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TSTS

PREFACE

Dear Readers,

We trust you have a great year in 2015, and a happy beginning in the New Year 2016.

We truly apologize for the delay in the publication of these last two issues of 2015, the 3rd and 4th issues of Volume 6. Due to some technical glitches, our website was temporarily not available for a few weeks, but thanks to the dedicated work of our members, especially our webmaster team, Dr. Chalat Tipakornkiat, Assoc. Prof. Dr. Pawinee Iamtrakul and her hard working and able assistants, Chompoonut Kongphunphin, Puriched Kritayanukul, and Gussana Phromsonthi; we have now got it up and running again.

A big welcome to the September and December issues of Volume 6 of our online peer-reviewed International Journal of the Society of Transportation and Traffic Studies (JSTS). The 3rd issue consists of 5 interesting papers from various countries, India, Indonesia, Vietnam and Thailand. Four deal with the critical subject of road safety, two on road aspect and the others on human aspect. Another paper addresses the issue of school trips in Bangkok, a key parameter in the management of traffic congestion in Bangkok and other big cities.

The December issue comprises 5 papers which address different aspects of transportation. The paper from Latvia describes the long term performance of asphaltic mixes. The paper from Sri Lanka describes a new method for developing the driving cycle. Three papers from Thailand address the ongoing critical issue of road crashes which is arguably the number one public health issue for the country. One paper looks into the potential of defective motorcycles in causing road crashes. Another describes the use of Poisson and Binomial Regression Model in predicting road crashes on highway with a rest area. The final paper investigates the impact of road crashes as an important cause of household poverty and human trauma.

Again, we thank all authors who contribute to these issues of our journal and we express our gratitude to members of the International Editorial Board and reviewers for their valuable comments and continued supports. We trust our readers will enjoy and benefit from the articles in our online publication.

Again, a Happy and Safe New Year 2016 to everyone,

With Best wishes from all of us,

Professor Pichai Taneerananon
Chair of Editorial Board

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General Issue

ROAD SAFETY EVALUATION AT THAI U-TURNS USING CZECH TRAFFIC CONFLICT SEVERITY GRADES

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ABSTRACT:

The purpose of this study is to evaluate the road traffic safety at the at-grade U-turns on 4-lane divided highways of Thailand with focusing their layout geometric. In Thailand, the U-turns are considered as one of the major segments of highways that contributing a higher number of crashes. The several layout geometric designs of the U-turns and variation in dimensions of their variables (acceleration lane, deceleration lane and loon/ widening) are influencing factors for the drivers' expectancy; causing undesirable driving behavior and confusion among the road users. These characteristics led to a higher frequency of crashes at the U-turns. For the study purposes a total eight types of at-grade U-turn layout geometric identified throughout Thailand. Due to the limitation of availability and reliability of road crash data in Thailand a surrogate approach, based on the traffic conflict was adopted for the study. Although the Traffic Conflict Technique (TCT) is widely accepted as an alternative and proactive approach but the subjective nature of its parameters is debatable since its origin. The U-turns' geometric data, traffic conflicts and volume data were recorded in the field. The *Severity Conflict Rates* (SCR) is assessed by applying the weighing factors (based on severity grades according to the Czech TCT) to the observed conflicts exposed to the conflicting traffic volumes. A higher value of SCR represents a lower level of traffic safety at a U-turn and a significant relationship was obtained between dimension of the variables of U-turn and the level of road traffic safety.

Keywords: Road traffic safety, U-turn, Severity Conflict Rates, CZECH Traffic Conflict Technique

1. INTRODUCTION

1.1 Road traffic crash trend in Thailand

Road traffic crashes in developing and emerging countries tend to be one of the major causes of fatalities and disabilities. In 2010 the United Nations General Assembly unanimously adopted a resolution calling for a "Decade of Action for Road Safety 2011–2020". The goal of the Decade (2011–2020) is to stabilize and reduce the increasing trend in road traffic fatalities, saving an estimated 5 million lives over the period (WHO Committee, 2013). Road traffic injuries take an enormous toll on individuals and communities as well as on national economies. The middle-income countries, which are motorizing rapidly, are the hardest hit. The economic growth in Thailand has brought about an expanding network of roads and an increasing number of the driving public. The growing number of vehicles on the roads, in turn, has contributed to significant increases of road crashes annually. In Thailand, the road traffic crash problem is now also regarded as one of the most serious social problems. The total economic losses due to road crashes in Thailand were estimated to be 140,000 million Baht or 2.56 Percent of the Gross Domestic Product (GDP) in 2002 (Luathep & Tanaboriboon, 2005). The total traffic crash costs for Thailand for the year 2004 were estimated as 153,755 million Baht or approximately 2.37 Percent of the GDP (Thongchim, Taneerananon, Luathep, & Prapongsena, 2007). The reported road traffic fatalities (in 2010) 13766 and estimated GDP lost due to road traffic crashes about 3% (WHO Committee, 2013). Although there is declining trend of traffic crashes in Thailand (Prapongsena, Sangphet, & Kraisingsom, 2012), yet the number of crashes are high among Southeast Asian countries (WHO Committee, 2013). The Figure 1 shows traffic crash trend in Thailand.

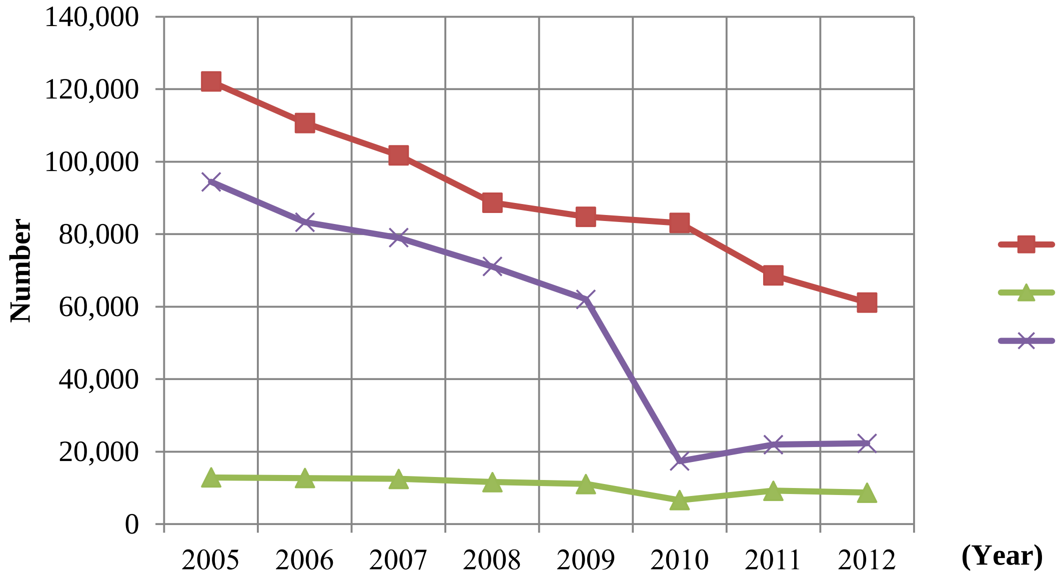


Figure 1. Road traffic crashes trend in Thailand *(Source: Prapongsena, 2012)*

1.2 Function of the U-turns on the Thai highways

The median at-grade U-turns on the divided Thai highways are provided for the U-turning movements to facilitate road users to join the opposite direction traffic stream. The basic functions of the median at-grade U-turns on the Thai highways are shown in the Figure 2.

The U-turns are also constructed to reduce the number of at-grade X-junctions (to avoid direct right turn from a highway to a minor road and direct right turn from a minor road to a highway (for left hand traffic)). Other purposes are to reduce travel time for emergency services, efficient law enforcement and for highway maintenance purposes etc. The distance between the U-turn and minor road is varying (approximately 100 m to 2 km); also there are no specific guidelines available for the separation distance between the U-turns. The experts believe the separation distance between two adjacent U-turns is varying from approximately 1.5 to 3 km on Thai highways, depends upon field geography and local road design practice. The several type layout geometric design practice of the U-turn followed in Thailand, some are standard (as per design guidelines of the Department of Highways) and the remaining are non-standard (based on the local design practice). For the study purpose, the U-turns were classified based on the applications of the geometric variables.

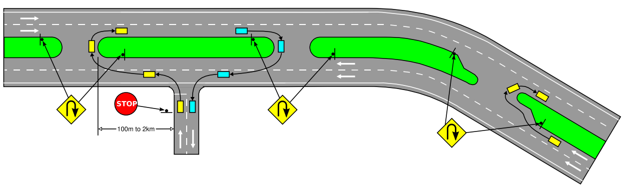


Figure 2. The basic functions of the median U-turns

1.3 Road traffic safety at the U-turns

The midblock U-turn junctions interrupt the through traffic movement. The U-turning vehicles affect the through traffic movement in the opposite direction when they merge. The U-turning vehicles also affect the through traffic movement in the same direction when they stop and create queue. Sometimes the deceleration lane may get occupied completely. This may lead to a dangerous situation where the vehicles will extend back onto the highway (spill back), obstructing the through movement traffic.

According to the observation at the U-turn junction, when the U-turn traffic has long queue or waited for longer time, the U-turn traffic tends to be more aggressive to make U-turn. At the same time, the conflicting through traffic tends to be willing to stop and allow the U-turn traffic to go. In theory, the through traffic should get priority over the U-turn traffic all the time.

1.4 U-turn density and geometric design consistency

At the U-turns, the merging and diverging movements are performed at the inner lanes which make these susceptible to traffic crashes. Frequent lane-changes on highways at merging, diverging, and weaving areas could disrupt traffic flow and, even worse, lead to crashes. Also lane-changes could have significant bottleneck effects on overall traffic flow. The practitioners believe that crash frequency augments rapidly when the density (number of U-turns per kilometer length) of at-grade U-turns rises.

Furthermore the several type of layout geometric of the U-turns produces inconsistent design characteristics of road infrastructure. This means that drivers cannot drive safely at high speeds all the time and everywhere, since changes in the road environment require constant adaption in speed and influence driver expectancy. The requirement of adapting speed to suit the environment can increase the opportunity for human error and lead to high risk of crash and injury. The posted speed limit at the Thai U-turns is same as mid-block speed limit (80 Kilometers per hour). The higher speed increases the severity of the impact in a collision. The conjunction of the high speed and the varying geometric conditions are major factors in crash causation with a high fatal crash rate.

1.5 Effect of geometric variables of the U-turns

The U-turn geometric design varies with application and dimensions of its variables, such as auxiliary lanes (acceleration, deceleration and loons). The acceleration (merging) lane and deceleration (diverging) lane are provided along inner lanes of highways at the U-turns. Practically the inner lanes are used for overtaking and for vehicles moving with a higher speed. So the merging and diverging maneuvers at the inner lanes make the U-turns susceptible towards traffic crash hazards. The lengths of these auxiliary lanes are not uniform at most of the U-turns. The shorter length of these does not have enough space to make comfortable lane change; this may result in a safety problem for the weaving and storage maneuvers. The Thai motorcyclists mostly travel on the outer paved shoulder and rarely use inner auxiliary lanes for the U-turning movements, so these have to cross all through lanes of both the directions. Similarly heavy commercial vehicles having difficulty to use inner acceleration lanes due to requirement of larger turning radius, so these vehicles either merge into through lanes or use loons (outer paved area).

2. LITERATURE REVIEW

2.1 NCHRP 524 report (Potts, et al., 2004)

The NCHRP 524 report focused on the safety of the U-turns at unsignalized intersections. It included an intensive safety evaluation of the U-turns for different types of median openings and the places of the median openings on major roads. Some of the findings related to the layout geometric of the U-turns are presented in following sections.

2.1.1 Classification of the U-turns

The U-turns were classified on the basis of layout geometric and used following key variables to classify the design:

— Application of acceleration and/ or deceleration lanes,
— Application of directional island, and
— Application of loons.

2.1.2 Spacing of median openings

The report stated that by increasing the spacing between median openings improves arterial flow and safety by reducing the number of conflicts and conflict points per mile, providing greater distance to anticipate and recover from turning maneuvers. Spacing of openings should be consistent with access management classifications of criteria.

2.1.3 Median acceleration lanes

They provide vehicles a path to accelerate to an appropriate speed before entering into the through travel lanes on a divided highway. Median acceleration lanes provide both safety and operational benefits in that the entering vehicles do not cause vehicles on the through travel lanes to decelerate substantially. They have following advantage and disadvantages as shown in the Table 1.

Table 1. The advantage and disadvantages of acceleration lanes

Advantage	Disadvantages
— reduce delays when traffic volumes are high — provide higher merging speeds — reduce the crashes	— It is difficult to merge from median acceleration lanes because of blind spots — are not used properly by drivers — create anxiety to through traffic

2.1.4 Loons or outer-widening

The loons are defined as expanded paved aprons opposite a median crossover. Their purpose is to provide additional space to facilitate the larger turning path of commercial vehicles along narrow medians. With the use of loons, it may be possible to gain the safety and operational benefit at a divided roadway. In spite of benefits of loons at the U-turns, following are the safety concerns at loons:

— Fixed-object crashes with delineator posts, sign posts, and guardrail,
— Sideswipe crashes involving vehicles merging into mainline traffic from the loon,
— Commercial vehicles backing up and parking within the crossover.

2.2 Near-crash events as an alternative approach

If there are shortcomings (limitations of the availability and reliability of crash and traffic data) of collision based safety measure, the road traffic safety analysis can benefit greatly from the methods that use an observable and non-collision based interactions. In order to perform an alternative and comprehensive form of safety analysis, and to assess and predict levels of traffic safety at specific types of traffic facilities, there is a distinct need for faster, more informative, and more resource effective methods that yield valid and reliable safety measures in the short-term without the need for (or in addition to) crash data.Traffic conflict technique (TCT)

The approach is to study traffic conflicts or near miss events which occur more frequently, can be clearly observed and are related to probability of collisions. The main advantage of such measures is related to their resource-effectiveness given that they occur more frequently than crashes and require relatively short periods of observation in order to establish statistically reliable results.

A formalized definition of a traffic conflict was adopted as "an observable situation in which two or more road users approach each other in space and time for such an extent that there is a risk of collision if their movements remain unchanged" (Amundsen & Hyden, 1977), and the observation method formalized in the term as Traffic Conflict Technique (TCT).

The conflict safety indicators are particularly useful where there is an emphasis on the assessment and comparison of safety enhancement measures at specific traffic facilities and, in some cases, the interactions of specific road-user categories. The methodologies used to collect conflict data also make the results sensitive to site-specific elements related to roadway design and the dynamic and complex relationships among different traffic variables such as traffic flows, speed and proportions of turning movements (Archer, 2005).

2.2.1 Validity and Reliability of TCT

Despite the many advantages related to the use of TCT, a number of fundamental problems have been identified. The reliability and validity are two issues strongly connected to the usability of TCT. These concern the lack of a consistent definition, their validity as a measure of traffic safety, and the reliability of their associated measurement technique.

A number of studies have tried to address reliability and validity issues ((Williams, 1981), (Hauer, Traffic conflicts and exposure, 1982), (Migletz, Glauz, & Bauer, 1985), (Hauer & Garder, Research into the validity of the traffic conflicts technique, 1986)). Some empirical studies found that there were clear relationships between traffic conflicts and crashes (Glauz, Bauer, & Migletz, 1985). Despite the concerns about those issues, traffic conflict techniques have been used in various studies to evaluate safety.

The relationship between traffic volumes and conflicts has been another subject for researchers to investigate. Salman and Al-Maita (1995, (Salman & Al-Maita, 1995)) had a research on three leg intersections. The summation of all volumes entering the intersection and the square root of the product of the volumes that generated the conflicts were used to correlate conflicts and volumes. It was found that the correlation between the conflicts and the square root of the product of volumes was higher than that of the summation of volumes.

For the subjective TCT, the field observers are a source of error when collecting conflict data, due to the subjective nature of deciding if a given driving event is a conflict or not. Each observer is required to judge whether or not a situation is a conflict, resulting in variability in the grading of traffic conflicts by different people. As a result, the human-collected data was not necessarily accurate, especially if multiple observers were used. Nonetheless, traffic conflicts have been shown to have some correlation with crash frequency, and the consensus is that higher rates of conflicts correlate to lower levels of safety (Gettman, Pu, Sayed, & Shelby, 2008).

2.2.2 Traffic conflict indicators and conflict severity measurement

The conflict indicators are defined as measures of crash proximity, based on the temporal and/or spatial measures that reflect the 'closeness' of road-users (or their vehicles), in relation to projected point of collision. The objective evidence of a traffic conflict by the (NCHRP) definition is the evasive action which is indicated by a brake-light or a lane change affected by the offended driver. First definition of a conflict was mainly based on brake light indications. A variety of observation methods have been developed to measure traffic conflicts including the observation of driver behaviour and recording the number of near misses or avoidance maneuvers. Broadly these can be classified into subjective and objective methods. Subjective methods include considerable judgment by the conflict observer and conflict severity taking into account the level of deceleration (weighted deceleration, which included longitudinal-braking and lateral-swerving-deceleration). To eliminate the subjectivity from traffic conflict analysis, objective measures are used. As objective measures for traffic conflicts having higher validity and include a cardinal or ordinal time-proximity dimension in the severity scale.

There are mainly three indicators are widely recognized and discussed to assess the severity of conflicting situation, Time to Accident / Speed (TA/Speed), Time To Collision (TTC) and Post Encroachment Time (PET).

2.2.2.1 Time to Accident / Speed (TA/Speed)

The conflict measure is determined at a point in time and space when evasive action is first taken by one of the conflicting road-users (Perkins & Joseph, 1967). The TA/Speed value is based on the necessity of a collision course and evasive action. An event with a low TA and a high Speed value indicates an event with high severity.

The Conflicting Speed is the speed of the road user taking evasive action, for whom the TA value is estimated, at the moment just before the start of the evasive action.

Table 2. Characteristics of severity grades according to the Czech TCT
(traffic conflicts are highlighted)

Severity grade (CSG) and description	Indicators	Physical reactions	Events (Related to vehicles)
0 – (mis)behaviour	none	none	breaking the rules without consequences, misbehaviour of road users
1 – slight conflict	low	common	fluent, controlled, predictable maneuvers
2 – medium conflict	obstruction	sudden	pronounced, sudden, unpredictable maneuvers
3 – severe conflict	endangerment	sharp	critical, emergency maneuvers

The Time to Accident (TA value) is the time that remains to an accident from the moment that one of the road users starts an evasive action if they had continued with unchanged speeds and directions.

2.2.2.2 Time to Collision (TTC)

The TTC value is also based on the necessity of a collision course. The proximity is estimated during the approach. TTC is a continuous function of time as long as there is a collision course; the time required for two road users to collide if no evasive action is taken. The TTC_{min} is a specific estimate of the TTC during the entire interactive process of the conflict event, rather than the value recorded at the time evasive action is first taken as in the TA/Speed. So, TTC_{min} is the lowest value of TTC in the approaching process of two road-users on a collision course. A lower value of the TTC or TTC_{min} indicates an event with high severity (Hayward, 1972).

2.2.2.3 Post Encroachment Time (PET)

Post-encroachment time (PET) is the time between two vehicles on a near-collision course passing at a common point (Allen, Shin, & Cooper, 1978), (Van der Horst & Kraay, 1986). To measure PET a collision course or an evasive action of road user(s) is not necessary. As with TTC, a lower PET indicates higher severity, and the minimum value is also the critical value.

2.2.2.4 Grading severity of conflicts

The Table 2 shows the characteristics of severity grades which are assigned to observed conflict situations based on severity of an evasive maneuvers. Situations of specific behaviour or misbehaviour have severity grade 0, since they are situations of one user only and thus do not conform to a conflict definition.

The *Conflict Severity Grades* 1, 2, 3 (highlighted in the Table 2) are assigned to conflict according to the observed evasive maneuvers severity, together with physical reactions and other characteristics. Obstruction and endangerment, used to distinguish between 2nd and 3rd severity grade, is defined according to the Czech TCT (2014, (J, R, & J, November 27-28, 2014)).

2.2.2.5 Traffic exposure

Yi and Thompson (2011, (Yi & Thompson, 2011)) used a relationship between the traffic conflicts and the conflicting volumes at intersections as “the total number of traffic conflicts is proportional to the square root of the product of the conflicting volumes”. This referred to by Sayed and Zein (1999, (Sayed & Zein, 1999)) as the “product of entering vehicles” (PEV):

$$PEV = \sqrt{(V_2) \times (V_2)} \qquad (1)$$

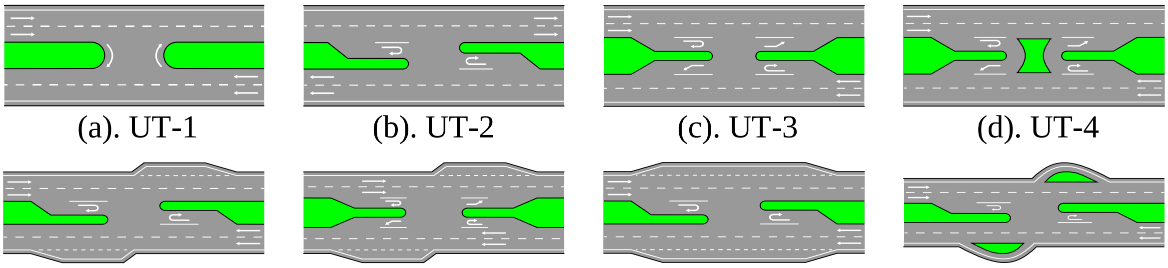
where:

V_1 and V_2 represent the traffic volumes (vehicles/hour) of the two conflicting traffic streams.

3. METHODOLOGY

3.1 Classification of the U-turns on the Thai highways

The U-turns were classified based on several combinations of its four layout geometric variables, viz. deceleration lane, acceleration lane, directional-island and outer widening or loon. Based on these combinations, for this study purpose the eight types of layout geometry of the U-turns were identified as shown in the Figure 3 and the Table 3



(a). UT-1 (b). UT-2 (c). UT-3 (d). UT-4

(e). UT-5 (f). UT-6 (g). UT-7 (h). UT-8

Figure 3. U-turn types on Thai highway

Table 3. Classification of U-turn types on Thai highways

U-turn type	Application of Deceleration lane	Application of acceleration lane	Application of directional island	Application of outer-widening
UT-1	No	No	No	No
UT-2	Yes	No	No	No
UT-3	Yes	Yes	No	No
UT-4	Yes	Yes	Yes	No
UT-5	Yes	No	No	at downstream
UT-6	Yes	Yes	No	at downstream
UT-7	Yes	No	No	at upstream and downstream
UT-8	Yes	No	No	Loons

3.2 Zones at a U-turn

For the study purpose the functional area of a U-turn was considered to be composed of three zones, as shown in the Figure 4. The Upstream Zone consists of through lanes, deceleration lane and sometimes outer widening is also provided. It is used by the U-turning vehicles for substantial speed reduction and storage. The Turning Zone is an open area between the medians and its width is equal to width of the median. For a directional U-turn, an island is installed at this zone to separate both directions turning streams. The Downstream Zone consists of through lanes, acceleration lane and either of outer widening or a loon. This zone is used by the U-turning road users for the acceleration before merging into through traffic streams with an adequate speed.

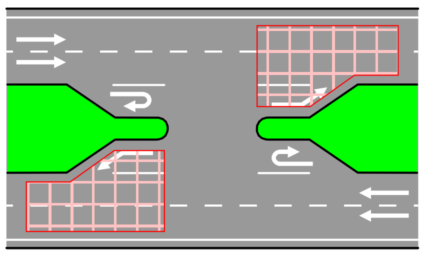


Figure 4(a). Downstream Zones

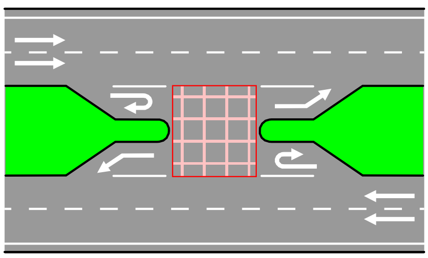


Figure 4(b). Turning Zone

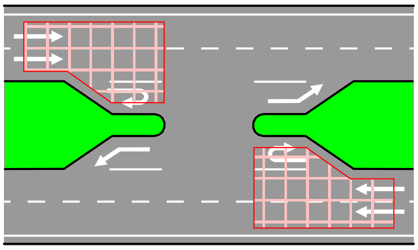


Figure 4(c). Upstream Zones

Figure 4. The three zones at a U-turn

3.3 Layout geometry of the U-turns

The Figure 5 demonstrates a typical example of U-turn diagram containing layout geometry of its variables.

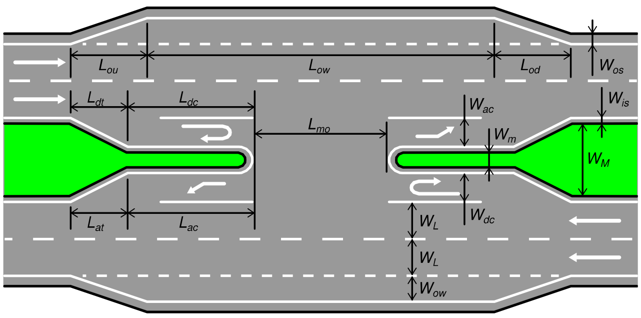


Figure 5. The dimentions of the layout geometric variable at a U-turn

Where:

W_M — Width of median
W_m — Width of median along aux. lane
W_L — Width of through lane
W_{dc} — Width of deceleration lane
W_{ac} — Width of acceleration lane
W_{ow} — Width of outer widening
W_{os} — Width of outer shoulder
W_{is} — Width of inner shoulder
L_{mo} — Length of median opening
L_{dc} — Length of deceleration lane
L_{dt} — Taper section length of deceleration lane
L_{ac} — Length of acceleration lane
L_{at} — Taper section length of acceleration lane
L_{ow} — Length of outer widening
L_{ou} — Length of taper section of outer widening at Upstream
L_{od} — Length of taper section of outer widening at Downstream

3.4 Functional length of the auxiliary lane

The functional length of a deceleration lane (L_{df}) is defined as the summation of the length of the section of the deceleration lane with full width (L_{dc}) and the half of the length of the tapper section (L_{dt}) of the deceleration lane. The functional length of an acceleration lane (L_{af}) is defined in the similar manner. The typical example of the functional length of auxiliary lanes are shown in the Figure 6

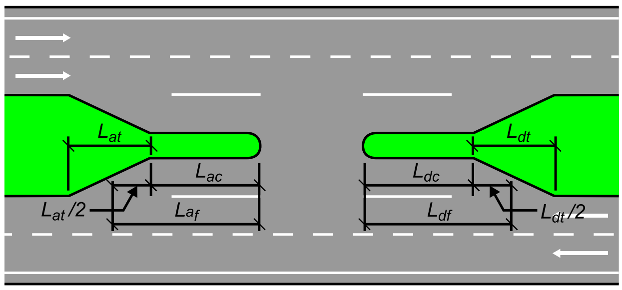


Figure 6. The functional lengths of the auxiliary lanes

3.5 Selection of Conflict severity indicators

The U-turns have a distinct geometry, longer conflict area in longitudinal direction and a higher operating speed. It makes difficult to judge the speed & space between conflicting vehicles and measure the severity of a conflict. Also as this study focus on the U-turns in non-built-up areas, were the elevated spots were unavailable to install a camera in a position to get the aerial view. Therefore the use of the indicators *TA/CS* and *TTC* were not practically viable for this study. At the U-turns the majority of conflicting events are produced due to the merging and diverging maneuvers, and the *PET* is suitable to measure the crossing conflict events, therefore the indictor *PET* was not used in this study.

Due to the above mentioned constraints, a subjective approach was considered to measure the severity of traffic conflicts and the complexity of evasive action of the road users was considered as indicator of conflict.

3.6 Product of the conflicting volumes for the U-turns

The Product of Through and turning (merging & diverging) Volumes (PTTV) were computed for the U-turns as the traffic exposure to the observed conflicts for calculating the conflict rates. It is defined as "the square root of the product of (average hourly) traffic volumes of conflicting streams (through and turning)".

3.7 Exclusion of the Turning Zone conflicts

During the field investigation it was observed that the conflicts at the Turning Zone were very much infrequent and measurement of the conflict indicators based on a subjective traffic-conflict-technique was practically cumbersome and inappropriate. Therefore Turning Zone conflicts were not considered for the safety investigation.

3.8 Conflict Number

3.8.1 Hourly Traffic Conflict Number (HCN)

The Hourly Traffic Conflict Number (HCN) is defined as the number of observed conflicts at a zone divided by the number of observation hours for that zone. The three types of Hourly Traffic Conflict Numbers were computed based on the classification of the severity of conflicting situation as slight, moderate and severe and location of conflict (Upstream and Downstream Zone).

3.8.2 Average Hourly Traffic Conflict Number (AHN)

The each U-turn has two Downstream Zones and two Upstream Zones, and for the each U-turn type the two locations were investigated. Therefore, for a particular type of zone, of a group of particular U-turn type, the Average Hourly traffic conflict Number (AHN) is defined as the summation of Hourly Traffic Conflict Numbers (HCN) at that particular zones divided by the number of that type of zones in that group. Further the Average Hourly traffic conflict Numbers were classified based on the severity of the conflicting situations.

3.9 Severity Conflict Rate (SCR) for the U-turns

The values of Conflict Severity Grade (CSG) from the Table 2 were used as weighting coefficient for giving relative weightiness (importance) to the conflict events and to assess Severity Conflict Rates (SCR) . The SCR is defined as a ratio of the summation of the product of the Average Hourly Slight, Moderate & Sever Traffic Conflict Numbers (AHN) and their respective value of Conflict Severity Grade (CSG) to the Product of Through and Turning Volumes (PTTV) for U-turns. A higher value of SCR at a traffic facility represent comparative a lower level of traffic-safety. The SCR for the U-turns were computed by the following equation:

$$SCR = \frac{AHN_{sl} \times CSG_{sl} + AHN_{mo} \times CSG_{mo} + AHN_{se} \times CSG_{se}}{PTTV}$$

$$SCR = \frac{AHN_{sl} \times CSG_{sl} + AHN_{mo} \times CSG_{mo} + AHN_{se} \times CSG_{se}}{PTTV} \qquad (2)$$

SCR – *Severity Conflict Rate* for a U-turn type,
CSG_{sl} – *Weighting coefficient* of CSG for slight conflict = 1,
CSG_{mo} – *Weighting coefficient* of CSG for moderate conflict = 2,
CSG_{se} – *Weighting coefficient* of CSG for severe conflict = 3,
AHN_{sl} – *Average Hourly Slight Traffic Conflict Number*s,
AHN_{mo} – *Average Hourly Moderate Traffic Conflict Numbers*,
AHN_{se} – *Average Hourly Severe Traffic Conflict Numbers*,
$PTTV$ – Product of through and turning (merging & diverging) volumes

4. DATA TYPE AND DATA COLLECTION

The data which were collected depended on the form of the U-turn being studied and included traffic volumes, U-turning movement counts, using auxiliary lane counts, vehicle compositions, operating speed, geometric data and traffic conflicts. For the classified eight types of U-turn, two locations of each U-turn type were selected. A total 16 sites were selected and investigated throughout Thailand.

The traffic conflicts were recorded by the video cameras in the fields on working days during day light hours (2 hours in the morning/ evening and 2 hours in the afternoon) avoiding adverse weather conditions. A total of 128 hours video of traffic operations data were recorded in the field (16 hours at each U-turn types). The recorded data were later reviewed in the laboratory for obtaining the traffic operations data.

5. RESULTS

5.1 Traffic volumes

At a U-turn there are three types of traffic streams viz. through, diverging and merging. The volume of turning vehicles is a major variable that influencing the numbers of conflict out-turn. The Percent of Hourly Turning Volume (PHTV) is deified as in the Equation (3)

5.2 Severity Conflict Rate (SCR)

The assessed Severity Conflict Rates, the applications auxiliary lanes and the functional length of the auxiliary lanes at the U-turns are illustrated in the Table 4 and the Figure 8

$$PHTV = \frac{Hourly\ Merging\ Volume\ +\ Hourly\ Diverging\ Volume}{Hourly\ Through\ Volume +\ Hourly\ Merging\ Volume\ +\ Hourly\ Diverging\ Volume} \quad (3)$$

The observed PHTV are illustrated in the figure 7

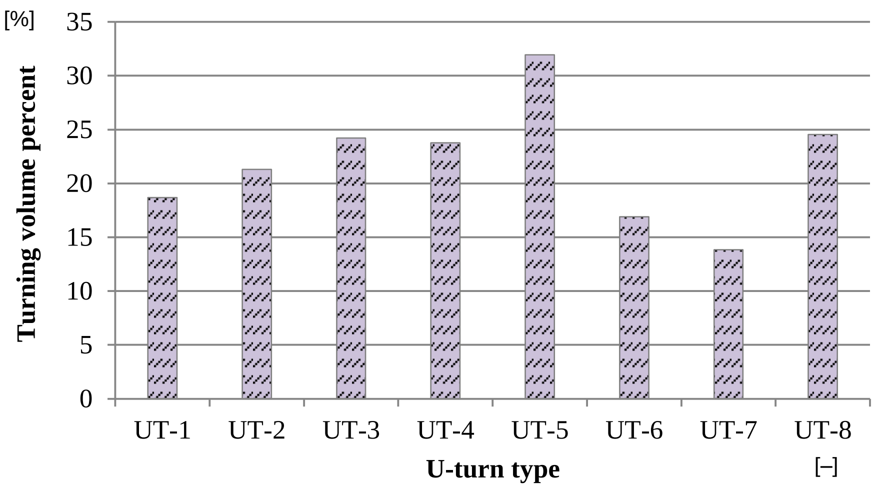


Figure 7. Percent of the Hourly Turning Volumes

Table 4. The Severity Conflict Rates and the length of the auxiliary lanes

U-turn type	SCR $(\times 100)$ [conflicts/veh]	Functional length of acceleration lane (L_{af})	Functional length of deceleration lane (L_{df})	Application of acceleration lane	Application of deceleration lane	Application of outer-widening or loon
UT-1	16.77	0 m	0 m	No	No	No
UT-2	13.08	0 m	56 m	No	Yes	No
UT-3	7.30	177 m	139 m	Yes	Yes	No
UT-4	7.00	124 m	124 m	Yes	Yes	No
UT-5	7.18	0 m	97 m	No	Yes	Yes
UT-6	9.67	108 m	106 m	Yes	Yes	Yes
UT-7	8.89	0 m	127 m	No	Yes	Yes
UT-8	7.26	0 m	129 m	No	Yes	Yes

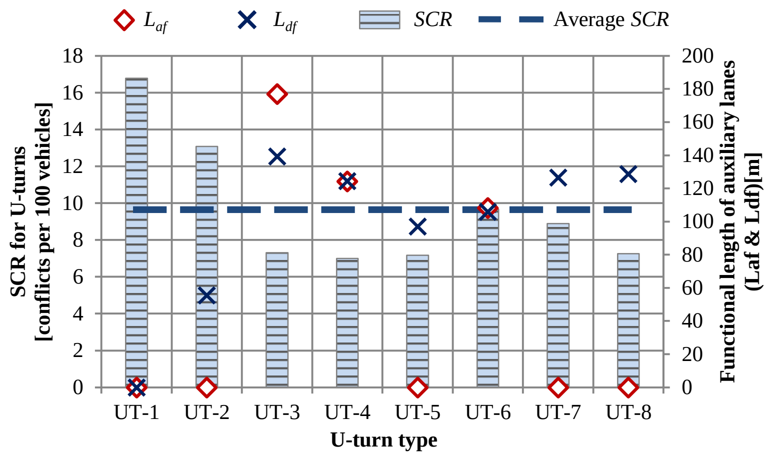


Figure 8. The relationship between SCR and functional length of auxiliary lanes

6. CONCLUSIONS

A comparative higher value of the Severity Conflict Rate represents a lower level of road traffic safety at a traffic facility.

6.1 Severity Conflict Rates (SCR) for the U-turns

The U-turn type UT-1 has a highest value of SCR because non of the acceleration lane, deceleration lane and outer-widening/ loons are applied on it, therefore this layout geometric design could be judge with a lowest level of traffic safety followed by the UT-2, which has only the deceleration lanes with a shorter length.

The U-turn types UT-3, UT-4, UT-5 and UT-8 have almost equal and lowest values of SCRs; therefore these could have a comparative higher level of traffic safety. These U-turn types have only the two layout geometric variables.

The U-turn types UT-6 and UT-7 have the medium values of SCRs and the moderate level of traffic safety. The one of the possible reason of these findings could be the over-dimensioning of these U-turns which could provide the higher opportunities for undesirable driving behaviors. The U-turn type UT-6 has three geometric variables the deceleration lanes at the Upstream Zones and, the acceleration lanes and the outer-widening at Downstream Zones. Similarly the UT-7 also has three geometric variables the deceleration lanes and the outer-widening at the Upstream Zones, and the outer-widening at Downstream Zones. These combinations of the three variables is not only provide a larger area of interaction for the conflicting through and merging streams, and also causing confusion among the drivers of conflicting vehicles to judge each-other maneuvers. The outer-widening at Upstream Zones of the U-turn type UT-7 is unnecessary and mostly it is only used by the commercial vehicles for illegal parking.

The Standard Drawing from the ‘Department of Highways’ of Thailand illustrate the length of deceleration lane as 160 meters (including 60 meters length of taper section), but only 4 among 8 identified U-turn types were have these dimensions. The rest of U-turn types have a shorter length of the deceleration lanes. A shorter length of deceleration lane does not provide adequate space for comfortable deceleration and lane change for the diverging vehicles; this may result in a lower level of traffic safety for the weaving and storage maneuvers of diverging vehicles.

7. RECOMMENDATIONS

The very first recommendation could be a very serious need of establishment of a well-structured and systematic traffic crash data system in the Thailand for improving the road safety strategies to ensure timely & quality results. As this study has undergone to use a surrogate and subjective to human judgment approach, which is frequently debated by the experts and practitioners for its reliability and subjectivity.

The U-turn types UT-1 and UT-2 having the lowest level of traffic safety therefore these should be modified as earliest possible and should not applied to the future projects. The U-turn types UT-6 and UT-7 also having a comparative lower level of traffic safety therefore these are also needed to modify and should not adopted for the future projects.

Furthermore, there are some areas of this research, which are needed to be improved in future studies. The several conflict severity levels measuring objective methods such as Time-to-Collision, Post-Encroachment-Time should be considered as an important factor predicting the crash severity and reducing dependency of human judgments.

For the future assessment of the comparative road traffic safety at the U-turns, in contrast to subjective Traffic Conflict Techniques the uses of micro-simulation software and programs could be the advanced technological tools to produce the results with a higher level of accuracy, reliability and validity.

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FOUR TRIALS TO CRACK THE CHILD HELMET QUANDARY

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ABSTRACT:

Thailand has the second highest rate of road deaths per population in the world. Of those who die on Thailand's roads, 73% are motorcyclists. Despite a legal mandate, less than half of motorcyclists, and only 7% of children, wear helmets. To identify possible models to increase child helmet use, the Asia Injury Prevention (AIP) Foundation conducted four small scale trials: (1) a helmet bank, (2) police enforcement, (3) petrol station retail, and (4) taxi stands. Trials 1, 2, and 4 resulted in increased child helmet use, but each had instructive challenges and strengths. Trial 3 presented a number of challenges leading to the conclusion that child helmet retail at petrol stations is not viable.

Keywords: Injury prevention, Helmet, Motorcycle, School-based intervention, Evaluation

1. INTRODUCTION

Road crashes are among the world's foremost public health issues with 1.24 million deaths and 20-50 million injuries per year. (World Health Organization, 2013) Thailand ranks second in road traffic deaths per population worldwide. (Michael Sivak and Brandon Schoettle, 2014) Motorcyclists account for 73% of Thailand's road deaths. (World Health Organization, 2013)

Helmets are proven to reduce the risk of head injury by 69% and death by 42% in a crash. (Liu et al., 2008) Even though Thai law has mandated helmet use for motorcycle drivers and passengers since 1996, fewer than half of motorcyclists, and only 7% of children wear helmets nationwide. (Thai Roads Foundation et al., 2013) Road injury is the second leading cause of death among children aged 10-14 in Thailand. (Lozano et al., 2012)

To identify possible models to increase child helmet use, the Asia Injury Prevention (AIP) Foundation, in collaboration with Save the Children and the Road Safety Fund, conducted four small-scale trials (see Table 1) to pilot innovative ideas for increasing child helmet use in Thailand. The overall objective in conducting the trials was to identify initiatives that would be most suitable, in terms of sustainability and impact, for expansion.

From November 2013 to January 2014, AIP Foundation conducted four trials for two to three weeks each at locations throughout Bangkok.

Trials 1, 2, and 4 were modeled on a pre-test, implementation, post-test design. The helmet wearing rate of children traveling to the school by motorcycle was measured before and after the trial based on AIP Foundation's helmet observation methodology. Focus group discussions and in-depth interviews were conducted with key stakeholders after the trials ended in order to gain their insights on the trials and on factors that motivate or hinder child helmet use.

Trial 3 was modeled on an implementation, investigation design. During the 2-3 week trial, customers completed a short questionnaire or were interviewed on-site about the trial, possible motivations, and barriers for helmet purchase and use.

This paper describes the methodology, findings, and recommendations of each trial.

Table 1. Four trials tested to increase child helmet use in Bangkok

	Name of Trial	Description
Trial 1	Helmet Bank	Loaning helmets to students from within schools
Trial 2	Police Enforcement	Law enforcement by police officers at school gates
Trial 3	Petrol Station Retail	Convenient accessibility through helmet retail kiosks at petrol stations
Trial 4	Taxi Stand	Motorcycle taxi drivers offer helmets to all child passengers

2. TRIAL 1: HELMET BANK

In Thailand, child helmets are available through direct purchase or donation via educational schemes operated by government agencies, private corporations, and non-governmental organizations (NGOs). This trial aimed to test whether school-based helmet loans could increase child helmet use.

2.1 Methodology

Ban Nong Bon Primary School in Suan Luang, Bangkok was selected for the trial, because nearly half of its students travel by motorcycle, it is in close proximity to a major road, and helmet use is low. Students who traveled by motorcycle regularly, but did not regularly wear helmets when riding on motorcycles (making up about 30% of the school body), were targeted for the project. The trial was implemented from November 21 - December 12, 2013.

A “helmet bank” was established on the school grounds and operated each school day. The helmet bank stored 200 child helmets for students to borrow. Borrowers could keep helmets for a maximum of three days but could borrow helmets again if they wished.

Before implementation, AIP Foundation conducted a helmet observation and a training workshop. The observation took place at the school gate to assess baseline helmet use among students. The one-hour training workshop with 200 target students covered road safety, the importance of helmet wearing, and how to wear a helmet properly. It also introduced the helmet bank and how to access a helmet through the helmet bank.

During implementation, several activities aimed to increase awareness about the importance of child helmet use among parents and teachers. At the beginning of the trial, teachers informed parents about the helmet bank as they collected their children from school. Children informed their parents when they borrowed helmets from the helmet bank. Helmet observations assessed helmet use during and after the trial.

After implementation, AIP Foundation conducted two focus group discussions with students who borrowed helmets and one with teachers at the trial school about their perception of the helmet bank and insights on helmet use.

2.2 Key Findings

During the trial, a high proportion of students borrowed helmets at the bank. Daily borrowing rates ranged from 59% (with 117 out of 200 helmets borrowed) to 64% (128 helmets borrowed). On average, 60% of target students borrowed helmets during the trial.

Helmet use among students traveling on motorcycles at Ban Nong Bon Primary School increased from 8.8% prior to the trial, to 18.6% after the trial (see Figure 1). While a significant number of children borrowed helmets from the helmet bank, very few were wearing the borrowed helmets. The findings showed that child helmet use at the trial school more than doubled in only three weeks, but this increase did not parallel the rate of participation at the helmet bank. If all the children who borrowed helmets wore them, the rate of helmet use would be around 60%. The actual change in helmet use (of 9.8 percentage points) is equivalent to only 16 additional children wearing helmets.

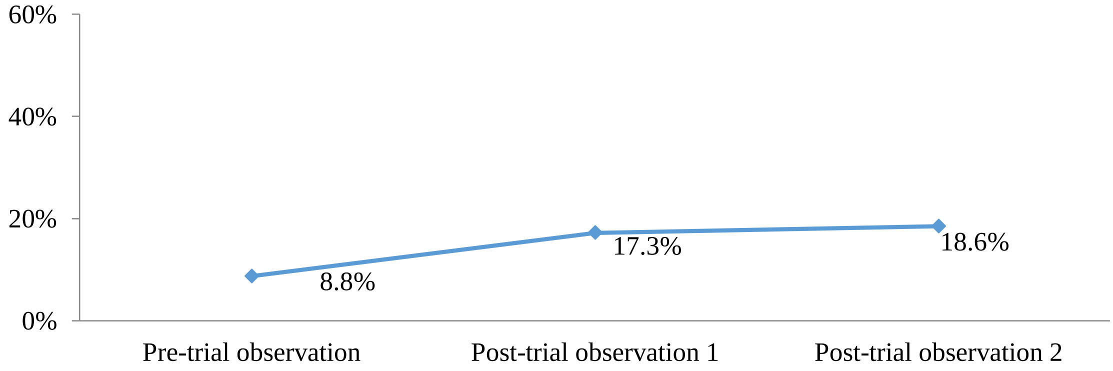

Figure 1. Helmet use before and after the "helmet bank" trial at Ban Nong Bon School

A focus group discussion among students borrowing helmets revealed that students did not have their own child-sized helmets. Before the trial, some students wore their parents' helmets, but they expressed that they did not like wearing the adult helmets due to the size and weight. The students said that they borrowed helmets to protect them from road injury. However, the students reported borrowing helmets but not wearing them, because:

- Borrowed helmets were kept at home, and the students forgot to bring helmets to school
- Parents were afraid of helmet theft and having to pay for replacement helmets
- Some of the borrowed helmets were too small, and some had uncomfortable chin straps
- Students were uncomfortable wearing helmets in hot weather
- Helmets affected students', especially girls', hair styles

Many students responded that certain styles, based on helmet size, color selection, appealing designs, and windshields, would motivate them to wear helmets.

Teachers were very enthusiastic about continuing the helmet bank initiative beyond the trial period and suggested a cluster model expansion, in which a group of schools would each implement helmet banks, under the guidance of one lead school. Teachers emphasized the value of educational activities to inform children about the importance of correct helmet use. They suggested that further activities on road safety could be adapted and delivered by teachers in the classroom and that the involvement of police in delivering these activities would further engage the children.

2.3 Discussion

The helmet bank trial increased helmet use at the trial school and received enthusiastic support among teachers. That the helmets borrowed from the bank were free of charge created a perception of high value within the school, but due to concerns of hygiene, parents were also interested in purchasing helmets. The helmet bank's capacity to draw attention to the importance of helmet wearing is a valuable lesson. The school environment is an ideal setting to communicate messages to students, parents, and the wider community about child helmet wearing. The helmet bank, perhaps incorporating an element of helmet retail to meet demand from parents, can act as the focal point of these communications.

The greatest potential cost of implementing helmet banks at scale would be the acquisition and maintenance of the helmets. This trial was implemented at "no cost" to the school. To implement helmet banks at scale, there would need to be careful consideration of resourcing. If resources were more limited, requiring additional commitment from schools, this may impact schools' support and in turn reduce the effectiveness of the helmet bank itself.

Despite its benefits, the trial faced several barriers that prevented children from wearing helmets.

These barriers indicate the need to invest more on behavior change if the trial is expanded. The trial could be improved upon by addressing the identified barriers, integrating comprehensive educational activities, and encouraging teachers to enforce child helmet use.

3. TRIAL 2: POLICE ENFORCEMENT

Although Thai law requires all motorcyclists to wear helmets, this mandate is not widely or consistently enforced by the police and, as a result, helmet use is low nationwide. Experience from road safety interventions around the world has shown that increased enforcement leads to an increase in helmet wearing. (Pervin, 2009; World Health Organization, 2009) This trial investigated the impact of increased police enforcement and its barriers.

3.1 Methodology

Sai Mai Police Station is located close to Thai Rath Wittaya 75 School in Sai Mai, Bangkok, which was selected for the trial based on proximity to the police station, high rates of students traveling by motorcycle, and low helmet use. Officers from the station were asked to patrol the school's entrance as children arrived and departed from the school for the duration of the trial.

While patrolling, police officers were told to enforce the helmet wearing law.

Before the trial began on November 25, 2014, AIP Foundation conducted observations to assess baseline helmet use. For the first week, traffic police verbally warned parents whose children were traveling without helmets. In the second week of the trial, traffic police issued fines to parents whose children were traveling without helmets. In the third week, traffic police gave away rewards for children wearing helmets. The trial finished on December 14, 2013. On January 9, 2014, AIP Foundation conducted post-implementation helmet observations and focus group discussions with participating police, students, and teachers.

3.2 Key Findings

In the first week of the trial, only warnings, no fines, were issued. In the second week, a total of 16 fines were issued to parents who carried children without helmets.

Motorcycle helmet wearing rates among students at Thai Rath Witthaya 75 School increased from 7% before the trial to 14.4% afterward (see Figure 2).

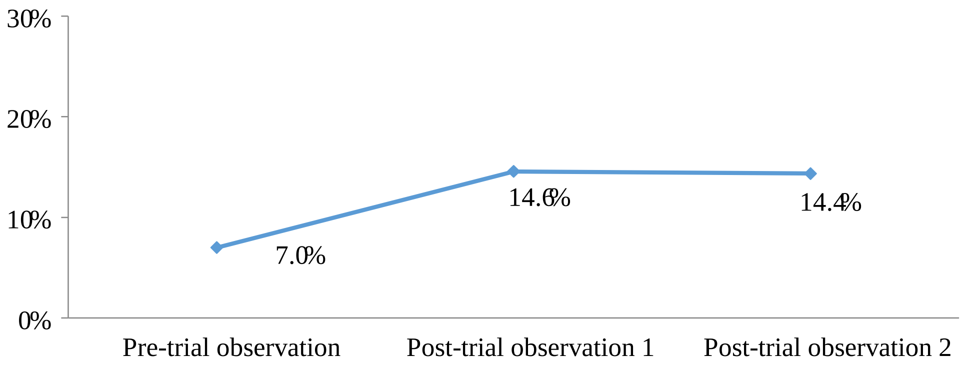

Figure 2. Child helmet wearing rates before, during, and after police enforcement trial at Thai Rath Witthaya 75 School

Students reported that their encounters with police patrols usually ended with warnings instead of fines and a few reported that their parents gave them adult helmets on the following days. Other students reported that they saw police officers infrequently, indicating that the police presence was inadequate as a visual deterrent. Students reported awareness of the importance of wearing helmets to protect themselves from injury in road crashes, and they said they felt good seeing police in front of the school.

Teachers reported that police enforcement is not a significant motivating factor for children to wear helmets and that police enforcement would instead impact the behavior of motorcycle taxi drivers, whose income would be directly affected by child passengers without helmets.

Despite the support of the head of traffic police at the Sai Mai Police Station, securing sufficient resources for the trial was challenging. Originally, police were asked to establish a checkpoint at the entrance of the school with many police officers to issue warnings and fines. A prominent checkpoint was hoped to be a visual deterrent to discourage children from riding motorcycles without helmets. At the time of the trial, there were significant demands on the Royal Thai Police throughout Bangkok. Ultimately, only one officer from the station was released to participate in the trial, so a prominent checkpoint was not possible.

In focus group discussions, traffic police explained their discomfort with enforcing the helmet law due to its potentially negative impact on their relationship with the local community. To fine children not wearing helmets seemed to them an inappropriate practice. The police officers also advised that, regardless of resources, it would not be possible to create a checkpoint outside a school as it would cause problems with traffic flow around the school.

Officers also mentioned a lack of resources for patrolling and enforcing the helmet law among children and suggested that efforts to increase enforcement should focus on negotiations with high levels of the Royal Thai Police. The police needed to protect its image due to demonstrations in Thailand during the trials. Any actions within the community had to be carefully managed. Successful advocacy with the leaders of the Royal Thai Police would hopefully provide the support for local police to increase enforcement of the helmet law.

When asked about the most effective way to increase child helmet use, the police officers felt that education or reminders, not increased enforcement, was the best option. They expressed that enforcement should be the final measure taken after education and awareness raising. If additional support was provided by the Royal Thai Police, the officers suggested that police could engage with and inform the community of the need to wear helmets.

3.3 Discussion

In this trial, the increase in children’s helmet wearing was limited, possibly due to the police officers’ unwillingness to issue fines for those who did not wear helmets. Insufficient police resources available for the trial were also a barrier to improved enforcement.

Future initiatives need to account for police sensitivities about community reaction and include components that allow police to address community concerns. The trial could be improved through continued high-level negotiations to increase police enforcement of the helmet law and supplemental activities to allowing local police officers to provide education about the importance of child helmet use, the helmet law, and law enforcement activities to combat negative reactions in the community.

4. TRIAL 3: PETROL STATION RETAIL

In Thailand, the primary distribution channels for adult and child helmets are motorcycle and related accessory shops. Supermarkets are a comparatively minor retail channel. Prior research with manufacturers indicated that helmets had never been sold in petrol stations. (Rubinyi, 2013) This trial investigated if petrol stations could be viable helmet retail channels.

4.1 Methodology

Two temporary retail kiosks were set-up to sell children's helmets to customers of two petrol stations, selected in high traffic locations. One retail kiosk sold discounted children's helmets from November 29 - December 29, 2013, while the second kiosk sold helmets at market price January 6 - 19, 2014. The kiosks were located outside the petrol stations' offices with shelves to display the children's helmets and vinyl banners displaying customized advertisements.

Two retail assistants were recruited to staff the kiosks. The retail assistants were trained to assist customers with queries, process transactions, and conduct interviews with customers about reasons for buying or not buying a helmet.

4.2 Key Findings

During the trial, helmet sales were very low. An average of four helmets per day (55 total over the trial period) were sold at the discounted trial kiosk. Only two were sold at the market price kiosk over a period of 13 days. The reasons for low sales were investigated through customer interviews and observation.

In interviews with 40 customers at the discount kiosk and with 17 customers at the market price kiosk, cost and design were the most-cited reasons parents did not purchase helmets. Safety and the helmet law were the main reasons cited by parents who did purchase helmets. Although many more discounted helmets were sold than market price helmets, none of the customers who purchased helmets cited cost as their primary motivation for purchasing.

Increasing accessibility was insufficient to motivate customers to purchase. Customers whose children did not wear helmets cited the difficulty of finding child helmets as a reason for their children's behavior, but of those customers, only 20% proceeded to purchase helmets.

Although 73.7% of customers agreed that petrol stations would be convenient locations for helmet retail, most customers had limited time at the petrol station, and additional time would be required to ensure the helmets correctly fit their children. Adults often ride to the petrol station without their children, thus creating an additional barrier to purchasing helmets.

Furthermore, to establish helmet retail at a petrol station requires substantial investment of time and money to create a space to display and store helmets in a range of sizes and designs, in what is often a small retail environment.

4.3 Discussion

This trial has shown that accessibility and affordability were not sufficient to trigger high demand for child helmets. The petrol station environment presents a number of challenges for helmet retail in terms of customers' time and inventory management. The combination of these factors leads to the conclusion that child helmet retail at petrol stations is not viable.

Based on the small number of helmets sold at the trial petrol stations, we do not recommend further pursuit of petrol stations as a child helmet retail channel.

5. TRIAL 4: TAXI STANDS

Motorcycle taxis are a popular means of transport in Thailand, and many children take motorcycle taxis to and from school. This trial investigated whether child helmet use would increase if motorcycle taxi drivers offer helmets to child passengers.

5.1 Methodology

The trial was implemented from January 2 - 17, 2014. Two taxi stands located close to the Royal Thai Navy residential community and one taxi stand located close to Sanpawut Wittaya School in the Bang Na sub-district of Bangkok were selected for the trial. While the head of a motorcycle taxi drivers' association supported the trial, drivers at the proposed taxi stands were not eager. A number of stands were consulted before the three trial stands were finalized. Two of the three selected stands were located at a Royal Thai Navy residential complex. Consequently, the Royal Thai Navy oversaw the operation of the stands.

The motorcycle taxi drivers were asked to offer helmets to child passengers, but they could still take a child passenger if they did not accept the helmet. If a child passenger refused the helmet, the motorcycle taxi driver would ask the child for his/her reason before commencing the trip. Child helmets, helmet storage, and helmet disinfectant spray were provided to the taxi stands for use during the trial.

Child helmet use was monitored at the two locations before the trial, one week after the trial began, and at the end of week three of implementation to observe any changes.

5.2 Key Findings

During the 16-day trial, taxi drivers offered helmets to 308 child passengers. Of those, 235 (76%) accepted the helmet (See Table 2). The number of drivers offering helmets to child passengers fluctuated throughout the trial and ultimately reduced over the period of the trial.
The finding of helmet observations in two locations (one near the community and one at the school) showed that rates significantly increased before and after the trial, from 0% prior to the trial, to more than 24% (See Figure 3).

The child passengers who did not accept helmets cited the short distance of the journey as the main reason for not wearing helmets. Others cited their dislike of helmets, size, and hygiene.

Table 2. Child passengers who accepted helmets offered by taxi drivers

Number of days in the trial	16
Number of child passengers carried by taxi drivers	308
Number of students who accepted helmets offered by taxi drivers	235
Students who accepted helmets as percentage of all carried	76%

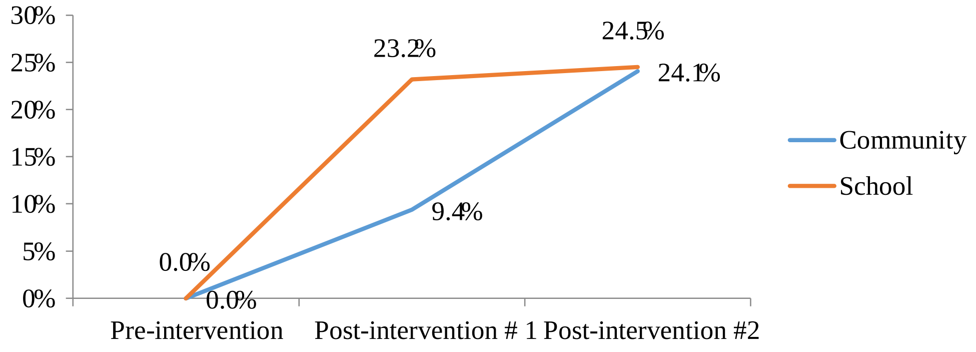

Figure 3. Child helmet wearing rates before, during and after the taxi stand trial

Although the Royal Thai Navy greatly facilitated the participation of two taxi stands, maintaining motorcycle taxi drivers' participation was challenging. Each taxi stand operated in isolation, moreover, the motorcycle taxi drivers at each taxi stand also acted with a degree of autonomy. Initiatives focusing on motorcycle taxi drivers will need to motivate and educate them about the importance of child helmet use, in order to secure their commitment.

5.3 Discussion

The trial showed that motorcycle taxi drivers can have an impact on children's helmet wearing behavior. While there could be positive ripple effects influencing other children to wear helmets, the impact of initiatives focusing on motorcycle taxi drivers alone may be limited in audience. Motorcycle taxi drivers can persuade their child passengers to wear helmets, but this may not directly impact children who ride motorcycles with their parents or other relatives. This model would be best implemented in combination with other educational and advocacy initiatives to reach children who ride non-taxi motorcycles.

The trial would be improved on with continued negotiations with motorcycle taxi associations to engage taxi stands and increased educational communications to promote the importance of child helmet wearing among drivers.

6. LIMITATIONS

The trials were conducted at a small scale, and the sites were chosen to fit the requirements of the project. Many factors impacted the results of the trials. Political protests in Bangkok affected implementation, particularly of Trial 2, which relies on the willingness of the police to enforce the law. The police officers were concerned that enforcement could increase tensions with the public during the protests. In addition, the replicability of the taxi stand trial depends on the cooperation offered by other autonomous taxi stands. It was not possible to exclude external factors to determine causality.

7. CONCLUSION

The helmet bank, police enforcement, and taxi stand trials resulted in increased child helmet wearing rates, but each trial had instructive challenges and strengths. The number of challenges presented by the petrol station retail trial in terms of customers' time and demand, as well as inventory management, led to the conclusion that child helmet retail at petrol stations is not viable.

The findings of all four trials indicate that child helmet use could be increased through a combination of the following interventions:

1. High-level negotiations to increase police enforcement of the helmet law. Without high-level support, it is challenging for individual police stations and/or police officers to find the resources to enforce the helmet law.
2. Communications to convert helmet access into helmet wearing. Both the petrol station retail and the helmet loan bank results help demonstrate that access to helmets should not be the primary area of concern – in contrast, behavior change must be prioritized. Education, enforcement, and peer influence may motivate children to wear helmets, and encourage parents to acquire helmets.
3. Leveraging teachers as champions of helmet wearing. Teachers have significant influence on children's behavior and parents' attitudes. The helmet bank trial showed that teachers have the capacity to draw children's and parents' attention to helmet wearing.
4. Investigation of schools and taxi stands as channels for accessing helmets**.** The trials suggest that accessibility and cost of children's helmets are not the primary obstacles to child helmet use. However, while helmet retail at petrol stations was proven to be unviable, schools and taxi stands can be effective channels for helmet loans and retail.

5. Educational activities conducted by local police officers. Police are eager to inform the community about the helmet law and enforcement and raise awareness that police enforcement of the helmet law saves lives.
6. Customized child helmets in visually desirable designs. Based on students' feedback during the helmet bank trial, the range of helmet design choices should include new and trendy designs, popular cartoon characters, and various color options.

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A COMPARISON OF TRIPS TO SCHOOLS IN SUBURBAN BANGKOK

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ABSTRACT:

In the morning peak hours, about 90% of the parents of students of School B used private cars to transport their children to school. This behavior can contribute to creating or increasing the severity of traffic jams during the morning rush hours. In contrast, only 3.78% take a school bus. We will look at another school to see if the findings are similar or different from those of School A. The objectives of this paper are to study and compare school bus management, and compare the key factors of School A and School B that influence parents' behaviors who allow their children to use their school buses. The methods used are an analysis of the factors that affect school bus management e.g., school bus cost, driver, assistance, and school bus operation. The results indicates that about 75.76% of the parents of students of School A send their children by private car. This is similar to School B and is the favorite mode of transportation for parents of School A students. However, it is found that the percentage of parents who decide to use a bus from School A (15.50%) is higher than the percentage of parents who use a bus from School B (3.78%). Furthermore, it is noticed that the school bus management of School A is more efficient than School B's in terms of assistance of School A buses by school staff who work at school, and their daily check of the number of children being transported. The school bus service of School A serves 2 trips; the first trip transports a group of pre-kindergarten and kindergarten students, and the second trip carries students of the primary school. However, the bus of School B serves one trip only. In addition, the school bus fare of School A is calculated based on distance, while the fare system of School B is dissimilar.

KEYWORDS: School bus, Private car, Children, School bus management

1. INTRODUCTION

In Bangkok, the private car is favored more than other transportation modes; it is the most favorite method to send or pick up students from home to school and vice versa (Dissanayake & Morikawa, 2010). However, private cars are the main reason for traffic congestion around schools such as blockage of streets and areas around schools (La Vigne, 2007).

Parents who have high incomes choose private schools or selected schools for their children to attend, and they tend to drive their children by themselves in the morning and park their cars to wait for those students to finish class and get them home in the evening. That is the reason of traffic congestion around schools (Khan et al., 2011). And, School B has the same problems of traffic congestion like other private schools. About 90.22% of the parents of School B decide to send their children to school by private car and only 3.78% choose the school bus (Srisurapanon et al., 2014).

From the School B data, it shows that parents' decision to use a school bus is very low. However, if we change the location of schools, do we observe the same characteristics of parent behavior? If the results are similar to School B, then suburban schools display similar characteristics. If the results are not similar, it shows that suburban schools do not exhibit similar characteristics, and the characteristics of parents are influenced by other factors. That is the interesting reason why we should study this phenomenon.

The objectives of this study are to conduct a comparison of two schools and find the reasons. If we change our focus from School B to another school which is in the same location or same district, and the type of school is private school or selected school similar to School B, is the percentage of parents who decide to drive to school similar to School B or not? Table 1 shows that the tuition fees of School A and School B at kindergarten levels, primary school grades 1-3, and primary school grades 4-6 are similar.

Table 1. School A and School B Tuition Fees

Level	School A Tuition fee (Baht)	School B Tuition fee (Baht)
Pre-kindergarten	27,000	-
Kindergarten	30,000	26,500
Primary school grades 1-3	34,000	36,500
Primary school grades 4-6	36,000	36,500
Junior high school	-	41,500
Senior high school	-	41,500

2. BACKGROUND OF SCHOOLS

This part will discuss the issues about school bus use in Thailand, followed by two suburban school case studies, and finally a comparison of locations and facilities around the schools.

2.1 Literature review

Thailand has a number of problems surrounding school bus use such as expensive school charges or fares, parents' level of awareness or consciousness about risks of school bus travel, and the discomfort of students waiting for a school bus at home or school (Department of Land Transport, non-specified year).

In Thailand, school buses can be divided into two groups based on their vehicle type such as minibus and van. The favorite type of school bus in Bangkok is a van because it is easier to negotiate in traffic congestions than a minibus, and the size of a van is smaller than a minibus. In Bangkok, parents who decide to use school buses are typically those who have occupations such as employees of businesses or business owners themselves, have a high level of education, have more than one child in a particular school, and have high incomes. The reasons that influence more parents to switch to school bus use are school bus fare and the development of school bus condition (Limmonthol et al., 2011).

Furthermore, additional interesting issues to analyze in this study consist of the following:

- Issues for comparison
  - School location, number of students/teacher
  - Methods of traveling to school
  - Mode selection to school
  - School bus provided
  - Factors influencing the decision of parents
- Composition of school bus systems
- School bus management
- Degree of importance of the management

2.2 Methodology

For this study, two different schools were selected which were analyzed by sending questionnaires to parents, conducting interviews, and observing physical facilities around the schools.

2.2.1 Observation by sending questionnaires to parents

The questionnaires query the following information:

- Mode
- Trip length
- Trip cost
- Arrival time
- Perception or attitude of traffic

2.2.2 Interview

The details of the interviews are as follows:

- General issues e.g., starting time, types of school buses, number of school buses
- Tuition fees/entrance fees
- Bus fare system
- Management of school bus

2.2.3 Observation of physical facilities around schools

The physical facilities observed around schools are the following:

- Sidewalks, public transportation, parking
- School bus operation
- Use of facilities in school bus e.g., safety belts

2.3 School A

This section discusses school location, sidewalks around schools, types of public transport, and school parking.

2.3.1 School location

School A is an alternative school and is located in suburban Bangkhuntian District on Rama II Road, which is the “Thonburi - Pakthor” Highway No. 35 that connects Suksawat Road to Phet Kasem Road. It has about 590 students and is divided into three subsections – Prekindergarten, Kindergarten Level 1 – Level 3, and Primary Level 1 – Level 6.

- Kindergarten students attend class in the morning before 0900.
- Primary students attend class starting at 0810.
- All levels of School A have about 20 students per class room.

School A has one type of school bus which picks up pupils from home to school. The direction of School A buses consist of 5 routes; the first route is Phetkasem, the second route is Tha Kham, the third route is Pracha Uthit, the fourth route is Phutthabucha, and the fifth route is Tha Phra.

Figure 1. School A

2.3.2 Sidewalks around schools

Sidewalks are pedestrian lanes that are paths along a roadway. The recommended width of a sidewalk is about five to six feet so two students can walk side by side (SRTS, 2014). The sidewalks of School A are wide and convenient with low numbers of street vendors along the roadway so students can walk or bike to school with ease, as shown in Figure 2.

Figure 2. Sidewalk of School A

2.3.3 Types of public transport

Public transport will take you almost anywhere you want to go, and taxis are generally easy to catch, with door-to-door service, however, you must pay more money for taxis than for public transport (Vuchic, 2007). School A has varied types of public transport, as shown in Table 2, and paratransit.

Table 2. Types of public transport at School A

NO.	TYPES	ROUTES
1	Bus (BMTA)	No. 17, 68, 76, 85, 105, 140, 141, 142, 147, 169, 172, 173, 529, 558, 720
2	Van	- Ramkhamhaeng University - Central Plaza Ladprao - MBK Center - Central Plaza Pinklao

2.3.4 School parking

School A has about 140 parking spaces, as shown in Figure 3. From the questionnaire data, it is found that 75.76% of parents drive private cars to school. School A is located near Rama 2 Road which is a main road with 3 lanes. An additional reason for increased private car use is that the school is not located in the same direction as the morning work traffic. So, School A does not have traffic congestion or points of conflict.

Figure 3. School A Parking

2.4 School B

This section mentions location, sidewalks around school, types of public transport, and school parking.

2.4.1 School location

School B is an alternative school and is located in suburban Bangkhuntian District. The school is sited in Soi Anamai Ngam Charoen 25 and the distance from the school to Rama II Road is about

2 km. It has about 1,192 students and is divided into three subsections — Kindergarten Level 1 - Level 3, Primary Level 1 - Level 6, Junior High School and Senior High School.

- Kindergarten students attend class in the morning before 0900.
- Primary school, junior high school and senior high school students attend class in the morning at 0750.
- All levels of School A have a student population of about 25 students per classroom.

School B has two types of school bus; the first type is a bus which transports pupils from home to school. The direction of the buses of School B consists of 4 routes — the first route is Sukhumvit, the second route is Bangbon, the third is Pracha-Uthit, and the fourth route is Phetkasem. School bus drivers serving each district must live in that district in order to pick up their pupils on time in the morning. In the evening, drivers pick up pupils from their school and take them to their homes. The second type, the shuttle bus, travels only one direction from the drop-off point at a Petronas fuel station where parents drop off their children only in the morning.

Figure 4. School B

2.4.2 Sidewalk around school

The sidewalk of School B is not wide (narrow path) because it is controlled by the roadway. So, students cannot bike on the sidewalk which means they need to share the road with vehicles and that is harmful for children. The sidewalk of School A is better than that of School B because it is about 3 meters wide, not obstructed by trees, street signage and other obstructions, e.g. traffic signs, post boxes, phone boxes, streetlamps, traffic lights, and bus stops, as shown in Figure 5. Moreover, the sidewalk is a safe path because of traffic separation from Rama II Road.

Figure 5. Sidewalk of School B

2.4.3 Types of public transport

School B is dissimilar to School A because School B doesn't have any public transport; only taxis or motorcycles support travel to and from the school.

2.4.4 School parking

School B has a total parking area limit of about 210 spaces, of which about 100 spaces are parking spots in the primary school section and about 110 spaces for parking in the high school section, as shown in Figure 6. However, parents from about 90% of 825 households, approximately 742 households, drive private cars to school. (Srisurapanon et al., 2014). Especially, it is the reason of traffic congestion in the morning in the School B area.

Figure 6. School B Parking

3. SCHOOL BUS MANAGEMENT

This section discusses school bus routes, school bus cost, and school bus operation.

3.1 School bus service time

In the morning, School A buses conduct delivery only one trip per direction. Whereas in the evening, the delivery is two trips per direction. The first trips are for groups of prekindergarten and kindergarten students who finish class at 2.50 p.m., and the second trips are for groups of primary school students who early than primary school at 03.50 p.m. The total number of students who take the school bus is approximately 89 students. The average per school bus is 18 students.

Figure 7. School Bus A

School B buses do deliveries only one trip per direction both in the morning and in the evening, and kindergartens finish class early and must wait for primary school students. These are some of the reasons why parents drive private cars to school. The total number of students who take the school bus is approximately 49 students. The average per school bus is 12 students.

The difference between School A buses and School B buses is that, in the evening, School A buses serve 2 trips and the first trips transport groups of pre-kindergarten and kindergarten students, and the second trips transport groups of primary school pupils. Whereas, School B buses serve one trip only. The similarity is in the morning trip — School A buses and School B buses both undertake only 1 trip.

Figure 8. School B buses

3.2 School bus fares

In this section on rates, the school bus fare of School A is based on distances — if students live near school, they pay less money than students who live a long distance from school. For the round trips, the rates start at 0-5 km. and parents pay 1,300 baht. If the distance is more than 5 km. parents pay 200 baht for approximately 1 km. The price range of School A buses is between 1,500–3,800 baht. School B bus fares are based on distances, but no rates of distance are specified, and start at approximately 2,500 baht. While rates increase from distances to school, how much parents should pay based on range of distances is unclear. The range of fares of School B buses is between 2,500–3,800 baht.

For the one way trips, the rates of School A buses start at 0-5 km. for which parents pay 800 baht. If the distance is more than 5 km., parents pay approximately 200 baht per additional km. The

rate range of School A buses is between 800–2,300 baht. While School B has no rates of distance and the fares are not clear, it appears to start up at approximately 1,500 baht. The rates increase based on distances to school.
This study found that, for School A, the school officials are responsible for maintaining the fare accounting system, so parents must pay money at the school or transfer money to the account of School A.

Whereas, for School B, parents must pay money by contacting a school official, or sometimes the parents contact the bus drivers themselves to give money on an unofficial basis. The monthly salary of school bus drivers of School A is approximately 20,000 baht per month. However, for any excess money that students pay per route that amounts to more than 20,000 baht per month, drivers have an monthly bonus incentive in the following proportion — approximately 80 percent goes to the drivers and School A’s proportion is approximately 20 percent. Whereas, School B bus drivers have a fixed salary rate of approximately 20,000 baht per month with no incentive bonus proportion.

3.3 School bus accessory

The accessories of both School A and School B buses include seat belts and air conditioning. The specification of the student/seat ratio in a school bus is 1 seat per student. The capacity of a school bus is 14 seats - 12 seats for students, 1 seat for the driver, and 1 seat for an assistant.

3.4 School bus operation

School A bus operation refers to school bus factors e.g., the driver is an outsider or a private contractor and is not a member of the school staff. The assistant is a member of the school staff and reports to the vehicle division every day the number of students who use the school bus, as shown in Figure 9.

School B bus operation refers to school bus factors e.g., the driver is an outsider or a private contractor and is not a member of the school staff. The assistant is an outsider, not working at the school. Sometimes, the assistant is absent, so the drivers must take care of additional children themselves, as shown in Figure 10.

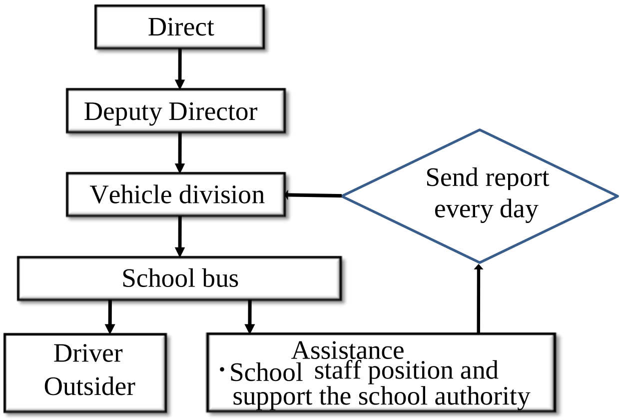

Figure 9. School A Bus Operations

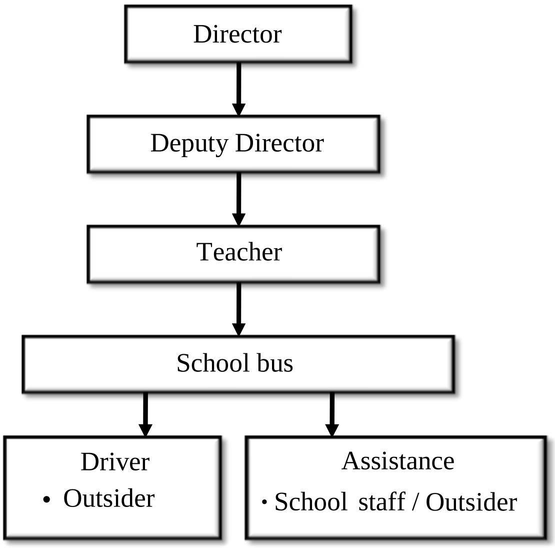

Figure 10. School B Bus Operations

4. CHARACTERISTICS OF PARENTS

The topics of parents’ characteristics are data collection, travel behavior, and questions about traffic.

4.1 Data collection

In this case study, data was collected through 583 questionnaire surveys which were distributed to several parents at School A with a return rate of 460 responses, which is a response rate of 78.90 School B involved the dissemination of 825 questionnaires surveys with 450 responses received, which is a response rate of 54.54%, as shown in Table 3.

4.2 Travel behavior

From the data, it is found that approximately 75.76% of the School A respondents drive private cars to school in the morning, while 15.50% transport their children on a school bus, as shown in Figure 11. For School B, approximately 90.22% of the respondents drive private cars to school in the morning, while 3.78% have their children take a school bus, as shown in Figure 12.

Table 3. School Bus Questionnaires

Level	School A Questionnaires		School B Questionnaires	
	Sent	Received	Sent	Received
Kindergarten	494	389	279	195
Primary school	89	71	320	219
Secondary school	-	-	226	36
TOTAL	583	460	825	450

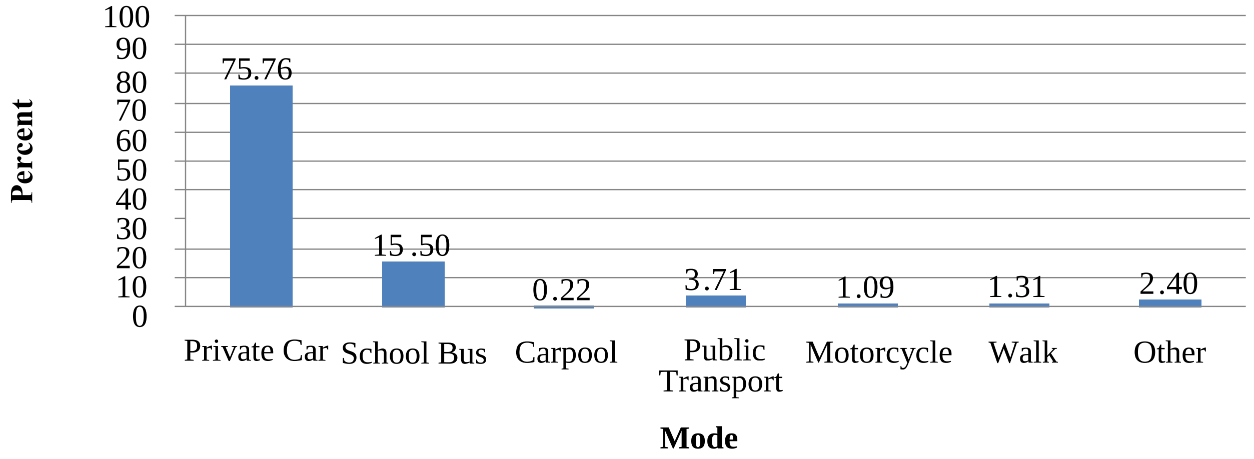

Figure 11. Mode of School A

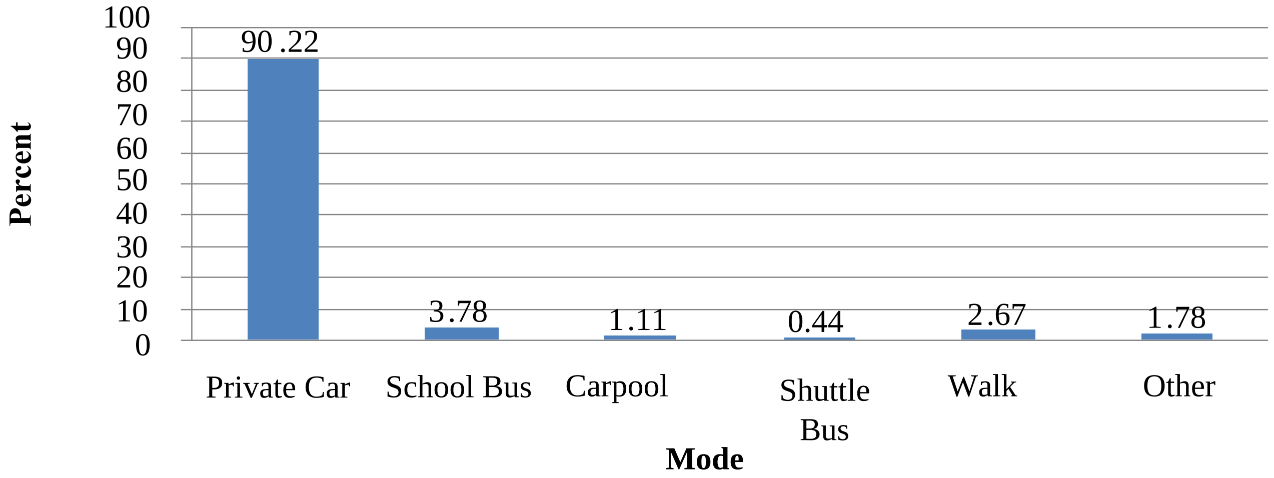

Figure 12. Mode of School B

The arrival times to School A are spread out, ranging from 10 minutes to 60 minutes. Of the respondents, 46.32% stated that their children arrive at school between 7:31 a.m. and 8:00 a.m., and 26.84% arrive between 8:01 a.m. and 8:30 a.m. Some students, mostly at kindergarten level, arrive between 8:00 a.m. to 9.00 a.m., as shown in Figure 13. The arrival times to School B are also spread out, ranging from 10 minutes to 60 minutes. Of the respondents, 46.20% of the students arrive at school between 7:31 a.m. and 8:00 a.m., and 31.90% arrive between 7:01 a.m. and 7:30 a.m. Some students, mostly at kindergarten level, arrive between 8:00 a.m. to 9.00 a.m., as shown in Figure 14.

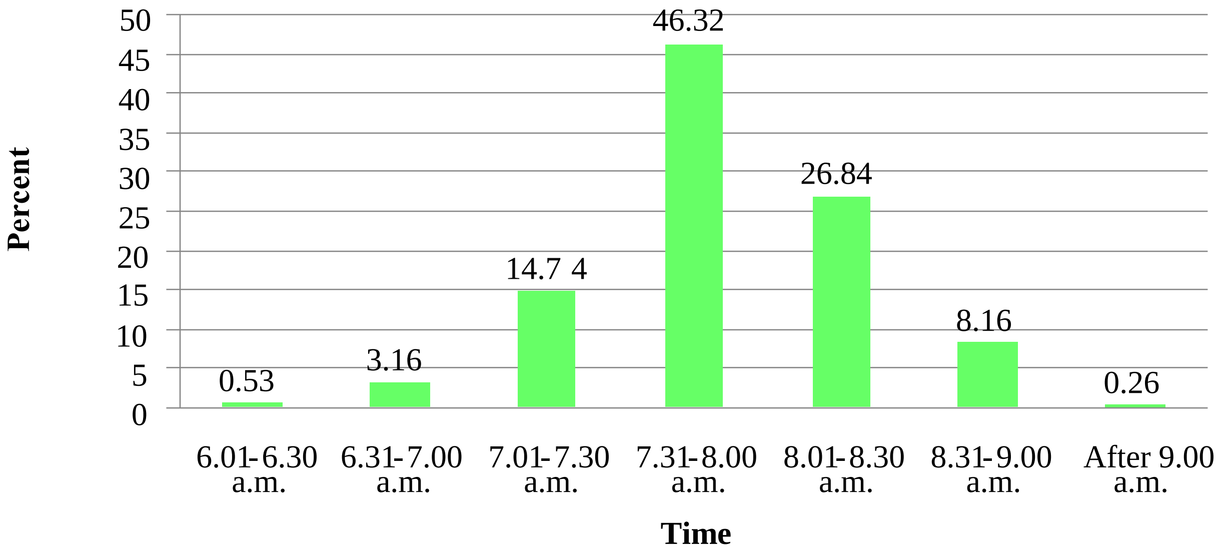

Figure 13. Morning Arrival Time of School A

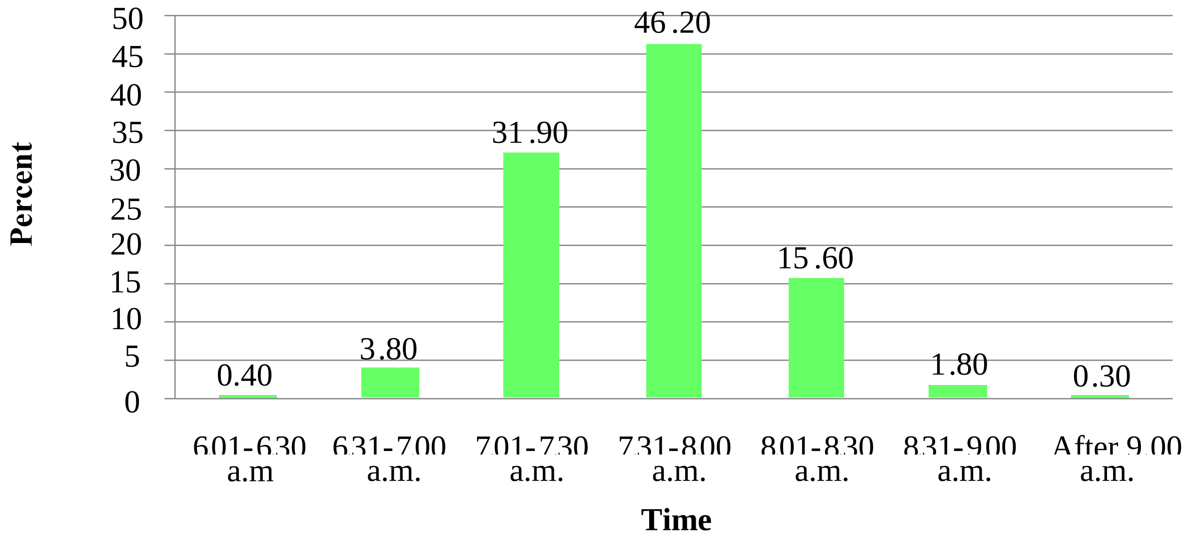

Figure 14. Morning Arrival Time of School B

From the data, regarding the relationship between the modes and numbers of students going to School A, it is found that most parents, approximately 48% of respondents, have 1 student who goes to school by private car, and approximately 28% of responding parents have 2 students who go to school by private car. Furthermore, approximately 11% of respondents have 1 student who takes the school bus to school, and approximately 3% of responding parents have 2 students who take the school bus to school, as shown in Figure 15.

School B data shows the relationship between modes and numbers of students who go to school. It is found that most parents who have 1 student, approximately 50% of respondents, take their child to school by private car, whereas parents who have 2 students, approximately 35% of respondents, transport their children to school by private car. Parents who have 1 student and send their child to school using a school bus are approximately 2% of respondents, whereas parents with 2 students who take the school bus to school are approximately 2% of respondents, as shown in Figure 16.

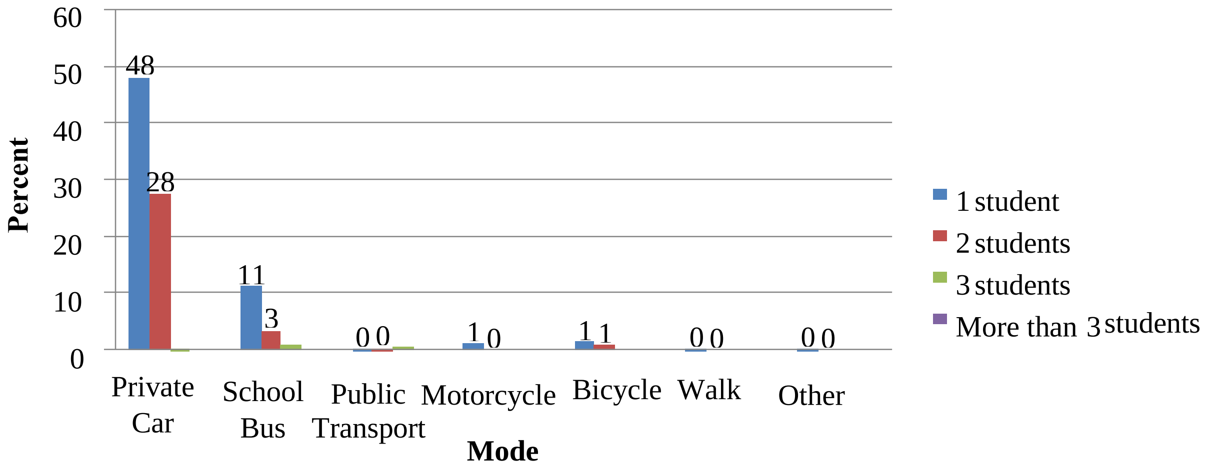

Figure 15. Relationship between Modes and Number of Students at School A

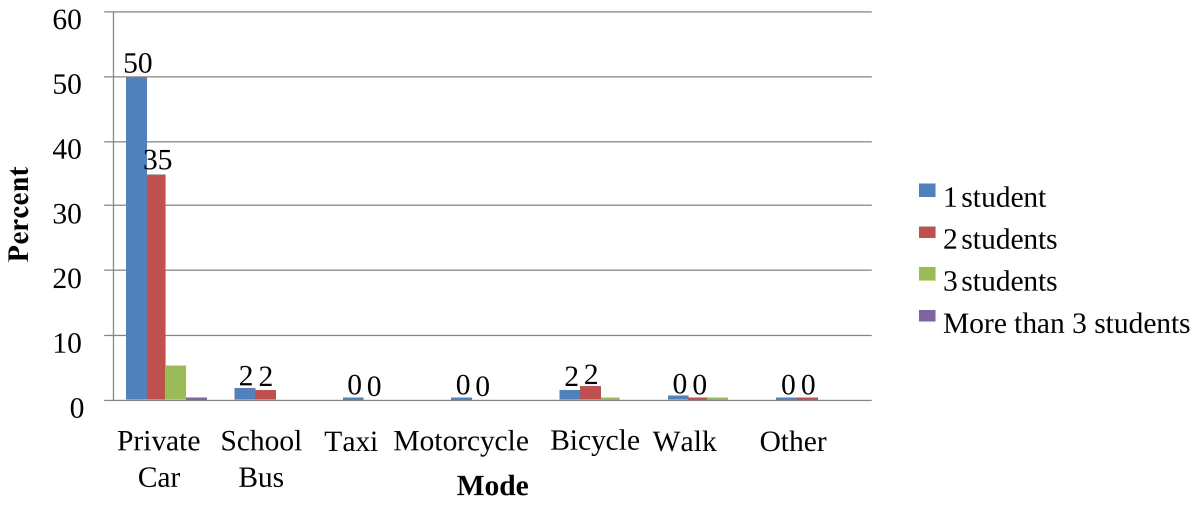

Figure 16. Relationship between Modes and Number of Students at School B

From the analysis of School A, it is observed that 43% of respondents return home after dropping off their children to school, and 42% continue on to work, as shown in Figure 17. From the analysis of School B, it is observed that 63% continue on to work, and 27% of respondents come back home, as shown in Figure 18.

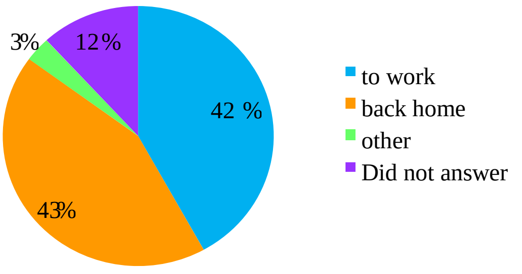

Figure 17. Activity after Transporting Children to School A

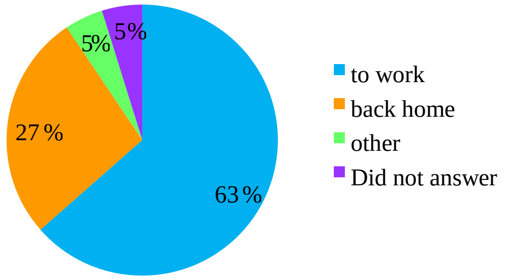

Figure 18. Activity after Transporting Children to School B

From the School A data in Table 4, it is observed that 41% of respondents choose driving to school due to the reasons relating to school bus issues. This is close to half of the total number of reasons and shows that the probability of their children using the school bus if the changing school bus system. While the School B data in Table 5 shows that 37% of respondents do so because of the reasons relating to school bus factors.

The first reason, a proportion of about 30%, why parents drive their children to School A is to be able to stay close to their children. Whereas, for School B, the first reason, a proportion of about 43%, why parents drive their children to school is due to the school being on the way to work or because the parents want to do other activities. Since a significant portion, about 43%, of the parents of School A children come back home without the restriction of outside work or obligations, it shows that several parents of School A students can spend more time to stay close to their children. However, most parents of School B students, about 63%, continue on to work places. This shows that several parents of School B students continue on to their work after taking their children to school.

The second reason, a proportion of about 22%, why parents drive their children to School A is the close proximity of their homes to the school, whereas for School B parents living close to the school, only 3% of the parents indicate the same reason. In terms of time spent driving to school, most parents of School A students take about 21-30 minutes, approximately 33.76%, and those driving for 1120 minutes are approximately 29.64% of the total, as shown in Figure 19. For School B, several parents require about 21-30 minutes travel time, approximately 26.30%, while others, approximately 19.60% spend about 31-40 minutes, as shown in Figure 20. This indicates that several parents of School A students use less time to drive to school than do parents of School B students.

Table 4. Reasons why parents drive their children to School A

Reason	Respondent	%
Be able to stay close to their children	117	30
Living nearby school	83	22
Not in the service area of school bus*	58	15
School bus cost is expensive*	52	14
Not assured school bus service*	32	8
the way to work/do other activities	17	4
Late school bus*	16	4
Others	9	2
Total	384	100.00

* Reasons relating to school bus.

Table 5. Reasons why parents drive their children to School B

Reason	Respondent	%
the way to work/do other activities	130	43
Not in the service area of school bus*	51	17
Be able to stay close to their children	37	12
Inappropriate pick-up/drop-off station*	37	12
Not assured school bus service*	19	6
Living nearby school	10	3
A parent works at school	5	2
Late school bus*	5	2
Others	10	3
Total	308	100

* Reasons relating to school bus.

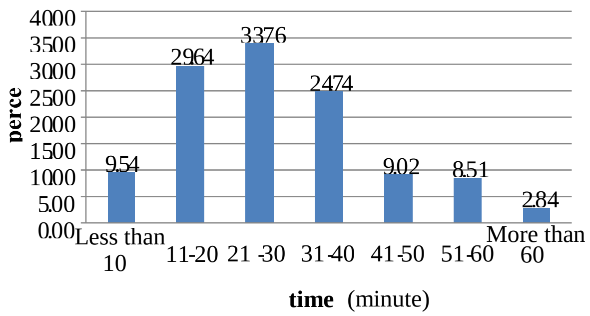

Figure 19. Travel Time from Home to School A

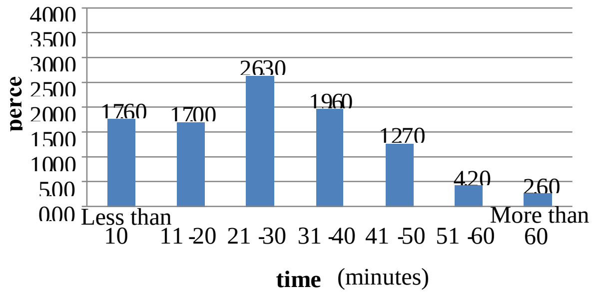

Figure 20. Travel Time from Home to School B

Most of the School A parents who travel to school must spend between 51-100 baht, while most of the School B parents who travel to school must spend money in the same range, as shown in Figures 23 and 24.

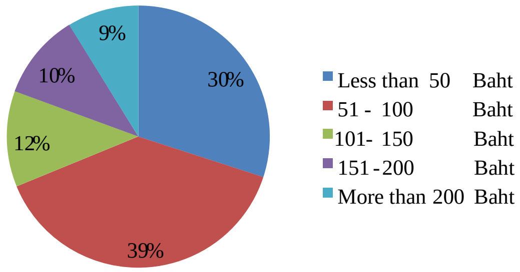

Figure 23. Travel Cost to School A

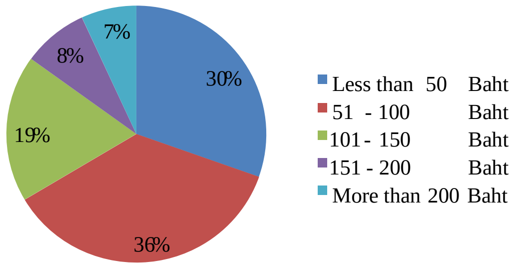

Figure 24. Travel Cost to School B

4.3 Traffic Data

From the questionnaire data inquiring about traffic being a problem in the morning related to sending students to School A, it is found that all respondents who go to school by private cars don't think traffic congestion is a problem, as shown in Figure 25. From the questionnaire data, related to morning traffic problem while transporting students to school B, it is found that 33% of respondents who go to school by private cars think traffic congestion is a problem between 7:31 a.m. and 8:00 a.m., and 10% of the respondents who go to school by private cars think traffic is problematic between 8:01 a.m. and 8:30 a.m., as shown in Figure 26.

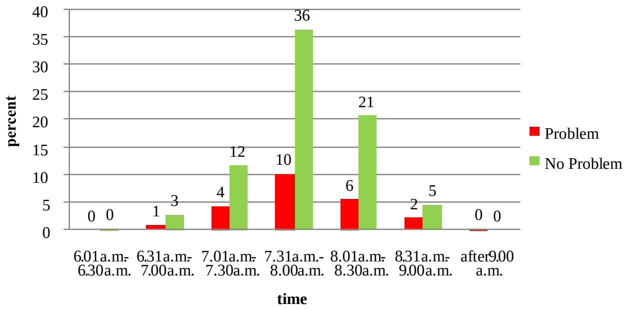

Figure 25. Traffic is a Problem in School A

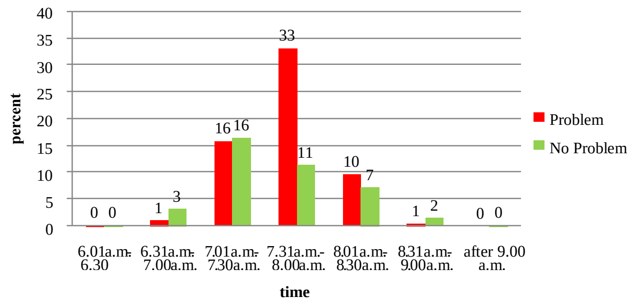

Figure 26. Traffic is a Problem in School B

From the analysis of School A data, it is observed that 42% of respondents believed school buses can reduce traffic congestion around school, as shown in Figure 27. From the analysis of School B data, it is observed that 33% believed shuttle buses can reduce traffic congestion around school, as shown in Figure 28.

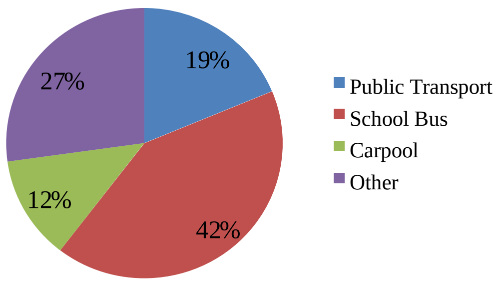

Figure 27. How to Reduce Traffic Congestion in School A

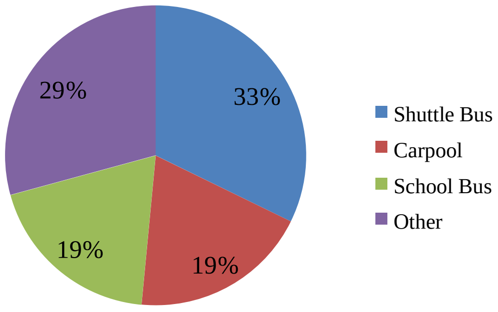

Figure 28. How to Reduce Traffic Congestion in School B

5. RESULTS

The results of this study of School A data found that 75.76% of households drive private cars to school, and the reasons why parents drive to school are, firstly, an inappropriate school bus system; secondly, a desire to stay closer to their children; and thirdly, living near the school, in the proportions of 41%, 30%, and 22%, respectively. Whereas, a study of the School B data found that 90% of households drive private cars to school, and the reasons why students are driven to school by their parents are, firstly, the convenience of ride-sharing with their parents as a household trip; secondly, an inappropriate school bus system; and, thirdly, the desire for parents to stay closer to their children, in the proportions of 43%, 37%, and 12%, respectively. It is notable hat several parents of both schools drive private cars.

As for school bus management, School A parents are interested in using the school bus, a proportion equal to 15.50% which is greater than the 3.78% of School B parents indicating the same interest. It shows that management of School A buses is more efficient than that of School B buses in terms of the following factors: rates of School B buses are based on real distances, and assistants of School A buses are school staff who work at the school and check the number of children every day. Additionally, there are incentives per month paid to drivers which makes it an attractive proposition to drive well. Finally, parents must pay money directly to School A or transfer money to a School A bank account.

The School A bus fares of round trips are calculated based on distances, and the rates start at 1,300 baht related to distances about 0-5 km. And the payment range of School A buses is between 1,500–3,800 baht. While School B calculates fares based on distances, there are no rates of distance and the payment scheme is not clear, it should be start up approximately 2,500 Thai baht. The payment range of School B buses is between 2,500–3,800 baht, which shows that the method to calculate fares of School A is greater than School B.

In addition, the school bus fares of a one-way trip for School A is calculated based on distances, and the rates start at 800 baht for distances about 0-5 km. Additionally, the payment rate of School A buses is between 800–2,300 baht. While School B calculates fares based on distances, no rates of distance are stated and not clear, it should be start up approximately 1,500 Thai baht, This shows that the method to calculate fares of School A is greater than School B that similar the fares of round trips.

From the first reason indicated by parents who drive their children to school, it shows that the behavior of School A and School B parents are different. School A parents are able to stay close to their children for a proportion of about 30%, while the reason of School B parents is that the school is on the way to work/other activities, a proportion of about 43%. Another reason is that most parents of School A students come back home and several of those parents can spend more time staying close to their children, whereas most parents of School B pupils continue on to work or to perform other activities outside the home.

From the physical data, it is apparent that the locations of the two schools are dissimilar. School A is located in an arterial road, the location is not in the same direction as parents' workplaces, and it can support high traffic volume in peak hours. School B is sited on a local road, the location is conveniently in the same direction as the workplaces of some parents, and there are traffic jams in morning peak hours. Notice that the location of School A is better than that of School B. It is recommended to improve the sidewalks around the two schools, and this enhancement would support nonmotorized mode of travel, e.g., walking or biking to school.

From the traffic data, it is found that most parents of School A students think traffic congestion isn't a problem around their school, while most parents of School B think the traffic congestion is a problem. Regardless, 90% of them still drive to school which shows that a different perception exists about traffic congestion around these two schools despite School A and School B being located in the same district.

6. CONCLUSION

The results indicate that parents' decision to use school bus management for their children's transportation to school includes school bus service time, school bus fares, and school bus operation. Further work would be interesting and is recommended to construct the logit model for School A.

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AN EVALUATION OF FLYOVER-IMPROVED INTERSECTIONS: A CASE STUDY OF AIRPORT INTERSECTION

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ABSTRACT:

A flyover over an existing at-grade intersection is constructed to reduce traffic congestion. However, under the flyover which has been shown to help relieve traffic congestion at the intersection, the traffic signal control still uses the same control method as the "before" situation; that is the fixed time control plan. After the installation of the flyover, it was found that about 45% of traffic diverted to it, the time delay reduced by 34% over the same period. The economic evaluation results show that the net present value equals 361.64 million baht, benefit cost ratio, 1.34 and internal rate of return, 37.58 percent. The paper describes economic benefits of the flyover and presents the performance of the flyover improved intersection and points out the remaining problems under the flyover. Suggestions for improving performance of the existing traffic signal are made using results from SIDRA software.

Keywords: Flyover, Cost-benefit analysis, Delay, Traffic congestion

1. INTRODUCTION

The site in the case study is an existing at- grade signalized intersection where a flyover was built. The site is located at the intersection of intercity Highway no. 43 and provincial Highway no. 4135 which runs to the Hatyai international airport in Songkhla province, Thailand. This cost of the flyover is 249.5 million baht.

A flyover is a bridge constructed along an intersecting highway over an at-grade intersection. It allows two –direction traffic to flow at free flow speed on the bridge. The flyover is one of the methods for solving traffic problems at at-grade junctions on highways including capacity, congestion, long delay and queue length. Traffic signalization at the improved intersection still uses the same fixed time control plans, even after the installation of a flyover over the intersection.

Most of the flyovers in Thailand are constructed at the junctions on highway bypasses of big cities. There are 29 of these flyovers bridges constructed on one of the two intersecting highways over existing at-grade fixed-time control signalized intersections in Thailand (excluding Bangkok and its vicinity), it can support traffic volume of around 25,000 – 45,000 vehicles/day.

To assess the benefits of a flyover, a study case was chosen. It was an at-grade signalized intersection where two 4-lane highways intersect. The flyover was built along the intercity highway over the highway to the Hatyai airport (Figure 1). Economic evaluation of the flyover was conducted in terms of Net Present Value (NPV), Benefit–Cost Ratio (BCR) and Internal Rate of Return (IRR). To improve the overall performance of this intersection, a better traffic signal timing is needed; optimum cycle times and green times are obtained using the SIDRA software for input into the various fixed time plans.

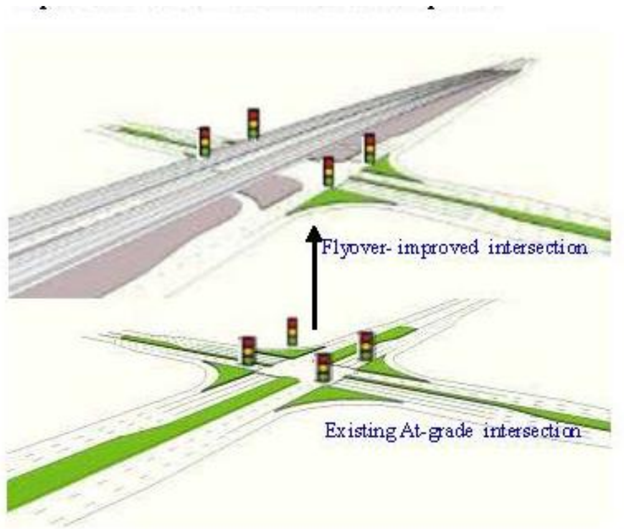

Figure 1. Layout of an at-grade intersection converted to a flyover-improved intersection

2. RESEARCH FRAMEWORK

The research addresses two issues: the efficiency and the road safety aspects of the flyover intersection. This paper focuses on the economic efficiency. The research framework consists of six steps (see Figure 2) covering three time periods (before, during and after construction), (see Table 1). The first is the literature review on road safety, cost-benefit analysis and SIDRA software etc,. Second step involves the selection of case study location. The third is data collection; intersection traffic movement count, time of vehicle delay, traffic signal timing, physical layout, accident statistics, and inspection of all hazardous zones. The fourth is the analysis/evaluation step; effect of the flyover on traffic flow, economic analysis, hazardous areas, cause of accidents and accident costs. The fifth is conclusions followed by the recommendations on how to improve the flyover model in terms of traffic flow, vehicles delays and other problems that still exist.

3. DATA COLLECTION

This intersection data were collected over the three time periods (before, during and after construction). Physical and traffic data, accident statistics and construction cost data were collected. Data were collected for the year 2009 to 2012. These data were used to analyze the benefits by comparing the before and after situations, the required data include traffic movements, vehicle delays, signal control plans, and flyover construction cost.

3.1 Traffic movement count

For the existing at-grade intersection; traffic movements were recorded for each of the legs/directions for all vehicles entering the intersection, at locations marked as 1, 2, 3 and 4 in Figure 4 (A), (Figure 3a).

For the flyover- improved situation; traffic movements were counted at the locations marked A, 1, B, C, 2 and D on the main road, and on the secondary road at the locations marked 3 and 4 (Figure 3b). Vehicles were categorized into five groups: 2-wheelers (MC), 3 and 4-wheelers (PC), 6-wheelers (MT), Bus (B) and Heavy truck (L), (Goyal et al., 2009). The traffic volumes were converted to equivalent passenger car unit (PCU) by the unit factor 0.33, 1.0, 1.75, 2.25 and 2.25 (Vesper, A. 2011), respectively.

The 12- hour traffic volumes before the flyover construction equal 60,351 PCU. On highway route 43; from the "East" traffic entering the intersection equals 24,359 PCU, and the "West" entering the intersection 11,842 PCU. On highway route 4135, traffic from the "South" entering the intersection equals 12,196 PCU and traffic from the "North" equals 11,954 PCU (Figure 4 (a)).

After the completion of the flyover, the 12- hour traffic volumes equals 64,219 PCU, a significant increase from the before situation. The traffic on highway route 43, at the ground level, from the "East" entering the intersection equals 9,777 PCU, from the “West” equals 2,546 PCU. On highway route 4135; the corresponding volumes from the "South" and the "North" are 14,298 PCU 13,294 PCU respectively. On the flyover, the traffic from "East" to "West" and vice versa was 13,426 PCU, and 15,958 PCU respectively (Figure 4 (b)).

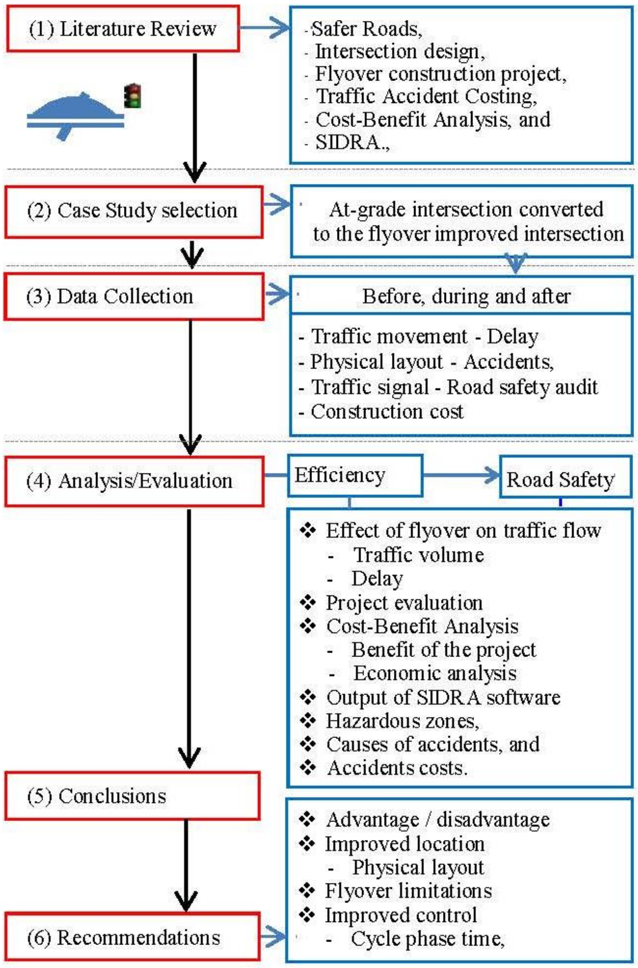

Figure 2. Research framework

3.2 Delay (DL)

This data depend on the cycle phase time of each event, the total delay at the at-grade intersection is 535.27 minutes (32,116 seconds) (Figure 5 (a)) and at the flyover- improved intersection is 347.42 minutes (20,845 seconds) (Figure 5 (b)). Average delay per vehicle for the at-grade situation is 94.88 second and for the flyover improved situation 90.41 second.

Table 1. Summary collected data

Items \ Time period	At-grade intersection being converted to Flyover intersection		
	Before	During	After
1. Flyover location	Highway route no 43 and highway route no 4135		
2. Traffic movement	Yes	Yes	Yes
3. Delay	Yes	-	Yes
4. Queue length	Yes	-	Yes
5. Traffic Signal	Cycle time 244 s.	Cycle time 254 s.	Cycle time 224 s.
6. Speed	Avg: 28.5 km/hr.	-	Avg: 45.7 km/hr.
7. Dimensions	Yes	-	Yes
8. Conflict points	50 points	-	64 points
9. Road Safety Audit	Yes	Yes	Yes
10. Accident statistics	17 crashes (28 months)	52 crashes (30 months)	9 crashes (15 months)
	7.3 crashes/year	20.8 crashes/year	7.2 crashes/year
11. Construction cost	249,597,672.5 Baht		

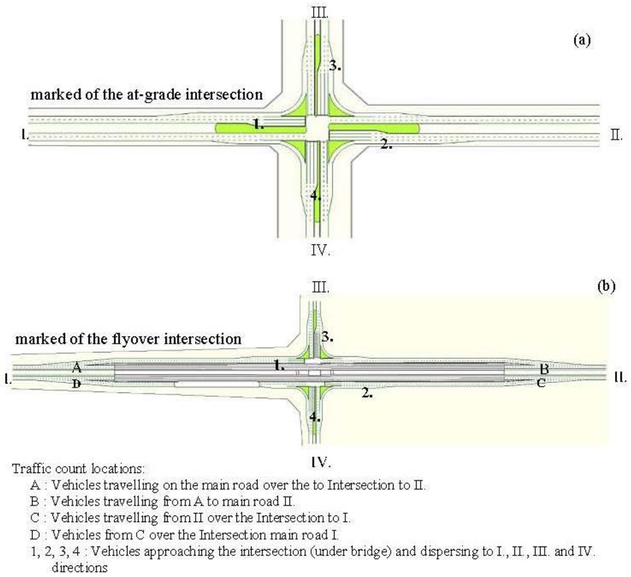

Figure 3. Turning movement count locations at the existing and flyover improved intersection

3.3 Queue Length (QL)

The q-length of the vehicles that stop to wait for new cycle time on each leg of the intersection depends on the red period of the cycle time. After the installation of the flyover, the queue is reduced. The stopped vehicle ratio of the at-grade situation is 1.55: 1 and the flyover situation 3.16: 1.

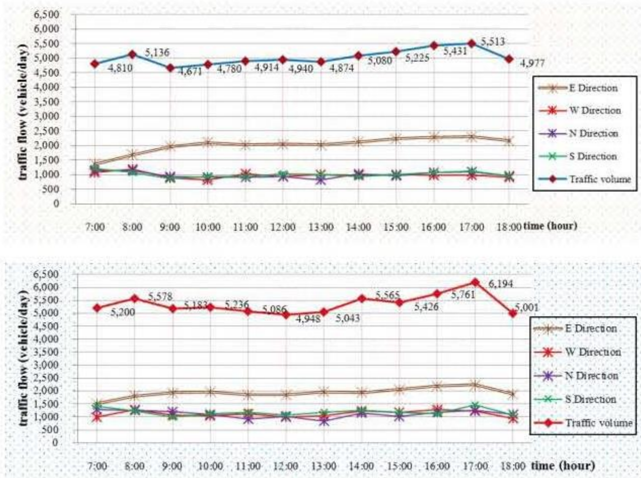

Figure 4. At-grade intersection traffic volume and Flyover intersection traffic volume

3.4 Traffic Signal

Traffic signal for both situations was controlled by fixed time plans. The before situation was controlled by two programs; the cycle time in the first program is 244 seconds (Figure 6 (a)), applied during 0600 to 2100 (4 phases per cycle), and the second program was flashing yellow, applied during 2100 - 0600. The flyover-improved intersection is similarly controlled as in the before situation of the at-grade intersection, although the length of the cycle time has been reduced to 224 seconds (DOH, 2011), but it is still a long cycle time (Figure 6 (b)).

3.5 Other important data

Accident statistics: Accident statistics collected between 2007 – August 2013 by the Department of Highways, Police and Emergency Medical Services System (EMS) are shown in Table 2.

Vehicle Speed: Vehicle speeds in the direction of the flyover were measured by means of a radar-gun are shown in Figure 7, which displays the 50 percentile (mean speed) and the 85 percentile data.

Investment cost: The investment cost of the flyover is about 249 Million Baht, the standard construction cost of a flyover is about 75,000 (2,318.9 USD) Baht/square meter.

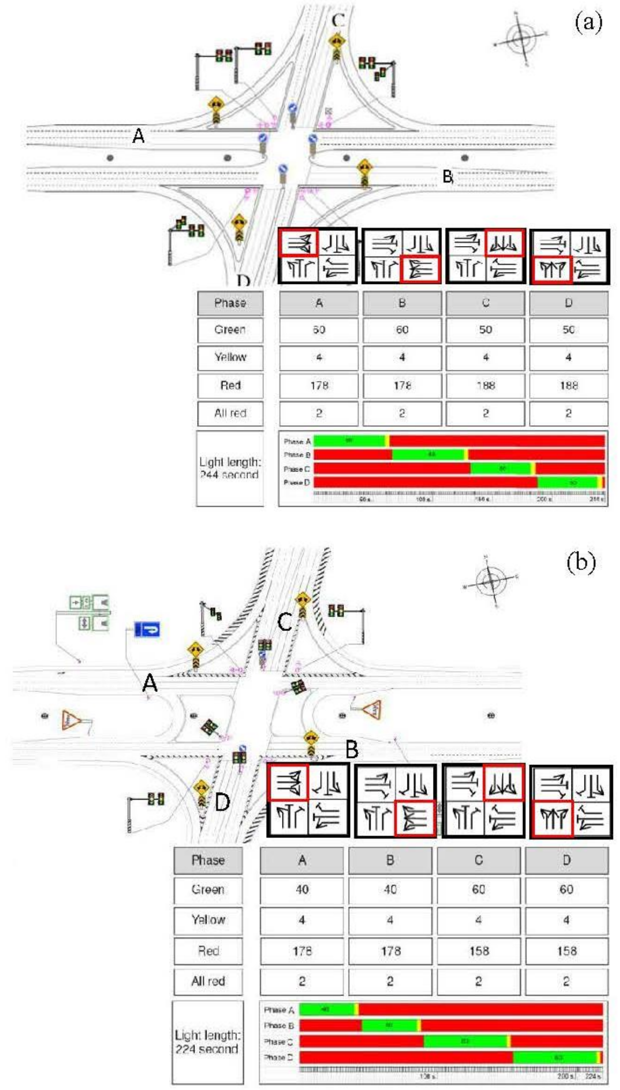

Figure 6. Traffic signal programs for At-grade and Flyover- improved situation

Table 2. Accident statistics (2007–August 2013)

Casualty type	Number of casualties for the 3 periods		
	Existing intersection	During construction	Flyover-improved intersection
Fatal	-	6	-
Disabled	0.85	1.95	0.45
Seriously injured	8	23	1
Slightly injured	17	39	9
Property damage only	25	67 times + 701,400 Baht	10
Damage to DOH property	-	533,500 Baht	-
Number of Years considered	2.33	2.50	1.25

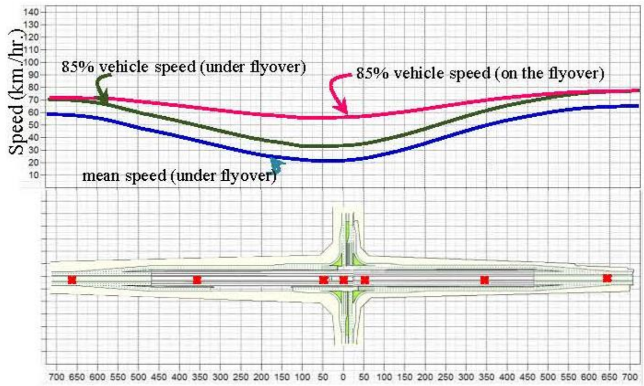

Figure 7. Vehicle speed at marked locations

4. PROJECT EVALUATION

The project evaluation compares the case with and without the flyover project in order to assess the benefits arising from the project. The benefits include savings in the value of time (VOT), vehicle operating cost (VOC) and saving in cost of accidents as shown in Table 3. Details are as follows;

4.1 Vehicle operating costs (VOC)

Vehicle operating costs comprise the cost of fuel, lubricant cost, idling of the engine and operating cost, these correlated to traffic volume, composition, and vehicle speed (V.Watcharin, 1994).

When vehicles are waiting for green signal at the intersection stop line with the engine running; wasteful fuel consumption results which also vary with types of vehicles (Goyal, S. K., Goel, S., & Tamhane, S. M., 2009). The different traffic volume between the case without and with project can be converted to equivalent monetary term.

This study used an average fuel cost of 37.18 Baht/litre (6/08/2013, http://www.pttplc.com/th/Pages/home.aspx), and fuel consumption of an average passenger car unit (PCU) which stops and idles for 1 minute = 20 cc. (http://www.sahavicha.com/?name=knowledge&file=readknowledge&id=1623).

This amounts to a monetary loss of 0.75 Baht per minute. On the bridge, Luophongsok used the

HDM-4 software to calculate the cost in terms of transportation saving cost at free flow speed, the results are show in Table 4 (Luophongsok et al., 2011).

4.2 Value of time (VOT)

Value of time means the cost (equivalent to money) that is lost due to delay during a trip, but when traffic flow through the intersection is improved after the flyover is operational, the increased intersection efficiency helps reduce travel time and road users can use this time to do other activities.

Value of time in the province of the case study can be calculated from the gross province product (GPP), number of people employed and average hours of work (Table 5). Accordingly, the value of time in Songkhla province was 83.86 Baht/PCU/hour in 2011, adjusted for 2012, the value of time for 2012 was estimated at 84.38 Baht/ PCU/hour.

On the flyover bridge, Luophongsok using the data from Department of Highways estimated the VOT at 117 Baht/PCU/hr (Luophongsok et al., 2011). Adjusted for inflation in at 3.3% (Bank of Thailand, 2012), give the value of time for 2012 at 120.86 Baht/PCU/ hour.

The benefits of the project that consisted of savings in vehicle operating costs (VOC) and the value of time (VOT) are summarized in Table 6.

Table 3. Summary of delay, traffic volume and accident statistics

No.	Items: Issues	Items: (units)	Intersection situation: At-grade	Intersection situation: Flyover		Results: Reduction		Results: Increase	
1	Total vehicle delay per day	(second)	32,116	20,845		11,271	34.5% -		
		(minute)	535.3	347.4		187.9			
		(hour)	8.9	5.8		3.1			
2	Traffic volume per day	(PCU/ day)	60,351	64,219		-		3,904	6.0%
				PCU	Truck				
				47,261	16,958				
				73.6%	26.4%				
	Under the flyover		60,351	39,915 (62.16%)		20,436	33.8%	-	
				PCU	Truck				
				32,837	7,078				
				82.2%	17.8%				
	On the flyover		-	24,304 (37.8%)		-		24,304 (37.8%)	
				PCU	Truck			PCU	Truck
				14,424	9,880			14,424	9,880
				59.4%	39.6%			59.4%	39.6%
3	Accident statistics		Before	During	After	After - Before			
	Fatality (Fal)		-	6	-	-	-	-	
	Disability (Dis)		0.85	1.95	0.45	0.01	1%	-	
	Serious Injury (SI)		8	23	1	6 people	75.0%	-	
	Slight Injury (SL)		17	39	9	0 people	1.0%	-	
	Property Damage Only (PDO)		25	67 times + 701,400 Baht	10	22.6%		-	
	DOH damage		-	533,500 Baht	-	set at 28 months		-	
	Months		28	30	15				
	Crash/year		7.3	20.8	7.2	0.1	1.37%	-	

Table 4. Vehicle operating costs in PCU (Luophongsok et al., 2011)

VOC	Speed (kilometer per hour): 10	20	30	40	50	60	70	80	90	100	110	120
Baht/PCU/ Km.)	10.23	6.15	4.91	4.34	4.09	3.99	4.01	4.13	4.35	4.65	5.04	5.54

Source : Calculated by HDM-4 software

Table 5. Value of time (VOT) in Songkhla province

Year	GPP (Million THB)	Employed	Avg of hours work (year)	Value of time: VOT (THB/hour)
2007	159,008	744,042	2,950	72.44
2008	160,683	766,674	2,985	70.21
2009	151,755	790,553	2,930	65.52
2010	186,457	815,618	2,870	79.65
2011	214,799	837,093	3,060	83.86

Source: Adapted from the National Statistical Office (2012)

4.3 Cost of Accidents

Accident costs were obtained by using Equation. As the accident statistics from the 3 agencies did not record the number of disability people, the calculation was based on the work of Dr.Nima Asgari (WHO, 2013) who stated that " for every road crash, where there is one death, there will be 20 injured people and 1 of 20 injured people will become to a disabled person". Thus for this study, 5% of the number of injured number are taken as the number of disabled.

Table 6. The benefits of the project in terms of VOC and VOT

No.	At-grade to Flyover	Value	Unit	Vehicle operating cost (VOC)	Value of time (VOT)
1	**Under the flyover (intersection)**			Fuel consumption (0.75 Baht/PCU/minute)	Loss of time (84.38 Baht/PCU/hour)
	Time of all vehicle delay educed results)	187.9	minute/ day	187.9 x 0.75 = 140.93 Baht/day	187.9 x (84.38/60) = 264.25 Baht/day
				140.93 x 300 = 42,279.00 Baht/year	264.25 x 300 = 79,275.01 Baht/year
				Total = 121,554.01 Baht per year	
2	**On the flyover-bridge**			At 60 Km/hr speed (3.99 Baht/PCU/km)	Value of time on highway (120.86 Baht/PCU/hour)
	Free flow speed of the vehicles in two directions over the bridge	24,304	PCU/ day	24,304 x 3.99 = 96,972.96 Baht/day	2,025 x 120.86 = 244,741.5 Baht/day
		2,025	PCU/ hour	96,972.96 x 300 = 29,091,888 Baht/year	244,741.5 x 300 = 73,422,450 Baht/year
				Total = 102,514,338 Baht per year	

$$ACa = \frac{A(F)*MCA(F) + A(Dis)*MCA(Dis) + A(SI)*MCA(SI) + A(LI)*MCA(LI) + A(PDO)*MCA(PDO)}{t} \quad (1)$$

Where, ACa : annual average accident cost (Baht/year),
A : number of accidents (acci),
MCA : the mean cost per accident (Baht/acci) as shown in Table 7, and
t : the period of time under review (year).

An annual average accident costs for the three situations calculated by Equation (1) are shown in Table 8

Table 7. Mean cost per accident for various

Severity	Thailand (Million Baht)	Bangkok (Million Baht)	Other Provinces (Million Baht)
Fatality (F)	5.062 – 5.956	10.561 - 12.413	4.757 - 5.599
Disability (DI)	5.114 - 6.910	11.611 - 13.934	5.608 - 6.729
Serious Injury (SI)	0.158 - 0.164	0.328 - 0.337	0.148 - 0.155
Slight Injury (SL)	0.0386 - 0.0389	0.1731 - 0.1733	0.0297 - 0.0298
Property Damage Only	0.052	0.164	0.039

Source: Department of Highways, Thailand (2012)

Table 8. Annual average accident cost in each situation
situation

Mean cost per accident / Locations		Number of casualties in 3 situations: At-grade intersection	During construction	Flyover intersection
Fatal	5,178,000	-	6	-
Disabled	6,168,500	0.85	1.95	0.45
Seriously injured	151,500	8	23	1
Slightly injured	29,750	17	39	9
Property damage only	39,000	25	67 times + 701,400 Baht	10
DOH damage		-	533,500 Baht	-
Year consider (year)		2.33	2.50	1.25
Cost		3,405,997	20,635,690	2,868,060
Saving in accident costs resulting from converting at-grade intersection to the flyover intersection per year = 537,937.85 Baht				

5. COST-BENEFIT ANALYSIS (CBA)

CBA is the method for calculating all benefits and costs. The CBA is normally carried out in terms of three key indicators: the Net Present Value (NPV), Benefit–Cost Ratio (BCR) and Internal Rate of Return (IRR) (Garber, N. J., & Hoel, L. A. (2009)).

In this study, the recommended interest rate (i) of 12% was used (DOH, 2009 and World Bank and Office of the National Economic and Social Development). The period of analysis is 10 years (n). The result of analysis is shown in Figure 8.

5.1 Net Present Value (NPV)

This method is defined as the summation of the present values of the individual cash flows of the same entity, Eq (2).

$$NPV = \sum_{t=0}^{n} \frac{(B_t - C_t)}{(1+i)^t} \qquad (2)$$

$$NPV = \sum_{t=12}^{10} \frac{(B_{10} - C_{10})}{(1+0.12)^{10}} = \frac{88.7 * 10^6}{(1.12)^1} + \ldots + \frac{43.2 * 10^6}{(1.12)^{10}} - 270.2 * 10^6 - 3.8 * 10^6$$

$NPV = 361{,}641{,}982$ Baht

5.2 Benefit–Cost Ratio (BCR)

A ratio is showing the relationship between the costs and benefits of a proposed project, Eq (3);

$$BCR = \frac{Benefits}{Cost} = \frac{361{,}641{,}982 + 537{,}938 + 121{,}544}{249{,}597{,}672.5 + 20{,}635{,}690} \qquad (3)$$

$BCR = 1.34$

5.3 Internal Rate of Return (IRR)

The interest rate for which NPV equals to zero. For the flyover project, i = 37.58 %

6. ANALYSIS RESULTS FROM SIDRA

To make recommendation to the DOH to improve the performance of the intersection, the authors used SIDRA to analyze the current traffic signal control under the flyover. The software is an advanced micro-analytical tool used for evaluating of alternative intersection designs in terms of capacity, level of service and a wide range of performance measures, including time delay, queue length, as well as fuel consumption, pollutant emissions and operating costs (Akcelik & Associates Pty Ltd., (2011)). The software was used to analyze the performance of the traffic flow, cycle phase time, delay and level of service.

Table 9. Shows the optimum cycle times as computed by SIDRA, the values are much smaller than the existing cycle time of 224 seconds.

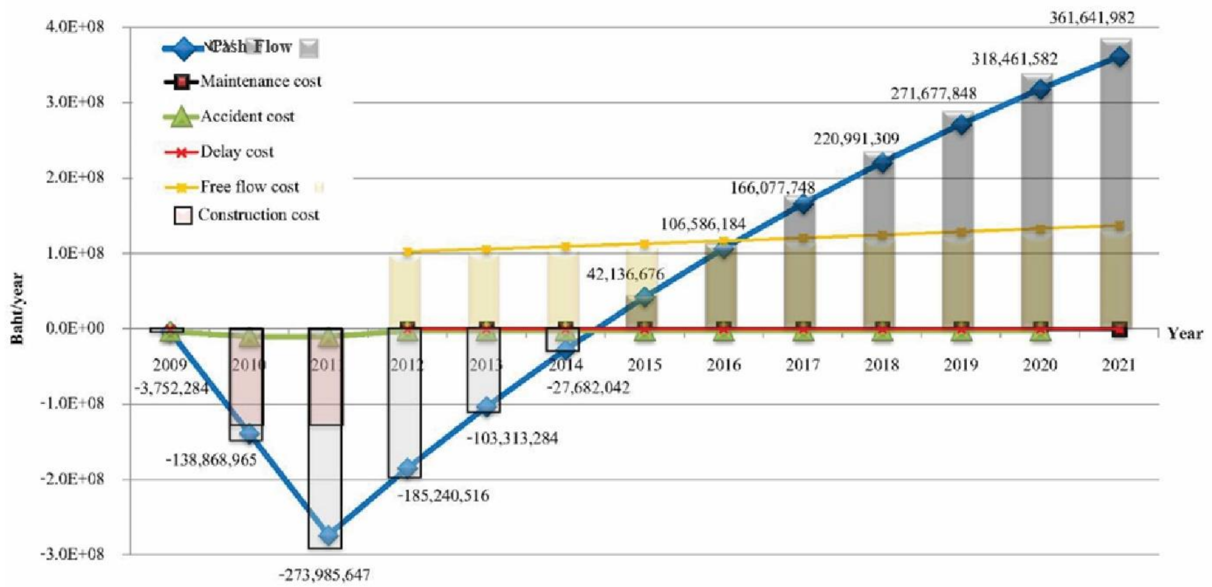

Figure 8. Cost benefit results (2009 – 2021)

Intersection		Before	During		After Construction					
Items	Year	2009	2010	2011	2012	2015	2018	2019	2020	2021
Traffic data										
Traffic volume					64219	70789	78031	80606	83266	86013
On the bridge	PCU/day	54912			24304	26791	29532	30506	31513	32553
Under the bridge					39915	43998	48499	50100	51753	53461
Delay	minute	32116			20845	23035	25392	26230	27096	27990
Cost										
Investment cost	Baht	-249597672.5								
Maintenance cost	Baht/year				-27000	-27000	-27000	-27000	-27000	-27000
Accident cost	Baht/year	-3405998	-20635690		-2868060		-2868060	-2868060	-2868060	-2868060
Saving accident cost	Baht				537938					
Delay cost	Baht/year	-346286			-224732	-248346	-273756	-282790	-292122	-301762
Saving delay cost	Baht				121544					
Free flow cost	Baht/year				102.5E+6	113.0E+6	124.6E+6	128.7E+6	132.9E+6	137.3E+6
Sum	Baht/year	-3.8E+6	-270.2E+6		99.4E+6	109.9E+6	121.4E+6	125.5E+6	129.7E+6	134.1E+6
Cash Flow	**Baht**	-3.8E+6	-138.9E+6	-274.0E+6	-185.2E+6	42.1E+6	221.0E+6	271.7E+6	318.5E+6	361.6E+6

Table 9. Optimum cycle-times by SIDRA for 12 time periods (7:00 – 19:00)

Time Periods	New cycle time run by SIDRA (second/cycle)	Time Delay (second)
7:00 – 8:00	140	45.5
8:00 – 9:00	140	45.8
9:00 – 10:00	130	42.2
10:00 – 11:00	130	41.5
11:00 – 12:00	125	40.8
12:00 – 13:00	125	41.4
13:00 – 14:00	115	44.1
14:00 – 15:00	115	48.0
15:00 – 16:00	120	45.2
16:00 – 17:00	130	47.5
17:00 – 18:00	145	61.6
18:00 – 19:00	135	45.8

7. CONCLUSIONS

An at-grade intersection was upgraded with an installation of a flyover-bridge at a cost of 249.5 million THB, with the aim of increasing capacity of the intersection and reduce vehicle delay and long queue at the ground level. The study results can be summarized as follows:

Traffic volume at the intersection increases around 4,000 PCUs or 6.02%, the volume at ground level accounts for 33.8% and free flow on the bridge 45.7%.

Delay at intersection: average time delay was reduced by 34.5%.

Queue length at intersection: The stopped vehicle ratio at this intersection for the at- grade situation and the flyover situation is 1.55: 1 and 3.16: 1 respectively.

Traffic signalization: Both before and after situations were controlled by fixed time control plans. At-grade situation operated two daily plans, the first plan used 244 seconds of cycle length, for the period 0600 -2100 (4 phases per one cycle); the second plan used flashing signal for the period 2100-0600. The flyover-improved intersection used similar fixed time control plan, but with the shorter cycle time of 224 seconds.

Speed: saving in travel time from increased vehicle speed, especially on the flyover where the speed increased from 29.8 to 52.5 km/hr.

Project evaluation: the benefits were considered in terms of saving in VOC, VOT and Accident Costs. The saving in costs of 29.13, 73.50 and 0.54 million THB were realized respectively realized with the flyover installation.

The project net present value (NPV) was 361.64 million THB, benefit cost ratio (B/R) 1.34 and internal rate of return (IRR) 37.58%, indicating that it is a worthwhile project.

8. RECOMMENDATIONS

Overall, the project is economically worthwhile and can reduce congestion at the intersection. However, the operation of traffic signal has been and is still controlled by fixed time control plans as the previous situation of before the construction of the flyover. Long queue and delay of vehicles especially on the minor highway still exist.

To improve performance of the intersection, shorter optimum cycle times as calculated by SIDRA should be adopted for different time of day. The cycle times are shown in Table 9.

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INITIAL DEVELOPMENT OF INDONESIAN MOTORCYCLE RIDER BEHAVIOUR

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ABSTRACT:

The use of motorcycle in Jakarta increased rapidly in the last ten years. This is due to lack of sufficient public transport services. The public tried to overcome the congestion problem individually by using motorcycle. Among the daily users of motorcycles were university students. This paper discusses the development of motorcyclist behaviour questionnaire in Indonesian context. Interviews were conducted to 10 male motorcyclist and 50 female motorcyclists. All respondents were Tarumanagara University students in Jakarta. The questionnaire consists of 31 statements reflecting motorcyclist behaviour. The statements were the result of focus group discussion among researchers in this topic. Respondents were asked to rate whether they strongly agree (1), agree (2), disagree (3) or strongly disagree (4) to each statement. The collected data were analyzed using exploratory factor analysis (EFA).

Keywords: Motorcyclist behaviour questionnaire, University students, Exploratory factor analysis

1. INTRODUCTION

In the last ten years congestion in Jakarta, Indonesia became worse. This is due to uncontrolled city development and lack of sufficient public transport system. As the public felt that the government did not overcame this problem seriously, they tried to find instant individual "solution" by riding motorcycle daily that allow them to find gap in a congested roads, ease them to find parking space and relatively affordable in terms of ownership, maintenance and operation cost. University students ride motorcycle daily. In this paper only the students from Tarumanagara University, Jakarta were observed.

2. PREVIOUS STUDENTS

As motorcycle is not a daily mode of road transport in most countries, previous journal papers on motorcycle rider behaviour questionnaire were limited. Persian Motorcycle Rider Behavious Questionnaire (MRBQ) was developed by (Motevalian et al, 2011). It consists of 48 items reflecting six subscales, i.e. speed violation, traffic errors, safety violations, traffic violations, stunts and control errors. Four years earlier Elliott et al (2007) develop MRBQ to predict motorcycle crash risk in Great Britain. It was following Driver Behaviour Questionnaire (DBQ) developed by Reason et al (1991) in classifying driver behaviour into errors and violations subscales. Traffic errors were the main predictors of crash risk according to Elliot et al (2007).Sexton et al (2004) used 24 items in their MRBQ reflecting four factors, i.e. traffic errors, speeding, and stunt and control error. Examples of traffic errors are fail to notice that pedestrians are crossing when turning into a side street from a main road; attempt to overtake someone that you hadn't noticed to be signaling a right turn, etc. Examples of speeding are exceed the speed limit on a residential road; race away from traffic lights with the intention of beating the driver/rider next to you; open up the throttle and just go for it on country roads, etc. Examples of performing stunts and other high risk behaviours are attempt to do, or actually do, a wheelie; intentionally do a wheel spin, etc. Examples of control errors are run wide when going round a corner; brake or throttle back when going round a corner or bend; find that you have difficulty in controlling the bike when riding at speed. In a study on Risk and Motorcyclist in Scotland, Sexton et al (2006) divided the interview instrument into three main sections i.e. motorbike and riding experience, risk and attitudes, and risk and enjoyment factors.

Behaviour questionnaires were sensitive to culture difference. For example, Fergusson and Horwood (2000) modified Driver Behaviour Questionnaire (DBQ) developed by Reason et al (1991) to Reflect New Zealand condition. Xie and Parker (2002) considered Chinese culture di developing Chinese DBQ. Similarly Lajunen et al (2004) considered local culture when using Manchester DBQ in safety research in the Netherland and Finland. Persian MRBQ (Motevalian et al, 2011) adjusts significantly items in MRBQ developed by Elliott et al (2007) in Great Britain. During focus group discussion with Persian local experts some items in Elliot's MRBQ were deleted especially items concerning the use of riding protective clothings. Some specific Persian riding behaviour were added, for example in terms of riding right of way, helmet use, red light running, etc. Therefore the need to develop Indonesian MRBQ is justified. This paper is aimed to discuss the initial development of Indonesian MRBQ.

3. METHODOLOGY

3.1 Data Collection

In the pilot survey to test the validity and reliability of the questionnaires, there were 10 male respondents and 5 female respondents. After deleting non-valid and non-reliable questions, the final questionnaires were then distributed to 100 male respondents and 50 female respondents of Tarumanagara University who ride motorcycle daily. Number of male respondents were more than number of female respondents, considering gender proportion of Tarumangara University students who ride motorcycle daily. Likert scales were used in the questionnaire. Respondents were asked to rate

Table 1. Rotated Component

Items	Component									
	1	2	3	4	5	6	7	8	9	
Avoid speeding in divided road	0.720									Speed Related Aggressive Behaviour
Speeding while angry	0.638									
Avoid to use bus lane	0.634									
Avoid speeding although the vehicle can do it	0.617									
Avoid to text on trip		0.841								Safety Violation
Avoid to answer incoming call or sms on trip		0.838								
Keep reasonable distance to vehicle in front		0.609								
Look at rearview mirror while turning in an intersection			0.842							Control Error
Look at rearview mirror while overtake			0.828							
Larger advertisement size distract concentration more				0.895						External Disturbance
Advertisement displayed electronically is more attractive				0.850						
Advertisement billboards disturb/ distract concentration				0.819						
Always wear helmet even in short trip					0.762					Traffic Violation
Always wear standardized helmet on trip					0.644					
Always bring rider license if on trip					0.571					
Avoid to listen to music through headset on trip					0.461					
Predict incoming vehicle speed while overtake a vehicle						0.817				Prediction Error
Predict overtook vehicle speed						0.794				
Homeless people, beggars & street singers are annoying							0.823			External Human Disturbance
Hawkers are annoying							0.806			
Carefully passing pot holes								0.793		Braking Error
Start braking when signal turn amber								0.396		
Pull over to help other rider involve in accident									0.719	Selfish Behaviour

whether they strongly agree (1), agree (2), disagree (3) or strongly disagree (4) with each statement in questionnaires items.

3.2 Data Analysis

During pilot survey, temporary constructs were used to enable to conduct validity and reliability tests. Construct validity was measured by calculating product moment correlation between item score and total item score in a construct. A significant level of 0.05 was used. Reliability analysis was conducted using Cronbach Alpha value. To be reliable, the value should be at least 0.6. In this step 44 items were in the questionnaire, reflecting 4 constructs, i.e. aggressive behaviour, traffic violation, riding error and external disturbance. After validity and reliability test, 13 items were deleted. The remaining 31 items were used in the main survey. Before the factor analysis was conducted, the results of questionnaires were evaluated. Further deletion were required to 2 misleading items. Therefore only 29 items were extracted using principal component analysis and rotated using varimax with Kaizer Normalization. IBM SPSS Statistics 22 was used to help analysis.

4. RESULTS

Mean value of each item in the questionnaire was less than 2.5. This imply that in general respondents have a relatively safe riding behaviour. The varimax rotation converged in 13 iterations. The result is reported in Table 1. Nine factors were extracted which accounted for 65.6% of the total variance. Kaiser-Meyer-Olkin Measure of Sampling Adequacy was 0.72. Value greater than 0.7 justify sampling adequacy of the factor analysis. Some items were belong to more than one factors and therefore deleted due to unclear factor membership. 8 factors were finally used, i.e. speed related aggressive behaviour, safety violation, control error, external disturbance, traffic violation, prediction error, external human disturbance, braking error and selfish behaviour.

5. DISCUSSION

Some items in Persian MRBQ (Motevalian et al, 2011) were similar with the developed Indonesian MRBQ. For example regarding:

- Speeding
- Red light running
- Space between vehicles
- Joining main traffic from side road
- Helmet use
- Brake use

However there were some items from Persian MRBQ (Motevalian et al, 2011) that can be added into Indonesian MRBQ, for example:

- Pedestrian related items
- Speeding in residential area
- Riding between two lanes
- Riding with impaired motorcycle
- Carry a passenger who have not worn helmet
- Carry more than one passenger

There were also differences in constructs used in Persian MRBQ (Motevalian et al, 2011) with the factors found in this paper as can be seen in Table 2. The phrases typed in Italic show same or similar constructs between two instruments.

6. CONCLUDING REMARKS

Indonesian MRBQ is still in a very early stage of development. It needs further research in terms of the scope of the items and in terms the scope of the respondents. Further methodological advancement also required to enhance the quality of the instrument.

Table 2. Comparison between Persian MRBQ (2011) and Indonesian MRBQ Constructs

Persian MRBQ (Motevalian et al, 2011) Constructs	Indonesian MRBQ Constructs
Speed Violation	*Speed Related Aggressive Behaviour*
Safety Violation	*Safety Violation*
Control Error	*Control Error*
Traffic Error	External Disturbance
Traffic Violation	*Traffic Violation*
Stunt	Prediction Error
	External Human Disturbance
	Braking Error
	Selfish Behaviour

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