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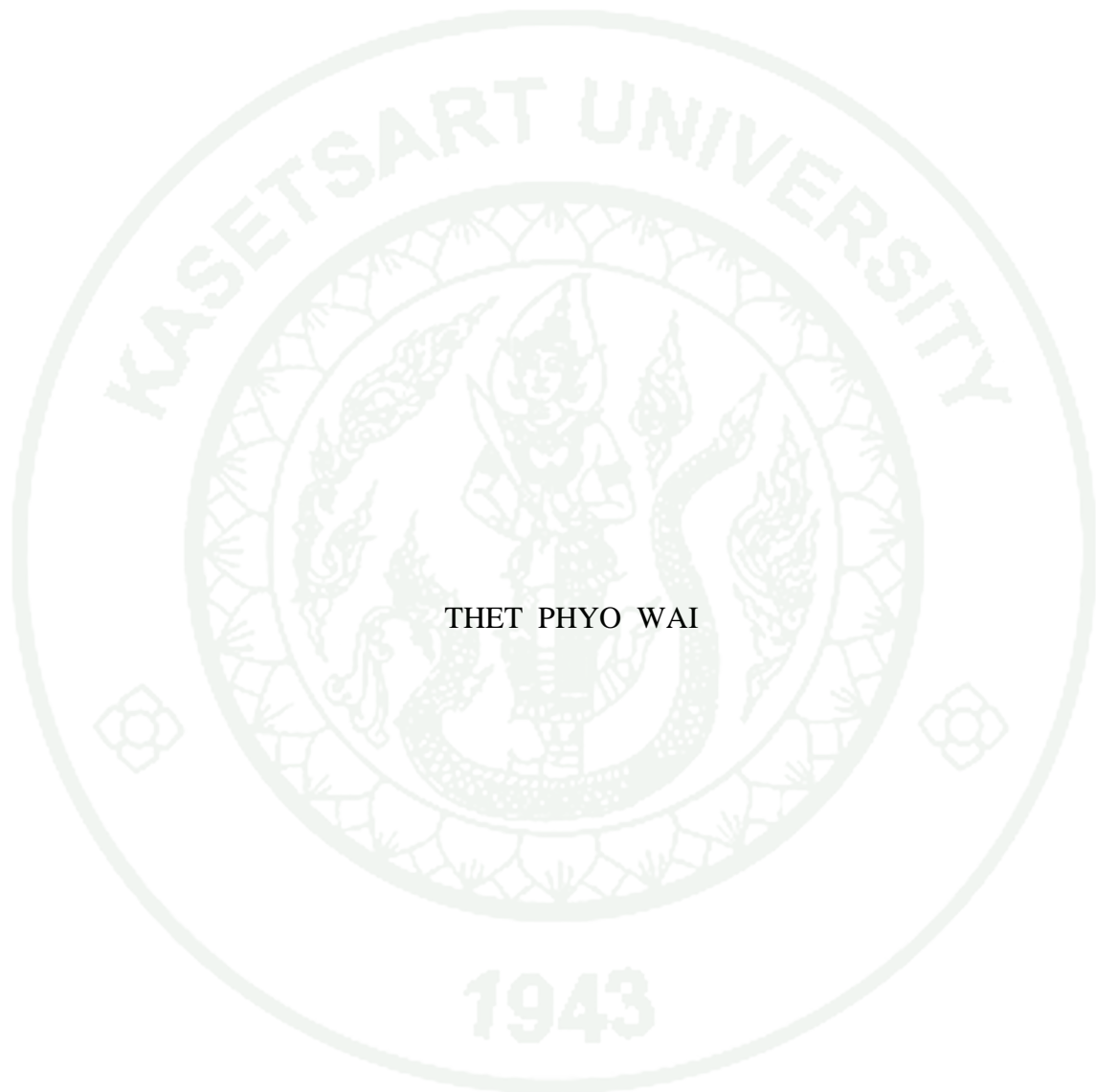
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THESIS

TRAFFIC SAFETY ASSESSMENT AT MAJOR INTERSECTIONS ON  
YANGON-PYAY ROAD IN YANGON CITY



THET PHYO WAI

A Thesis Submitted in Partial Fulfillment of  
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Thet Phyo Wai 2011: Traffic Safety Assessment at Major Intersections on Yangon-Pyay Road in Yangon City. Master of Engineering (Civil Engineering), Major Field: Civil Engineering, Department of Civil Engineering. Thesis Advisor: Associate Professor Pongsak Suriyavanagul, Ph.D. 78 pages.

This thesis describes one of the effective methodologies in determining the traffic safety at signalized intersections. The research was based on three major at-grade signalized intersections. These were selected according to the severity of accident rates and crash rates, traffic related injuries and fatalities. The main objective is to study the traffic safety assessment based on conflict observations at these intersections on Yangon-Pyay Road in Yangon City, Myanmar. The police reported accidents data from the past five-year period of each intersection was compared with the conflict observation data collected by using Traffic conflict technique which was used as the proximal and short-term traffic safety measure. The results from serious conflict observation data for each intersection were compared with the police reported accident data and then a comparison of intersections was made using the statistical correlation. Conflict observation data from the 16 hours for each intersection were calculated with Time to Accident (TA) to classify into serious and non-serious conflicts. Inter-observer variance based on the three separate conflict studies is also considered. The limitations and potential of vehicle-vehicle (rear-end and exclusive rear-end) collision, and vehicle-pedestrian collision have also been compared with each other from a theoretical and practical perspective, which resulted in the need for the reliable and effective methodology.

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Student's signature

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Thesis Advisor's signature

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Finally, the author would like to dedicate his work to his parents, wife, and daughter as they always want to see him grow academically.

Thet Phyo Wai  
June 2011

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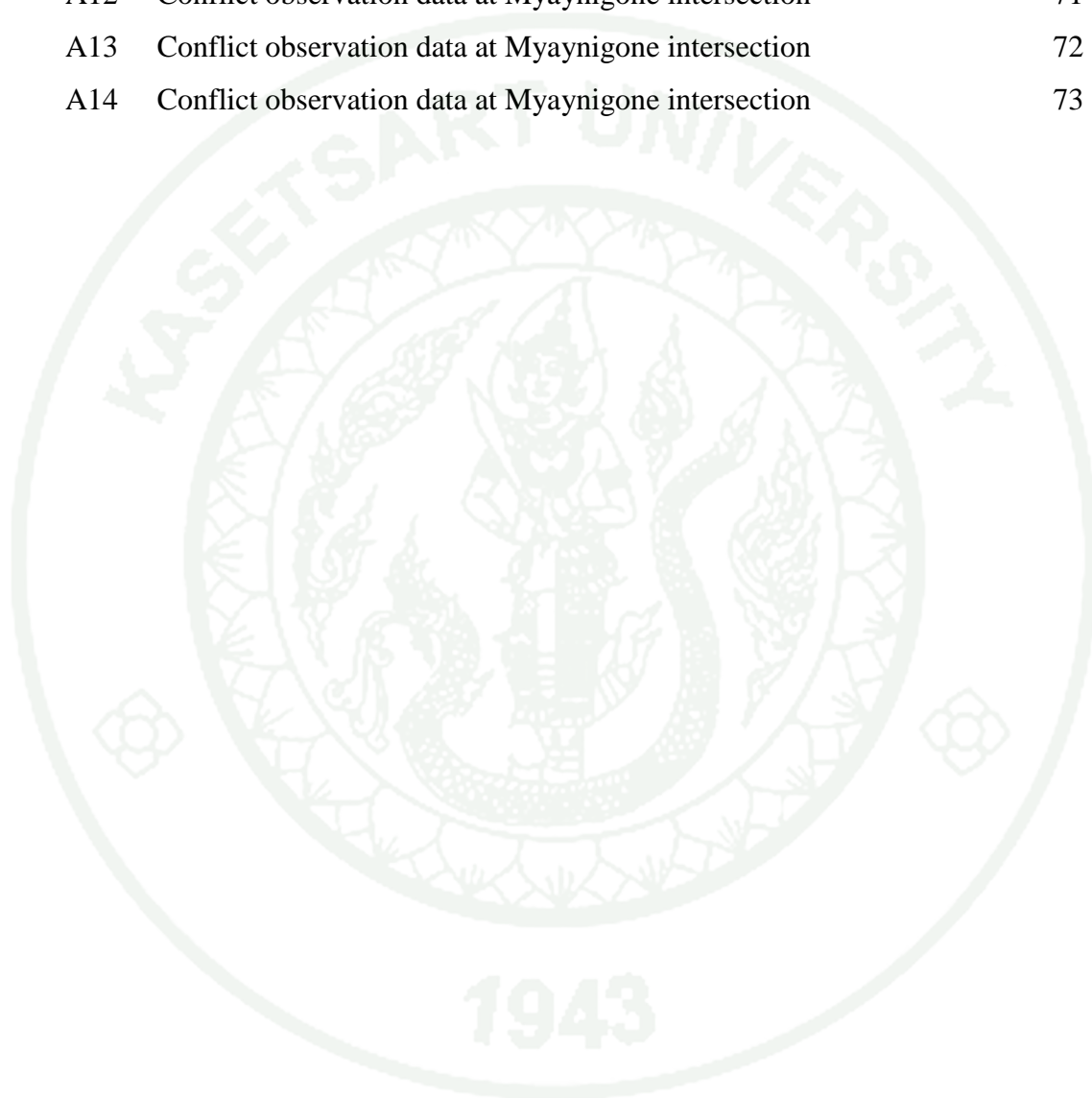
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# TRAFFIC SAFETY ASSESSMENT AT MAJOR INTERSECTIONS ON YANGON-PYAY ROAD IN YANGON CITY

## INTRODUCTION

### General

The main goals of traffic engineering are focused on the planning design and operation of traffic facilities and various parts of the traffic system to best meet the safety, performance and environmental demands of different road-users given the resources available. Since resources are usually a finite factor, there is commonly a need for optimization and balance between different and often conflicting traffic system objectives.

Today, traffic safety is generally measured in terms of the negative performance of the traffic system, whereby accidents involving injury, fatality and property damage occur as the result of inappropriate intersections between road-users, their vehicles, and the roadway that together form the fundamental elements of the prevailing situational context in the traffic system.

Traffic safety is a major concern on major city road where there is a high volume of vehicles and a large number of unprotected road-users in the form of pedestrians and cyclists. In environments with mixed compositions of road-users, the complexity of the traffic environment is amplified. At the same time, there is also a greater need for interaction between and among different road-user groups. Consequently, the number of traffic conflicts, accidents and road-user injuries is increased.

Traffic safety and accessibility are important and often conflicting objectives with regard to the city road environment. Particular safety problems can be identified at intersections, often involving pedestrians and cyclists. A problem faced by traffic

planners and engineers, concerns the identification of effective traffic safety and accessibility solutions that are equally representative of the needs and demands of all road-user categories.

This thesis is concerned primarily with road traffic safety from a traffic planning and engineering perspective. Traffic safety is investigated in relation to different types of signalized intersections that exist on the same road in the urban city environment.

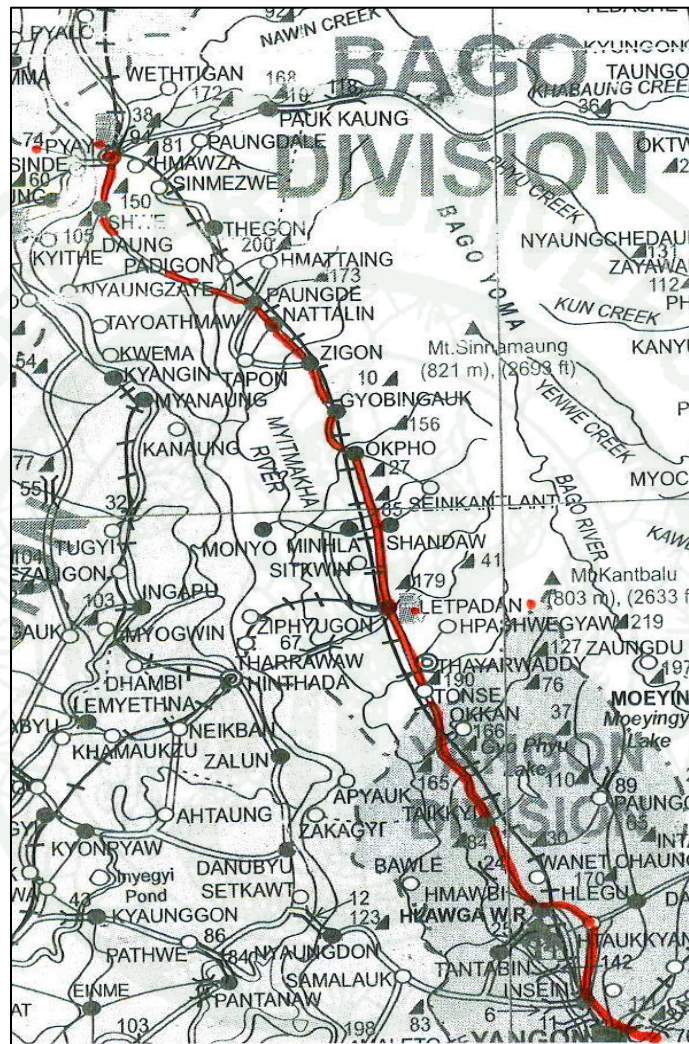
### **Statement of Problems**

Yangon, also known as Rangoon is a former capital of Myanmar and the capital of Yangon Region. The city is located at the convergence of the Yangon and Bago Rivers about 30 km away from the Gulf of Martaban. Yangon, with a population of an estimated six million, continues to be the country's largest and most industrialized city and the most important commercial center. The land size of Yangon is 598.75 km<sup>2</sup> and population density is 7261.8 per km<sup>2</sup>.

Before 1988, the development pattern of Yangon City was from south to north. After 1988, sub-urban townships and new satellite towns have been developed to the east and west. Such growth has taken place in the form of urban sprawl and scattered development, and consequently a large growth in population. The growth of new towns and townships has also led to an increased need for mobility and the volume of vehicles occupying the road infrastructure. The increase in vehicles has far outweighed the projected capacities and adaptive capabilities of the existing road infrastructure in Yangon City, leading to deterioration in traffic performance and difficulties in maintaining an acceptable traffic safety standard.

Nowadays, the most critical problem facing the traffic system is to assure a safe environment for road-users in Yangon. Insufficient transportation facilities and unsafe environment for road-users causes poor safety, discomfort and inconvenience.

Such poor safety damages not only the local economy, but also the quality of life of local road-users. Safety conditions will be needed to be enhanced in the future.



**Figure 1** Yangon-Pyay Highway in Myanmar

**Source:** JTCA (2009)

The city road chosen for this thesis was Yangon-Pyay Highway, a typical arterial main road with a heterogeneous traffic flow and a traffic composition that includes many different groups of road-user. Yangon-Pyay (Rangoon-Prome) Road was built with the aid of the Japanese Government, and considered the best highway

in Myanmar. It runs west of the Pegu Range (Bago Yoma) and has a length of 288 km (Figure 1). It is six-lane, two-way road. There are many signalized and unsignalized intersections on this road in Yangon City environment. Three major signalized intersections on Yangon-Pyay Road were selected as a case study according to the severity of accident rates and crash rates, traffic related injuries and fatalities.

Today, traffic related injuries and fatalities are recognized as a major hazard for society. The problem is also global, common to both third world and industrialized countries. The World Health Organization (WHO) rates traffic fatalities as the ninth most common cause of death in the world today, and predicts an increase in the near future as a result of the rapid growth of road traffic in developing countries. The worldwide traffic safety situation has also been described as a “global catastrophe” by the Red Cross.

## OBJECTIVES

The main purposes of the present thesis are as follows:

1. To study conflict observation conducted at major at-grade signalized intersections in order to evaluate the use of the Traffic Conflict Technique as a method for short-term traffic safety assessment.
2. To compare the results with regarding the data of conflict observations and police reported accidents.

### Scope of Study



**Figure 2** Road networks and study intersections of Yangon City

**Source:** JTCA (2009)

1. Three major signalized intersections, namely 8 mile intersection, Hledan intersection and Myaynigone intersection were selected for this thesis (Figure 2).

2. Conflict observation studies were carried out at three signalized intersections on Yangon-Pyay Road in Yangon City environment.

3. Most of the survey data were collected from other department such as Traffic Police Force.

### **Review Existing Conditions of the Selected Three Major Signalized Intersections**

#### **(1) 8 Mile Intersection**

This traffic site represents a four-way signalized intersection. 8 mile intersection is located at the convergence of Yangon-Pyay Road and Kabaraye Pagoda Road which is six-lane, two-way road. It is near to the Myainghaywon Park and Yangon City Hotel (Figure 3). There is a four phase signal-controlled system. The cycle length of all phases is 115 seconds. The green times for left-turn vehicles from Yangon-Pyay Road into Kabaraye Pagoda Road and straight ahead vehicles along Yangon-Pyay Road are 17 seconds and 38 seconds respectively. Likewise, the green times for left-turn vehicles from Kabaraye Pagoda Road into Yangon-Pyay Road and straight ahead vehicles along Kabaraye Pagoda Road are also 17 seconds and 38 seconds respectively. There are no pedestrian crossings and grade crossings at this intersection. There is only one pedestrian crossing without signal-controlled system near the bus stop on Yangon-Pyay Road.



**Figure 3** 8 mile intersection

**Source:** TPF (2010)

(2) Hledan Intersection

This traffic site is a five-way signalized intersection. It is located at the convergence of Yangon-Pyay Road, Insein Road and University Avenue Road. Insein Road is six-lane, two-way and University Avenue Road is four-lane, two-way. Hledan intersection is near Yangon University, Seingayhar Supermarket and Hledan Market (Figure 4). There is a three phase signal-controlled system. The cycle length of all phases is 200 seconds. Left-turn vehicles and straight ahead vehicles move simultaneously during green time of each road. There are also no pedestrian and grade crossings at this site. There is only one pedestrian crossing without signal-controlled system near Seingayhar Supermarket and Hledan Market on University Avenue Road.



**Figure 4** Hledan intersection

**Source:** TPF (2010)

### (3) Myaynigone Intersection

Myaynigone intersection is located at the meeting point of the Yangon-Pyay Road and Bargayar Road which is four-lane, two-way road. It is a four-way signal-controlled intersection. This traffic site is near Dagon Center Supermarket and Padonmar Stadium (Figure 5). There is a three phase signal-controlled system. The cycle length of all phases is 155 seconds. The green times for left-turn vehicles from Yangon-Pyay Road into Bargayar Road and straight ahead vehicles along Yangon-Pyay Road are 15 and 75 seconds respectively. But red, yellow and green time for Bargayar Road is 92, 3 and 60 seconds respectively. Left-turn vehicles and straight ahead vehicles move simultaneously during 60 seconds green time. There are also no pedestrian and grade crossings at this intersection like above described two other intersections. There are two pedestrian crossings without signal near this site. One is

near the bus station on Yangon-Pyay Road and another one is near the Dagon Center Supermarket on Bargayar Road.



**Figure 5** Myaynigone intersection

**Source:** TPF (2010)

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## **LITERATURE REVIEW**

### **1. The Science of Traffic Safety**

In relation to traffic safety studies, it has been suggested that successful research has two basic requirements: substantive knowledge of the subject under study, and skill in the pertinent techniques of investigation (Goldstein, 1963). These two pre-requisites are both necessary, and evidence of one element does not assure the presence of the other. Thus, for all studies related to traffic safety one must have a good knowledge of the world of accidents and scientific research methodology.

The substantive knowledge of traffic safety that Goldstein refers to is impossible to attain without a deeper examination and scientific criticism of the foundations of knowledge that emanate from the logic of scientific inference and its application to experimental data. This knowledge includes concepts of measurement, control, variables, manipulation and analysis, and theories related to sampling, probability, and mathematical statistics. Among the many basic disciplines related to traffic safety are psychology, sociology, physiology, political science, and most importantly different engineering disciplines and specific underlying knowledge related to areas such as modeling, systems analysis, computer science and simulation.

Thus, a multidisciplinary approach is required for the study of traffic safety and it must be realized that people are rarely experts in more than one scientific area. Multi-disciplinary co-ordination and co-operation must therefore be key aspects in all traffic safety related scientific research in order to resolve problems of a conceptual methodological nature. In his philosophically inspiring report, Goldstein identified a number of conceptual methodological problems that are “peculiar” to traffic safety research and which do not become apparent from the study of only one isolated area.

### **2. Safety Influencing Factors**

Safety influencing factors are as follows:

- (i) Speed and speed variance
- (ii) Gap-acceptance in yielding situations
- (iii) Gaps/Headway between vehicles in traffic streams (measured at a particular point in the roadway)
- (iv) Traffic flow rates (including derived measures such as saturation, density, etc.)
- (v) Frequency of red-light violations
- (vi) Relative frequencies of turning maneuvers or numbers of vehicles in simultaneous conflicting streams at intersection
- (vii) Aspects related to roadway design and traffic regulation (e.g. possibility to make left-turn maneuvers across oncoming streams of traffic)

There is an overwhelming amount of literature concerning the relationship between the above measures and traffic safety, and it is not the intention here to diverge into any exhaustive in-depth description. It is however useful to briefly emphasize the importance of such measures with regard to traffic safety research (Archer, 2004).

### **3. Accident Data Quality and Underreporting**

The quality of accident data usually refers to the relationship between the numbers of police reported road traffic accidents and the actual number of road traffic accidents. The validity and reliability of data is affected by a number of factors from the time when accidents are recorded. A particular problem already at the scene of an accident is the fact that the police rarely have the expertise required to classify the extent of the injuries incurred by those involved.

Other problems have been found with regard to the accident description and location, and lack of important information from the accident scene that can be used to help derive the reasons behind the accident. Many of the problems related to data quality have been rectified during manual and logical control checks at the time the data is registered into the accident database. Comparisons have also been made

between the police reported data and hospital data to assure data quality (Englund, *et al.* 1998; SIKa, 2003).

#### **4. Review of Historical Accident Data**

In order to establish an overview of traffic safety along a particular stretch of road or at a particular intersection it is standard procedure to examine the database containing statistics from police reported accidents. There are a number of well-known problems with this type of data, most significantly that of underreporting.

The introduction of the STRADA (Swedish Traffic Accident Data Acquisition)-database in year 2000 in Sweden was designed to overcome some of these problems by integrating data from several sources including hospital. However, it has also been decided that only accidents involving injury are to be recorded in this database, thereby eliminating important information with regard to the frequency of minor accidents that only result in property damage. Accidents of this nature are more common in the urban environment and could otherwise be used to identify potentially dangerous traffic sites before the occurrence of more serious accidents.

Despite the known problems with police reported accident data, the resulting statistics represent an important source of traffic safety information and form the basis for a great deal of the national and local traffic safety policy decisions and countermeasures strategies at the macroscopic level. At the microscopic level, these statistics (in combination with suitable measures of exposure) represent a valuable source of information and safety analyses and a basis for socio-economic calculation for traffic planning related work (SRA, 2002; SIKa, 2003).

#### **5. Traffic Conflict Technique (TCT)**

Traffic Conflict Technique (TCT) is a most modern and appropriate method applied to investigate and audit the safety in traffic. This method aims to find out the most traffic behavior of road-users. The technique has been refined through the years

and its applicability is large - not only in motorized countries but even in developing countries worldwide, primarily in urban areas.

The technique enables study of “hazards” in traffic in an uncomplicated way and to judge whether the site is dangerous after only three to five days of conflict studies, and if so, propose suitable countermeasures. It is better than waiting three to five years for sufficient statistical data.

The technique was conducted by observation at the site and camera taking of traffic flow at black spot on certain duration of time. The objectives of the conflict technique are:

- (i) To identify characteristic of accidents at the black spot including collision type, numbers of vehicle involved, vehicle type, severity, time, weather, causes of the accidents.
- (ii) To observe vehicle and pedestrian maneuvers at the black spots.
- (iii) To calculate Time-to-Accident (TA) to evaluate whether a collision is potentially dangerous or not.

Conflict survey form for description of position, time, weather, type of vehicle, type of reaction, distance to collision point, conflict level, type of conflict, direction of move, type of move, etc. were established by direct and continuous observation on certain time at specific area. Then types of conflict were marked in a conflict diagram and dangerous movements of road-users were constructed in a dangerous movement diagram. Based on distance to collision point, Time-to-Accident was calculated to define whether a collision is a potential accident or not.

The conflict technique works best in combination with other method. The paper interview survey with road-user was conducted (Trinh Thuy ANH *et al.*, 2005).

The Traffic Conflict Technique has its origins in the research conducted at the Detroit General Motors laboratory in the late 1960's for identifying safety problems

related to vehicle construction (Perkins and Harris, 1967, 1968). The approach adopted was to observe and record unsafe interactions between vehicles determined by the use of evasive action to avoid a potential collision. The potential of this technique was received enthusiastically by researchers in different parts of the world who sought to find ways to establish the relationship between conflicts and accidents. However, research soon revealed a number of fundamental weaknesses, which cast doubt and scepticism on this approach as a study of traffic safety (Cooper, 1977; Williams, 1981; Chin and Quek, 1997). Transport Research Laboratory (TRL) in England soon recognized the need to add a subjective scale for observed conflicts as a measure of severity (Spicer, 1979). This technique was based on observer judgements using time-lapse filming, thereby proving costly and time-consuming. Despite the many problems related to validity and measurement reliability, a number of other researchers proceeded with conflict experiments to establish definitions and methods for conflict measurement and analysis (Grayson *et al.*, 1984).

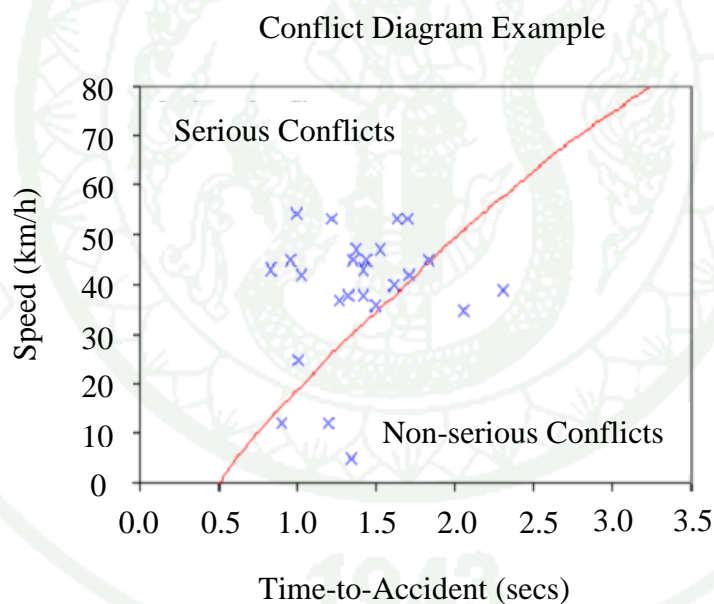
The development of the Swedish Traffic Conflict Technique was based at the University of Lund where it was refined in a number of different projects during the 1970's and 1980's before finally reaching its present level of development (Hydén, 1987). The Swedish technique, which is now generally accepted as a de facto standard in many other countries, defines a conflict as "An observable situation in which two or more road-users approach each other in time and space to such an extent that there is risk of collision if their movements remain unchanged." (Amundsen and Hydén, 1977)

Other conflict techniques were also developed parallel to the Lund version. The variance among eight different existing conflict techniques was investigated by the International Committee for Traffic Conflict Techniques (now the International Cooperation on Theories and Concepts in Traffic Safety chaired by Christer Hydén) in 1984 (Grayson, 1984).

An American study by Migletz *et al.* (1985), indicated that normal conflict studies could produce estimates of average accident frequency that were at least as

accurate as those based on historical accident data. Similarly, Svensson (1992) concluded from Swedish data that serious conflicts could provide a better estimate of the number of expected accidents involving personal injury than actual accident data.

As with the original definition by Perkins and Harris (1967), the conflict measure is determined at a point in time and space when evasive action is first taken by one of the conflicting road-users. The 'Time-to-Accident' (TA) measure is calculated using estimations of speed and distance made by trained conflict observers. In order for the TA-measure to be valid, a collision course (or actions that suggest a collision course) must be established between conflicting road-users based on the estimated speed and distance values at the point when evasive action is first taken by either party (Hydén, 1987).



**Figure 6** Distinguishing between serious and non-serious conflict events in accordance with the Traffic Conflict Technique

**Source:** Hydén (1987)

On the basis of the determined TA-value and the speed of determined road-user, the conflict event is described as 'serious' or 'non-serious' in accordance with a

non-linear function that takes into consideration the average rate of deceleration needed to avoid a collision at different speeds and a standard friction coefficient (Hydén, 1987). An illustration of the function separating serious and non-serious conflicts is illustrated above in Figure 6.

## 6. The Validity of the Traffic Conflict Technique

The validity of the Traffic Conflict Technique is most often determined by the level of statistical correlation between observed conflicts and accident data (i.e. product or predictive validity). This was considered particularly important in the early years of development in order to establish the technique as an alternative to the use of accident data. During this time, however, there were as many studies that indicated poor levels of correlation as there were studies that suggested the existence of acceptable levels of correlation (Williams, 1981).

Chin and Quek (1997) suggest that these validity problems were at least partially due to the quality and coverage of accident data. In order to resolve the validity issues, two different approaches were suggested, the first involved limiting the use of the technique to only those cases where accident data was insufficient to be of use in accident analysis, and the second involved attempts to redefine conflict concepts and measurement techniques to ensure better correlation or finding suitable explanations for the lack of correlation (Amundsen and Hydén, 1977; Zimolong, *et al.*, 1980; Hydén *et al.*, 1982).

There are a number of studies that question some of the fundamental issues related to the need for validity. Hauer (1979) opposed the very idea of predicting accidents, suggesting instead that there was a greater need to prevent accidents rather than predict them. In a later report by Hauer and Gårder (1986) it is argued that the validity of the TCT should be assessed by comparing levels of variance in the estimates of conflict and accident rates. It is suggested that the method producing the most unbiased estimate with the smallest amount of variance is that with the greatest degree of validity.

Grayson and Hakkert (1987) suggest that the question of validity should not only be confined to establishing a statistical relationship between accidents and conflicts and propose that construct validity should be established in relation to a “common causation process” that can lead to different outcomes for conflicts and accidents rather than measures of validity based on a comparison between these two data-sets. This suggests that validity should be determined by how well safety analysis based on the TCT can identify and evaluate operational deficiencies and improvements. Oppe (1986), has further suggested the need to classify conflicts and accidents according to maneuver type and severity level in order to make comparisons relevant to validity.

In light of the uncertainties in relation to the quality of accident and conflict data, Chin and Quek (1997) suggest that it may be a futile and unnecessary exercise to establish a statistically significant relationship to justify the use of the TCT, particularly where it is used as a diagnostic and evaluative instrument rather than for accident prediction. This argument emphasizes the need for proximal safety indicators, to be useful in their own right without the need for validation against measures of accident occurrence. Arguably, the long-standing tradition of using accident data as a measure of safety has established its general acceptability and largely unquestioned validity. While this situation prevails, studies by Migletz and colleagues (1985) and Svensson (1992), have indicated that conflict studies can produce estimates of accident occurrence that are as good as, or better than, those based on accident data (and require a considerably shorter data-collection time-period).

## **7. The Reliability of the Traffic Conflict Technique**

The methodology of the Traffic Conflict Technique has been heavily criticized for relying on the subjective judgment of speed and distance by trained observers (Hauer and Gårder, 1986). This subjectivity allows for the possibility of unreliable measurements, although it has been suggested that such uncertainties can be accounted for by the use of various statistical techniques (Chin and Quek, 1997).

Two types of reliability problem have been identified. The first, intra-observer reliability is related to the variability in the recordings of an individual observer, and the second, inter-observer reliability, is related to the variability between different observers. The inconsistencies of an individual observer can be attributed to a number of factors including: lack of training, inadequate definitions of the situations to be observed, fatigue, excessive numbers of conflicts, and the occurrence of complex conflict types (Older and Spicer, 1976; Chin and Quek, 1997). The use of manuals and adequate training programs can be used to remedy some of these problems, and video-recordings can be used to verify more difficult conflict scenarios (Hauer, 1987; Glauz and Migletz, 1980; FHWA, 1989). Research has shown that observers can provide good estimates of speed and distance with small margins of error (Hydén, 1987).

The problems found at the individual level are likely to be emphasized in comparisons between individuals or groups of observers. In the large-scale comparison of different Traffic Conflict Techniques reported by Grayson and colleagues (1984), on-site video-recordings were made in addition to the conflict observations. As mentioned previously, the results of this study showed variations in the frequencies of conflicts observed by different teams although the rank ordering according to severity was found to be consistent.

Differences in conflict detection rates were found in the comparison study by Grayson and colleagues (1984) that were affected by the way in which the conflicts were defined and observed. In particular, detection was found to be more difficult and therefore also more variant in relation to conflicts with lower levels of severity. Chin and Quek, (1997) suggest that even where conflicts are well defined and observers are well trained; the subjective observations of conflicts may still result in a good deal of variation among observers.

The reliability of conflict measures can be improved by the use of objectively defined measures to verify difficult and complex conflict situations, for example, through processes involving video-analysis. A number of alternative proximal safety

indicators such as Time-to-Collision and Post-Encroachment Time are largely dependent on photometric techniques rather than on-site observation. The use of video-analysis, while allowing events to be repeatedly observed, has certain disadvantages related to the limited coverage and quality of the two dimensional imagery, which makes the identification of safety critical events considerably more difficult (Hallert, 1964; Van der Horst, 1990; Hydén, 1996; Hupfer, 1997).

### **8. Police Reported Accident and Conflict Observation Data**

The frequency of serious traffic conflicts observed in accordance with the Traffic Conflict Technique can be used to estimate the expected number of police reported accidents at a given traffic location. This process has been described by Hydén (1987). The first step, involves calculating an equivalent period of exposure for both accidents and serious conflicts. It is important here, to take into consideration the time-periods and days during which conflict observation was performed. It may be necessary, for example to exclude accidents occurring during evening and night hours and during weekend days. Given an equivalent number of hours (which ideally represent a one-year period), a quotient can be calculated between police reported accidents and conflict occurrence. Hydén also points to the fact that severity distributions of accidents and conflicts are different, i.e. most accidents correspond to relatively severe conflicts with heavy changes in acceleration (and/or swerving) while conflicts are generally abated well before the potential collision event and therefore involve lower average changes in acceleration.

The difference between the two severity distributions might be taken to imply that only common levels of severity should be compared. However, this type of data is not readily available from accident data. In a validation project by Hydén in 1982 (Grayson, 1984), an approximate ratio between police reported accidents and serious conflicts for vehicle-vehicle interactions was found to be 1:7500. This was based on seven years of accident data from 115 different locations and conflict studies from 109 different sites with between 12 and 6 hours conflict study per site. Similarly, the ratio for vehicle-cycle accidents and conflicts was found to be 1:4400, and the ratio

for vehicle-pedestrian accidents and conflicts was 1:4880. For accidents and conflicts involving vehicles and vulnerable road-users, the ratios increased disproportionately when compared to vehicle-vehicle accidents suggesting greater vulnerability for this class of road-users.

In his discussion regarding product validity, Hydén also presents data that compares the numbers of serious conflicts per hour recorded on major arterial streets in different towns around the world, against the number of fatalities per year in direct proportion to the city population. Using Gothenburg data as an index value, a high level of consistency was found between the ratios of serious conflicts per hour and number of fatalities per year and population.

## MATERIALS AND METHODS

### Materials

PC-Computer with CPU speed 2.0 GHz and 1.99 GB of RAMS

### Methods

#### 1. Literature Review

The conflict observation data and police reported accidents data were collected and analyzed to assess, predict, and improve traffic safety at major signalized intersections on the same road. The facts concerned with the traffic safety, Traffic Conflict Technique, and conflict observation based on vehicle and pedestrian flows were studied and followed according to the literature review.

#### 2. Conflict Observation

A review of the accident data obtained from police reports, revealed three major intersections along Yangon-Pyay Road with a comparatively poor safety record. These intersections, all signalized and situated in the southern section of the road, include the following:

- (1) 8 mile
- (2) Hledan
- (3) Myaynigone

In order to ascertain the current safety situation at each of these major signalized intersections conflict observation studies based on the vehicle and pedestrian flows were carried out in accordance with the Traffic Conflict Technique. A conflict observation study was undertaken to establish safety impact.

A total of 16 hours conflict observation was carried out at each site. Four trained and experienced conflict observers were used for data collection at these intersections. Three different accident estimations were made, one reflecting vehicle-vehicle conflicts (exclusive rear-end collisions), one for vehicle-vehicle conflicts (rear-end collisions), and one for vehicle-pedestrian conflicts. Other safety relevant observations, such as red-light violations, problems with parked vehicles, illegal turning maneuvers, etc., were also noted during the designated observation periods at each site.

In an attempt to minimize inter-observer bias, a rotation scheme was designed whereby each observer would record conflicts for four-hours (maximum total observation time per day) at each of the three sites. The time-periods for the observation studies at a particular site were also varied from day-to-day in order to include both morning and evening peak periods. These intersections mentioned above were studied during the same week.

Prior to conflict observation, observer-accuracy in relation to speed and distance judgment was tested using a calibrated speed-radar device.

### **3. Traffic Conflict Technique**

Traffic Conflict Technique was used as a suitable proximal safety measure to evaluate the situation at three major at-grade signalized intersections along Yangon-Pyay Road. The theoretical issues described concern issues related to the use of the Traffic Conflict Technique and most important aspects related to its validity and reliability as an indicator of traffic safety.

### **4. Conduct Traffic Conflict Technique**

Traffic Conflict Technique was conducted by conflict observation studies of the traffic flows at each of three traffic sites or intersections in order to ascertain the current safety situation. This method requires no complicated equipment and makes

advantage of simple application. The field survey was conducted during 4 days conflict observation, from 8 am to 10 am during morning peak hours and from 5 pm to 7 pm during evening peak hours. One of the observers collected conflict observation data during 4 hours per day at each intersection. So, a total of 16 hours conflict observation data was gathered by four trained and experienced observers at each intersection.

Traffic Conflict Technique form or conflict observation form was constructed to identify location or intersection, date, time, weather, vehicle type, vehicle movement, conflict type, and conflict level, etc (see appendix, Table A1). Conflict observation data collected from this study was filled up by using signs for interpretation including vehicle type, reaction type, movement type, conflict level, and conflict type, etc. (see appendix, Table A2). Based on distance to potential point of collision and vehicle speed when the evasive action is taken, Time-to-Accident was calculated to determine whether conflict is dangerous or not. Then all of this information was marked in conflict diagram and figure for location of different types of serious conflicts.

The conflict technique works best in combination with other method, and data collection of police reported accidents were conducted.

## **5. Time-to-Accident**

Serious conflicts are in the same way as traffic accidents, the result of a breakdown in the interaction between the road-user, environment and vehicle. The necessary evasive action is usually braking, but may also be swerving or acceleration, or a combination of these. The border between serious and slight conflicts (non-serious conflicts) is showed in Figure 7.

The time is remaining from when the evasive action is taken until the collision would have occurred if the road-users had continued with unchanged speeds and

directions. The TA-value can be calculated based on estimates of distances D and speed V which are estimated by the conflict observer.

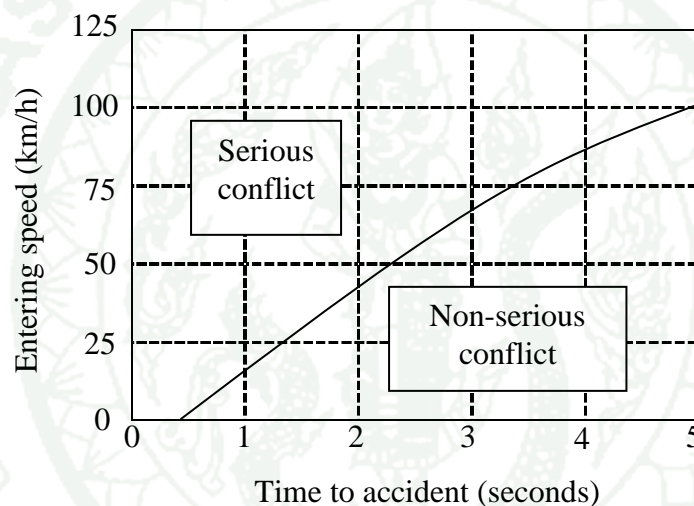
$$TA=D/V \quad (1)$$

Where:

TA= Time-to-Accident

D = Distance to potential point of collision

V = Speed when the evasive action is taken (Trinh Thuy ANH, *et al.*, 2005)



**Figure 7** Serious and slight conflict (non-serious conflict) based on Time-to-Accident

**Source:** Trinh Thuy ANH *et al.* (2005)

## 6. Police Reported Accident Data

The data were collected from other department such as Traffic Police Force to obtain information regarding the details of each accident, including: the type of accident (e.g. rear-end, crossing, turning, signal), the number of people injured, the exact location of the accident, and short descriptions of the event. The data of

accidents occurring at each intersection during the five-year period between 2006-2010 were collected.



## RESULTS AND DISCUSSION

### 1. Estimation of Vehicle and Pedestrian Flows

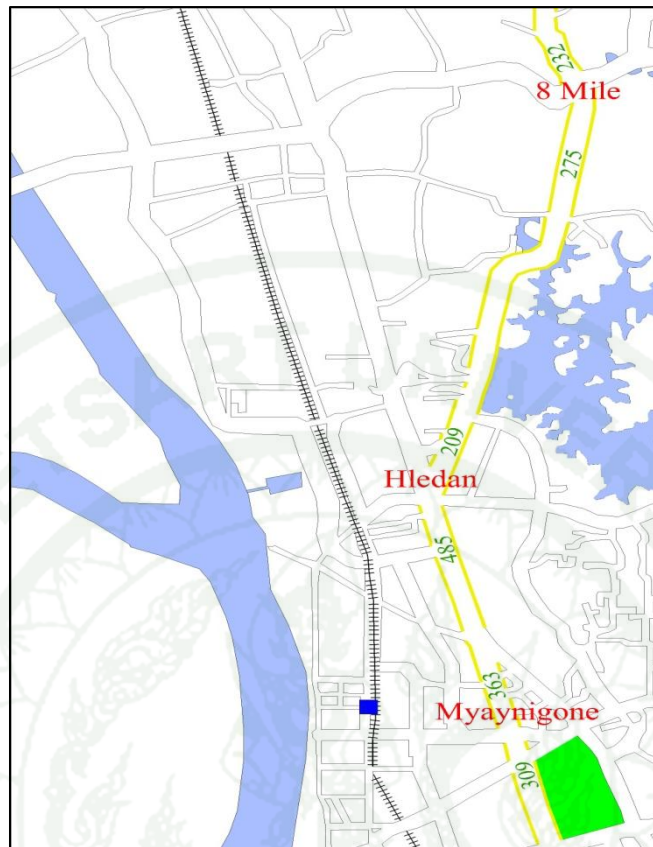
The flow rates for vehicles, and pedestrian volumes were measured during the peak time-periods (08:00-10:00 a.m. and 17:00-19:00 p.m.). North-South direction represents Yangon-Pyay Road at each intersection. Furthermore, Insein Road is represented as North-South direction at Hledan intersection, shown in Table 1.

**Table 1** Vehicle and pedestrian flow rates at three intersections on Yangon-Pyay Road in Yangon City

Intersection	Direction	Vehicles (veh/hr)	Pedestrians (ped/hr)
8 Mile	North-South	275-232	245
	East-West	188-203	168
Hledan	North-South	267-209	315
	North-South (Insein Road)	218-174	225
Myaynigone	East-West	123-120	200
	North-South	309-363	263
	East-West	200-183	173

#### Vehicle Traffic

The speed along Yangon-Pyay Road in Yangon City environment is 40 km/h. Both northern and southern sections have six lanes in both directions of travel. Most of the major intersections are regulated by traffic signals, but some minors are unsignalized intersections. The vehicle traffic at three intersections on Yangon-Pyay Road is illustrated below in Figure 8.

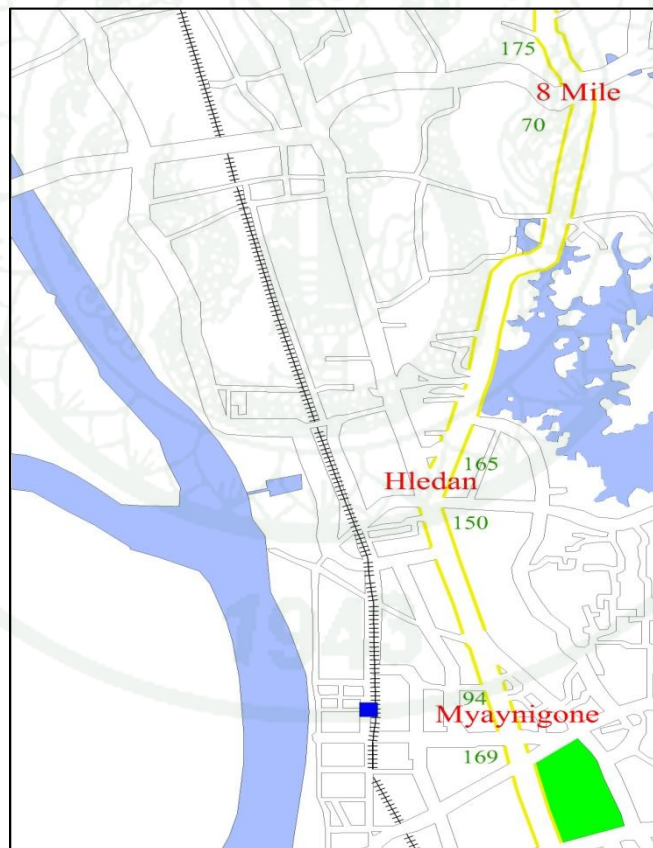


**Figure 8** The flow rate for vehicle traffic at three intersections on Yangon-Pyay Road during Time Periods 08:00-10:00 a.m. and 17:00-19:00 p.m.

The flow rate varies between 275-232 vehicles/hr on the northern side of Yangon-Pyay Road due to the vehicles entering and leaving via the 8 mile intersection. The flow rate varies between 267-209 and 309-363 vehicles/hr on the southern section of this road due to the vehicles entering and leaving via the intersections of Hledan and Myaynigone. The flow rate 267 vehicles/hr from north-south direction of Yangon-Pyay Road are added to the flow rate 218 vehicles/hr from north-south direction of Insein Road at Hledan intersection. Approximately 20 per cent of the total traffic volume is categorized as heavy traffic including buses. Earlier measurements indicate that a maximum traffic flow rate (i.e. the peak hours) is attained during the time-period 8:00-10:00 a.m. and 17:00-19:00 p.m..

### Pedestrian Traffic

In addition to the large volume of vehicle traffic, there are also a considerable number of pedestrians on Yangon-Pyay Road. The pedestrian traffic is particularly noticeable at the crossings on this road where the pedestrian flows are often in excess of 600 during the morning and evening peak hour. There are pedestrian crossings without signal near the bus stop on this road. Pedestrian crossings are not situated on transverse road and adjoining side roads immediately after the stop lines at intersections. Measurements carried out by observers indicate that as many as 5000 pedestrians cross Yangon-Pyay Road during the four hours covered by time-periods 8:00-10:00 a.m., 17:00-19:00 p.m. (Figure 9).



**Figure 9** The flow rate for pedestrian traffic at three intersections on Yangon-Pyay Road during Time Periods 08:00-10:00 a.m. and 17:00-19:00 p.m.

## 2. Results

Results from the conflict observation study for each intersection are described in detail below. The conflict observation results for each intersection are compared with the police reported accident data maintained by Police Traffic Force. In the last section of the results, a comparison of the intersections is made and the predictive ability of the Traffic Conflict Technique is assessed. Inter-observer variance based on the three separate conflict studies is also considered.

### (1) 8 mile Intersection

#### Time-to-Accident

Among 26 observed conflicts from the 16 hours at 8 mile intersection, 19 conflicts were serious conflict and 7 conflicts were non-serious conflict with TA calculated in Table 2.

**Table 2** Time to accident calculated for 26 observed conflicts at 8 mile intersection

Conflict	Distance to potential point of collision (m)	Speed when the evasive action is taken (km/h)	Time to accident (seconds)	Level of conflict
1	5	25	0.7	Serious conflict
2	7	30	0.8	Serious conflict
3	8	20	1.4	Non-serious conflict
4	6	25	0.9	Serious conflict
5	8	35	0.8	Serious conflict
6	15	35	1.5	Serious conflict
7	10	25	1.4	Non-serious conflict
8	8	30	1.0	Serious conflict

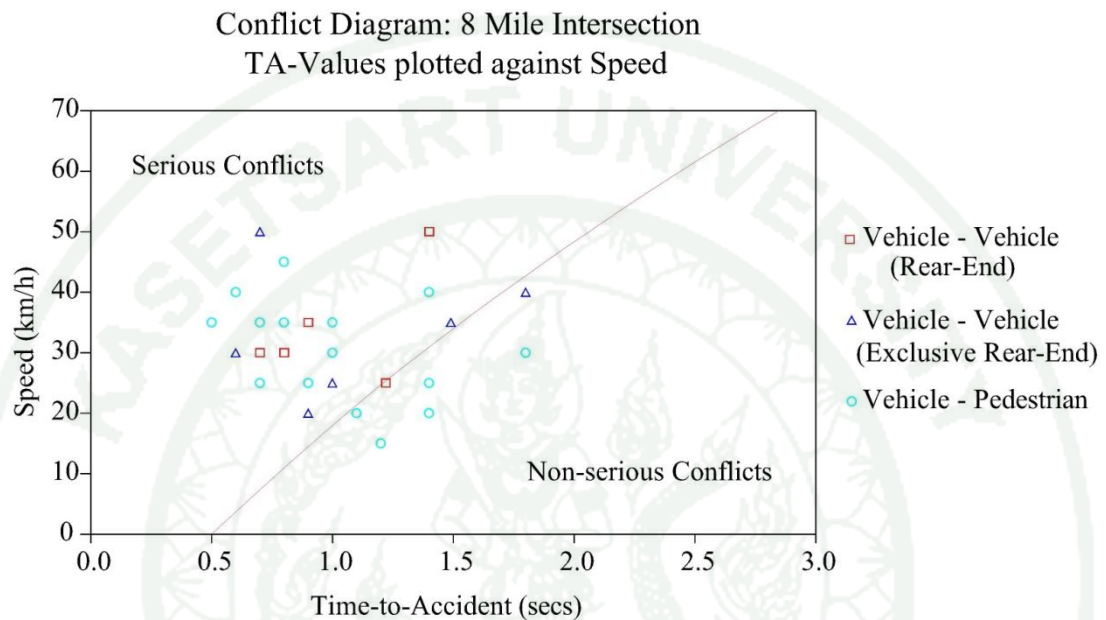
**Table 2** (Continued)

Conflict	Distance to potential point of collision (m)	Speed when the evasive action is taken (km/h)	Time to accident (seconds)	Level of conflict
9	10	35	1.0	Serious conflict
10	7	25	1.0	Serious conflict
11	6	20	1.1	Non-serious conflict
12	5	20	0.9	Serious conflict
13	9	35	0.9	Serious conflict
14	8	25	1.2	Non-serious conflict
15	6	30	0.7	Serious conflict
16	5	35	0.5	Serious conflict
17	20	40	1.8	Non-serious conflict
18	15	40	1.4	Serious conflict
19	7	35	0.7	Serious conflict
20	5	30	0.6	Serious conflict
21	15	30	1.8	Non-serious conflict
22	20	50	1.4	Serious conflict
23	10	45	0.8	Serious conflict
24	5	15	1.2	Non-serious conflict
25	7	40	0.6	Serious conflict
26	10	50	0.7	Serious conflict

#### Conflict Observation Results

The results from the 16 hours of conflict observation at 8 mile intersection are shown below in Figure 10. This figure is the standard conflict diagram that distinguishes among serious and non-serious conflicts with severity increasing

perpendicular to the dividing line. The diagram also identifies three main types of conflicts; vehicle-vehicle conflicts that are rear-end events and are not rear-end events, and conflicts involving vulnerable road-users (i.e. pedestrians).



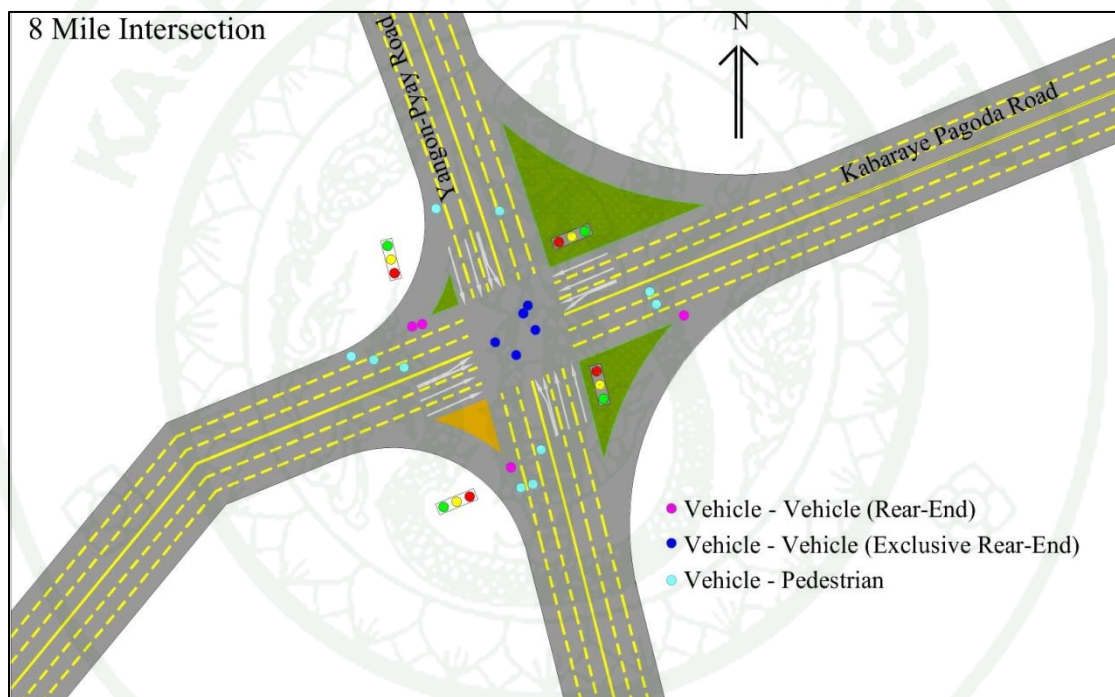
**Figure 10** Conflict diagram for 8 mile intersection

A total of 19 serious and 7 non-serious conflicts were observed at this intersection. The serious conflicts included 10 incidents with pedestrians, four vehicle-vehicle rear-end serious conflicts and five vehicle-vehicle exclusive rear-end serious conflicts. Conflicts with pedestrians were most predominant, representing 53 percent of the total. The vehicle-pedestrian conflicts occurred when pedestrians cross through the roads without pedestrian crossings and grade crossings against the traffic signal. A problem for pedestrians that go against the green time of traffic signal is caused by the speed of vehicles entering this intersection.

During green time, the vehicle-vehicle conflicts occurred when straight ahead vehicles moved from Yangon-Pyay Road and met with left-turn vehicles moved from this road in opposite direction. Likewise, the vehicle-vehicle conflicts occurred when

straight ahead vehicles from Kabaraye Pagoda Road met with left-turn vehicles moving from this road in opposite direction.

The conflict diagram indicates the generally low speed involved in most conflicts, with the vast majority under 35 km/h. The most serious incident involved insufficient pedestrian crossings, pedestrian crossings without signal-controlled system, and causing a vehicle with high speed to break heavily. The locations of the serious conflicts occurring at this intersection are shown in Figure 11 below.



**Figure 11** Location of different types of conflicts occurring at 8 mile intersection

#### Other Safety Relevant Observations

Observations at this site indicated that there were a number of vehicle red-light violations. The exact proportion of vehicles driving against red is particularly difficult to observe given the size of this intersection and the (single) observation point. A total of four clear-cut cases were noted during four hours of observation. A far greater problem with regard to both accessibility and traffic safety was caused by the

incidence of left-turning vehicles from the southbound Yangon-Pyay Road approach into Kabaraye Pagoda Road. A total of 15 cases were registered during four hours of observation. Left-turn maneuvers from the other direction were also noted, though these were less frequent.

A problem mentioned earlier, is caused by the free way that allows right-turns from the northbound Yangon-Pyay Road approach into Kabaraye Pagoda Road. There was insufficient parking area around Myainghaywon Park and Yangon City Hotel during observation. Therefore, traffic congestions occurred during morning and evening peak hours.

There are no pedestrian and grade crossings at this intersection. Pedestrian crossing without signal is situated near the bus-stop on Yangon-Pyay Road. A high frequency of red-light violations was also noted for pedestrians.

During the main morning and evening peak, the intersection becomes blocked causing accessibility and traffic safety problems. The occurrence of blocking is however, sporadic and does not occur during each signal cycle when the traffic volume is excessive. As mentioned above, this blocking resulted in a number of conflict incidents.

## (2) Hledan Intersection

### Time-to-Accident

Among 45 observed conflicts from the 16 hours at Hledan intersection, 29 conflicts were serious conflict and 16 conflicts were non-serious conflict with TA calculated in Table 3.

**Table 3** Time to accident calculated for 45 observed conflicts at Hledan intersection

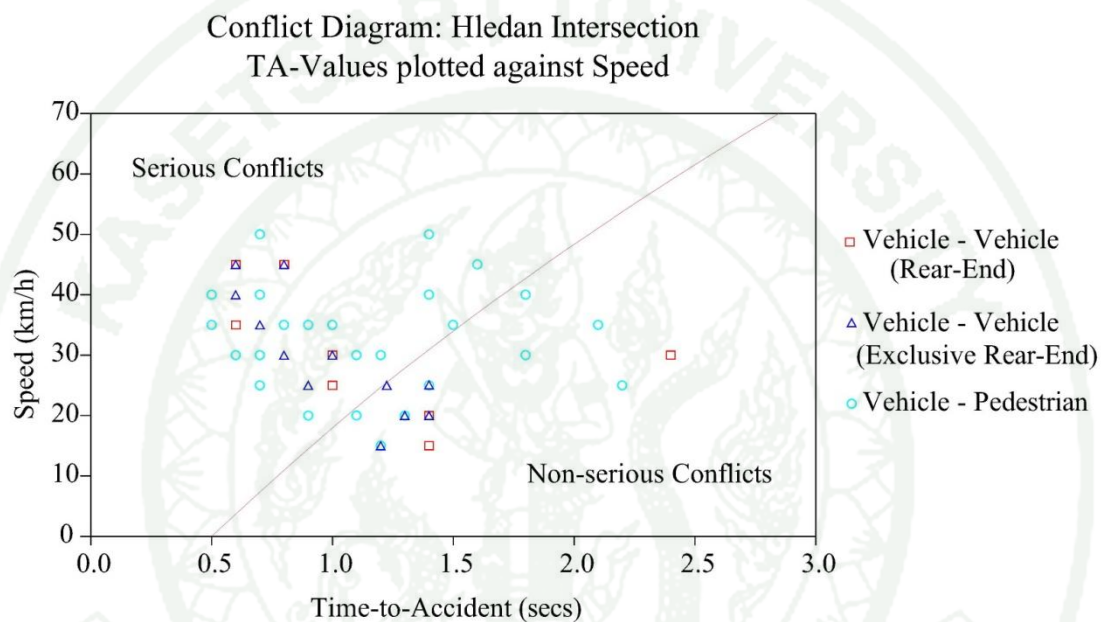
Conflict	Distance to potential point of collision (m)	Speed when the evasive action is taken (km/h)	Time to accident (seconds)	Level of conflict
1	8	20	1.4	Non-serious conflict
2	6	25	0.9	Serious conflict
3	15	40	1.4	Serious conflict
4	6	15	1.4	Non-serious conflict
5	7	20	1.3	Non-serious conflict
6	8	40	0.7	Serious conflict
7	5	15	1.2	Non-serious conflict
8	10	45	0.8	Serious conflict
9	7	25	1.0	Serious conflict
10	6	35	0.6	Serious conflict
11	8	30	1.0	Serious conflict
12	10	25	1.4	Non-serious conflict
13	5	35	0.5	Serious conflict
14	9	30	1.1	Serious conflict
15	20	40	1.8	Non-serious conflict
16	5	30	0.6	Serious conflict
17	7	20	1.3	Non-serious conflict
18	20	45	1.6	Serious conflict
19	15	30	1.8	Non-serious conflict
20	5	20	0.9	Serious conflict
21	8	45	0.6	Serious conflict
22	10	45	0.8	Serious conflict
23	20	50	1.4	Serious conflict
24	20	35	2.1	Non-serious conflict

**Table 3** (Continued)

Conflict	Distance to potential point of collision (m)	Speed when the evasive action is taken (km/h)	Time to accident (seconds)	Level of conflict
25	7	40	0.6	Serious conflict
26	15	25	2.2	Non-serious conflict
27	7	45	0.6	Serious conflict
28	10	30	1.2	Serious conflict
29	8	20	1.4	Non-serious conflict
30	9	35	0.9	Serious conflict
31	5	25	0.7	Serious conflict
32	10	25	1.4	Non-serious conflict
33	10	35	1.0	Serious conflict
34	7	35	0.7	Serious conflict
35	6	20	1.1	Non-serious conflict
36	10	50	0.7	Serious conflict
37	8	25	1.2	Non-serious conflict
38	7	30	0.8	Serious conflict
39	20	30	2.4	Non-serious conflict
40	8	35	0.8	Serious conflict
41	6	30	0.7	Serious conflict
42	8	30	1.0	Serious conflict
43	5	15	1.2	Non-serious conflict
44	6	40	0.5	Serious conflict
45	15	35	1.5	Serious conflict

### Conflict Observation Result

The results from the 16 hours of conflict observation at Hledan intersection are shown in Figure 12 with conflict diagram which identifies three main types of conflict.



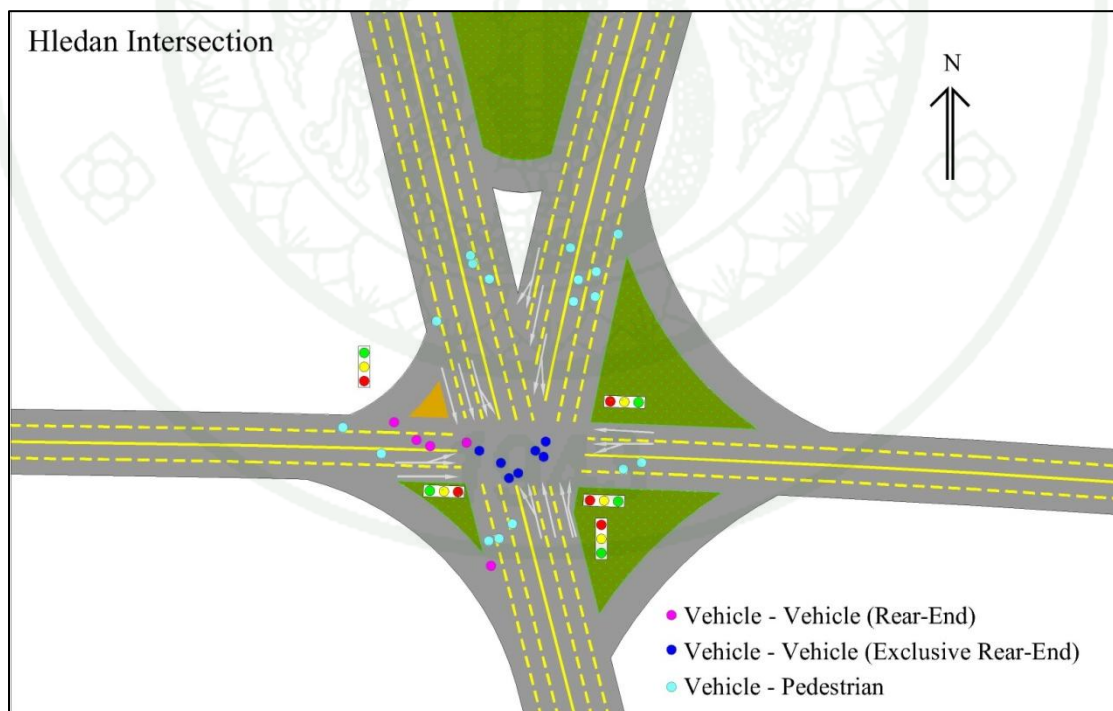
**Figure 12** Conflict diagram for Hledan intersection

A total of 29 serious and 16 non-serious conflicts were observed. Pedestrians were involved in 17 of the serious conflicts. Furthermore, there were 5 vehicle-vehicle rear-end serious conflicts and 7 vehicle-vehicle exclusive rear-end serious conflicts. Conflicts involving pedestrians were again most predominant, representing 59 percent of the total. The vehicle-pedestrian conflicts occurred when pedestrians cross through the roads without pedestrian crossings and grade crossings against the traffic signal. Serious pedestrian conflicts were noted on three roads at this intersection. Most especially, vehicle-pedestrian conflicts mainly occurred on Yangon-Pyay Road. A particular problem that resulted in five vehicle-pedestrian conflicts involved vehicles from the eastbound approach on University Avenue Road turning left into Yangon-

Pyay Road and vehicles from the northbound approach moving straight ahead on Yangon-Pyay Road.

The vehicle-vehicle conflicts occurred when straight ahead vehicles moved from Yangon-Pyay Road and met with left-turn vehicles which moved from this road in opposite direction. Likewise, the vehicle-vehicle conflicts occurred when straight ahead vehicles moved from University Avenue Road and met with left-turn vehicles which moved from this road in opposite direction.

The conflict diagram indicates the generally low speed involved in most conflicts, with the vast majority under 35 km/h. The most serious incident involved insufficient pedestrian crossings, pedestrian crossings without signal-controlled system, and causing a vehicle with high speed to break heavily. The locations of the serious conflicts occurring at this intersection are shown in Figure 13 below.



**Figure 13** Location of different types of conflicts occurring at Hledan intersection

### Other Safety Relevant Observations

Observations at this traffic site or intersection indicated a suspected high number of vehicle red-light violations from the exits of Insein Road and University Avenue Road. No red-light violations were observed at the stop lines on Yangon-Pyay Road at this intersection. Red-light violations were also a problem on the pedestrian crossing, which represented the only place to cross the street for several hundred meters in either direction. No red-light violations were recorded for other road-users.

A far greater problem with regard to both accessibility and traffic safety was caused by the incidence of left-turning and straight ahead vehicles from the southbound Yangon-Pyay Road approach into University Avenue Road and Insein Road, respectively. A total of 25 cases were registered during observation periods. Left-turn maneuvers from the other direction were also noted, though these were less frequent.

Other important safety relevant observations include the occurrence of parked vehicles beside University Avenue Road in the directions of eastbound and westbound. There are insufficient parking areas surrounding the Seingayhar Supermarket and Hledan Market in the westbound direction and Yangon University in the eastbound direction of University Avenue Road.

A further problem is represented by the position of the pedestrian crossing without signal-controlled system in all the directions at this intersection. Pedestrian crossings are situated near Seingayhar Supermarket and Hledan Market. A high frequency of red-light violations was also noted for pedestrians.

During the morning and evening peak hours, the intersection becomes blocked causing the problems of accessibility and traffic safety. The occurrence of blocking is however, sporadic and does not occur during each signal cycle when the traffic

volume is excessive. As mentioned above, this blocking resulted in a number of conflict incidents.

### (3) Myaynigone Intersection

#### Time-to-Accident

Among 31 observed conflicts from the 16 hours at Myaynigone intersection, 21 conflicts were serious conflict and 10 conflicts were non-serious conflict with TA calculated in Table 4.

**Table 4** Time to accident calculated for 31 observed conflicts at Myaynigone intersection

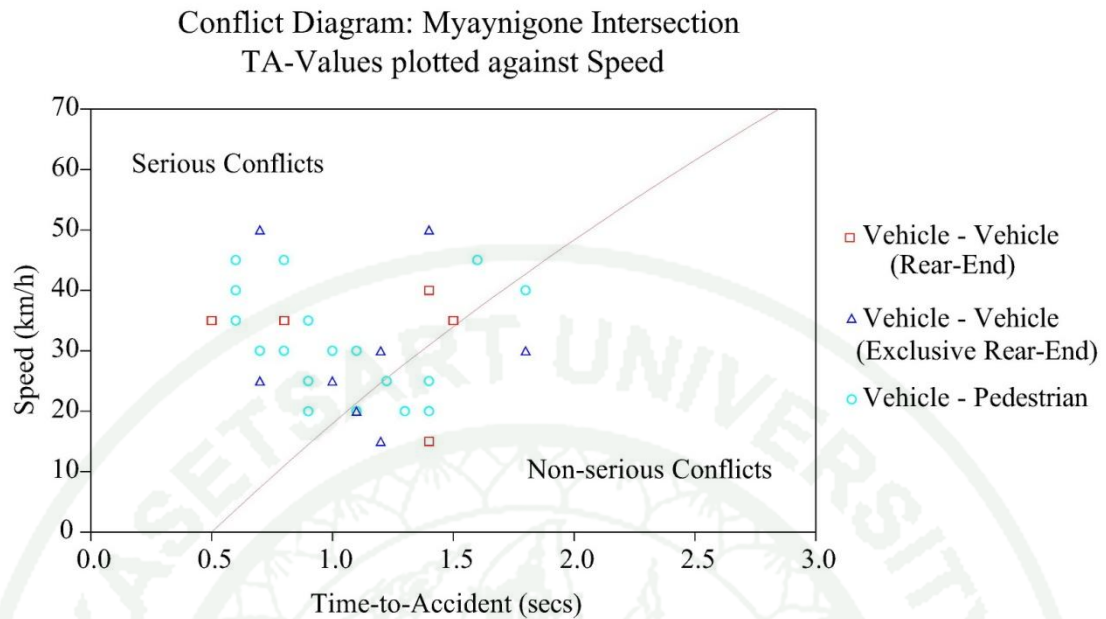
Conflict	Distance to potential point of collision (m)	Speed when the evasive action is taken (km/h)	Time to accident (seconds)	Level of conflict
1	6	35	0.6	Serious conflict
2	10	45	0.8	Serious conflict
3	15	40	1.4	Serious conflict
4	10	25	1.4	Non-serious conflict
5	20	50	1.4	Serious conflict
6	8	30	1.0	Serious conflict
7	20	40	1.8	Non-serious conflict
8	6	15	1.4	Non-Serious conflict
9	9	30	1.1	Serious conflict
10	15	30	1.8	Non-serious conflict
11	7	20	1.3	Non-Serious conflict
12	20	45	1.6	Serious conflict
13	15	35	1.5	Serious conflict

**Table 4** (Continued)

Conflict	Distance to potential point of collision (m)	Speed when the evasive action is taken (km/h)	Time to accident (seconds)	Level of conflict
14	5	15	1.2	Non-serious conflict
15	5	35	0.5	Serious conflict
16	6	25	0.9	Serious conflict
17	10	30	1.2	Serious conflict
18	6	20	1.1	Non-serious conflict
19	7	40	0.6	Serious conflict
20	8	35	0.8	Serious conflict
21	5	20	0.9	Serious conflict
22	8	20	1.4	Non-serious conflict
23	10	50	0.7	Serious conflict
24	9	35	0.9	Serious conflict
25	7	25	1.0	Serious conflict
26	6	30	0.7	Serious conflict
27	8	25	1.2	Non-serious conflict
28	5	25	0.7	Serious conflict
29	7	30	0.8	Serious conflict
30	6	20	1.1	Non-serious conflict
31	7	45	0.6	Serious conflict

#### Conflict Observation Results

The results from the 16 hours of conflict observation at Myaynigone intersection are shown in Figure 14 with conflict diagram which identifies three main types of conflict.



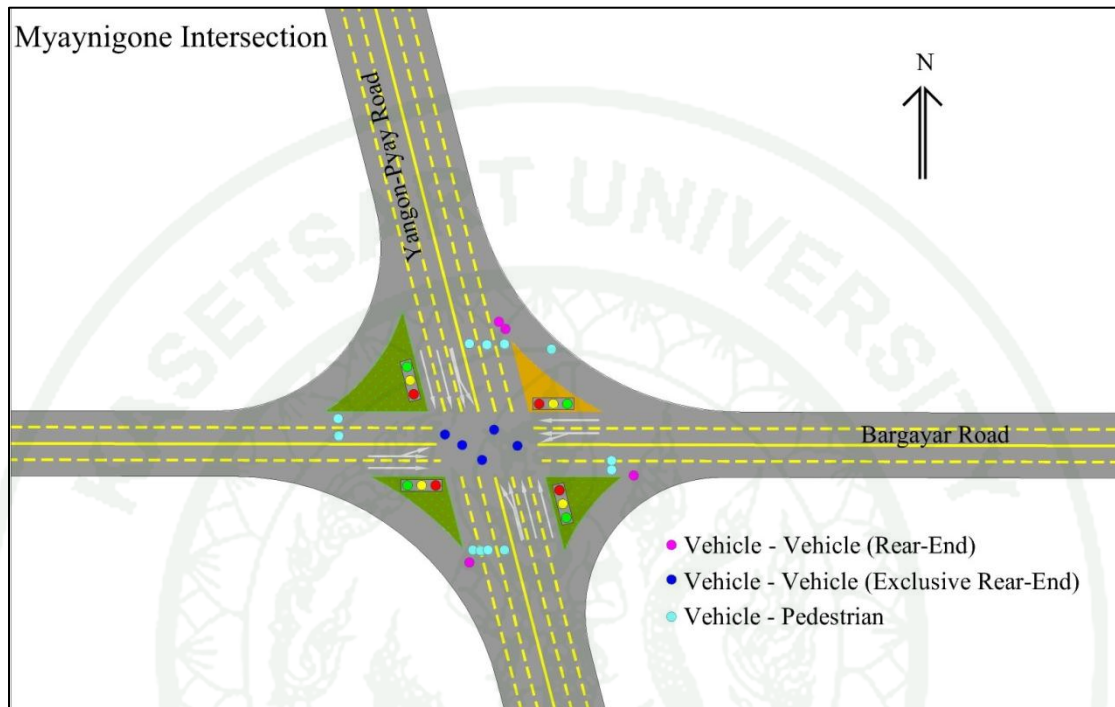
**Figure 14** Conflict diagram for Myaynigone intersection

12 of the serious conflicts involved pedestrians, four of these vehicle-vehicle rear-end conflicts and five of these vehicle-vehicle exclusive rear-end conflicts. Conflicts with pedestrians were most predominant, representing 57 percent of the total. The vehicle-pedestrian conflicts occurred when pedestrians cross through the roads without pedestrian crossings and grade crossings against the traffic signal. A problem for pedestrians that go against the green time of traffic signal is caused by the speed of vehicles entering this intersection.

During green time, the vehicle-vehicle conflicts occurred when straight ahead vehicles moved from Yangon-Pyay Road and met with left-turn vehicles which moved from this road in opposite direction. Likewise, the vehicle-vehicle conflicts occurred when straight ahead vehicles moved from Bargayar Road and met with left-turn vehicles which moved from this road in opposite direction.

The conflict diagram indicates the generally low speed involved in most conflicts, with the vast majority under 35 km/h. The most serious incident involved insufficient pedestrian crossings, pedestrian crossings without signal-controlled

system, and causing a vehicle with high speed to break heavily. The locations of the serious conflicts occurring at this intersection are shown in Figure 15 below.



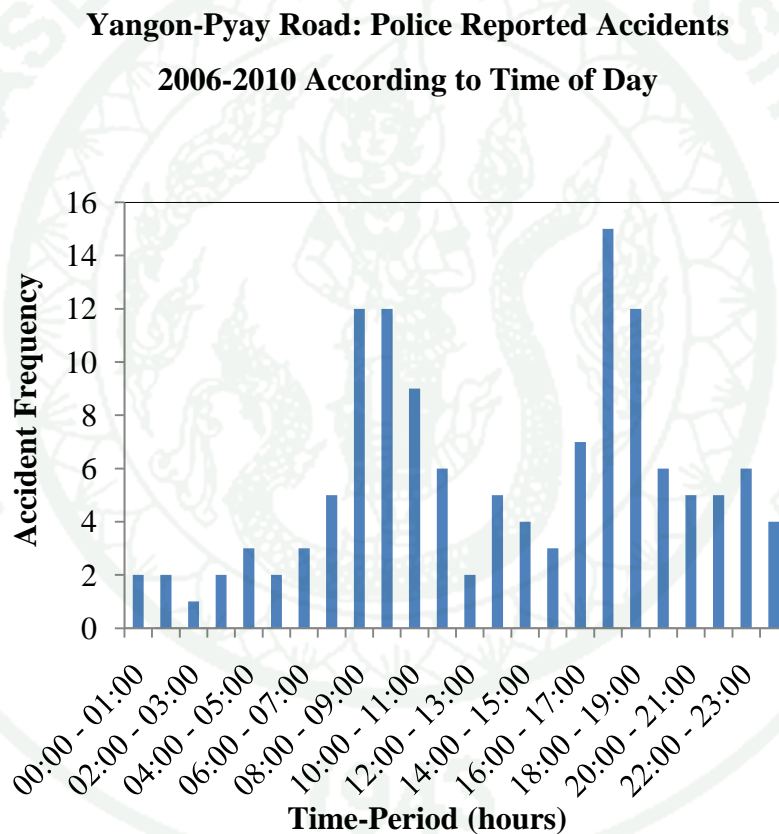
**Figure 15** Location of different types of conflicts occurring at Myaynigone intersection

#### Other Safety Relevant Observations

Observations at this traffic site also indicated a number of vehicle red-light violations. Nine clear-cut cases were noted during one of the six-hour of observation periods, although the actual figure is likely to be significantly higher. A high frequency of red-light violations was also noted for both pedestrians and drivers, many of these resulting in serious conflicts. A particular problem at this intersection was parked vehicles that greatly restricted accessibility for heavy goods vehicles and buses.

### 3. Police Reported Accident Data

During the period 2006 to 2010, there have been 133 traffic accidents along Yangon-Pyay Road in Yangon City environment reported to the police. These accidents have resulted in 35 serious injuries and 140 injuries of a less serious nature. These figures suggest that an average of 28 people per year is injured on this road, and that 7 people suffer injuries of a more serious nature. 5 fatalities have been recorded during this five-year period.

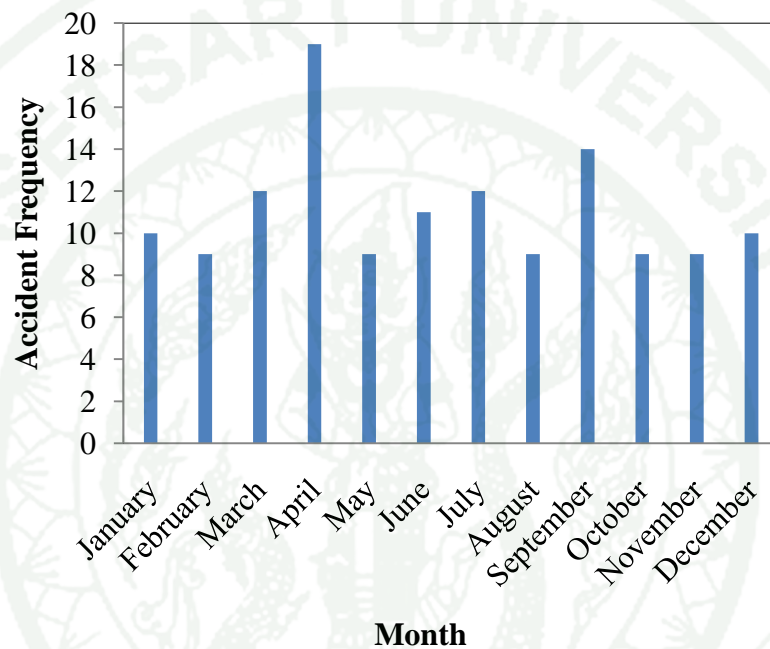


**Figure 16** Police reported accidents 2006-2010 according to time of day on Yangon-Pyay Road in Yangon City environment

The accident statistics also indicate that the majority of injury related accidents occur during the morning peak between the hours 8:00 to 10:00 a.m. and evening peak between the hours 5:00 to 7:00 p.m. when traffic volumes are also at

their peak (Figure 16). Monthly accident variation indicates that there is a peak in April (Figure 17).

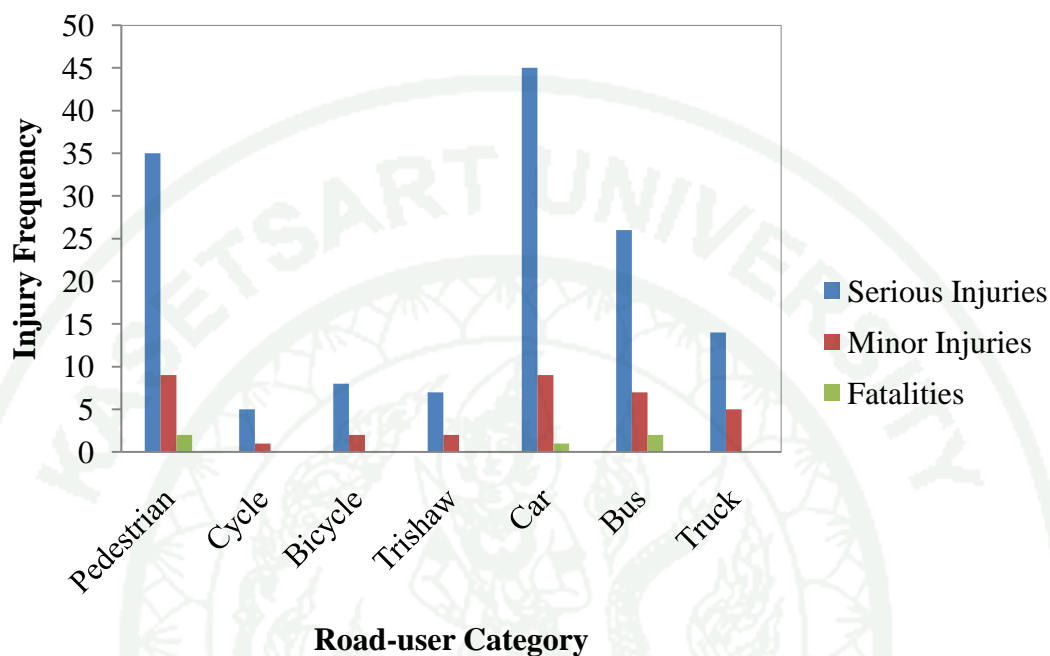
**Yangon-Pyay Road: Police Reported Accidents  
2006-2010 According to Month of Year**



**Figure 17** Police reported accidents 2006-2010 according to month of year on Yangon-Pyay Road in Yangon City environment

The most common type of traffic accident on Yangon-Pyay Road in Yangon City environment involves private cars usually in combination with other cars, or alternatively with pedestrians or buses (Figure 18). Minor injuries involving private cars and pedestrians account for approximately one-third and one-fourth of the total number. However, serious injuries for private cars and pedestrians occurred in one-third of the total number of serious injuries. The most common types of accidents involving private cars are exclusive rear-end, followed by accidents that involve left-turns (i.e. across opposing streams of traffic), and so-called “single” accidents that involve only one vehicle and the occupants thereof.

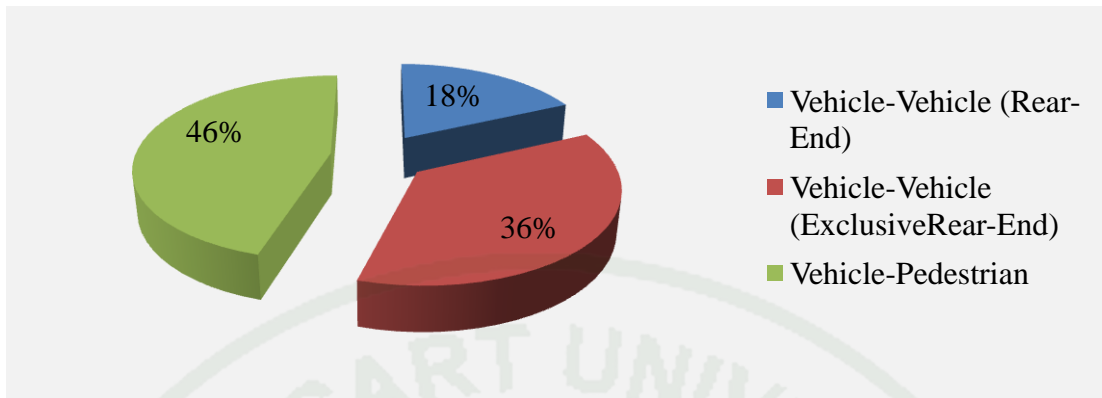
**Yangon-Pyay Road: Injuries in Police Reported Accidents 2006-2010**  
**According to Road-user Category and Accident Outcome Severity**



**Figure 18** Injuries in police reported accidents 2006-2010 according to road-user category and accident outcome severity on Yangon-Pyay Road in Yangon City environment

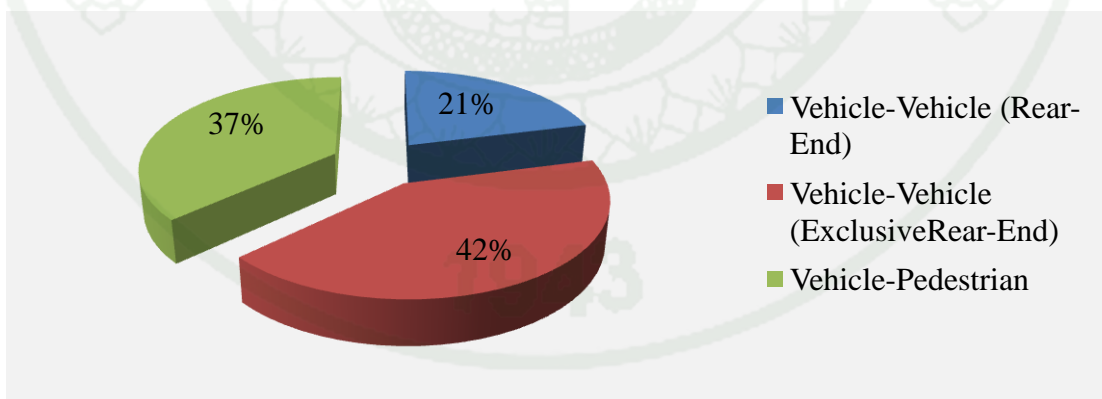
The data of accidents occurring at each of three major intersections on Yangon-Pyay Road during the past five-year period between 2006-2010 are described below.

At the 8 mile intersection, 11 police reported accidents have been recorded. These accidents resulted in 23 minor injuries. Pedestrians were involved in five of the accidents. The six accidents involved only vehicles. The percentages of vehicle-vehicle (rear-end) collisions, vehicle-vehicle (exclusive rear-end) collisions, and vehicle-pedestrian collisions are 18%, 36% and 46% respectively (Figure 19).



**Figure 19** The percentages of different conflict types from police reported accidents between 2006-2010 at 8 mile intersection

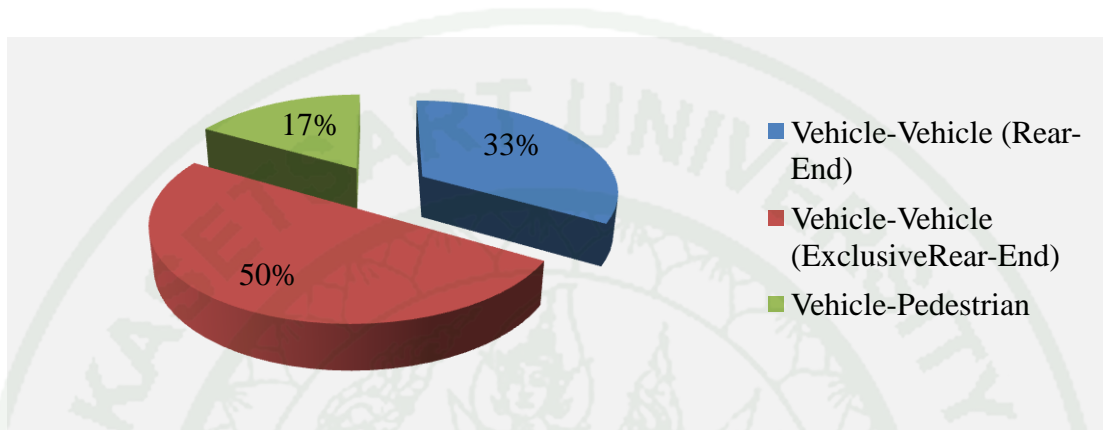
The second intersection, Hledan intersection showed 19 police reported accidents resulting in 24 minor injuries and four serious injuries. Pedestrians were otherwise involved in seven of the accidents. Twelve of the remaining accidents concerned vehicles. The percentages of vehicle-vehicle (rear-end) collisions, vehicle-vehicle (exclusive rear-end) collisions, and vehicle-pedestrian collisions are 21%, 42% and 37% respectively (Figure 20).



**Figure 20** The percentages of different conflict types from police reported accidents between 2006-2010 at Hledan intersection

Similarly, 6 police reported accidents have been recorded at the third intersection or Myaynigone intersection. These accidents resulted in 9 minor injuries

and one serious injury. Pedestrian were involved in one accident. Five of the remaining accidents concerned vehicle. The percentages of vehicle-vehicle (rear-end) collisions, vehicle-vehicle (exclusive rear-end) collisions, and vehicle-pedestrian collisions are 33%, 50% and 17% respectively (Figure 21).



**Figure 21** The percentages of different conflict types from police reported accidents between 2006-2010 at Myaynigone intersection

#### 4. Comparison of Conflict Observation Data and Police Reported Accident Data

In order to make a quantitative and qualitative comparison between the conflict observation data and police reported accident data for each of the three intersections studied, the conflicts and accidents were divided into three main categories: vehicle-vehicle rear-end; vehicle-vehicle exclusive rear-end; and vehicle-pedestrian. This comparison is shown in Table 5 for each of the three intersections.

In theory, the accident data should be corrected to include only those events that occurred during the conflict observation period. As an initial assessment, the numbers of police reported accident data over the past five-year period between 2006-2010, and serious conflict frequencies based on 16 hours of conflict observation data at each intersection are directly compared.

**Table 5** Comparison of serious conflict data and police reported accident data at each intersection in accordance with conflict/ accident type

		Conflict/ Accident Type			Total
		Vehicle-Vehicle (Rear-End)	Vehicle-Vehicle (Exclusive Rear-End)	Vehicle-Pedestrian	
8 Mile Intersection	Conflicts* (16hours Obs.)	4	5	10	19 (28%)
	Accidents** (5 years)	2	4	5	11 (30%)
Hledan Intersection	Conflicts* (16hours Obs.)	5	7	17	29 (42%)
	Accidents** (5 years)	4	8	7	19 (53%)
Myaynigone Intersection	Conflicts* (16hours Obs.)	4	5	12	21 (30%)
	Accidents** (5 years)	2	3	1	6 (17%)
Total	Conflicts* (16hours Obs.)	13 (19%)	17 (25%)	39 (56%)	69
	Accidents** (5 years)	8 (22%)	15 (42%)	13 (36%)	36

\*=Serious conflicts only, \*\*= Police reported accidents only

According to the above table, the total numbers of conflicts and accidents show the ratio for vehicle-pedestrian conflict type is 3:1 and the ratio for vehicle-vehicle (rear-end) conflict type is nearly 2:1. The ratio for the vehicle-vehicle (exclusive rear-end) event type is nearly 1:1. The total percentage of conflicts is greater than that of accidents for vehicle-pedestrian conflict type. But the total

percentage of conflicts is less than that of accidents for vehicle-vehicle (rear-end and exclusive rear-end) conflict type. Among each intersection individually, there appears to be dissimilar patterns for the accident and conflict frequencies according to conflict type. The only exception appears to be the Myaynigone intersection, where there is good correlation.

Vehicle-Pedestrian conflicts are the most frequent of the three conflict types for three intersections with regard to serious conflicts. For the accidents, the vehicle-pedestrian events for Hledan intersection are more than those for two remaining intersections. Generally, the serious conflict data also identifies vehicle-vehicle (exclusive rear-end) conflicts as more common than vehicle-vehicle (rear-end), while the accident data also shows vehicle-vehicle (exclusive rear-end) events are greater than vehicle-vehicle (rear-end) events.

## **5. Comparison of Intersections**

A further comparison can be made in relation to the total accidents and conflict frequencies for each intersection regardless of conflict types. This comparison reveals large number of differences in the relative proportions of accident and conflicts among the intersections. There are relatively large number of serious conflicts and the relatively low number of accidents at Myaynigone intersection. That indicates a ratio of approximately 3.5:1 for conflicts and accidents. The corresponding ratio is approximately 1.5:1 for Hledan intersection. Myaynigone intersection appears to have nearly less than one and half times the number of conflicts and slightly less than three times the number of accidents, in comparison to Hledan intersection. This finding suggests that the relationship between conflicts and accidents is subject to other influences, such as the form of traffic regulation and perhaps factors related to traffic flow and speed. A further comparison can be made in relation to the total percentage of conflicts and accidents for each intersection. The total percentage of conflicts is greater than that of accidents in both intersections of 8 mile and Hledan. Therefore, there are differences between theoretical conflict data and actual accident data for each intersection.

## 6. Inter-observer Reliability

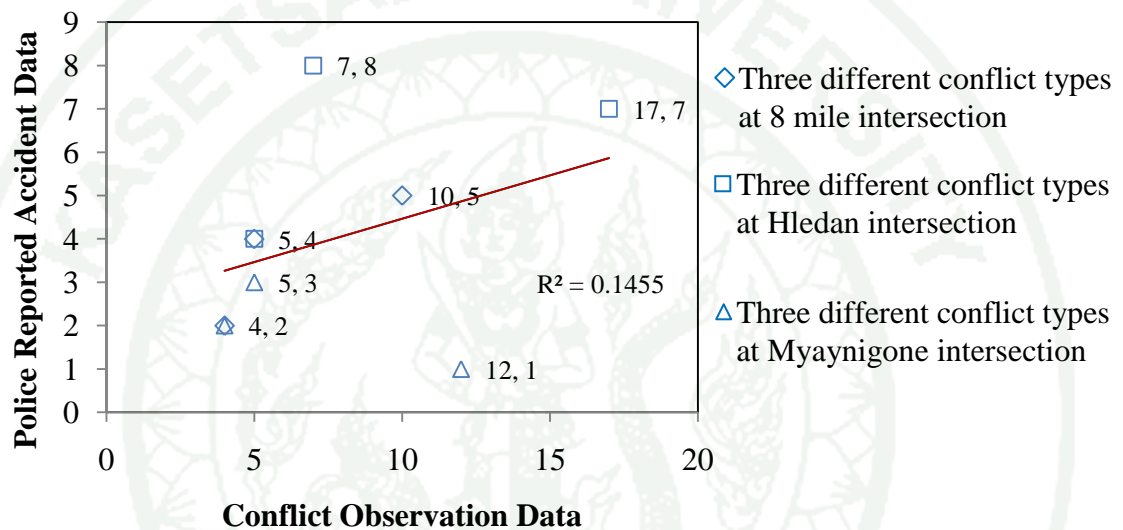
**Table 6** Comparison of the numbers of observed serious and non-serious conflicts for the four observers at each of the three different sites (4-hours observation per observer and site)

	Observer A	Observer B	Observer C	Observer D	Average Number Per Site
	No. of Conflicts Serious / (Non- serious)	No. of Conflicts Serious / (Non- serious)	No. of Conflicts Serious / (Non- serious)	No. of Conflicts Serious / (Non- serious)	
8 Mile	9 (1)	7 (2)	1 (3)	2 (1)	4.75 (1.75)
Hledan	11 (3)	14 (5)	3 (4)	1 (4)	7.25 (4.00)
Myaynigone	6 (0)	7 (5)	4 (3)	4 (2)	5.25 (2.50)
Average Number Per Observer	8.67 (1.33)	9.33 (4.00)	2.67 (3.33)	2.33 (2.33)	5.75 (2.75)

The Traffic Conflict Technique is often criticized for the fact that the indicative Time to Accident (TA) values are based on subjective estimates of entering speed and distance by experienced and trained observers. In this study, significant differences were identified in the frequencies of serious and non-serious conflicts recorded by the four observers during the four-hour study period at each intersection as shown in Table 6 above. The results indicate a higher number of recorded serious conflicts for observers A and B in comparison to observers C and D. Only one intersection (Myaynigone), showed a reasonable level of consistency for all four observers; at the other intersections consistency was found only for observers A and B. Results indicated that the Hledan intersection generated most conflicts (both serious and non-serious).

## 7. Correlation between Conflict Observation and Police Reported Accident Data

A scatter plot that represents the conflict observation and police reported accident data of three different conflict types; vehicle-vehicle (rear-end) collisions, vehicle-vehicle (exclusive rear-end) collisions and vehicle-pedestrian collisions for three signalized intersections is illustrated below in Figure 22.



**Figure 22** A scatter plot of conflict observation and police reported accident data for three different conflict types at three intersections

Each point represents one of the three conflict types of respective signalized intersections. A point's location in the horizontal direction (x-axis) represents the conflict observation data. That same point's location in the vertical direction (y-axis) represents the police reported accident data.

The coefficient of determination ( $R^2$ ) is 0.1455 and the correlation coefficient ( $R$ ) is 0.3814. Therefore, the correlation between conflict observation and police reported accident data of three different conflict types for three intersections is a weak relationship according to the small correlation coefficient.

## CONCLUSION AND RECOMMENDATIONS

### Conclusion

The results of this study have indicated the value of the Traffic Conflict Technique as a quantitative and qualitative method for identifying and comparing safety problems at intersections in urban areas. The Traffic Conflict Technique was used foremost in urban areas for studying sites with traffic signals. In this research, this measuring method helps to demonstrate conflicts which resemble accidents by calculating the time to accident. The results were classified into serious and non-serious conflicts based on TA described as above figure and analyzed for each intersection. Myaynigone intersection is good correlation among two other intersections. Poor traffic safety mostly occurred at Hledan intersection according to the many conflict observation points and police reported accident data during past five-year period. It is five-way signalized intersection but there is three phase signal-controlled system. There is no other individual phase for left-turning vehicles. Straight ahead and left turning vehicles move simultaneously during green time. It is near Yangon University, Seingayhar Supermarket, Hledan Market, and other high rise buildings but there were insufficient parking areas. Signalized pedestrian crossings and grade crossings did not occur. Therefore vehicle-pedestrian conflict points from 16 hour observation studies occurred as recorded by experienced and trained observers.

### Recommendations

The signal-controlled system should be changed to six phases instead of three phases to solve the existing poor traffic safety condition. Two phases for each road should be used with a separation of only left-turning vehicles and straight ahead vehicles according to the new cycle length. Not only the severity of accident rates and crashes, traffic related injuries and fatalities but also the theoretical conflict points can be reduced by changing the control system. The signal-controlled pedestrian crossings and grade crossings should be constructed to solve the problem for vehicle-pedestrian

collisions. Practical traffic safety can be improved by reducing the theoretical conflict points of vehicle-vehicle (rear-end and exclusive rear end) and vehicle-pedestrian collisions. Most especially, vehicle-pedestrian conflicts should be reduced according to the above findings.

In this study, only three intersections were considered making correlations between conflicts and accidents statistically unsound. Given the fact that only three intersections were studied and that available data was insufficient, it was difficult to make a comparison of conflict observation and police reported accident data. Therefore, number of considered intersections need to be increased to obtain sufficient data for traffic safety assessment and to achieve strong results for statistical correlations between accidents and conflicts. Finally, this thesis is expected to have a contribution into methodology and experience on traffic safety at the intersections of Yangon-Pyay Road in Yangon City.

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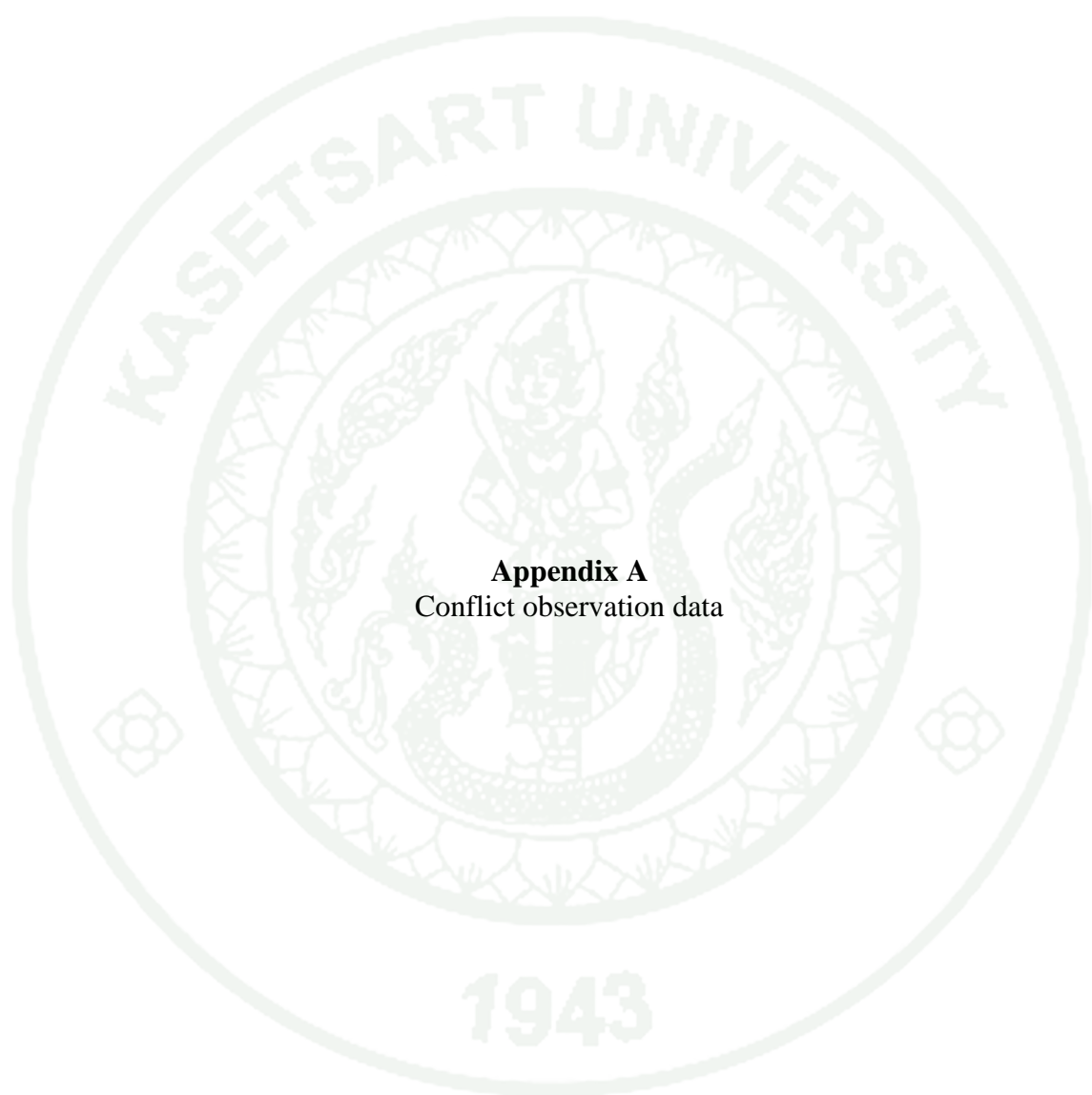
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**Appendix A**  
Conflict observation data

**Appendix Table A1** Conflict observation form

Date.....month.....year.....

Weather: .....

Intersection; .....

Observer: .....

No.	Time		Type of Vehicle			Type of reaction			Conflict level	Conflict Type	Type of move		
	H	M	veh 1	veh 2	veh 3	veh 1	veh 2	veh 3			veh 1	veh 2	veh 3

**Intersection Described**

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**Appendix Table A2** Signs used in conflict observation form

Sign	Interpretation	Sign	Interpretation
Type of Vehicle		Conflict Level	
V1	Motorcycle	S1	Slight conflict
V2	Car	S2	Serious conflict
V3	Bus	Conflict Type	
V4	Truck	A1	Veh-veh (rear-end)
V5	Bicycle	A2	Veh-veh (Ex rear end)
V6	Pedestrian	A3	Vehicle-Pedestrian
V7	Other	Type of Movement	
Type of Reaction		M1	Turn left
B1	Brake	M2	Go straight
B2	Change direction	M3	Turn right
B3	No reaction		

**Appendix Table A3** Conflict observation data at 8 mile intersection

Date - 31, Month - January, Year - 2011

Weather: Sunny

Intersection; 8 Mile

Observer: A

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	14	V2	V2	B2	B3	S2	A2	M1	M2
2	8	27	V2	V2	B3	B1	S2	A2	M2	M1
3	8	42	V3	V2	B3	B2	S2	A1	M2	M3
4	9	10	V2	V6	B1	B3	S1	A3	M2	M2
5	9	32	V6	V2	B3	B1	S2	A3	M2	M2
6	17	11	V6	V2	B3	B2	S2	A3	M2	M2
7	17	35	V2	V2	B3	B2	S2	A1	M2	M3
8	18	05	V3	V6	B2	B3	S2	A3	M2	M2
9	18	20	V2	V6	B1	B3	S2	A3	M2	M2
10	18	45	V6	V2	B3	B2	S2	A3	M2	M3

**Appendix Table A4** Conflict observation data at 8 mile intersection

Date - 1, Month - February, Year - 2011

Weather: Sunny

Intersection; 8 Mile

Observer: B

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	21	V2	V3	B1	B3	S2	A2	M1	M2
2	8	47	V6	V2	B3	B1	S2	A3	M2	M3
3	9	10	V2	V6	B2	B3	S1	A3	M2	M2
4	9	25	V2	V2	B1	B3	S2	A1	M2	M3
5	9	44	V2	V2	B2	B3	S2	A1	M2	M3
6	17	05	V3	V6	B1	B3	S1	A3	M2	M2
7	17	25	V2	V6	B2	B3	S2	A3	M2	M2
8	17	56	V2	V6	B1	B3	S2	A3	M2	M2
9	18	25	V2	V3	B3	B2	S2	A2	M1	M2

**Appendix Table A5** Conflict observation data at 8 mile intersection

Date - 3, Month - February, Year - 2011

Weather: Sunny

Intersection; 8 Mile

Observer: C

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	50	V3	V6	B1	B3	S2	A3	M2	M2
2	9	36	V2	V6	B1	B3	S1	A3	M2	M2
3	18	17	V2	V6	B1	B3	S1	A3	M2	M2
4	18	52	V2	V2	B3	B1	S1	A2	M2	M1

**Appendix Table A6** Conflict observation data at 8 mile intersection

Date - 4, Month - February, Year - 2011

Weather: Sunny

Intersection; 8 Mile

Observer: D

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	35	V2	V2	B1	B3	S1	A1	M1	M2
2	9	00	V2	V6	B2	B3	S2	A3	M2	M2
3	18	10	V2	V2	B3	B2	S2	A2	M2	M1

**Appendix Table A7** Conflict observation data at Hledan intersection

Date - 7, Month - February, Year - 2011

Weather: Sunny

Intersection; Hledan

Observer: A

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	04	V2	V6	B1	B3	S2	A3	M2	M2
2	8	20	V2	V6	B2	B3	S2	A3	M2	M2
3	8	36	V2	V2	B3	B1	S2	A1	M1	M3
4	8	55	V2	V6	B1	B3	S1	A3	M3	M2
5	9	12	V6	V3	B3	B1	S1	A3	M2	M2
6	9	30	V6	V2	B3	B1	S2	A3	M2	M3
7	9	43	V2	V2	B3	B2	S2	A2	M2	M1
8	10	00	V3	V6	B2	B3	S2	A3	M2	M2
9	17	11	V2	V6	B1	B3	S2	A3	M2	M2
10	17	30	V6	V2	B3	B1	S2	A3	M2	M3
11	17	50	V2	V2	B2	B1	S2	A1	M2	M3
12	18	18	V2	V6	B3	B2	S1	A3	M2	M2
13	18	35	V2	V6	B2	B2	S2	A3	M2	M2
14	18	57	V2	V2	B1	B3	S2	A2	M1	M2

**Appendix Table A8** Conflict observation data at Hledan intersection

Date - 8, Month - February, Year - 2011

Weather: Sunny

Intersection; Hledan

Observer: B

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	06	V2	V6	B1	B3	S1	A3	M2	M2
2	8	11	V2	V6	B1	B3	S2	A3	M2	M2
3	8	20	V3	V6	B2	B3	S2	A3	M2	M2
4	8	28	V2	V6	B2	B3	S1	A3	M2	M2
5	8	45	V2	V2	B2	B1	S2	A2	M2	M1
6	8	57	V6	V2	B3	B2	S2	A3	M2	M2
7	9	12	V2	V2	B3	B2	S2	A1	M1	M3
8	9	21	V2	V6	B3	B2	S2	A3	M2	M2
9	9	44	V2	V6	B1	B3	S2	A3	M2	M2
10	9	50	V6	V2	B3	B2	S2	A3	M2	M3
11	9	58	V6	V2	B3	B2	S1	A3	M2	M3
12	17	10	V2	V6	B1	B3	S1	A3	M3	M2
13	17	31	V2	V2	B1	B2	S2	A2	M2	M1
14	17	46	V2	V2	B1	B1	S1	A2	M2	M1
15	18	00	V2	V3	B1	B3	S2	A1	M3	M2
16	18	15	V6	V2	B3	B2	S2	A3	M2	M2
17	18	27	V2	V2	B2	B1	S2	A2	M1	M2
18	18	47	V3	V6	B1	B3	S2	A3	M1	M2
19	19	00	V2	V2	B2	B1	S2	A2	M2	M1

**Appendix Table A9** Conflict observation data at Hledan intersection

Date - 10, Month - February, Year - 2011

Weather: Sunny

Intersection; Hledan

Observer: C

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	25	V2	V2	B1	B1	S1	A2	M3	M2
2	8	47	V2	V6	B2	B3	S1	A3	M3	M2
3	9	16	V2	V6	B2	B3	S2	A3	M1	M2
4	9	45	V2	V2	B1	B2	S2	A1	M1	M3
5	17	35	V3	V2	B3	B1	S2	A2	M2	M1
6	18	10	V2	V2	B2	B3	S1	A2	M2	M1
7	18	35	V2	V2	B3	B1	S1	A1	M1	M3

**Appendix Table A10** Conflict observation data at Hledan intersection

Date - 11, Month - February, Year - 2011

Weather: Sunny

Intersection; Hledan

Observer: D

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	35	V6	V2	B3	B1	S2	A3	M2	M2
2	8	50	V2	V2	B2	B1	S1	A1	M3	M2
3	9	22	V2	V2	B2	B2	S1	A2	M1	M2
4	17	45	V2	V2	B3	B2	S1	A2	M1	M2
5	18	25	V2	V2	B3	B1	S1	A1	M1	M3

**Appendix Table A11** Conflict observation data at Myaynigone intersection

Date - 14, Month - February, Year - 2011

Weather: Sunny

Intersection; Myaynigone

Observer: A

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	00	V2	V6	B2	B3	S2	A3	M2	M2
2	8	34	V2	V6	B1	B3	S2	A3	M2	M2
3	9	42	V2	V2	B3	B2	S2	A1	M3	M2
4	17	07	V2	V6	B1	B3	S2	A3	M2	M2
5	17	46	V6	V2	B3	B2	S2	A3	M3	M2
6	18	31	V2	V2	B1	B3	S2	A2	M1	M2

**Appendix Table A12** Conflict observation data at Myaynigone intersection

Date - 15, Month - February, Year - 2011

Weather: Sunny

Intersection; Myaynigone

Observer: B

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	00	V2	V2	B3	B1	S2	A1	M2	M3
2	8	40	V2	V3	B2	B3	S2	A2	M2	M1
3	8	56	V2	V6	B1	B3	S2	A3	M1	M2
4	9	08	V6	V2	B3	B1	S1	A3	M2	M2
5	9	30	V6	V2	B3	B2	S1	A3	M2	M1
6	9	43	V2	V2	B1	B3	S2	A2	M1	M2
7	9	57	V6	V2	B3	B1	S1	A3	M2	M3
8	17	20	V2	V6	B2	B3	S2	A3	M2	M2
9	17	48	V2	V6	B2	B3	S1	A3	M2	M2
10	18	11	V3	V6	B1	B3	S2	A3	M2	M2
11	18	35	V2	V2	B1	B1	S1	A2	M2	M1
12	19	00	V6	V2	B2	B3	S2	A3	M2	M2

**Appendix Table A13** Conflict observation data at Myaynigone intersection

Date - 17, Month - February, Year - 2011

Weather: Sunny

Intersection; Myaynigone

Observer: C

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	23	V2	V2	B3	B1	S2	A2	M1	M2
2	8	45	V2	V6	B1	B3	S1	A3	M3	M2
3	9	00	V2	V6	B2	B3	S2	A3	M2	M2
4	9	18	V2	V6	B1	B3	S2	A3	M2	M2
5	17	25	V2	V6	B1	B3	S1	A3	M1	M2
6	18	36	V2	V2	B1	B2	S1	A2	M1	M2
7	19	00	V2	V2	B2	B1	S2	A1	M3	M2

**Appendix Table A14** Conflict observation data at Myaynigone intersection

Date - 18, Month - February, Year - 2011

Weather: Sunny

Intersection; Myaynigone

Observer: D

No.	Time		Type of Vehicle		Type of reaction		Conflict level	Conflict. type	Type of move	
	H	M	veh 1	veh 2	veh 1	veh 2			veh 1	veh 2
1	8	10	V3	V2	B1	B2	S1	A2	M2	M1
2	8	37	V6	V2	B3	B2	S2	A3	M2	M2
3	9	15	V2	V2	B2	B3	S2	A1	M2	M3
4	9	42	V2	V6	B2	B3	S2	A3	M1	M2
5	18	00	V2	V2	B3	B2	S2	A2	M1	M2
6	18	45	V2	V2	B1	B2	S1	A1	M3	M2



**Appendix B**  
Photos of intersection described

### Intersection Described



**Appendix Figure B1** Existing condition of 8 mile intersection

### Intersection Described



**Appendix Figure B2** Existing condition of Hledan intersection

### Intersection Described



**Appendix Figure B3** Existing condition of Myaynigone intersection

## CURRICULUM VITAE

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**BIRTH PLACE** : Patheingyi, Myanmar

<b>EDUCATION</b>	<b>: <u>YEAR</u></b>	<b><u>INSTITUTE</u></b>	<b><u>DEGREE/DIPLOMA</u></b>
	2002	Yangon Technological University, Myanmar	B.Eng (Civil Engineering)
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