An Optimized Design of Roundabout for Safety Enhancement on Road Users: A Case Study of Suranaree University of Technology

Interim report presentation

27th August 2022

Research project for fiscal year of 2022-2023

RESEARCH MEMBERS

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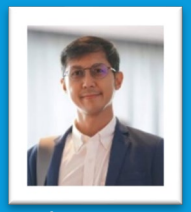

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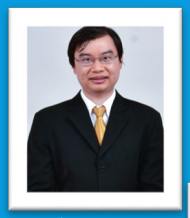

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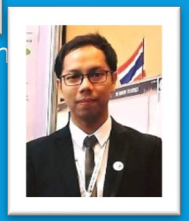

Project advisors

1) Prof. Dr. Atsushi Fukuda

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2) Dr. Tuenjai Fukuda

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3) Asst. Prof. Dr. Sittha Jaensirisak

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OUTLINE

- Introduction
- Objectives
- Methodology
- Progress works
- Further works
- Responses to IATSS advisors' comments

INTRODUCTION (1)

- **Roundabout** is one of the most effective tools that help reducing the chance and severity of traffic collision by **reducing the conflict points** and forcing drivers to reduce their **speeds**.
- Two conditions must be met for a roundabout to reduce the frequency and severity of traffic collisions (Dabbour et al., 2018):
  1) **The design** of the roundabout **must conform to the design guides** (e.g., Austroads, 2015; AASHTO, 2018) **and the best practices** so that the geometry of the roundabout would force drivers to reduce their speeds without causing unnecessary delays; and
  2) **Drivers must be familiar** with the rules of driving at roundabouts (Harkey & Carter, 2006). This is usually achieved through proper education, licensing, procedures, and law enforcement techniques.

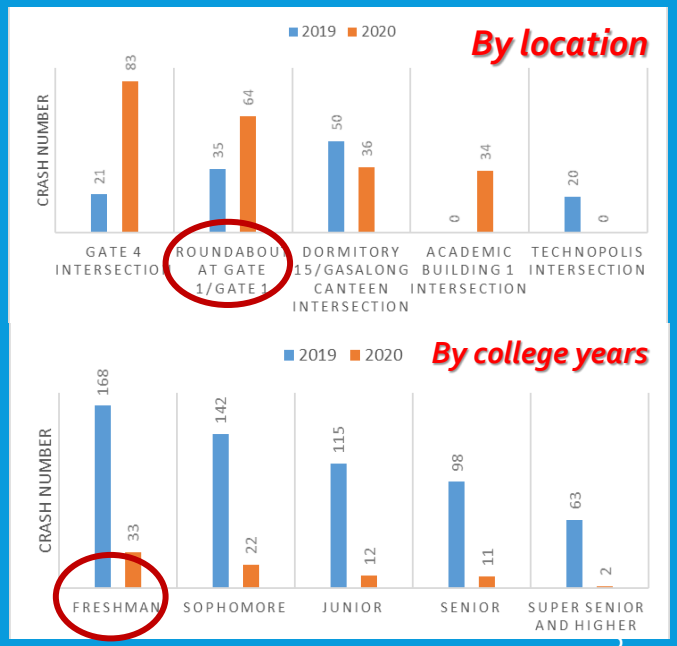
INTRODUCTION (2)

- In Thailand, several roundabouts have been installed. However, there are some **unsafe problems in the design** of roundabouts and in the **behaviors of road users**, especially **MC** (Koren, et al., 2010).
- Some drivers/riders may not be conscious and misunderstanding the rules of using roundabouts.

The roundabout in front of SUT, Nakhon Ratchasima

Source: Rattanaporn Kasemsri, recorded on 22 February 2022, 5.00 p.m.

Number of crashes



Source: Security office, SUT

OBJECTIVES

1) To investigate potential risks and risky driving behaviors at the existing roundabout.
2) To redesign the roundabout for safety enhancement on road users considering both safety and traffic performances.
3) To educate students and staffs on basic knowledge of driving and riding safely at roundabouts.

Source: towardszero.nsw.gov.au

RESEARCH METHODS

1) Literature reviewing on roundabout design standards, good practices, road rules, and related works

2) Data collection
- Road geometry (roundabout diameter, number of legs, number of lanes, lane width, etc.) was investigated by surveyors.
- Traffic characteristics of road users) were recorded by UAV (drone).

3) Data analysis
- Traffic trajectory has been analyzed by the algorithm developed based on AI and digital technologies.
- Safety measures (e.g., no. conflicts, TTC, PET, lane departure, approaching speed) will be determined.
- Traffic performances (e.g., travel time, capacity) will be measured.

4) Comparison 4 types of roundabouts
- R1: Existing roundabout
- R2: Physically enhanced roundabout (with trial test)
- R3: Priority motorbike lane application (with trial test)
- R4: Priority exclusive motorbike lane (conceptual design)

5) Educational training for road users
- 300 students + 30 staffs at SUT
- Pre and post training evaluations
- Asking opinion on R1, R2, R3, and R4

6) Proposal of redesigned roundabout based on traffic safety performances and road users' opinion

7) Conclusions and recommendations

EXPECTED OUTPUTS

1) The algorithm developed in this research could be used an effective tool for tracking traffic trajectory of vehicles and analyzing related parameters in other roundabouts.
2) Roundabout redesign process could be applied to other areas.
3) The optimal (safer) design of roundabout will be proposed to the concerned authority for further actions.
4) The trained road users could comply with traffic rules, avoid risks, and drive safely at the roundabout.
5) The content and materials from the roundabout training could be applied to other areas.

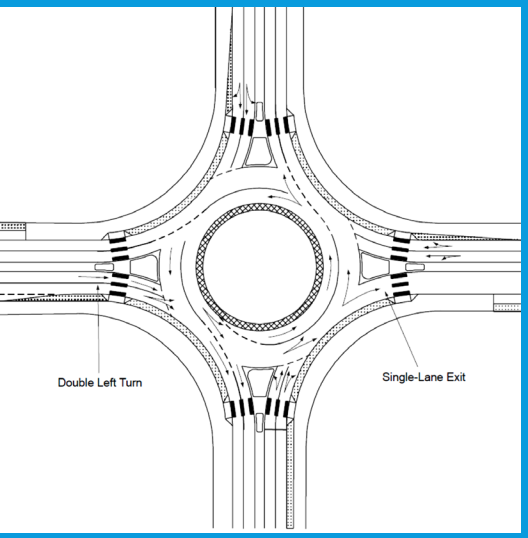
PROGRESS WORKS

LITERATURE REVIEWS

ROUNDABOUT DESIGN STANDARDS AND GUIDELINES (1)

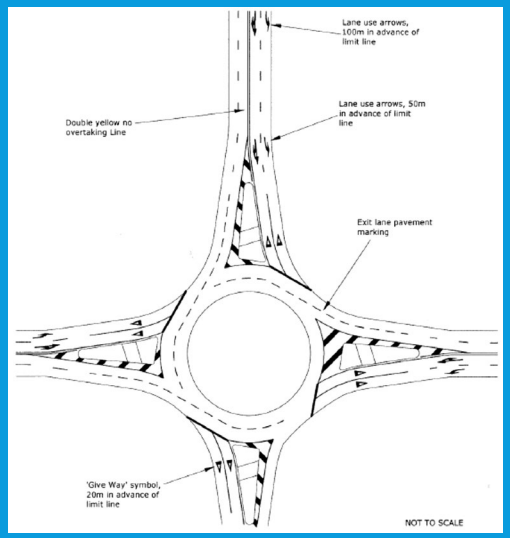
Typical designs

Roundabout lane configuration example



Source: AASHTO (2018) A Policy on Geometric Design of Highways and Streets, Figure 9-62.

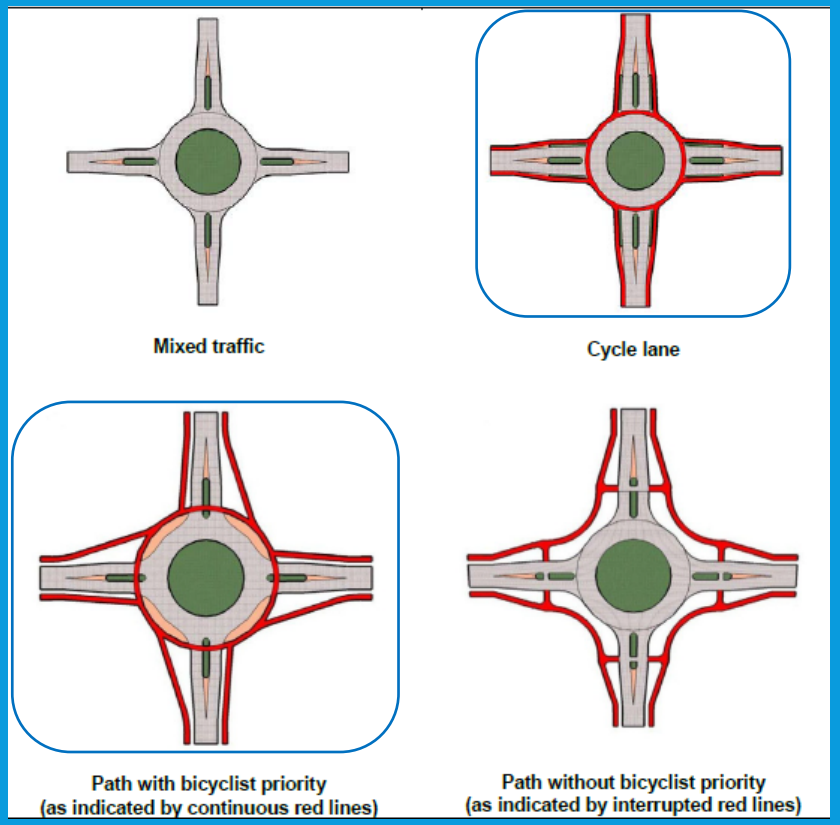
Linemarking of multi-lane roundabout



Source: Austroads (2021) Guide to Road Design Part 4B: Roundabouts, Figure D1.

- Most updated design standards and guidelines of roundabout for all road users were reviewed.

Roundabouts with bike lanes

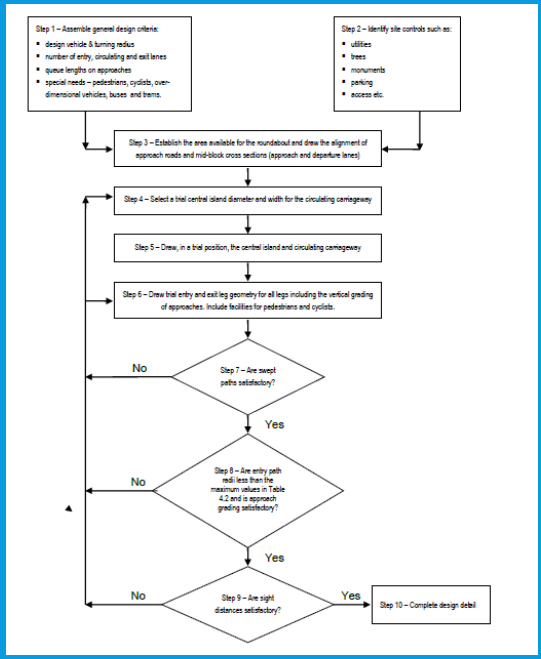


Source: Austroads (2014) Assessment of the effectiveness of on-road bicycle lanes at roundabouts in Australia and New Zealand

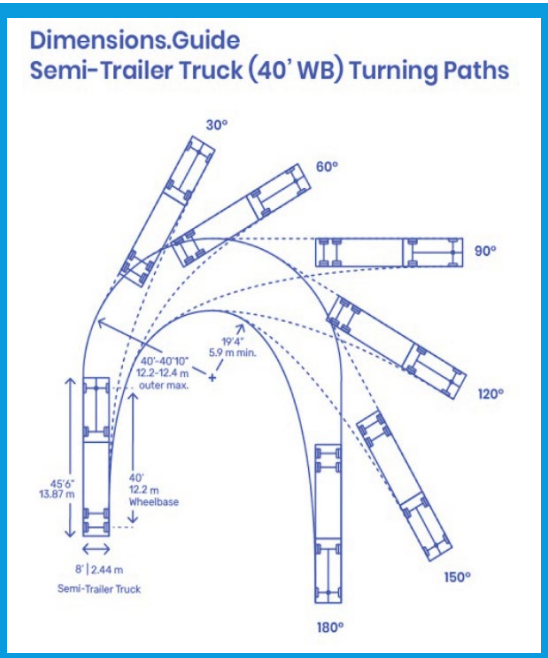
LITERATURE REVIEWS

ROUNDABOUT DESIGN STANDARDS AND GUIDELINES (2)

Design procedure

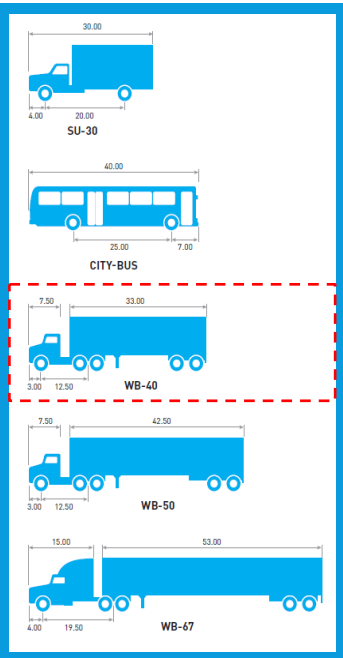


Source: Austroads (2015)



Source: Roadway Design Manual (2020)

Design criteria



Source: Austroads (2015)

Table 4.1: Guide for selecting the minimum central island radius for a circular roundabout

Desired driver speed on the fastest leg prior to the roundabout (km/h)	Central island radius of a single-lane roundabout (m)		Central island radius of a two-lane roundabout (m)		Speed reduction treatments required prior to the entry curve[1]
	Minimum[5]	Desirable	Minimum[5]	Desirable	
≤ 40[2]	5[4]	10	8	12	No
50[2]	8	11	8	12	No
60[3]	10	12	14	16	No
70[3]	12	18	18	20	No
80[3]	14	22	20	24	Desirable
≥ 90[3]	14	22	20	24	Yes

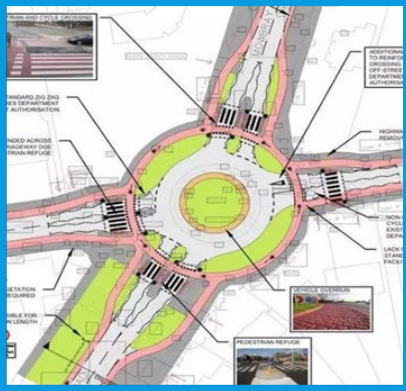
LITERATURE REVIEWS

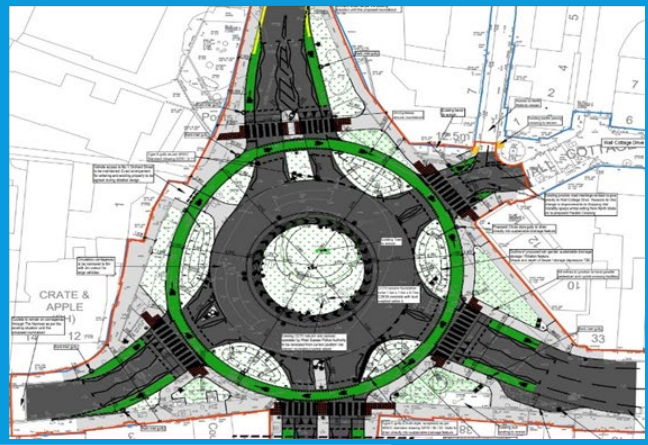
GOOD PRACTICES

UK'S first Dutch-style roundabout

Source: BBC news

Roundabouts with exclusive bicycle lane

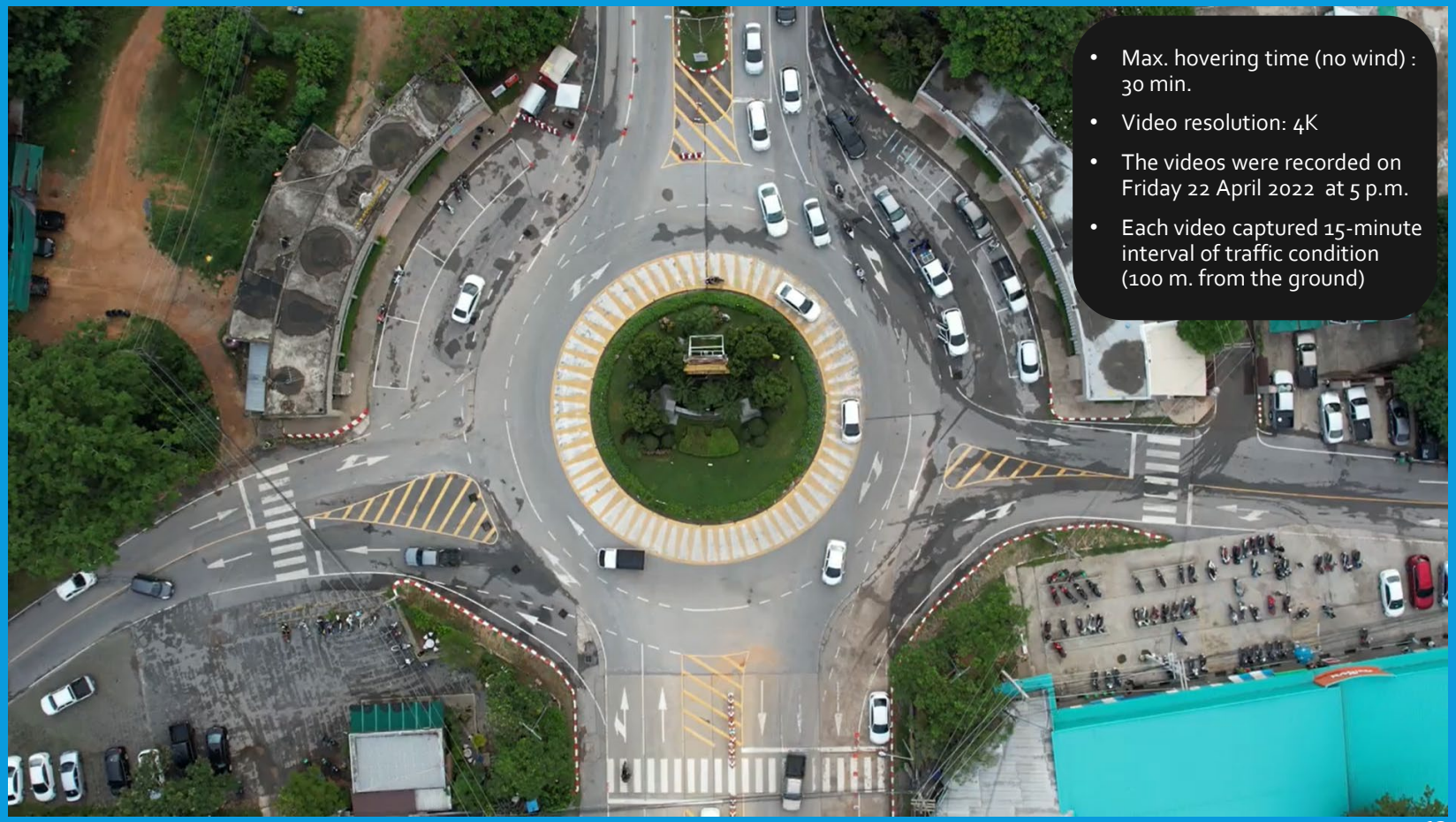




- Good practices of roundabout for vulnerable road users (e.g., bicycle) were also reviewed.

DATA COLLECTION

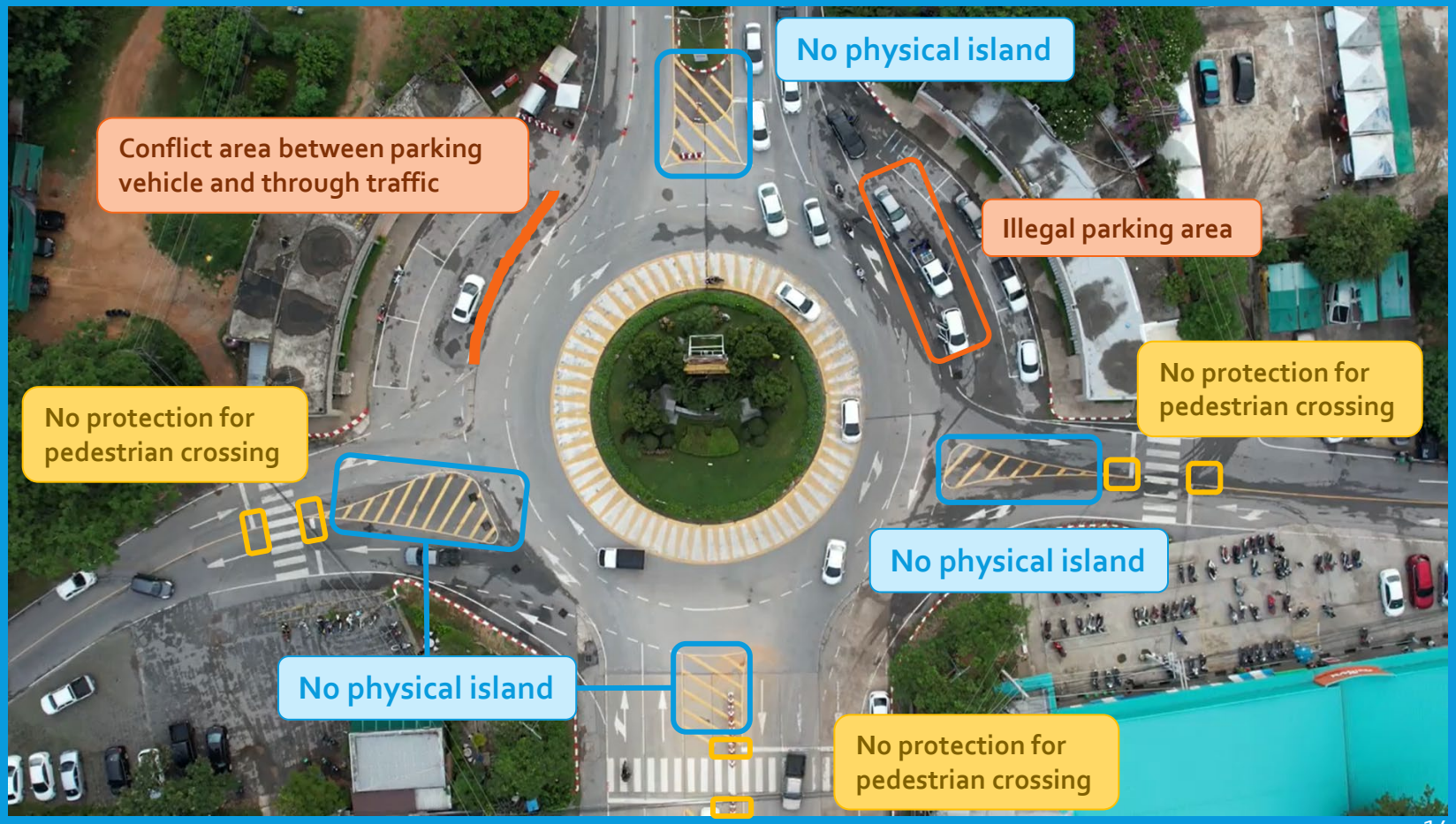
ARIAL PHOTOGRAPHY



- Max. hovering time (no wind) : 30 min.
- Video resolution: 4K
- The videos were recorded on Friday 22 April 2022 at 5 p.m.
- Each video captured 15-minute interval of traffic condition (100 m. from the ground)

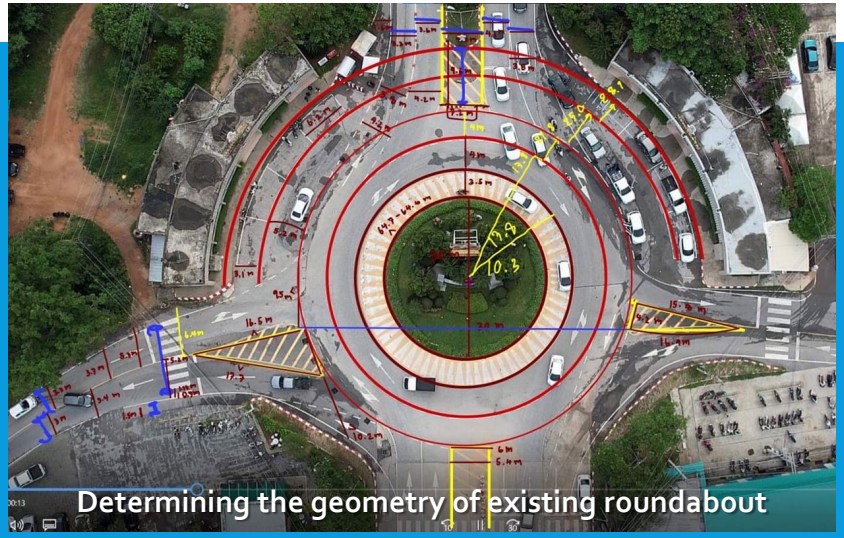
SITE INVESTIGATION (1)

POTENTIAL RISKS FROM IN-APPROPRIATED ROAD GEOMETRY



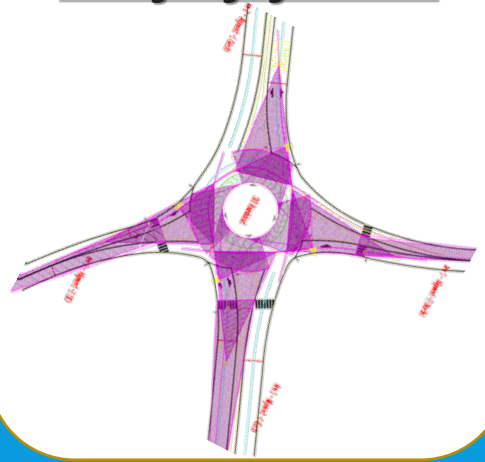
SITE INVESTIGATION (2)

SIGHT DISTANCE AND APPROACH DEFLECTION

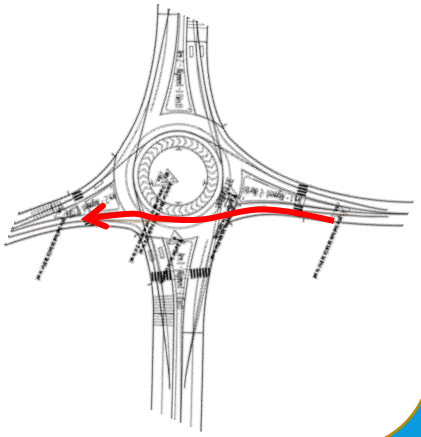


Determining the geometry of existing roundabout

Investigating sight distance



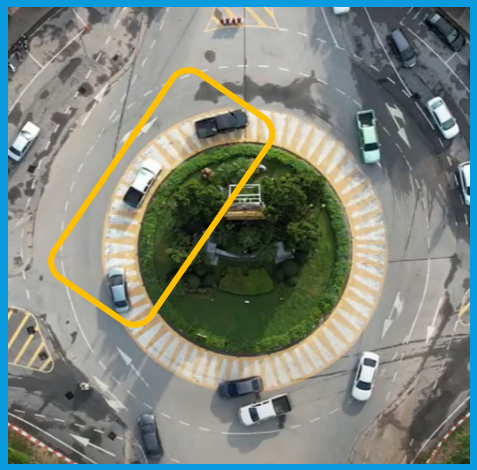
Less deflection leads to speeding



SITE INVESTIGATION (3)

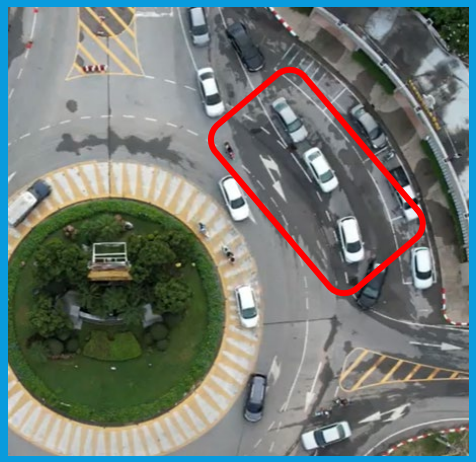
RISKY DRIVING BEHAVIORS

1) Driving over the truck apron (both motorcycle and car)

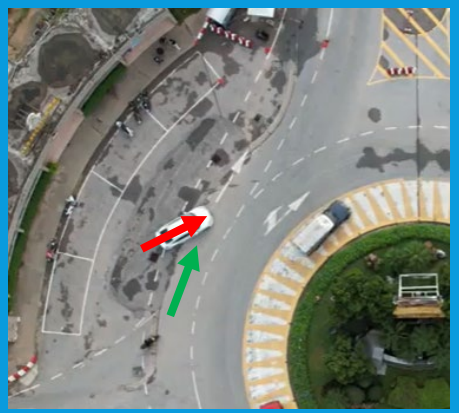


2) Conflicts between motorcycle and car

3) Parking on travel lane



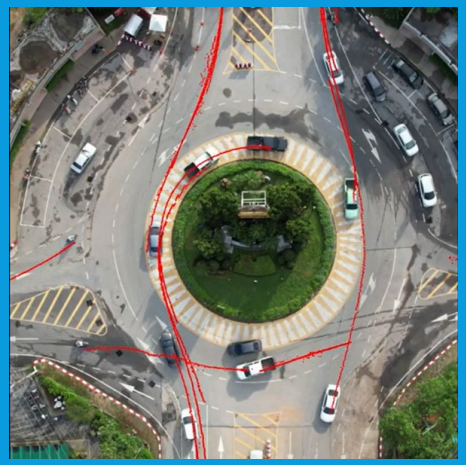
4) Merging conflicts



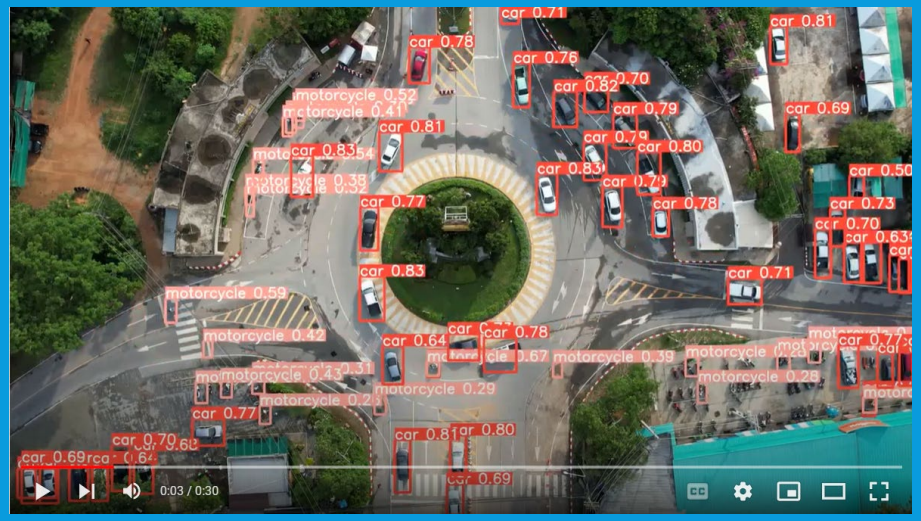
DATA ANALYSIS

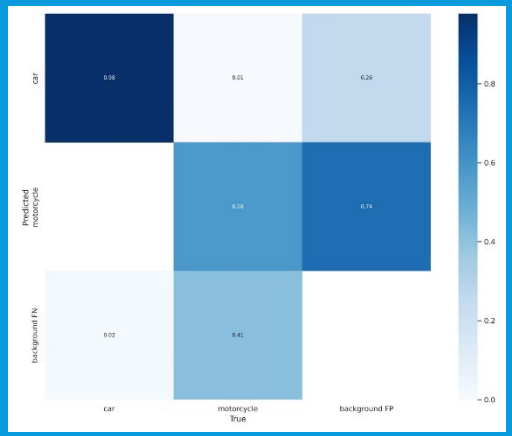
ALGORITHM DEVELOPMENT FOR VEHICLE DETECTION & TRACKING

Vehicle detection & tracking process



Accuracy improvement process

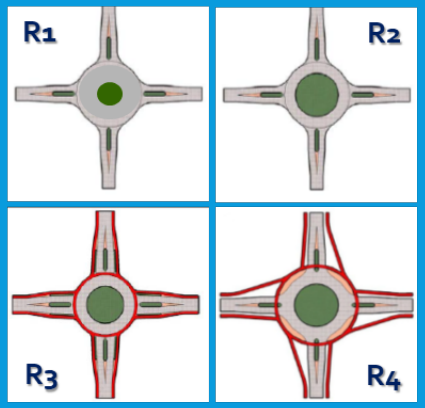




- The accuracy of vehicle detection was found at
  - 80% for cars
  - 50% for motorcycles
- On the accuracy improvement process.

FURTHER WORKS

REDESIGN AND COMPARE DIFFERENT TYPES OF ROUNDABOUT



- 4 types will be compared:
  - R1: Existing roundabout
  - R2: Physically enhanced roundabout (with trial test)
  - R3: Priority motorbike lane application (with trial test)
  - R4: Priority exclusive motorbike lane (conceptual design)
- Trial tests will be conducted for the case of R2 and R3 by
  - installing temporary traffic poles at, e.g., truck apron and conflicting areas,
  - and recording the traffic movements by drone.
- Traffic safety performances will be investigated and compared to the existing roundabout.
  - Safety measures: e.g., no. conflicts, time to collision or TTC (vehicle vs vehicle), post encroaching time or PET (vehicle vs pedestrian), lane departure, approaching speed
  - Traffic performance: e.g., travel time, capacity

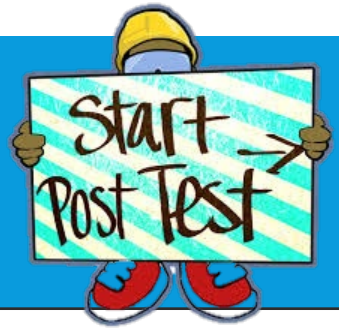
EDUCATIONAL TRAINING

Public relation to SUT students and staffs

Pre-test to evaluate their basic knowledge of using roundabout

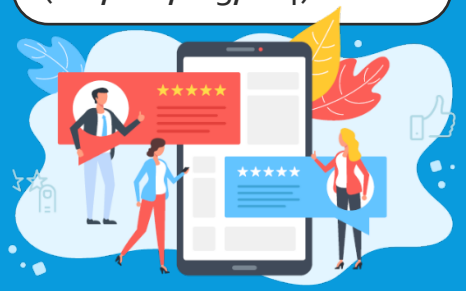
Roundabout training program

- Review on the existing situation
- Overview of international rule using roundabout
- Demonstrate the safety parameters
- Discussion on the existing roundabout and possible solutions for safer roundabout



Post-test to evaluate the knowledge after the training

Ask the road users' opinion on different types of roundabout (M1, M2, M3, M4)



PROJECT SCHEDULE

Work task	Month											
	1 Apr	2 May	3 Jun	4 Jul	5 Aug	6 Sep	7 Oct	8 Nov	9 Dec	10 Jan	11 Feb	12 Mar
1. Literature review												
2. Data collection												
3. Data analysis												
4. Comparison of 4 types of roundabout												
5. Educational training												
6 Proposal of redesign roundabout												
7. Report submission	Inception					Interim						Final

Notes

plan

progress

RESPONSES TO IATSS ADVISOR'S COMMENTS

Prof. Hideki Nakamura (1/3)

Comments	Responses
○ Some of the proposed subtopics should be excluded and each of the remaining subtopics should also be reconsidered so that they can obtain some significant results. The reviewer strongly recommends to concentrate particularly on the analysis of the present situation of users.	○ The proposed main and subtopics were revised to include three main topics: ○ Investigating potential risks and risky driving behaviors of the existing roundabout ○ Designing the roundabout for safety enhancement on road users considering both safety and traffic performances. ○ Educating students and staffs on basic knowledge of driving and riding safely at roundabouts.
○ It is important to convert the video data of positions of users recorded by a UAV to the map coordinates. UAV cannot be completely standstill every moment. It is unclear how they will deal with the conversion to the map coordinates.	○ The algorithm for detecting and tracking vehicle movements has been developed in this research (under the accuracy improvement process).

Prof. Hideki Nakamura (2/3)

Comments	Responses

○ It is unclear which indices will be used to evaluate safety.	○ In this research, some surrogate safety measures (SSMs) will be applied:
	  ○ Time to collision (TTC) will be used to evaluate the safety between two conflicting vehicles entering the roundabout.
	  ○ Post encroaching time (PET) will be used to evaluate the safety between a vehicle and pedestrian crossing.
	  ○ Lane departure which will be used to determine the conflict of vehicles traveling inside the roundabout.
	  ○ Approaching speeds will be used to assess the risk of two vehicles entering the roundabout.

○ Application of the genetic algorithm (GA) is being proposed to apply for designing roundabouts. However, the reviewer is very skeptical that this kind of technic can propose appropriate and sophisticated design which is suitable enough for the local conditions. It is recommended to abandon this.	○ We totally agree with the reviewer's comment and exclude the optimization task from this research.

Prof. Hideki Nakamura (3/3)

Comments

- It is recommended to carefully redesign the roundabout so that it can contribute to avoid or reduce risky and/or unfavorable behaviors by following recommendations described in the existing guidelines on modern roundabout design, after carrying out intensive and careful analyses on the present situation of risky behaviors at the roundabout.

Responses

- We totally agree with the reviewer's comment and revised the research tasks as follows:
  - Existing guidelines on modern roundabout design have been reviewed and will be thoroughly applied to the case study.
  - Trial test of the redesigned roundabouts will be conducted to capture risky behaviors (if any)
  - The SSMs will be analyzed and compared between the existing roundabout and the redesigned roundabouts.

Dr. Koji Suzuki (1/2)

Comments	Responses
○ It is necessary to check the situation of the target intersection, such as the number of traffic accidents and whether serious accidents have decreased in the situation before the RAB installation and the current situation of the target intersection.	○ The roundabout has been installed for along time. However, we will try to collect the crash data between before and after RAB installation. ○ In addition, we will apply some SSMs to compare safety situations between the existing roundabout and redesigned roundabout

○ It is difficult to understand how to approach the two research purposes, and the relationship between the two is unclear.	○ The research objectives were revised as follows:
	  ○ To investigate potential risks and risky driving behaviors at the existing roundabout.
	  ○ To redesign the roundabout for safety enhancement on road users considering both safety and traffic performances.
	  ○ To educate students and staffs on basic knowledge of driving and riding safely at roundabouts.

Dr. Koji Suzuki (2/2)

Comments	Responses
○ If you want to improve one intersection, it is necessary to confirm what kind of dangerous behavior and smoothness problems are caused by on-site observations, and to hypothesize and verify what causes these problems.	○ We have carefully taken this comment into account.
○ it is desirable to examine how much educational effects can be observed.	○ In this research, we will evaluate the educational effects mainly based on pre- and post- tests of the training.

Prof. Akinori Morimoto

Comments	Responses
○ It will be interesting to see how roundabout standards relate to different road safety cultures in different regions. ○ Last year, Prof. Nakamura and his colleagues conducted a comparative study in the IATSS project, which we hope you will refer to in your research. It would be fascinating to see what differences there are between Western and Asian countries.	○ We have carefully taken this comment into account.

Dr. Nagahiro Yoshida

Comments	Responses
○ Need to revise Figure-3 because the flowchart has been broken.	○ We do apologize for this problem. The figure (research methods) was revised to be clearer.
○ It is recommended to interview Prof. Hideki Nakamura for the case of roundabout in Japan.	○ We have carefully taken this comment into account.
○ What is the difference between the heuristic algorithm approach and the evolutionary algorithm approach?	○ Regarding Prof. Nakamura's comments, in this research the optimal design task was excluded.
○ Could you also tell us about the objective function for dealing with safety issues as well as traffic delays?	○ Safety measures will include no. conflicts, TTC, PET, and approaching speeds, when traffic performances will include travel time and capacity.

THANK YOU FOR YOUR ATTENTION

ATRANS
asian transportation research society

Prince of Songkla University

มหาวิทยาลัยเทคโนโลยีสุรนารี

MAHASARAKHAM UNIVERSITY