Improving Urban Road Safety in Vietnam Focusing on Motorcycles: A Case Study in Ho Chi Minh City

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ABSTRACT

In road safety improvement, black spot management has been considered an effective safety tool which employs identification and treatment of black spots as the two basic stages. Traditionally, these two stages base themselves mainly on recorded accidents rather than safety potential. Such traditional approaches have a number of limitations in black spot identification and analysis. In order to minimize these limitations, this research intends to propose a new black spot management approach called *Safety-potential-based Black Spot Management*, which was developed based on the *Network Safety Management* (Bast & Sétra, 2005). The innovation lies in three aspects. First, *safety potential* is used as the main indicator in black spot identification. Second, such use of safety potential makes it possible to integrate black spot prioritization into black spot identification. And third, the performance of computer-based microsimulations of traffic situation before and after treatment at the same black spot was considered an important task in black spot analysis so as to have the optimal safety improvement measure. In order to illustrate the effectiveness of the approach, this research provided an empirical investigation in which the proposed approach is practically applied to the local urban road traffic conditions in Ho Chi Minh City, Vietnam.

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ABBREVIATION

AADT : Annual Average Daily Traffic

AC : Accident Cost

ACD : Accident Cost Density

ACR : Accident Cost Rate

AD : Accident Density

ADT : Average Daily Traffic

APB : Accident Pin Board

AR : Accident Rate

bACD : Basic Accident Cost Density

bACR : Basic Accident Cost Rate

Bast : Federal Highway Research Institute (BASt), Germany

BSM : Black Spot Management

CEDR : Conference of European Directors of Roads

DFID-MVA : Department for International Development - Martin and Voorhees Associates

EB : Empirical Bayesian

F : Fatal

GDP : Gross Domestic Product

ha : hectare

HCMC : Ho Chi Minh City

HIS : Household Interview Survey

HOUTRANS : The Study on Urban Transport Master Plan and Feasibility Study in Ho Chi Minh Metropolitan Area

JICA : Japan International Cooperation Agency

LI : Light Injury

LOS : Level of Service

MC : Motorcycle

NHTSA	: National Highway Traffic Safety Administration
NSM	: Network Safety Management
NTSC	: Vietnam National Traffic Safety Committee
PDO	: Property Damage Only
QD-BGTVT	: Decision issued by the Ministry of Transport Vietnam
ROC	: Receiver Operating Characteristic
ROSA	: Road Safety European Project (ROSA European Project, 2011)
RoSCoE	: EU-Asia Road Safety Centre of Excellence
RSA	: Road Safety Audits
RSI	: Road Safety Inspection
RSIA	: Road Safety Impact Assessment
SAPO	: Safety Potential
SEMCOG	: Southeast Michigan Council of Governments
Sétra	: Roads and Motorways Engineering Department (Sétra), France
SI	: Serious injury
SPF	: Safety Performance Function
SWOV	: Netherlands Institute for Road Safety Research
TRB	: Transportation Research Board
VISSIM	: A Microscopic Multi-Modal Traffic Flow Simulation Software
WHO	: World Health Organization

CHAPTER 1

INTRODUCTION

1.1 Overview

Urban transportation in Vietnam, a developing country, is facing a number of problems some of which are serious, namely traffic jams, pollution and traffic safety.

The urban population, the number of vehicles and urbanization are on a rapid increase. Nevertheless, the development of the urban transportation system is too slow to respond to such increase. This fact presents tremendous challenges of urban transport improvement to Vietnam.

Like other major cities in Vietnam, Ho Chi Minh City (HCMC) is facing a traffic problem which bases itself on the fact that the commuter stick to their motorcycles. In fact, this type of vehicle makes up 90% of the total number of registered vehicles in the city.

Together, the previously mentioned facts, and road systems built or upgraded with little consideration given to road safety have subjected the urban road traffic in HCMC to a state of poor safety. Consequently, black spots and black links are created, resulting in regrettable personal injuries and even human loss.

This study was intended to (1) find out the key safety problems of urban road traffic in HCMC; (2) identify factors contributing to the problems; and (3) develop appropriate engineering solutions for such urban road traffic safety problems.

1.2 Problem statement

The current black spot identification in HCMC relies only on one-year records in terms of number of accidents. Such reliance has strong impacts on the accuracy of black spots identification. Specifically, the identification has turned out to include a number of misidentification cases and missing cases. More importantly, the identification does not facilitate the ranking of the identified black spots which is useful when it is impossible to treat all of the identified black spots due to financial constraints. Consequently, in order to improve the road traffic safety in HCMC, this research develops a new black spot management approach that can both accurately identify and effectively rank black spots so as to establish suitable safety countermeasures. The safety-potential-based black spot management proves itself to be a good choice for this case. This is why the approach was employed as a methodological instrument in this case study, which was conducted with Phu-Nhuan, an urban district in HCMC, as the study area.

1.3 Significant

Poor road traffic safety not only directly increases road casualties and causes damage to the means of transport involved but also indirectly creates consequential social problems. The physical and mental pains of road-accident victims as well as their families and the financial loss have become topics of concern to traffic administrations in particular and the whole society in general. Recently, the concern about road safety and its consequences has become even greater with an alarming increase in road accidents.

Specifically, road accidents in HCMC cause remarkable loss of human, as well as damage of vehicles and properties. Reported statistics show that each year road accidents in this city cause approximately 1,000 cases of death, 2000 cases of serious injury, 10,000 cases of slight injury and a considerable number of damaged vehicles. Financially, these cases take away approximately 7% the city's GDP which accounts for 40% Vietnam's GDP.

Accordingly, it is necessary to find out satisfactory solutions to reduce the number of accidents as well as their severities in this city.

1.4 Research questions

(1) What problems of urban road safety is HCMC facing?

(2) What factors are contributing to the current problems of urban road safety in HCMC?

(3) What are the effective solutions to the current problems of urban road safety in HCMC?

1.5 Research objectives and scope

1.5.1 Research objectives

Conducted for the case of road traffic safety in HCMC, this research focuses on the following objectives:

(1) To identify the key urban road traffic safety problems of HCMC;

(2) To develop a new black spot management approach suitable for the local conditions of HCMC; and

(3) To propose safety engineering countermeasures for selected black spots in which motorcycles are considered as a majority vehicle.

1.5.2 Scope of study

This research is limited to improving safety of road networks located within the urban areas where there is a frequent occurrence of accidents by means of safety engineering solutions.

1.6 Dissertation structure

The dissertation is organized as follows.

- **Chapter 1** briefly introduces the backgrounds, the rationale as well as the significance of this research.
- **Chapter 2** provides the literature review including a number of key researches on black spot identification, black spot analysis, and safety measure development. This chapter also presents a comprehensive review of motorcycle safety in Asian countries and current engineering approaches.
- **Chapter 3** outlines the research frame work and methodology employed in this study.
- **Chapter 4** describes the current situation of road traffic safety in HCMC and the key road safety problems which city was facing.
- **Chapter 5** is the detailed description of the safety-potential-based black spot management approach and practical implementation of the approach.
- **Chapter 6** discusses the contributions of the proposed approach done for and reported in this study. Also, this chapter presents the suggestions for the practical implementation.

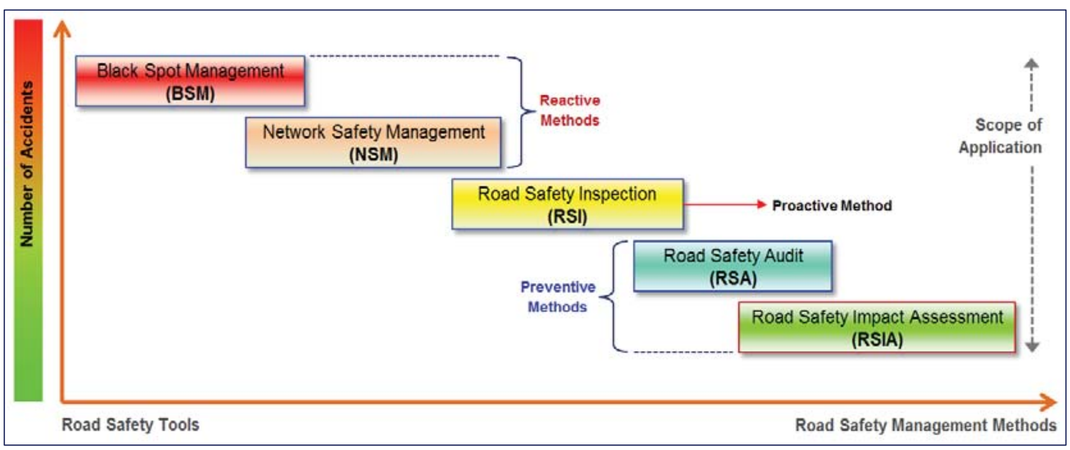
CHAPTER 2

LITERATURE REVIEW

The question of how to better identify and analyze black spots so as to develop effective safety improvement measures has been discussed in a large number of researches. However, with the space available, it is difficult to mention all of such researches in this dissertation. Therefore, it is only possible to present hereby a summary of the major conclusions regarding the identification, analysis and development of safety improvement measures. In addition, this chapter also presents a comprehensive review of motorcycle safety situation in Asian countries and current engineering approaches of motorcycle safety.

2.1 Application of road safety methods

Figure 2.1 shows the five instruments of the road infrastructure safety management and their scope of application according to the number of accidents which have been occurring on the road network.



Source: Nguyen (2013)

Figure 2.1 Application of road safety methods

CEDR (2008) claimed that the infrastructure safety management focuses on the five instruments: Road Safety Impact Assessment (RSIA), Road Safety Audits (RSA), Road Safety Inspection (RSI), Network Safety Management (NSM), and Black Spot Management (BSM). These five instruments can be basically defined as follows.

- The RSIA is a strategic comparative analysis of the impact of a new road or a substantial modification to the existing network on the safety performance of the road network, at the initial planning stage before the infrastructure project is approved.
- The RSA is an independent detailed systematic and technical safety check relating to the design characteristics of a road infrastructure project and covering all stages from planning to early operation as to identify, in a detailed way, unsafe features of a road infrastructure project.
- The RSI is a systematic, periodic, objective and proactive safety review of a road in operation. The objectives of RSI are to identify and eliminate hazardous conditions, faults and deficiencies in order to improve the road safety for the road users.
- The NSM is used to manage the existing road network or the parts of the road network with the aim to identify, localize and rank road sections according to their potential savings in accident costs.
- The BSM is the reactive investigation and implementation of remedial measures at single localized (e.g. curves, junctions), short road segments or sites with a high number of injury accidents.

The BSM and the NSM are reactive approaches to improve the safety performance of road infrastructure during operation. When many accidents of the same type happened at more or less the same place, BSM is certainly the first method to apply for the road manager. When black spots are eradicated, NSM can be processed and will be a very efficient method to identify road stretches with a high safety potential. When there are no concentrations of accidents on the road anymore, RSI can be processed as a pro-active approach (CEDR, 2008).

2.2 Application of road safety analysis

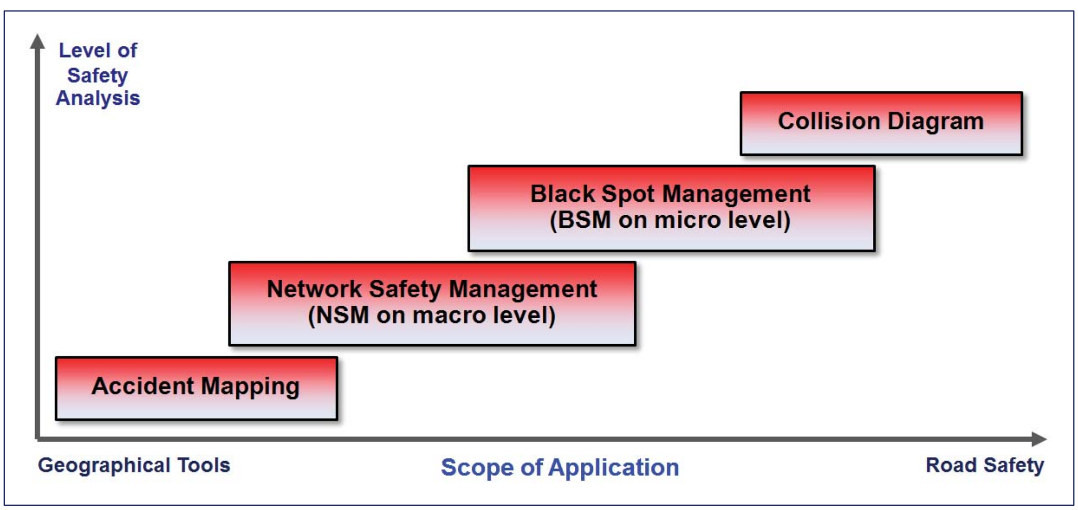
Analysis of road safety is an important field of road engineering in order to provide quantitative results for the evaluation of safety efficiency of road safety countermeasures. Brannolte and Munch (2009) pointed out four levels of safety analysis as shown in Figure 2.2. The process of these four safety analysis levels can be described as follows.

First, a general view on the whole road network will be provided by mapping accidents. Mapping accidents (i.e. location, categories, types, circumstances, road users, etc.) is an essential prerequisite for drawing sound conclusions with regard to accident countermeasures. This lowest level of safety analysis enables to find out which particular areas in a specific region should be considered to improve road traffic safety.

Second, macroscopic level of safety analysis NSM focuses on identifying, analyzing and classifying parts of the existing road network according to their potential for safety development and accident cost saving. This method can also enable the road administrations to detect the sections where there is the highest safety potential, i.e. where an infrastructural countermeasure can be efficient in terms of socioeconomic prospective.

Third, BSM goes up to microscopic level of safety analysis with the aim to identify, analyze, and rank the high accident concentration sections or spots within the road network which have been in operation for more than three years and upon which a large number of fatal accidents in proportion to the traffic flow have occurred.

The highest level of safety analysis is the collision diagram analysis with focus on the concentrations and similarities of accidents at selected black spots. After black spots are identified, the accident data at those spots can be analyzed in order to find common patterns in accidents. A visit of the black spot site is usually part of the process of analysis. Collision diagram can be used in investigation of conflict situations on local spots. On the other hand, collision diagrams have been proven as very useful tools for detecting safety deficits easily.



Source: Brannolte (2009)

Figure 2.2 Application of road safety analysis

2.3 Limitations in identifying black spots of traditional methods

Traditional approaches only rely on the recorded number of accidents for identification of black spots. Any value of the recorded number of accidents at a site during a certain period always is a sum of two values, the first value is the very systematic number, and the second value is random number. Because of this, if a value of recorded number is used as a critical value in identifying black spots, then the identified black spots will be a set of true and false black spots.

Indeed, Elvik (2008a) used expected number of accidents and simulated data to point out the limitations and pitfalls of identifying road accident black spots in terms of the recorded number of accidents only. Based on the analysis we may now define four categories of sites as follows.

(1) *Correct positives:* if $E \geq [c]$ and $R \geq [c]$;

(2) *False positives:* if $E < [c]$ and $R \geq [c]$;

(3) *Correct negatives:* if $E < [c]$ and $R < [c]$; and

(4) *False negatives:* if $E \geq [c]$ and $R < [c]$.

Whereas: E denotes the expected number of accidents; [c] denotes the selected critical value; and R denotes the recorded number of accidents at a site during a given period of time.

"The performance of the various criterion values can be assessed quantitatively in terms of screening performance criteria developed in epidemiology (Deeks, 2001; Rothman and Greenland, 1998). Two of the most common criteria for diagnostic tests are sensitivity and specificity," (cited in Elvik, 2008a, p. 26). They are defined as follows:

$$Sensitivity = \frac{Number\_of\_correct\_positives}{Total\_number\_of\_positives} \tag{2.1}$$

$$Specificity = \frac{Number\_of\_correct\_negatives}{Total\_number\_of\_negatives} \tag{2.2}$$

The total number of positives equals the number of correct positives plus the number of false negatives, and the total number of negatives equals the number of correct negatives plus the number of false positives.

The performance of different values for the critical number of accidents used to identify a black spot can now be assessed in terms of a *receiver operating characteristic curve* (ROC-curve). Such a curve, derived from the simulated data, is shown in the Figure 2.3.

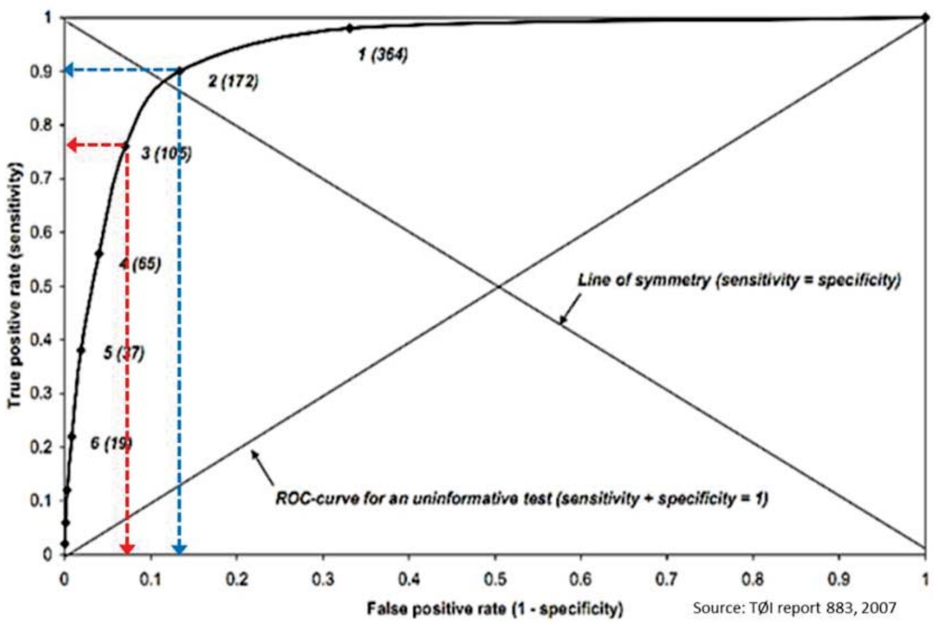
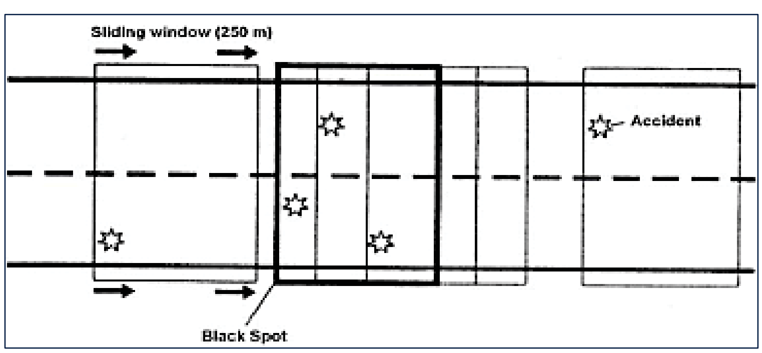


Figure 2.3 ROC-curve for detecting road accident black spots. Simulated data

The false positive rate is plotted along the abscissa. This is equal to *1 minus specificity*. The true positive rate *(sensitivity)* is plotted on the ordinate. If the diagnostic test discriminates well, the ROC-curve will rise steeply, close to the ordinate and flatten out near the top of the diagram. If the diagnostic test is uninformative, the ROC-curve will follow the diagonal line indicated in Figure 2.3.



Source: Austrian guidelines for black spot identification

Figure 2.4 Identification of road accident black spots in Austria by sliding window approach

With regard to the sliding window method (refers to Figure 2.4), Elvik (2008a) had two important conclusions. One is that using this method artificially inflates the number of black spots, and makes each spot look blacker than it really is (i.e. having a higher recorded number of accidents); the other is that sliding window has the advantage of identifying more correct positives, but the disadvantage of identifying more false positives.

2.4 Limitations in analyzing black spots of traditional methods

Traditional approaches employ only recorded number of accidents to identify black spots. As a consequence, any set of identified hazardous road locations will contain both true and false positives. This may lead to the discrimination of true and false positive sites. This section summarizes some results from past studies in order to highlight the limitations in black spot analysis of traditional approaches.

Danielsson (1988) showed that “one commonly used criterion for identifying a truly hazardous road location, namely the over-representation of a particular type of accident is vulnerable to regression-to-the-mean-bias, because over-representation could be attributable mainly to chance,” (cited in Elvik, 2008a, p. 30).

“A commonly applied criterion to discriminate between true and false black spots is the presence of a dominant accident pattern. A dominant accident pattern is characterized by the over-representation of a particular type of accident,” (cited in Elvik, 2008a, p. 31). It is therefore of some interest to probe whether there is any difference in the regression-to-the-mean effect between hazardous road locations that have a dominant accident pattern and those that do not. In order to test this, Elvik (2006) conducted a study on regression-to-the-mean at hazardous road sections with and without a dominant accident pattern and came to the conclusion that the presence of a clearly identifiable pattern of accidents characterized by the dominance of a particular type of accident may not effectively separate true from false black spots.

Harwood *et al.* (2002) pointed out that “some sites with a high number of accidents do not have readily identifiable accident pattern. A given deficiency in highway design or traffic control can contribute to accidents at one site, while at another site with similar deficiency, there are no accidents or no clear pattern of accidents associated with the deficiency,” (cited in Elvik, 2008a, p. 32). Finally, a given deficiency can contribute to different accident types. This suggests that an analysis of accidents designed to identify true black spots must go beyond merely identifying a dominant accident pattern. Thus, an approach to accident analysis is needed that provides clearer criteria for identifying true black spots, recognizes the possibility that analysis might be inconclusive, and minimizes the role of analyst expectancies.

2.5 Evolution of criteria for identifying black spots

This section chronologically reviews the developments of black spot identification methods in which different accident parameters are employed as identification criteria. Over time, new parameters have been added so as to optimize the efficiency and the flexibility of black spot treatment. Such gradual addition depicts the evolution of criteria for black spot identification which is illustrated by the following researches.

Norden *et al.* (1956), Rudy (1962), and Morin (1967) used the method of industrial statistical quality control for highway safety. In this method upper control limit of accident count and upper control limit of accident rate were used as criteria in identifying black spots. Such black spot identification method employed only two parameters: the observed accident number and the traffic volume.

Tamburri and Smith (1970) introduced the notion of the safety index which is actually a combined criterion of accident number and accident severity. The establishment of this criterion led to the development of a method of black spot identification which initially incorporated the accident-severity-based prioritization in identifying black spots. As a result, accident severity was employed as a new parameter in black spot identification.

Jorgensen (1972) introduced a new method which employed two new factors: (1) mean of expected accident counts calculated by multivariable model, and (2) the observed accident number. The identification of black spots is based on the difference between the expected number and the observed number of accidents. As a result, expected number of accident was employed as a new parameter in black spot identification.

Taylor and Thompson (1977) suggested that a hazardousness index should be defined for each road section or spot as a weighted sum of a mix of accident frequency, rate, severity, volume-to-capacity ratio, sight distance, conflicts, erratic maneuvers, and driver expectancy. There is general recognition here that there are clues to hazardousness other than accident occurrence. As a result, hazardousness index was considered a new aspect in black spot identification.

McGuigan (1981, 1982) suggests that for each road section and intersection one calculate the difference between the actual number of accidents and the expected number of accidents for such a class of road or intersection given the same traffic. This suggestion furthered the accuracy of black spot identification by using accident rate rather than accident frequency.

Higle and Witkowski (1988) used the Empirical Bayes approach and focused on the identification of road sections with unusually large accident rates. These two authors showed how the probability distribution function of the accident rate at a specific road section can be obtained. A road section is then said to be hazardous if the probability that its accident rate exceeds a certain value is sufficiently large. With this point of view, Higle and Witkowski (1988) initialized why and how to minimize the inaccuracy of actual accident rate. In other words, the correction of actual accident rate was introduced.

Overgaard Madsen (2005) discussed in detail criteria for identifying black spots. This author proposed that an adequate definition of a black spot should satisfy these four criteria:

(1) It should control for random fluctuations in the number of accidents.

(2) It should account for as many of the factors that are known to influence road safety as possible.

(3) It should identify sites at which fatal and serious injury accidents are over-represented.

(4) It should identify sites at which local risk factors related to road design and traffic control make a substantial contribution to accidents.

With this proposal, the author managed to systematize the aspects and the corresponding criteria for black spot identification suggested by previous researches. Such systematization drew up a set of guidelines which can enable proper selection of criteria for black spot identification.

Elvik (2008b) practically evaluated criteria used to identify black spots and provided the list of the five most common ones as follows:

(1) Upper tail accident count,

(2) Upper tail accident rate,

(3) Upper tail accident count and high accident rate,

(4) Upper tail expected number of accident (Empirical Bayes estimate), and

(5) Upper tail Empirical Bayes dispersion criterion.

The author concluded that of the five criteria, Empirical Bayes estimates of safety is the most reliable.

Nguyen *et al.* (2013) proposed a black spot identification method, which relies on safety potential. The criteria of such identification considered a number of parameters: accident number, accident severity, accident cost, traffic volume, and road type. In short, the evolution of criteria for identifying black spots can be summarized by evolutionary history chart as shown in Figure 2.5.

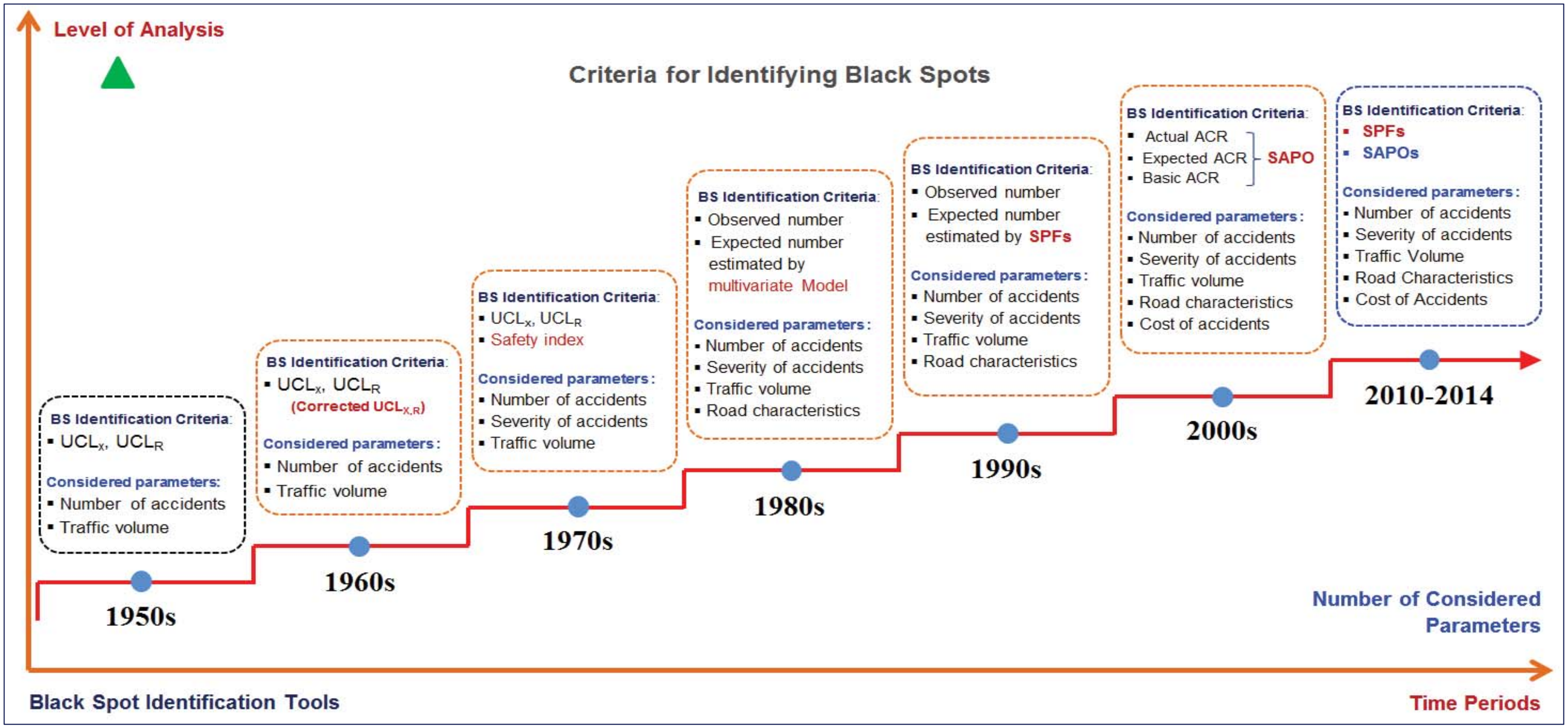


Figure 2.5 Evolutionary of criteria for identifying black spots, Nguyen *et al.* (2014)

2.6 Motorcycle safety in Asian countries

2.6.1 Introduction

As a basic means of individual transport, motorcycles play an important role in transport in most countries in Asia. However, this type of vehicle poses serious problems in terms of road safety. Statistics shows that the world's total number of motorcycle deaths in 2010 was 297,434; seventy-eight percent of which occurred in Asian countries (WHO, 2013). Despite this fact, the number of motorcycles in Asian countries is on the increase. Such increase may change the current motorcycle use pattern and influence motorcycle safety in Asia in the near future. This research provides a closer look at the current motorcycle use pattern and safety so as to develop suitable measures for the case of Asia motorcycle traffic.

2.6.2 Definition and scope

In this research, the following terms are employed with the particular meanings as follow.

- *Motorcycle* refers to mopeds, scooters, two- or three-wheeled motorcycles, off-road motorcycles, mini bikes, and pocket bikes;
- *Motorcyclist* is either the rider or the passenger.

The focus of this research is the on-road use and safety of motorcycles in Asian countries.

2.6.3 Noticeable characteristics of motorcycles

(1) Agility in traffic

The great maneuverability and small size of motorcycles allow them to operate in spaces and situations that are not suitable for cars (Grava, 2003). Motorcycles are highly maneuverable vehicles that can be steered around as well as rapidly slowed to avoid objects and obstacles in their path (Shuman *et al.*, 2003).

(2) Accessibility and ease of operation

As mechanical transportation equipment, motorcycles are relatively inexpensive and affordable to a much larger population cohort than automobiles. Operation skill requirements do not extend much beyond an ability to ride a bicycle (Grava, 2003). Accessibility and ease of operation are important factors in locations where significant traffic congestion exists.

(3) Instability

Contrary to cars and other four-wheeled vehicles a motorcycle has only two points of contact with the surface and can therefore not remain upright when it has come to standstill. Certain maneuvers and road conditions carry a higher risk to motorcyclists than to drivers. For example, motorcycles are less stable, and so riders are more likely to lose control of their vehicle when cornering (ACEM, 2004).

(4) Less visible

"The failure of motorists to detect and recognize motorcycles in traffic is the predominating cause of motorcycle accidents" cited in Hurt report, 1981.

(5) Lack of physical protection

Unlike other forms of motorized transport, there is very little protection for motorcycle riders and passengers. When crashes do occur, they often have very severe consequences, especially at higher speeds or in situations where larger vehicles are involved (from www. motorcycle-facts.com).

(6) Personal danger

The high speed that can be reached by motorcycles, coupled with the lack of any protection for the users and exacerbated frequently by the irresponsible traffic behavior of some drivers, has led to a dismal safety record (Grava, 2003). Per vehicle mile traveled, motorcyclists are over 30 times more likely than passenger car occupants to die in a traffic crash (NHTSA, 2013).

2.6.4 Motorcycles across the world

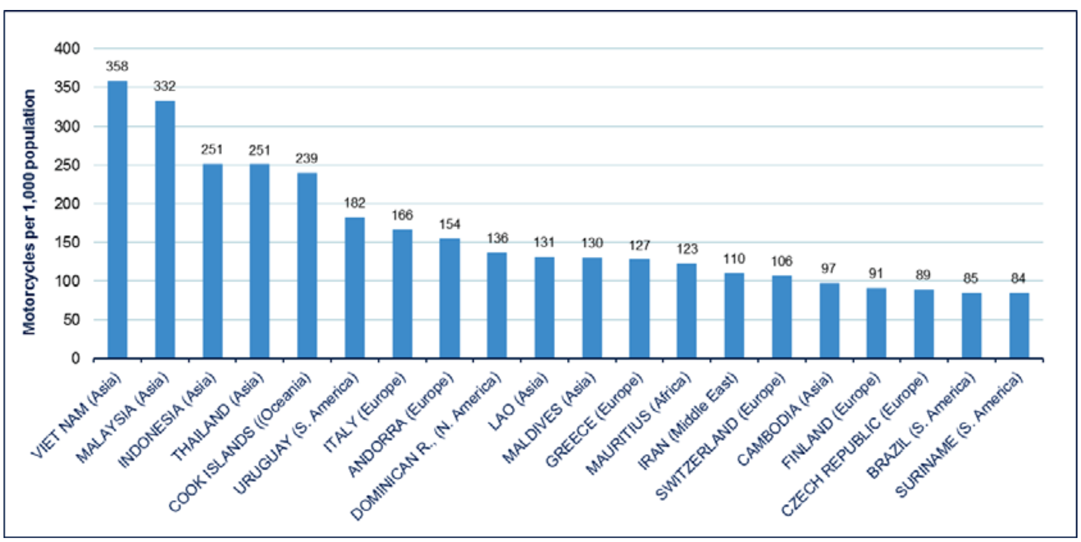
Motorcycles are one of the most affordable forms of motorized transport in many parts of the world and, for most of the world's population, they are also the most common type of motor vehicle. There are around 455 million motorcycles in use worldwide in 2010, or about 69 motorcycles per 1,000 people and around 782 million cars, or about 118 per 1000 people (WHO, 2013). Most of the motorcycles, approximately 79% are in the Asia.

Table 2.1 The world's registered motorcycles and cars (2002, 2006, and 2010)

Items	2002	2006	2010
The World's registered motorcycles (Million)	200	313	455
Number of motorcycles per 1000 population	33	50	69
The World's registered cars and 4-wheel light vehicles (Million)	590	686	782
Number of cars per 1000 population	91	109	118

Data source: Haworth (2012) and WHO (2013)

Statistics shows that in the period (2002 - 2010) the rate of increase in motorcycles seems to surpass the rate of car growth. This fact can be seen in Table 2.1 with the reference to the rates of motorcycles and cars per 1,000 population. The total number of registered motorcycles in the year 2010 reached to a percentage of 30% of all vehicles in the world.



Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.6 The twenty countries with the greatest number of motorcycles per 1,000 population

Figure 2.6 shows the twenty countries with the greatest number of motorcycles per 1,000 population. Four Asian countries (Vietnam, Malaysia, Indonesia, and Thailand) have more than one motorcycle for every four people. Considering that some people will be too young to ride motorcycle, this could be one motorcycle per two people in the relevant age group.

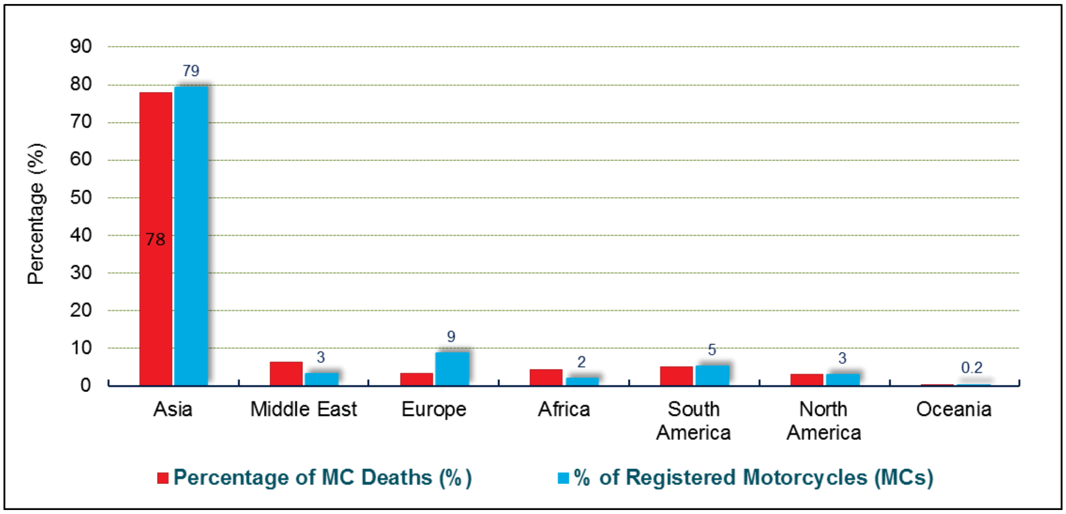
2.6.4.1 Motorcycle use and fatalities

It is perhaps not surprising that most of the world's motorcycles are in Asia (79% of total registered motorcycles in the world) as shown in Table 2.2 and Figure 2.6, given that a very large proportion of the world's population lives there. Asia is a continent with highest number of motorcycles per 1,000 population. Within Asia, China has the most motorcycles (110 million), followed by India (82 million), Indonesia (60 million) and Vietnam (31 million) (WHO, 2013).

Table 2.2 The overall total of registered motorcycles in the world (2010)

No.	Continent/Region	Registered Motorcycles (2010)	Percentage of total motorcycles (%)	Motorcycles per 1000 population	Percentage of MCs of all vehicles (%)
1	Asia	359,567,713	78.94	100.80	59.35
2	Middle East	13,240,634	2.91	28.35	25.21
3	Europe	38,767,389	8.51	43.90	9.56
4	Africa	7,938,939	1.74	10.35	22.88
5	South America	22,801,731	5.01	58.12	22.54
6	North America	12,395,764	2.72	23.82	3.86
7	Oceania	778,936	0.17	21.80	4.01
	Total	**455,490,566**	**100 (%)**	**World's rate: 68.68**	**30% of all vehicles**

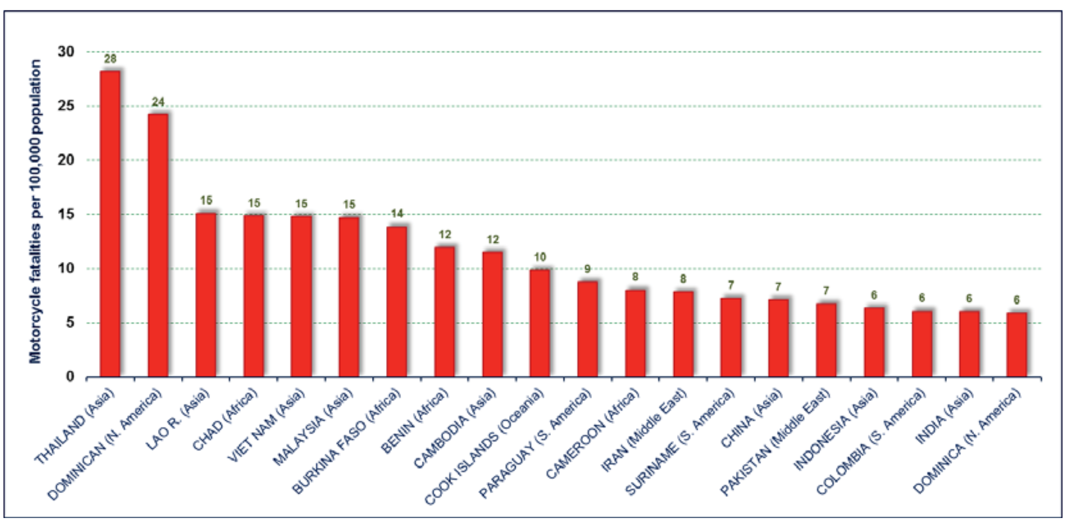
Data source: Global Status Report on Road Safety, WHO (2013)



Data source: Global Status Report on Road Safety, WHO (2013) and Rogers (2008)

Figure 2.7 Percentage of motorcycle use and fatalities by continents

In Asian countries, motorcycles are an increasingly common mean of transport, and the users make up a large proportion of those injured or killed on the roads (Haworth, 2012). Most of the motorcycle deaths happened in Asia, accounting for a percentage of 78% as shown in the Figure 2.7.



Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.8 The twenty countries with greatest rate of motorcycle deaths per 100,000 population

Five Asian countries (Thailand, Lao, Vietnam, Malaysia, and Cambodia) are among the top ten of countries with greatest motorcycle deaths per 100,000 population in which Thailand is a country has highest death rate per 100,000 people as shown in the Figure 2.8.

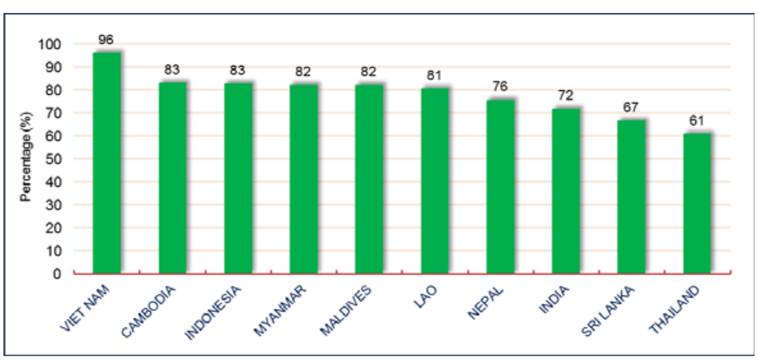
2.6.4.2 Differences in use of motorcycles between developed and developing countries

Motorcycles come in diverse forms and are used for a range of purposes in very different parts of the world. The types of motorcycles and their main purposes of use also differ markedly among and between developed and developing countries. In large cities of some developed countries (particularly European countries), motorcycles are commonly used for commuting, while in other developed countries (such as Japan, US), touring is more common than commuting. In developing countries motorcycles are largely used as a means of mobility and most motorcycles are low and medium engine capacity motorcycles (Haworth, 2012).

Perversely, larger motorcycles in developed countries tend to be used by single riders, while the smaller motorcycles and scooters in developing countries frequently carry passengers and are used with a variety of attachments for carriage, delivery, vending and passenger transport. Enjoyment was an important factor in many high-income countries but that employment/entrepreneurship was important in many low and middle-income countries (Haworth, 2012).

2.6.5 Pattern of motorcycle use and fatalities in Asian countries

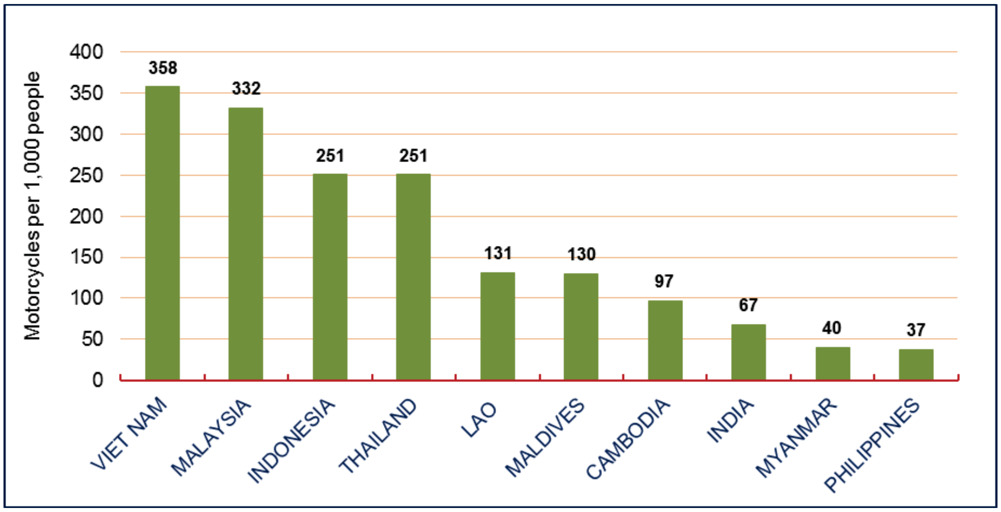
2.6.5.1 Patterns of motorcycle use and fatalities in Asian countries



Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.9 The top ten countries in Asia with greatest percentage of motorcycles of all vehicles

Figure 2.9 shows the top ten countries in Asia which have greatest percentage of motorcycles of all types of vehicle. Within this top ten, Thailand is a country has lowest percentage of motorcycle (61%), and Vietnam has highest percentage of motorcycles (96%) in Asia and also in the world.



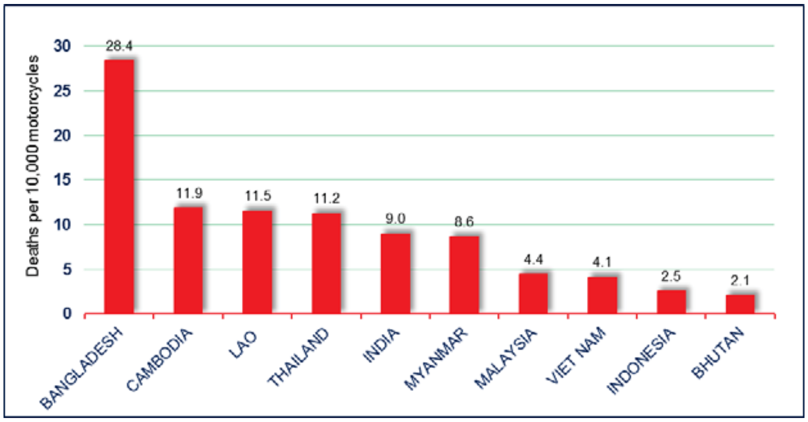
Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.10 The top ten countries in Asia with greatest rate of motorcycles per 1,000 people

It is very easy to realize from Figure 2.10 that Vietnam and Malaysia are two countries in Asia have more than one motorcycle for every three people. Indonesia and Thailand have approximately one motorcycle for every four people. This indicates the motorcycles play an important role in transport in a number of Asian countries.

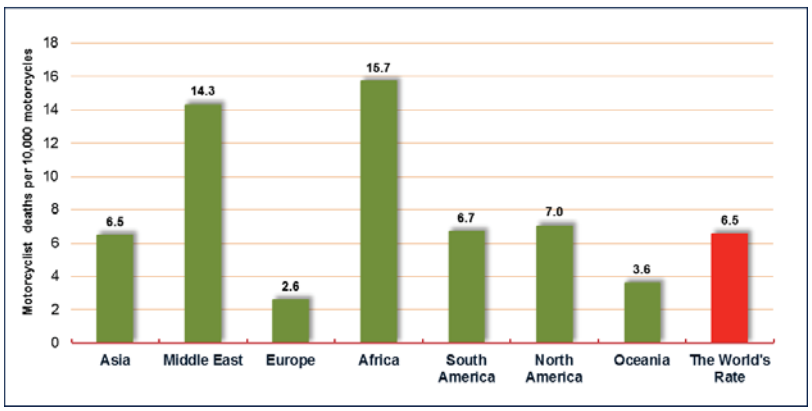
2.6.5.2 Safety of motorcycles in Asian countries

Due to their comparatively low cost, motorcycles tend to be the first affordable type of vehicles that can be purchased in Asian countries. Unfortunately, these riders have high-risk thresholds this fact can be found in the Figure 2.11. The Asia is a continent has death rate the same world’s rate of deaths per 10,000 motorcycles as shown in the Figure 2.12. Six Asian countries (Bangladesh, Cambodia, Lao, Thailand, India, and Myanmar) have death rate higher than average rate of Asia, in which Bangladesh has the death rate found to be about 4 times greater than the Asia and World’s rate of deaths per 10,000 motorcycles.



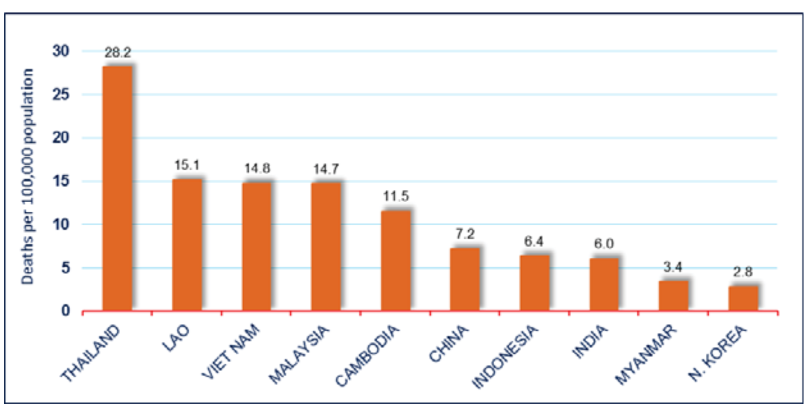
Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.11 The top ten countries in Asia with greatest motorcyclist deaths per 10,000 motorcycles



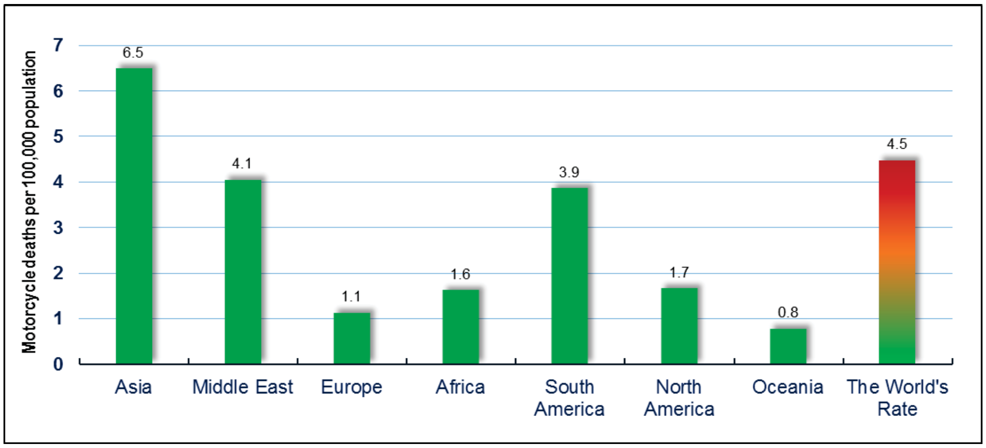
Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.12 The rate of motorcyclist deaths per 10,000 motorcycles by continents



Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.13 The top ten countries in Asia with greatest motorcyclist deaths per 100,000 population



Data source: Global Status Report on Road Safety, WHO (2013)

Figure 2.14 The rate of motorcyclist deaths per 100,000 population by continents

In the top ten countries which have greatest motorcyclist deaths per 100,000 people in Asia as shown in Figure 2.13, six countries (Thailand, Lao, Vietnam, Malaysia, Cambodia, and China) have death rate higher than average rate of Asia and the World's rate as well. Thailand has rate of motorcycle deaths per 100,000 people approximately 4 times greater than Asia's average rate, and 6 times greater than the World's rate. Next, Lao, Vietnam, and Malaysia have death rate about 2.5 times greater than average rate of Asia, and 3.5 times of the World's rate (refers to Figure 2.14).

2.6.6 Current problems of the road infrastructure concerning motorcycle safety

The ROSA (2011) has pointed out a series of problems of road infrastructure system concerning motorcycle safety to be solved. The key problems can be listed as follows:

- Lack of consideration of motorcycles and motorcyclists during road design from a road safety point of view;
- Lack of road design guidelines for roundabouts and intersections;
- Lack of guidelines for traffic calming systems;
- Lack of anti-skid properties and lack of reflectivity;
- Lack of knowledge about general recommendations;
- Lack of knowledge about interaction between potholes and road safety;
- Harmful design of roadsides;

- Poor maintenance of shoulders;
- Lack of information about existing products and current standards;
- Lack of recommendations;
- Lack of definition of road safety audits from motorcyclist point of view;
- Interaction among motorcyclists and the rest of road users;
- The problem of black spots and allocation of accidents; and
- The problem of road works.

2.6.7 Motorcycle crash contributing factors

The road environment has a significant influence on the risk of crashes involving motorcycles. The contributing factors include (from www.toolkit.irap.org based on Road Safety TOOLKIT):

- Interaction with larger vehicles (cars, trucks);
- Road surface issues (such as roughness, potholes or debris on the road);
- Water, oil or moisture on the road;
- Excessive line-marking or use of raised pavement markers;
- Poor road alignment;
- Presence of roadside hazards and safety barriers; and
- Number of vehicles and other motorcyclists using the route.

2.6.8 Current engineering approaches of motorcycle safety

2.6.8.1 Segregation of motorcycle traffic from other as an effective engineering approach to reduce accidents

One of the sentences of ROSA project (2011) has been "On the road, stay alive together is survive". The reason of this sentence is the fact that one of the problems that motorcyclists has is the interaction with the rest of road users (cars, trucks, vans, etc.). A number of researches stressed the importance of segregation of motorcycles and heavier vehicles as follows.

- A major risk factor for motorcyclists is their interaction with larger, heavier vehicles, particularly if the motorcycles are small and relatively slow. One way of addressing this problem is to segregate motorcycles from heavier vehicles through the provision of exclusive motorcycle lanes (APEC, 2009).
- Many problems result from the mixing of different types of traffic. Some road users i.e. pedestrians, cyclists, and motorcyclists are far more vulnerable than those road users travelling in heavier, motorized 4-wheeled vehicles. Segregating fast moving motorized vehicles from these slow moving vulnerable road users is one of the basic tools available to the highway safety engineer. Therefore, it is important for the designer, wherever feasible, to introduce measures to segregate certain road users in order to minimize the opportunities for collisions to occur, and to improve the urban street environment (Quimby *et al*., 2003).
- The key road safety problem in developing world like Asian countries is motorcycle safety. Motorcycle is a popular mode of personal travel and formed as the major road user. Studies proved that segregation is the best engineering practice to save lives of motorcyclists (Hussain *et al*., 2005).
- Mixed traffic can cause rise to the number and severity of motorcycle accidents. Segregation of motorcycle traffic from other is an effective measure to prevent motorcycle-involved crashes (Hussain et al., 2011).
- Motorcycle safety can be increased with the separation of two wheeled motorcycles from large, high-speed vehicles (from www.gtkp.com, based on Global Transport Knowledge Practice).
- Motorcycle safety can also be improved by separating motorcycles from larger vehicles in the traffic stream (from www.toolkit.irap.org, based on Road Safety TOOLKIT).
- Segregating motorcycles from other vehicles appears to show significant positive effects on the number and severity of motorcycles casualties. The key element is

the reduction in collisions between motorcycles and other vehicles, reducing the collision mass ratio from approximately 5:1 to 1:1 (ROSA, 2011).

2.6.8.2 Motorcycle lane

The potential conflicts in mixed traffic can be reduced by installing separated lanes where motorcycles make up a considerable proportion of the traffic volume. Radin *et al.* (2000) found that motorcycle lanes on federal highway were of greatest benefit for a traffic volume in excess of 15,000 vehicles a day where the proportion of motorcycles in the traffic was between 20% and 30%. Motorcycle lanes can be ‘exclusive’ or ‘inclusive’.

(1) Exclusive motorcycle lane

Exclusive motorcycle lanes require a carriageway completely separate from that used by other vehicles (see Figure 2.15a). Use of exclusive motorcycle lanes can minimize crashes at intersections.

a. Exclusive motorcycle lane **b.** Inclusive motorcycle lane

Source: Malaysian Institute of Road Safety (2003)

Figure 2.15 *Exclusive* and *Inclusive* motorcycle lanes in Malaysia

(2) Inclusive motorcycle lane

Inclusive motorcycle lanes can be constructed on the existing road and are often situated on the outside of the main carriageway for each direction of traffic flow. Painted lines or physical separators can be used to separate these lanes from the rest of the road (see Figure 2.15b). However, at intersections the rejoining of these lanes into the main carriageway can lead to conflicts.

According to Teik Hua and Radin Umar (2005) the exclusive motorcycle lane needs a control width of 3.81 meters (inclusive of marginal 0.38 meter stripe at both edges of the road) for two riders to travel side by side comfortably at a speed of 70 km/h. This value was higher than the 3.5 meters adopted by the Ministry of Works Malaysia (1986). International Road Assessment Program (iRAP) suggested that the width motorcycle lanes should be at least 1.8 meters for each direction (from www.toolkit.irap.org).

The Malaysian design guidelines (Public Works Department, 1986 - *A Guide on Geometric Design of Roads*, Public Works Department 8/86, Ministry of Works Malaysia) stated: *"In areas where there is usually a high proportion of motorcyclists, the volume may be so substantial as to affect the smooth flow of traffic. In such instances, the provision of separate and exclusive motorcycle lanes should be considered. The general warrants for determining the need for an exclusive motorcycle lane are:*

(i) the total volume of traffic exceeds the provided lane capacity, and

(ii) *the volume of motorcycles exceeds 20% of the total volume of traffic."*

Table 2.3 below gives the width of exclusive motorcycle lanes for different traffic volumes.

Table 2.3 Malaysian guidelines for separate motorcycle lanes

Volume of motorcycles/hour	Width of motorcycle lane (m)	
1000 - 1500	2.0	2.5
1500 - 2000	2.5	3.0
> 2000	3.0	3.5

Source: Public Works Department 8/86, Ministry of Works Malaysia (1986)

2.6.8.3 Traffic management at intersections

The nature of the traffic at intersections is quite different from that of other segments in road networks. The exchange function is supposed to have stronger impacts on the traffic situation at intersections than the flow function does. As a rule, intersections on distributor roads, collector roads and local roads are at-grade intersections. Accordingly, when on such roads road users are exposed to more traffic conflicts at intersections than when they are on other road segments where there are large differences in direction, size, and speed. Furthermore, there are more difficult tasks for road users to do due to the complexity of traffic nature in terms of flow and exchange at intersections. Within quite a short time, drivers are bound to decide which route to take, how to change their directions, and also how to facilitate potential movements of other vehicles (SWOV, 2012).

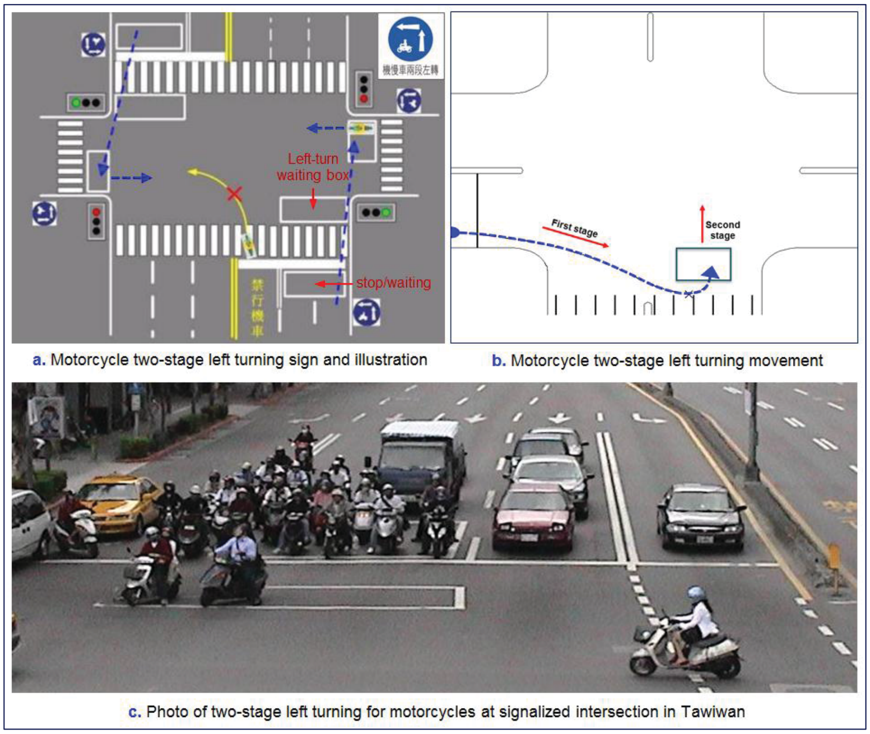
In busy urban areas there is a competition for road space among different groups of road users. Some traffic management measures can be applied in reducing the collisions between motorcycles and other vehicles, reducing the conflict between left turn motorcycles and straight-out cars at intersections, and provision of a safer place for motorcyclists to wait for the green light as shown in the Figures 2.17 and 2.18. These measures improve the safety of motorcycles, whereas there appears to be little or no disadvantage for other road users.

(1) Head start holding zone (or advanced stop lines for motorcycles) at signalized intersections

a. Plan view of head start waiting zone for motorcycles in Taiwan **b.** Photo of head start waiting zone for motorcycles in Taiwan

Figure 2.16 Head start waiting zone for motorcycles at signalized intersections in Taiwan, Hsu (2012)

(2) Two-stage left turning for motorcycles at signalized intersections



a. Motorcycle two-stage left turning sign and illustration
b. Motorcycle two-stage left turning movement
c. Photo of two-stage left turning for motorcycles at signalized intersection in Tawiwan

Source: Hsu (2012); Wang *et al.* (2013)

Figure 2.17 Two-stage left turning for motorcycles at signalized intersections in Taiwan

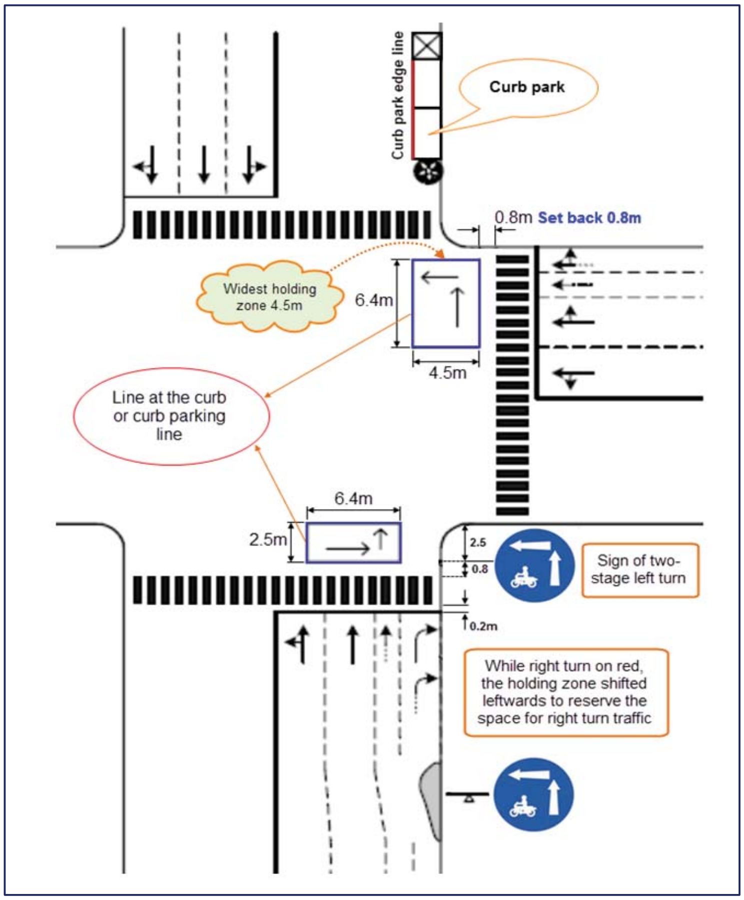
Studies of motorcycle accidents in Taipei, Taiwan indicated that the majority are one of two types: (1) sideswipe collisions along roadways which generally caused by lane switching behavior; and (2) both head-on and sideswipe collisions at intersections which involving left turning motorcycles (Hook and Fabian, 2009).

Motorcyclists tend to drive down the space between the curb lane and the mixed traffic lane adjacent to it, whether or not this space is marked as a motorcycle lane. When they reach the intersection, they will proceed forward until they reach a storage area if one has been provided. If the road is two lanes or less, they are generally allowed to turn left by moving across the road and to the front of the left-turn lane.

However, this movement of motorcycles from the right to the left-turn lane (in India, Malaysia, Singapore, Thailand, and Indonesia, the movement would be from the left to the right) sometimes leads to accidents. To minimize the number of left-or-right turning accidents while maintaining simple and efficient signal phasing, some intersections have banned left turns by motorcycles and require them to make a two-phase turning movement. Hsu (2006) recommended this configuration if there are 200 or more left-turning motorcycles per signal phase and three or more mixed traffic lanes.

If direct left-hand turns are banned, motorcyclists wishing to turn left must proceed through the intersection during the green phase and then wait in a specially designated waiting area ahead of the pedestrian crosswalk in front of the perpendicular traffic. This design introduces some additional delay for motorcycles reaching the intersection during the red phase. If a motorcycle reaches the traffic signal during the red phase, it must proceed to the perpendicular road and wait through the entire signal phase to turn left, while motorists can make a direct left turn. In cities without strict enforcement capacity, such left-turn configuration tends to lead motorcyclists to make illegal left-turns to save time (Hook and Fabian, 2009).

The motorcycle waiting area in Taipei allows approximately 0.8 meters of width and 2.3 meters of length for each turning motorcycle. This solution eventually reduced motorcycle accidents at intersections after having initially increased them at crosswalks between motorcycles and pedestrians. To avoid such a setback, the waiting area must be properly sized, and the pedestrian crosswalk needs to be setback from the junction by the full length of the turning box and an additional 0.8 meters as shown in Figure 2.18 (Hook and Fabian, 2009).



Source: Hook and Fabian (2009)

Figure 2.18 Motorcycle waiting area at intersection Taipei, Taiwan

2.6.9 Conclusions

Traffic problems in Asian countries with high proportion of motorcycles have been becoming serious accompanying with the growth of motorcycles. Action needs should be taken on the safety and mobility of motorcycles and motorcyclists as well.

Safe design requires that road users must have sufficient time to be able to see, process and react to information. The principles are the same for all road users, but the standards are more critical for motorcyclists as errors can have more severe consequences. Road design and safety engineering countermeasures should be paid attention to the specific needs of motorcycles.

CHAPTER 3

METHODOLOGY

Generally, this research was conducted based on a mixed method as shown in Table 3.1. Firstly, the related data on road traffic safety in HCMC was collected from a variety of sources. Then the data were categorized and analyzed so as to find out the actual problems of road traffic safety the city was facing. Next, a new black spot management approach was proposed as a safety tool to effectively solve the identified problems. Finally, the suggested approach was implemented with the specific traffic conditions in an urban district named Phu-Nhuan as the subject site to evaluate the effectiveness of the approach.

Table 3.1 Research framework and methodology

	Identifying Actual Safety Problems in HCMC		
	Content	**Outcome**	**Methodology**
Stage I	■ Collecting data on road safety in HCMC - Accident number & severity by road type - Accident number & severity by vehicle type - Accident number by year, moth, day, time - Accidents by age of road users - Under-Reported accident numbers - Road network characteristics - Traffic volume data - Registered vehicle data … ■ Processing/Analyzing data ■ Reviewing previous studies ■ Identifying road safety problems ■ Prioritizing road safety problems	■ Road safety problems in HCMC ■ The most important road safety problem of HCMC	■ Statistical analysis ■ Meta analysis

Stage	Content	Outcome	Methodology
Stage II	**Developing a New Black Spot Management Approach for HCMC**		
	Content	**Outcome**	**Methodology**
	■ Searching for papers, reports, etc.	■ A new black spot management approach	■ Urban road safety management
	■ reviewing literature		
	■ Identifying limitations of traditional methods		
	■ Developing a new approach		
Stage III	**Practically Implementing Proposed Approach (1) – Identifying Black Spots**		
	Content	**Outcome**	**Methodology**
	■ Selecting study area	■ The 1-year Accident Pin Board, and 3-year Accident Pin Board ■ List of identified black spots ranked by safety potential	■ Statistical analysis ■ Inspection of Accident maps
	■ Collecting input data		
	- Accident reports (2009 – 2011)		
	- Road network geometric data		
	- Traffic data		
	■ Classifying accidents		
	- Severity-based accident types		
	- Conflict-based accident types		
	- Direction-based accident types		
	- Time-based accident types		
	- Motorcycle-related accident types		
	- Special circumstances …		
	■ Making accident maps		
	■ Identifying black spots		
	■ Ranking black spots		
Stage IV	**Practically Implementing Proposed Approach (2) – Analyzing Black Spots**		
	Content	**Outcome**	**Methodology**

	Content	Outcome	Methodology
	■ Analyzing collision diagrams - Preparing collision diagram template - Plotting collision diagram - Identifying accident patterns - Diagnosing accident contributing factors - Selecting appropriate measures ■ On-site investigating - Observing traffic situation, conflicts - Measuring road layout - Investigating road surface, visibility conditions - Investigating traffic control, obstacles …	■ Factors contributing to accidents ■ Appropriate safety countermeasures	■ Accident structure analysis ■ In-depth investigation

Stage V — Simulating Black Spots by VISSIM Software

Content	Outcome	Methodology
■ Simulating before treatment - Preparing input data - Simulating - Evaluating results ■ Proposing safety countermeasures ■ Simulating after treatment - Preparing input data - Simulating - Evaluating results	■ Verification of identified safety problems ■ Evaluation of safety performances of proposed countermeasures	■ Microscopic analysis using VISSIM Software

Conclusions and Recommendations

- Generally summarizing
- Drawing conclusions
- Presenting recommendations for implementation

3.1 Stage I – Identifying actual safety problems in HCMC

This stage was aimed to identify the actual road safety problems in HCMC. The identification was composed of three basic steps. First, the related data on traffic safety was collected. Then, the data was categorized according to different aspects. Finally, the data was analyzed so as to find out the actual road safety problems which city was facing.

3.2 Stage II – Developing a new black spot management approach for HCMC

This stage was aimed to develop a new black spot management approach for the particular case of HCMC based on the *Network Safety Management* (Bast & Sétra, 2005). The approach takes *safety-potential* as a key parameter, and is therefore called *Safety-potential-based Black Spot Management Approach (SAPO-based BSM Approach)*. There are eight basic steps in this approach as shown in Figure 3.1.

3.3 Stage III – Practically implementing proposed approach in identifying black spots

This stage was aimed to verify the reliability and the effectiveness in black spot identification of SAPO-based BSM Approach by means of a practical implementation. This implementation includes eight main steps:

(1) selection of study area;

(2) collection accident and road network geometric data;

(3) grouping/classifying accident data;

(4) establishment of accident pin boards (1-year APB & 3-year APB);

(5) identifying high accident frequency locations by inspection of the 3-year APB;

(6) statistical tests for identified high accident frequency locations;

(7) calculation of SAPO of high accident frequency locations which passed statistical test; and

(8) ranking black spots by safety potential.

3.4 Stage IV – Practically implementing proposed approach in analyzing black spots

This stage was aimed to verify the reliability and the effectiveness in analyzing black spots and proposing safety countermeasures of SAPO-based BSM Approach by means of a practical implementation. Specifically, the black spot with highest safety potential was selected to analyze. The analysis was conducted by means of accident collision diagram analysis. On the basis of this analysis and local investigation, the appropriate safety improvement measures were identified.

3.5 Stage V – Simulating traffic situation at the black spot

This stage was aimed to simulate the traffic situation by using the specialized software called VISSIM so as to have further verification and evaluation of factors relative to the black spot. The simulation was expected to:

- further verify the ‘trueness’ of the identified safety problems of black spots as well as the reliability and the effectiveness of the selected safety countermeasures;
- further evaluate the effects of the treatments on the traffic situation at the spot; and
- visualize the ‘potentially invisible impacts’ of the countermeasures on the current traffic system.

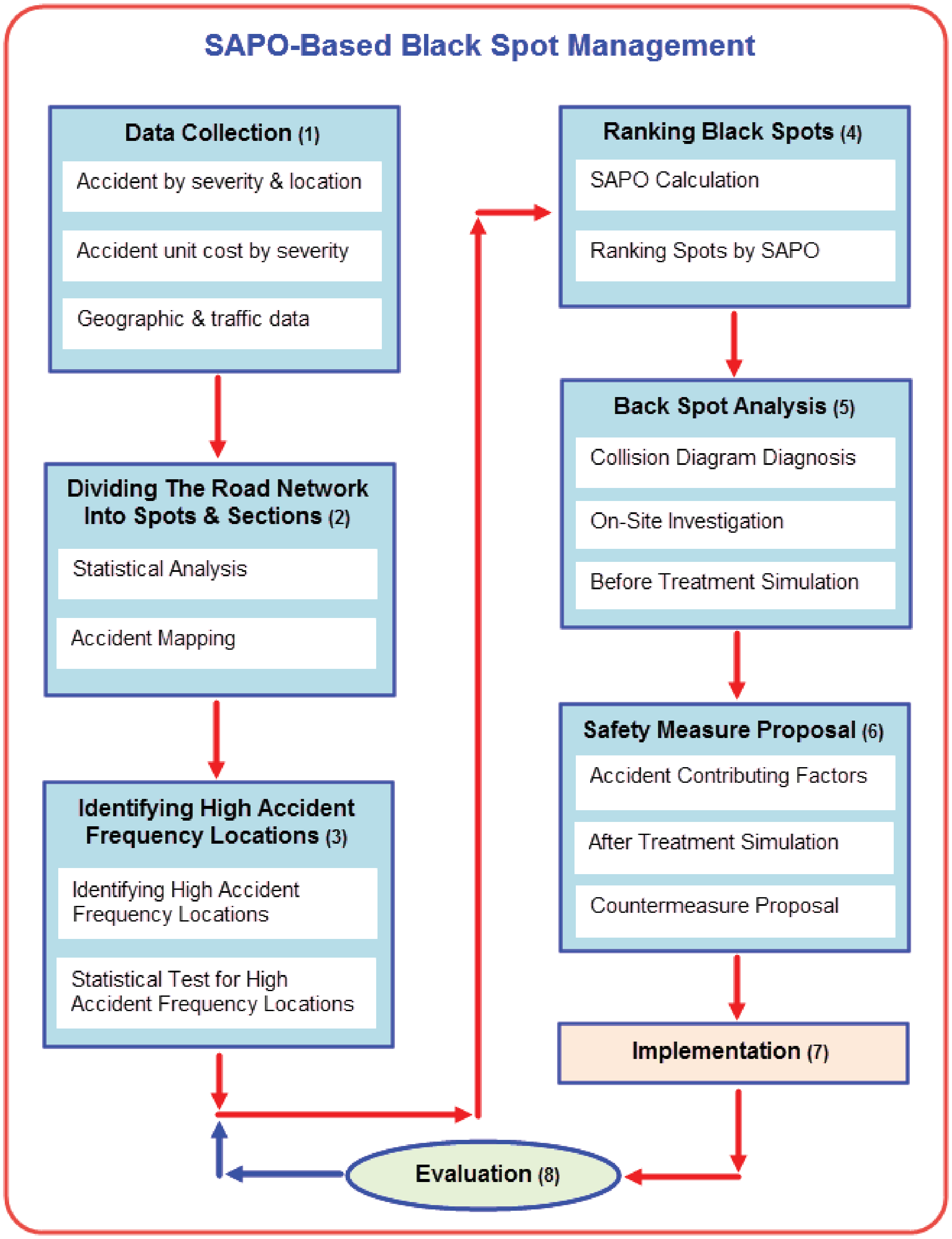


Figure 3.1 Reference framework diagram for the *SAPO-based Black Spot Management*

CHAPTER 4

ROAD TRAFFIC SAFETY IN HO CHI MINH CITY

This chapter provides a brief introduction of the road network in Ho Chi Minh City (HCMC) as well as an overview of the travel demand, registered vehicles, modal share, road traffic accidents, and under-reported issue in this city which make it necessary to do further research so as to solve or minimize such problems.

4.1 Road network in HCMC

The city's road network is made up of national roads, provincial roads, urban roads, and rural roads. The existing road network is unevenly developed. There are a lot of difference in road density between the inner city districts and the suburban areas. There is so much traffic conflict of different natures due to the great number of vehicles most of which are motorcycles. The current traffic system seems to be unable to accommodate such a number of vehicles. In other words, such a system cannot meet the increasing civil travel demand as well as the need for other types of transportation.

4.1.1 National and Provincial road networks

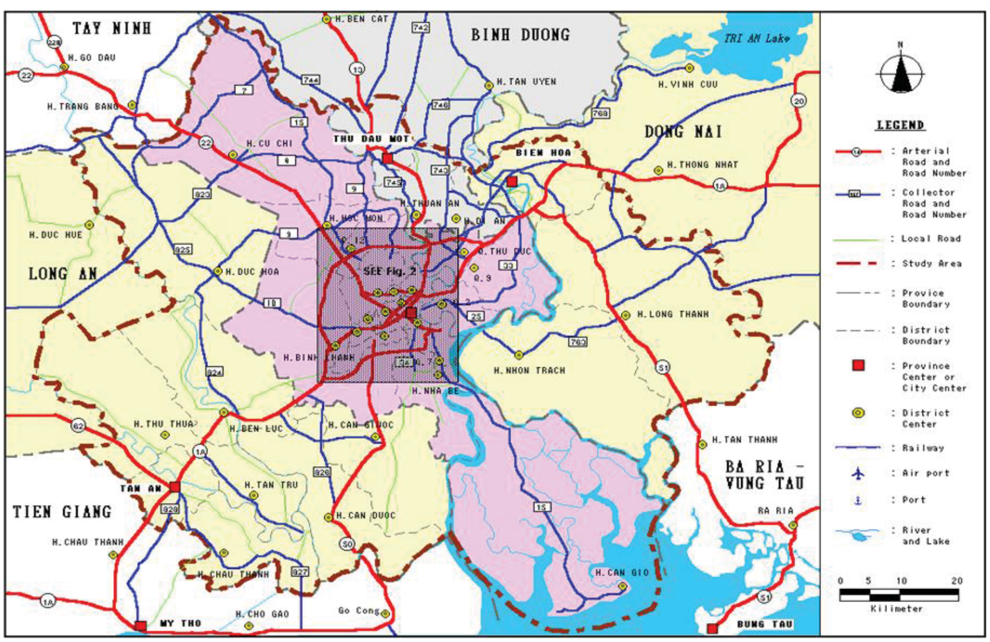
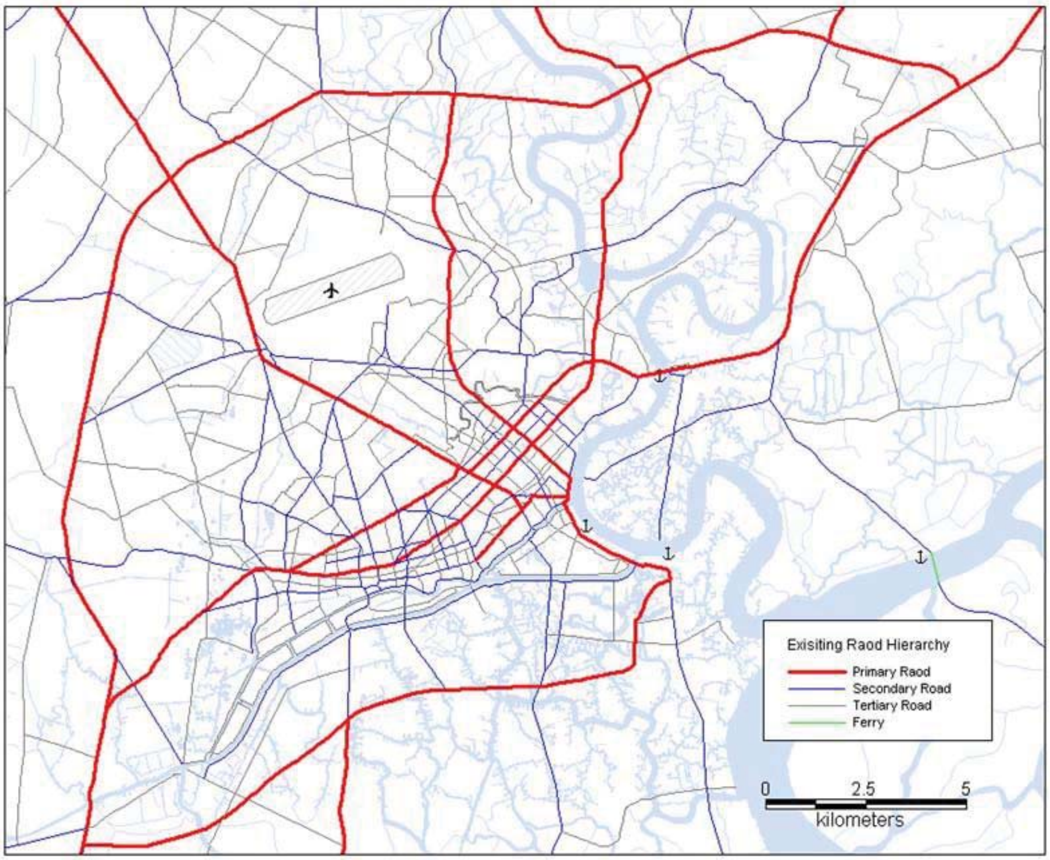


Figure 4.1 Current road networks in HCMC and surrounding areas, JICA (2008)

The current road networks in HCMC and surrounding regions are as in Figure 4.1. All of the national roads either start or ends in HCMC, connecting this city with the surrounding regions and connecting these regions with one another. The provincial road networks are of poor quality and ineffectively connect the centres of the districts with national roads.

4.1.2 Urban road network in HCMC

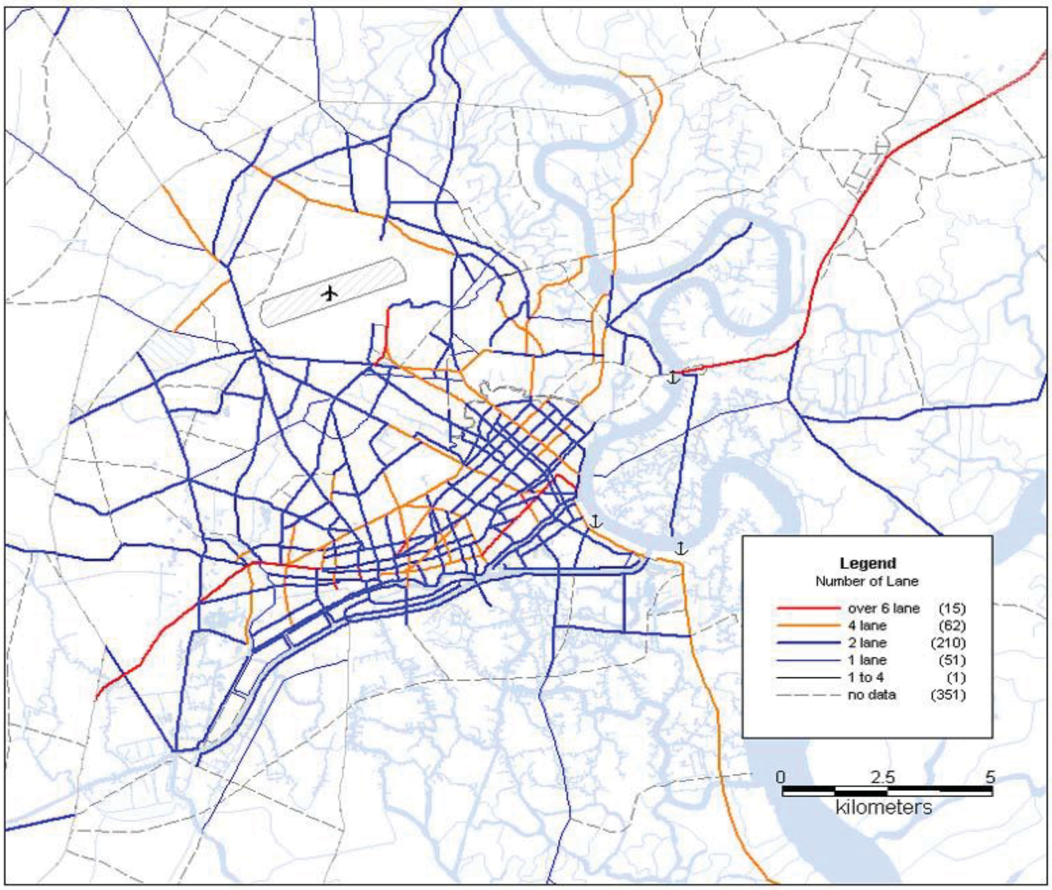


Source: JICA (2008), HOUTRANS

Figure 4.2 The existing road networks inner HCMC

The road networks in HCMC are under imbalanced development and there has been almost no proper system of function-based categorization of road networks in the city. There is a high density of urban roads in central or inner-city districts. On the contrary, there is a very low density of roads in outer-city districts, especially the regions on the East bank of Saigon River, i.e. in the East and Southeast of the city. Figure 4.2 describes the existing road networks inner HCMC. The total length of roads in HCMC is 1,242.13 km. Roads of level 1 (designed speed: 120 kph) account for 14%; level 2 (designed speed: 100 kph) account for 32%; and the rest account for 54%.

Most of the urban roads are two-lane roads as presented in Figure 4.3. Only a few are four-lane or six-lane roads the numbers of lanes of which are reduced in a few stretches. These facts seriously affect the smoothness of the traffic flows. All of the two-lane roads are less then 15m in width. Therefore, either the road-beds and road shoulders of these roads are narrow or there are no sidewalks.



Source: JICA (2008), HOUTRANS

Figure 4.3 Number of lanes of roads inner HCMC

4.2 Travel demand

The Household Interview Survey (HIS) conducted for the HOUTRANS in 2002 showed that the total transport demand in HCMC was estimated to be 13.38 million trips (excluding walking but including bicycle) a day. Total demand increased in the period of time from 1996 to 2002 at an average annual growth rate of 8.4%. The estimate made by the DFID-MVA study conducted in 1996 on the total travel demand in HCMC was 8.23 million trips a day, while the HOUTRANS HIS data was 13.383 million trips a day. The annual growth rate for the study population was 1.9% in the same period, which resulted in significant increases in trip rates in HCMC, from 1.7 to 3.41 (trips/day/person) in the year 2012 as showed in Table 4.1.

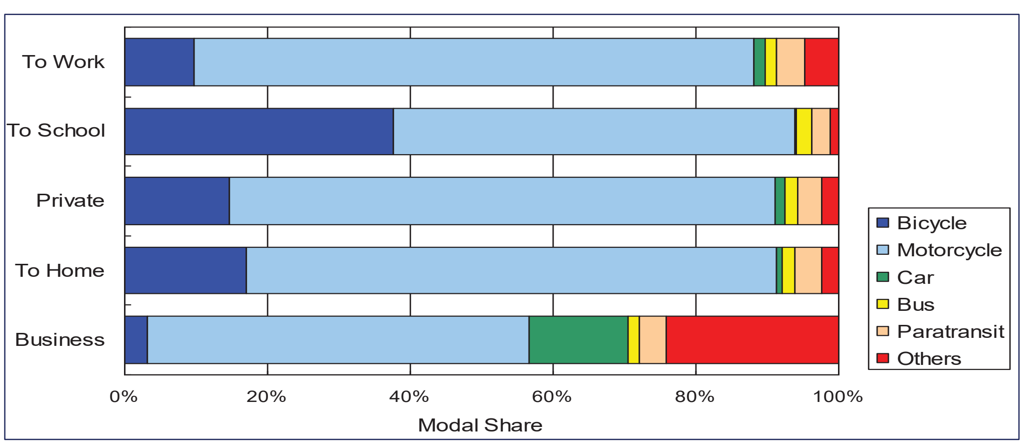
Table 4.1 Total travel demand in HCMC

Item	1996	2002	Growth rate (%/year)	Estimation in 2012
Population (000)	4,839	5,410	1.9	7,500
Number of trips/day (000)	8,229	13,383	8.4	25,610
Trip rate (number of trips/day/person)	1.7	2.47	6.5	3.41

Source: JICA (2008); Nguyen and Taneerananon (2012)

4.3 Modal share by purpose

Of the total demand of 13.38 million trips per day in the year 2002, 75% were made by motorcycle (63% by drivers and 12% by pillion passengers), followed by bicycle at 17%. Public transport including para-transit shared 5.6% of which bus, including Lambro, contributed only 1.7%.

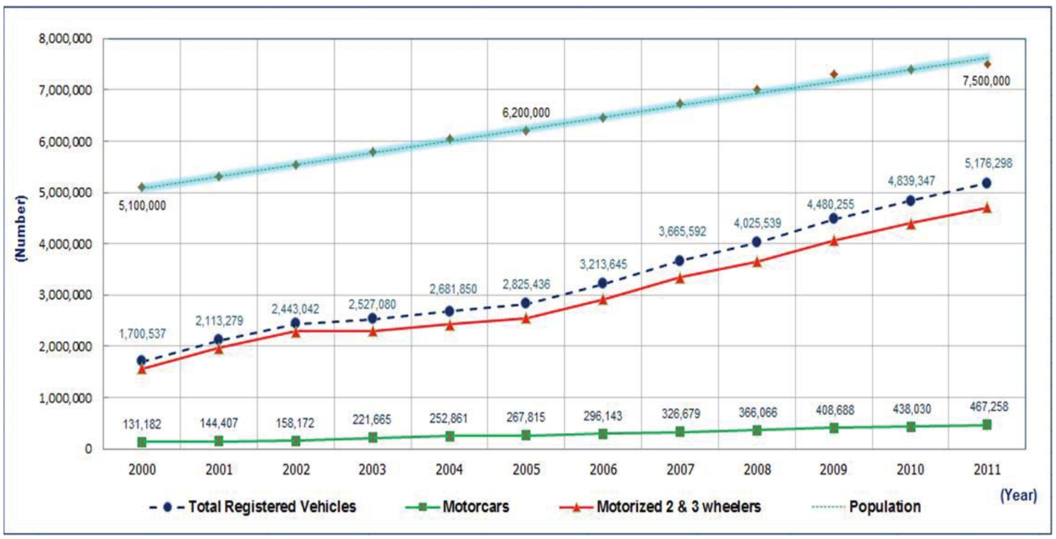


Source: JICA (2008), HOUTRANS

Figure 4.4 Modal share by purpose (excluding walking)

The modal share, however, was fairly different by travel purpose. “To work” trips were made by motorcycles (76.2%), whereas “to school” trips were done by bicycles (38.3%), motorcycles (32.0%) and shared motorcycles (13.0%). “Business” trips were also made by motorcycles (58%), but those of cars (9.3%) and trucks (16.1%) were also notable. Public transport modes were not popular for all-purpose trips (refer to Table 4.1 and Figure 4.4).

4.4 Registered vehicles in HCMC



Source: Nguyen and Taneerananon (2012)

Figure 4.5 The trend of registered vehicles and population in HCMC (2000 - 2011)

There are currently approximate 5.2 million vehicles in HCMC, approximately of 10 percent of which are cars operating on the streets. Each year, the city sees an increase of 10 percent of the existing vehicles, which means approximately 120 additional cars and 1,200 motorbikes per day. Statistics of the period from 2000 to 2011 points out that the rate of increase in vehicles seems to surpass the rate of population growth. This fact can be seen in Figure 4.5.

4.5 Road traffic safety in HCMC

4.5.1 Road accidents and under-reported accidents in HCMC

Statistics shows that, in HCMC from 2009 to 2011 there were 30,076 accidents recorded. In consequence of these accidents 5,759 persons were killed, 12,727 seriously and 25,766 slightly injured. Figure 4.6 and Table 4.2 shows the difference in quantity of road traffic accidents reported by the two sources. This means that a considerable number of accident cases are under-reported. Actually, the number of serious injury and fatality cases recorded by HCMC Health Inspection Division is much higher than that by HCMC Traffic Police.

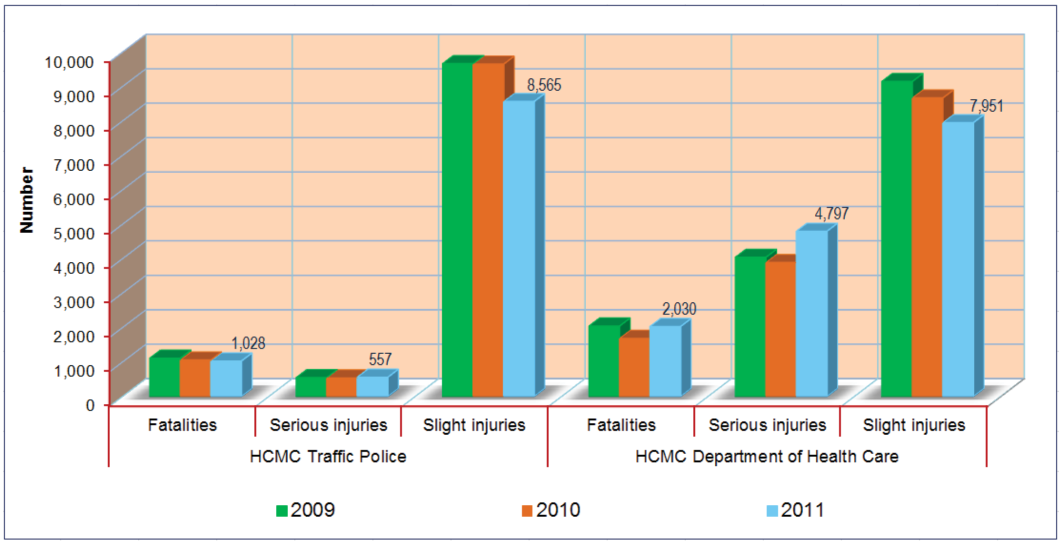


Figure 4.6 Comparison between two accident data sources in HCMC (2009-2011)

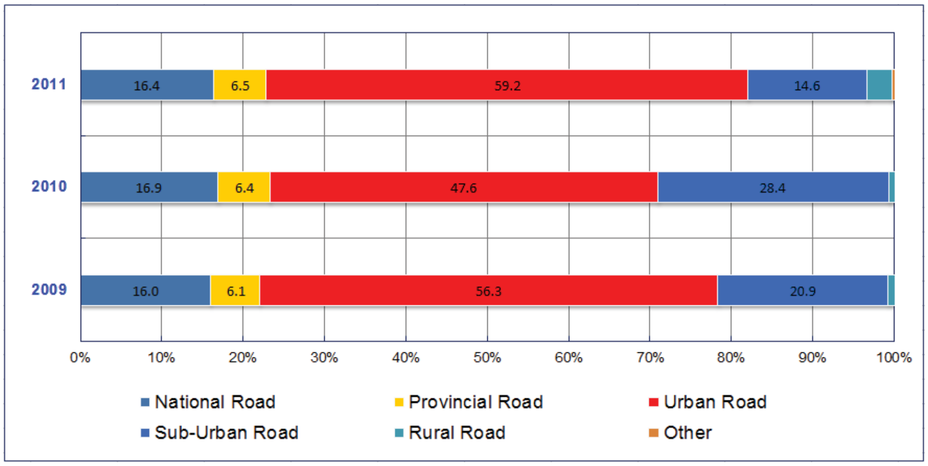
Table 4.2 Comparison between two accident data sources in HCMC (2010-2011)

Data source	**Year 2010**				**Year 2011**			
	No. of Accidents	Fatalities 1)	Serious Injuries 2)	Slight Injuries 3)	No. of Accidents	Fatalities 1)	Serious Injuries 2)	Slight Injuries 3)
[1]	10,928	1,058	536	9,651	8,641	1,028	557	8,565
[2]	-	1,685	3,889	8,669	-	2,030	4,797	8,565

- Not available; [1] Data from HCMC Traffic Police; [2] Data from HCMC Health Inspection Division; 1) Refers to cases of death within 24 hours from arrived at hospital; 2) Refers to cases of injury which require 30 days of treatment or over; 3) Refers to cases of injury which require one day of treatment or less

4.5.2 Accident according to road types

Owing to heavy traffic with strong conflict between vehicles of different sizes and speeds, the percentage of road accidents happening on urban roads is relatively higher than that of accidents happening on sub-urban roads and national roads. The distribution of road accidents according to road types in the city in the period from 2009 to 2011 is illustrated as in Figure 4.7.

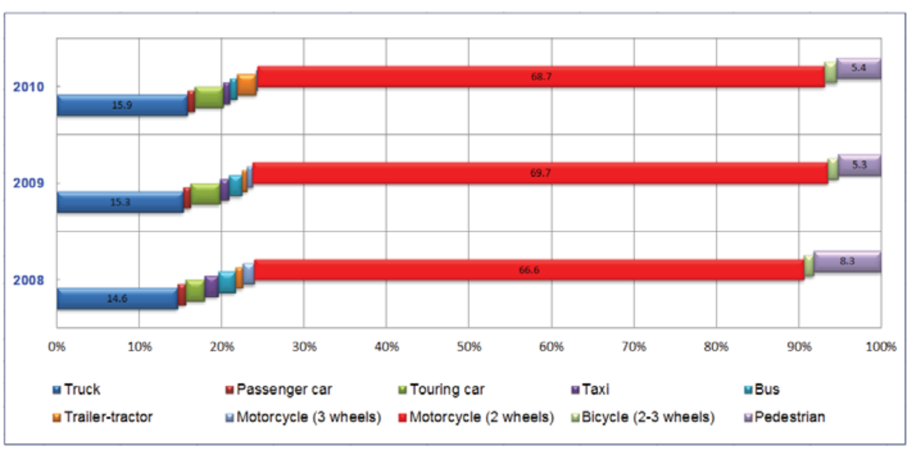


Source: Nguyen and Taneeranaon (2012)

Figure 4.7 Road traffic accidents according to type of roads (2009-2011)

4.5.3 Accident according to vehicle types

The prominent feature of vehicle types in HCMC is that motorcycles account for 90% of the total number of vehicles. As a result, this type of vehicles takes up 90% of the road traffic capacity of the city. 70% of the road accidents are caused by motorcycles, 15% by taxis and 5% by trucks. The remaining 10% are caused by other types of vehicles such as trailers, buses, coaches, and so on. The distribution of road accidents according to vehicle types in the city in the period from 2008 to 2010 is illustrated as in the Figure 4.8.

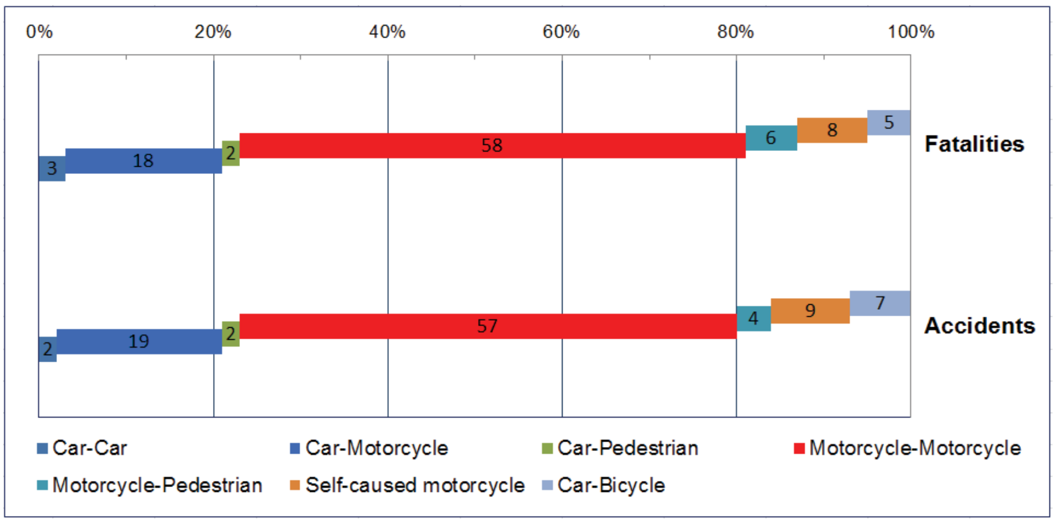


Source: Nguyen and Taneeranaon (2012)

Figure 4.8 Road traffic accidents according to type of vehicles (2008-2010)

4.5.4 Accident according to crash types

Most of the road accidents are crashes between motorcycles, accounting for a percentage of approximately 60%. Next comes, the case of between motorcycles and cars, accounting for a percentage of 18%. The remaining 22% are the cases of car-car accidents, motorcycle-pedestrian accidents, and so on. The distribution of road accidents according to crash types in the city in the 2010 is illustrated as in the Figure 4.9.

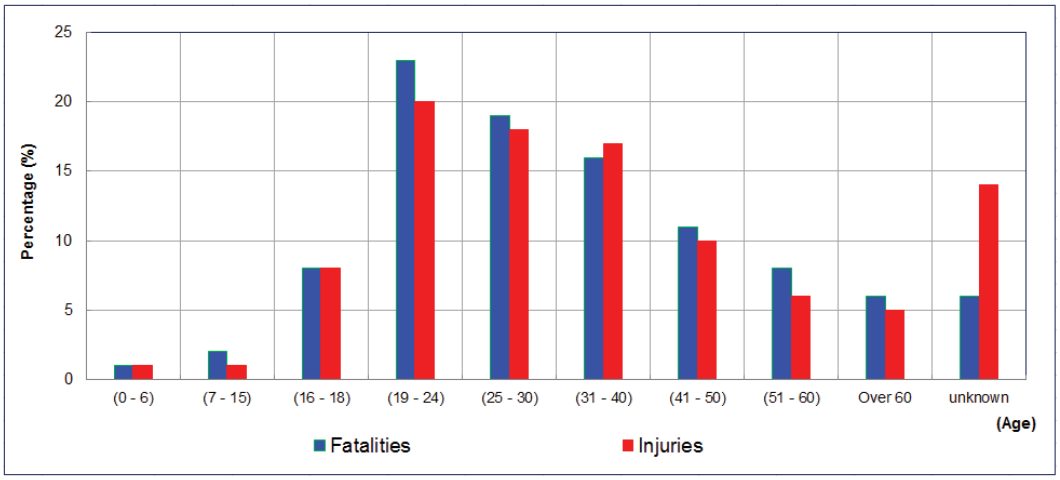


Source: Nguyen and Taneerananon (2012)

Figure 4.9 Road traffic accidents according to crash types (2010)

4.5.5 Accident according to the age of road users

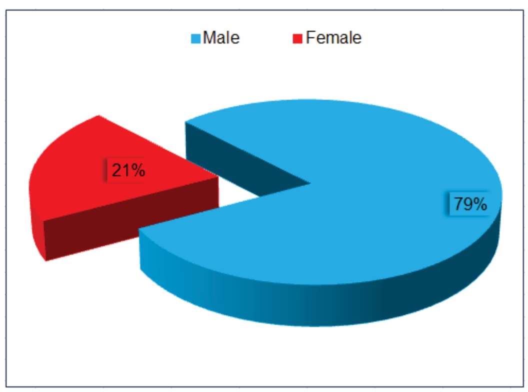
According to the statistics for road accidents in 2010, most of the accidents are caused with the involvement of road users of the age between 19 and 40. The distribution of road accidents according to the age of road users in the 2010 is illustrated as in the figure below. The Figure 4.10 shows that most of cases of death and serious injury in road accidents in HCMC happen to people who are still at the age of labour. These people are often the breadwinner in their families and also the main labour force the society.



Source: Nguyen and Taneerananon (2012)

Figure 4.10 Road traffic accidents according to age of road users in the year 2010

4.5.6 Accident according to gender



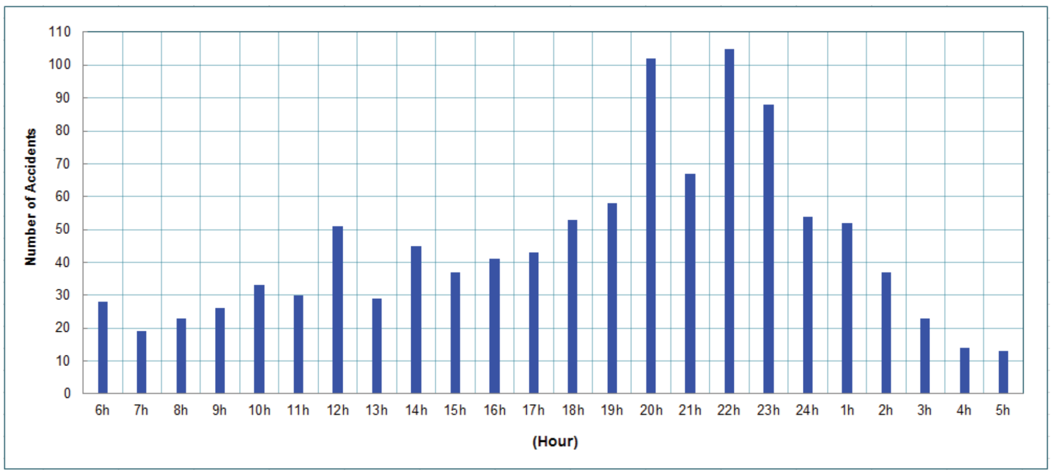
Source: Nguyen and Taneerananon (2012)

Figure 4.11 Gender distribution on road traffic fatalities in HCMC – 2010

Figure 4.11 shows that approximately 80% of death cases in road accidents in HCMC happen to male road users. The combined analysis of Figure 4.10 and Figure 4.11 leads to the conclusion that the impact of road accidents can be felt with not only the surficial loss of human and property which can easily be recorded but also with the potential loss of belief, of financial stability and educational support in the victim's families. Further considered, it can be seen that road accidents create potential social burdens both materially and spiritually.

4.5.7 Accident according to time of the day

An important point to consider is that road accidents in HCMC didn't often happen during rush hour, but from early in the evening (19:00) until late at night (01:00) as shown in Figure 4.12. During this period of time, there is not much traffic on the streets. Therefore, traffic patrol is done only at some important points. And accordingly, road users are more likely to break traffic laws, leading to accidents.



Source: Nguyen and Taneerananon (2012)

Figure 4.12 Road traffic accidents according to time of the day in HCMC - 2010

4.5.8 Causes of road traffic accidents in HCMC

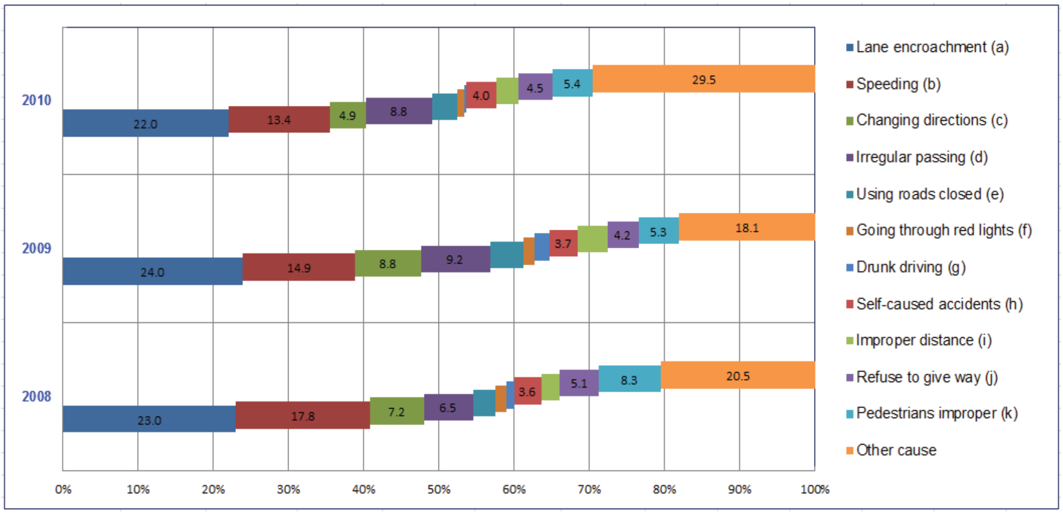
Statistical analysis from HCMC Traffic Police suggests that of the 11 basic causes of accidents in HCMC, lane encroachment is the most common, accounting for a proportion of 22%. Next comes speeding, and ranked third is changing directions at wrong places. At the fourth position is irregular passing of pedestrians. The fifth position goes to using roads closed to responding vehicles. Most of these causes originate from road user's poor awareness of traffic laws and their morality. This is an important issue which should be further considered so as to make better plans and establish more satisfactory solutions for traffic safety in HCMC. Details of the corresponding rates of the 11 most common causes of road accidents in HCMC in the period from 2008 to 2010 are showed in Table 4.3 and Figure 4.13.

Table 4.3 Causes of road traffic accidents in HCMC (2008 - 2010)

No.	Cause of accidents	Proportion (%)		
		2008	2009	2010
1	Lane encroachment (a)	22.96	23.95	22.04
2	Speeding (b)	17.85	14.87	13.45
3	Changing directions at wrong places (c)	7.17	8.82	4.86
4	Irregular passing (d)	6.55	9.17	8.78
5	Using roads closed to responding vehicles (e)	2.96	4.36	3.36
6	Going through red lights (f)	1.43	1.51	0.84
7	Drunk driving (g)	1.08	1.96	0.28
8	Self-caused accidents (h)	3.59	3.74	4.01
9	Improper distance between moving vehicles (i)	2.51	4.01	2.99
10	Refuse to give way to other vehicles as required (j)	5.11	4.19	4.48
11	Pedestrians improper use of roads (k)	8.25	5.34	5.42
12	Other causes (unknown or under investigation)	20.54	18.08	29.51

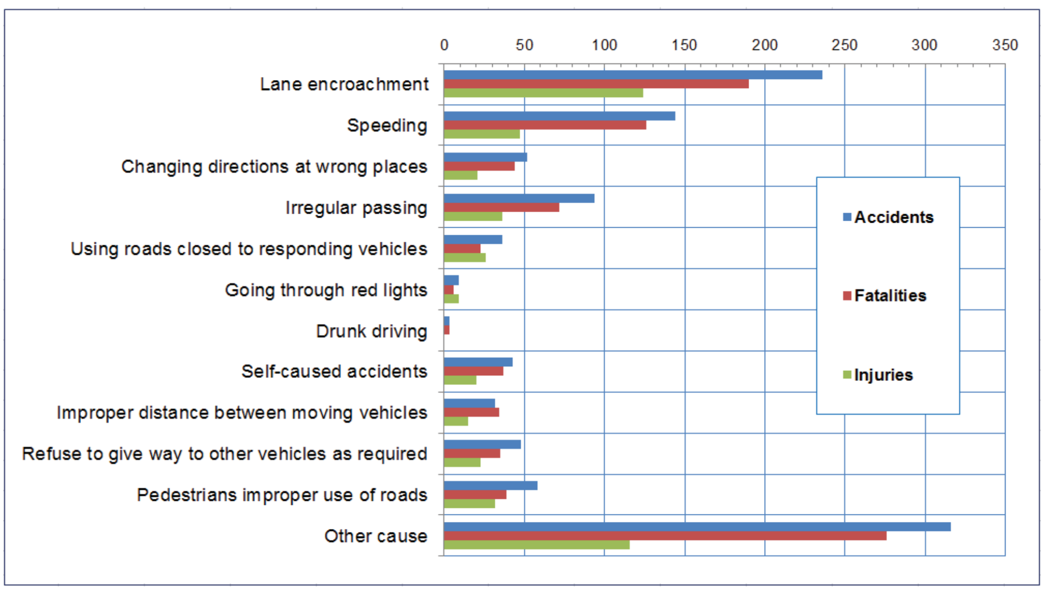
Data source from HCMC Traffic Police (2011)

It is necessary to add an interesting idea that the 11 causes mentioned in Table 4.3 exclude the impact of the poor road traffic infrastructure in HCMC despite the fact that recent annual reports by HCMC Traffic Safety Committee pointed out that HCMC has a rather old road networks of poor quality which need upgrading and widening. Hopefully, research and analysis in coming stages will launch more practical and reliable findings about the causes of road accidents in HCMC. Figure 4.14 is added for the purpose of providing readers with the detailed statistics of causes of road accidents in HCMC recorded in 2010, a considerable proportion of which (accounting for 30% of the total number) has remained unknown up to now.



Source: Nguyen and Taneerananon (2012)

Figure 4.13 Causes of road accidents in HCMC (2008 - 2010)



Source: Nguyen and Taneerananon (2012)

Figure 4.14 Number of accidents, casualties and injuries according to cause types (2010)

4.6 Black spot identification in HCMC

Since 2005, the identification of black spots in HCMC has been carried out as required in Decision No 13/2005/QD-BGTVT issued by the Ministry of Transport of Vietnam. In fact, the identification progress encountered a number of practical impediments.

On the one hand, there was a serious lack of practicable guidance and employable database due to the following problems:

- The guide on identifying black spots by the Ministry of Transport of Vietnam is not a detailed-enough set of instructions to practically follow;
- There has been almost no accident database system; and
- Related criteria and standards have not been established.

On the other hand, as a result of such lack, the current black spot identification in HCMC relies mainly on one-year records of accidents in terms of number. This reliance made it impossible to avoid a number of statistical impacts such as statistical fluctuation, and regression-to-the-mean effect. Moreover, the set of the one-year records accidents could not server as a sufficient set of input data so as to launch reliable results.

Together, these problems led to hidden inaccuracy in identification which lies in the fact that the identification turned out to include a number of false black spots and exclude a number of true black spots. Furthermore, the financial constraints posed the need for black spot prioritization which cannot be effectively done using the current method.

4.7 Key safety problems of urban road traffic in HCMC

The analysis of the collected data on HCMC's current road traffic safety indicates that this city was facing the following problems of road safety:

(1) There has been almost no road safety method used for road network safety management.

(2) Motorcycles have accounted for the majority of vehicles in mixed traffic flows.

(3) Motorcycle safety has not been fully taken into account in road designing.

(4) The designed space for motorcycles is not adequate due to the lack of designing standards.

(5) There has been strong conflict at intersections due to poor traffic management, and poor safety engineering design.

CHAPTER 5

SAFETY-POTENTIAL-BASED BLACK SPOT MANAGEMENT APPROACH

An important task for road administrations is to determine road spots with poor safety properties that could be improved by changes in the roadway and its equipment. Since the available funds are always limited, the necessity of the possible improvements and their degree of priority has to be assessed in order to determine a ranking of the most effective projects.

This chapter describes a new approach to analyze road networks from the safety point of view and to help the road administrations to detect those spots within the network with the highest safety potential i.e. where an improvement of the infrastructure is expected to be highly cost efficient. Then suitable measures can be derived from a comprehensive analysis of the accidents combined with traffic simulation of spots. The safety potential and the calculated cost of the measure form the basis for an economic assessment which is usually conducted as a benefit-cost analysis.

The new black spot management approach called *Safety-potential-based Back Spot Management Approach* provides all the necessary information for an objective assessment of road safety and an establishment of a ranking of spots for further analysis and treatment. This way, the limited resources are spent in the best way to improve road safety for the whole society.

5.1 The aim of the safety-potential-based back spot management approach

The aim of the approach is to enable road administrations to:

(1) Determine spots within the road network with a poor safety performance based on accident data and where deficits in road infrastructure have to be suspected;

(2) Rank the spots by potential savings in accident costs in order to provide a priority list of spots to be treated.

The accident structures of the spots are then analyzed combined with before-and-after-treatment traffic simulation at black spots, which can lead to optimal safety improvement measures. Finally, this offers the possibility of comparing the costs of improvement measures to the potential savings in accident costs, allowing the ranking of safety measures by their cost – benefit ratio.

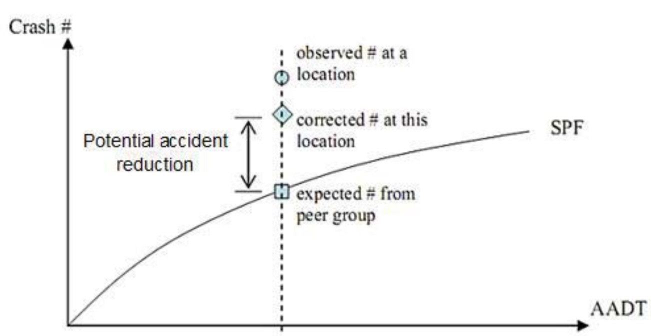
5.2 Potential accident reduction vs. potential saving in accident cost

Traditional black spot management approaches are based on numbers of accidents as the main indicator. As a result, the expected improvement is weighted by the reduction in numbers of accidents only, almost ignoring other important aspects such as severity and economical effectiveness. Therefore, it is necessary to integrate these factors as indicators in identifying black spots. Such integration can be found in a new black spot management approach which based on accident costs as a 'master indicator'. This approach enables the identification of the black spots whose treatment can bring the optimal economical effectiveness. In order to have better view of this approach, it is vital to tell the difference between *potential accident reduction* and *potential saving in accident cost*.

5.2.1 Potential accident reduction

Locations with potential accident reduction are locations where the recorded number of accidents is bigger than the expected number which is determined by using safety performance functions. These locations exhibit a potential accident reduction known as potential for safety improvement (Kononov, 2002).

Potential accident reduction is defined as the difference between the predicted crashes frequency determined by Empirical Bayesian estimation and the crashes frequencies predicted by the safety performance function (SPF), as shown in Figure 5.1 (Tegge *et al.*, 2010).



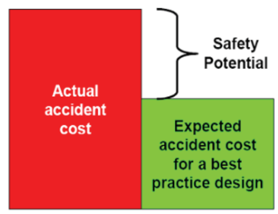
Source: Tegge *et al.* (2010)

Figure 5.1 Definition sketch of the *potential accident reduction*

5.2.2 Potential saving in accident cost

Locations with potential saving in accident costs are locations where the actual accident costs are higher than the expected accident costs which are estimated based on real accident data. These locations exhibit a potential saving in accident costs known as safety potential (Ganneau and Lemke, 2008).

Safety potential is defined as the difference between actual accident cost and basic accident cost (expected accident cost) as shown in Figure 5.2. It describes the potential savings in accident costs that could be reached by remedial measures (Bast and Sétra, 2005).



Source: Ganneau and Lemke (2008)

Figure 5.2 Definition sketch of the *safety potential*

5.3 Analytical framework for safety-potential-based black spot management

The safety-potential-based black spot management can be divided into eight steps as shown in Figure 5.3.

5.3.1 Step 1 - Data collection and statistical analysis of accidents

The data collection is supposed to come up with the quantitative statistics of the following three sets of data:

- Accident data by severity and location;
- Accident unit cost by accident severity;
- Traffic data and basic accident cost rate of the road networks.

The process of collecting such data may pose these two common issues – (1) the inaccessibility of basic accident cost rate, and (2) the decision as to which crash period to select. However, there are applicable solutions for both of the two issues.

- If the data on basic accident cost rate is insufficient, a specific percentile (e.g. 15%) of the overall distribution of the accident cost rates can be used (Bast and Sétra, 2005).

- The crash period of three to five years is the best choice for the sake of data validity and reliability.

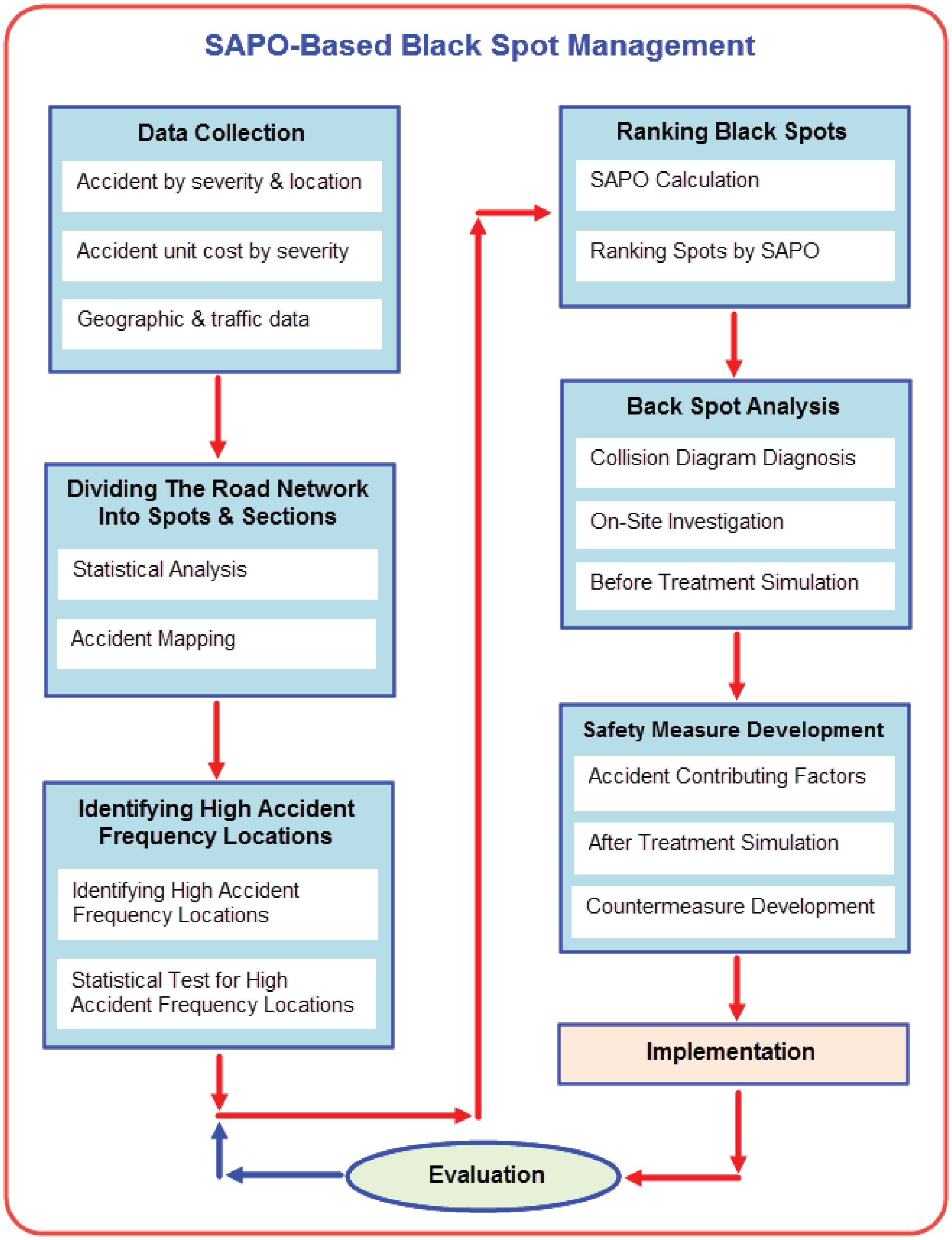


Figure 5.3 Framework diagram for safety-potential-based black spot management

Actually, a number of experts of road safety present the support of this point of view. First, Elvik (2008b) claims that the length of the period used to identify black spots varies from 1 year to 5 years, a period of 3 years is used frequently. Next, research by Cheng and Washington (2005) shows that the gain in the accuracy of black spot identification obtained by using a longer period of three years is marginal and declines rapidly as the length of the period is increased. There is little point in using a longer period than 5 years. Additionally, LTNZ (2004) stressed out that a 3-year crash period could be used in heavily trafficked networks or areas where road changes are recent or ongoing. A three-to-five-year period is preferred because:

- It is long enough to provide a sufficient number of crashes for meaningful results;
- It is short enough to limit the number of traffic and environmental changes that may bias results;
- It helps remove statistical fluctuation and reduce the impact of the regression-to-the-mean effect; and
- It provides a consistent base for before and after comparisons.

5.3.2 <u>Step 2</u> - Identification of spots by dividing the roads into spots and sections

According to Bast and Sétra (2005), there are two possible ways of dividing the roads into spots and sections: *dividing based on network structure* and *dividing based on accident map*.

(1) Dividing based on the network structure: This method is appropriate if a visualization of the accident occurrence on the road network is not available or the accident occurrence is to be analyzed in interaction with other influencing parameters in the road network such as accessibility, traffic.

(2) Dividing based on the accident map: This method is appropriate if a visualization of the accident occurrence is available and no other section demarcations are required on the basis of a joint consideration of various influencing parameters.

Additionally, Ogden (1994), SEMCOG (1997), and TRB (2009) suggested that spots should be defined to include the area of influence of the features in question. For example, driver behavior can be influenced as far as 150 metres from a curve and 76 metres from an intersection (or further with severe congestion and queuing). Considering an influence area of at least 150 metres from both ends of a non-intersection spot location also helps ensure that a larger share of relevant crashes are properly identified, given typical uncertainties and errors in reporting crash position.

5.3.3 Step 3 - Identification of high accident frequency locations and statistical tests

■ *Identification of high accident frequency locations*

This step is aimed to identify the list of high accident frequency locations within the sample of locations established according to the dividing in Step 2. Such identification is based on the threshold value of observed numbers of injury accidents at every site in the sample in three consecutive years. The simplest way to select the threshold value for the sample is the following:

$$Threshold\_Value = Max[\bar{x}, m] \quad (5.1)$$

in which:

$\bar{x}$: the average value, and

m : the median value of the sample.

Any site with observed number of accidents higher than the threshold value is listed as a high accident frequency location. Sites that have more accidents than the mean plus one standard deviation should be the first to be single out for further consideration (Baguley, 1995).

■ *Statistical tests*

As crashes are rare and random, the number of reported accidents will change from one time period to another even if the expected average crash frequency remains the same (Elvik *et al.*, 2009). To make sure that the spots identified as hazardous are not merely the result of random variation in accident counts, statistical tests are performed. The test consists of the comparison of the observed number of accidents with the expected number of accidents of that spot and the determination of the importance of the deviation by calculating the confidence interval of the observed values (Bast and Sétra, 2005).

Furthermore, the Poisson test can be used to determine whether a recent increase in accidents at a site was due to random fluctuation only (Baguley, 1995). What is mentioned above can be explained by means of an example.

Example: Propose that the injury accident figures observed at a site are as shown in Table 5.1.

Table 5.1 Accidents for four year at a site

Year	Observed accidents
2010	3
2011	2
2012	2
2013	5

The statistics show that the observed numbers of accidents fluctuated over the years with the sharp increase in the year 2013 as a noticeable case. This fact poses the question of whether such increase was due to random variation only. To answer this question it is necessary to calculate the confidence interval of the observed accidents and then consider the relation between the number of observed accidents of the year 2013 and the confidence interval.

- If the interval encompasses the observed values, there is no random variation. That means the change in the number of the observed accidents is a real one.
- If the interval does not encompass the observed values, there is a random variation. That means the change in the number of the observed accidents is not a completely real one.

Specifically, for the case of this example, the confidence level of 95% corresponds to the confidence interval of from 0.76 to 5.24 accidents as shown in Table 5.2. This means that accidents may systematically happen in the range of 1 – 6. In other words, the increase in 2013 is real because the corresponding observed number is 5.

Table 5.2 Calculation of 95% confidence interval

Calculation of confidence interval of statistical sample in 4 years period		
Long term average		3.00
Standard deviation		1.4142
Confidence level 95%		2.2436
95% Confidence interval	Minimum value	0.76
	Maximum value	5.24

The cumulative probability that there are more than 6 accidents with the long-term average value (μ = 3.0) is calculated by Poisson formula as follows.

$$P(X \geq x, \mu) = 1 - P(X \prec x, \mu) = \sum_{k=0}^{x-1} \frac{e^{-\mu}\mu^{k}}{k!} = P(X \geq 7, 3.0) = 0.0335 = 3.35\% \tag{5.2}$$

Here, probability of seven or more accidents with the long-term average being 3.0 is 0.0335 or 3.35%. This indicates that the random variation of accident count at the site is 3.35 percent.

5.3.4 Step 4 - Calculation of safety potential and ranking spots

This step is aimed to (1) calculate the safety potential of the spots identified and verified in Step 3, and (2) rank these spots according to the established safety potential.

The calculation of the safety potential is done using the following accident parameters: annual average accident cost, accident density, accident cost density, accident rate, accident cost rate, and basic accident cost rate as shown in Eqs. (5.3) to (5.9) in Table 5.3.

Then, the spots of the road network are ranked on the basis of the magnitude of the safety potential. Such ranking is of great use to further detailed studies so as to determine possible safety improvement measures. The higher the safety potential, the more societal benefits can be expected from improvements to the roads.

Table 5.3 Accident parameters for determination of safety potential of spots

Parameters	Formulas
AC_a	$$AC_a = \frac{\sum_{i=1}^{4} nA(c_i) \times MCA(c_i)}{t} \quad (5.3)$$ Where: AC_a : annual average accident cost [USD/year] $nA(c_i)$: number of accidents of specific accident category c_i, in t $\geq$ 3 years $MCA(c_i)$: mean cost per accident of accident category c_i [USD/accident] t : period of time under review [years]
AD	$$AD = nA / t \quad (5.4)$$ Where: AD : accident density nA : number of accidents t : time period [years]
ACD	$$ACD = AC / (1000 \cdot t) \quad (5.5)$$ Where: ACD : accident cost density [1000 USD/year] AC : accident cost t : time period [years]
AR	$$AR = 10^6 \cdot nA / (365 \cdot AADT \cdot t) \quad (5.6)$$ Where: AR : accident rate nA : number of accidents $AADT$: average annual daily traffic t : time period [years]
ACR	$$ACR = 1000 \cdot AC / (365 \cdot AADT \cdot t) \quad (5.7)$$ Where: ACR : accident cost rate [USD/1000.veh] AC : accident cost $AADT$: average annual daily traffic t : time period [years]

bACD	$$bACD = \frac{bACR \times ADT \times 365}{10^6} \quad (5.8)$$ Where: *bACD* : basic accident cost density [1000 USD/year] *bACR* : basic accident cost rate *ADT* : average daily traffic
SAPO	$$SAPO = ACD - bACD \quad (5.9)$$ Where: *SAPO* : safety potential [1000 USD/year] *ACD* : accident cost density *bACD* : basic accident cost density
bACR	The basic accident cost rate (bACR) can be defined for many different types of roads and intersections which are derived from the detailed assessment of existing accident cost rates.

5.3.5 Step 5 - Black spot analysis

The main purpose of black spot analysis is to identify factors contributing to accidents happening at the spot. These factors emerge from the safety problems at the spot which are identified by analyzing the accident patterns. However, accident history at a given site only provides partial information about safety at that site (Elvik, 2008a). This indicates that there are still potential safety problems which cannot be identified by means of the accident patterns analysis only. With its additional information about the safety at the spot, on-site investigation can facilitate the identification of such potential problems.

Furthermore, a black spot simulation should be conducted to help verify the identification of the safety problems as well as the detection of the potential problems at the spot.

The combination of the results from office diagnosis stage, site investigation, and spot simulation will form reliable conclusions on safety problems at the spot.

For each specific location to be investigated, the following sequence of steps should be performed:

(1) Prepare collision diagram template

(2) Plot collision diagram

(3) Identify accident patterns

(4) Analyze safety problems

(5) Identify factors contributing to accidents

5.3.6 Step 6 - Development and prioritization of safety improvement measures

■ Safety improvement measure development

Based on the detected conspicuous accident patterns and on the comprehensive analysis of individual accidents, suitable measures for the improvement of the road infrastructure will be derived. Basically, there are two types of measures: long-term measures and short-term measures. Long-term measures focus mainly on improvements of road users' behavior, which is the best way to lay the foundation for sustainable improvements in road safety. Usually, they are high-cost measures and require a lot of time for planning, financing, adoption of resolutions, and implementation.

Short-term measures focus mainly on improvements of roadway infrastructure. Usually, they are low-cost measures and do not require so much time to be carried out.

In order to find out the most effective measure, it is advisable to simulate the spot with different alternatives of safety measures. The simulation also helps to detect potential problems of the proposed measures.

■ Prioritization of measures

Safety measures are prioritized according to the ratio between the safety potential and the estimated cost. The calculated safety potential and the estimated cost of proposed measure form the basis for an economic assessment which is usually conducted as a benefit-cost analysis.

5.3.7 Step 7 - Implementation

The proposed sites should preferably be subject to a road safety audit to ensure that the proposed intervention is a suitable and effective safety measure. During the course of implementation, special attention should be paid to the following issues.

- The work should be planned so that the construction work is carried out during time periods when existing traffic is disturbed as little as possible. In addition, the work zone should be arranged in such a way that existing traffic is disturbed as little as possible.

- All road works are dangerous since all road users are not familiar with the situation. It is therefore necessary to have proper warning for work zones. It is important to give good guidance to road users passing the zone, especially at night and during other conditions when there is bad visibility.
- Speed reducing measures must be applied to ensure low speeds for vehicles passing the site. Changed speed limits are often not enough. Physical measures have to be used.
- The accident situation must be monitored during the whole construction period to ensure that the situation is under control.

When the work is finalized, another safety audit or inspection should be made before the road is re-opened for traffic.

5.3.8 Step 8 - Evaluation

Evaluation of effectiveness of black spot treatment is essential. The aim of evaluation is to estimate the effects of the countermeasures. This is usually done by before–and–after study method. Sørensen and Elvik (2008) suggested that the evaluation of effects of black spot treatment should employ the empirical Bayes before–and–after design. The argument for that is that the empirical Bayes method makes it possible to control for (1) local changes in traffic volume, (2) long–term trends in accidents, and (3) regression–to–the–mean. If accident migration is an issue, an attempt to control for it should also be made. However, the use of the empirical Bayes before–and–after design requires a large amount of data and relatively complicated statistical analyses. This fact poses a number of difficulties in practice due to the lack of needed data. In this case, the before–and–after method with non–treated as comparison can be used as a replacement.

5.4 Practical implementation of safety-potential-based black spot management

5.4.1 Study area

5.4.1.1 Selection of study area

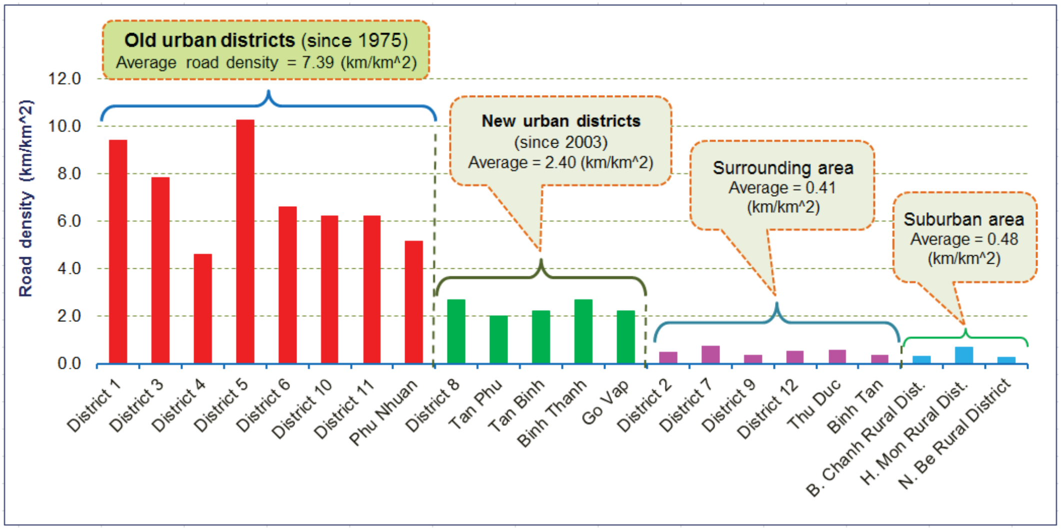
The selected study area for the research on urban road safety must have these three basic properties as follows:

(1) Including an urban road network;

(2) Having few recent changes in road network; and

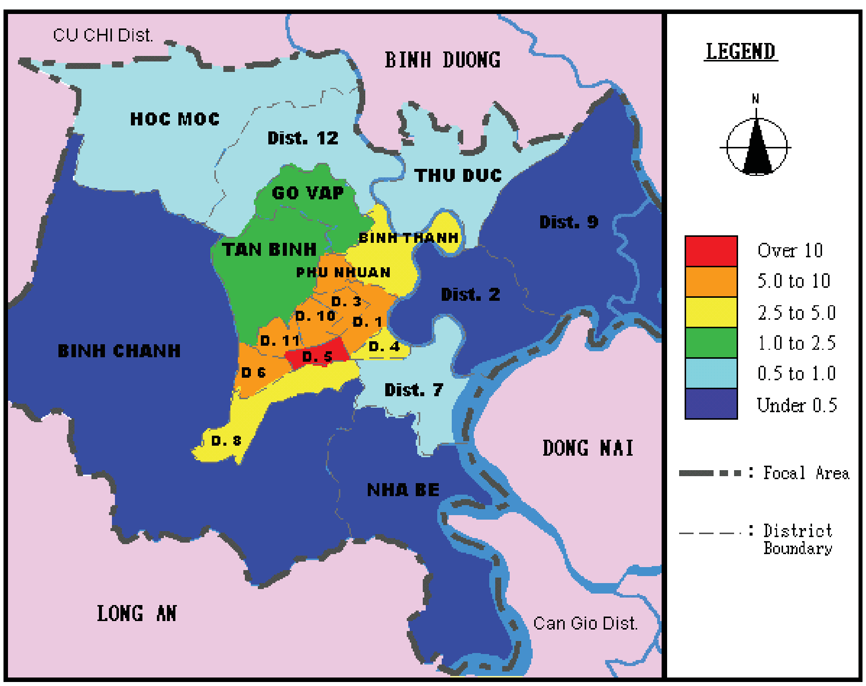
(3) Having fairly poor road safety.

In this light; with a road network of almost no recent changes, high density of road (Figure 5.4 and 5.5), and poor road safety (Figure 5.6); Phu-Nhuan district proves itself to be a fairly typical urban area in HCMC.



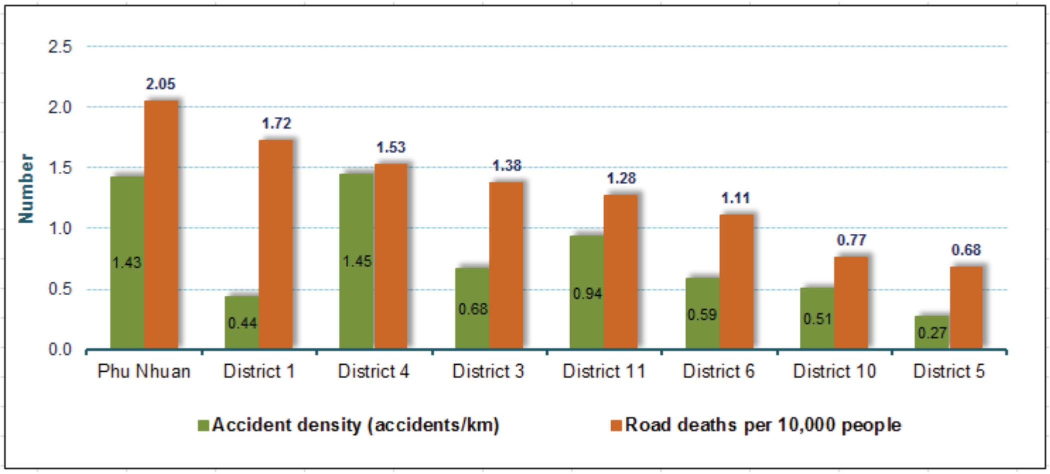
Data source from HCMC Department of Transportation and HCMC Traffic Police (2012)

Figure 5.4 Road network densities by districts in HCMC



Source: JICA (2008), HOUTRANS

Figure 5.5 Distribution of road density in HCMC



Accident data source from HCMC Traffic Police (2012)

Figure 5.6 Accident density and deaths per 10,000 population of selected urban districts in HCMC

Furthermore, Phu-Nhuan district actually bears almost every type of accident in questioned. Consequently, in order to facilitate the implementation of the proposed approach, Phu Nhuan District was selected as the study area.

5.4.1.2 Profile of study area

This section provides the general information about Phu Nhuan's land use, area, population and road density. The basic details are as follows.

- Area : 4.88 km²
- Population : 200,000 (2012)
- Road density : 5.16 (km/km2)

The further information about land use in Phu-Nhuan is presented in Table 5.4 (land use structure), Figure 5.7 (land use map).

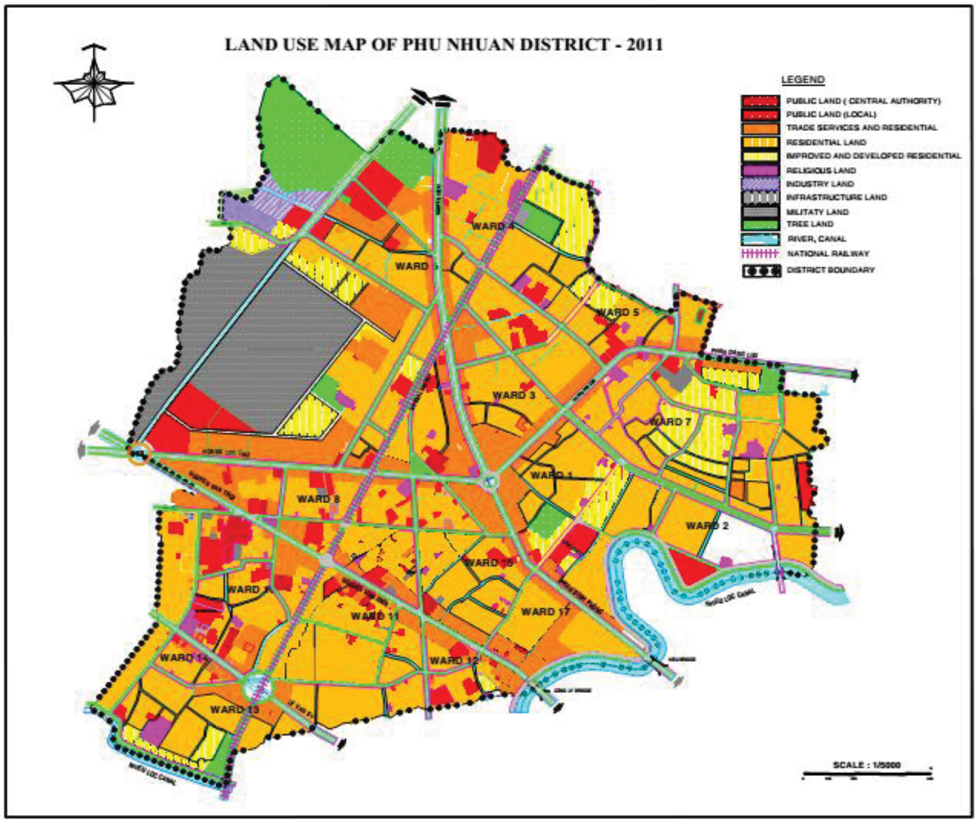


Figure 5.7 Land use map of Phu-Nhuan District, HCMC Department of Planning (2011)

Table 5.4 Land use of Phu Nhuan District (2011)

No.	Land uses	Area (ha)	Percentage (%)
1	Housing	234.95	48.15
2	Commercial	54.98	11.27
3	Industrial	5.5	1.13
4	Institution and facilities	36.11	7.40
5	Open space and recreation	28.95	5.93
6	Transportation	75.23	15.42
7	Military land	44	9.02
8	Religious land	8.28	1.70
Grand total		**488**	**100**

Data source: HCMC Department of Transportation (2011)

5.4.1.3 Preliminary results from statistical analysis of collected accidents

Between 2009 and 2011, 531 accidents with casualties or serious material damage were recorded within the study area. 489 accidents with casualties include 59 accidents with fatalities, 307 accidents with seriously injured, and 123 accidents with slightly injured as shown in the Figure 5.8. In consequence of these accidents 61 persons were killed, 397 seriously and 275 slightly injured. Furthermore in the same time period 42 accidents with serious material damage happened as well.

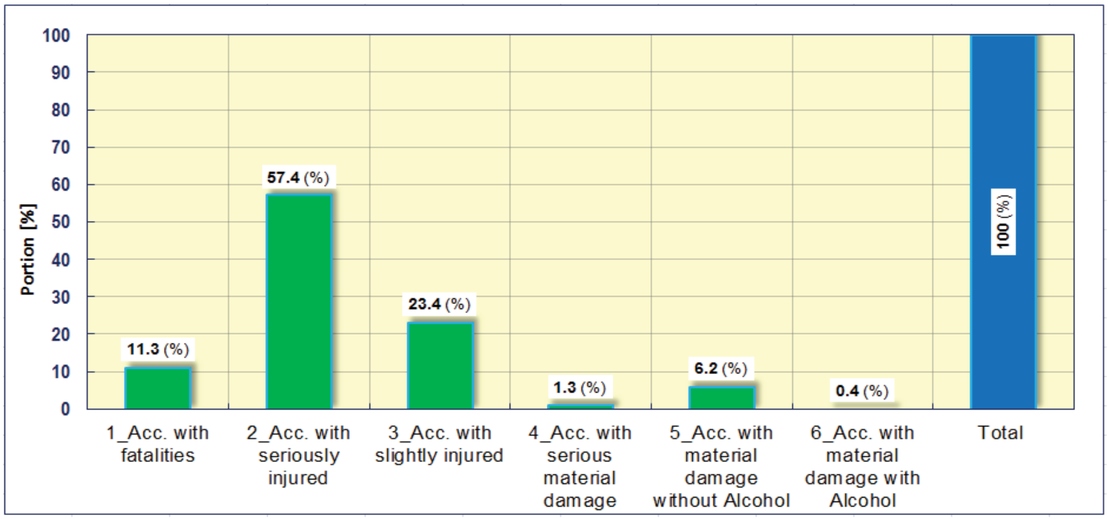


Figure 5.8 Distribution of severity-based accident types (total number 531)

The conflict-based accident type 6 (accidents in longitudinal direction), and type 3 are the most frequent accident types with 48% and 26% portions of the total number of accidents as shown in the Figure 5.9. The remaining accidents are attributed to accidents in pedestrian accidents (type 4), single accidents (type 1), parked vehicle accidents (type 5), and other accidents. The definition of *conflict-based accident types* is based on the conflict situation which has caused the accident.

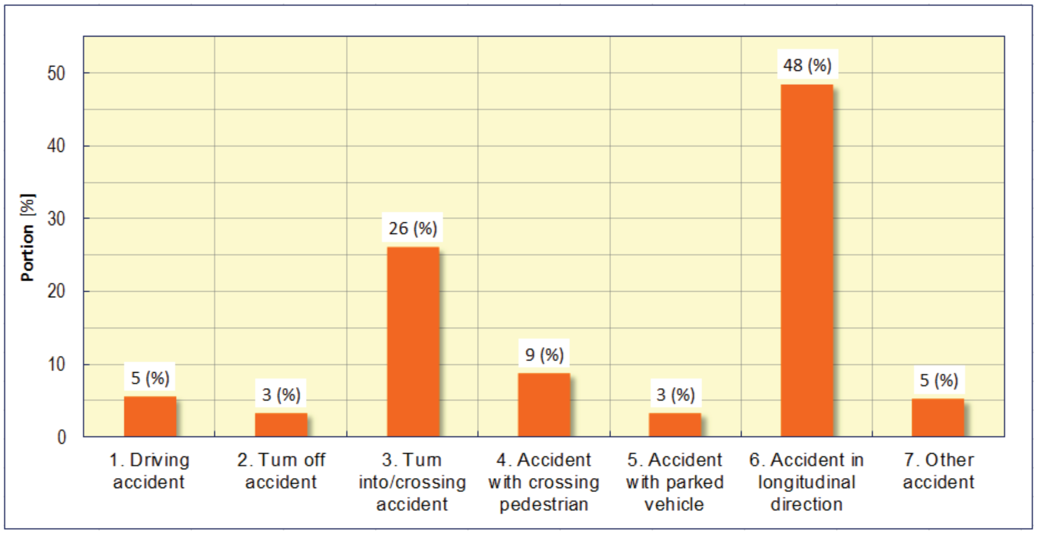


Figure 5.9 Distribution of conflict-based accident types

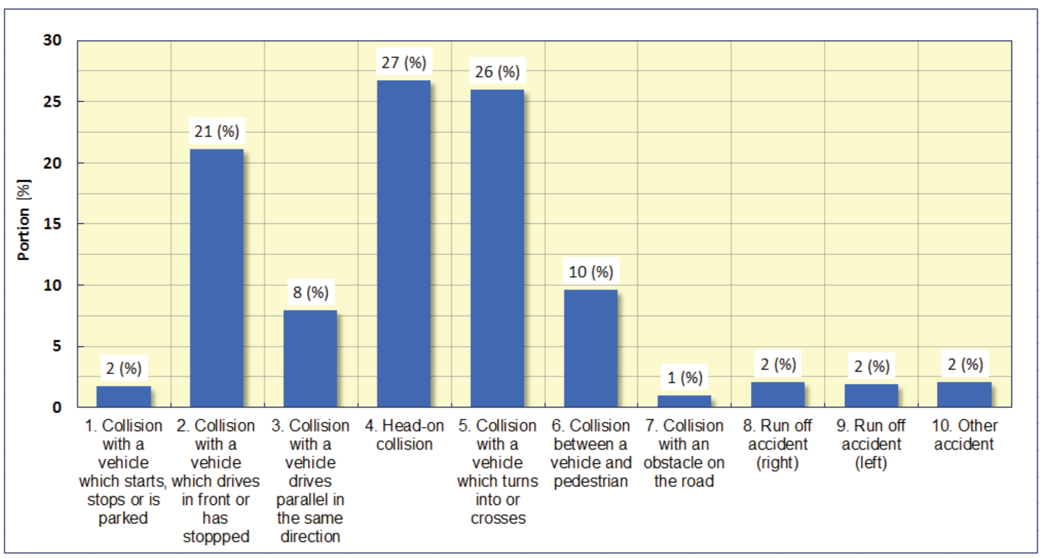


Figure 5.10 Distribution of direction-based accident types

Statistics show that the conflict-based accident type 6 has highest portion of serious injuries and fatalities. A more detailed analysis of the conflict-based accident type 6 is given in Figure 5.10 which shows the distribution concerning direction-based accident types. The *direction-based accident type* is defined by the moving direction of the involved vehicles at the time of the first collision. If there was no collision the first mechanical effect is important.

Accidents in longitudinal direction such as head-on collisions while overtaking with highest percentage (27%) are characterized by a high severity. Such accidents often result in fatal head-on collisions with serious consequences and might be the reason for the increased accident cost unit rates.

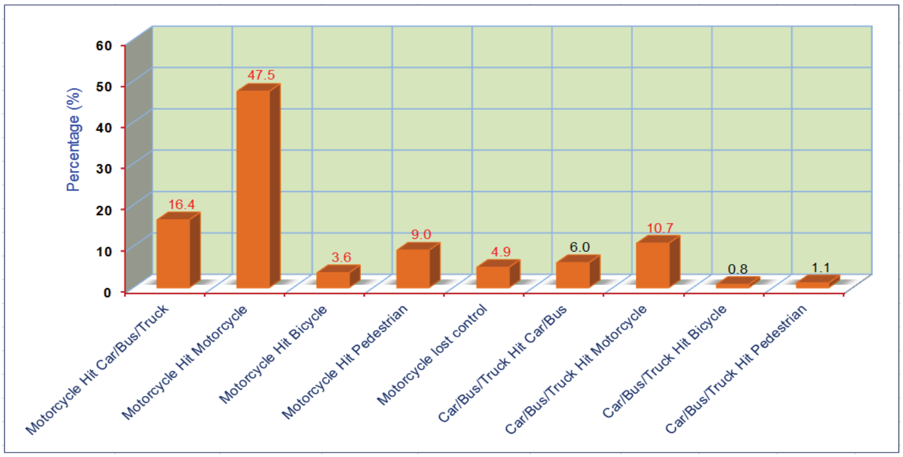


Figure 5.11 Distribution of cause-based collision types

Figure 5.11 presents the percentage of accidents according to cause-based collision types. From the figure it can be calculated that motorcycles accounted for up to 92% in terms of number of accidents.

Figure 5.12 depicts the percentage of accidents according to road network elements as reference location of accident. It can be inferred from the figure that most of the accidents happened on straight segments or links (51.4%) and intersections or connectors (40.7%).

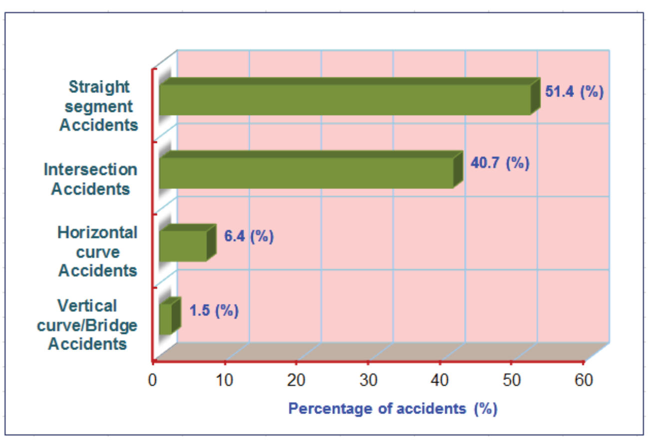


Figure 5.12 Distribution of location-based accident types

5.4.2 Black spot identification

Before identifying black spots based on safety potential, some amount of a priori knowledge about the safety performance of the road network is required. This knowledge was compiled in an extensive data set describing various characteristics of accident distribution profiles as shown in Table 5.5. This data set was compiled for all types of urban roads over a period of 3 years and contains 40 different parameters related to accident occurrence, such as accident type, severity, and roadway conditions. The set represents a source of a priori knowledge base required for accidents mapping and the estimating of basic accident cost rate.

Table 5.5 Normative values of various accidents characteristics

ACCIDENTS ON URBAN ROADS IN PHU-NHUAN DISTRICT, HCMC, VIETNAM				
Categories	**Description**	**Quantity**	**Percent**	
Severity-based accident types	**AS1**: Accidents with fatalities	59	11.11%	
	AS2: Accident with seriously injured	307	57.82%	
	AS3: Accident with slightly injured	123	23.16%	
	AS4: Accident with serious material damage	5	0.94%	
	AS5: Accident with material damage but with driving while intoxicated	33	6.21%	
	AS6: Accident with material damage but without driving while intoxicated	4	0.75%	100%
Consequences	Persons killed	61	N/A	
	Persons injured	672	N/A	
	Property damage with motorcycles	943	N/A	
	Property damage without motorcycles	186	N/A	
Special circumstances	Accidents with motorcycles are involved	493	92.84%	493/531
	Accidents with bicycles are involved	19	3.58%	19/531
	Accidents with pedestrians are involved	46	8.66%	46/531
	Drink-driving accidents	18	3.39%	18/531
Motorcycle-related types	**Motorcycle Accidents** (caused by a motorcycle)	432	81.36%	
	Non-Motorcycle accidents (not caused by a motorcycle)	99	18.64%	100%

Intersection-related types	**Intersection accidents** (occurring at intersections)	216	40.68%	
	Non-intersection accidents (occurring at a location other than intersections)	315	59.32%	100%
Time-based types	**Day-Time Accidents**	167	31.45%	
	Night-Time Accidents	364	68.55%	100%
Conflict-based accident types	**AC1: Driving Accidents** (caused by loss control of the vehicle without influence of other road users)	30	5.65%	
	AC2: Turn-off Accidents (caused by a collision between moving vehicles with other road users during a turn-off maneuver at junctions)	18	3.39%	
	AC3: Turn-into/Crossing Accident (caused by a collision between moving vehicles with other road users having right of way during a turn-into or crossing maneuver at junctions)	138	25.99%	
	AC4: Accident With Crossing Pedestrian (caused by a collision between a vehicle and a pedestrian crossing the road)	49	9.23%	
	AC5: Accident With Parked Vehicle (caused by a collision between moving vehicles with parked or stopped ones)	16	3.01%	
	AC6: Accident with Longitudinal Direction (caused by a collision between road users which drive in the same or opposite direction)	254	47.83%	
	AC7: Other Accidents (not classified as any of the six types above)	26	4.90%	100%
Direction-based accident types	**AD1**: Collision between a moving vehicle with a vehicle that has just started, is stopped, or parked	9	1.69%	
	AD2: Collision with a vehicle which drivers in front or has stopped	113	21.28%	
	AD3: Collision with a vehicle which drives parallel in the same direction	42	7.91%	
	AD4: Head-on collision	143	26.93%	
	AD5: Collision with a vehicle which turns into or crosses	136	25.61%	
	AD6: Collision between a vehicle and pedestrian	51	9.60%	

	AD7: Collision with an obstacle on the road	5	0.94%	
	AD8: Run-off accident (right)	11	2.07%	
	AD9: Run-off accident (left)	10	1.88%	
	AD10: Other accident	11	2.07%	100%
Road conditions	Dry road	449	84.56%	
	Wet road	19	3.58%	
	Unknown road condition	63	11.86%	100%
Total Accidents		**531**		
Total Number of Locations		**108**		

5.4.2.1 Stage 1 - *Accident data collection, statistical analysis, and mapping accidents*

Accident data collection and statistical analysis are the prerequisites for identifying spots based on safety potential. However, it was only possible to access a limited amount of raw road accident data from the local authorities. Accordingly, by means of the analysis of the raw data, a set of intermediate input data was established – the 3-year accident pin board of the period 2009-2011. The three-year accident pin board (3-year APB) serves as an accident map (Figure 5.13) with the detailed information in the following aspects:

- Location of accidents;
- Severity-based accident types;
- Conflict-based accident types;
- Special accident circumstances.

The locations of accidents are marked on the GIS-based map. The severity-based accidents are marked by pin sizes. The conflict-based accidents are marked by pin colours. Special circumstances of accidents are marked by coloured triangles as shown in the legends of 3-year APB (see Figure 5.13).

In addition, for the ease of reference, the pins are linked to text which presents details of accident data such as moving directions of the involved vehicles at the time of the first collision, date, time, location, cause of accident, number of involved persons, number of killed or injured persons, types of vehicles, weather condition, road condition, and personal data of involved persons.

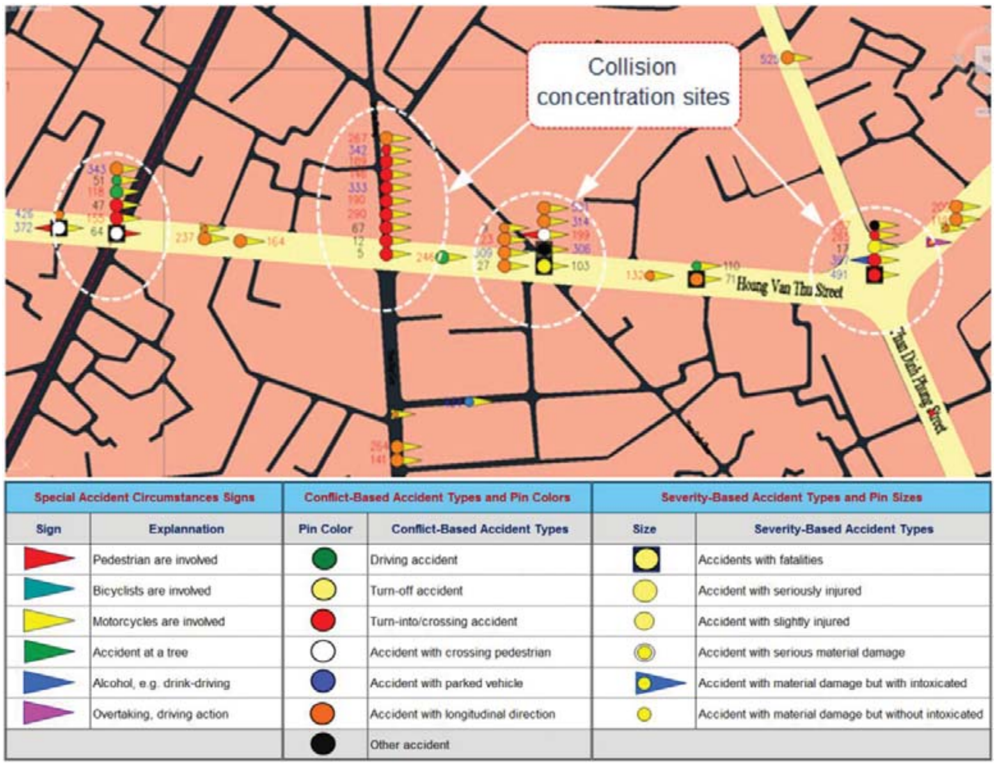


Figure 5.13 Three-year Accident Pin Board (3-year APB) of study area

5.4.2.2 Stage 2 - *Dividing the road network into spots and sections based on 3-year APB*

This stage was aimed to identify locations where accidents have clustered (see Figure 5.13) with the visual support of the 3-year APB. Collectively, 108 accident spots were identified, coded, and the total number of accidents at each of which was also determined. Such intermediate data not only established the divisions of the road network into spots and sections but also facilitates the identification of high accident frequency locations in the next step.

5.4.2.3 Stage 3 - *Identifying high accident frequency locations*

To identify high accident frequency locations, the data on 108 identified accident spots in Stage 2 are statistically processed. As a result, the statistical sample of number of injury accidents in three years is established. This sample has an average value of 5.93, median value of 5, and standard deviation of 3.34. Accordingly, the suitable threshold value of number of accidents should be 6. Any spot with more than 6 recorded injury accidents was considered a high accident frequency location. With this threshold as the criterion for identification, a total of 32 high accident frequency locations were determined. There were 302 injury accidents happened at 32 identified locations in three years, accounting for 52.86 percent of all injury accidents in the study area.

5.4.2.4 Stage 4 - *Statistical test for high accident frequency locations*

This stage was intended to estimate the percentage of random and systematic variation in accident count at each identified location. In order to have such estimation, it is necessary to calculate the confidence interval of the particular sample of accident count at each spot. The changes in observed accident numbers within the confidence interval form the systematic variation. The changes in observed number of accidents beyond the confidence interval form the random variation.

The occurrence probability of an observed accident value that is higher than the maximum value of the confidence interval can be calculated by using Poisson probability formula. The percentage of random variation of accident count at a spot is calculated by Poisson cumulative probability as shown in Table 5.6 and Figure 5.14.

The calculation method applied to the case of Spot S.002 as a typical one serves as the explanation for the calculation method applied to all other cases of high accident frequency locations. The year-based numbers of recorded injury accidents at this spot in the years of 2009, 2010 and 2011 were 3, 4, and 3 respectively (see Table 5.6). These figures form a sample of 3-year accident count whose long-term average value equals 3.33. The 95% confidence interval of the sample was determined with 1.90 as the minimum value, and 4.77 as the maximum value. The determined interval indicates that the change in number of observed accidents from 2 accidents to 5 accidents is the real change or systematic variation. This systematic variation makes it possible to estimate the quantity of random variation of observed accidents at this spot by considering the year-based numbers of observed accidents were distributed pursuant to Poisson probability distribution. Specifically, for the case of a random variable X with the mean number of successes (μ) being 3.33, the cumulative probability $P(X \geq 6, 3.33)$ would be 0.1207 or 12.07%. This value is the very random variation of observed accidents (see Table 5.6 and Figure 5.14).

Table 5.6 Statistical tests for 32 selected high accident frequency locations

No.	Spot ID	Observed Injury Accidents				Long-term Average	95% Confidence Interval		Poisson Cumulative Probability P(X≥x,μ)	
		2009	2010	2011	Total		Min	Max	Formula	Value
1	**S.002**	3	4	3	10	3.33	1.90	4.77	P(X≥6,3.33)	0.1207
2	**S.003**	4	3	3	10	3.33	1.90	4.77	P(X≥6,3.33)	0.1207
3	**S.010**	5	4	3	12	4.00	1.52	6.48	P(X≥8,4.00)	0.0511
4	**S.011**	4	2	3	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
5	**S.012**	2	3	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
6	**S.016**	4	3	3	10	3.33	1.90	4.77	P(X≥6,3.33)	0.1207
7	**S.018**	2	3	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
8	**S.027**	2	3	2	7	2.33	0.90	3.77	P(X≥5,2.33)	0.0873
9	**S.034**	5	5	4	14	4.67	3.23	6.10	P(X≥8,4.67)	0.1012
10	**S.036**	3	3	4	10	3.33	1.90	4.77	P(X≥6,3.33)	0.1207
11	**S.037**	4	2	3	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
12	**S.039**	4	3	2	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
13	**S.042**	3	2	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
14	**S.043**	3	5	3	11	3.67	0.80	6.54	P(X≥8,3.67)	0.0339
15	**S.044**	2	3	2	7	2.33	0.90	3.77	P(X≥5,2.33)	0.0873
16	**S.048**	4	3	5	12	4.00	1.52	6.48	P(X≥8,4.00)	0.0511
17	**S.050**	5	3	6	14	4.67	0.87	8.46	P(X≥10,4.67)	0.0214
18	**S.052**	3	2	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
19	**S.053**	3	2	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
20	**S.054**	2	3	4	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
21	**S.055**	3	2	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
22	**S.060**	3	4	3	10	3.33	1.90	4.77	P(X≥6,3.33)	0.1207
23	**S.061**	4	3	3	10	3.33	1.90	4.77	P(X≥6,3.33)	0.1207
24	**S.063**	2	4	3	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
25	**S.070**	2	3	2	7	2.33	0.90	3.77	P(X≥5,2.33)	0.0873
26	**S.072**	2	3	2	7	2.33	0.90	3.77	P(X≥5,2.33)	0.0873
27	**S.076**	2	3	4	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
28	**S.079**	3	2	3	8	2.67	1.23	4.10	P(X≥6,2.67)	0.0544
29	**S.090**	2	4	3	9	3.00	0.52	5.48	P(X≥7,3.00)	0.0335
30	**S.093**	4	3	4	11	3.67	2.23	5.10	P(X≥7,3.67)	0.0792
31	**S.105**	6	4	4	14	4.67	1.80	7.54	P(X≥9,4.67)	0.0487
32	**S.106**	3	2	2	7	2.33	0.90	3.77	P(X≥5,2.33)	0.0873
Sum		**103**	**98**	**101**	**302**					

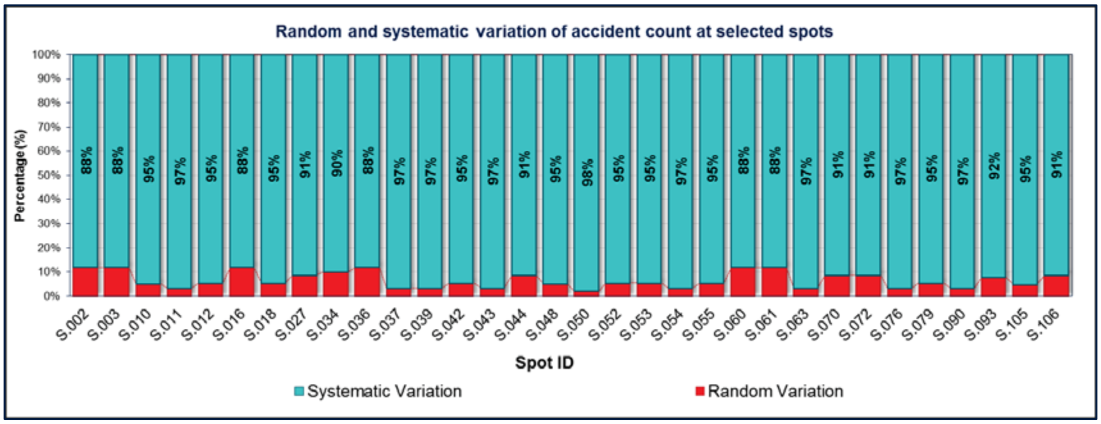


Figure 5.14 Percentage of random and systematic variations in accident counts at 32 selected spots

5.4.2.5 Stage 5 - *Safety potential calculation and spot ranking*

Table 5.7 shows the mean cost per accident or accident unit cost used in the calculation of safety potential.

Table 5.7 Mean cost per accident for various severities in Vietnam (price level 2008)

Severity Description	Cost per Accident [USD]
Fatal (F)	31,777
Serious Injury (SI)	9,488
Light Injury (LI)	1,071
Property Damage Only (PDO)	354

Source: JICA & NTSC (2009)

The results of calculating safety potential and ranking spots according to their safety potential are shown in Figure 5.15 and Table 5.8, in which the spots in were ranked by their SAPO in order to provide a priority list of spots to be treated.

Table 5.8 Calculation of SAPO and ranking spots by safety potential

Spot ID	ADT	Accidents (2009 – 2011)				AC_a	AD	AR	ACD	ACR	bACR	bACD	SAPO	Rank
		F	SI	LI	PDO									
S.002	11,500	0	7	3	1	44,558	3.33	0.79	44.56	10.62	1.25	**5.25**	**39.31**	20
S.003	5,783	1	5	4	0	53,435	3.33	1.58	53.44	25.31	2.84	**6.00**	**47.44**	14
S.010	4,983	1	8	3	0	70,965	4.00	2.20	70.97	39.01	3.31	**6.02**	**64.94**	8
S.011	5,267	1	4	4	1	47,364	3.00	1.56	47.36	24.64	2.84	**5.46**	**41.90**	19
S.012	6,033	2	3	3	0	60,942	2.67	1.21	60.94	27.67	2.84	**6.25**	**54.69**	10
S.016	13,233	2	3	5	1	62,313	3.33	0.69	62.31	12.90	1.96	**9.47**	**52.85**	12
S.018	8,800	0	5	3	0	32,414	2.67	0.83	32.41	10.09	2.84	**9.12**	**23.29**	28

S.027	7,733	0	2	5	0	15,570	2.33	0.83	15.57	5.52	2.84	**8.02**	**7.55**	32
S.034	11,650	1	9	4	0	77,722	4.67	1.10	77.72	18.28	1.96	**8.33**	**69.39**	7
S.036	8,517	1	5	4	0	53,435	3.33	1.07	53.44	17.19	2.84	**8.83**	**44.61**	17
S.037	24,367	0	4	5	1	27,713	3.00	0.34	27.71	3.12	1.25	**11.12**	**16.60**	29
S.039	14,450	2	3	4	0	61,628	3.00	0.57	61.63	11.68	1.96	**10.34**	**51.29**	13
S.042	16,533	1	6	1	0	57,451	2.67	0.44	57.45	9.52	1.96	**11.83**	**45.62**	16
S.043	28,050	1	8	2	0	70,280	3.67	0.36	70.28	6.86	1.25	**12.80**	**57.48**	9
S.044	28,050	0	4	3	1	26,343	2.33	0.23	26.34	2.57	1.25	**12.80**	**13.54**	31
S.048	11,150	2	6	4	0	79,843	4.00	0.98	79.84	19.62	1.96	**7.98**	**71.87**	4
S.050	13,500	4	7	3	0	125,900	4.67	0.95	125.90	25.55	1.96	**9.66**	**116.24**	**1**
S.052	14,933	1	4	3	0	46,678	2.67	0.49	46.68	8.56	1.96	**10.68**	**36.00**	22
S.053	17,600	2	4	2	0	66,329	2.67	0.42	66.33	10.33	1.96	**12.59**	**53.74**	11
S.054	6,600	0	5	4	0	33,100	3.00	1.25	33.10	13.74	2.84	**6.84**	**26.26**	27
S.055	6,033	0	3	5	1	21,642	2.67	1.21	21.64	9.83	2.84	**6.25**	**15.39**	30
S.060	20,100	0	10	0	0	60,717	3.33	0.45	60.72	8.28	1.96	**14.38**	**46.34**	15
S.061	8,083	2	6	2	0	78,472	3.33	1.13	78.47	26.60	2.84	**8.38**	**70.09**	6
S.063	20,750	1	4	4	0	47,364	3.00	0.40	47.36	6.25	1.96	**14.84**	**32.52**	24
S.070	13,233	1	4	2	1	45,993	2.33	0.48	45.99	9.52	3.31	**15.99**	**30.01**	25
S.072	7,133	1	4	2	0	45,993	2.33	0.90	45.99	17.66	3.31	**8.62**	**37.37**	21
S.076	4,467	0	6	3	0	38,486	3.00	1.84	38.49	23.61	2.84	**4.63**	**33.86**	23
S.079	4,133	0	5	3	2	32,414	2.67	1.77	32.41	21.49	2.84	**4.28**	**28.13**	26
S.090	18,200	3	4	2	0	86,664	3.00	0.45	86.66	13.05	1.96	**13.02**	**73.64**	**3**
S.093	10,183	1	10	0	0	81,052	3.67	0.99	81.05	21.81	2.84	**10.56**	**70.50**	5
S.105	14,400	2	10	2	1	102,759	4.67	0.89	102.76	19.55	2.93	**15.40**	**87.36**	**2**
S.106	6,800	1	4	2	1	45,993	2.33	0.94	45.99	18.53	1.25	**3.10**	**42.89**	18

The Figure 5.15 shows that safety potential of a spot is the difference between actual accident cost and its expected accident cost of the spot. This expected value depends on the basic accident cost rate for a best-practice design. In this research, the value of basic accident cost rate was estimated from 15 percent of the overall distribution of accident cost rate of every specific type of spots. The highest value of safety potential in Figure 5.15 is 116,240 U.S. dollars per year. This means that each year at the spot, accident cost could be saved 116,240 USD if it had a best-practice design. Therefore, if the cost of the safety countermeasure at the spot is given, the benefit-cost ratio of the safety improvement project can be identified.

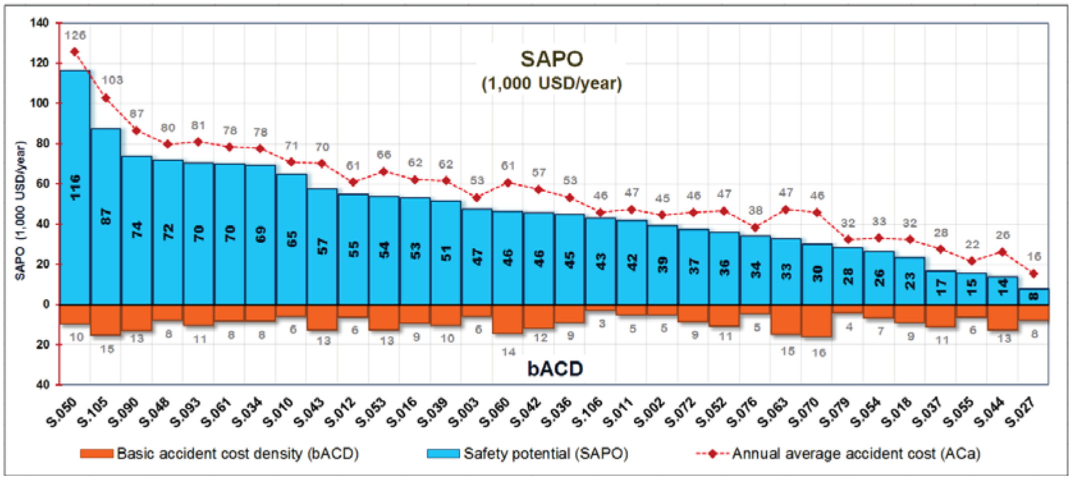


Figure 5.15 Safety potentials of 32 selected spots within the road network (2009 -2011)

Furthermore, with the ranking of spots by safety potential, it is easy to decide which and how many spots to be treated depending on the financial resources. This fact adds new aspects to the concept of black spots and increases the flexibility of the selection of black spots to be treated by means of the prioritization which is based on economical effectiveness.

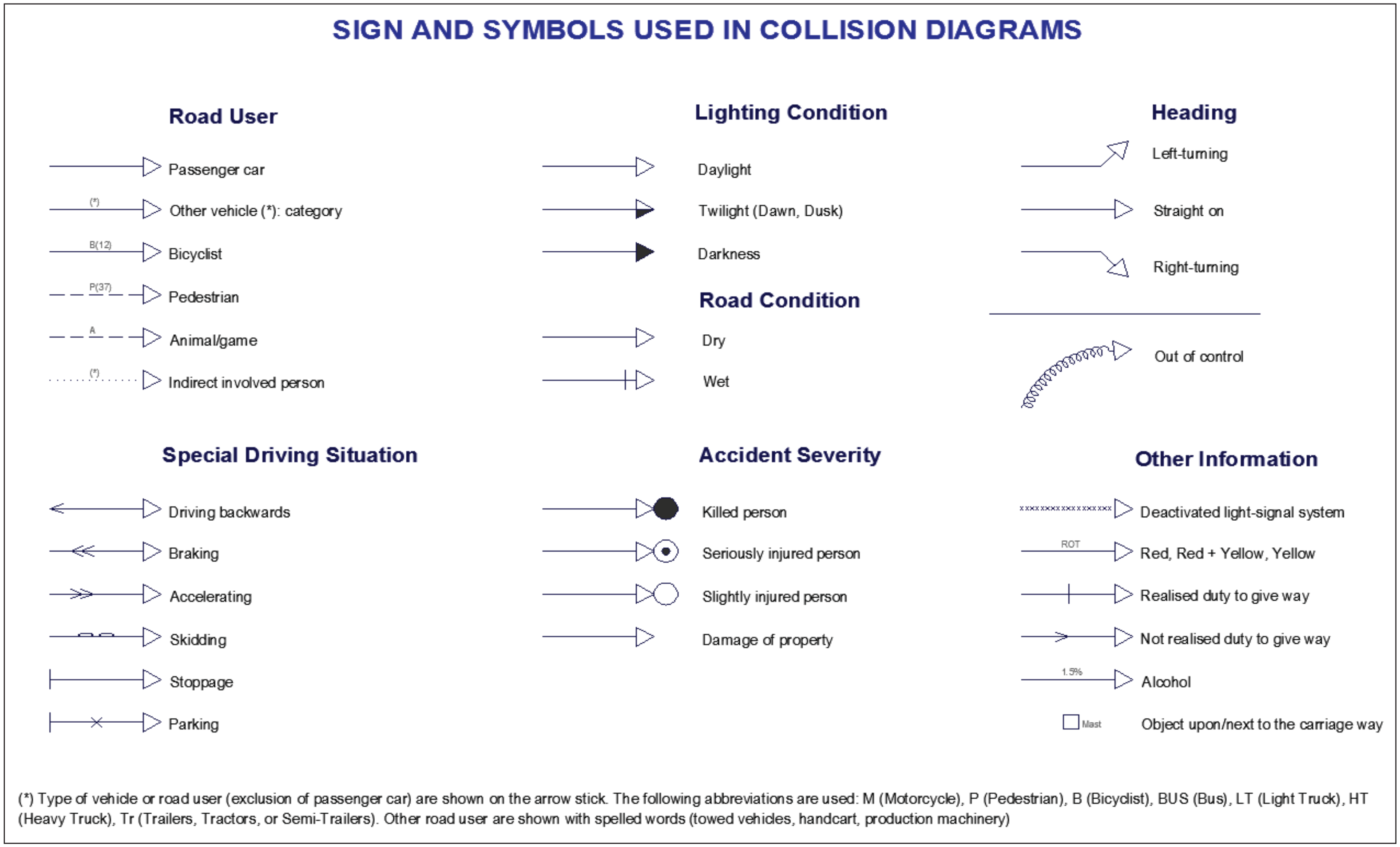
5.4.3 Black spot analysis

The implemental analysis was applied to a typical black spot which, in this case, is the spot with highest safety potential. Such analysis was done so as to identify factors contributing to accidents at the spot. These factors, in their turn, would lay the foundations for the development of safety improvement measures.

5.4.3.1 Collision diagram analysis

- System of signs and symbols

In order to make the collision diagram, a system of signs and symbols was employed. This system is specifically described in Figure 5.16.



Source: Road Accident Investigation Guidelines for Road Engineers, PIARC (2007)

Figure 5.16 Sign and symbol used in collision diagram

■ Collision diagram

Based on the collected data on the recorded accidents at the spot, the collision diagram was established as in Figure 5.17. With the plotting technique employed, the diagram can depict different types of information about the accidents including distribution, circumstance, type, severity, and most importantly how the accidents happened.

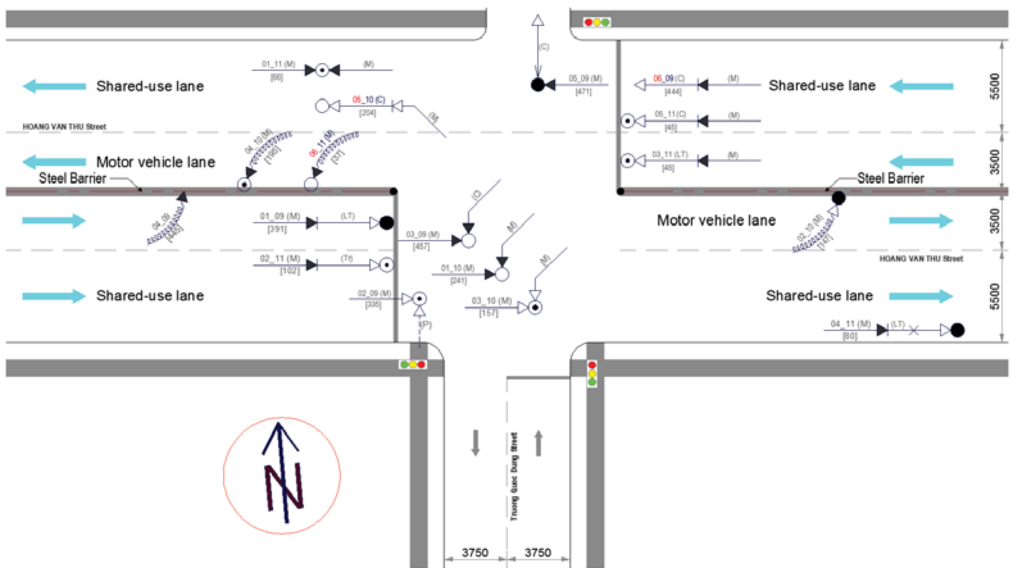


Figure 5.17 Collision diagram at black spot with highest safety potential

■ Dominant accident patterns

Table 5.9 Summary of accident characteristics at the black spot

	Date	1/09	2/09	3/09	4/09	5/09	6/09	1/10	2/10	3/10	4/10	5/10	1/11	2/11	3/11	4/11	5/11	6/11	Sum of accident characteristics
	Severity	F	SI	LI	PDO	F	PDO	LI	F	SI	SI	LI	SI	SI	SI	F	SI	LI	
Accident Type	Single vehicle running off the road				X				X		X							X	4
	Left-turn heading			X				X		X									3
	Right-turn heading																		0
	Right angle collision					X													1
	Head-on collision												X						1
	Rear-end collision	X					X					X		X	X		X		6
	Pedestrian-vehicle collision		X																1
	Parked or stopped vehicle collision															X			1
Circumstance	Darkness	■		■	■	■	■	■			■			■	■	■	■	■	12
	Wet surface																		0
	Excessive speed	X							X		X					X			4

F = Fatal, **SI** = Serious Injury, **LI** = Light Injury, **PDO** = Property Damage Only

The information about accident occurrence in Figure 5.17 can be summarized in Table 5.9, which enabled the identification of the accident patterns at the spot. Table 5.10 suggests the pattern of the 17 recorded accidents at the spot as follows.

- 12 accidents during the hours of darkness
- 6 accidents of rear-end collision
- 4 accidents of single vehicle running off the road
- 3 accidents of left-turn heading
- 4 accidents with excessive speed

■ Safety problem diagnosis

The accident pattern indicates that the real safety problems at the signalized junction were:

- Night-time accidents,
- Rear-end collisions,
- Single vehicle running off the road, and
- Left-turn heading accidents.

Whereas, excessive speed is the factor that has strong impacts on the outcomes of the above safety problems.

The possible contributing factors can be identified based on the *Highway Safety Manual* – TRB (2009). The details of such identification are listed in Table 5.10.

Table 5.10 Possible factors contributing to accidents at the spot

No.	Accident types	Potential causal factors
1	*Night-time accident*	➢ Poor nighttime visibility or lighting ➢ Poor sign visibility ➢ Inadequate channelization ➢ Inadequate maintenance ➢ Excessive speed

2	*Rear-end collision*	➢ Inappropriate approach speeds ➢ Poor visibility of signals ➢ Unexpected lane changes on approach ➢ Narrow lanes ➢ Unexpected stops on approach ➢ Slippery pavement ➢ Excessive speed
3	*Single vehicle running off at the junction*	➢ Inadequate signal timing ➢ Inadequate advance warning signs ➢ Slippery pavement ➢ Excessive speed
4	*Left-turn heading accident*	➢ Misjudge speed of on-coming traffic ➢ Pedestrian or bicycle conflicts ➢ Inadequate signal timing ➢ Inadequate sight distance ➢ Conflict with right-turn-on-red vehicles ➢ Large traffic volume

5.4.3.2 Site investigation results

In order to find out whether the contributing factors in Table 5.10 were true or not, it was crucial to conduct necessary site investigations whose results are presented as follows.

- Designed traffic signal program and potential conflict points

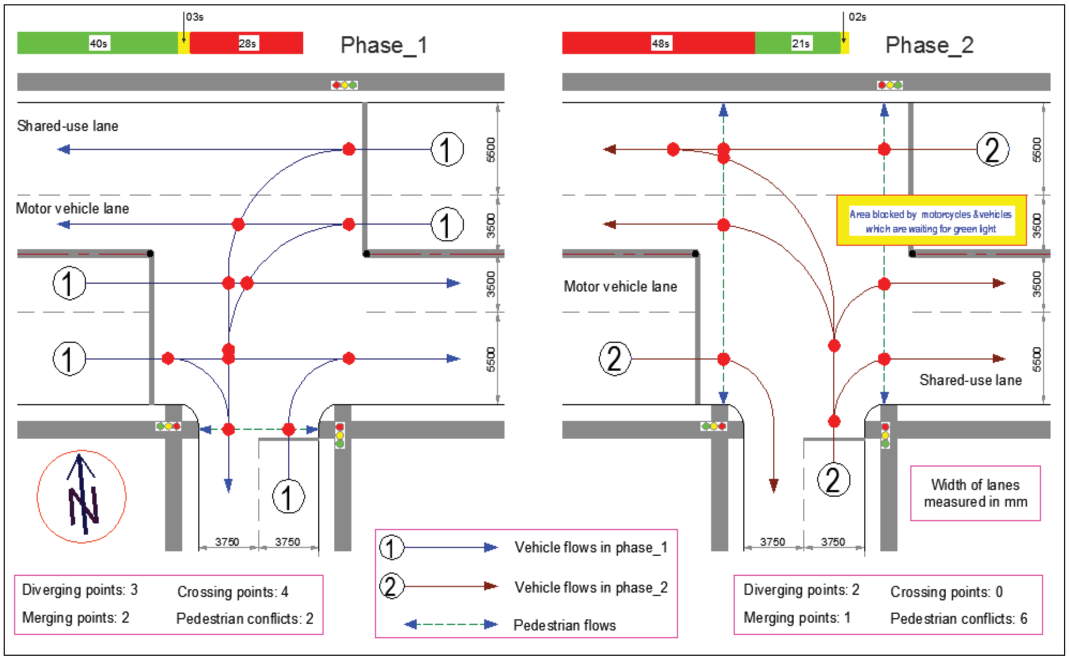


Figure 5.18 Designed traffic signal program, and potential conflict points at the site (T-junction)

- Traffic counts

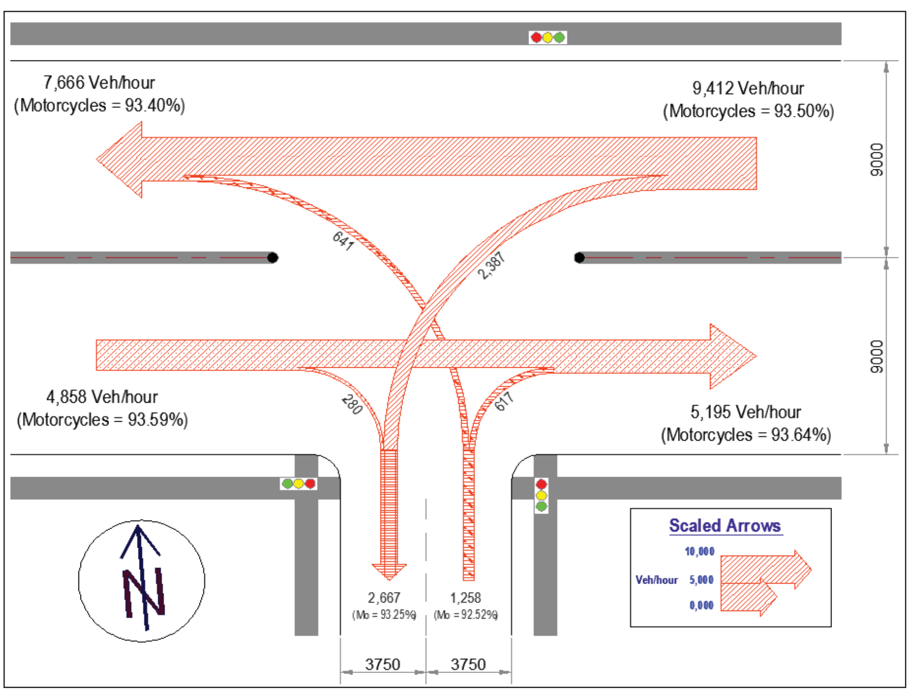


Figure 5.19 Traffic count according to traffic flows at the site (T-junction)

■ Other conditions

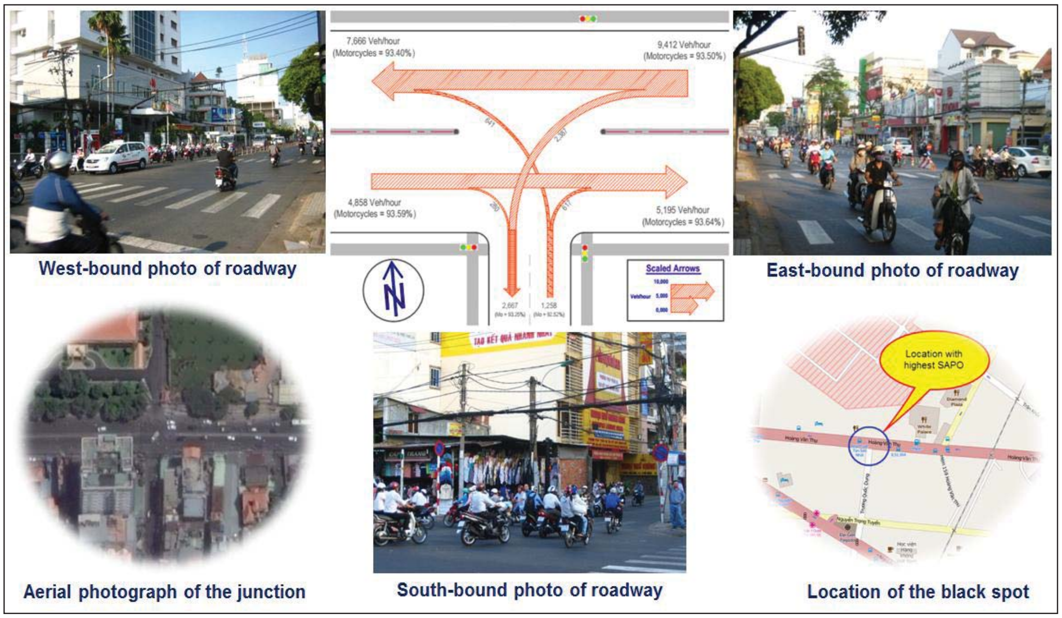


Figure 5.20 Other conditions at the site (T-junction)

5.4.3.3 Black spot simulation before treatment

In order to optimize the reliability of the identification of the contributing factors, the traffic situation at the spot was simulated. The details of the simulation are as follows.

■ Input data

➢ Geometric data: Number of lanes and lane width are shown in Figure 5.21

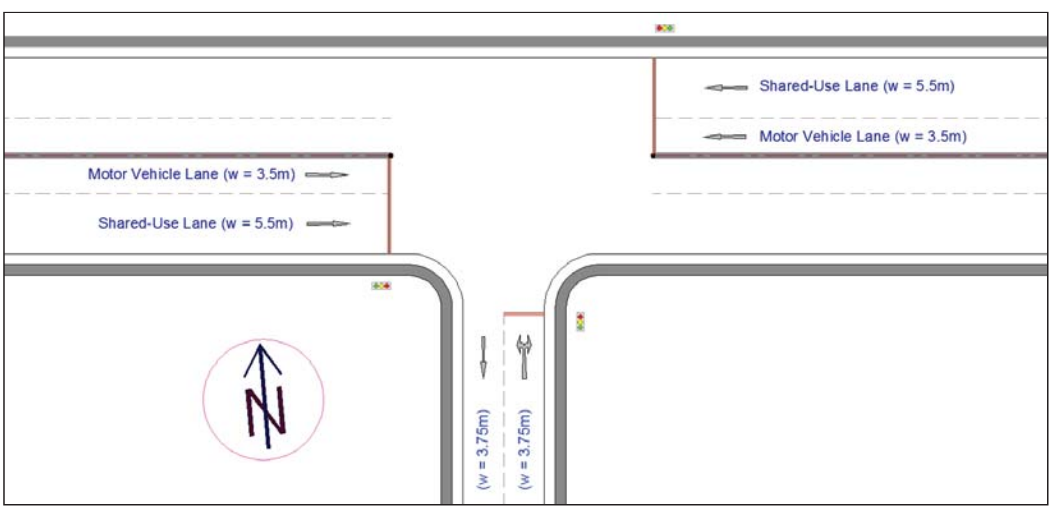


Figure 5.21 Road layout of the T-junction (black spot)

➢ Traffic data: Traffic volume and vehicle composition as shown in Figure 5.22

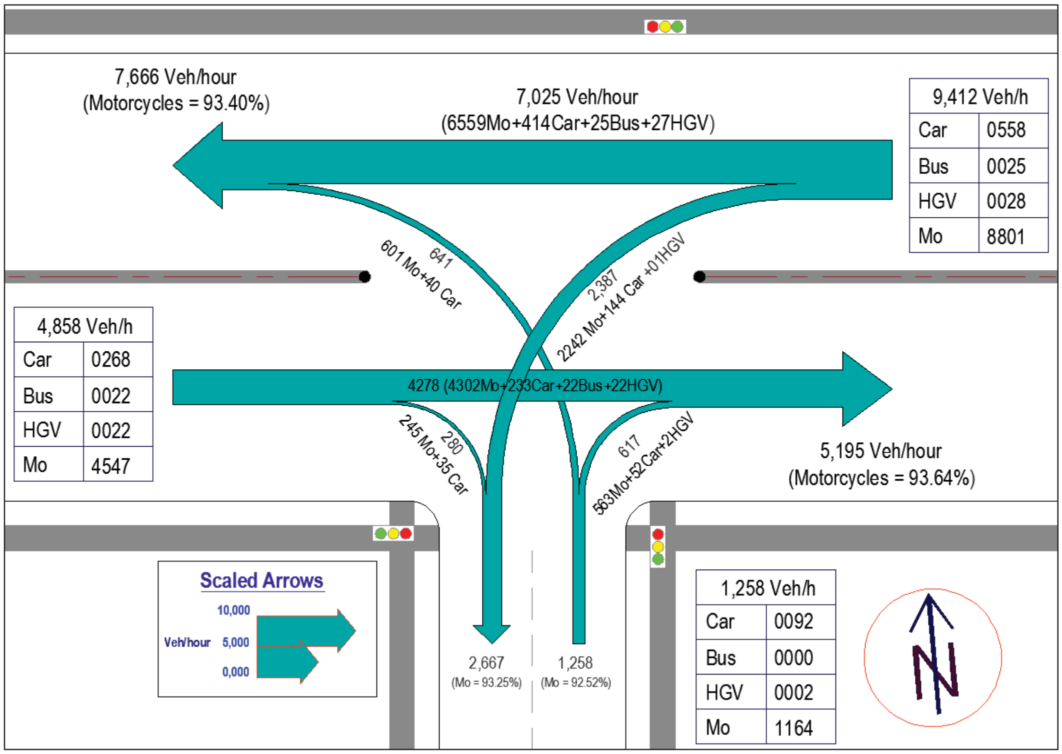


Figure 5.22 Presentation of traffic volume and vehicle composition at the junction

➢ Vehicle data: desired speed (min, max) in km/h: motorcycle (20.0, 45.0), car (35.0, 50.0), bus and light truck (30.0, 45.0).

➢ Traffic signal control

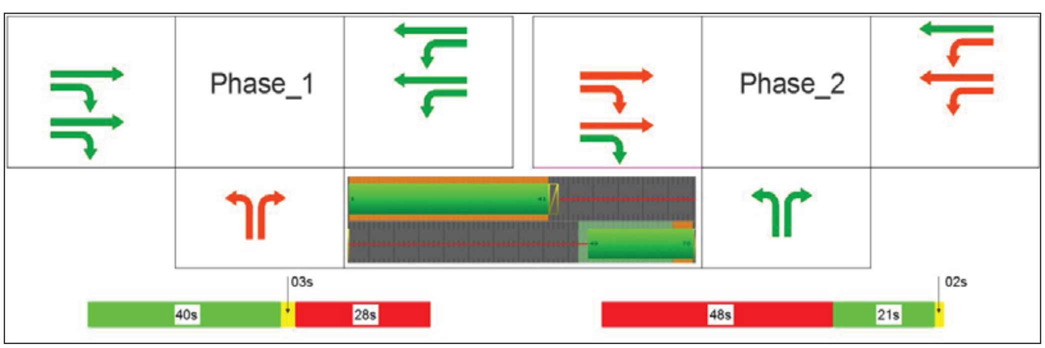


Figure 5.23 Current traffic signal control program at the junction

➢ Driving behaviour parameters

- Lane change: free lane selection
- Min. headway: 1.0m
- Look-ahead distance: Minimum 0.0m, Maximum 100.0m
- Additive part of desired safety: 1.0m
- Overtake on same lane: motorcycles

■ Modelling junction

Figure 5.24 Simulation process of current traffic situation at black spot

■ Simulation results

The results of traffic simulation before treatment at the black spot including Level of Service (LOS), delay time per movement by approach, and queue length are shown in the Figure 5.25 and Table 5.11 as below.

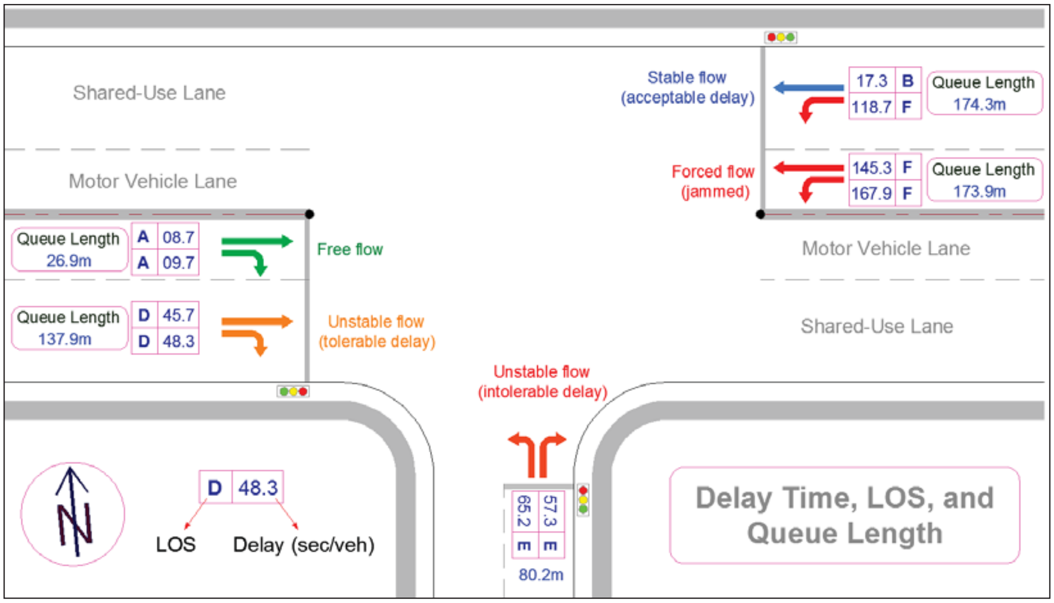


Figure 5.25 Level of Service (LOS), delay time per movement by approach, and queue length (before treatment) at the T-junction

Table 5.11 Level of Service (LOS) table per movement by approach and 95th percentile queue length (m)/traffic simulation output (before treatment) at the T-junction

Level of Service per Movement by Approach (Delay in sec/vehicle)									
Eastbound				**Westbound**				**Northbound**	
Share-use lane		Motor vehicle lane		Share-use lane		Motor vehicle lane		Share-use lane	
TH	**RT**	**TH**	**RT**	**TH**	**LT**	**TH**	**LT**	**LT**	**RT**
D	**D**	**A**	**A**	**B**	**F**	**F**	**F**	**E**	**E**
45.7	48.3	8.7	9.7	17.3	118.7	145.3	167.9	65.2	57.3
QueL: 137.9m		QueL: 26.9m		QueL: 174.3m		QueL: 173.9m		QueL: 80.2m	
LT = Left-turn; **TH** = Through; **RT** = Right-turn; QueL = Queue Length									

5.4.3.4 Identification of factors contributing to accidents at the spot

Collectively, the results from the collision diagram analysis, site investigation and simulation enabled to identify the following actual accident contributing factors.

- Heavily trafficked T-junction with small corner radii

- Large number of left-turning vehicles
- Non-protected left-turning movement with partial-conflicts
- Poor night-time visibility
- Inadequate signal timing
- Restrict sight distance
- Crossing pedestrians

5.4.4 Development of safety improvement measures focusing on motorcycles

Countermeasures were developed by reviewing the recorded accident data, on-site investigation reports, other related local conditions, and the before treatment traffic simulation. In this case, the dominant proportion in traffic composition and involvement in accidents of motorcycles was detected. Specifically, this type of vehicle accounted for 90% the traffic volume and was involved in 100% accidents happening at the spot. This is an important point will be considered in the development and selection of safety improvement measure at the site.

5.4.4.1 Developing safety improvement measures

Based on the identified contributing factors and the actual dominant involvement of motorcycles, two applicable safety measures were taken into consideration so as to select the practically optimal one. The details of the two alternatives are as follows.

■ <u>Measure 1</u> (refers to figures 5.26 and 5.27)

- Improve street lighting
- Redesign signal program with protected left-turning movement
- Provide motorcycle passing lane
- Provide motor vehicle left-turn lane
- Redesign turning radii
- Provide motorcycle left-turn waiting area

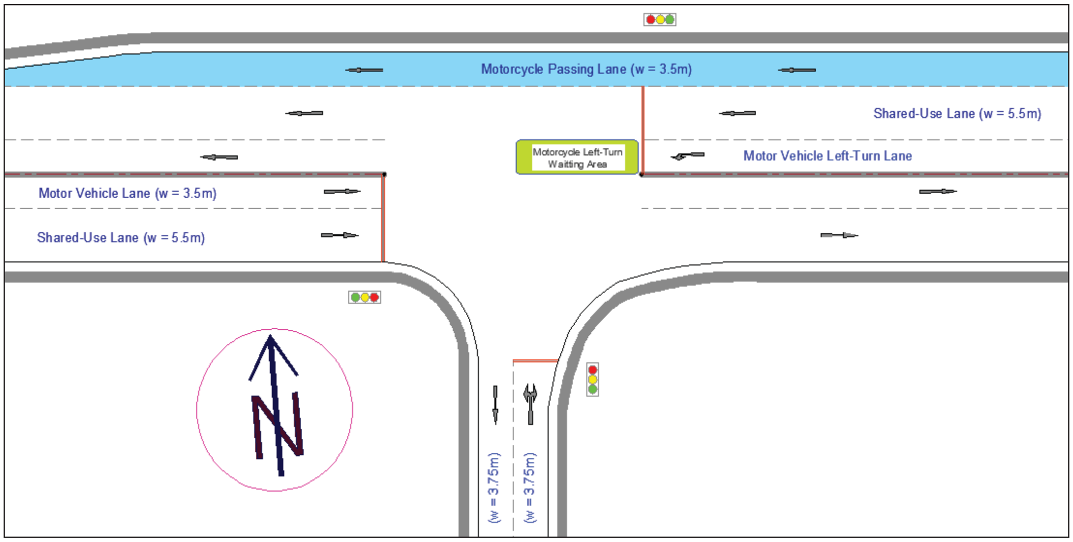


Figure 5.26 Road layout of Measure_1

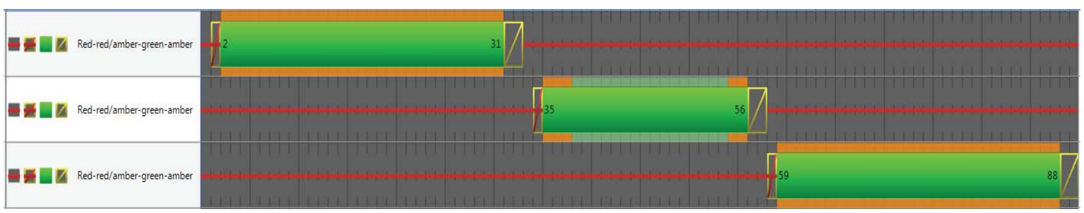


Figure 5.27 Signal program of Measure_1

■ Measure 2 (refers to figures 5.28 and 5.29)

- Improve street lighting
- Redesign signal program with protected left-turning movement
- Provide motorcycle passing lane
- Provide motor vehicle left-turn lane with raised island
- Redesign turning radii
- Provide motorcycle left-turn waiting area

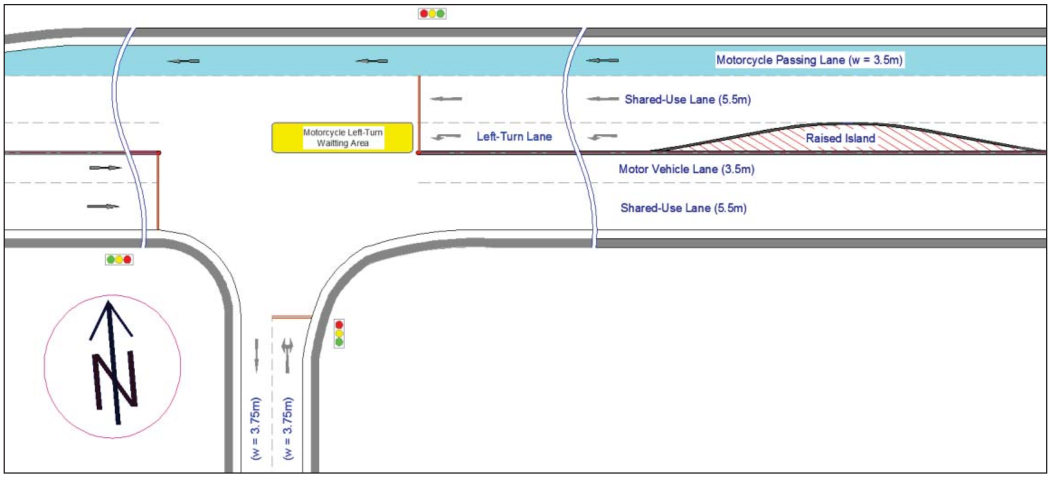


Figure 5.28 Road layout of Measure_2

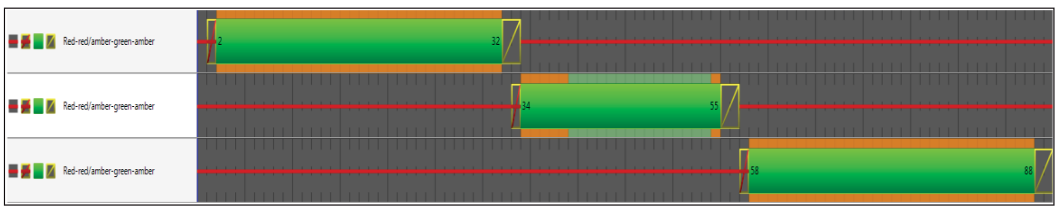


Figure 5.29 Signal program of Measure_2

5.4.4.2 Simulating proposed measures

The simulations of the traffic situation at the spot after implementing the proposed safety measures were done in order to:

- verify the expected safety improvement;
- detect the potential risks of the proposed measures; and
- evaluate the possible impacts on the current traffic system.

The details of the simulations and the outputs are as follows.

■ Simulation process and traffic simulation outputs of Measure_1 (Figures 5.30, 5.31 and Table 5.12)

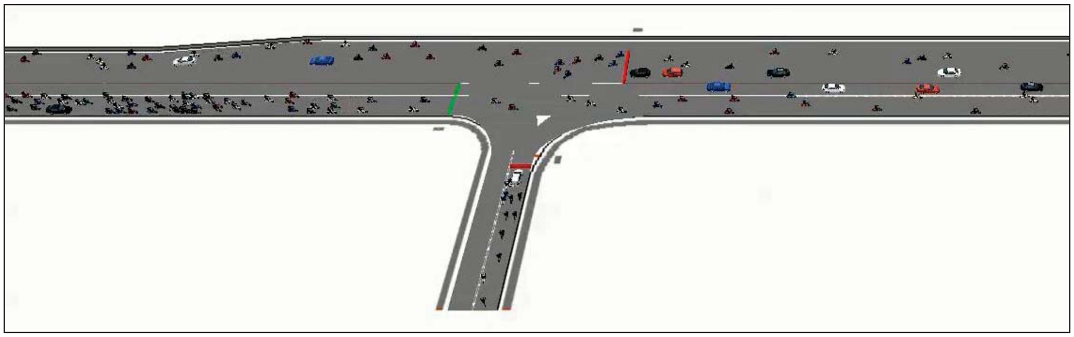


Figure 5.30 Simulation process of Measure_1

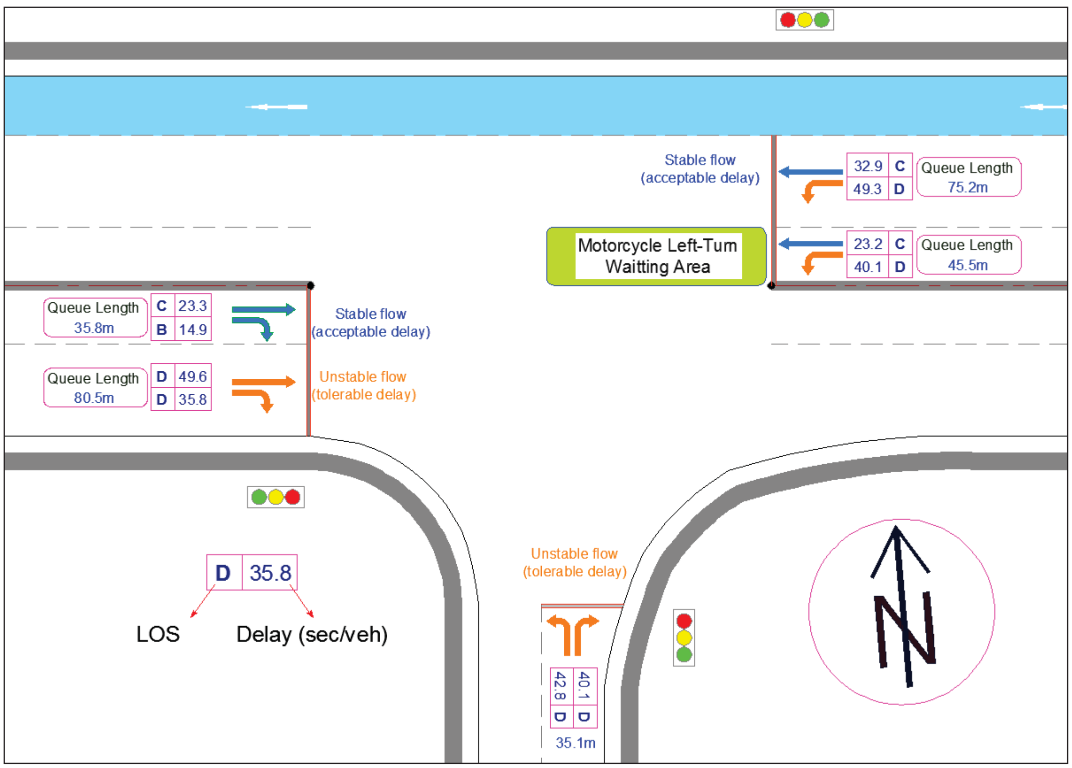


Figure 5.31 Level of Service (LOS), delay time per movement by approach and queue length (Measure_1)

Table 5.12 Level of Service (LOS) Table per movement by approach and 95th percentile queue length (m)/traffic simulation output (Measure_1)

Level of Service per Movement by Approach (Delay in sec/vehicle)									
Eastbound				**Westbound**				**Northbound**	
Share-use lane		Motor vehicle lane		Share-use lane		Motor vehicle lane		Share-use lane	
TH	**RT**	**TH**	**RT**	**TH**	**LT**	**TH**	**LT**	**LT**	**RT**
D	**D**	**C**	**B**	**C**	**D**	**C**	**D**	**D**	**D**
49.6	35.8	23.3	14.9	32.9	49.3	23.2	40.1	42.8	40.1
QueL: 80.5m		QueL: 29.3m		QueL: 75.2m		QueL: 45.5m		QueL: 35.1m	
LT = Left-turn; **TH** = Through; **RT** = Right-turn; QueL = Queue Length									

- Simulation process and traffic simulation outputs of Measure_2

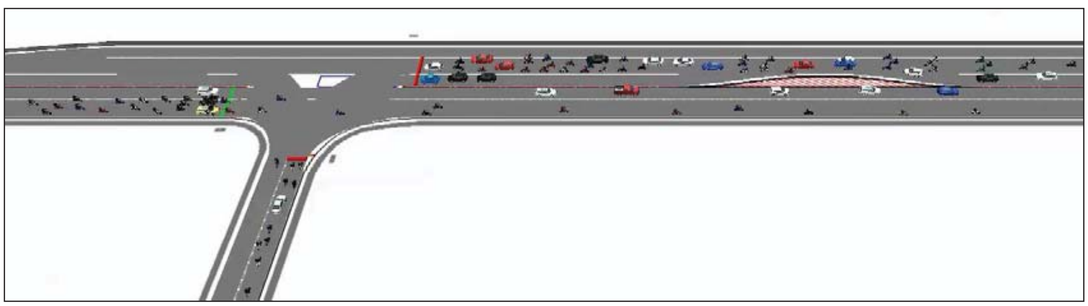


Figure 5.32 Simulation process of Measure_2

Table 5.13 Level of Service (LOS), delay time per movement by approach and 95th percentile queue length (m) (Measure_2)

Level of Service per Movement by Approach (Delay in sec/vehicle)									
Eastbound				**Westbound**				**Northbound**	
Share-use lane		Motor vehicle lane		Share-use lane		Motor vehicle lane		Share-use lane	
TH	**RT**	**TH**	**RT**	**TH**	**LT**	**TH**	**LT**	**LT**	**RT**
E	**D**	**C**	**C**	**D**	**D**	-	**D**	**D**	**C**
52.7	45.8	25.6	21.3	50.1	54.2	-	54.5	35.3	28.4
QueL: 90.5m		QueL: 38.7m		QueL: 90.7m		QueL: 46.6m		QueL: 30.2m	
LT = Left-turn; **TH** = Through; **RT** = Right-turn; QueL = Queue Length									

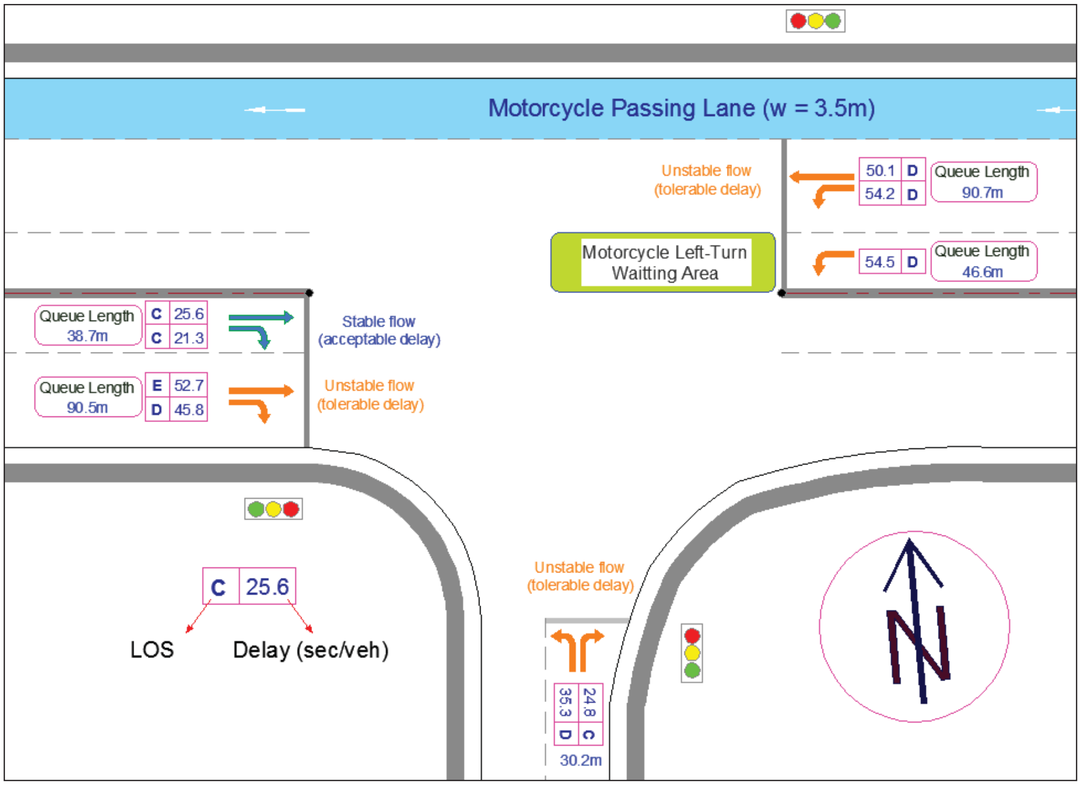


Figure 5.33 Level of Service (LOS), delay time per movement by approach and queue length (Measure_2)

5.4.4.3 Selecting the safety improvement measure

In order to finalize the selection of the measure to be practically implemented, a variety of factors must be taken into account, including:

- The outcomes of the simulation in terms of level of service, delay time, and queue length;
- The benefit-cost ratio of the measure; and
- The impacts of the measure on motorcycle safety.

Furthermore, it is important to make a compromise between these factors. That means the final selection depends mostly on which factor is considered the most important one.

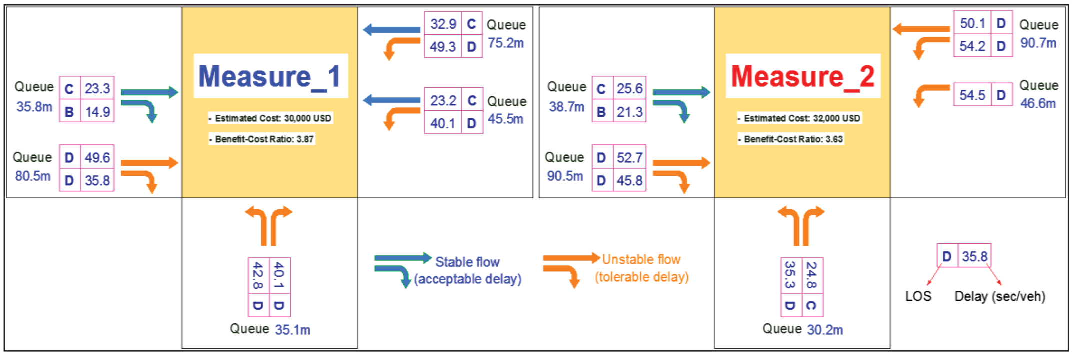


Figure 5.34 Comparison of LOS, delay time per movement and queue length by approach of two proposed safety countermeasures

Table 5.14 Comparison of LOS, delay time per movement and queue length by approach of two proposed safety countermeasures

Measures		**Level of Service per Movement by Approach** (delay in sec/vehicle)									
		Eastbound				**Westbound**				**Northbound**	
		Share-use lane		Motor vehicle lane		Share-use lane		Motor vehicle lane		Share-use lane	
		TH	**RT**	**TH**	**RT**	**TH**	**LT**	**TH**	**LT**	**LT**	**RT**
Measure_1	**LOS**	**D**	**D**	**C**	**B**	**C**	**D**	**C**	**D**	**D**	**D**
	Delay	49.6	35.8	23.3	14.9	32.9	49.3	23.2	40.1	42.8	40.1
	Queue	80.5m		29.3m		75.2m		45.5m		35.1m	
	Cost	**30,000 USD** (Estimated); **Benefit-Cost Ratio = 3.87**									
Measure_2	**LOS**	**E**	**D**	**C**	**C**	**D**	**D**	-	**D**	**D**	**C**
	Delay	52.7	45.8	25.6	21.3	50.1	54.2	-	54.5	35.3	28.4
	Queue	90.5m		38.7m		90.7m		46.6m		30.2m	
	Cost	**32,000 USD** (Estimated); **Benefit-Cost Ratio = 3.63**									
LT = Left-turn; **TH** = Through; **RT** = Right-turn											

The results show that Measure_1 better improved the traffic situation in terms of LOS with lower cost. However, this measure does not effectively improve the serious conflicts between motorcycles and motor vehicles which frequently lead to severe accidents.

On the contrary, with slightly higher cost, Measure_2 effectively eliminates the serious conflicts between motorcycles and motor vehicles, enabling the prevention of the potential severe accidents. With motorcycle safety as the first priority, Measure_2 was selected to be practically implemented.

5.5 Summary

The SAPO-based BSM approach suggests a new comprehensive procedure of black spot management from the very first step of black spot identification to the final step of implementation and evaluation of the selected improvement measure (Figure 5.3).

Such black spot management approach enables the administrations to first identify true black spots, and then decide which black spot(s) to improve so as to make the best of the treatment in terms of safety as well as economical effectiveness.

The reliability and effectiveness of the approach in the above prospects has been verified by the practical implementation in the case study. The approach is expected to fill the gaps left in traditional approaches in identifying and analysing black spots; and to give satisfactory remedies for the problems of road safety suitable for the local conditions of HCMC.

CHAPTER 6

CONCLUSIONS AND SUGGESTIONS

6.1 Theoretical contribution

The methodology employed in SAPO-based BSM approach focuses on the traffic volume, the severity of accidents, and the evaluation of accidents on the basis of accident cost rates. The comparison of the actual accident cost with the hypothetically-estimated accident cost provides information on safety potential of spots. In other words, the safety potential is determined by the comparison of the actual accident cost and the expected accident cost for the best practice design.

The advantage of the safety potential compared to classic accident parameters is that the former can allow assessing different road types and roads with different volumes at the same time while the latter cannot.

With safety potential as the main indicator of black spots, SAPO-based BSM approach makes it possible to integrate the prioritization into the identification of black spots. With such prioritization, it is easy to decide which and/or how many spots to be treated depending on the financial resources. This fact adds new aspects to the concept of black spots and increases the flexibility of the selection of black spots to be treated by means of the prioritization which is based on economical effectiveness.

Safety potential is calculated based on accident costs. And, safety potential is closely related to the cost of the improvement measures. As a result, the benefit-cost ratio of a safety improvement measure can be calculated by dividing safety potential by estimated cost of that safety improvement measure.

The performance of computer-based microsimulations of traffic situation before and after treatment at the same black spot is an important task in black spot analysis and safety measure development process. These simulations enable better identification of accident contributing factors at the spot and better selection of safety countermeasures.

6.2 Practical effectiveness

6.2.1 Effectiveness in black spot identification and ranking

In order to depict the significance and the effectiveness of the proposed method relative to the current method, it is necessary to compare the results of black spot identifying and ranking using the two methods. Such comparison is presented in the chart in Figure 6.1. In this chart, the black spots identified and ranked by the proposed method are presented in the upper part from the abscissa. The spots are ranked according to the safety potential priority index (SAPO priority index) which is equal to the safety potential of the given spot divided by the maximum safety potential of all the identified spots. And, the black spots identified and ranked by the current method are presented in the lower part from the abscissa. The spots are ranked according to the equivalent accident number priority index (EAN priority index) which is equal to the equivalent accident numbers of the given spot divided by the maximum equivalent accident number of all the identified spots. In the current method, the equivalent accident number is used with reference to injury accidents according to which one fatal accident is converted into two injury accidents.

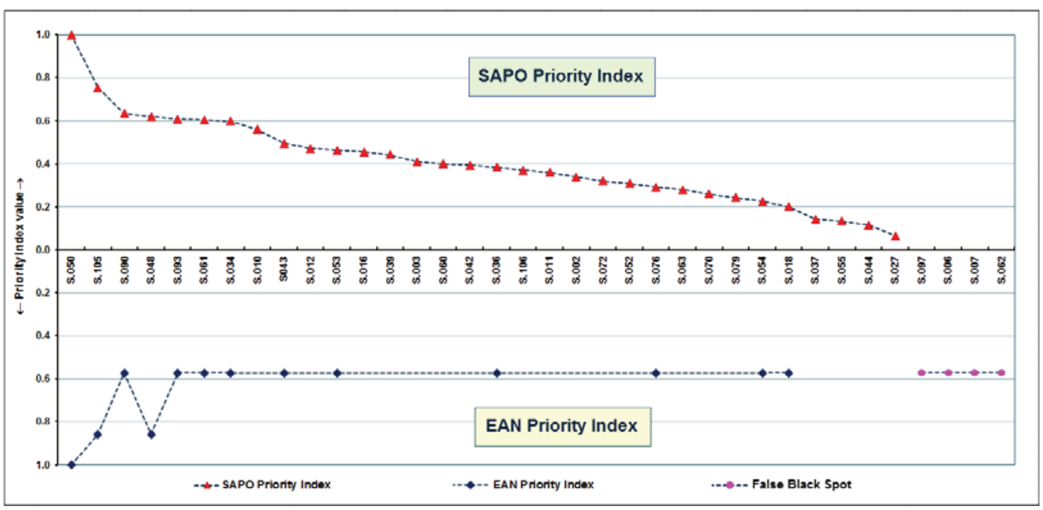


Figure 6.1 Black spot identification and ranking of the two methods

The advantages of the proposed method can be seen in the following two aspects.

(1) Ranking: Each of the black spots identified by the proposed method has a different SAPO priority index value varying from 1 to 0.07. This fact effectively facilitates the ranking of the black spots. On the contrary, most of the black spots identified by the current method

have the same EAN priority index value (0.57). This fact makes it difficult to rank the black spots.

(2) Identification Accuracy: The proposed method identified 32 black spots none of which were false. On the contrary, the current method identified 17 black spots 4 of which were false. These facts indicate that the proposed method can minimize the number of false positive black spots as well as the number of undetected true positive black spots.

In short, with the advantages of accurate identification and effective ranking, the proposed method can solve the problems arising in black spot identifying and ranking due to the limitations of the current method. Therefore, the proposed method can serve as a solution for the black spot identification in HCMC.

6.2.2 Effectiveness in black spot analysis and safety countermeasure development

It is well-known that the nature of accidents is that accidents are rare, random, and multi-causal.

Because accidents are rare, the presence of accident patterns provides compelling evidence of underlying safety deficiencies. This is why traditional method usually used collision diagrams as a mainstay of black spot analysis.

Because accidents are random, all results from black spot analysis based on recorded accidents cannot provide fully information on safety at the spot. In order to supplement lack of the information, traditional approach used supplementary information from on-site inspection. This is why black spot analysis was usually done together with on-site investigation or inspection.

And because of accident are multi-causal, on-site inspection is the best way to get further information on accident occurrence to help the analysis of accident causes.

However, traditional black spot analysis methods use accident structure or collision diagram analysis as the highest level of safety analysis. It is easy to realize that traditional black spot analysis based on the principle of 'cause – effect'. The causes are derived from the reviewing of past events (recorded accidents) but lay the foundation for the identification of accident contributing factors and the establishment of safety improvement measures which are intended to be applied to the current and future traffic situation. Hence, the disadvantage of traditional black spot analysis is that such analysis does not evaluate the impacts of the proposed safety improvement measures on the current and future traffic situations. Furthermore, the potential risks of the proposed improvement measures were not detected.

The black spot analysis method proposed in this dissertation not only uses all the steps of the current methods but also employs a number of new steps. It was recognized that doing so would make the analysis more demanding, but it would hopefully also make it more conclusive. The computer-based microsimulations of black spot before and after treatment make it possible to:

- Optimize the reliability of the identification of accident contributing factors;
- Detect the potential risk of proposed safety countermeasures;
- Evaluate the impact of proposed measures on the current and future traffic; and
- Evaluate the impact of proposed measures on the traffic situation of surrounding sites within the road network.

6.3 Suggestions for the implementation

The new black spot management approach is based on the safety potential in identifying and ranking black spots. The safety potential identifies network spots on which safety improvement measures are expected to have the greatest effect, but it requires a reliable basic data system. The basic data such as accident pin boards including 1-year APBs and 3-year APB, road network data, and traffic volume play the key role in identifying, ranking and treating black spots.

In order to avoid unexpected shortcomings in the implementation of the approach, it is important to pay special attention to the following aspects.

First, safety potential is the very difference between the actual accident cost and the expected accident cost conforming to the best-practice design standard. The expected accident cost depends on the basic accident cost rate. In ideal circumstances this expected accident cost contains no influence of the infrastructure on the accidents any more but represents the accident cost caused only by the other two components of the transport system – vehicle and road users. The best way to estimate the target values would be to calculate the accident cost rate for a sample of spots with best practice design. Another possibility would be to use a specific percentile of the overall distribution of the accident cost rates.

Second, statistical tests must be done to make sure that the random variation is not the decisive factor in the process of identifying the high accident frequency locations. Random variation in accident count at the identified locations can be estimated by Poisson probability distribution.

Third, the microsimulations of traffic situation before and after treatment should be conducted to ensure the trueness of identified factors contributing to accidents at the spots and minimize the positive effects of proposed improvement measures on current and future traffic system.

In conclusion, the approach proposed in this research introduces a new aspect in black spot management by integrating prioritization into the identification. In this way, the method can optimize the black spot treatment with limited financial resources which are facing most developing cities. Still, the benefits are considerable in terms of economic efficiency. Therefore, the method is expected to be a satisfactory solution for accident reduction in HCMC.

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APPENDIX

A. Publications

Year	Papers
2015	Nguyen, H. H., and Taneerananon, P. (2015) *Approach to Identifying Black Spots Based on Potential Saving in Accident Costs*, paper accepted for publication on the ENGINEERING JOURNAL, ISSN 0125-8281 (www.engj.org/).
2015	Nguyen, H. H., and Taneerananon, P., Koren, C. (2015) *Identifying Black Spots Based on Safety Potential – A Suitable Approach to Accident Reduction in Developing Countries*, paper accepted for publication on the Journal of the Eastern Asia Society for Transportation Studies, J-STAGE, ISSN 1881-1124 (www.jstage.jst.go.jp/browse/easts/).
2014	Nguyen, H. H., and Taneerananon, P., Koren, C., Luathep, P. (2014) *The Evolution of Criteria for Identifying Black Spots and Recommendations for Developing Countries, Journal of Society for Transportation and Traffic Studies (JSTS)*, Vol.5 No.3 Special Issue: Road Safety, pp. 16-28.
2013	Nguyen, H. H. (2013) *A Comprehensive Review of Motorcycle Safety Situation in Asian Countries, Journal of Society for Transportation and Traffic Studies (JSTS),* Vol.4 No.3, pp. 20-29.
2013	Nguyen, H. H., and Taneerananon, P., Koren, C., Iamtrakul, P. (2013) *Safety-Potential-Based Black Spot Safety Management Approach: A Case Study in Ho Chi Minh City, Journal of the Eastern Asia Society for Transportation Studies*, Vol. 10, 2013, pp 1991-2009.
2013	Nguyen, H. H., and Taneerananon, P., Koren, C., Iamtrakul, P. (2013) *The Significance of Developing A New Black Spot Safety Management Approach for The Local Road Traffic Safety Nature of Ho Chi Minh City, Acta Technical Journal,* Vol. 6, No. 2. 2013, pp. 91-106.
2012	Nguyen, H. H., and Taneerananon, P. (2012) *Reality of Urban Road Safety in Ho Chi Minh City and Suggested Solutions, Journal of Society for Transportation and Traffic Studies (JSTS)*, Vol.3 No.1 Special Issue: Road Safety, pp. 9-21.

B. Proceedings

Year	Proceedings
2015	Nguyen, H. H., and Taneerananon, P., Koren, C. (2015) Identifying Black Spots Based on Safety Potential – A Suitable Approach to Accident Reduction in Developing Countries, paper accepted to be presented at the 11th EASTS conference, Cebu, Philippines, 11-14 September 2015.
2015	Nguyen, H. H., and Taneerananon, P. (2015) Identifying Black Spots Using Safety-Potential-Based Method, proceeding of the 4th International Conference of TSTS "Transportation for Nation-Building", 2nd April 2015, Bangkok, Thailand, Thai Society for Transportation and Traffic Studies, pp. 6.
2015	Nguyen, H. H., and Taneerananon, P., Koren, C. (2015) Identifying Black Spots Using Safety-Potential-Based Approach, paper presented the 5th CoREST international conference "Collaboration in Research and Education for Sustainable Transport", Ho Chi Minh City University of Transport, Ho Chi Minh city, Vietnam, 15-16 May 2015.
2013	Nguyen, H. H., and Nguyen, T. L. (2013) Improving Safety Performance of Motorcycle Helmets Based on Simulation and Impact Analysis, paper presented at the13th Conference on Science and Technology, Vietnam National University, University of Technology, Ho Chi Minh City, 1st October 2013.
2013	Nguyen, H. H., and Taneerananon, P., Koren, C., Iamtrakul, P. (2013) Safety-Potential-Based Black Spot Safety Management Approach: A Case Study in Ho Chi Minh City, paper presented at the 10th International Conference of Eastern Asia Society for Transportation Studies, Taipei, Taiwan, 9 – 12 September 2013.
2013	Nguyen, H. H., and Taneerananon, P., Koren, C., Iamtrakul, P., and Vesper, A. (2013) Traditional Black Spot Safety Management Approaches: Potential Problems and Suggested Solutions, paper presented at the 18th National Convention on Civil Engineering (NCCE), Chiang Mai, Thailand, 8 - 10 May 2013.
2013	Nguyen, H. H., and Taneerananon, P. (2013) The Role of Engineering Approaches in Accident Prevention and Reduction, paper presented at the 4th CoREST international conference "Collaboration in Research and Education for Sustainable Transport", Ho Chi Minh City University of Transport, Ho Chi Minh city, Vietnam, 17 - 18 May 2013.

2013	Nguyen, H. H., and Taneerananon, P. (2013) The Significance of Developing A New Black Spot Safety Management Approach for The Local Road Traffic Safety Nature of Ho Chi Minh City, paper presented at the 4th CoREST international conference "Collaboration in Research and Education for Sustainable Transport", Ho Chi Minh City University of Transport, Ho Chi Minh city, Vietnam, 17 – 18 May 2013.
2013	Nguyen, H. H., and Taneerananon, P. (2013) Reality of Urbanization and Road Traffic Safety in Ho Chi Minh City, paper presented at the Conference on Construction and Sustainable Development (CIGOS), Lyon, France, 4-5 April 2013.
2012	Nguyen, H. H., and Taneerananon, P. (2012) The Impact of Urbanization on Road Traffic Safety in Ho Chi Minh City, Paper presented at the 5th Asian Transportation Research Society (ATRANS) Symposium, Bangkok, Thailand, 24 – 27 August 2012.
2012	Nguyen, H. H., and Taneerananon, P. (2012) Phenomenon of Black Spot Relocation in Ho Chi Minh City: Causes and Lessons, paper presented at the 8th Asia Pacific Conference on Transportation and the Environment - "Asian Transport Challenges" - APTE8 – 2012, Hat Yai, Thailand, 6-8 June 2012.
2011	Nguyen, H. H., and Taneerananon, P. (2011) Reality of Urban Road Safety in Ho Chi Minh City and Suggested Solutions, paper presented at the 2nd TSTS International Conference "Sufficiency Transport", Thai Society for Transportation and Traffic Studies, Pattaya, Thailand, 14 – 15 October 2011.

VITAE

Name: **Mr. Huy Huu Nguyen**

Student ID: 5410130028

Educational Attainment:

Degree	Name of Institution	Year of Graduation
Bachelor of Engineering (Civil Engineer)	Polytechnic University in Ho Chi Minh City, Vietnam	1996
Master of Engineering	European Master in Mechanics of Constructions, Liège University, Belgium	1998

Scholarship Awards during Enrolment:

The researcher was admitted to be a PhD student at Prince of Songkla University with full scholarship offered by the EU-Asia Road Safety Centre of Excellence (RoSCoE).

Work – Position and Address:

Period	Employing organization, position	Country	Summary of activities
2011 to present	PhD Student at EU-Asia Road Safety Centre of Excellence (RoSCoE), Department of Civil Engineering, Faculty of Engineering, Prince of Songkla University	Thailand	Carrying out the research entitled "Improving Urban Road Safety in Vietnam Focusing on Motorcycles: A Case Study in Ho Chi Minh City"
2007 – 2010	Employing Organization: Department of Transport Planning, Faculty of Transportation Engineering, Ho Chi	Vietnam	Teaching subjects such as Port and Harbor Planning, Inland Waterway Planning,

	Minh City University of Transport Position: Lecturer		Applied IT, Applied Hydrology Engineering
1999 – 2006	Employing Organization: Department of Hydro-Technical and Offshore Structure Ho Chi Minh City University of Transport Position: Lecturer	Vietnam	Teaching subjects such as Port and Harbor Planning, Port Structure Design, Applied IT.

Experience:

I worked as the chairman of the following projects:

- Computation of service-life of FPSO Ruby Princess mooring system (2010);
- Recovering differential settlement of rice silo in Kien Giang province (2009);
- Developing technical design of mooring buoy for fleet of lash ships of 9000DWT and 40 lash barges of 200DWT (2008);
- Calculation of reinforcing workshop structure of Long An Machinery Company (2007);
- Evaluation of damage to Phu My Jetty, Phu My Port caused by the impact of the ship named Truong-Thinh-09 (2006);
- Study on wave transformation on submerged permeable breakwater (2005);
- Developing technical design of LPG jetty, Long An province (2005);
- Study on behaviour of contacting structures (2004);
- Study on hydrodynamic field of 3-dimensional turbulence jet (2003);

I worked as a collaborator of the following projects:

- Master plans on Transport Development in the Focal Economic Southern Zone of Vietnam (2000);
- Feasibility Study of Project for Two Main Inland Waterways of Mekong Delta, Master Plans of the Mekong Delta of Vietnam (1998).

And, I have made some other contributions to the field of civil engineering, including:

- Science report at national conference on technology (2008);
- Co-supervisor of MSc theses in hydro-technical and offshore structures;

- Supervisor of BSc theses in hydro-technical and offshore structures.

List of Publications and Proceedings:

Publications

1) Institute : **ENGINEERING JOURNAL, ISSN 0125-8281**

Article Title : ***Approach to Identifying Black Spots Based on Potential Saving in Accident Costs.***

Article Number : paper has been accepted for publication

Year : 2015

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2) Institute : **Journal of the Eastern Asia Society for Transportation Studies, J-STAGE, ISSN 1881-1124**

Article Title : ***Identifying Black Spots Based on Safety Potential – A Suitable Approach to Accident Reduction in Developing Countries.***

Article Number : paper has been accepted for publication

Year : 2015

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3) Institute : **Journal of Society for Transportation and Traffic Studies (JSTS), ISSN 1906-8360**

Article Title : ***The Evolution of Criteria for Identifying Black Spots and Recommendations for Developing Countries.***

Article Number : Vol.5 No.3 Special Issue: Road Safety, pp. 16-28.

Year : 2014

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4) Institute : **Journal of Society for Transportation and Traffic Studies (JSTS), ISSN: 1906-8360**

Article Title : ***A Comprehensive Review of Motorcycle Safety Situation in Asian Countries***

Article Number : Vol.4 No.3, pp. 20-29

Year : 2013

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5) Institute : **Journal of the Eastern Asia Society for Transportation Studies J-STAGE, ISSN 1881-1124**

Article Title : ***Safety-Potential-Based Black Spot Safety Management Approach: A Case Study in Ho Chi Minh City***

Article Number : Vol. 10, 2013, pp 1991-2009

Year : 2013

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6) Institute : **Acta Technica Jaurinensis, Szechenyi Istvan University, ISSN 2064-5228**

Article Title : ***The Significance of Developing A New Black Spot Safety Management Approach for The Local Road Traffic Safety Nature of Ho Chi Minh City.***

Article Number : Vol. 6, No. 2. 2013, pp. 91-106.

Year : 2013

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7) Institute : **Journal of Society for Transportation and Traffic Studies (JSTS), ISSN: 1906-8360**

Article Title : ***Reality of Urban Road Safety in Ho Chi Minh City and Suggested Solutions.***

Article Number : Vol.3 No.1 Special Issue: Road Safety, pp. 9-21

Year : 2012

Proceedings

1) Institute : **Eastern Asia Society for Transportation Studies (EASTS)**

Article Title : ***Identifying Black Spots Based on Safety Potential – A Suitable Approach to Accident Reduction in Developing Countries.***

Article Number : Proceeding of the 11th EASTS Conference, Cebu, Philippines, 11-14 Sep 2015

Year : 2015

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2) Institute : **Thai Society for Transportation and Traffic Studies**

Article Title : ***Identifying Black Spots Using Safety-Potential-Based Method.***

Article Number : Proceeding of the 4th International Conference of TSTS "Transportation for Nation-Building", 2nd April 2015, Bangkok, Thailand,

Year : 2015

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3) Institute : **Ho Chi Minh City University of Transport, Vietnam**

Article Title : ***Identifying Black Spots Using Safety-Potential-Based Approach.***

Article Number : Proceeding of the 5th CoREST international conference "Collaboration in Research and Education for Sustainable Transport", Ho Chi Minh City University of Transport, Ho Chi Minh city, Vietnam, 15-16 May 2015

Year : January 2015

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4) Institute : **The 9th Asia Pacific Conference on Transportation and the Environment (APTE9)**

Article Title : ***The Evolution of Criteria for Identifying Black Spots and Recommendations for Developing Countries.***

Article Number : Proceeding of the 9th Asia Pacific Conference on Transportation and the Environment, Colombo, Sri Lanka, 6-8 August 2014

Year : 2014

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5) Institute : **Ho Chi Minh City National University, University of Technology, Vietnam**

Article Title : ***Improving Safety Performance of Motorcycle Helmets Based on Simulation and Impact Analysis.***

Article Number : Proceeding of the 13th Conference on Science and Technology, HCMC National University, University of Technology, Ho Chi Minh City, 1st October 2013

Year : 2013

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6) Institute : **Eastern Asia Society for Transportation Studies (EASTS)**

Article Title : ***Safety-Potential-Based Black Spot Safety Management Approach: A Case Study in Ho Chi Minh City.***

Article Number : Proceeding of the 10th International Conference of Eastern Asia Society for Transportation Studies, Taipei, Taiwan, 9 – 12 September 2013

Year : January 2013

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7) Institute : **The 18th National Convention on Civil Engineering (NCCE)**

Article Title : ***Traditional Black Spot Safety Management Approaches: Potential Problems and Suggested Solutions.***

Article Number : Proceeding of the 18th National Convention on Civil Engineering (NCCE), Chiang Mai, Thailand, 8 - 10 May 2013.

Year : 2013

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8) Institute : **Ho Chi Minh City University of Transport, Vietnam**

Article Title : ***The Role of Engineering Approaches in Accident Prevention and Reduction.***

Article Number : Proceeding of the 4th CoREST international conference "Collaboration in Research and Education for Sustainable Transport", Ho Chi Minh City University of Transport, Ho Chi Minh city, Vietnam, 17-18 May 2013

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Year : 2013

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10) Institute : **Asian Transportation Research Society (ATRANS)**

Article Title : ***The Impact of Urbanization on Road Traffic Safety in Ho Chi Minh City.***

Article Number : Proceeding of the 5th Asian Transportation Research Society Symposium, Bangkok, Thailand, 24 – 27 August 2012

Year : 2012

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11) Institute : **The 8th Asia Pacific Conference on Transportation and the Environment**

Article Title : ***Phenomenon of Black Spot Relocation in Ho Chi Minh City: Causes and Lessons.***

Article Number : Proceeding of the 8th Asia Pacific Conference on Transportation and the Environment - "Asian Transport Challenges" - APTE8 – 2012, Hat Yai, Thailand, 6-8 June 2012

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Article Number : Proceeding of the 2nd TSTS International Conference "Sufficiency Transport", Thai Society for Transportation and Traffic Studies, Pattaya, Thailand, 14 – 15 October 2011

Year : 2011
