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ENHANCING ATRANS SAFETY MAP APPLICATION WITH ROAD SAFETY ENGINEERING TOOLKIT

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List of Abbreviations and Acronyms

| | |
|--------|---|
| ATRANS | Asian Transportation Research Society |
| DOH | Department of Highways |
| DRR | Department of Rural Roads |
| OTP | Office of Transport and Traffic Planning and Policy |
| PSU | Prince of Songkla University |
| WHO | World Health Organization |

CHAPTER I INTRODUCTION

I.1 Statement of Problems

Road crash has been still a pressing problem causing fatalities and injuries to Thai citizens for many decades. According to the World Health Organization (WHO) Global Status Report in the year 2018, Thailand was ranked the first highest fatality rate in ASEAN. From the data integration, it was reported that Thailand has road traffic fatalities of 21,745 in 2016. However, the number of fatalities estimated by WHO was found at 22,491. This equals to a road traffic fatality rate of 32.7 persons per 100,000 populations (World Health Organization (WHO), 2018)

Last year, ATRANS financially supported the research project title “In-depth Analysis of Black Spot Characteristics in Thailand from ATRANS Safety Map Applica” that analyzed the data of crash locations and risk locations stored in the application in more detail. Also, the hazardous (Black Spot) location ranking system was developed based on the accident costing technique. Applying the ranking system, the top three hazardous locations in Phuket (the study area) were identified. Road-related proactive measures were proposed to correct the unsafe problems found in a hazardous location (Asian Transportation Research Society (ATRANS), 2018).

Austrroads (2015) explained three basic steps to diagnose the problems of crash locations, which include:

- analyze the crash data (including crash rates and densities) for any clustering by common crash types or factors such as common approach legs, common weather or daylight, the common age of those involved, etc. Construct a factor matrix and draw a collision diagram.
- inspect the site from the perspective of the involved road users, as well as undertaking a close-up examination of the site’s features and its users’ behavior.
- make any other investigations, then draw conclusions about the likely causes of crashes for which there are common factors. There may be other types of contributing factors (e.g. speeding) but focus on what it is about the road or traffic environment which is leading to crashes.

Austrroads (2015) noted that the selection of proper measures is to concentrate on the crash types which have been identified in the diagnosis steps. Moreover, the report provides several safe system treatments for various crash types (based on the data of collision diagram). Sorensen (2007) also recommended that hazardous locations should be identified by the use of model-based methods. The analysis should consist of general accident analysis and a collision diagram, which are compared with the normal accident pattern for similar locations.

Austrroads and ARRB Group Ltd. (2015) developed a Road Safety Engineering Toolkit as a reference tool for road engineering practitioners to reduce the severity and frequency of crashes involving road environment factors. It outlines best-practice, low cost, high return road environment measures to achieve a reduction in road trauma.

From the above works of literature, there were some gaps in the study of ATRANS (2018) needed for further research, which included:

- lack of collision diagram, which is a piece of basic information to select proper countermeasures
- the countermeasures proposed were based on an expert judgment which may be different from individuals.

1.2 Research Objectives

This research aims at enhancing the ATRAN Safety Map application by adding a user-friendly toolkit that allows users:

- 1) to easily input a collision diagram for each accident case,
- 2) to automatically retrieve a list of common crash causation and crash severity factors of a hazardous location, and
- 3) to obtain a list of potential safe road and roadside improvement schemes based on the data of 1) and 2). This is for local authorities to get ideas to solve the problems.

CHAPTER 2 LITERATURE REVIEW

2.1 Road Safety Engineering Toolkit

Austrroads and ARRB Group Ltd. (2015) developed the Road Safety Engineering Toolkit (www.engtoolkit.com.au) as a reference tool for road engineering practitioners in state and local governments. It outlines best-practice, low cost, high return road environment measures to achieve a reduction in road trauma.

The Toolkit seeks to reduce the severity and frequency of crashes involving road environment factors. In Australia, the provision of safer roads and roadsides is a major area of gain under the National Road Safety Strategy 2003 – 2010.

The Toolkit draws together existing road safety engineering knowledge as far as possible into one Toolkit for easy access by practitioners, as shown in Figure 1. The presented knowledge has been updated with recent experience from local and state government agencies, and with the results of comprehensive road safety research reviews. The Toolkit is a ‘living’ document including updates and revisions, so that more recent safety ‘wins’ are captured and disseminated.

The information included in the Toolkit is based on extensive research into the effectiveness of crash countermeasures. Nonetheless, the Toolkit is not a replacement for sound engineering judgment or good design. An in-depth investigation is required at locations that have a crash history or high crash risk to identify causes or potential causes of crashes. If necessary, seek professional advice from practitioners specializing in road safety engineering.

Crash type: Pedestrian crashes

Description

This group of crashes includes collisions between pedestrians and vehicles in a number of likely situations, e.g.:

- walking out onto the path of a vehicle
- playing or working on the road
- walking with traffic
- pedestrians struck on driveways
- pedestrians struck by vehicles on footpaths
- while boarding/alighting public transport vehicles.

More detailed information about pedestrians and pedestrian safety factors is contained in the **Road users** section under **Pedestrians** and **School children** links.

Road-related contributing factors are listed in the **Related safety deficiencies** section.

Detailed analysis of the site and of the crash data is required to establish the specific reasons for the pedestrian crash pattern.

Treatment types

Suitable engineering countermeasures include:

- Linemarking improvements
- Parking bans
- Pedestrian fencing
- Sight distance improvements at intersections
- Sight distance improvements at road sections
- Traffic signals operation review
- Warning signs
- Kerb extensions
- Pedestrian refuge island
- Raised pedestrian crossings
- Remove vegetation
- Skid resistance improvements
- Convert angle parking to parallel parking
- Splitter Islands
- Street lighting
- Fully controlled right turn phase
- Grade separation
- Median retrofit
- Pedestrian improvements at slip lanes
- Pedestrian signals
- Traffic signals

Related safety deficiencies

- Bridge width too narrow
- Parking on-street friction and conflicts
- Pavement poor skid resistance
- Pedestrians, intersection inadequate crossing facilities
- Pedestrians, mid-block inadequate crossing facilities
- Road lighting inadequate
- Roundabout inadequate design
- Sight distance restricted
- Signalised intersection filtering movements
- Signalised intersection inadequate layout
- Signalised intersection inadequate phasing, timing or linking
- Signalised intersection insufficient sight distance
- Signalised intersection linemarking inadequate
- Signalised intersection see through effect
- Traffic calming ineffective, unsafe, redundant
- Unsignalised intersection inadequate layout
- Unsignalised intersection insufficient sight distance
- Unsignalised intersection linemarking inadequate
- Vegetation interference with driving task
- Visual clutter driver distraction

Related case studies

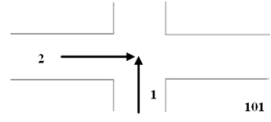
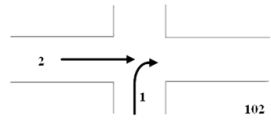
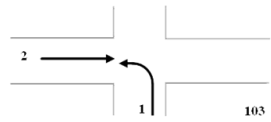
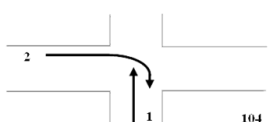
- High speeds on roundabout
- Main street in semi-rural town centre
- Pedestrian conflicts in school zone

Source: www.engtoolkit.com.au

Figure 1 Example of treatments for pedestrian crashes

Table 1 shows good examples of black spot treatments categorized by four levels of improvement cost. These good examples were collected and reported in the Austroads Road Safety Engineering Toolkit.

Table 1 Good examples of black spot treatment for the crash pattern of entering from adjacent directions

| Collision code | Crash pattern | Treatment types* |
|----------------|--|---|
| 101 |  | <ul style="list-style-type: none"> ➢ Cost < \$5,000 • All-red time extension • Give Way/Stop signs • Line marking improvements • Sight distance improvements – intersections • Traffic signals operation review • Warning signs |
| 102 |  | <ul style="list-style-type: none"> ➢ Cost \$5,001 - \$20,000 • Red light cameras • Remove vegetation • Signal display visibility improvements • Skid resistance improvements |
| 103 |  | <ul style="list-style-type: none"> ➢ Cost \$20,001 - \$50,000 • Median break closure • Splitter islands • Street lighting |
| 104 |  | <ul style="list-style-type: none"> ➢ Cost > \$100,000 • Grade separation • Roundabouts • Slip lane angle modification • Staggered intersection • Traffic signals |

*Source: Austroads and ARRB Group Ltd. (2015)

2.2 Road Safety Engineering

Federal Highway Administration (FHWA) has provided an online road safety-related tools via <https://safety.fhwa.dot.gov>, as shown in Figure 2. The website covers several topics, which include highway safety improvement program, intersection safety, guardrail resources, roadway departure safety, roadway safety, and data analysis, pedestrian and bicycle safety, local and rural road safety, and professional capacity building. In each topic, several facts, design guidelines, and good practices are provided.

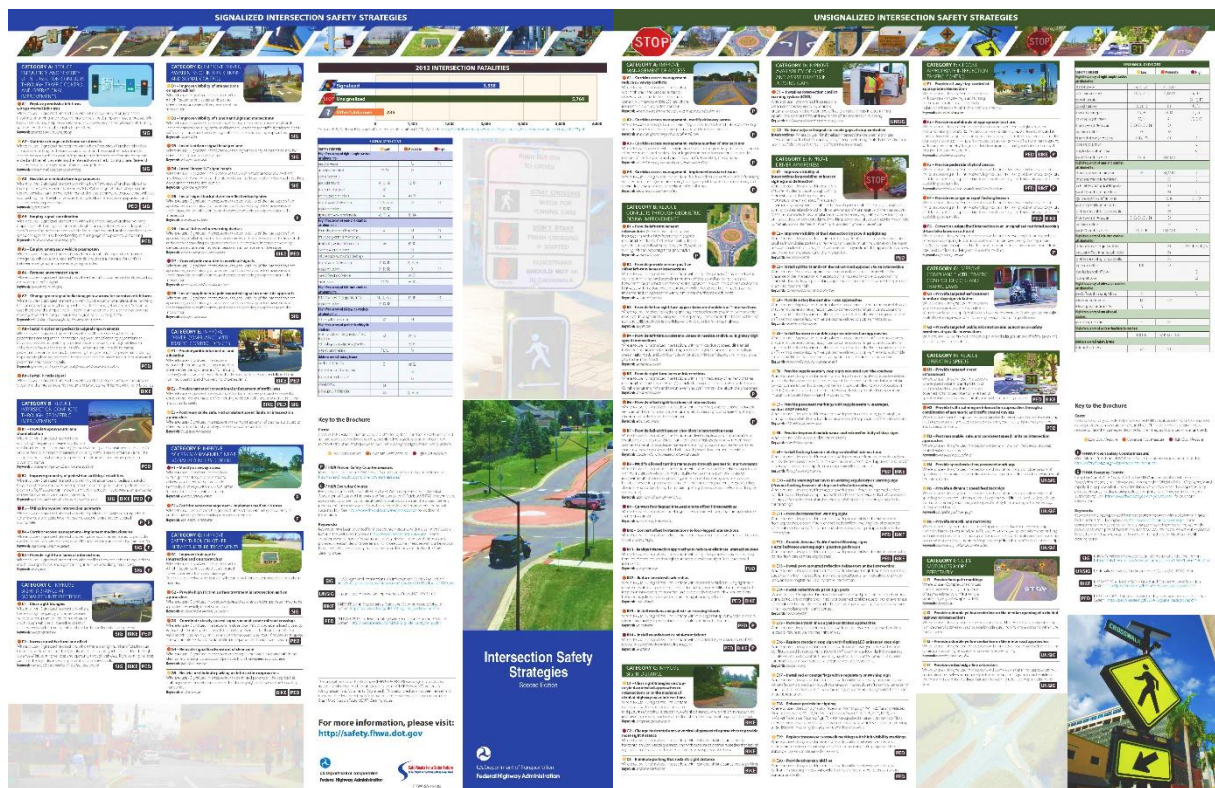
For example, the intersection safety, FHWA (2015) published the Intersection Safety Strategies Brochure, as shown in Figure 3, that provides the guideline of several treatment types for signalized intersection and unsignalized intersection.

Office of Safety



Source: FHWA (<https://safety.fhwa.dot.gov>)

Figure 2 Main menu of FHWA online road safety-related tools



a) Signalized Intersection

b) Unsignalized Intersection

Source: FHWA (2015)

Figure 3 Intersection safety strategies brochure

CHAPTER 3 METHODOLOGY

3.1 Research framework

The research framework consists of 5 tasks as shown in Figure 4, which include:

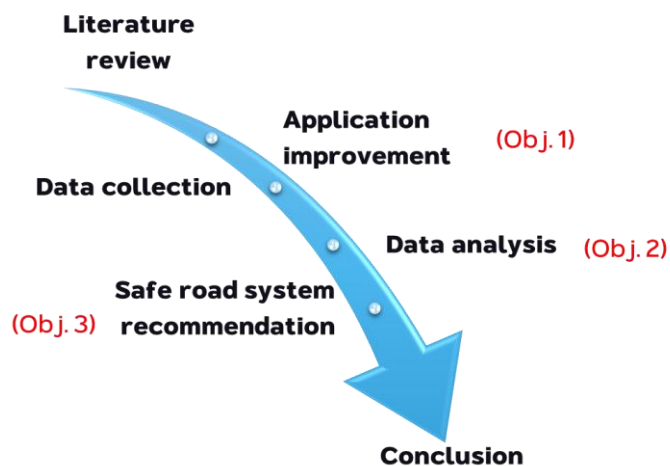


Figure 4 Research framework

Task 1: A literature review

Some works of literature related to crash risk assessment, management, and treatment were reviewed. Good practices of collision diagram were reviewed (e.g. Department of Highways, DOH; Department of Rural Roads, DRR; Austroads).

Moreover, good practices of road safety enhancement from provincial traffic master plan published by the Office of Transport and Traffic Policy and Planning (OTP) were reviewed as a guideline for improvement of ATRANS Safety Map application.

This is also to gather experiences of previous black spot treatments, to develop a database for the application to be able to suggest possible road safety engineering improvement schemes.

Task 2: Application improvement

The application was improved by developing three user-friendly interfaces, which include:

- add/modify collision diagram in the crash data menu,
- summarize a factor matrix (includes crash causation and severity factors) in the crash report menu, and
- recommend for safety improvement schemes in the hazardous location menu.

After the improvement, the application was assessed its efficiency and compatibility by key users in Phuket and revised before applying it to final production.

Task 3: Data collection

Using the improved application, crash data in the Phuket study area (and if any other areas) were collected by police officers. The collision diagram of each crash was also collected. Then, the crash data were verified by the research team. Also, traffic volume and speed data of hazardous locations were collected to be used to recommend road safety improvement measures.

Task 4: Data analysis

The data obtained from Task 3 were analyzed to identify hazardous locations. Also, crash causation and severity factors of those locations were summarized.

Task 5: Safe system recommendation

Safe system measures for the top three hazardous locations in Phuket (and if any other areas) were recommended based on the toolkit developed. Site visits were also needed for site investigation. Then, safety recommendations (e.g. shortlist, preliminary drawing) were given.

Task 6: Conclusion

Some significant findings from the study were concluded and highlighted. Recommendations for safety improvement and future research were also mentioned.

CHAPTER 4 RESEARCH ACTIVITIES AND RESULTS

4.1 Development of Road Safety Engineering Toolkit

Before developing the road safety engineering toolkit, common crash patterns were defined following the collision diagrams published by OTP and DOH as summarized in Figure 5.

Following Austroads and ARRB Group Ltd. (2015), the common crash patterns were then classified into 17 crash types, which include:

- | | |
|--------------------------------------|------------------------------|
| 1) Pedestrian crashes | 10) Run-off-road on straight |
| 2) Entering from adjacent directions | 11) Run-off-road on curve |
| 3) Opposing vehicles, turning | 12) Vehicle – animal |
| 4) Head-on | 13) Vehicle – train |
| 5) Lane change/sideswipe | 14) While overtaking |
| 6) Loss of control on turns | 15) While U-turning |
| 7) Parked/parking vehicles | 16) Motorcyclist crashes |
| 8) Entering from driveway | 17) Cyclist crashes |
| 9) Rear-end | |

Also, potential treatments to prevent each crash type were reviewed from Austroads and ARRB Group Ltd. (2015) and matched with the collision diagrams used in this research. The summaries are presented from Table 2 to Table 18, respectively.

Table 2 Treatments for pedestrian crashes

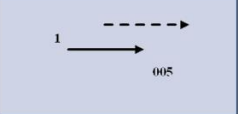




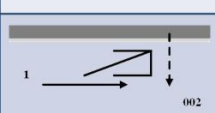
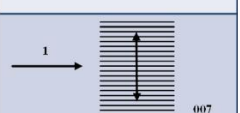


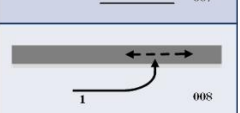
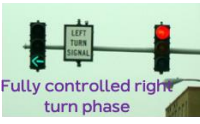
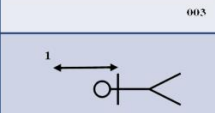
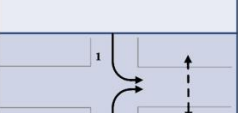

| Code | Figure | Code | Figure | Treatment types | |
|------|---|------|---|---|--|
| 000 | OTHERS 000 | 005 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Line marking improvements – Parking bans – Pedestrian fencing – Sight distance improvements – intersections – Sight distance improvements – road sections – Traffic signals operation review – Warning signs |  Line marking improvements |
| 001 |  | 006 |  | <ul style="list-style-type: none"> • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Curb extensions – Pedestrian refuge island – Raised pedestrian crossings – Remove vegetation – Skid resistance improvements |  Curb extensions |
| 002 |  | 007 |  | <ul style="list-style-type: none"> • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> – Convert angle parking to parallel parking – Splitter island – Street lighting |  Convert angle parking to parallel parking |
| 003 |  | 008 |  | <ul style="list-style-type: none"> • Cost rating: \$50,001 - \$100,000 <ul style="list-style-type: none"> – Fully controlled right turn phase |  Fully controlled right turn phase |
| 004 |  | 009 |  | <ul style="list-style-type: none"> • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Grade separation – Median retrofit – Pedestrian improvements at slip lanes – Pedestrian signals – Traffic signals |  Grade separation |

Table 3 Treatments for entering from adjacent directions

| Code | Figure | Code | Figure | Treatment types |
|------|---------------|------|--------|---|
| 100 | OTHERS 100 | 105 | | <ul style="list-style-type: none"> Cost rating: Under \$5,000 <ul style="list-style-type: none"> All-red time extension Give Way/Stop signs Line marking improvements Sight distance improvements – intersections Traffic signals operation review Warning signs Cost rating: \$5,001 – \$20,000 <ul style="list-style-type: none"> Red light cameras Remove vegetation Signal display visibility improvements Skid resistance improvements Cost rating: \$20,001 – \$50,000 <ul style="list-style-type: none"> Median break closure Splitter islands Street lighting Cost rating: Over \$100,000 <ul style="list-style-type: none"> Grade separation Roundabouts Slip lane angle modification Staggered intersection Traffic signals |
| 101 | | 106 | | |
| 102 | | 107 | | |
| 103 | | 108 | | |
| 104 | | | | |



Give Way/Stop signs



Red light cameras



Splitter Islands



Roundabouts

Table 4 Treatments for opposing and turning vehicles

| Code | Figure | Code | Figure | Treatment types |
|------|--------|------|--------|--|
| 202 | | 205 | | <ul style="list-style-type: none"> Cost rating: Under \$5,000 <ul style="list-style-type: none"> All-red time extension Line marking improvements Restrict access points Sight distance improvements – intersections Speed limit change Traffic signals operation review Turn bans Cost rating: \$5,001 – \$20,000 <ul style="list-style-type: none"> Red light cameras Signal display visibility improvements Skid resistance improvements Cost rating: \$20,001 – \$50,000 <ul style="list-style-type: none"> Median break closure Splitter islands Street lighting Cost rating: \$50,001 – \$100,000 <ul style="list-style-type: none"> Fully controlled right turn phase Cost rating: Over \$100,000 <ul style="list-style-type: none"> Roundabouts Traffic signals |
| 203 | | 206 | | |
| 204 | | | | |



Speed limit change



Skid resistance improvements



Street lighting



Fully controlled right turn phase



Traffic signals

Table 5 Treatments for head-on collisions

| Code | Figure | Treatment types |
|------|--------|---|
| 201 | | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Chevron alignment markers (CAMs) - Curve warning signs - Line marking improvements - Raised reflective pavement markers (RRPMs) - Reinstate shoulder - Separation lines - Sight distance improvements – road sections - Speed limit change • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Barrier lines - Edge drop removal - Edge lines - Guide posts - Painted/flush median - Profile line marking - Safety barriers • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Splitter islands - Street lighting - Traffic lane widening • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Additional lanes for overtaking - Median retrofit - Road realignment - Shoulder widening and/or sealing |
| 501 | | |
| | | |



Raised reflective pavement markers (RRPMs)



Safety barriers



Splitter islands



Additional lanes for overtaking

Table 6 Treatments for lane changes or sideswipe

| Code | Figure | Code | Figure | Treatment types |
|------|--------|------|--------|--|
| 305 | | 308 | | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Advisory speed signs - Chevron alignment markers (CAMs) - Curve warning signs - Line marking improvements - Parking bans - Sight distance improvements – road sections • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Barrier lines - Bicycle facilities – on-road - Clear zone widening - Direction signs (guide signs) - Safety barriers • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Painted turn lanes - Traffic lane widening • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Indented parking - Road realignment - Slip lane angle modification - Superelevation improvement - Turn lanes |
| 306 | | 309 | | |
| 307 | | 310 | | |



Advisory speed signs



Safety barriers


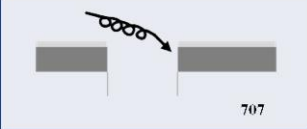
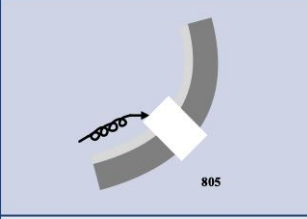



Painted turn lanes



Turn lanes

Table 7 Treatments for loss of control on turns

| Code | Figure | Treatment types |
|------|---|--|
| 706 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Advisory speed signs - Curve warning signs - Line marking improvements - Sight distance improvements – intersections - Sight distance improvements – road sections - Turn bans • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Clear zone widening - Direction signs (guide signs) - Safety barriers - Signal display visibility improvements - Skid resistance improvements - Traffic signals coordination • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Painted turn lanes - Pavement drainage improvements - Splitter islands - Street lighting - Traffic lane widening - Vehicle activated signs • Cost rating: \$50,001 - \$100,000 <ul style="list-style-type: none"> - Combine access points - Fully controlled right turn phase • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Road realignment - Roundabouts - Slip lane angle modification - Turn lanes |
| 707 |  | |
| 805 |  | |
| 806 |  | |


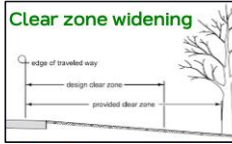

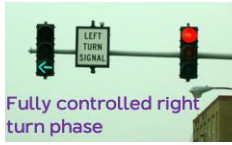

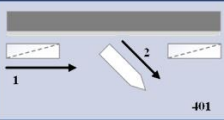

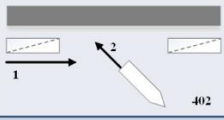

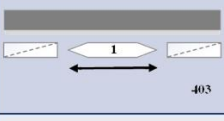

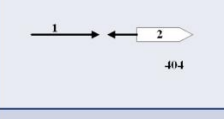
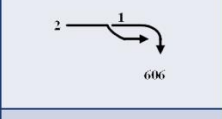
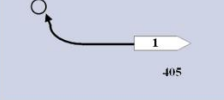






Table 8 Treatments for parking vehicles

| Code | Figure | Code | Figure | Treatment types |
|------|---|------|---|---|
| 401 |  | 601 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Line marking improvements - Parking bans - Sight distance improvements – road sections • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Bicycle facilities – on-road - Edge lines - Curb extensions - Raised pedestrian crossings - Remove vegetation • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Convert angle parking to parallel parking - Traffic lane widening • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Indented parking |
| 402 |  | 602 |  | |
| 403 |  | 603 |  | |
| 404 |  | 606 |  | |
| 405 |  | | | |










Table 9 Treatments for entering from a driveway

| Code | Figure | Treatment types |
|------|--------|---|
| 406 | | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Parking bans - Restrict access points - Sight distance improvements – intersections - Warning signs |
| 407 | | <ul style="list-style-type: none"> • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Barrier lines - Edge lines - Remove vegetation • Cost rating: \$50,001 - \$100,000 <ul style="list-style-type: none"> - Combine access points • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Shoulder widening and/or sealing |



Sight distance improvements



Barrier lines



Shoulder widening and/or sealing

Table 10 Treatments for rear-end crashes

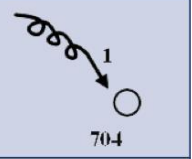
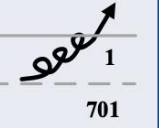
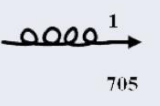
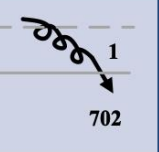
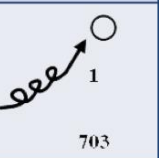
| Code | Figure | Treatment types |
|------|--------|---|
| 301 | | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - All-red time extension - Traffic signals operation review - Turn bans - Warning signs • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Signal display visibility improvements - Skid resistance improvements - Traffic signals coordination • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Convert angle parking to parallel parking - Median break closure - Painted turn lanes - Pavement drainage improvements - Vehicle activated signs • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Grade separation - Roundabouts - Turn lanes |
| 302 | | |
| 303 | | |



Turn bans



Table 11 Treatments for run-off-road on straight

| Code | Figure | Code | Figure | Treatment types |
|------|---|------|---|--|
| 700 | OTHERS 700 | 704 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Raised reflective pavement markers (RRPMs) – Reinstate shoulder – Separation lines – Sight distance improvements – road sections – Warning signs |
| 701 |  | 705 |  | <ul style="list-style-type: none"> • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Clear zone widening – Edge drop removal – Edge lines – Guide posts – Profile line marking – Safety barriers – Skid resistance improvements |
| 702 |  | | | <ul style="list-style-type: none"> • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> – Pavement drainage improvements – Street lighting |
| 703 |  | | | <ul style="list-style-type: none"> • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Additional lanes for overtaking – Road realignment – Shoulder widening and/or sealing |



Raised reflective pavement markers (RRPMs)



Guide posts

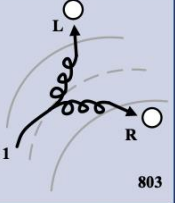
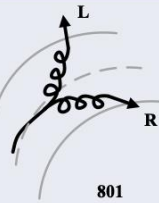
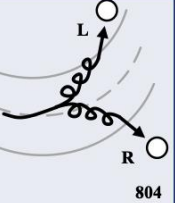
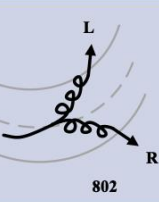


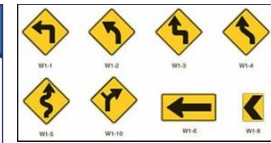
Street lighting



Additional lanes for overtaking

Table 12 Treatments to prevent loss of control on turns

| Code | Figure | Code | Figure | Treatment types |
|------|---|------|---|---|
| 800 | OTHERS 800 | 803 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Advisory speed signs – Chevron alignment markers (CAMs) – Curve warning signs – Line marking improvements – Raised reflective pavement markers (RRPMs) – Reinstate shoulder – Separation lines – Sight distance improvements – road sections – Turn bans – Warning signs |
| 801 |  | 804 |  | <ul style="list-style-type: none"> • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Clear zone widening – Crash cushion/impact attenuator – Edge drop removal – Edge lines – Guide posts – Remove vegetation – Safety barriers – Skid resistance improvements |
| 802 |  | | | <ul style="list-style-type: none"> • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> – Pavement drainage improvements – Traffic lane widening – Vehicle activated signs • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Curve widening – Road realignment – Shoulder widening and/or sealing – Superelevation improvement – Turn lanes |



Curve warning signs



Crash cushion/impact attenuator




Pavement drainage improvements



Curve widening

Table 13 Treatments for vehicle-animal crashes

| Code | Figure | Treatment types |
|------|---|--|
| 607 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Reinstating shoulder – Warning signs • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Clear zone widening – Edge drop removal – Skid resistance improvements • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Shoulder widening and/or sealing |



Warning signs




Skid resistance improvements



Shoulder widening and/or sealing

Table 14 Treatments for vehicle–train crashes

| Code | Figure | Treatment types |
|------|---|--|
| 902 |  | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Line marking improvements – Sight distance improvements – intersections – Traffic signals operation review – Warning signs • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Skid resistance improvements – Traffic signals coordination • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> – Vehicle activated signs • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Railway crossing upgrade |



Warning signs



Traffic signals coordination



Railway crossing upgrade

Table 15 Treatments for overtaking crashes

| Code | Figure | Code | Figure | Treatment types |
|------|--------|------|--------|--|
| 502 | | 507 | | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Line marking improvements - Raised reflective pavement markers (RRPMs) - Separation lines - Sight distance improvements – road sections - Speed limit change • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Barrier lines - Clear zone widening - Painted/flush median - Remove vegetation - Safety barriers • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Pavement drainage improvements • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Additional lanes for overtaking - Median retrofit - Road realignment - Shoulder widening and/or sealing |
| 504 | | 508 | | |
| 505 | | | | |



Raised reflective pavement markers



Painted/flush median



Pavement drainage improvements



Additional lanes for overtaking

Table 16 Treatment for u-turning crashes

| Code | Figure | Treatment types |
|------|--------|---|
| 207 | | <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> - Line marking improvements - Sight distance improvements – intersections - Turn bans • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> - Barrier lines - Signal display visibility improvements • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> - Median break closure - Street lighting - Traffic lane widening • Cost rating: \$50,001 - \$100,000 <ul style="list-style-type: none"> - Fully controlled right turn phase • Cost rating: Over \$100,000 <ul style="list-style-type: none"> - Median retrofit - Roundabouts |
| 304 | | |



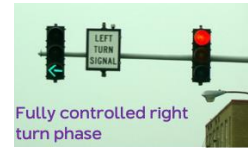
Sight distance improvements



Barrier Lines



Street lighting



Fully controlled right turn phase



Roundabouts

Table 17 Treatment for motorcycle crashes

| Treatment types | Example |
|---|--|
| <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Advisory speed signs – Chevron alignment markers (CAMs) – Curve warning signs – Give Way/Stop signs – Separations lines – Sight distance improvements - Intersections – Sight distance improvements - road sections – Warning signs |  <p>Advisory speed signs</p> |
| <ul style="list-style-type: none"> • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Barrier lines – Clear zone widening – Edge drop removal – Edge lines – Safety barriers – Skid resistance improvements |  <p>Safety barriers</p> |
| <ul style="list-style-type: none"> • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> – Pavement drainage improvements – Street lighting – Traffic lane widening – Vehicle activated signs |  <p>Street lighting</p> |
| <ul style="list-style-type: none"> • Cost rating: \$50,001 - \$100,000 <ul style="list-style-type: none"> – Fully controlled right turn phase • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Road realignment – Roundabouts – Shoulder widening and/or sealing – Superelevation improvement |  <p>Fully controlled right turn phase</p> |

Table 18 Treatment for cyclist crashes

| Treatment types | Example |
|--|--|
| <ul style="list-style-type: none"> • Cost rating: Under \$5,000 <ul style="list-style-type: none"> – Give Way/Stop signs – Linemarking improvements – Parking bans – Sight distance improvements - Intersections – Speed limit change – Warning signs |  <p>Speed limit change</p> |
| <ul style="list-style-type: none"> • Cost rating: \$5,001 - \$20,000 <ul style="list-style-type: none"> – Bicycle facilities on-road – Edge drop removal – Edge lines |  <p>Bicycle facilities on-road</p> |
| <ul style="list-style-type: none"> • Cost rating: \$20,001 - \$50,000 <ul style="list-style-type: none"> – Convert angle parking to parallel parking – Street lighting – Traffic lane widening |  <p>Convert angle parking to parallel parking</p> |
| <ul style="list-style-type: none"> • Cost rating: \$50,001 - \$100,000 <ul style="list-style-type: none"> – Bicycle facilities - off-road • Cost rating: Over \$100,000 <ul style="list-style-type: none"> – Pedestrian signals – Shoulder widening and/or sealing – Traffic signals |  <p>Pedestrian signals</p> |

The treatments for different crash types shown in the tables above can be summarized from Table 19 to Table 26.

Table 19 Summary of treatments for pedestrian crashes

| Code | Treatments | Collision codes related to pedestrian crashes | | | | | | | | | | |
|--|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | | 000 | 001 | 002 | 003 | 004 | 005 | 006 | 007 | 008 | 009 | 901 |
| Group A: Cost rating under \$5,000 | | | | | | | | | | | | |
| A1 | Advisory speed signs | - | - | - | - | - | - | - | - | - | - | - |
| A2 | All-red time extension | - | - | - | - | - | - | - | - | - | - | - |
| A3 | Chevron alignment markers (CAMs) | - | - | - | - | - | - | - | - | - | - | - |
| A4 | Curve warning signs | - | - | - | - | - | - | - | - | - | - | - |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - | - | - | - | - |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A7 | Parking bans | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A8 | Pedestrian fencing | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A9 | Raised reflective pavement markers (RRPMs) | - | - | - | - | - | - | - | - | - | - | - |
| A10 | Reinstate shoulder | - | - | - | - | - | - | - | - | - | - | - |
| A11 | Restrict access points | - | - | - | - | - | - | - | - | - | - | - |
| A12 | Separation lines | - | - | - | - | - | - | - | - | - | - | - |
| A13 | Sight distance improvements – intersections | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A14 | Sight distance improvements – road sections | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A15 | Speed limit change | - | - | - | - | - | - | - | - | - | - | - |
| A16 | Traffic signals operation review | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A17 | Turn bans | - | - | - | - | - | - | - | - | - | - | - |
| A18 | Warning signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | | | | | |
| B1 | Barrier lines | - | - | - | - | - | - | - | - | - | - | - |
| B2 | Bicycle facilities – on-road | - | - | - | - | - | - | - | - | - | - | - |
| B3 | Clear zone widening | - | - | - | - | - | - | - | - | - | - | - |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - | - | - | - | - |
| B6 | Edge drop removal | - | - | - | - | - | - | - | - | - | - | - |
| B7 | Edge lines | - | - | - | - | - | - | - | - | - | - | - |
| B8 | Guideposts | - | - | - | - | - | - | - | - | - | - | - |
| B9 | Curb extensions | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B10 | Painted/flush median | - | - | - | - | - | - | - | - | - | - | - |
| B11 | Pedestrian refuge island | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B12 | Profile line marking | - | - | - | - | - | - | - | - | - | - | - |
| B13 | Raised pedestrian crossings | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B14 | Red light cameras | - | - | - | - | - | - | - | - | - | - | - |
| B15 | Remove vegetation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B16 | Safety barriers | - | - | - | - | - | - | - | - | - | - | - |
| B17 | Signal display visibility improvements | - | - | - | - | - | - | - | - | - | - | - |
| B18 | Skid resistance improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B19 | Traffic signals coordination | - | - | - | - | - | - | - | - | - | - | - |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C3 | Median break closure | - | - | - | - | - | - | - | - | - | - | - |
| C4 | Painted turn lanes | - | - | - | - | - | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | - | - | - | - | - | - | - | - | - | - | - |
| C6 | Splitter islands | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C7 | Street lighting | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C8 | Traffic lane widening | - | - | - | - | - | - | - | - | - | - | - |
| C9 | Vehicle activated signs | - | - | - | - | - | - | - | - | - | - | - |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - | - | - | - | - |
| D2 | Fully controlled right turn phase | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Group E: Cost rating over \$100,000 | | | | | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | - | - | - | - | - | - | - | - |
| E2 | Curve widening | - | - | - | - | - | - | - | - | - | - | - |
| E3 | Grade separation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E4 | Indented parking | - | - | - | - | - | - | - | - | - | - | - |
| E5 | Median retrofit | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E6 | Pedestrian improvements at slip lanes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E7 | Pedestrian signals | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - | - | - | - | - |
| E9 | Road realignment | - | - | - | - | - | - | - | - | - | - | - |
| E10 | Roundabouts | - | - | - | - | - | - | - | - | - | - | - |
| E11 | Shoulder widening and/or sealing | - | - | - | - | - | - | - | - | - | - | - |
| E12 | Slip lane angle modification | - | - | - | - | - | - | - | - | - | - | - |
| E13 | Staggered intersection | - | - | - | - | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | - | - | - | - | - | - | - | - | - | - | - |
| E15 | Traffic signals | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E16 | Turn lanes | - | - | - | - | - | - | - | - | - | - | - |

Table 20 Summary of treatments for entering from adjacent directions crashes

| Code | Measures | Collision codes related to Entering from adjacent directions | | | | | | | | | |
|--|---|--|-----|-----|-----|-----|-----|-----|-----|-----|---|
| | | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | |
| Group A: Cost rating under \$5,000 | | | | | | | | | | | |
| A1 | Advisory speed signs | - | - | - | - | - | - | - | - | - | - |
| A2 | All-red time extension | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A3 | Chevron alignment markers (CAMs) | - | - | - | - | - | - | - | - | - | - |
| A4 | Curve warning signs | - | - | - | - | - | - | - | - | - | - |
| A5 | Give Way/Stop signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A7 | Parking bans | - | - | - | - | - | - | - | - | - | - |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | - | - | - | - | - | - | - | - | - | - |
| A10 | Reinstate shoulder | - | - | - | - | - | - | - | - | - | - |
| A11 | Restrict access points | - | - | - | - | - | - | - | - | - | - |
| A12 | Separation lines | - | - | - | - | - | - | - | - | - | - |
| A13 | Sight distance improvements – intersections | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A14 | Sight distance improvements – road sections | - | - | - | - | - | - | - | - | - | - |
| A15 | Speed limit change | - | - | - | - | - | - | - | - | - | - |
| A16 | Traffic signals operation review | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A17 | Turn bans | - | - | - | - | - | - | - | - | - | - |
| A18 | Warning signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | | | | |
| B1 | Barrier lines | - | - | - | - | - | - | - | - | - | - |
| B2 | Bicycle facilities – on-road | - | - | - | - | - | - | - | - | - | - |
| B3 | Clear zone widening | - | - | - | - | - | - | - | - | - | - |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - | - | - | - |
| B6 | Edge drop removal | - | - | - | - | - | - | - | - | - | - |
| B7 | Edge lines | - | - | - | - | - | - | - | - | - | - |
| B8 | Guideposts | - | - | - | - | - | - | - | - | - | - |
| B9 | Curb extensions | - | - | - | - | - | - | - | - | - | - |
| B10 | Painted/flush median | - | - | - | - | - | - | - | - | - | - |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | - | - | - | - | - | - | - |
| B13 | Raised pedestrian crossings | - | - | - | - | - | - | - | - | - | - |
| B14 | Red light cameras | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B15 | Remove vegetation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B16 | Safety barriers | - | - | - | - | - | - | - | - | - | - |
| B17 | Signal display visibility improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B18 | Skid resistance improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B19 | Traffic signals coordination | - | - | - | - | - | - | - | - | - | - |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | - | - | - | - | - | - | - | - | - | - |
| C3 | Median break closure | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C4 | Painted turn lanes | - | - | - | - | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | - | - | - | - | - | - | - | - | - | - |
| C6 | Splitter islands | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C7 | Street lighting | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C8 | Traffic lane widening | - | - | - | - | - | - | - | - | - | - |
| C9 | Vehicle activated signs | - | - | - | - | - | - | - | - | - | - |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - | - | - | - |
| D2 | Fully controlled right turn phase | - | - | - | - | - | - | - | - | - | - |
| Group E: Cost rating over \$100,000 | | | | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | - | - | - | - | - | - | - |
| E2 | Curve widening | - | - | - | - | - | - | - | - | - | - |
| E3 | Grade separation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E4 | Indented parking | - | - | - | - | - | - | - | - | - | - |
| E5 | Median retrofit | - | - | - | - | - | - | - | - | - | - |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - | - | - | - |
| E9 | Road realignment | - | - | - | - | - | - | - | - | - | - |
| E10 | Roundabouts | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E11 | Shoulder widening and/or sealing | - | - | - | - | - | - | - | - | - | - |
| E12 | Slip lane angle modification | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E13 | Staggered intersection | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E14 | Superelevation improvement | - | - | - | - | - | - | - | - | - | - |
| E15 | Traffic signals | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E16 | Turn lanes | - | - | - | - | - | - | - | - | - | - |

Table 21 Summary of treatments for opposing and turning vehicles crashes and head-on crashes

| Code | Measures | Opposing and turning vehicles crashes | | | | | Head-on crashes | |
|--|---|---------------------------------------|-----|-----|-----|-----|-----------------|-----|
| | | 202 | 203 | 204 | 205 | 206 | 201 | 501 |
| Group A: Cost rating under \$5,000 | | | | | | | | |
| A1 | Advisory speed signs | - | - | - | - | - | - | - |
| A2 | All-red time extension | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A3 | Chevron alignment markers (CAMs) | - | - | - | - | - | ✓ | ✓ |
| A4 | Curve warning signs | - | - | - | - | - | ✓ | ✓ |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A7 | Parking bans | - | - | - | - | - | - | - |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | - | - | - | - | - | ✓ | ✓ |
| A10 | Reinstate shoulder | - | - | - | - | - | ✓ | ✓ |
| A11 | Restrict access points | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A12 | Separation lines | - | - | - | - | - | ✓ | ✓ |
| A13 | Sight distance improvements – intersections | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A14 | Sight distance improvements – road sections | - | - | - | - | - | ✓ | ✓ |
| A15 | Speed limit change | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A16 | Traffic signals operation review | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A17 | Turn bans | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A18 | Warning signs | - | - | - | - | - | - | - |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | |
| B1 | Barrier lines | - | - | - | - | - | ✓ | ✓ |
| B2 | Bicycle facilities – on-road | - | - | - | - | - | - | - |
| B3 | Clear zone widening | - | - | - | - | - | - | - |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - |
| B6 | Edge drop removal | - | - | - | - | - | ✓ | ✓ |
| B7 | Edge lines | - | - | - | - | - | ✓ | ✓ |
| B8 | Guideposts | - | - | - | - | - | ✓ | ✓ |
| B9 | Curb extensions | - | - | - | - | - | - | - |
| B10 | Painted/flush median | - | - | - | - | - | ✓ | ✓ |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | - | - | ✓ | ✓ |
| B13 | Raised pedestrian crossings | - | - | - | - | - | - | - |
| B14 | Red light cameras | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B15 | Remove vegetation | - | - | - | - | - | - | - |
| B16 | Safety barriers | - | - | - | - | - | ✓ | ✓ |
| B17 | Signal display visibility improvements | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B18 | Skid resistance improvements | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B19 | Traffic signals coordination | - | - | - | - | - | - | - |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | - | - | - | - | - | - | - |
| C3 | Median break closure | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| C4 | Painted turn lanes | - | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | - | - | - | - | - | - | - |
| C6 | Splitter islands | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C7 | Street lighting | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C8 | Traffic lane widening | - | - | - | - | - | ✓ | ✓ |
| C9 | Vehicle activated signs | - | - | - | - | - | - | - |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - |
| D2 | Fully controlled right turn phase | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| Group E: Cost rating over \$100,000 | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | - | - | ✓ | ✓ |
| E2 | Curve widening | - | - | - | - | - | - | - |
| E3 | Grade separation | - | - | - | - | - | - | - |
| E4 | Indented parking | - | - | - | - | - | - | - |
| E5 | Median retrofit | - | - | - | - | - | ✓ | ✓ |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - |
| E9 | Road realignment | - | - | - | - | - | ✓ | ✓ |
| E10 | Roundabouts | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E11 | Shoulder widening and/or sealing | - | - | - | - | - | ✓ | ✓ |
| E12 | Slip lane angle modification | - | - | - | - | - | - | - |
| E13 | Staggered intersection | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | - | - | - | - | - | - | - |
| E15 | Traffic signals | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E16 | Turn lanes | - | - | - | - | - | - | - |

Table 22 Summary of treatments for lane change/sideswipe and loss of control on turns crashes

| Code | Measures | Lane change/sideswipe | | | | | | Loss of control on turns | | | |
|--|---|-----------------------|-----|-----|-----|-----|-----|--------------------------|-----|-----|-----|
| | | 305 | 306 | 307 | 308 | 309 | 310 | 706 | 707 | 805 | 806 |
| Group A: Cost rating under \$5,000 | | | | | | | | | | | |
| A1 | Advisory speed signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A2 | All-red time extension | - | - | - | - | - | - | - | - | - | - |
| A3 | Chevron alignment markers (CAMs) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| A4 | Curve warning signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - | - | - | - |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A7 | Parking bans | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | - | - | - | - | - | - | - | - | - | - |
| A10 | Reinstate shoulder | - | - | - | - | - | - | - | - | - | - |
| A11 | Restrict access points | - | - | - | - | - | - | - | - | - | - |
| A12 | Separation lines | - | - | - | - | - | - | - | - | - | - |
| A13 | Sight distance improvements – intersections | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| A14 | Sight distance improvements – road sections | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A15 | Speed limit change | - | - | - | - | - | - | - | - | - | - |
| A16 | Traffic signals operation review | - | - | - | - | - | - | - | - | - | - |
| A17 | Turn bans | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| A18 | Warning signs | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | | | | |
| B1 | Barrier lines | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| B2 | Bicycle facilities – on-road | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| B3 | Clear zone widening | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B6 | Edge drop removal | - | - | - | - | - | - | - | - | - | - |
| B7 | Edge lines | - | - | - | - | - | - | - | - | - | - |
| B8 | Guideposts | - | - | - | - | - | - | - | - | - | - |
| B9 | Curb extensions | - | - | - | - | - | - | - | - | - | - |
| B10 | Painted/flush median | - | - | - | - | - | - | - | - | - | - |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | - | - | - | - | - | - | - |
| B13 | Raised pedestrian crossings | - | - | - | - | - | - | - | - | - | - |
| B14 | Red light cameras | - | - | - | - | - | - | - | - | - | - |
| B15 | Remove vegetation | - | - | - | - | - | - | - | - | - | - |
| B16 | Safety barriers | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B17 | Signal display visibility improvements | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| B18 | Skid resistance improvements | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| B19 | Traffic signals coordination | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | - | - | - | - | - | - | - | - | - | - |
| C3 | Median break closure | - | - | - | - | - | - | - | - | - | - |
| C4 | Painted turn lanes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C5 | Pavement drainage improvements | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| C6 | Splitter islands | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| C7 | Street lighting | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| C8 | Traffic lane widening | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C9 | Vehicle activated signs | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| D2 | Fully controlled right turn phase | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| Group E: Cost rating over \$100,000 | | | | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | - | - | - | - | - | - | - |
| E2 | Curve widening | - | - | - | - | - | - | - | - | - | - |
| E3 | Grade separation | - | - | - | - | - | - | - | - | - | - |
| E4 | Indented parking | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| E5 | Median retrofit | - | - | - | - | - | - | - | - | - | - |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - | - | - | - |
| E9 | Road realignment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E10 | Roundabouts | - | - | - | - | - | - | ✓ | ✓ | ✓ | ✓ |
| E11 | Shoulder widening and/or sealing | - | - | - | - | - | - | - | - | - | - |
| E12 | Slip lane angle modification | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E13 | Staggered intersection | - | - | - | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - | - | - |
| E15 | Traffic signals | - | - | - | - | - | - | - | - | - | - |
| E16 | Turn lanes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

Table 23 Summary of treatments for parking vehicles crashes and entering from driveway crashes

| Code | Measures | Parked/parking vehicles | | | | | | | | Entering... | | |
|--|---|-------------------------|-----|-----|-----|-----|-----|-----|-----|-------------|-----|-----|
| | | 401 | 402 | 403 | 404 | 405 | 601 | 602 | 603 | 606 | 406 | 407 |
| Group A: Cost rating under \$5,000 | | | | | | | | | | | | |
| A1 | Advisory speed signs | - | - | - | - | - | - | - | - | - | - | - |
| A2 | All-red time extension | - | - | - | - | - | - | - | - | - | - | - |
| A3 | Chevron alignment markers (CAMs) | - | - | - | - | - | - | - | - | - | - | - |
| A4 | Curve warning signs | - | - | - | - | - | - | - | - | - | - | - |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - | - | - | - | - |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A7 | Parking bans | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | - | - | - | - | - | - | - | - | - | - | - |
| A10 | Reinstate shoulder | - | - | - | - | - | - | - | - | - | - | - |
| A11 | Restrict access points | - | - | - | - | - | - | - | - | - | ✓ | ✓ |
| A12 | Separation lines | - | - | - | - | - | - | - | - | - | - | - |
| A13 | Sight distance improvements – intersections | - | - | - | - | - | - | - | - | - | ✓ | ✓ |
| A14 | Sight distance improvements – road sections | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A15 | Speed limit change | - | - | - | - | - | - | - | - | - | - | - |
| A16 | Traffic signals operation review | - | - | - | - | - | - | - | - | - | - | - |
| A17 | Turn bans | - | - | - | - | - | - | - | - | - | - | - |
| A18 | Warning signs | - | - | - | - | - | - | - | - | - | ✓ | ✓ |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | | | | | |
| B1 | Barrier lines | - | - | - | - | - | - | - | - | - | ✓ | ✓ |
| B2 | Bicycle facilities – on-road | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B3 | Clear zone widening | - | - | - | - | - | - | - | - | - | - | - |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - | - | - | - | - |
| B6 | Edge drop removal | - | - | - | - | - | - | - | - | - | - | - |
| B7 | Edge lines | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B8 | Guideposts | - | - | - | - | - | - | - | - | - | - | - |
| B9 | Curb extensions | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B10 | Painted/flush median | - | - | - | - | - | - | - | - | - | - | - |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | - | - | - | - | - | - | - | - |
| B13 | Raised pedestrian crossings | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B14 | Red light cameras | - | - | - | - | - | - | - | - | - | - | - |
| B15 | Remove vegetation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B16 | Safety barriers | - | - | - | - | - | - | - | - | - | - | - |
| B17 | Signal display visibility improvements | - | - | - | - | - | - | - | - | - | - | - |
| B18 | Skid resistance improvements | - | - | - | - | - | - | - | - | - | - | - |
| B19 | Traffic signals coordination | - | - | - | - | - | - | - | - | - | - | - |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| C3 | Median break closure | - | - | - | - | - | - | - | - | - | - | - |
| C4 | Painted turn lanes | - | - | - | - | - | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | - | - | - | - | - | - | - | - | - | - | - |
| C6 | Splitter islands | - | - | - | - | - | - | - | - | - | - | - |
| C7 | Street lighting | - | - | - | - | - | - | - | - | - | - | - |
| C8 | Traffic lane widening | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| C9 | Vehicle activated signs | - | - | - | - | - | - | - | - | - | - | - |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - | - | - | ✓ | ✓ |
| D2 | Fully controlled right turn phase | - | - | - | - | - | - | - | - | - | - | - |
| Group E: Cost rating over \$100,000 | | | | | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | - | - | - | - | - | - | - | - |
| E2 | Curve widening | - | - | - | - | - | - | - | - | - | - | - |
| E3 | Grade separation | - | - | - | - | - | - | - | - | - | - | - |
| E4 | Indented parking | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E5 | Median retrofit | - | - | - | - | - | - | - | - | - | - | - |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - | - | - | - | - |
| E9 | Road realignment | - | - | - | - | - | - | - | - | - | - | - |
| E10 | Roundabouts | - | - | - | - | - | - | - | - | - | - | - |
| E11 | Shoulder widening and/or sealing | - | - | - | - | - | - | - | - | - | ✓ | ✓ |
| E12 | Slip lane angle modification | - | - | - | - | - | - | - | - | - | - | - |
| E13 | Staggered intersection | - | - | - | - | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | - | - | - | - | - | - | - | - | - | - | - |
| E15 | Traffic signals | - | - | - | - | - | - | - | - | - | - | - |
| E16 | Turn lanes | - | - | - | - | - | - | - | - | - | - | - |

Table 24 Summary of treatments for rear-end crashes and run-off-road on straight crashes

| Code | Measures | Rear-end | | | Run-off-road on straight | | | | | |
|--|---|----------|-----|-----|--------------------------|-----|-----|-----|-----|-----|
| | | 301 | 302 | 303 | 700 | 701 | 702 | 703 | 704 | 705 |
| Group A: Cost rating under \$5,000 | | | | | | | | | | |
| A1 | Advisory speed signs | - | - | - | - | - | - | - | - | - |
| A2 | All-red time extension | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| A3 | Chevron alignment markers (CAMs) | - | - | - | - | - | - | - | - | - |
| A4 | Curve warning signs | - | - | - | - | - | - | - | - | - |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - | - | - |
| A6 | Line marking improvements | - | - | - | - | - | - | - | - | - |
| A7 | Parking bans | - | - | - | - | - | - | - | - | - |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A10 | Reinstate shoulder | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A11 | Restrict access points | - | - | - | - | - | - | - | - | - |
| A12 | Separation lines | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A13 | Sight distance improvements – intersections | - | - | - | - | - | - | - | - | - |
| A14 | Sight distance improvements – road sections | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A15 | Speed limit change | - | - | - | - | - | - | - | - | - |
| A16 | Traffic signals operation review | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| A17 | Turn bans | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| A18 | Warning signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | | | |
| B1 | Barrier lines | - | - | - | - | - | - | - | - | - |
| B2 | Bicycle facilities – on-road | - | - | - | - | - | - | - | - | - |
| B3 | Clear zone widening | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - | - | - |
| B6 | Edge drop removal | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B7 | Edge lines | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B8 | Guideposts | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B9 | Curb extensions | - | - | - | - | - | - | - | - | - |
| B10 | Painted/flush median | - | - | - | - | - | - | - | - | - |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B13 | Raised pedestrian crossings | - | - | - | - | - | - | - | - | - |
| B14 | Red light cameras | - | - | - | - | - | - | - | - | - |
| B15 | Remove vegetation | - | - | - | - | - | - | - | - | - |
| B16 | Safety barriers | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B17 | Signal display visibility improvements | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| B18 | Skid resistance improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B19 | Traffic signals coordination | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| C3 | Median break closure | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| C4 | Painted turn lanes | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C6 | Splitter islands | - | - | - | - | - | - | - | - | - |
| C7 | Street lighting | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| C8 | Traffic lane widening | - | - | - | - | - | - | - | - | - |
| C9 | Vehicle activated signs | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - | - | - |
| D2 | Fully controlled right turn phase | - | - | - | - | - | - | - | - | - |
| Group E: Cost rating over \$100,000 | | | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E2 | Curve widening | - | - | - | - | - | - | - | - | - |
| E3 | Grade separation | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| E4 | Indented parking | - | - | - | - | - | - | - | - | - |
| E5 | Median retrofit | - | - | - | - | - | - | - | - | - |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - | - | - |
| E9 | Road realignment | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E10 | Roundabouts | ✓ | ✓ | ✓ | - | - | - | - | - | - |
| E11 | Shoulder widening and/or sealing | - | - | - | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E12 | Slip lane angle modification | - | - | - | - | - | - | - | - | - |
| E13 | Staggered intersection | - | - | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | - | - | - | - | - | - | - | - | - |
| E15 | Traffic signals | - | - | - | - | - | - | - | - | - |
| E16 | Turn lanes | ✓ | ✓ | ✓ | - | - | - | - | - | - |

Table 25 Summary of treatments for run-off-road on curve, vehicle-animal and vehicle-train crashes

| Code | Measures | Run-off-road on curve | | | | | Vehicle-animal | Vehicle-train |
|--|---|-----------------------|-----|-----|-----|-----|----------------|---------------|
| | | 800 | 801 | 802 | 803 | 804 | 607 | 902 |
| Group A: Cost rating under \$5,000 | | | | | | | | |
| A1 | Advisory speed signs | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A2 | All-red time extension | - | - | - | - | - | - | - |
| A3 | Chevron alignment markers (CAMs) | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A4 | Curve warning signs | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | - | ✓ |
| A7 | Parking bans | - | - | - | - | - | - | - |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A10 | Reinstate shoulder | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - |
| A11 | Restrict access points | - | - | - | - | - | - | - |
| A12 | Separation lines | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A13 | Sight distance improvements – intersections | - | - | - | - | - | - | ✓ |
| A14 | Sight distance improvements – road sections | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A15 | Speed limit change | - | - | - | - | - | - | - |
| A16 | Traffic signals operation review | - | - | - | - | - | - | ✓ |
| A17 | Turn bans | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A18 | Warning signs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | |
| B1 | Barrier lines | - | - | - | - | - | - | - |
| B2 | Bicycle facilities – on-road | - | - | - | - | - | - | - |
| B3 | Clear zone widening | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - |
| B4 | Crash cushion/impact attenuator | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - |
| B6 | Edge drop removal | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - |
| B7 | Edge lines | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B8 | Guideposts | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B9 | Curb extensions | - | - | - | - | - | - | - |
| B10 | Painted/flush median | - | - | - | - | - | - | - |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | - | - | - | - |
| B13 | Raised pedestrian crossings | - | - | - | - | - | - | - |
| B14 | Red light cameras | - | - | - | - | - | - | - |
| B15 | Remove vegetation | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B16 | Safety barriers | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B17 | Signal display visibility improvements | - | - | - | - | - | - | - |
| B18 | Skid resistance improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B19 | Traffic signals coordination | - | - | - | - | - | - | ✓ |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | - | - | - | - | - | - | - |
| C3 | Median break closure | - | - | - | - | - | - | - |
| C4 | Painted turn lanes | - | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| C6 | Splitter islands | - | - | - | - | - | - | - |
| C7 | Street lighting | - | - | - | - | - | - | - |
| C8 | Traffic lane widening | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| C9 | Vehicle activated signs | ✓ | ✓ | ✓ | ✓ | ✓ | - | ✓ |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - |
| D2 | Fully controlled right turn phase | - | - | - | - | - | - | - |
| Group E: Cost rating over \$100,000 | | | | | | | | |
| E1 | Additional lanes for overtaking | - | - | - | - | - | - | - |
| E2 | Curve widening | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E3 | Grade separation | - | - | - | - | - | - | - |
| E4 | Indented parking | - | - | - | - | - | - | - |
| E5 | Median retrofit | - | - | - | - | - | - | - |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | ✓ |
| E9 | Road realignment | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E10 | Roundabouts | - | - | - | - | - | - | - |
| E11 | Shoulder widening and/or sealing | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | - |
| E12 | Slip lane angle modification | - | - | - | - | - | - | - |
| E13 | Staggered intersection | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E15 | Traffic signals | - | - | - | - | - | - | - |
| E16 | Turn lanes | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |

Table 26 Summary of treatments for overtaking and u-turning crashes

| Code | Measures | While overtaking | | | | | While u-turning | |
|--|---|------------------|-----|-----|-----|-----|-----------------|-----|
| | | 502 | 504 | 505 | 507 | 508 | 207 | 304 |
| Group A: Cost rating under \$5,000 | | | | | | | | |
| A1 | Advisory speed signs | - | - | - | - | - | - | - |
| A2 | All-red time extension | - | - | - | - | - | - | - |
| A3 | Chevron alignment markers (CAMs) | - | - | - | - | - | - | - |
| A4 | Curve warning signs | - | - | - | - | - | - | - |
| A5 | Give Way/Stop signs | - | - | - | - | - | - | - |
| A6 | Line marking improvements | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| A7 | Parking bans | - | - | - | - | - | - | - |
| A8 | Pedestrian fencing | - | - | - | - | - | - | - |
| A9 | Raised reflective pavement markers (RRPMs) | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A10 | Reinstate shoulder | - | - | - | - | - | - | - |
| A11 | Restrict access points | - | - | - | - | - | - | - |
| A12 | Separation lines | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A13 | Sight distance improvements – intersections | - | - | - | - | - | ✓ | ✓ |
| A14 | Sight distance improvements – road sections | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A15 | Speed limit change | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| A16 | Traffic signals operation review | - | - | - | - | - | - | - |
| A17 | Turn bans | - | - | - | - | - | ✓ | ✓ |
| A18 | Warning signs | - | - | - | - | - | - | - |
| Group B: Cost rating \$5,001 - \$20,000 | | | | | | | | |
| B1 | Barrier lines | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| B2 | Bicycle facilities – on-road | - | - | - | - | - | - | - |
| B3 | Clear zone widening | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B4 | Crash cushion/impact attenuator | - | - | - | - | - | - | - |
| B5 | Direction signs (guide signs) | - | - | - | - | - | - | - |
| B6 | Edge drop removal | - | - | - | - | - | - | - |
| B7 | Edge lines | - | - | - | - | - | - | - |
| B8 | Guideposts | - | - | - | - | - | - | - |
| B9 | Curb extensions | - | - | - | - | - | - | - |
| B10 | Painted/flush median | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B11 | Pedestrian refuge island | - | - | - | - | - | - | - |
| B12 | Profile line marking | - | - | - | - | - | - | - |
| B13 | Raised pedestrian crossings | - | - | - | - | - | - | - |
| B14 | Red light cameras | - | - | - | - | - | - | - |
| B15 | Remove vegetation | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B16 | Safety barriers | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| B17 | Signal display visibility improvements | - | - | - | - | - | ✓ | ✓ |
| B18 | Skid resistance improvements | - | - | - | - | - | - | - |
| B19 | Traffic signals coordination | - | - | - | - | - | - | - |
| Group C: Cost rating \$20,001 - \$50,000 | | | | | | | | |
| C1 | Combine access points | - | - | - | - | - | - | - |
| C2 | Convert angle parking to parallel parking | - | - | - | - | - | - | - |
| C3 | Median break closure | - | - | - | - | - | ✓ | ✓ |
| C4 | Painted turn lanes | - | - | - | - | - | - | - |
| C5 | Pavement drainage improvements | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| C6 | Splitter islands | - | - | - | - | - | - | - |
| C7 | Street lighting | - | - | - | - | - | ✓ | ✓ |
| C8 | Traffic lane widening | - | - | - | - | - | ✓ | ✓ |
| C9 | Vehicle activated signs | - | - | - | - | - | - | - |
| Group D: Cost rating \$50,001 - \$100,000 | | | | | | | | |
| D1 | Combine access points | - | - | - | - | - | - | - |
| D2 | Fully controlled right turn phase | - | - | - | - | - | ✓ | ✓ |
| Group E: Cost rating over \$100,000 | | | | | | | | |
| E1 | Additional lanes for overtaking | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E2 | Curve widening | - | - | - | - | - | - | - |
| E3 | Grade separation | - | - | - | - | - | - | - |
| E4 | Indented parking | - | - | - | - | - | - | - |
| E5 | Median retrofit | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| E6 | Pedestrian improvements at slip lanes | - | - | - | - | - | - | - |
| E7 | Pedestrian signals | - | - | - | - | - | - | - |
| E8 | Railway crossing upgrade | - | - | - | - | - | - | - |
| E9 | Road realignment | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E10 | Roundabouts | - | - | - | - | - | ✓ | ✓ |
| E11 | Shoulder widening and/or sealing | ✓ | ✓ | ✓ | ✓ | ✓ | - | - |
| E12 | Slip lane angle modification | - | - | - | - | - | - | - |
| E13 | Staggered intersection | - | - | - | - | - | - | - |
| E14 | Superelevation improvement | - | - | - | - | - | - | - |
| E15 | Traffic signals | - | - | - | - | - | - | - |
| E16 | Turn lanes | - | - | - | - | - | - | - |

4.2 Application Improvement

ATRANS SafetyMap application was further improved to embed the road safety engineering toolkit into the application. The following subsections present the improvement of the application.

4.2.1 Collision Diagram Function

The crash types and collision diagrams presented in the previous works were used to develop the collision diagram function that allows the user to add and rotate the collision diagram in crash data and risk data. An example of a collision diagram input in crash reporting function is illustrated in Figure 6 when the results of collision diagrams reported in the application can be shown in Figure 7.

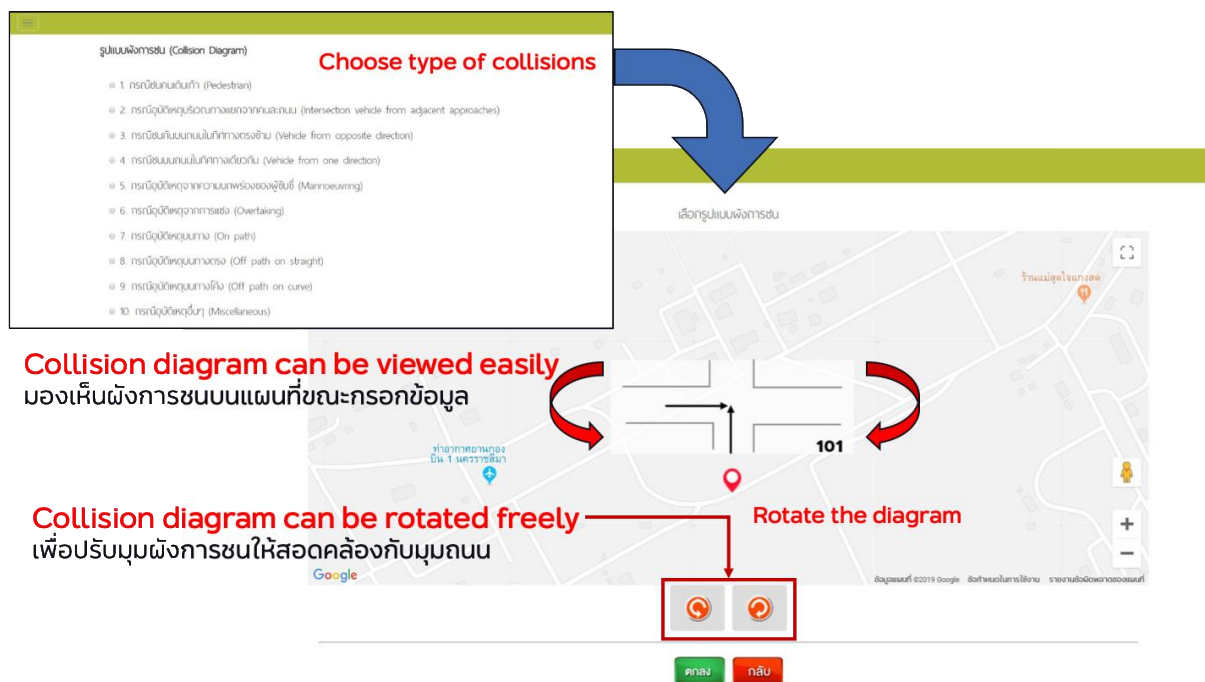


Figure 6 Example of collision diagram input in the crash reporting function

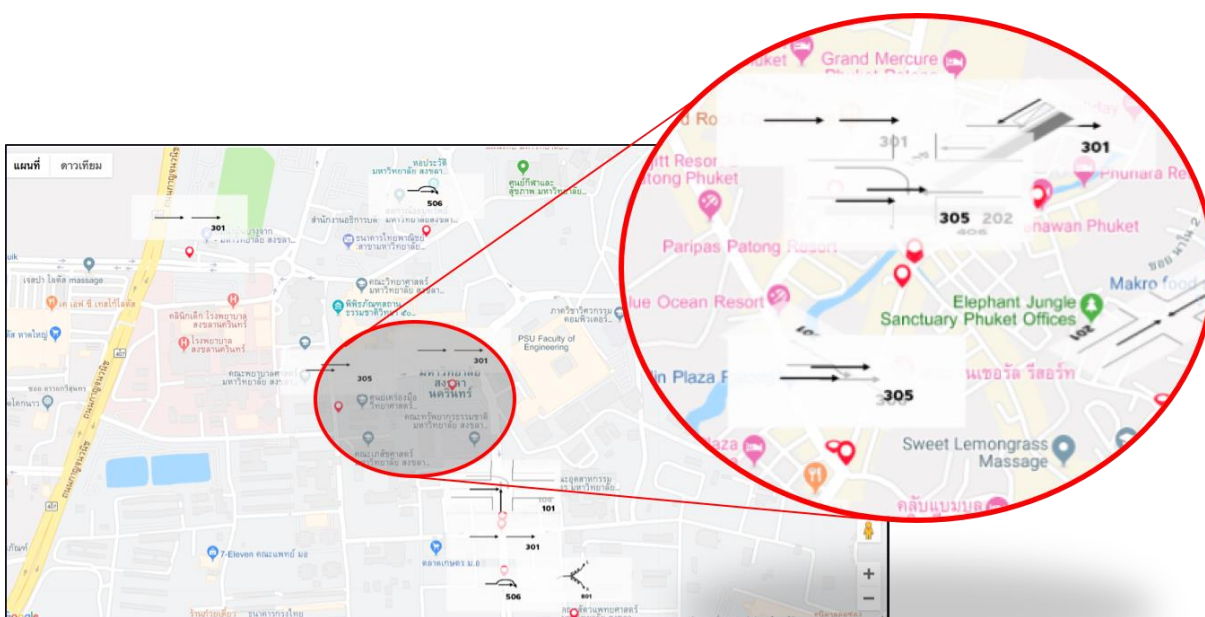


Figure 7 Collision diagrams reported in the application

4.2.2 Potential Collision Function

The collision diagrams were also applied to the risk location function by developing a potential collision subfunction, as shown in Figure 8. The user can identify possible collision types of the risk location by selecting the collision diagrams in Figure 8. Example results of the risk locations with potential collision diagrams are presented in Figure 9.

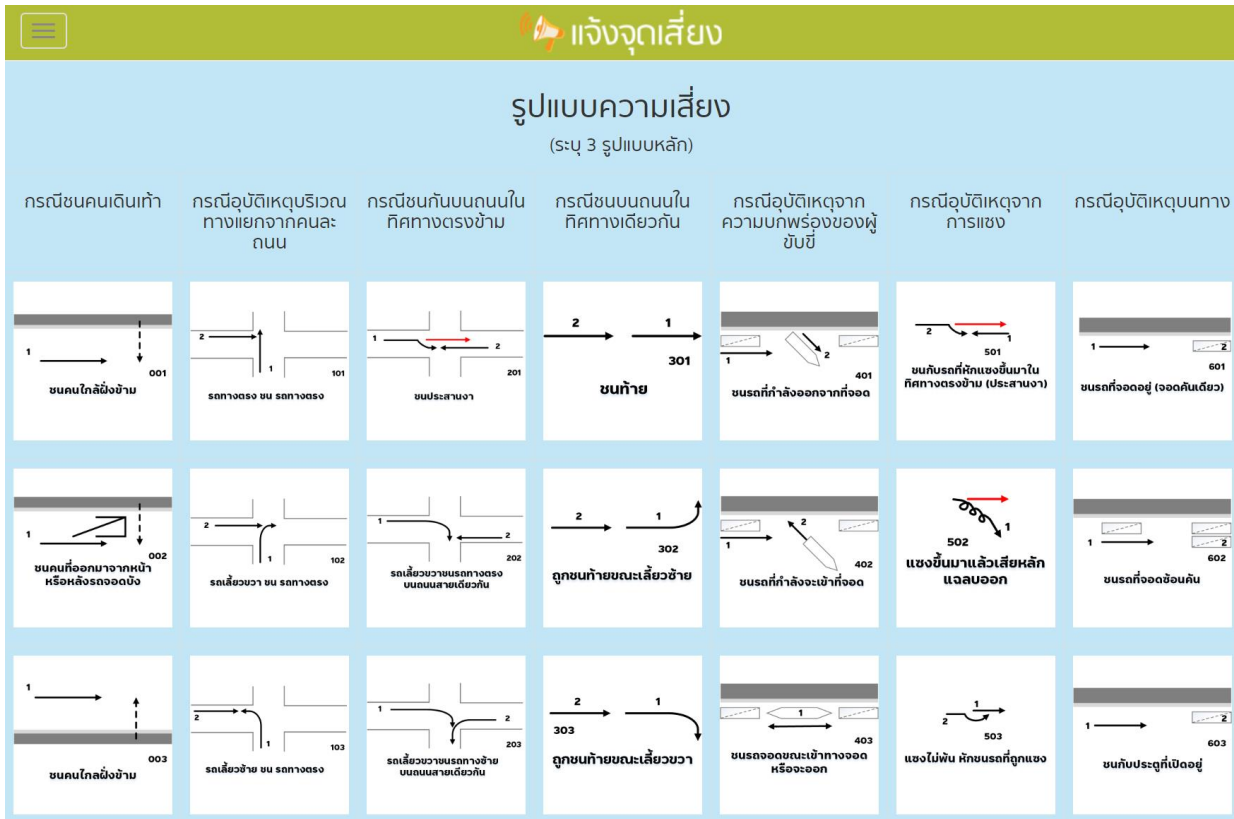


Figure 8 Example screen of Potential Collision Function

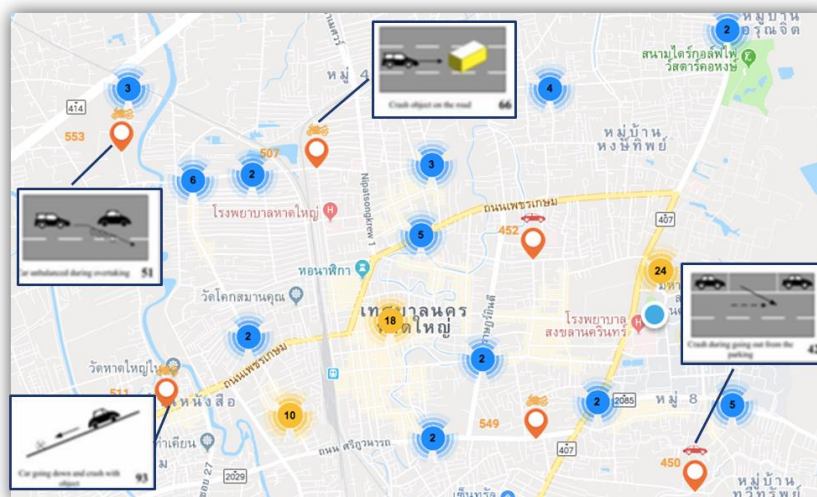


Figure 9 Example results of the risk locations with potential collision diagrams

4.2.3 Customized Hazardous Location Function

The hazardous location function developed in the previous year research was improved by customizing the factors related to the hazardous location identification. As shown in Figure 10, a user can manually identify hazardous locations by customizing the distance (i.e. radius) between neighboring crash locations, and the number of crash locations to be considered as a hazardous location. Note that this number was set to be 3 in the previous project. But this project allows the users to manually change based on their desired definition of the hazardous location. The results of a hazardous location (or boundary) can be presented by the estimated loss or by the center of a specific location.

Customized hazardous location function

ภาพรวมการรายงานจุดอันตราย

การระบุค่าความเสียหาย ปรมาณการความสูญเสีย (ตัวเงิน)

จังหวัด:

ระหว่างวันที่: ถึงวันที่:

รัศมี: Distance between neighboring locations

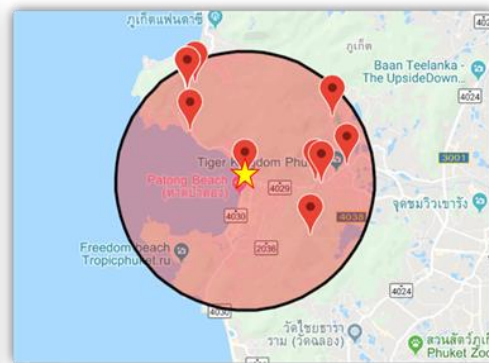
จำนวนจุดใกล้เคียง: No. crash locations



Results of hazardous locations



By the estimated loss



By the center of a specific location

Figure 10 Example results of Customized Hazardous Location Function

4.2.4 Crash Factor Matrix Function

Crash Factor Matrix Function was developed so that a user can retrieve factors related to the crashes within a specific area (location). An example is illustrated in Figure 11. It shows that the first part of the screen is the search menu bars allowing a user to select the start and end period of the crash data. The radius of a searching boundary is also allowed to input manually. Then, the map with a specific searching location (center location) and surrounding crash locations is displayed. The next section shows a table presenting several factors related to the crash locations which include the date, time, lighting, road surface, collision code, and vehicles involved. The last part is a summary of collision codes related to the crashes. These data would be basic information for road safety practitioners to identify effective safety measures to suit the specific location.

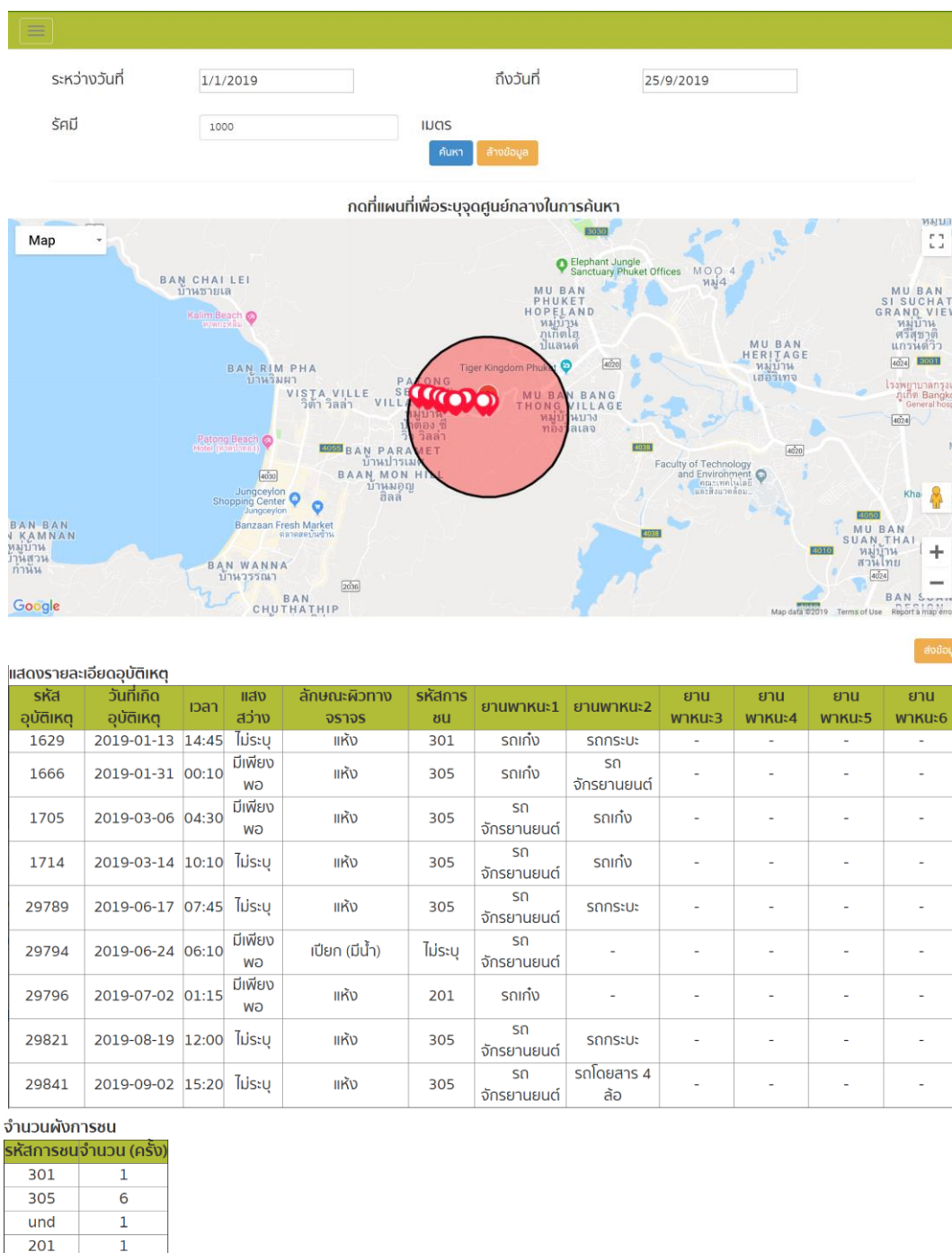


Figure 11 Example screen of Crash Factor Matrix Function

4.2.5 Executive Summary Report Function

Executive Summary Report Function has been developed allowing head staff of road safety agencies or practitioners in each province (e.g. provincial governor, police commander) to comprehensively retrieve and daily monitor the number of fatalities this year compared to the last year. An example screen is shown in Figure 12.

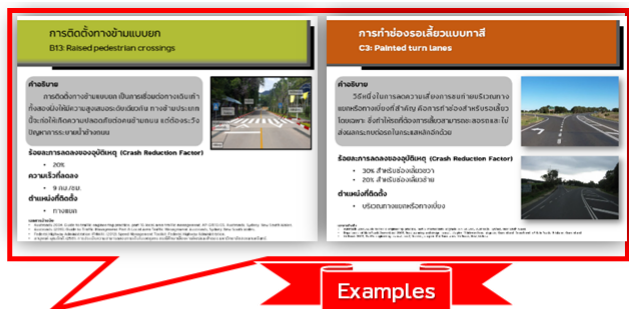
| Comparison | สรุปยอดเสียชีวิต ตั้งแต่ 1 มกราคม 2562 - จนถึงปัจจุบัน No. fatalities | | | |
|---------------------------|--|-------------------------|--------------------------|--|
| | Year | Annual | Daily | Av. fatalities rate/month |
| | ปี พ.ศ. | ยอดเสียชีวิตทั้งปี(ราย) | ยอดเสียชีวิตทั้งวัน(ราย) | อัตราการเสียชีวิตเฉลี่ยต่อเดือน(ราย/เดือน) |
| 2562 | | 7 | 7 | 1.00 |
| 2561 | | 13 | 9 | 1.08 |
| เปรียบเทียบ 2562 กับ 2561 | | -6 | -2 | วันที่ผ่านจากต้นปี: 201 วัน วันที่เหลือถึงสิ้นปี: 164 วัน |

| Vehicle type | Present ปี 2562 | | | Last year ปี 2561 | | |
|--------------------------|--------------------|--------|--------------------------|----------------------|--------|--------|
| | ประเภทผู้ใช้งาน | ภูเก็ต | ประเทศ | ประเภทผู้ใช้งาน | ภูเก็ต | ประเทศ |
| รถจักรยานยนต์ | 7 | 8 | รถจักรยานยนต์ | 12 | 50 | |
| บิ๊กไบค์ (400 cc ขึ้นไป) | 0 | 0 | บิ๊กไบค์ (400 cc ขึ้นไป) | 0 | 0 | |
| รถจักรยานยนต์พ่วงข้าง | 0 | 0 | รถจักรยานยนต์พ่วงข้าง | 0 | 0 | |
| รถจักรยาน | 0 | 0 | รถจักรยาน | 0 | 0 | |
| รถกึ่ง | 0 | 0 | รถกึ่ง | 1 | 9 | |
| กระบะ | 0 | 0 | กระบะ | 0 | 0 | |
| แท็กซี่ | 0 | 0 | แท็กซี่ | 0 | 0 | |
| 6 ล้อ | 0 | 0 | 6 ล้อ | 0 | 0 | |
| 10 ล้อ | 0 | 0 | 10 ล้อ | 0 | 0 | |

Figure 12 Example screen of Executive Summary Report Function

4.2.6 Road Safety Engineering Function

This function was developed to show (or guide) a list of potential road safety engineering measures based on the collision diagrams found in a specific hazardous (or risk) location. The example screen of the function is presented in Figure 13. Other road safety measures included in the application are presented in Appendix A.



Potential road safety measures

| รูปแบบการชน | รหัสการชน | จำนวน (ครั้ง) | ร้อยละ | มาตรการ | | | | |
|-------------|-----------|---------------|---------|--|---|---|---|--|
| | | | | กลุ่ม A (ค่าก่อสร้างน้อยกว่า 150,000 บาท) | กลุ่ม B (ค่าก่อสร้าง 150,000-600,000 บาท) | กลุ่ม C (ค่าก่อสร้าง 600,000-1,500,000 บาท) | กลุ่ม D (ค่าก่อสร้าง 1,500,000-3,000,000 บาท) | กลุ่ม E (ค่าก่อสร้างมากกว่า 3,000,000 บาท) |
| | 301 | 1 | 2.63% | A2,A6,A11,A13,A15,A16,A17 | B14,B17,B18 | C3,C6,C7 | D2 | E10,E15 |
| | 305 | 2 | 5.26% | A1,A3,A4,A6,A7,A14 | B1,B2,B3,B5,B16 | C4,C8 | | E4,E9,E12,E14,E16 |
| | 202 | 1 | 2.63% | A2,A6,A11,A13,A15,A16,A17 | B14,B17,B18 | C3,C6,C7 | D2 | E10,E15 |
| | 601 | 1 | 2.63% | | | | | |
| | 702 | 1 | 2.63% | A9,A10,A12,A14,A18 | B3 | B6,B7,B8,B12,B16,B18 | C5,C7 | |
| | 801 | 1 | 2.63% | A1,A3,A4,A6,A9,A10,A12,A14,A17,A18B3,B4,B6,B7,B8,B15,B16,B18 | | C5,C8,C9 | | E2,E9,E11,E14,E16 |
| ไม่ระบุ | 31 | | 81.58% | | | | | |
| รวม | 38 | | 100.00% | | | | | |

Figure 13 Example screen of Road Safety Engineering Function

4.3 Application Demonstration and Workshops

The developed application was demonstrated to the potential users for crash data reporting through several workshops, as shown in Figure 14. The main purposes of the workshops are to allow potential users in communities to understand the importance of crash data for road safety enhancement and reporting crash data in their responsible areas.

Prince of Songkla University



- 1st: 5th April 2019
- 19 traffic personals

Songkhla province



- 20th November 2019
- 30 road safety staffs in Songkhla



- 2nd: 22th November 2019
- 16 traffic personals

Figure 14 Application demonstration and workshops for traffic and road safety-related agencies

Also, the application was demonstrated to the students in PSU, Chainat technical college and Suphanburi technical college, Figure 15, in the hope that they would report risk (Hiyari) locations in their communities.

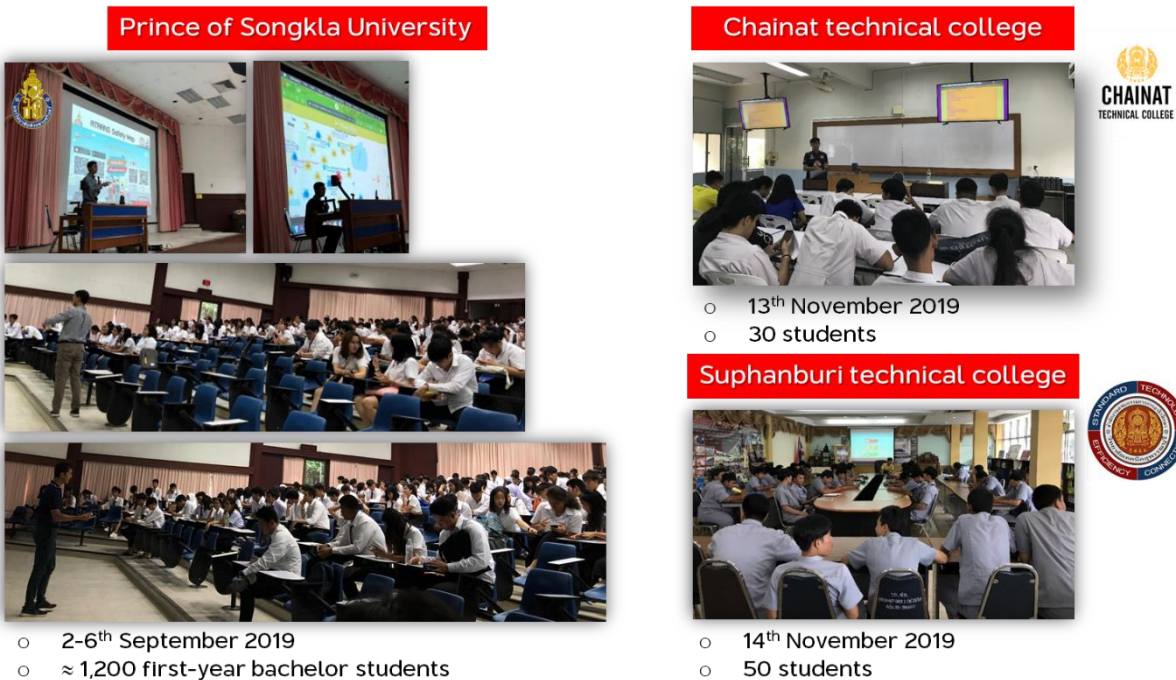


Figure 15 Application demonstration and workshops for students

4.4 Crash Data Collection and Analysis

The improved application was used to collect the primary crash data and collision diagram reported by police officers in the Phuket study area. Also, secondary crash data from other potential sources, e.g. Department of Highways (DOH) were collected and inputted in the application.

From the crashes that occurred during October 2016 – September 2019 (3-year crash data), the top five hazardous locations in Phuket were analyzed using the application. The results show in Figure 16. The top two locations are those identified and reported in the previous year's research project. Therefore, in this research, the other three hazardous locations were investigated. Traffic volume and speed data were also collected. The details are as follows.

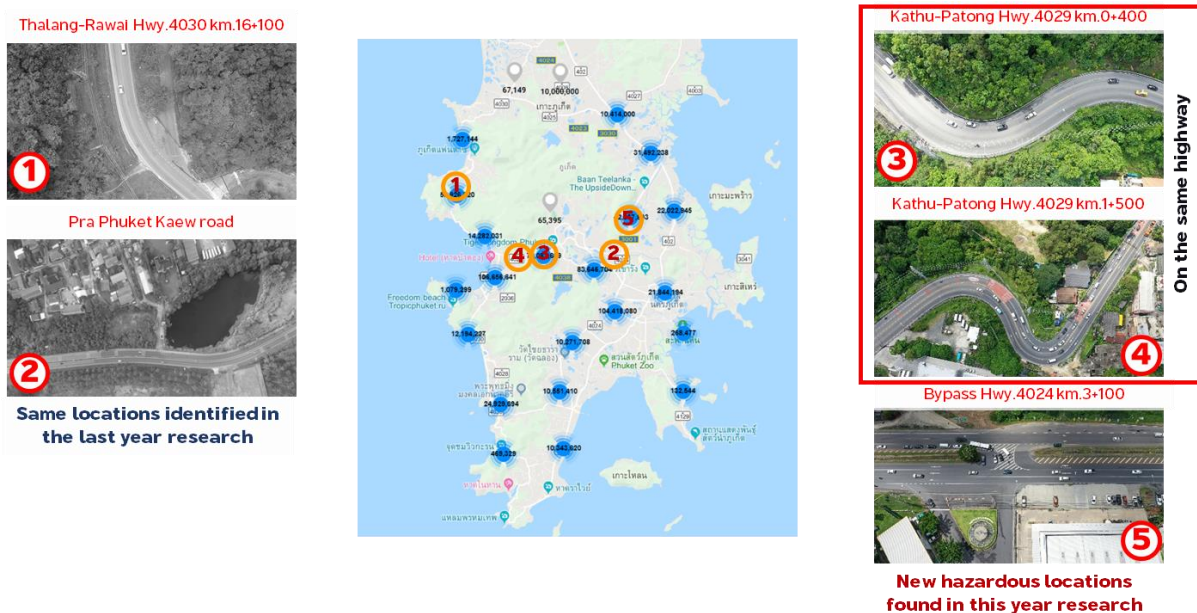


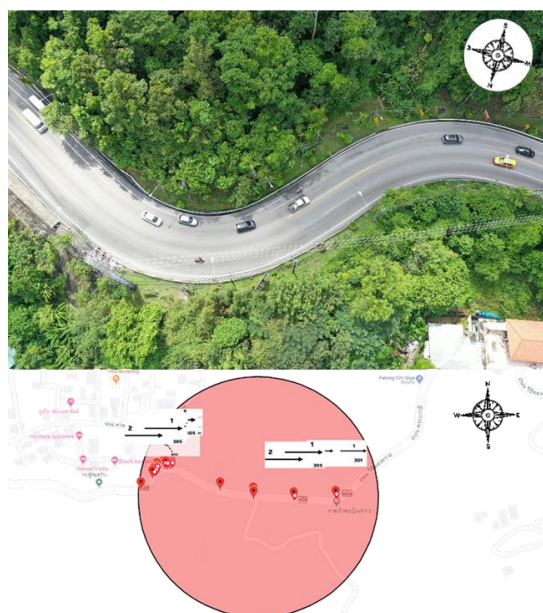
Figure 16 Top five hazardous locations identified in Phuket

4.4.1 Kathu-Patong Highway No. 4029 km. 0+400

Kathu-Patong Highway No. 4029 km. 0+400 is the mountainous road section connecting between Kathu district and Patong beach, which is one of the most attractive tourist areas. The study section (km. 0+400) is the mountainous section with a reverse curve as shown in Figure 17. From the database of ATRANS Safety Map, there were 24 crashes in the last three years. Considering the crash pattern, more than half were the rear end and sideswipe (30% each), followed by off-path on a curve (20%), off carriageway (10%), and head-on (10%), respectively. Regarding the vehicles involved, the motorcycle (57%) mainly involved in the crashes. Two of them (8% of all casualties) died.

Figure 18 shows the results of traffic volume and speed studies conducted on 25th October 2019, from 11:15 a.m. to 12:15 p.m. The traffic volume during the study period was 3,756 vehicles per hour with the traffic composition: passenger car 59%, motorcycle 39%, and the others 2%. Regarding the 85th percentile of vehicle speed from the speed study, it was found that the passenger car speeds (40.5 kph for inbound and 38 kph for outbound) were over a safe speed (assume 30 kph for the case that a passenger car probably hit a motorcycle). Also, the motorcycle speeds (46 kph for inbound and 42 kph for outbound) were over a safe speed (assume 30 kph for the case that a motorcycle was probably hit by another car).

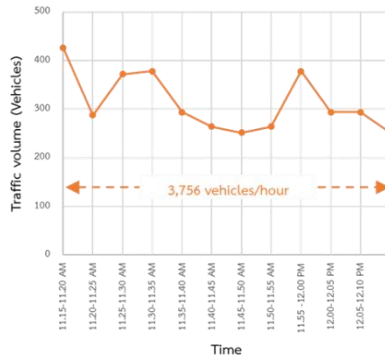
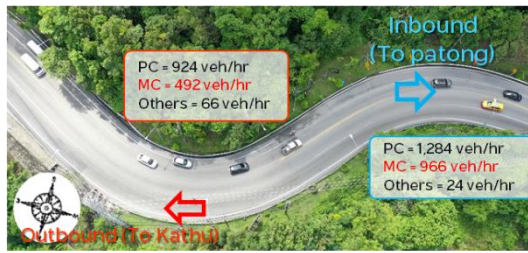
From the traffic volume, speed, and crash data and the site investigation, road safety measures to improve this hazardous location were studied and designed. The preliminary measures can be illustrated in Figure 19. The measures include improving traffic line marking and painted markings on the road surface, installing separated motorcycle lanes on both side shoulders with traffic poles and motorcycle barriers. Note that the installation of traffic poles or concrete barriers along the median could be considered where is appropriate and safe. The preliminary results of the benefit and cost analysis of the proposed road safety improvement are presented in Appendix B (Figure B1).



| Case | Crash ID | Date | Time | Lighting | Surface | Collision code | No. casualties | | | Vehicle 1 | Vehicle 2 |
|--------------|----------|-----------|-------|------------|---------|----------------|----------------|----------|-----------|------------|---------------|
| | | | | | | | Fatal | Serious | Slight | | |
| 1 | 608 | 3/2/2018 | 19:00 | Sufficient | Dry | N/A | 0 | 0 | 0 | Pickup | 4 wheeler bus |
| 2 | 643 | 9/2/2018 | 12:10 | N/A | Dry | N/A | 0 | 0 | 2 | Motorcycle | - |
| 3 | 711 | 19/2/2018 | 12:00 | N/A | Dry | N/A | 0 | 0 | 3 | Motorcycle | - |
| 4 | 755 | 6/3/2018 | 23:30 | Sufficient | Dry | N/A | 0 | 0 | 0 | Motorcycle | - |
| 5 | 758 | 6/3/2018 | 3:39 | Sufficient | Dry | N/A | 0 | 0 | 2 | Motorcycle | 4 wheeler bus |
| 6 | 771 | 9/3/2018 | 11:11 | N/A | Dry | N/A | 0 | 0 | 1 | Motorcycle | 4 wheeler bus |
| 7 | 861 | 6/4/2018 | 2:40 | Sufficient | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 8 | 1048 | 4/6/2018 | 18:30 | N/A | Dry | N/A | 0 | 0 | 0 | Motorcycle | Saloon |
| 9 | 1151 | 21/6/2018 | 9:55 | N/A | Dry | N/A | 0 | 0 | 1 | Motorcycle | Big bike |
| 10 | 1190 | 28/6/2018 | 11:30 | N/A | Dry | 800 | 0 | 0 | 1 | Motorcycle | 4 wheeler bus |
| 11 | 1301 | 22/8/2018 | 13:00 | N/A | Moist | N/A | 0 | 0 | 2 | Motorcycle | - |
| 12 | 1307 | 28/8/2018 | 12:37 | N/A | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 13 | 1308 | 29/8/2018 | 6:10 | Sufficient | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 14 | 1343 | 13/9/2018 | 12:30 | N/A | Wet | N/A | 0 | 0 | 1 | Motorcycle | - |
| 15 | 1345 | 14/9/2018 | 10:30 | N/A | Moist | 301 | 0 | 0 | 1 | Motorcycle | Van |
| 16 | 1377 | 23/9/2018 | 7:30 | N/A | Wet | 800 | 0 | 0 | 1 | Motorcycle | Motorcycle |
| 17 | 1549 | 1/12/2018 | 1:30 | Sufficient | Dry | 802 | 0 | 0 | 2 | Motorcycle | - |
| 18 | 1560 | 6/12/2018 | 20:30 | Sufficient | Wet | 301 | 0 | 0 | 0 | Saloon | Saloon |
| 19 | 1629 | 13/1/2019 | 14:45 | N/A | Dry | 301 | 0 | 0 | 0 | Saloon | Pickup |
| 20 | 1705 | 6/3/2019 | 4:30 | Sufficient | Dry | 305 | 0 | 0 | 2 | Motorcycle | Saloon |
| 21 | 1714 | 14/3/2019 | 10:10 | N/A | Dry | 305 | 0 | 0 | 1 | Motorcycle | Saloon |
| 22 | 29789 | 17/6/2019 | 7:45 | N/A | Dry | 305 | 2 | 0 | 0 | Motorcycle | Pickup |
| 23 | 29794 | 24/6/2019 | 6:10 | Sufficient | Wet | N/A | 0 | 0 | 1 | Motorcycle | - |
| 24 | 29796 | 2/7/2019 | 1:15 | Sufficient | Dry | 201 | 0 | 0 | 2 | Saloon | - |
| Total | | | | | | | 2 | 0 | 26 | | |

Collision types: 301: Rear end (30%) 305: Side swipe (30%)
 800: Others off path on curve (20%)
 802: Off carriageway (10%) 201: Head on (10%)

Figure 17 Study section and crash data



Traffic volume:
○ 3,756 vehicles/hour

Traffic composition:
○ PC : MC : others
○ 59 : 39 : 2
○ MC safe facilities?

85th percentile speeds:
○ PCs were over safe speed (30 kph to hit MC).
○ MCs were over safe speed (30 kph, assumed to be the same as pedestrian).

| Speed (kph) | Outbound | | Inbound | |
|-----------------------------|----------|------|---------|------|
| | MC | PC | MC | PC |
| 85 th Percentile | 42.0 | 38.0 | 46.0 | 40.5 |
| Mode | 41.5 | 36.5 | 43.5 | 37.0 |
| 50 th Percentile | 39.0 | 31.5 | 40.5 | 35.0 |
| 15 th Percentile | 37.5 | 27.5 | 37.5 | 28.5 |

Data collection: 25th October 2019 (11:15 a.m. - 00:15 p.m.)

Figure 18 Traffic volume and speed data collected at the study section

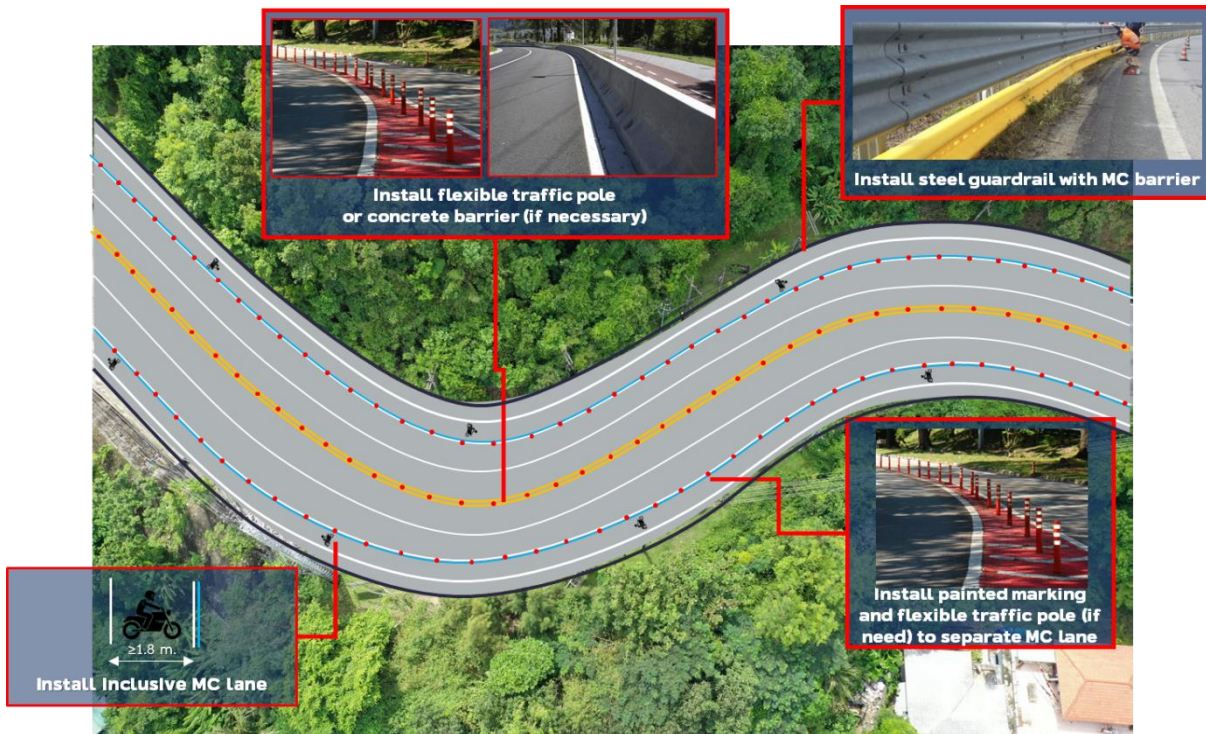


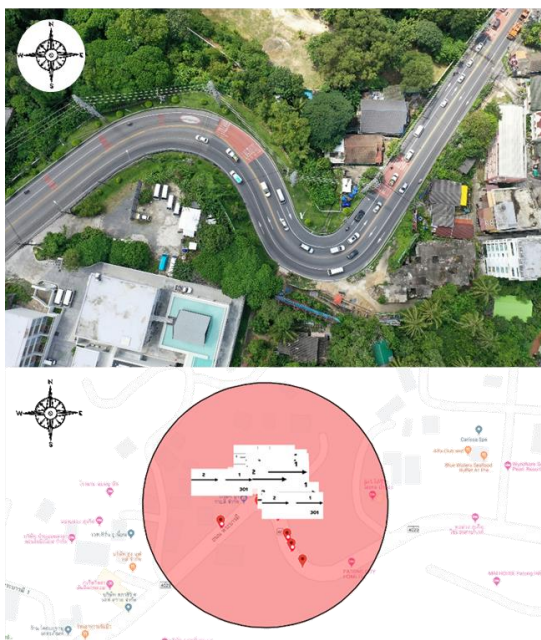
Figure 19 Preliminary measures for Kathu-Patong Highway No. 4029 km. 0+400

4.4.2 Kathu-Patong Highway No. 4029 km. 1+500

Like the previous hazardous location, Kathu-Patong Highway No. 4029 km. 1+500 is the mountainous road section which is further from the previous location. The study section (km. 1+500) is the mountainous section with a more bending curve as shown in Figure 20. From the database of ATRANS Safety Map, there were 20 crashes in the last three years. Considering the crash pattern, the top crash pattern was the rear end (37%), followed by sideswipe (27%), crash from the opposite direction (18%), off carriageway (9%) and head-on (9%), respectively. Regarding the vehicles involved, the motorcycles (41%) mainly involved in the crashes. Two of them (14% of all casualties) died.

Figure 21 shows the results of traffic volume and speed studies conducted on 25th October 2019, from 10:00 a.m. to 11:00 a.m. The traffic volume during the study period was 4,212 vehicles per hour with the traffic composition: passenger car 55%, motorcycle 44%, and the others 1%. Regarding the 85th percentile of vehicle speed from the speed study, it was found that the passenger car speeds (27 kph for inbound and 28 kph for outbound) and the motorcycle speeds (31 kph for inbound and 32 kph for outbound) were closely a safe speed (30 kph). The reasons were possible because the reverse curve of this section is sharper compared to the previous location. Also, the traffic volume is more congested.

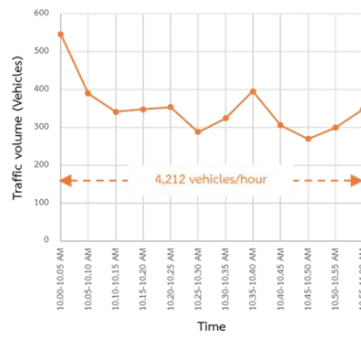
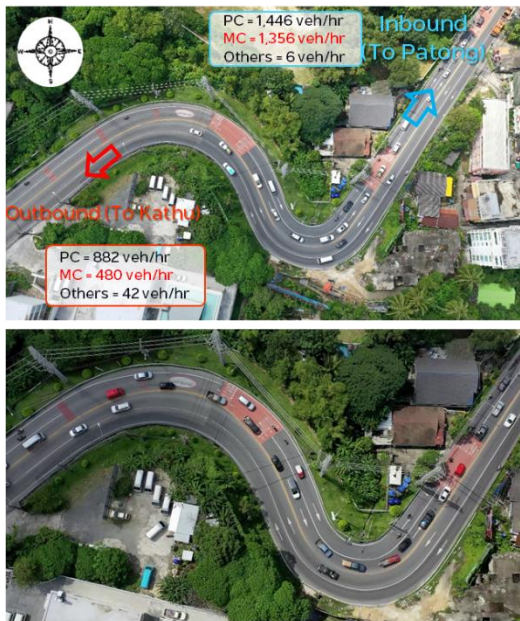
From the traffic volume, speed, and crash data and the site investigation, road safety measures to improve this hazardous location were studied and designed. The preliminary measures can be illustrated in Figure 22. The measures include improving traffic line marking and painted markings on the road surface, installing separated motorcycle lanes on both side shoulders with traffic poles and motorcycle barriers. Note that the installation of traffic poles or concrete barriers along the median could be considered where is appropriate and safe. The preliminary results of the benefit and cost analysis of the proposed road safety improvement are presented in Appendix B (Figure B2).



| Case | Crash ID | Date | Time | Lighting | Surface | Collision code | No. casualties | | | Vehicle 1 | Vehicle 2 |
|--------------|----------|------------|-------|------------|---------|----------------|----------------|----------|-----------|-----------------|---------------|
| | | | | | | | Fatal | Serious | Slight | | |
| 1 | 658 | 13/2/2018 | 23:00 | Sufficient | Dry | N/A | 0 | 0 | 5 | Motorcycle | Bus |
| 2 | 754 | 5/3/2018 | 13:16 | N/A | Dry | N/A | 0 | 0 | 0 | Motorcycle | Pickup |
| 3 | 757 | 6/3/2018 | 155 | Sufficient | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 4 | 1049 | 5/6/2018 | 4:40 | Sufficient | Wet | N/A | 0 | 0 | 1 | Motorcycle | - |
| 5 | 1089 | 13/6/2018 | 5:30 | Sufficient | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 6 | 1249 | 3/8/2018 | 10:20 | N/A | Dry | 802 | 0 | 0 | 0 | Bus | - |
| 7 | 1479 | 26/10/2018 | 7:00 | N/A | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 8 | 1498 | 6/11/2018 | 16:40 | N/A | Dry | 305 | 0 | 0 | 1 | Motorcycle | 4 wheeler bus |
| 9 | 1508 | 11/11/2018 | 05:0 | Sufficient | Dry | 200 | 0 | 0 | 0 | Pickup | Trailer truck |
| 10 | 1509 | 13/11/2018 | 10:07 | Sufficient | Dry | N/A | 0 | 0 | 0 | 6 wheeler truck | - |
| 11 | 1569 | 9/12/2018 | 20:30 | Sufficient | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 12 | 1582 | 17/12/2018 | 12:10 | N/A | Dry | 301 | 0 | 0 | 0 | Pickup | Saloon |
| 13 | 1638 | 16/1/2019 | 15:30 | N/A | Dry | 305 | 0 | 0 | 0 | Van | Saloon |
| 14 | 1652 | 23/1/2019 | 9:30 | Sufficient | Dry | 200 | 0 | 0 | 0 | Bus | Pickup |
| 15 | 1683 | 10/2/2019 | 22:37 | Sufficient | Dry | 201 | 2 | 0 | 0 | Motorcycle | Pickup |
| 16 | 1687 | 12/2/2019 | 11:00 | N/A | N/A | 301 | 0 | 0 | 1 | Motorcycle | Motorcycle |
| 17 | 1693 | 20/2/2019 | 9:00 | N/A | Dry | 301 | 0 | 0 | 0 | Pickup | Pickup |
| 18 | 1710 | 8/3/2019 | 6:40 | N/A | Dry | N/A | 0 | 0 | 1 | Motorcycle | - |
| 19 | 29780 | 31/5/2019 | 8:00 | N/A | Moist | 305 | 0 | 0 | 1 | Motorcycle | Pickup |
| 20 | 29835 | 29/8/2019 | 17:10 | Sufficient | Dry | 301 | 0 | 0 | 0 | Pickup | Saloon |
| Total | | | | | | | 2 | 0 | 14 | | |

Collision types: 301:Rear end (37%)
 305:Side swlpe (27%)
 200:Others from opposite direction (18%)
 802: Off carriageway (9%) 201:Head on (9%)

Figure 20 Study section and crash data



Traffic volume:
 ○ 4,212 vehicles/hour

Traffic composition:
 ○ PC : MC : others
 ○ 55 : 44 : 1
 ○ MC safe facilities?

| Speed (kph) | Outbound | | Inbound* | |
|-----------------------------|----------|------|----------|------|
| | MC | PC | MC | PC |
| 85 th Percentile | 32.0 | 28.0 | 31.0 | 27.0 |
| Mode | 29.0 | 27.0 | 29.5 | 25.5 |
| 50 th Percentile | 28.0 | 25.5 | 28.5 | 24.0 |
| 15 th Percentile | 25.5 | 23.0 | 25.5 | 22.5 |

85th percentile speeds:
 ○ Speeds of PCs and MCs were slow due to sharp curve.

Note: * speeds slow down due to sharp curve

Data collection: 25th October 2019 (10:00-11:00 a.m.)

Figure 21 Traffic volume and speed data collected at the study section

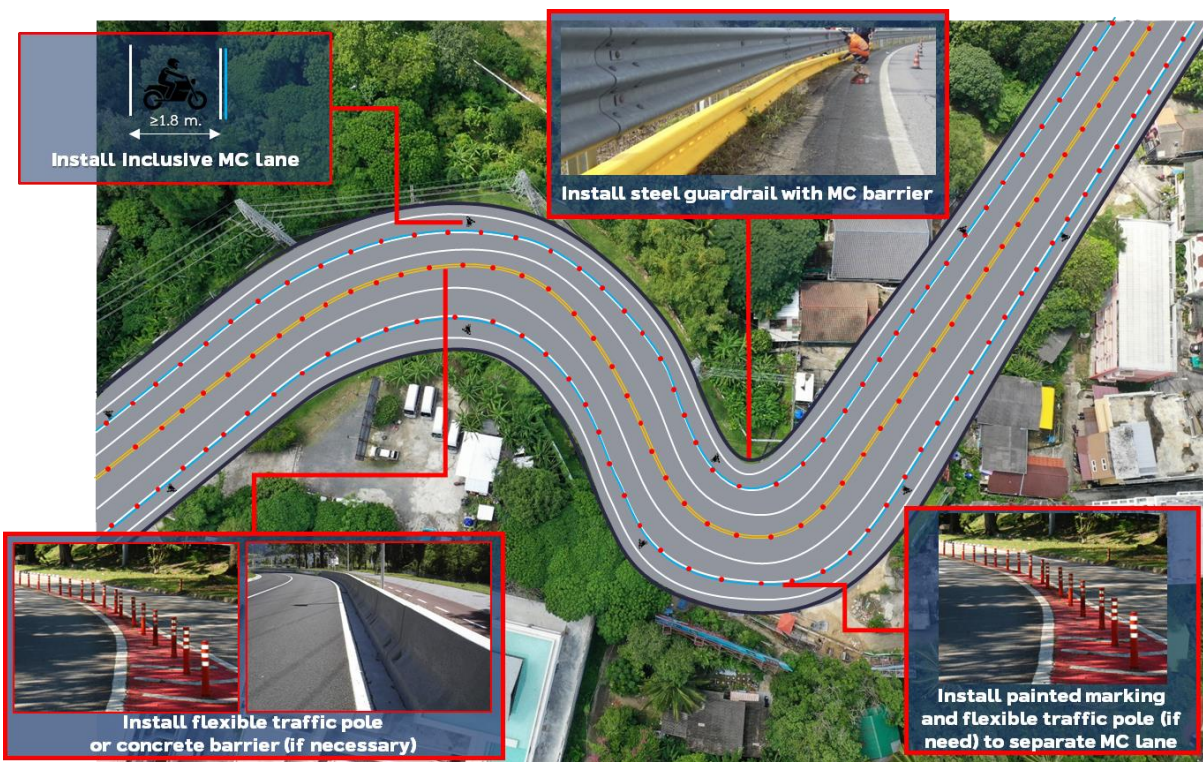


Figure 22 Preliminary measures for Kathu-Patong Highway No. 4029 km. 1+500

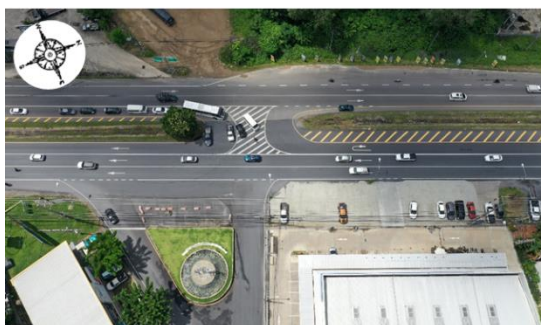
4.4.3 Bypass Highway No. 4024 km. 2+300

For the last hazardous location, Highway No. 4029 km. 2+300 is the median opening on the bypass highway connecting the northern and southern areas of Phuket island. The study location as shown in Figure 23 is the median opening with the two-way connecting road and roadside parking in the east.

From the database of ATRANS Safety Map, there were 3 crashes in the last three years. The crashes were off carriageway (i.e. bypass road) and hit the fixed object, and other maneuvering crash. 2 motorcycles (50%) involved in the crashes. One of them seriously injured, the other was slightly injured.

Figure 24 shows the results of traffic volume and speed studies conducted on 24th October 2019, from 12:00 p.m. to 1:00 p.m. The traffic volume during the study period was 4,635 vehicles per hour with the traffic composition: passenger car 78%, motorcycle 17%, and the others 5%. Regarding the 85th percentile of vehicle speed from the speed study, it was found that the passenger car speeds (74 kph for inbound and 82 kph for outbound) were over a safe speed (assume 50 kph for the case that two passenger car probably hit each other at the right angle). Similarly, the motorcycle speeds (45 kph for inbound and 50 kph for outbound) were over a safe speed (assume 30 kph for the case that a motorcycle was probably hit by another car).

From the traffic volume, speed, and crash data and the site investigation, road safety measures to improve this hazardous location were studied and designed. The preliminary measures can be illustrated in Figure 25. The measures include installing physical median with safe opening and auxiliary lanes, installing flexible traffic polls to separate u-turn vehicles and through traffic, and managing safe access along the roadside. The preliminary results of the benefit and cost analysis of the proposed road safety improvement are presented in Appendix B (Figure B3).



| Case | Crash ID | Date | Time | Lighting | Surface | Collision code | No. casualties | | | Vehicle 1 | Vehicle 2 |
|-------|----------|------------|-------|------------|---------|----------------|----------------|---------|--------|------------|-----------|
| | | | | | | | Fatal | Serious | Slight | | |
| 1 | 964 | 24/5/2018 | 15:43 | N/A | N/A | N/A | 0 | 1 | 0 | Motorcycle | Saloon |
| 2 | 29907 | 23/7/2019 | 23:30 | Sufficient | Dry | 703 | 0 | 0 | 0 | Pickup | - |
| 3 | 29908 | 29/12/2017 | 13:00 | Sufficient | Dry | 400 | 0 | 0 | 1 | Motorcycle | - |
| Total | | | | | | | 0 | 1 | 1 | | |

Collision types: 703: Off carriage way and hit the fixed object
400: Other maneuvering crash

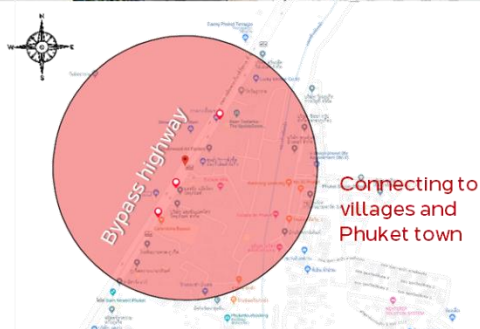
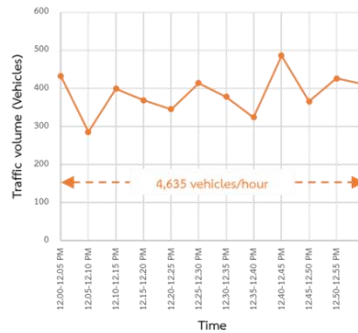
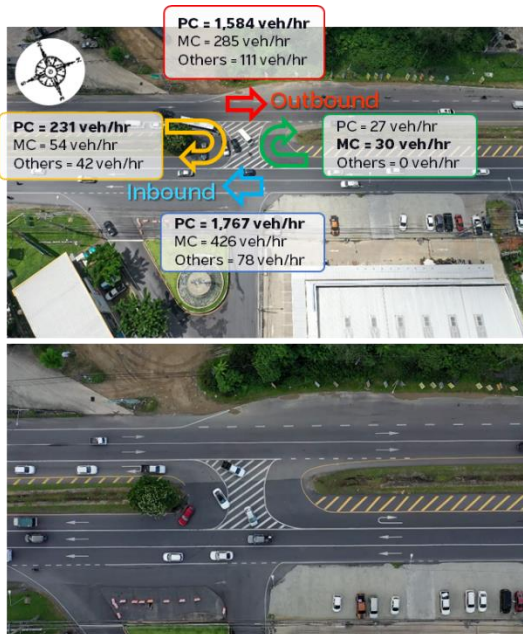


Figure 23 Study section and crash data



Traffic volume:

- 4,635 vehicles/hour

Traffic composition:

- PC : MC : others
- 78 : 17 : 5

| Speed (kph) | Outbound | | Inbound | |
|-----------------------------|----------|------|---------|------|
| | MC | PC | MC | PC |
| 85 th Percentile | 50.0 | 82.0 | 45.0 | 74.0 |
| Mode | 44.5 | 75.0 | 44.0 | 60.0 |
| 50 th Percentile | 44.5 | 73.0 | 40.5 | 65.0 |
| 15 th Percentile | 39.5 | 64.0 | 38.0 | 58.0 |

85th percentile speeds:

- PCs were **over safe speed** (50 kph for side collision).
- MCs were **over safe speed** (30 kph, assumed to be the same as pedestrian)

Data collection: 24th October 2019 (12:00-01:00 p.m.)

Figure 24 Traffic volume p.m and speed data collected at the study section

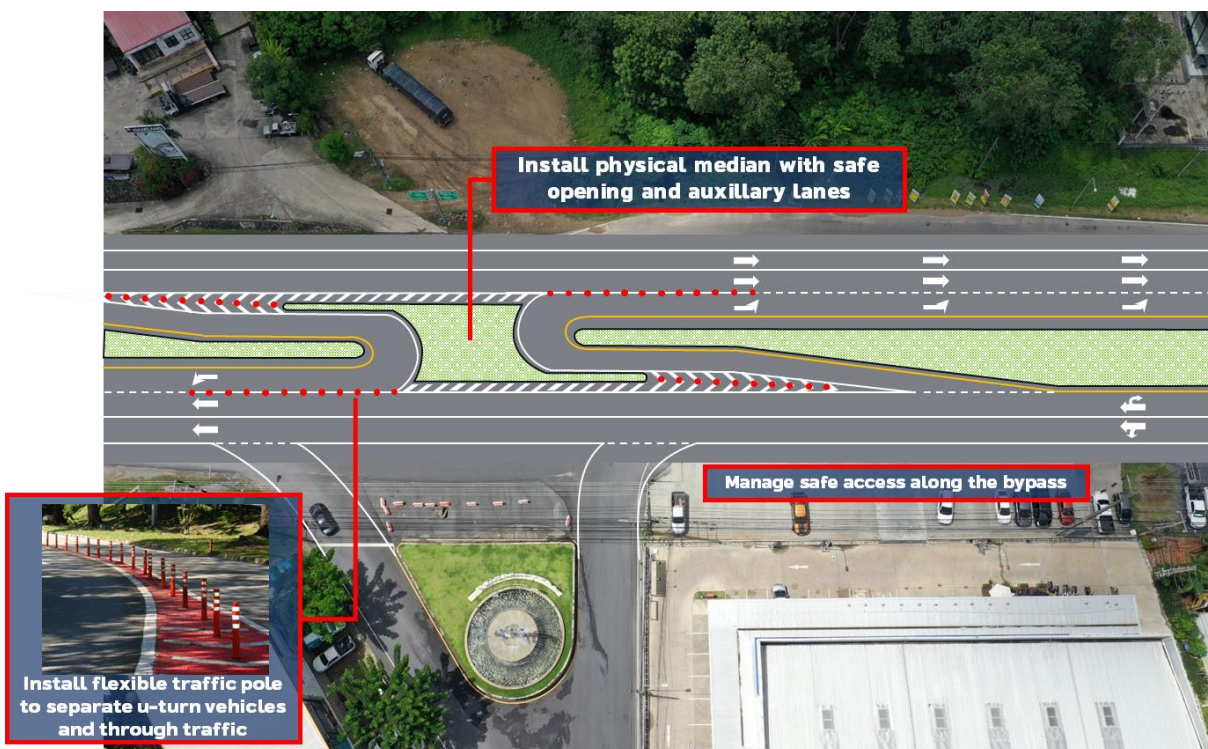


Figure 25 Preliminary measures for Highway No. 4024 km. 2+300

CHAPTER 5 CONCLUSIONS

5.1 Conclusions

In this research, some features of the ATRANS Safety Map application were further improved to allow any road safety staff to identify the causation of crashes and retrieve potential treatments for hazardous locations.

Several workshops were conducted to demonstrate the improved application to traffic and safety staff (potential users to report crash data) in local areas and students (potential users to report risk data) in four provinces (Suphanburi, Chainay, Saraburi, and Songkhla).

Crash data in Phuket reported by the police and the DOH were collected and used to identify the top 5 hazardous locations in Phuket. From the crash data, it was found that most crashes related to the motorcycle. All deaths were motorcyclists. However, from the site inspection, it was found that few safe facilities were provided to the motorcyclist. Therefore, the road safety measures proposed to improve the hazardous location were mainly focused on the motorcyclist, which included for example motorcycle lane, motorcycle barrier. However, typical traffic marking and traffic pole installations, physical median installation, and roadside access management were also recommended in the road safety improvements. The potential measures for each hazardous location were proposed and analyzed the benefit to cost ratio that would be a preliminary guideline for local road safety agencies before their detail design stage.

5.2 Recommendations

For application improvement, a decision support system for the safety improvement program should be further developed.

For data collection, road user behavior data (e.g. driving skill, experience) may be needed for further analysis. Complete common data of a crash are another challenge.

For sustainability, implementation of the application to other potential areas is another challenge.

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Appendix A

Road safety measures included in ATRANS Safety Map

Table A List of road safety measures (English and Thai)

| Code | Measures | มาตรการ |
|--|---|--|
| Group A: Cost rating under \$5,000 | | กลุ่ม ก (ค่าก่อสร้างน้อยกว่า 150,000 บาท) |
| A1 | Advisory speed signs | การติดตั้งป้ายแนะนำความเร็ว |
| A2 | All-red time extension | การเพิ่มเวลาสัญญาณไฟแดงทุกทิศทาง (All -red) |
| A3 | Chevron alignment markers (CAMs) | การติดตั้งป้ายเตือนแนวทางโค้ง (Chevron) |
| A4 | Curve warning signs | การติดตั้งป้ายเตือนทางโค้ง |
| A5 | Give Way/Stop signs | การติดตั้งป้ายให้ทาง/ป้ายหยุด |
| A6 | Line marking improvements | การปรับปรุงเส้นจราจร |
| A7 | Parking bans | การห้ามจอดรถ |
| A8 | Pedestrian fencing | การติดตั้งรั้วกันคนเดิน |
| A9 | Raised reflective pavement markers (RRPMs) | การติดตั้งปุ่ม/หมุดสะท้อนแสง |
| A10 | Reinstate shoulder | การคืนสิทธิ์ไหล่ทาง |
| A11 | Restrict access points | การจำกัดการเชื่อมต่อทางหลัก |
| A12 | Separation lines | การติดตั้งเส้นแบ่งแยกกระแสจราจร |
| A13 | Sight distance improvements – intersections | การปรับปรุงระยะมองเห็นบริเวณทางแยก |
| A14 | Sight distance improvements – road sections | การปรับปรุงระยะมองเห็นบริเวณช่วงถนน |
| A15 | Speed limit change | การปรับขีดจำกัดความเร็ว |
| A16 | Traffic signals operation review | การทบทวนการทำงานของสัญญาณไฟจราจร |
| A17 | Turn bans | การห้ามเลี้ยว |
| A18 | Warning signs | การติดตั้งป้ายเตือน |
| Group B: Cost rating \$5,001 - \$20,000 | | กลุ่ม ข (ค่าก่อสร้าง 150,000-600,000 บาท) |
| B1 | Barrier lines | การติดตั้งเส้นจราจรแบ่งกลางถนน |
| B2 | Bicycle facilities – on-road | การติดตั้งอุปกรณ์ความปลอดภัยบนทางสำหรับจักรยาน |
| B3 | Clear zone widening | การขยายเขตปลอดภัย |
| B4 | Crash cushion/Impact attenuator | การติดตั้งอุปกรณ์ซับแรงกระแทก |
| B5 | Direction signs (guide signs) | การติดตั้งป้ายบอกทิศทาง (นำทาง) |
| B6 | Edge drop removal | การลบขอบผิวทางที่ต่างระดับ |
| B7 | Edge lines | การติดตั้งเส้นจราจรขอบทาง |
| B8 | Guideposts | การติดตั้งป้ายนำทาง |
| B9 | Curb extensions | การขยายขอบคันหิน |
| B10 | Painted/flush median | การติดตั้งเกาะกลางแบบทาสี |
| B11 | Pedestrian refuge island | การติดตั้งเกาะพักสำหรับคนข้ามถนน |
| B12 | Profile line marking | การติดตั้งเส้นจราจรแบบสันนูน (Profile line) |
| B13 | Raised pedestrian crossings | การติดตั้งทางข้ามแบบยก |
| B14 | Red-light cameras | การติดตั้งกล้องฝ่าไฟแดง |
| B15 | Remove vegetation | การเคลื่อนย้ายพุ่มไม้/ต้นไม้ |
| B16 | Safety barriers | การติดตั้งราวกันอันตราย |
| B17 | Signal display visibility improvements | การปรับปรุงการมองเห็นโคมสัญญาณไฟจราจร |
| B18 | Skid resistance improvements | การเพิ่มความเสียดทานของผิวจราจร |
| B19 | Traffic signals coordination | การประสานสัญญาณไฟจราจร |

| Code | Measures | มาตรการ |
|--|---|--|
| Group C: Cost rating \$20,001 - \$50,000 | | กลุ่ม ค (ค่าก่อสร้าง 600,000-1,500,000 บาท) |
| C1 | Convert angle parking to parallel parking | การปรับการจอดมุมเฉียงเป็นขนานขอบทาง |
| C2 | Median break closure | การปิดปลายของเกาะกลาง |
| C3 | Painted turn lanes | การจัดทำช่องรอยเลี้ยวแบบทาสี |
| C4 | Pavement drainage improvements | การปรับปรุงการระบายน้ำของผิวทาง |
| C5 | Splitter islands | การติดตั้งเกาะแยกกระแสจราจร (Splitter island) |
| C6 | Street lighting | การติดตั้งไฟฟ้าส่องสว่าง |
| C7 | Traffic lane widening | การขยายความกว้างช่องจราจร |
| C8 | Vehicle activated signs | การติดตั้งป้ายแจ้งเตือนความเร็วแบบกระตุ้น (Activated sign) |
| Group D: Cost rating \$50,001 - \$100,000 | | กลุ่ม ง (ค่าก่อสร้าง 1,500,000-3,000,000 บาท) |
| D1 | Combine access points | การรวมจุดเชื่อมต่อบนทางหลัก |
| D2 | Fully controlled right turn phase | การจัดช่วงสัญญาณไฟเฉพาะสำหรับรถเลี้ยวขวา |
| Group E: Cost rating over \$100,000 | | กลุ่ม จ (ค่าก่อสร้างมากกว่า 3,000,000 บาท) |
| E1 | Additional lanes for overtaking | การก่อสร้างช่องทางเสริมสำหรับแซง |
| E2 | Curve widening | การขยายช่วงทางโค้ง |
| E3 | Grade separation | การก่อสร้างทางยกระดับ |
| E4 | Indented parking | การสร้างที่จอดรถข้างทางแบบหลบจากทางวิ่ง |
| E5 | Median retrofit | การติดตั้งเกาะกลางเพิ่มเติม |
| E6 | Pedestrian improvements at slip lanes | การปรับปรุงทางเท้า/ทางข้ามบริเวณทางเลี้ยว |
| E7 | Pedestrian signals | การติดตั้งสัญญาณไฟจราจรสำหรับคนข้ามถนน |
| E8 | Railway crossing upgrade | การปรับปรุงทางตัดรถไฟ |
| E9 | Road realignment | การปรับปรุงแนวทางถนน |
| E10 | Roundabouts | การติดตั้งวงเวียน |
| E11 | Shoulder widening and/or sealing | การขยาย/ปูผิวไหล่ทาง |
| E12 | Slip lane angle modification | การปรับปรุงมุมบริเวณทางเลี้ยว |
| E13 | Staggered intersection | การทำแยกเอียงกัน |
| E14 | Superelevation improvement | การปรับปรุงการยกโค้ง |
| E15 | Traffic signals | การติดตั้งสัญญาณไฟจราจร |
| E16 | Turn lanes | การก่อสร้างช่องจราจรสำหรับเลี้ยว |

Group A: Cost rating under \$5,000

การติดตั้งป้ายแนะนำความเร็ว

A1: Advisory speed signs

คำอธิบาย
การติดตั้งป้ายแนะนำความเร็ว เพื่อบังคับให้ผู้ใช้ขับขี่
ทราบและปฏิบัติตามคำแนะนำของป้าย แต่ประสิทธิภาพใน
การจัดการความเร็วอาจไม่ดีเท่าที่ควร จึงควรใช้ร่วมกับ
มาตรการอื่นด้วย




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 40%

ความเร็วที่ลดลง

- 3.6 กิโลเมตรต่อชั่วโมง

ตำแหน่งที่ติดตั้ง

- ก่อนเข้าทางแยก/ช่วงถนน/ทางโค้ง

หมายเหตุ:
 • AS 1742.8-1993, Manual of uniform traffic control devices, part 6: advisory speed signs for roads.
 • Australia (2016) Guide to Traffic Management Part 10: 6.2.2 Traffic Management, Australia, Sydney, New South Wales.
 • Federal Highway Administration (FHWA) (2011) Speed Management Toolkit, Federal Highway Administration.
 • คู่มือปฏิบัติ: การจัดการจราจร (2019) - มาตรการควบคุมความเร็ว (2019) (ฉบับแก้ไข) 3 หน้า, 30 ตุลาคม 2563, สถาบันวิชาการป้องกันประเทศ

การขยายเวลาสัญญาณไฟแดงทุกทิศทาง

A2: All-red time extension

คำอธิบาย
การขยายเวลาสัญญาณไฟแดงทุกทิศทาง เป็นเพิ่มการ
เคลื่อนที่ของรถให้ผ่านทางแยกที่แอดได้ปลอดภัย ซึ่งลด
ความเสี่ยงจากการชนด้านข้างและการชนท้ายบริเวณทาง
แยกได้



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- ไม่มีผลการศึกษา

ตำแหน่งที่ติดตั้ง

- ทางแยกที่มีสัญญาณไฟจราจร

หมายเหตุ:
 • AS 1742.3-1993, Manual of uniform traffic control devices part 10: pedestrian control and protection, Appendix E5: Signal Timing.
 • คู่มือ: <http://thai.aitab.com/product-detail/new-design-lathing-light-red-light-traffic-signals-86-0058120141111>

การติดตั้งป้ายเตือนแนวทางโค้ง

A3: Chevron alignment markers (CAMs)

คำอธิบาย
การติดตั้งป้ายเตือนแนวทางโค้ง เพื่อบังคับให้ผู้ใช้ขับขี่
มองเห็นแนวทางโค้งข้างหน้า และขับขี่ด้วยความระมัดระวัง




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 25%

ตำแหน่งที่ติดตั้ง

- ตลอดแนวทางโค้ง

หมายเหตุ:
 • AS 1742.8-1993, Manual of uniform traffic control devices, part 2: traffic control devices for general use.
 • Federal Highway Administration (FHWA) (2011) Speed Management Toolkit, Federal Highway Administration.

การติดตั้งป้ายเตือนทางโค้ง

A4: Curve warning signs

คำอธิบาย
การติดตั้งป้ายเตือนทางโค้ง เพื่อเตือนให้ผู้ใช้ขับขี่ทราบว่า
ข้างหน้ามีทางโค้ง ปฏิบัติตามคำแนะนำของป้าย และขับขี่
ด้วยความระมัดระวัง




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 25%

ความเร็วที่ลดลง

- 3.6 กิโลเมตรต่อชั่วโมง

ตำแหน่งที่ติดตั้ง

- ก่อนถึงทางโค้ง

หมายเหตุ:
 • AS 1742.8-1993, Manual of uniform traffic control devices - traffic control devices for general use.
 • Australia (2016) Guide to Traffic Management Part 10: 6.2.2 Traffic Management, Australia, Sydney, New South Wales.
 • Federal Highway Administration (FHWA) (2011) Speed Management Toolkit, Federal Highway Administration.

การติดตั้งป้ายให้ทาง/ป้ายหยุด

A5: Give Way/Stop signs

คำอธิบาย
การติดตั้งป้ายให้ทาง เพื่อบังคับให้ผู้ใช้ขับขี่ให้ทางแก่คน
เดิน และรถที่ขวางข้างหน้าก่อนไปก่อน
ส่วนป้ายหยุด เพื่อบังคับผู้ใช้หยุดรถก่อนถึงทางที่
ขวางข้างหน้า หรือ เลี้ยวหยุด




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 25%

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยก

หมายเหตุ:
 • AS 1742.8-1993, Manual of uniform traffic control devices - parking controls.
 • Federal Highway Administration (FHWA) (2011) Speed Management Toolkit, Federal Highway Administration.

การปรับปรุงเส้นจราจร

A6: Line marking improvements

คำอธิบาย
การปรับปรุงเส้นจราจร เพื่อเพิ่มความชัดเจนของเส้น
จราจร ซึ่งส่งผลต่อการตอบสนองของผู้ขับขี่ และทำให้ผู้ใช้
ขับขี่ง่าย อันเป็นการลดความผิดพลาดของผู้ขับขี่ได้




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- ไม่มีผลการศึกษา

ตำแหน่งที่ติดตั้ง


- ทางแยก/ช่วงถนน/ทางโค้ง

หมายเหตุ:
 • AS 1742.8-1993, Manual of uniform traffic control devices - traffic control devices for general use.
 • Federal Highway Administration (FHWA) (2011) Speed Management Toolkit, Federal Highway Administration.
 • คู่มือ: การจัดการจราจร (2019) - มาตรการปรับปรุงเส้นจราจร (2019) (ฉบับแก้ไข) 1 หน้า, 30 ตุลาคม 2563, สถาบันวิชาการป้องกันประเทศ

การห้ามจอดรถ

A7: Parking bans

คำอธิบาย
การห้ามจอดรถ จะช่วยลดโอกาสการชนด้านข้างหรือ
ชนท้าย และช่วยลดโอกาสการเกิดอุบัติเหตุของคนเดิน
เนื่องจากคนเดินมักจะมองเห็นที่จอด (ไม่ถูกรถที่จอด
บดบัง)



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 20%

ตำแหน่งที่ติดตั้ง


- บริเวณทางแยก/ช่วงถนน/ทางโค้ง

หมายเหตุ:
 • AS 1742.8-1993, Manual of uniform traffic control devices - parking controls.

การติดตั้งรั้วกันคนเดิน

A8: Pedestrian fencing

คำอธิบาย
การติดตั้งรั้วกันคนเดิน เพื่อลดอุบัติเหตุระหว่างคนเดิน
กับยานพาหนะ และส่งเสริมให้คนเดินข้ามถนนบริเวณที่
ปลอดภัยกว่า

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 20%

ตำแหน่งที่ติดตั้ง

- บริเวณทางข้ามที่มีคนเดินปริมาณมาก

หมายเหตุ:
 • AS 1742.3-1993, Manual of uniform traffic control devices, part 10: pedestrian control and protection, section 7.5 Physical pedestrian aids, pedestrian fencing.

Group A: Cost rating under \$5,000 (Continue)

การติดตั้งปุ่ม/หมุดสะท้อนแสง A9: Raised reflective pavement markers (RRPMs)

คำอธิบาย
การติดตั้งปุ่ม/หมุดสะท้อนแสง เป็นการติดตั้งเพื่อเตือนไม่ให้ชนขอบถนนหรือช่องจราจร และทำให้มองเห็นในการขับขี่เวลากลางคืนหรือฝนตกชุก



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 5%


ตำแหน่งที่ติดตั้ง

- ทางแยก/ช่วงถนน/ทางโค้ง

เอกสารอ้างอิง
• ASTR42-1994 Manual of uniform traffic control devices, part 2: Traffic control devices for general use, section 4: Pavement Markings and Devices

การคืนสภาพไหล่ทาง A10: Reinstatement shoulder

คำอธิบาย
การคืนสภาพไหล่ทาง เป็นการปรับสภาพของไหล่ทางให้รองรับยานพาหนะที่เสียการควบคุมให้สามารถหยุดหรือควบคุมยานพาหนะให้กลับสู่ช่องจราจรได้อย่างปลอดภัย



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 25%


ตำแหน่งที่ติดตั้ง

- ช่วงถนน

เอกสารอ้างอิง
• Austroads 1991 Road maintenance practice, chapter 16: Shoulders AP-12/91 Austroads, Sydney, New South Wales

การจำกัดการเชื่อมต่อ A11: Restrict access points

คำอธิบาย
การจำกัดการเชื่อมต่อ เพื่อลดจำนวนจุดเข้าถึง ลดโอกาสเกิดอุบัติเหตุของยานพาหนะ และอุบัติเหตุของคนเดินจากการถูกยานพาหนะที่ออกจากทางเชื่อมขม



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- ไม่มีผลการศึกษา

ตำแหน่งที่ติดตั้ง

- ช่วงถนนสายหลัก

เอกสารอ้างอิง
• Austroads 2002 Urban road design guide to the geometric design of major urban roads, AP-355/02, Austroads, Sydney, New South Wales

การติดตั้งเส้นแบ่งทิศทางจราจร A12: Separation Lines

คำอธิบาย
การติดตั้งเส้นแบ่งทิศทางจราจร เป็นเส้นที่ใช้แบ่งทิศทางของกระแสจราจร เพื่อให้ยานพาหนะสามารถขับได้อย่างเป็นระเบียบและปลอดภัย



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30%


ตำแหน่งที่ติดตั้ง

- ทางแยก/ช่วงถนน/ทางโค้ง

เอกสารอ้างอิง
• ASTR42-1994 Manual of uniform traffic control devices - traffic control devices for general use

การปรับปรุงระยะมองเห็นบริเวณทางแยก A13: Sight distance improvements – intersections

คำอธิบาย
การปรับปรุงระยะมองเห็นบริเวณทางแยก เป็นการเพิ่มมุมมองและระยะการมองเห็นของผู้ขับขี่ให้สามารถตัดสินใจได้ถูกต้อง ปลอดภัย และลดความผิดพลาด ก่อนเข้าทางแยก



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30%


ตำแหน่งที่ติดตั้ง

- บริเวณทางแยก

เอกสารอ้างอิง
• Austroads 2002 Urban road design guide to the geometric design of major urban roads, AP-355/02, Austroads, Sydney, New South Wales
• ดูได้ที่: <http://netc.nsw.gov.au/publications/urban-road-design-guide/intersections-3550-2002/intersections-sight-triangles-sight-lines/>

การปรับปรุงระยะมองเห็นบริเวณช่วงถนน A14: Sight distance improvements – road sections

คำอธิบาย
การปรับปรุงระยะมองเห็นบริเวณช่วงถนน เป็นการเพิ่มมุมมองและระยะการมองเห็นของผู้ขับขี่ให้สามารถตัดสินใจถูกต้อง ปลอดภัย และลดความผิดพลาด ตลอดเส้นทางที่ขั้วผ่าน



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30%


ตำแหน่งที่ติดตั้ง

- ช่วงถนน

เอกสารอ้างอิง
• Austroads 2002 Urban road design guide to the geometric design of major urban roads, AP-355/02, Austroads, Sydney, New South Wales
• ดูได้ที่: <http://netc.nsw.gov.au/publications/urban-road-design-guide/intersections-3550-2002/intersections-sight-triangles-sight-lines/>

การปรับขีดจำกัดความเร็ว A15: Speed Limit change

คำอธิบาย
การปรับขีดจำกัดความเร็ว เพื่อบังคับให้ผู้ขับขี่ทราบและปฏิบัติตามคำแนะนำเป็นไปในที่ แต่ประสิทธิภาพในการจัดการความเร็วอาจไม่ได้เท่าที่ควร ดังนั้น ควรใช้ป้ายดังกล่าวควบคู่กับมาตรการอื่น ๆ ด้วย



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 20% (สำหรับลดความเร็วจาก 80 กม./ชม. เป็น 60 กม./ชม. และ 60 กม./ชม. เป็น 50 กม./ชม.)
- 15% (สำหรับลดความเร็วจาก 100 กม./ชม. เป็น 80 กม./ชม.)

ความเร็วที่ลดลง

- 3.6 กม./ชม.


ตำแหน่งที่ติดตั้ง

- ทางแยก/ช่วงถนน/ทางโค้ง

เอกสารอ้างอิง
• ASTR42-1994 Manual of uniform traffic control devices - speed control
• Austroads 2009 Guide to Traffic Management Part 10 of 11: Speed Management, Austroads, Sydney, New South Wales
• Austroads 2009 Guide to Traffic Management Part 10 of 11: Speed Management, Austroads, Sydney, New South Wales
• Austroads 2009 Guide to Traffic Management Part 10 of 11: Speed Management, Austroads, Sydney, New South Wales
• Austroads 2009 Guide to Traffic Management Part 10 of 11: Speed Management, Austroads, Sydney, New South Wales

การตรวจสอบการทำงานของสัญญาณไฟจราจร A16: Traffic signals operation review

คำอธิบาย
การตรวจสอบการทำงานของสัญญาณไฟจราจร เพื่อตรวจสอบและปรับปรุงสัญญาณไฟจราจรให้สอดคล้องกับคุณลักษณะของกระแสจราจรและพฤติกรรมที่ขับขี่ในปัจจุบัน



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 55%

ตำแหน่งที่ติดตั้ง

- ทางแยกที่มีสัญญาณไฟจราจร

เอกสารอ้างอิง
• ASTR42-1994 Manual of uniform traffic control devices - traffic signals

Group A: Cost rating under \$5,000 (Continue)

การห้ามเลี้ยว A17: Turn bans

คำอธิบาย
การห้ามเลี้ยว เป็นวิธีการกำจัดหรือลดจุดขัดแย้งบริเวณทางแยก



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 60%


ตำแหน่งที่ติดตั้ง

- ทางแยก

เอกสารอ้างอิง
• A1742-1-1914 Manual of Uniform Traffic Control Devices - Traffic control devices for general use

การติดตั้งป้ายเตือน A18: Warning signs

คำอธิบาย
การติดตั้งป้ายเตือน เพื่อบังคับให้ผู้ขับขี่ทราบและปฏิบัติตามคำแนะนำในป้าย เช่น ป้ายเตือนลดความเร็ว ป้ายเตือนเขตชุมชน เป็นต้น



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)


- 40% และ 30% (สำหรับป้ายเตือนความเร็ว และสะพาน)
- 25% (สำหรับป้ายเตือนทางโค้ง)

ความเร็วที่ลดลง

- 3.6 กม./ชม.

ตำแหน่งที่ติดตั้ง

- ทางแยก/ช่วงถนน/ทางโค้ง



เอกสารอ้างอิง
• Australia 2010 Guide to Traffic Engineering Practice Part 6 Traffic Control Devices AP-10106 Australia 2010 New South Wales
• Australia 2009 Guide to Traffic Management Part 6 Local Area Traffic Management Australia Sydney New South Wales
• Institute of Transportation Engineers (ITE) 2010 Speed Management Traffic Engineering Handbook
• สัญญาจ้างที่ปรึกษาที่ปรึกษาจราจร 1299 โครงการพัฒนาระบบจราจร (RIT) ถนนสาย 3 ทางจังหวัดนนทบุรี มหาวิทยาลัยเทคโนโลยีพระจอมเกล้าธนบุรี

Group B: Cost rating \$5,001 - \$20,000

การติดตั้งเส้นจราจรห้ามแซง B1: Barrier Line marking

คำอธิบาย
การติดตั้งเส้นจราจรห้ามแซง เป็นเส้นแบ่งที่แทนที่เส้นกั้นแยกเดี่ยว เพื่อห้ามการเคลื่อนย้ายข้ามจากทิศทางเดียวหรือทั้งสอง

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35%

ตำแหน่งที่ติดตั้ง

- ทางแยก/ช่วงถนน/ทางโค้ง

หมายเหตุอ้างอิง

- Austroads 2004 Manual of uniform traffic control devices - traffic control devices for general use.
- Main Roads Western Australia, Guideline Barrier Line Marking Assessment.

การติดตั้งอุปกรณ์บนทางสำหรับจักรยาน B2: Bicycle facilities – on road

คำอธิบาย
การติดตั้งอุปกรณ์บนทางสำหรับจักรยาน เช่น สัญลักษณ์ทางจักรยาน เพื่อเพิ่มความปลอดภัยให้แก่ผู้ใช้รถจักรยาน

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30%

ตำแหน่งที่ติดตั้ง

- ช่วงถนนที่มีการใช้จักรยาน

หมายเหตุอ้างอิง

- Austroads 2004 Manual of uniform traffic control devices - part 2 bicycle parking facilities.
- Aungmye, Sam and Jackson 2000, Guidelines for bicycle facilities.

การขยายเขตปลอดภัย B3: Clear zone widening

คำอธิบาย
การขยายเขตปลอดภัย เพื่อรองรับยานพาหนะที่เสีย การควบคุมให้สามารถหยุดหรือควบคุมยานพาหนะให้กลับสู่ช่องจราจรได้อย่างปลอดภัย

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 24% (สำหรับความกว้าง 2-4 เมตร)
- 49% (สำหรับความกว้าง 4-8 เมตร)
- 54% (สำหรับความกว้าง >8 เมตร)

ตำแหน่งที่ติดตั้ง

- ช่วงถนน

หมายเหตุอ้างอิง

- Austroads 2013 Road side design, a guide to the geometric design of rural roads (R) vol. AP-001, Australia, Sydney, NSW.

การติดตั้งอุปกรณ์ซับแรงกระแทก B4: Crash cushion/impact attenuator

คำอธิบาย
การติดตั้งอุปกรณ์ซับแรงกระแทก เพื่อลดความรุนแรงของอุบัติเหตุที่เกิดขึ้น

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 50%

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยก/จุดแยก

หมายเหตุอ้างอิง

- Austroads 2006, Roadside design guide, 3rd edn, Association of State Highway and Transportation Officials, Washington, DC.

การติดตั้งป้ายบอกทิศทาง (นำทาง) B5: Direction signs (guide signs)

คำอธิบาย
การติดตั้งป้ายบอกทิศทาง (นำทาง) เพื่อให้ผู้ใช้ขีกรบบตามตำแหน่งที่ทิศทางหรือการนำทางของป้าย

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 15%

ตำแหน่งที่ติดตั้ง

- ก่อนถึงทางแยก/ช่วงถนน/ทางโค้ง

หมายเหตุอ้างอิง

- Austroads 2004, Manual of uniform traffic control devices, part 2 traffic control devices for general use, section 2.6 Guide signs, 2.9 Road markers.

การปรับขอบผิวทางที่ต่างระดับ B6: Edge drop removal

คำอธิบาย
การลบขอบผิวทางที่ต่างระดับ เป็นปรับผิวของช่องทางวิ่งและช่องไหล่ทางให้อยู่ในระดับเดียวกัน (ต่อเนื่องกัน) เพื่อความปลอดภัยของยานพาหนะ (ลดความเสี่ยงของโอกาสเกิดอุบัติเหตุกรณีกระโดดข้ามช่องทาง)

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- ไม่มีผลการศึกษา

ตำแหน่งที่ติดตั้ง

- ช่วงถนน/ทางโค้ง

หมายเหตุอ้างอิง

- Austroads 1997, Guide to the visual environment of pavement condition, AP-6187, Australia, Sydney, NSW.
- คู่มือ 569 สำหรับงาน (1991) (ตีพิมพ์โดย ส.ป.ว. 1991)

การติดตั้งเส้นจราจรขอบทาง B7: Edge Lines

คำอธิบาย
การติดตั้งเส้นจราจรขอบทาง เพื่อให้ผู้ใช้ขีกรบบสามารถมองเห็นแนวของช่องทางวิ่งได้ชัดเจน และขับขี่ยานพาหนะอยู่บนช่องทางวิ่งอย่างเบี่ยงเบนและปลอดภัย

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 10%

ตำแหน่งที่ติดตั้ง

- ทางแยก/ช่วงถนน/ทางโค้ง

หมายเหตุอ้างอิง

- Austroads 2004, Manual of uniform traffic control devices, part 2 traffic control devices for general use, section 2.2 Pavement markings and delineation, general markers, 4.11 Edge lines, 4.12 Longitudinal lines at intersections, 4.15.3.9 Augmenting, painted line markers.

การติดตั้งป้ายนำทาง B8: Guideposts

คำอธิบาย
การติดตั้งป้ายนำทาง เพื่อให้ผู้ใช้ขีกรบบแนวทางของถนนตามป้ายนำทาง

ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 5%

ตำแหน่งที่ติดตั้ง

- ช่วงถนน/ทางโค้ง

หมายเหตุอ้างอิง

- Austroads 2004, Manual of uniform traffic control devices - parking controls.
- Austroads 2000, Guide to traffic engineering practice, part B parking AP-61000, Australia, Sydney, New South Wales.

Group B: Cost rating \$5,001 - \$20,000 (Continue)

การเพิ่มความชัดเจนของสัญญาณไฟจราจร B17: Signal display visibility improvements

คำอธิบาย
อุบัติเหตุบริเวณทางแยกที่การชนด้านข้างหรือชนท้ายหลายครั้งเกิดจากการมองเห็นสัญญาณไฟจราจรไม่ชัดเจน การเพิ่มความชัดเจนของโคมสัญญาณไฟจราจร จึงเป็นมาตรการที่ลดโอกาสการเกิดอุบัติเหตุบริเวณทางแยกได้



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35% - replace pedestal mount with mast arm mount
- 5% - increase lens size to twelve inches
- 20% - provide additional signal head

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยกที่มีสัญญาณไฟจราจร



หมายเหตุอ้างอิง

- AS 1944-2005, Rules and regulations governing the traffic signals, 18th Edition, Australian Standards, Sydney, New South Wales.
- Australian 2013 Guide to traffic engineering practice, part 7 Traffic signals, ANZS17013, Australia, Sydney, New South Wales.
- Main Road, Western Australia 2005, Traffic signals, document No TR2005/03, Perth, WA, Main Road, Western Australia, East Perth, Western Australia.
- Traffic New Zealand 2001, Traffic signals, Traffic New Zealand, Wellington, New Zealand and New Zealand Transport Agency, Wellington.
- Traffic New Zealand 2003, Traffic signals, document No TR2003/03, Wellington, New Zealand.
- Traffic New Zealand 2005, Traffic signals, document No TR2005/03, Wellington, New Zealand.
- Queensland Department of Main Roads 2005, Main Roads standard specifications - Traffic signals, MR1105, Queensland Department of Main Roads, Brisbane, Queensland.
- Singapore 2011, Singapore Traffic Engineering Manual, Singapore, Singapore.
- Singapore 2012, Singapore Traffic Engineering Manual, Singapore, Singapore.

การเพิ่มความเสียดทานของผิวจราจร B18: Skid resistance improvements

คำอธิบาย
ถนนเมื่อใช้งานระยะหนึ่งความเสียดทานของผิวจราจรจะลดลง การเพิ่มความเสียดทานของผิวจราจรมีหลายวิธี แต่การที่ผิวจราจรใหม่เป็นวิธีหนึ่งที่เพิ่มความเสียดทานได้ดี



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35%

ตำแหน่งที่ติดตั้ง

- ทิวเส้นทางที่มีความเสี่ยง

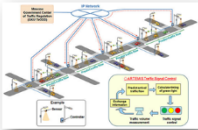


หมายเหตุอ้างอิง

- AS 1944-2005, Rules and regulations governing the traffic signals, 18th Edition, Australian Standards, Sydney, New South Wales.
- Australian 2013 Guide to traffic engineering practice, part 4 Treatment of road surfaces, ANZS17014, Australia, Sydney, New South Wales.
- Australian 2013, Guidelines for the management of maintenance and materials, ANZS17015, Australia, Sydney, New South Wales.
- Main Road, Western Australia 2005, Traffic signals, document No TR2005/03, Perth, WA, Main Road, Western Australia, East Perth, Western Australia.
- Traffic New Zealand 2001, Traffic signals, Traffic New Zealand, Wellington, New Zealand and New Zealand Transport Agency, Wellington.
- Traffic New Zealand 2003, Traffic signals, document No TR2003/03, Wellington, New Zealand.
- Queensland Department of Main Roads 2005, Main Roads standard specifications - Traffic signals, MR1105, Queensland Department of Main Roads, Brisbane, Queensland.
- Singapore 2011, Singapore Traffic Engineering Manual, Singapore, Singapore.
- Singapore 2012, Singapore Traffic Engineering Manual, Singapore, Singapore.

การประสานสัญญาณไฟจราจร B19: Traffic signals coordination

คำอธิบาย
การประสานสัญญาณไฟจราจรทำได้โดยการเชื่อมต่อสัญญาณไฟจราจรในแต่ละทางแยก ให้ระยะเวลาของสัญญาณไฟจราจรประสานการทำงานกับ เพื่อให้การเคลื่อนที่ของการจราจรต่อเนื่องและสอดคล้องกัน เพื่อลดความล่าช้าโดยรวมของจุดทางแยกที่พิจารณา และลดโอกาสเกิดอุบัติเหตุขึ้นได้




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 15%

ตำแหน่งที่ติดตั้ง

- จุดทางแยกที่มีสัญญาณไฟจราจร



หมายเหตุอ้างอิง

- AS 1944-2005, Rules and regulations governing the traffic signals, 18th Edition, Australian Standards, Sydney, New South Wales.
- Australian 2013 Guide to traffic engineering practice, part 7 Traffic signals, ANZS17013, Australia, Sydney, New South Wales.
- Main Road, Western Australia 2005, Traffic signals, document No TR2005/03, Perth, WA, Main Road, Western Australia, East Perth, Western Australia.
- Main Road, Western Australia 2007, Traffic signals, document No TR2007/02, Perth, WA, Main Road, Western Australia, East Perth, Western Australia.
- Main Road, Western Australia 2008, Traffic signals, document No TR2008/03, Perth, WA, Main Road, Western Australia, East Perth, Western Australia.
- Queensland Department of Main Roads 2005, Main Roads standard specifications - Traffic signals, MR1105, Queensland Department of Main Roads, Brisbane, Queensland.
- Singapore 2011, Singapore Traffic Engineering Manual, Singapore, Singapore.
- Singapore 2012, Singapore Traffic Engineering Manual, Singapore, Singapore.

Group C: Cost rating \$20,001 - \$50,000

การปรับมุมจอดรถให้ขนานขอบทาง C1: Convert angle parking to parallel parking

คำอธิบาย
การปรับมุมจอดรถให้ขนานขอบทาง ช่วยให้ผู้ใช้ขับขี่รถยนต์สามารถเข้าและออกที่จอดรถได้ง่ายและปลอดภัย เนื่องจากการมองเห็นด้านหลังตัวอาคารจอดรถแบบเฉียง




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 40%

ตำแหน่งที่ติดตั้ง

- บริเวณที่มีการจอดรถขนาน

หมายเหตุ:

- AS 1742-2003: Manual of uniform traffic control devices - parking controls
- Australia 2010 Urban road design guide to the generic design of major urban roads, AP-2010/01, Australia, Sydney, New South Wales
- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Singapore: Design Manual for Roadways, Volume 15: Parking (http://www.singapore.gov.sg/roads/roads15.htm)

การปิดปลายของเกาะกลาง C2: Median break closure

คำอธิบาย
ควรมีการปิดปลายเกาะกลางของถนนสายรอง ที่เชื่อมกับถนนสายหลักแบบมีเกาะกลาง (divided major road) เพื่อป้องกันไม่ให้รถสายรองเลี้ยวเข้ามาบนถนนสายหลัก (เบี่ยงซ้ายเลี้ยวซ้าย)




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 53%

ตำแหน่งที่ติดตั้ง

- บริเวณจุดกลับรถบนถนนสายหลักที่เป็นทางแยก

หมายเหตุ:

- Australia 2010 Urban road design guide to the generic design of major urban roads, AP-2010/01, Australia, Sydney, New South Wales
- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Queensland Department of Main Roads, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Singapore: Design Manual for Roadways, Volume 15: Parking (http://www.singapore.gov.sg/roads/roads15.htm)

การทาสีช่องรถเลี้ยวแบบทาสี C3: Painted turn lanes

คำอธิบาย
วิธีหนึ่งในการลดความเสียหายการชนท้ายบริเวณทางแยกหรือทางโค้งที่สำคัญ คือการทาสีช่องสำหรับรถเลี้ยว โดยเฉพาะ ซึ่งทำให้รถที่ต้องการเลี้ยวสามารถลดรอบและไม่ส่งผลกระทบต่อรถในกระแสหลักอีกด้วย




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30% สำหรับช่องเลี้ยวขวา
- 20% สำหรับช่องเลี้ยวซ้าย

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยกหรือทางโค้ง

หมายเหตุ:

- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Queensland Department of Main Roads, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Victoria 2009, Traffic engineering manual, vol. 2, 3rd edn, chapter 8: turn lanes, Victoria, New Victoria

การปรับปรุงการระบายน้ำของผิวทาง C4: Pavement drainage improvements

คำอธิบาย
การปรับปรุงการระบายน้ำมีส่วนช่วยลดโอกาสเกิดอุบัติเหตุ เนื่องจากหากมีน้ำขังหรือน้ำระเหยได้ช้า ความต้านทานการสั่นไถลของผิวจราจรจะน้อยลง หรือผู้ใช้ขับขี่ไม่สามารถมองเห็นเส้นจราจรได้ชัดเจน มีโอกาสเกิดอุบัติเหตุได้




ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 32%

ตำแหน่งที่ติดตั้ง


- เส้นทางที่มีความเสี่ยง/ฝนตกชุก

หมายเหตุ:

- United States: Booklet of countermeasures and their potential effectiveness for roadway departure crashes
- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Australia 2010 Urban road design guide to the generic design of major urban roads, AP-2010/01, Australia, Sydney, New South Wales
- Australia 2010 Road design guide to the generic design of rural roads, AP-2010/02, Australia, Sydney, New South Wales
- Department of Main Roads Queensland, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Land Transport New Zealand, 2002 State highway design manual, section 5: vertical alignment, Land Transport New Zealand, Wellington, New Zealand
- Land Transport New Zealand, 2002 State highway design manual, section 5: horizontal alignment, Land Transport New Zealand, Wellington, New Zealand
- Roadway design guide to the design of road drainage systems, volume 1: road drainage, Australia, Victoria, ACT
- Roadway design guide to the design of road drainage systems, volume 2: road drainage, Australia, Victoria, ACT
- Queensland Department of Main Roads, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Queensland Department of Main Roads, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Singapore: Design Manual for Roadways, Volume 15: Parking (http://www.singapore.gov.sg/roads/roads15.htm)
- Singapore: Design Manual for Roadways, Volume 15: Parking (http://www.singapore.gov.sg/roads/roads15.htm)

การติดตั้งเกาะแยกกระแสรถ C5: Splitter Islands

คำอธิบาย
เกาะแยกกระแสรถถูกติดตั้งบริเวณทางแยก เพื่อแยกทิศทางจำกัดการเคลื่อนที่ และชะลอความเร็วของรถที่เข้าสู่ทางแยก บางครั้งใช้เป็นจุดพักสำหรับคนข้ามถนน



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30% กรณีเกาะแบ่งช่องจราจร (channelization)
- 30% กรณีเกาะแยกกระแสรถ (พื้นที่ทั่วไป)
- 35% กรณีเกาะแยกกระแสรถ (ในเขตเมือง)
- 15% กรณีเกาะกลางแบบขามได้ (mountable median)
- 25% กรณีเกาะกลางแบบขามไม่ได้ (non-mountable median)

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยก

หมายเหตุ:

- AS 1742-2003: Design for access and mobility - for roadways
- Australia 2010 Urban road design guide to the generic design of major urban roads, AP-2010/01, Australia, Sydney, New South Wales
- Australia 2010 Road design guide to the generic design of rural roads, AP-2010/02, Australia, Sydney, New South Wales
- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Main Roads Victoria, Australia 2007 Intersections at grade, document No. TR-02-03, Victoria, Victoria, Australia
- Main Roads Victoria, Australia 2007 Intersections at grade, document No. TR-02-03, Victoria, Victoria, Australia

การติดตั้งไฟฟ้าแสงสว่าง C6: Street Lighting

คำอธิบาย
ไฟฟ้าแสงสว่างเป็นสิ่งที่จำเป็นที่ช่วยให้ผู้ใช้ขับขี่มองเห็นเส้นทางและทำให้ผู้ใช้ได้ปลอดภัย ที่ความเร็วลดลงเมื่อแสงสว่างดับน้อยลง



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35% กรณีทั่วไป
- 50% กรณีทางแยก
- 40% กรณีช่วงถนน
- 30% กรณีทางแยกในชนบท
- 30% กรณีในเมือง
- 50% กรณีทางเชื่อมมอเตอร์เวย์/ทางด่วน
- 60% กรณีทางตัดรถไฟ

หมายเหตุ:

- AS 1742-2003: Design for access and mobility - for roadways
- Australia 2010 Guide to traffic engineering practice, part 6: intersection, design manual, section 6.10: intersection, Queensland Department of Main Roads, Brisbane, Queensland
- Victoria 2009, Traffic engineering manual, vol. 2, 3rd edn, chapter 8: turn lanes, Victoria, New Victoria
- Department of Main Roads Queensland, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Main Roads Victoria, Australia 2007 Intersections at grade, document No. TR-02-03, Victoria, Victoria, Australia
- Land Transport New Zealand, 2002 State highway design manual, section 5: vertical alignment, Land Transport New Zealand, Wellington, New Zealand
- Land Transport New Zealand, 2002 State highway design manual, section 5: horizontal alignment, Land Transport New Zealand, Wellington, New Zealand

การขยายความกว้างช่องจราจร C7: Traffic lane widening

คำอธิบาย
การขยายช่องจราจรทำได้ทั้งช่วงทางโค้ง ทางตรงและทางแยก ซึ่งจะช่วยลดความเสี่ยงของการชนปะสานงาได้



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 13% กรณีช่องจราจรกว้าง 2.7 - 3.0 เมตร
- 19% กรณีช่องจราจรกว้าง 3.0 - 3.3 เมตร
- 5% กรณีช่องจราจรกว้าง 3.3 - 3.7 เมตร

ตำแหน่งที่ติดตั้ง


- ทางโค้ง/ทางตรง/ทางแยก

หมายเหตุ:

- Australia 2010 Urban road design guide to the generic design of major urban roads, AP-2010/01, Australia, Sydney, New South Wales
- Australia 2010 Road design guide to the generic design of rural roads, AP-2010/02, Australia, Sydney, New South Wales
- Queensland Department of Main Roads, 2010 Road planning and design manual, chapter 3: road planning and design, Queensland Department of Main Roads, Brisbane, Queensland
- Singapore: Design Manual for Roadways, Volume 15: Parking (http://www.singapore.gov.sg/roads/roads15.htm)

การติดตั้งป้ายเตือนแบบกระตุ้น C8: Vehicle activated signs

คำอธิบาย
ป้ายเตือนแบบกระตุ้นเป็นป้ายที่มีอุปกรณ์ตรวจจับยานพาหนะที่เข้าใกล้ โดยหากยานพาหนะนั้นไม่ปฏิบัติตามกำหนดก็จะแสดงไฟเตือน เช่น ป้ายเตือนความเร็ว ป้ายเตือนใหญ่รถ



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35%

ตำแหน่งที่ติดตั้ง

- ทุกพื้นที่ที่มีความเสี่ยง

หมายเหตุ:

- Winnett, MA & Wheeler, AH 2002, Vehicle-activated signs - a large scale evaluation, report 548, TRL Limited, Crowthorne, UK

Group D: Cost rating \$50,001 - \$100,000

การรวมจุดเชื่อมต่อ
D1: Combine access points

คำอธิบาย

การรวมจุดเชื่อมต่อเป็นการจัดการการเชื่อมถนนสายรองกับถนนสายหลัก หรืออาจเป็นทางแยก โดยทำให้ผู้ขับช้รับรู้ได้ว่าข้างหน้าเป็นจุดเชื่อมต่อหรือทางแยก และสามารถขับผ่านได้ปลอดภัย



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- ไม่มีผลการศึกษา

ตำแหน่งที่ติดตั้ง

- บริเวณจุดเชื่อมต่อ/ทางแยก/วงเวียน



เอกสารอ้างอิง

- A5 174218-1999. Manual of uniform traffic control devices - parking controls.
- Austroads 1988. Guide to traffic engineering practice, part 11 parking AP-111188. Austroads, Sydney, New South Wales

การจัดช่วงสัญญาณไฟเฉพาะสำหรับรถเลี้ยวขวา
D2: Fully controlled right turn phase

คำอธิบาย

การจัดช่วงสัญญาณไฟจราจรสำหรับรถเลี้ยวขวาช่วยลดการขัดแย้งบริเวณทางแยก ทั้งระหว่างยานพาหนะด้วยกันและกับคนข้ามถนน



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35% สำหรับอุบัติเหตุทุกประเภท
- 60% สำหรับอุบัติเหตุรถทางตรงชนรถเลี้ยวขวา
- 45% สำหรับอุบัติเหตุรถในทิศทางใกล้เคียงกัน
- 10% สำหรับกรณีควบคุมการเลี้ยวขวาบางส่วน
- 70% สำหรับกรณีควบคุมการเลี้ยวขวาทั้งหมด

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยกที่มีสัญญาณไฟจราจร

เอกสารอ้างอิง

- Austroads 2013. Guide to traffic engineering practice, part 11 traffic signals AP-111183. Austroads, Sydney, NSW, section 6.3. Parking design
- Queensland Department of Main Roads 2002. Traffic and road sign management manual, vol. 2, issue 2/9/2002. Queensland Department of Main Roads, Brisbane. Queensland section 2.4 Traffic signal phasing selection section 2.7 Control of right-turn movements at traffic signals
- RTA 2004. Traffic signal design 2004. RTA 2004. Road and Traffic Authority, Sydney, New South Wales

Group E: Cost rating over \$100,000

การก่อสร้างช่องจราจรเฉพาะสำหรับแซง
E1: Additional Lanes for overtaking

คำอธิบาย

กรณีถนนสองช่องจราจรและมีรถวิ่งช้า การแซงมีโอกาสจำกัด การเพิ่มช่องจราจรเฉพาะสำหรับแซงในช่วงถนน จะช่วยเพิ่มความปลอดภัย รวมทั้งการไหลของกระแสจราจรดีขึ้น



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 25%

ตำแหน่งที่ติดตั้ง

- บริเวณทางตรงที่มีสองช่องจราจร และมีรถวิ่งช้า



เอกสารอ้างอิง

- Austroads 2013. Road road design a guide to the practice design of main roads, part 11, AP-111183. Austroads, Sydney, NSW, section 6.4. Overpass and underpass design
- Main Roads Western Australia 2007. Overtaking lanes. Document No. 07-00-02. Perth WA. Main Roads of Western Australia, East Perth, Western Australia
- Transport New Zealand 2004. Transport signal standards 2004-2005. RT1310-1. Part 11. Overpass, underpass, tunnel and bridge. Queensland Department of Main Roads, Brisbane, Queensland
- Transport New Zealand 2007. Transport signal standards 2007-2008. RT1310-1. Part 11. Overpass, underpass, tunnel and bridge. Queensland Department of Main Roads, Brisbane, Queensland
- Transport New Zealand 2007. Transport signal standards 2007-2008. RT1310-1. Part 11. Overpass, underpass, tunnel and bridge. Queensland Department of Main Roads, Brisbane, Queensland

การขยายช่วงทางโค้ง
E2: Curve widening

คำอธิบาย

การขยายช่วงทางโค้ง เป็นการขยายช่องจราจรหรือใส่ทางด้านนอกโค้ง ร่วมกับการติดตั้งเส้นจราจร ป้ายเตือนแนวทางโค้ง (Chevron) เพื่อให้ยานพาหนะเข้าโค้งด้วยความเร็วได้ปลอดภัยขึ้น

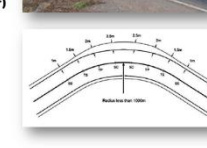


ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 17% กรณีอุบัติเหตุทั่วไป
- 44% กรณีอุบัติเหตุที่มีผู้เสียชีวิต
- 40% กรณีอุบัติเหตุที่มีผู้บาดเจ็บสาหัส

ตำแหน่งที่ติดตั้ง

- บริเวณทางโค้ง



เอกสารอ้างอิง

- Austroads 2013. Road road design a guide to the practice design of main roads, part 11, AP-111183. Austroads, Sydney, NSW
- Transport New Zealand 2005. Safe highway geometry design manual, section 6.3. Curves. Queensland Department of Main Roads, Brisbane, Queensland
- Queensland Department of Main Roads 2007. Road planning and design manual, Chapter 5. Curves. Queensland Department of Main Roads, Brisbane, Queensland
- สัตยกุลศรี 1996. การออกแบบทางจราจรและสัญญาณจราจร. 5. การออกแบบทางโค้ง. กรุงเทพฯ: อสมท

การก่อสร้างทางยกระดับ
E3: Grade separation

คำอธิบาย

การก่อสร้างทางยกระดับเป็นการแยกการเคลื่อนไหวยานพาหนะที่ขัดแย้งออกจากกัน มีทั้งก่อสร้างทางยกระดับหรือสะพานลอยบริเวณทางยกระดับระหว่างถนนสายหลักติดกับถนนสายรอง



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 55% - ทางยกระดับทางแยกรูปตัว X
- 20% - ทางยกระดับทางแยกรูปตัว Y

ตำแหน่งที่ติดตั้ง

- ถนนสายหลักที่มีทางแยก

เอกสารอ้างอิง

- Austroads 2017. Guide to traffic engineering, part 11 intersections, interchange and crossing, AP-111183. Austroads, Sydney, New South Wales
- Department of Main Roads Queensland 2005. Road planning and design manual, chapter 11. Intersections. Queensland Department of Main Roads, Brisbane, Queensland
- Department of Main Roads Queensland 2005. Road planning and design manual, chapter 11. Intersections. Queensland Department of Main Roads, Brisbane, Queensland
- Transport New Zealand 2004. Transport signal standards 2004-2005. RT1310-1. Part 11. Overpass, underpass, tunnel and bridge. Queensland Department of Main Roads, Brisbane, Queensland
- Transport New Zealand 2007. Transport signal standards 2007-2008. RT1310-1. Part 11. Overpass, underpass, tunnel and bridge. Queensland Department of Main Roads, Brisbane, Queensland
- Main Roads Western Australia 2009. Road design manual, section 11.1. Intersections. Queensland Department of Main Roads, Brisbane, Queensland

การสร้างที่จอดรถข้างทางแบบแยกจากทางวิ่ง
E4: Indented parking

คำอธิบาย

เป็นการก่อสร้างที่จอดรถแยกออกจากช่องทางวิ่ง เพื่อแยกพื้นที่ระหว่างยานพาหนะที่วิ่งผ่านกับยานพาหนะที่จอด



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 22% กรณีอุบัติเหตุทั่วไป
- 20% กรณีอุบัติเหตุที่มีผู้บาดเจ็บ
- 27% กรณีอุบัติเหตุทรัพย์สินเสียหายเท่านั้น

ตำแหน่งที่ติดตั้ง

- บริเวณชุมชนที่มีการจอดรถข้างทางหนาแน่น



เอกสารอ้างอิง

- FHWA 2006. Toolbox of Countermeasures and Their Potential Effectiveness for Roadway Departure Crashes
- Austroads 1998. Guide to traffic engineering, part 11, AP-111183. Austroads, Sydney, NSW
- Austroads 1998. Guide to traffic engineering, part 11, AP-111183. Austroads, Sydney, NSW
- Department of Main Roads Queensland 2005. Road planning and design manual, chapter 11. Intersections. Queensland Department of Main Roads, Brisbane, Queensland

Group E: Cost rating over \$100,000 (Continue)

การท่าแยกเอียงกัน E13: Staggered Intersection

คำอธิบาย
การท่าแยกเอียงกันเป็นมาตรการที่มีประสิทธิภาพเหมาะสำหรับถนนสายรองที่อยู่ตรงข้ามกันและมีปริมาณจราจรน้อย ทั้งนี้รถบนถนนสายรองต้องหยุดหรือชะลอความเร็วโดยใช้เกาะกึ่งภาพหรือการปรับแนวเส้นทาง ก่อนเลี้ยวเข้าหรือข้ามทางแยก



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35% (เพิ่มขึ้น) ทางแยกที่มีถนนสายรองปริมาณจราจร <15% มาต่อเชื่อม
- 25% ทางแยกที่มีถนนสายรองปริมาณจราจร 15-30% มาต่อเชื่อม
- 35% ทางแยกที่มีถนนสายรองปริมาณจราจร >30% มาต่อเชื่อม

ตำแหน่งที่ติดตั้ง

- เส้นทางสายหลัก ที่มีถนนย่อยมาเชื่อมต่อ

แหล่งข้อมูล:
- Design: Design Advisor
- Austroads 2015 Guide to traffic engineering practice, part 5 Intersections, at grade, AP-015/05, Austroads, Sydney, New South Wales

การปรับปรุงการยกโค้ง E14: Superelevation Improvement

คำอธิบาย
การปรับปรุงการยกโค้งต้องสามารถรองรับข้อผิดพลาดของผู้ขับขี่ที่เข้าโค้งด้วยความเร็วสูงได้อย่างปลอดภัย ผู้ออกแบบควรศึกษาและออกแบบรายละเอียดของการยกโค้งที่ถูกต้องและปลอดภัย



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 10% สำหรับการปรับปรุงแก้ไขการยกโค้ง

ตำแหน่งที่ติดตั้ง

- บริเวณทางโค้ง

แหล่งข้อมูล:
- Austroads 2012 Urban road design guide to the practice, design of major urban roads, AP-050/02, Austroads, Sydney, New South Wales
- Austroads 2012 Rural road design guide to the practice, design of rural roads, AP-010/02, Austroads, Sydney, New South Wales
- Austroads 2014 Engineering guide to the practice, design of rural roads, AP-010/03, Austroads, Sydney, New South Wales
- Main Roads Western Australia 2010 Engineering, Curve Guide, Main Roads Western Australia, East Perth, Western Australia
- Main Roads Western Australia 2010 Road engineering, document No 07-04-01, Western Australia, East Perth, Western Australia, section 4.4 Plan and super-elevation transitions
- Main Roads Western Australia 2010 Road profile, document No 07-04-02, Western Australia, East Perth, Western Australia

การติดตั้งสัญญาณไฟจราจร E15: Traffic signals

คำอธิบาย
บริเวณทางแยกมีจุดแอ่งและโอกาสเกิดอุบัติเหตุสูง การติดตั้งสัญญาณไฟจราจรเพื่อลดความขัดแย้งและควบคุมการไหลของกระแสนจราจรให้มีความปลอดภัยยิ่งขึ้น



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 30% - ติดตั้งสัญญาณไฟจราจรใหม่

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยก

แหล่งข้อมูล:
- AUSTROADS 2005, Manual of uniform traffic control devices - traffic signals
- Austroads 2013 Guide to traffic engineering practice, part 7 Traffic signals, AP-010/03, Austroads, Sydney, New South Wales
- AUSTROADS 2015, Guide to traffic engineering practice, part 5 Intersections, at grade, AP-015/05, Austroads, Sydney, New South Wales
- Main Roads Western Australia 2010 Traffic signals, document No 07-04-03, Western Australia, East Perth, Western Australia
- Main Roads Western Australia 2010 Traffic signals, document No 07-04-04, Western Australia, East Perth, Western Australia
- Queensland Department of Main Roads 2010, Main Roads Queensland specifications, traffic signals, AP-010/03, Queensland Department of Main Roads, Brisbane, Queensland
- Designing: https://www.fhwa.dot.gov/turnlanes/turnlanes.htm, AP-016/02

การก่อสร้างช่องจราจรสำหรับเลี้ยว E16: Turn lanes

คำอธิบาย
การลดความเสี่ยงของการชนท้ายบริเวณทางแยกทางตรง เพื่อให้การจราจรสำหรับรถเลี้ยวแยกจากช่องทางตรง เพื่อให้รถที่ต้องการเลี้ยวหยุดรอและเลี้ยวได้ปลอดภัย โดยไม่ส่งผลกระทบต่อรถทางตรงที่ตามหลัง



ร้อยละการลดลงของอุบัติเหตุ (Crash Reduction Factor)

- 35% - ช่องจราจรสำหรับเลี้ยวขวา (ขึ้นอยู่กับสภาพแวดล้อม)
- 20% - ช่องจราจรสำหรับเลี้ยวซ้าย

ตำแหน่งที่ติดตั้ง

- บริเวณทางแยกของถนนสายหลัก/สายรอง

แหล่งข้อมูล:
- Austroads 2015 Guide to traffic engineering practice, part 5 Intersections, at grade, AP-015/05, Austroads, Sydney, New South Wales
- Department of Main Roads Queensland 2005, Road planning and design manual, chapter 03 Intersections, at grade, Queensland Department of Main Roads, Brisbane, Queensland
- Main Roads Western Australia 2010 Road engineering, document No 07-04-02, Western Australia, East Perth, Western Australia
- VTI Road 2005, Traffic engineering manual, chapter 7.4 Turn lanes, vol.2, 301-303, VTI Road, New York

Appendix B

Benefit-Cost Analysis of safety improvement for the three hazardous locations

Cost

| Treatment | Crash reduction ⁽¹⁾ (%) | Cost (Baht) |
|-----------------------|------------------------------------|----------------|
| Motorcycle lane | 20-30 | 100,750 |
| Guardrail and barrier | 30-40 | 453,750 |
| Combination | 44.0⁽²⁾ | 554,500 |

⁽¹⁾Ogden (1996), Taneerananon (2006)

⁽²⁾Crash reduction from the combination treatments = 1 - (0.8x0.7) = 0.44 or 44.0%

Benefit

| Type of casualty | Total no. casualties (persons) | Average no. casualties (persons/years) | Crash reduction rate (%) | Crash cost (Baht) | Benefit from crash saving (Baht) |
|---------------------|--------------------------------|--|--------------------------|-------------------|----------------------------------|
| Fatal | 2 | 0.67 | 44.0 | 7,370,000 | 3,242,800 |
| Seriously injured | - | - | 44.0 | - | - |
| Slightly injured | 26 | 8.67 | 44.0 | 632,910 | 278,480 |
| Total (Baht) | | | | | 3,521,280 |

B/C

Given

Capital Recovery Factor = 0.277410 (Interest rate =12% per year and life time =5 years)
 Equivalent Uniform Annual Cost = 554,500 x 0.277410 = 153,824 Baht / year
 Maintenance cost (approximately) = 105,000 Baht/year

$$B/C = \frac{3,521,280}{153,824 + 105,000} = 13.6$$

Note: This B/C is approximately estimated. For implementation, a detailed analysis is needed.

Figure A1 Benefit-Cost Analysis of road safety improvement for Hwy.4029 km.0+400

Cost

| Treatment | Crash reduction ⁽¹⁾ (%) | Cost (Baht) |
|-----------------------|------------------------------------|----------------|
| Motorcycle lane | 20-30 | 100,750 |
| Guardrail and barrier | 30-40 | 453,750 |
| Combination | 44.0⁽²⁾ | 554,500 |

⁽¹⁾Ogden (1996), Taneerananon (2006)

⁽²⁾Crash reduction from the combination treatments = 1 - (0.8x0.7) = 0.44 or 44.0%

Benefit

| Type of casualty | Total no. casualties (persons) | Average no. casualties (persons/years) | Crash reduction rate (%) | Crash cost (Baht) | Benefit from crash saving (Baht) |
|---------------------|--------------------------------|--|--------------------------|-------------------|----------------------------------|
| Fatal | 2 | 0.67 | 44.0 | 7,370,000 | 3,242,800 |
| Seriously injured | - | - | 44.0 | - | - |
| Slightly injured | 14 | 8.67 | 44.0 | 340,910 | 150,000 |
| Total (Baht) | | | | | 3,392,800 |

B/C

Given

Capital Recovery Factor = 0.277410 (Interest rate =12% per year and life time =5 years)
 Equivalent Uniform Annual Cost = 554,500 x 0.277410 = 153,824 Baht / year
 Maintenance cost (approximately) = 105,000 Baht/year

$$B/C = \frac{3,392,800}{153,824 + 105,000} = 13.1$$

Note: This B/C is approximately estimated. For implementation, a detailed analysis is needed.

Figure A2 Benefit-Cost Analysis of road safety improvement for Hwy.4029 km.1+500

Cost

| Treatment | Crash reduction ⁽¹⁾ (%) | Cost (Baht) |
|--------------------|------------------------------------|----------------|
| U-turn improvement | 20-30 | 150,000 |
| Combination | 20.0⁽²⁾ | 150,000 |

⁽¹⁾Ogden (1996), Taneerananon (2006)

⁽²⁾Assumed to use the low value as a minimum bound.

Benefit

| Type of casualty | Total no. casualties (persons) | Average no. casualties (persons/years) | Crash reduction rate (%) | Crash cost (Baht) | Benefit from crash saving (Baht) |
|---------------------|--------------------------------|--|--------------------------|-------------------|----------------------------------|
| Fatal | - | - | - | - | - |
| Seriously injured | 1 | 0.33 | 20.0 | 1,040,118 | 208,024 |
| Slightly injured | 1 | 0.33 | 20.0 | 22,672 | 4,535 |
| Total (Baht) | | | | | 212,559 |

B/C

Given

Capital Recovery Factor = 0.277410 (Interest rate =12% per year and life time =5 years)
 Equivalent Uniform Annual Cost = 150,000 x 0.277410 = 41,612 Baht / year
 Maintenance cost (approximately) = 20,000 Baht/year

$$\mathbf{B/C} = \frac{212,559}{41,612 + 20,000} = \mathbf{3.45}$$

Note: This B/C is approximately estimated. For implementation, a detailed analysis is needed.

Figure A3 Benefit-Cost Analysis of road safety improvement for Hwy.4024 km.3+100

Final Report

Research Grant 2019