the TA-value (Time of accident) was defined based on the estimated speed of the road user and estimated distance from the road user when conflict occurred. From the observation, it was found that the conflicts between car and pedestrian were the most frequent conflict, with 50% of the total conflict, and that the conflict between car with car and the conflict between car with cyclist were high in terms of severity level based on the TA-value. By taking these into consideration, it can be concluded that unsafe crossing for pedestrian and cyclist, different speed, and peak hour traffic were the causes of conflict. Therefore, it was concluded that traffic conflict technique can be used to assess and measure traffic safety in a certain road segment. Furthermore, in term of safety, the Manteliusstraat – Dorpsstraat – Thonissenlaan intersection should be modified with some alternatives; signalized intersection with toucan crossing and traffic control devices improvement.

## Introduction

Traffic safety evaluation is important to understand the level of road safety in certain areas, which location or situation is dangerous, and why it is dangerous. Additionaly traffic safety evaluation is also important to determine whether if countermeasure is needed to improve the safety of the road itself. The majority of traffic safety evaluation has been conducted by analyzing historical accident data. The data will then being analyzed using risk prediction models or before-after study that require an exact and reliable data. Meanwhile, crashes accident data that available are rare and only a tip of pyramid where the rest are actually consist of near-crashes and abnormal behavior, which are mostly underreporting. Additionally the data obtained are usually lack of detail concerning the behavioral and situational of the event. Taking into account this situation, this type of accident data is deemed unreliable actual conflict data. Moreover, it needs accidents to fall before the evaluation can be made and will be require an extensive time to obtain the accident data.

Therefore, surrogated safety measure as another approach is needed to assess traffic safety rather than wait for several years until a number of accidents happened in a certain area, surrogate safety measure is enabled to complete the assessment within days or a few weeks without the necessity to wait the occurrence of accidents. By using this technique, one can get an understanding of road safety problem in a short-term period with more detailed data quality such as location characteristic, causes of conflict and road user behavior interaction. And with perceiving those detailed data information, several applications can be made such as determining unsafe locations, evaluating the impact of specific countermeasures by using before-after studies, and setting a standard priority on safety management.

Hence the objective of this study is to make a safety evaluation towards a specific intersection using surrogate safety measures technique. The aims of this report are:

1) Analyzing conflict patterns,
2) Looking if the conflicts differ according to the type of involved road user and determining which road users are mostly involved in the observed conflicts,
3) Assessing the conflict severity,
4) Investigating if the conflicts differ according to the time of day
5) Proposing measures to solve the traffic safety problem at the intersection.

## Literature Review

**Road Traffic Safety.**The traffic system can be described as the relation and interaction among road users, roadway and vehicles. Subsequently, according to Tight (2012), a road traffic accident came as the result from a combination of aspects related to a road system component, the users, the environment, vehicles and the way they interact as seen on Figure 1. Some aspects contribute to the event of conflict and are therefore part of accident causation. Those different factors and its combination will also lead to a different fatality rate of accident that is fatal, serious or slight accident. Therefore, identifying the risk factor that contribute to road traffic accident is essential to determine and identify the countermeasure that can improve road traffic safety and reduce the number of accident by decreasing the risk associated with those factors.

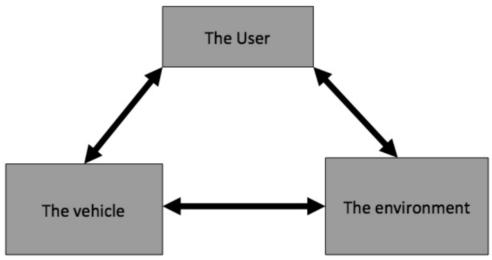



Fig.1 Road system interaction (Tight, 2012)

**Accident Data.** The evaluation of road safety is traditionally assessed by using the number of traffic accidents and their severity level called as direct indicators. However, in spite of this technique is useful for identifying a specific road safety problem, this method tends to be considered as inhuman (Folprecht, 2000). It is assumed that a number of accidents that involve human must occur in order to distinguish road safety problem. Another disadvantage of using historical accident data to measure road safety problem is that crashes are considered as rare event compared with conflict or near crashes and abnormal behaviour (Ceunynck, 2014).

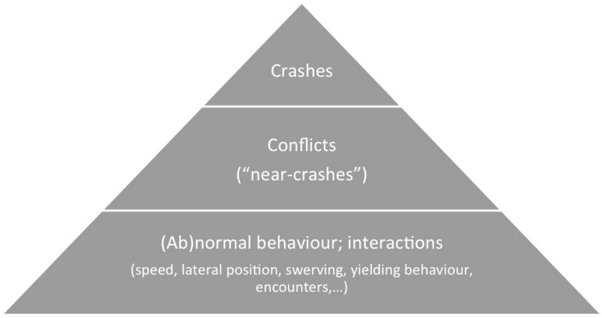



Fig. 2 Conflict type pyramid

In particular, accident is a dynamic event that is difficult to be analysed. Additionally, a lot of crashes have been under reporting due to the absence of police officer or traffic cameras on the crash scene. Therefore, not only historical accident data were lack of quality and behavioural details availability, but also the situational aspects of the event that was required for statistical various countermeasures is inadequate (Zajíc, 2012).

**Traffic Conflict Technique.** According to Laureshyn (2010), traffic conflict technique is the most direct of the all-indirect methods in road safety measurement. This technique is based on observing and recording the conflict event (near-crashes) in a real time on the normal day activity that is focused on the situational aspect of the conflict event. Two or more road users in the state of near crash would collide if neither of them take an action in order to avoid crashes which is visible from their motion changes.

When determining conflicts, according to the origin country of this method, the Swedish traffic conflict technique uses speed and distance. In 2001, Lotter define a conflict as the event where two road users with crossing courses would have collided if they had continued unchanged speed and direction (one or two road users take evasive action). The time that remains before collision if speed and direction were not change is defined as the 'Time to Collision' (TCC-value).

$$TCC = d_2/v_2\,,\ if\ d_1/v_1 < d_2/v_2 < (d_1 + l_1 + w_2)\,/\,v_1$$
$$TCC = d_1/v_1\,,\ if\ d_2/v_2 < d_1/v_1 < (d_2 + l_2 + w_1)\,/\,v_2 \quad \text{(Eq.1)}$$

$$TCC = \frac{X_1 - X_2 - l_1}{v_1 - v_2}\,,\ if\ v_2 < v_1 \quad \text{(Eq.2)}$$

$$TCC = \frac{X_1 - X_2}{v_1 + v_2} \quad \text{(Eq.3)}$$

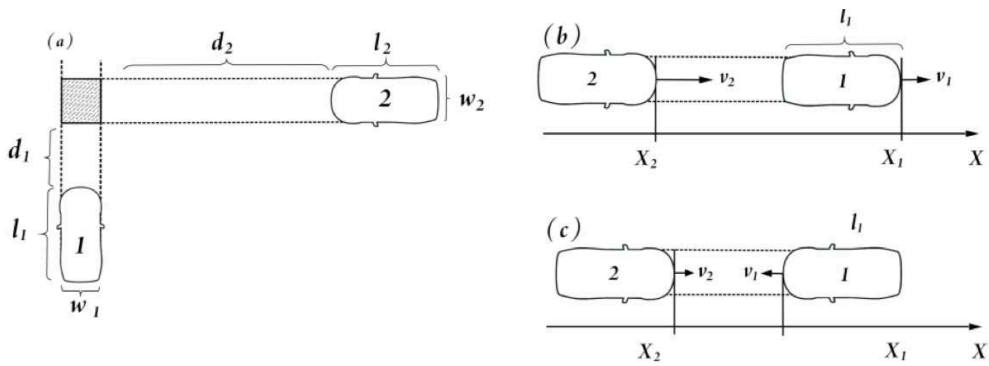



Fig. 3 Calculation of TTC for perpendicular (a) and parallel courses (b, c)

Subsequently, TCC at the moment of evasive action is called TA (Time to Accident). The evasive action carried out by road user including stopping or accelerating is recorded by the observer. The relation of TCC and TA can be seen as on Figure 4. The TA-value would be used to establish whether the conflict was severe or not (Hyden, 1987). The boundary to distinguish whether an accident is severe or not is based on the optimum braking time for an average vehicle that comes to stop with locked brakes on normal dry asphalt safely, just beforehand the point of crash, plus an extra margin of 0.5 seconds, which determined by Lund University (Patermans et al, 2002).

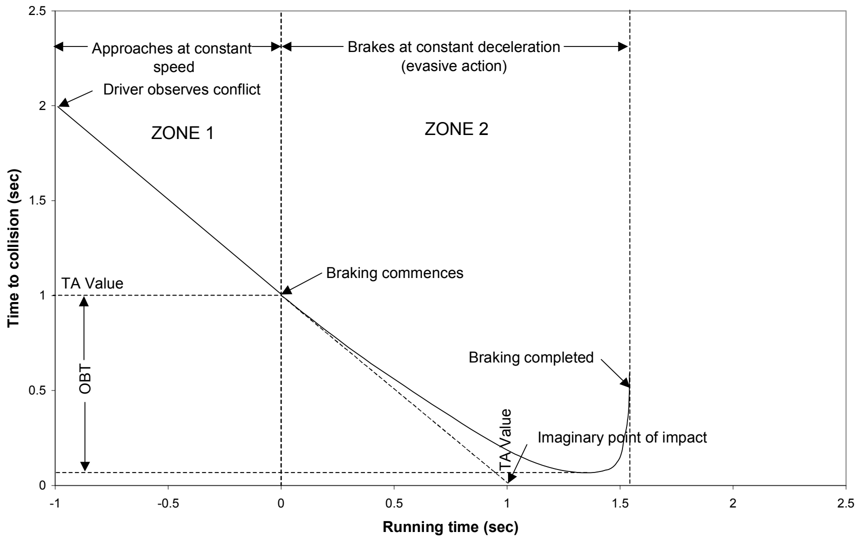



Fig. 4 The relation of TCC and TA Value

Traffic conflict technique is enabled to complete the assessment within days or a few weeks without the necessity to wait the occurrence of accidents. Dagmar (2012) considered that monitoring of conflict is not only more efficient (time and money), but also humane - safety of the site can be addressed before there are accidents, injuries, death and society damage.

## Methodology

This report demonstrates the evaluation of road safety at a specific intersection by using surrogated safety measures. The research was undertaken at a busy main road at the intersection of Manteliusstraat – Dorpsstraat – Thonissenlaan in the center of Hasselt, Belgium, as given in Figure 5.

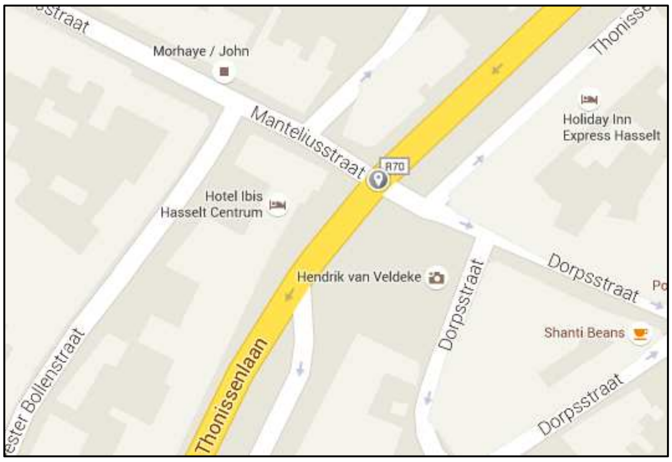



Fig. 5 Study areas

The intersection has the geometry configuration of T-Junction, as the Droopstrat Street is the access to the city center for pedestrian and cyclist only, while Thonissenlaan Street is a one-way street with speed limit of 50 km/hours. This intersection also has a specific characteristic with a bicycle path along the Thonissenlaan Street in two-way direction. That circumstance has caused a lot of conflict not only for the vehicles but also for the pedestrian and the cyclist who would cross the street.

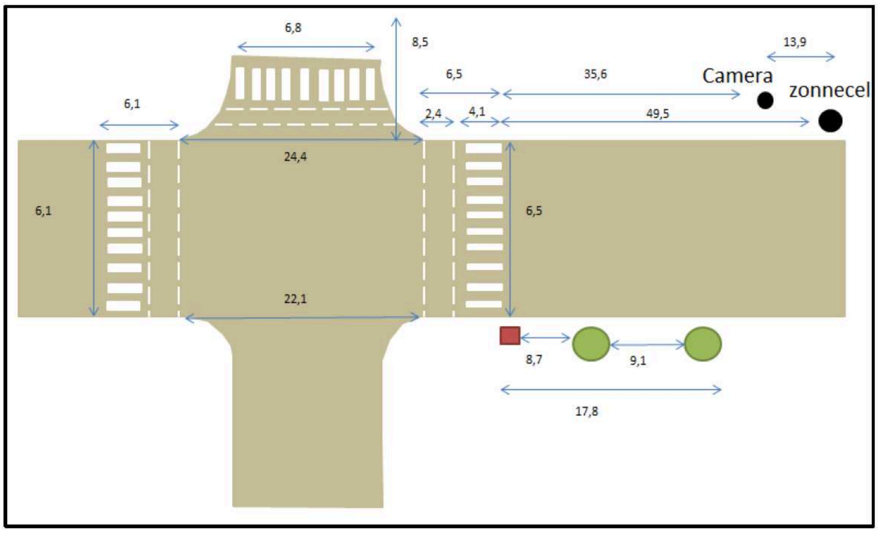


Fig. 6 Intersection configurations and distance references

Before the observation, information regarding the intersection configuration was collected for better understanding of observed location. Those information were including road width, road length, and also a certain distance from reference point to another reference point such as trees or electricity pole which then was used to help the observer estimating the distance between road users at the time of the conflict.

For this study, the observations were performed 3 years successively (successfully three times); 10-11 November 2012, 18 November 2013 and 15-16 September 2014. It was conducted by several observer groups of University of Hasselt. Observation period was determined to make sure that the timing of observation has represented the actual circumstances of daily traffic, for instance peak hour and weekdays timing. The observation was performed by noted down the record of the conflict onto a recording sheet which was contain of time and date observation, time of conflicts, location, type of conflicts, the involved road user in a certain conflict (car, bicycle, or pedestrian), speed and distance at the time of conflict, the evasive action, and sketch of study location. A camera was also installed to record the situation of the intersection to analyze the situation in more detail and to adjust the evaluation of distance and speed if required. The data was processed by made a distinction between slight and serious conflict, investigating the involved road user when certain conflicts occur, and evaluated time tendency of the conflicts. The distinction between slight and serious conflict can be done by defining the TA-value (Time of accident) base on the estimated speed of the road user and estimated distance from the road user. Analysis was then conducted in relation to find the explanation of the conflicts and unsafe situation causes based on the observation data and provide the effective countermeasure if necessary afterwards.

## Result

In this chapter, road safety observation of Manteliusstraat – Dorpsstraat – Thonissenlaan intersection will be presented as given.

**Conflict Type.** The result of the junction observation in 2014, as shown in Figure 7, indicate that there were several types of vehicle that frequently involved in the conflict.

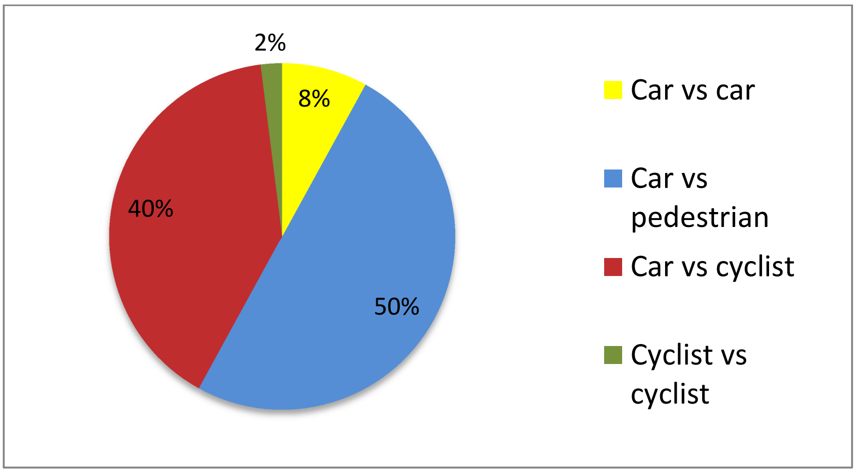



Fig. 7 Percentage of involved vehicle on the conflict

As seen on the Figure 7, there were several types of conflict in term of the vehicle that get involved in the conflict which were car with car, car with pedestrian, car with cyclist and cyclist with cyclist. The conflict between car and pedestrian was the most frequent conflict, with 50% of the total conflict. Conflict between car and cyclist was the second most frequent with almost the same percentage, 40% from all the conflict. On the contrary, the conflict that involving cyclist with cyclist was in the least frequent of all conflict, which is only 2%.

For the type of conflict severity, it can be divided into two types of conflict seriousness; slight conflict or non-serious conflict and serious conflict. The two types of conflict severity were determined based on the TA-Value of each conflict. The difference of type of slight conflict and serious conflict is presented in Figure 8.

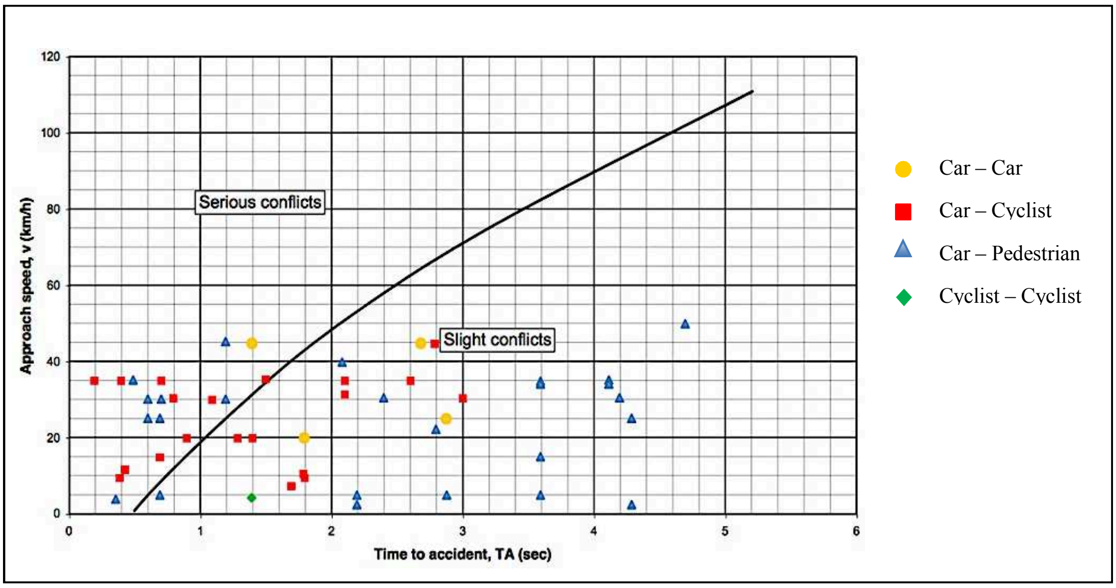



Fig. 8 Severity conflict graph

From the Figure 8, it can be obtain that even though the conflict between car and pedestrian was the most frequent conflict, this type of conflict was consider as non-serious conflict or slight conflict. Indicated by the pattern of the conflict, which tend to be in the bottom of the dividing line. While, at the same time, the conflict between car with car and car with cyclist apparently were higher in terms of conflict severity. These are showed by the pattern of red dots and yellow dots that represent the type of involved vehicles, in which generally are closer to the line. Moreover, the conflict between car and cyclist with the red dot pattern shows that this conflict is often generating more severe compared with the other types.

**Conflict Time Occurrence.** From the observation in September 2014, conflicts are likely happened at the afternoon traffic with total 20 collisions which consist of 6 slight conflicts and 14 serious conflicts as seen in Table 1. It also indicates that the serious conflict was occurred mostly during afternoon traffic (14 pm - 17 pm).

Table 1 Number of conflicts occurred in 2014

| Period | Morning Traffic 8am - 11am | Daytime Traffic 11am - 14pm | Afternoon Traffic 14pm - 17pm |
|---|---|---|---|
| Slight Conflict | 13 | 13 | 6 |
| Serious Conflict | 2 | 4 | 14 |
| Total Conflict | 15 | 17 | 20 |

From Table 2, it shows that the similar circumstances happened in September 2013, where the most accidents were occurred during afternoon traffic with total 10 conflicts compared with 6 total conflicts during daytime traffic.

Table 2 Number of conflicts occurred in 2013

| Period | Morning Traffic 8am - 11am | Daytime Traffic 11am - 14pm | Afternoon Traffic 14pm - 17pm |
|---|---|---|---|
| Slight Conflict | Not available | 4 | 2 |
| Serious Conflict | Not available | 2 | 8 |
| Total Conflict | Not available | 6 | 10 |

The highest number of serious conflict also occurred during the afternoon traffic with 8 serious conflicts. However, it should be noted that the conflict data 2013 in the morning traffic are not available.

Table 3 Number of conflicts occurred in 2012

| Period | Morning Traffic 8am - 11am | Daytime Traffic 11am - 14pm | Afternoon Traffic 14pm - 17pm |
|---|---|---|---|
| Slight Conflict | 7 | 5 | 9 |
| Serious Conflict | 9 | 2 | 5 |
| Total Conflict | 16 | 7 | 14 |

Conversely, the conflict data from the observation in September 2012 shows the differences in the conflict tendency as seen in Table 3. It indicates that more conflicts are generally happened from 8 am to 11 am during the morning period. The total of 16 conflicts, which consist of 9 serious conflicts and 7 slight conflicts, were record in the morning traffic. This number of conflict in the morning traffic is slightly higher compared by the conflict in the afternoon traffic.

**Conflict trends.** The deeper investigation of conflict trend from 2012 until 2014 shows that there is no trend in the number of the conflict occurrence as presented in Table 4.

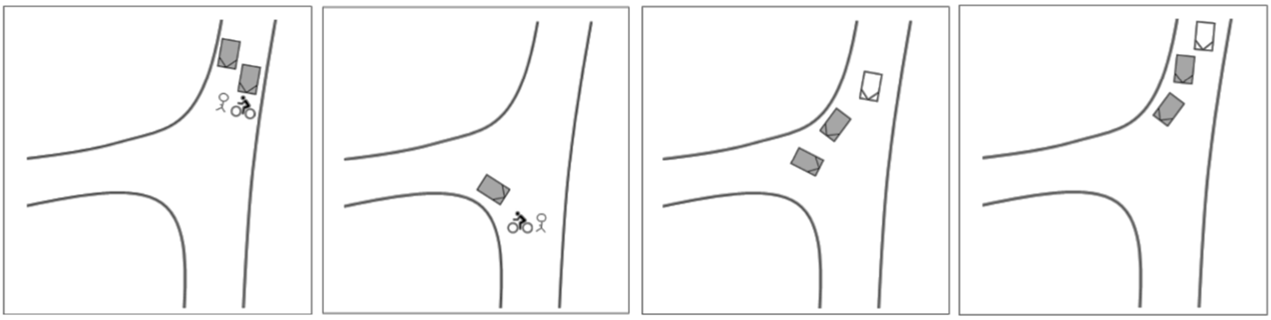
Table 4 Comparison of conflict rate

| | 2012 | 2013 | 2014 |
|---|---|---|---|
| Slight Conflict | 2.33 conflict/hour | 1 conflict/hour | 3.55 conflict/hour |
| Serious Conflict | 1.77 conflict/hour | 1.5 conflict/hour | 2.22 conflict/hour |
| Conflict rate | 4.11 conflict/hour | 2.67 conflict/hour | 5.77 conflict/hour |

In 2012, the conflict rate on certain weekday traffic was 4.11 conflict/hour. While in 2013, the conflict rate was significantly reduce into 2.67 conflict/hour. However, the conflict rate increased again by 5.77 conflict/hour in 2014.

## Discussion

**Identifying the problem.** Before certain countermeasure and improvement is proposed on the Manteliusstraat – Dorpsstraat – Thonissenlaan intersection. It is mandatory to analyze and identify the general safety problem on the site beforehand. The Manteliusstraat – Dorpsstraat – Thonissenlaan intersection was one of the intersections located in the inner ring of Hasselt city, the capital city of Limburg. The intersection has a specific characteristic of un-signalized one-way road with speed limit of 50 km/hour. By using traffic conflict technique, the cause of safety problem in Manteliusstraat – Dorpsstraat – Thonissenlaan intersection can be identified and subsequently the countermeasure alternative can be considered.



(a) (b) (c) (d)

Fig. 9 Type of conflict

From the observation result, there were four conflicts type as seen from figure 9. The most common conflict is a and b, were when cyclist or pedestrian tried to cross the street and the cars were unable to see or predict those movement so that an evasive acction must be done such as braked the car. While conflict type c and d between car and car, were mainly caused by the turning movement of cars from Thonissenlaan to Manteliusstraat, and vice versa.

Taking the result finding into consideration, it was found that car with pedestrian conflict shares the most percentage of the total involved-parties conflict type as much as 50% followed by the conflict between car and cyclist as 40%. In other words, it can be determined that the conflict involving non-motorized vehicle as the second party was the most occurred conflict by 90% of the total conflicts, which mostly occurred when the pedestrian or cyclist crossed the road on zebra cross. However, from the graph that distinguished the conflict severity, the most severe conflict that occurred was the conflict between car with car and the conflict between cars with cyclist. These were happened due to the speed of the involved parties (car and cyclist) has small rate of TA-value. As it can be concluded that the lower the TA-value, the more severe the conflict is. It was also showed from 2014 observation at Manteliusstraat – Dorpsstraat – Thonissenlaan intersection that the most frequent conflict occurred in the afternoon traffic was 20 total conflicts. Despite the fact that in 2012, most frequent conflicts occurred during the morning traffic was 16 total conflicts, which was slightly different with the afternoon traffic with 14 total conflicts. Therefore, with the similar range of conflict frequency, it could be determined that conflicts had the tendency to occur during peak hour which were in the morning from 8 am until 11 am and the afternoon from 14 pm until 17 pm.

**Proposed improvement.** Road as a transportation infrastructure should be designed for all road users not only for driver but also pedestrian and cyclist respectively. Taking into consideration, the result of observation review at Manteliusstraat – Dorpsstraat – Thonissenlaan intersection showed that the causes that contributed to these conflict types were unsafe crossing for pedestrian and cyclist, indicated by the high percentage of conflicts which were involving pedestrian and cyclist by 50% and 40% of the total conflict. This can be caused by the geometric of the intersection with narrow T-junction profile and added by the existence of tall building so that the car drivers was unable to see clearly pedestrian and cyclist that came to cross the street. The evasive movements were includes brakes and divert.

Another cause of the conflict was the speed of the road user particularly car and cyclist. Cars with higher speed would tend to get involved in the conflict. Car driver decreasing focus of the situation around while speeding may cause this situation, so that they would not be aware of people crossing the street or another cars that slowed down to veer. In addition, form the observation data, those causes worsen at the peak hour traffic such as in the afternoon traffic. Moreover, it can be seen from the trends that the number of conflict will generally be higher each year, thus a countermeasure was need to be implemented to increase the safety level in this intersection. Therefore, in term of safety, the Manteliusstraat – Dorpsstraat – Thonissenlaan intersection should be improved with some alternatives.

After the observation using traffic conflict technique some recommendations can be proposed. which were roundabout, signalized intersection, and traffic control devices improvement. Roundabout as an alternative of the countermeasures will have a significant impact to increase not only the safety aspect by decreasing the conflict between cars but also the road capacity by considering car growth forecast. Nevertheless, Manteliusstraat – Dorpsstraat – Thonissenlaan intersection has characteristic as one way road in which the most frequent conflict were between car with pedestrian and car with cyclist. On the contrary, implementation roundabout tended to neglect the existence of pedestrian and cyclist. Therefore, the alternative to implement roundabout in this junction can be eliminated.

One of signalized intersection purposes is almost similar with roundabout that is eliminating conflicts. In this intersection, traffic signals were used for assigning vehicles and pedestrian to an orderly movement. The advantages of the signals are not only to increase capacity of the intersection but also to accommodate safety purpose reducing the frequency of specific crash type by interrupting the traffic to permit other vehicles or pedestrian to cross the road. In addition, in the certain intersection, unsafe crossing caused the most frequent conflicts for pedestrian and cyclist while the justification for every pedestrian or cyclist crossing should be make crossing the road safer for all the road user. Therefore the specific traffic signal is needed in this intersection to protect pedestrian and cyclist to crossing the road. This purpose can be achieved by implementing a signalized intersection with a toucan crossing.

Toucan crossings are a stand-alone signaled where the pedestrian or cyclist can push a button to ask the need to cross. The toucan crossing has a red/green man and bicycle signal to indicate when they were allowed to cross the road, while the drivers were gave with the usual traffic light except for a flashing amber light which permits drivers to go if all pedestrian have crossed the road. This countermeasure was significantly useful when the pedestrian and cyclist flow is high, which is also the situation in this intersection. Another countermeasure was traffic control devices improvement that was also needed as the complementary of the traffic signal to increase the level of intersection safety. The traffic control improvement can be upgrading a sign or road marking. The initiatives to install these countermeasures were the relativity of low-cost realization. Traffic sign improvement that was needed in this intersection were increasing the number of speed zone sign, pedestrian crossing sign and one way lane sign due to it was found that car drivers drove against the road flow because of their ignorance. The road marking improvement can be performed by providing zigzag road marking to indicate that there will be a pedestrian/cyclist crossing. By implementing all the countermeasures as mentioned before, it was expected that the number of conflict in the Manteliusstraat – Dorpsstraat – Thonissenlaan intersection could be reduced and could lead reduction in the number of accidents.

## Conclusion and recommendation

This paper has shown that use of traffic conflict technique has considerable potential as a tool to assess and measure traffic safety in a certain road segment. The safety evaluation by using traffic conflict techique on Manteliusstraat – Dorpsstraat – Thonissenlaan intersection concluded the causes that contributed to the conflicts were unsafe crossing for pedestrian and cyclist, speed of the road user particularly car and cyclist, and those causes worsen at the peak hour traffic. Therefore this intersection needs to be improved by implementing signalized intersection with toucan crossing and improving road signs before and at the intersection.

further observation and analysis using traffic conflict technique could be made on the signalized intersection so that the differences of the conflict can be pattern. In the next investigation, the same observer is needed to avoid the difference perception of the traffic condition that leads to unreliability of the data. Also, longer observation time is necessary to obtain more complete and reliable traffic conflict data.

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