

THE APPLICATION OF MOBILE GPS PROBE DATA ON DETECTION OF REAL-TIME TRAFFIC CONGESTION LENGTH

TANSAWAT TITHIWACH (PHD)

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OUTLINE

- Biography
- Background
- Objective
- Methodology
- Result
 - Queue Length Judgement
 - Queue Length Comparison
 - Estimation of Adjusted Values
- Conclusion
- Next Step





TITHIACH TANSAWAT

Consultant, Transportation Planner
ALMEC Corporation

BIOGRAPHY

Working Experience

- 2018-Current: ALMEC Corporation
- 2013-2015: MAA Consultant Co., Ltd

Education Background

- 2022-Current: Thammasat University [MBA]
- 2015-2018: Hokkaido University [PhD]
- 2011-2013: AIT [MEng]
- 2007-2011: Kasetsart University [BEng]

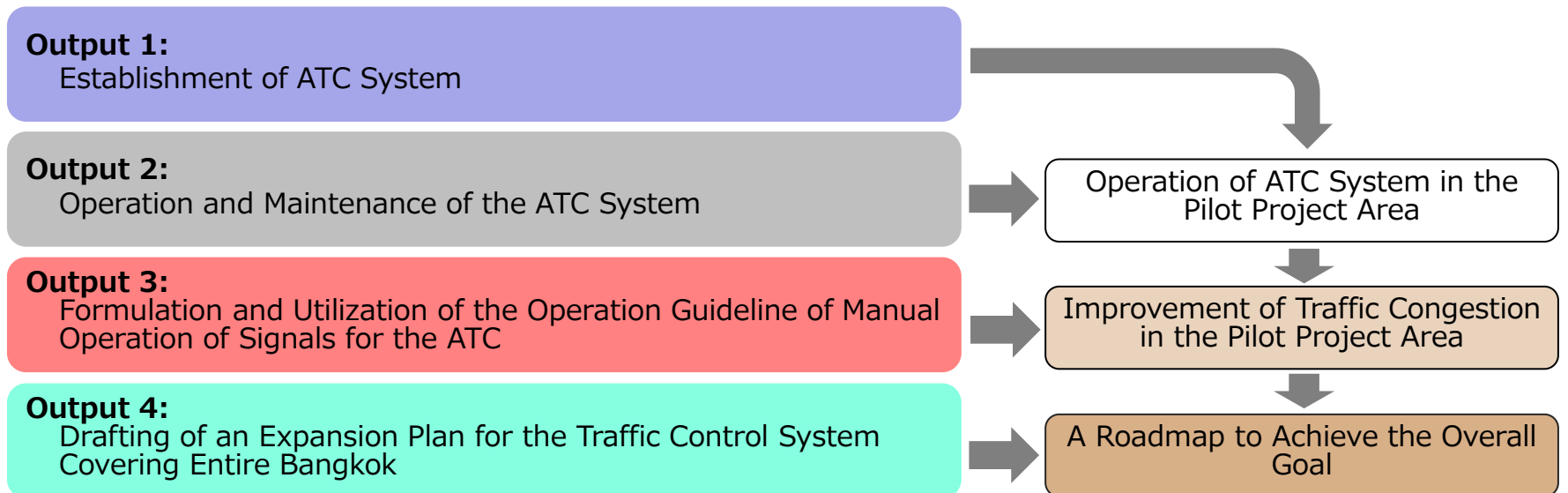
Project Involved

- Transport Planning & Policy
- Transport Economic & Finance
- ITS & Smart City
- Business Promotion & Marketing

Outline of BATCP

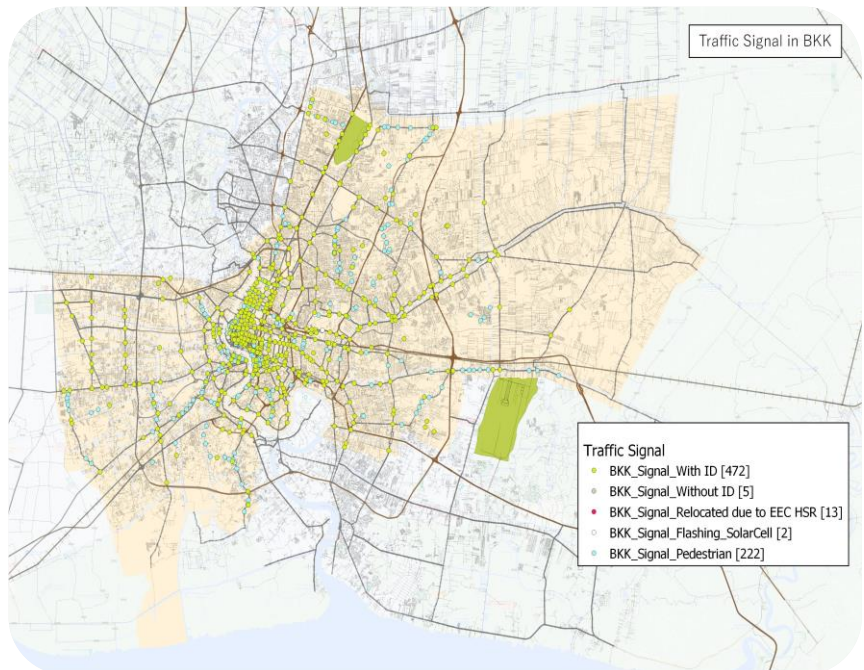


The Project for Improving Traffic Congestions in Bangkok Through the Establishment of Model Area Traffic Control System in the Kingdom of Thailand (BATCP)	
Scheme	Technical Cooperation
Project Area	Entire Bangkok Metropolitan Administration
Duration	April 2019 – February 2023
Overall Goal	The area covered by Area Traffic Control (ATC) System is expanded and traffic congestion and environment condition in the area are improved.
Project Purpose	ATC system is established in the Pilot Project area and traffic congestion is improved.



Situation in Bangkok

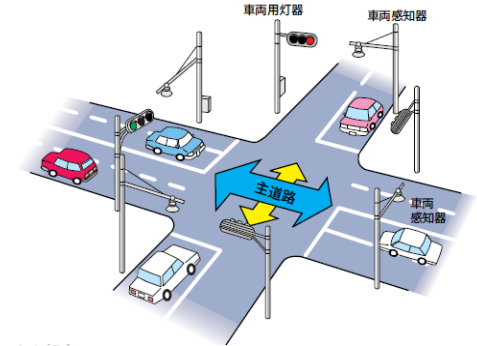
- Approx. 500 signalized intersection with pre-set timing
- During peak hours → severe fluctuated and congested traffic
- Manual traffic signal control by police during peak-hours
- Lack of coordination among intersections



Typical System

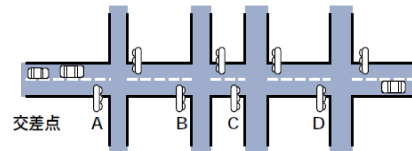
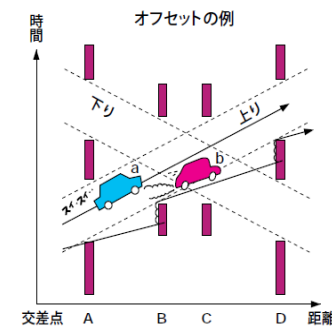
a. Isolated Signal

- Independently operated
- Variety of control methods (ex. pre-timed, time of day, human.)



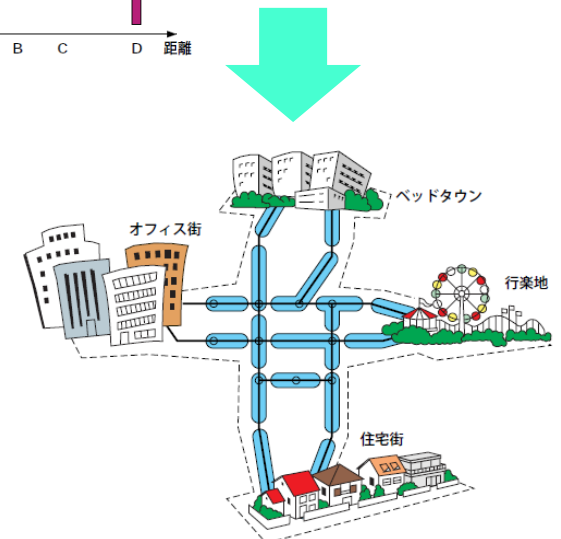
b. Coordinated Control

- A series of signals along a corridor
- Same cycle time but different starting green time



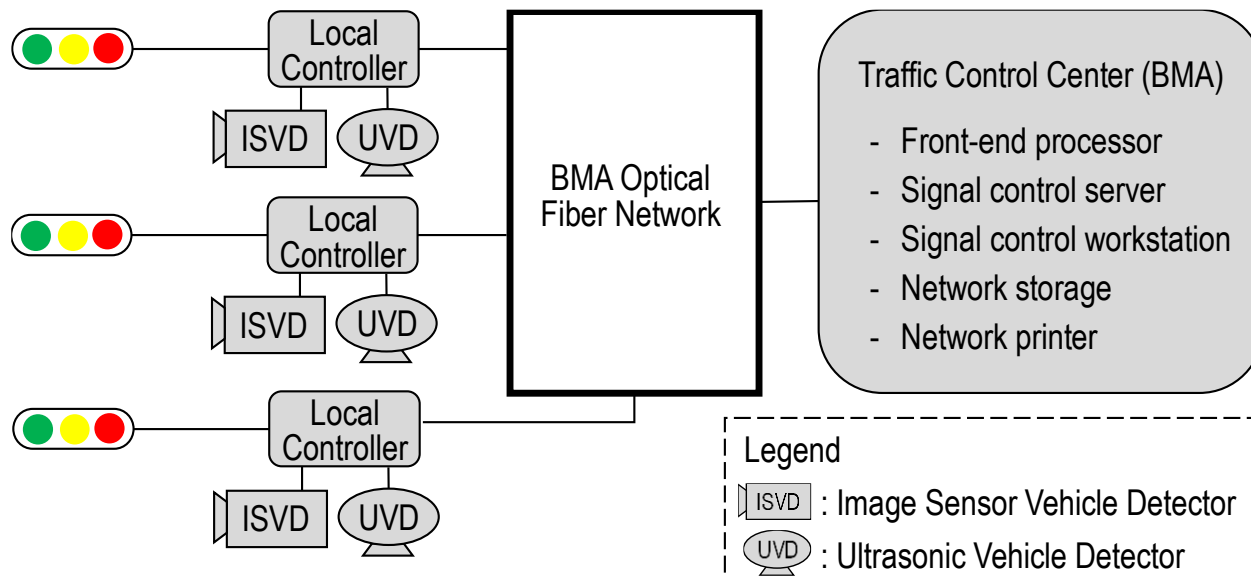
c. Area Traffic Control (ATC)

- A group of signals connected and controlled by traffic control center
- Adaptive control in the area based on traffic condition (volume, speed, queue length, etc.) gathered by the vehicle detector.



Establishment of ATC System

- Vehicle Detectors observe actual road traffic condition and send it to Traffic Control Center through BMA Optical Fiber Network.
- Traffic Control Center analyze the traffic condition data and calculate optimum signal timing for traffic signals in the area.
- The optimized green signal timing for traffic signals is sent to each traffic signal light through BMA Optical Fiber Network.



The Pilot Project Area

Project area covers entire BMA
(for short/medium-term plan)

Pilot Project Area

- Rama VI Road
- Ratchawithi Road
- Phaholyothin Road
- Pradipat Road

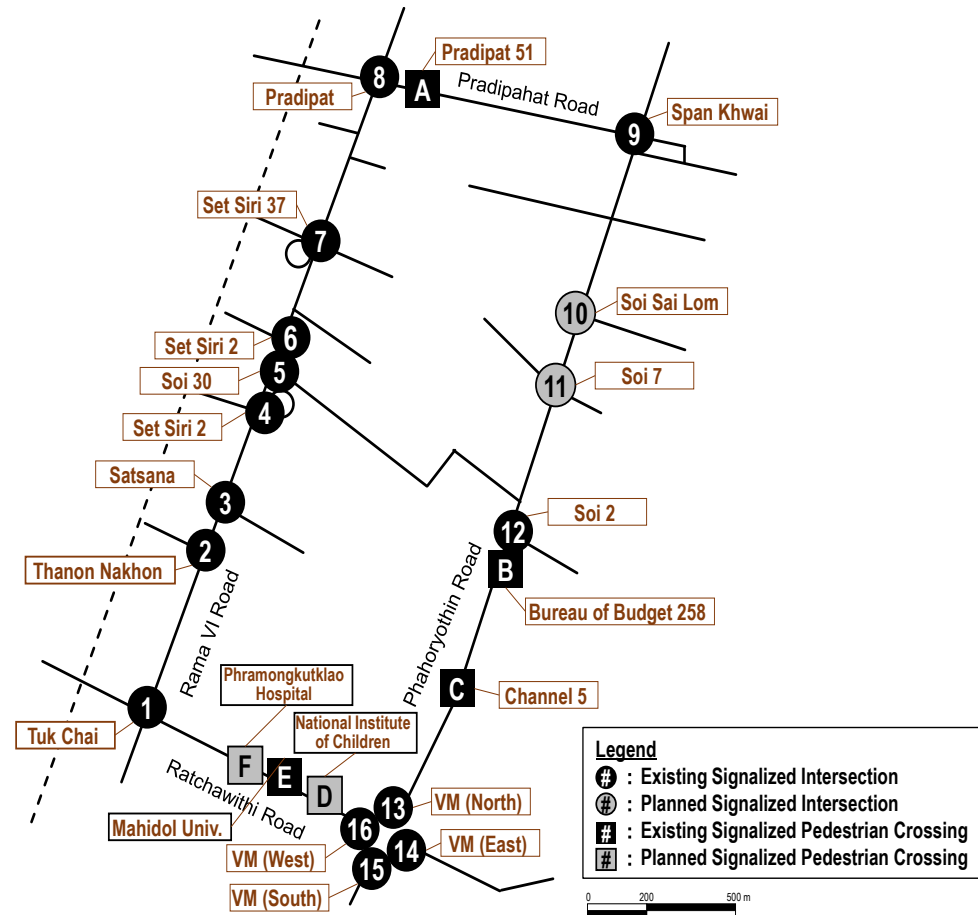
Existing traffic signal system:

- 13 signalized intersections
- 4 pedestrian signals

Control Center

- Traffic and Transportation Department, BMA

Location of Pilot Project Area



BACKGROUND [6/7]

Equipment on Site

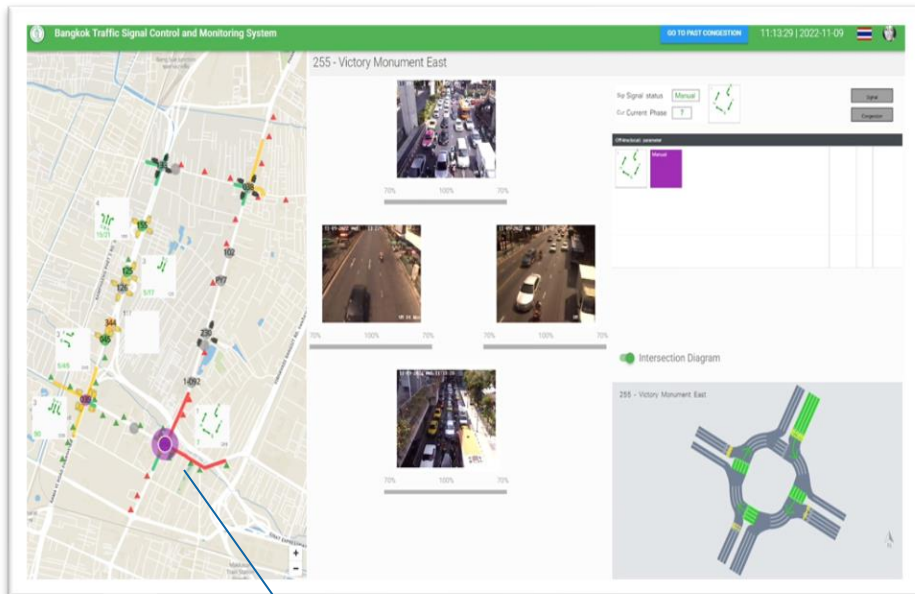


Legend

- : Traffic Signal ID
- : New signal at U-turn slot
- : Pedestrian Signal
- Image Vehicle Detector (New)
- Image Vehicle Detector (Converted)
- Image Vehicle Detector (Existing)
- Ultrasonic Vehicle Detector (Queue)
- Ultrasonic Vehicle Detector (Gap)
- Ultrasonic Vehicle Detector (Existing)
- Cabinet (Existing)

BANGKOK AREA TRAFFIC CONTROL SYSTEM PROJECT							
Detector Location Map				Designed by:	Checked by:		
				Submitted by:	Approved by:		
A	Detector code added	May '20	SR	Japan International Cooperation Agency	Bangkok Metropolitan Administration	Scale:	Drawing No: D001B
Code	Revision	Date	Initial			Date:	Total:

Traffic Control Center



Monitoring Screen

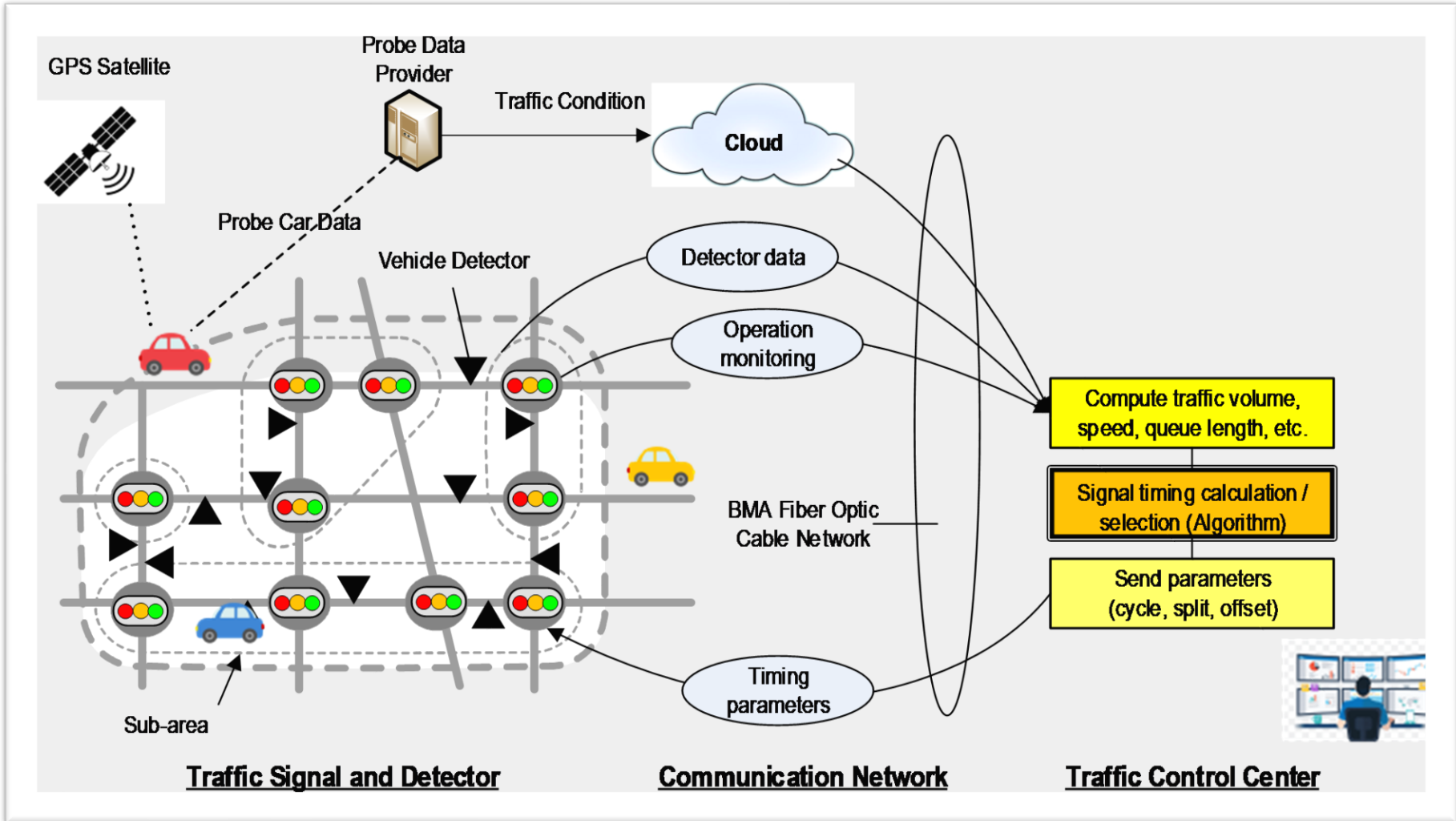


Control Center at TTD

Queue length of through traffic lane is important input to optimize traffic signal timing

OBJECTIVE [1/4]

Possible to utilize Probe GPS data ?

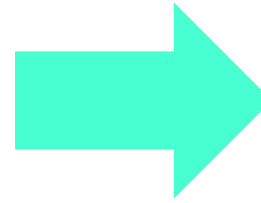


OBJECTIVE [2/4]

Possible to utilize Probe GPS data ?



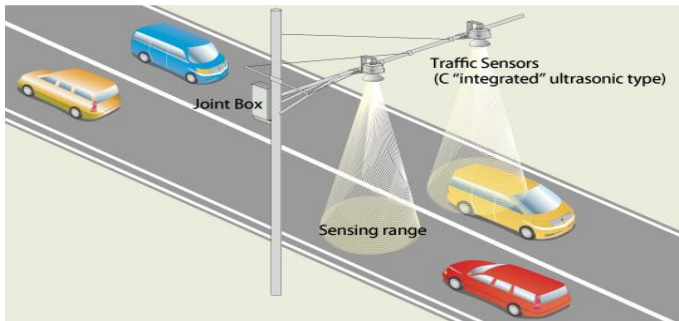
Ex. GPS-derived Q length



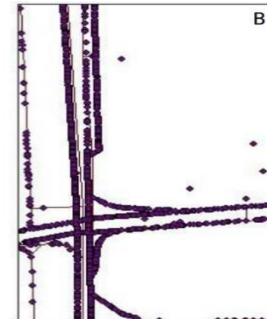
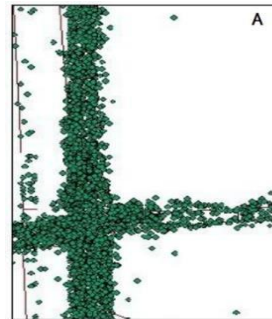
OBJECTIVE [3/4]

Potential Benefit of the Use of GPS Probe Data

Aspect	Stationary Sensor	Floating Car Data (GPS)
Installation	Required (under pavement/on pole)	Cellular phone/vehicle equipped with navigation system
Maintenance	Preventive and corrective maintenance by system owner required	Phone/vehicle owner
Power supply	Commercial power	Battery/provided by car
Coverage area	Fixed-location Spot	Area wide [Continuous]
Data gathering	Continuous	Sampling (1 min. 15 sec. etc.)
Data acquired	Vehicle presence, presence duration	Phone/vehicle ID, Time, location (longitude, latitude)
Data Processing	Vehicle presence -> vehicle count Presence duration -> occupancy (%) Occupancy -> speed (average vehicle length assumed)	Map matching Phone/vehicle matching Segment assignment Speed (average, median, high, low, etc.)
Sample rate	> 90%	< 30% (past case studies)
Accuracy	Accurate [if well set up]	Need to be confirmed



Stationary Sensor



FCD



Objective of the Study

- Focuses on the crucial input for calculating traffic signal timing parameters:
 - Queue length of through traffic lane
- Objectives
 1. Assess accuracy of Probe GPS-Derived Q
 2. Estimate adjustment value to improve accuracy

Three Method to Obtain Queue Length



**1. Ultrasonic
Detector**
[>200m interval]

**2. Processed GPS
Probe Data**
[Avr. Speed of each
road segment: all lane]

3. Field Survey
[Human – most
continuous]

Compare to measure accuracy

Queue Length Comparison

- Compare field survey and Probe GPS-derived queue lengths
- If the error is less than the gap between ultrasonic detector, there is high potential to substitute detector data by Probe

Method	Interval	Data Use	Source	Detail
1. Stationary sensor	200m [Low accuracy]	Threshold	Installed Ultrasonic Detector	Detectors were not installed yet at that time
2. Probe GPS-Derived	Road segmentation	Observed Data	TomTom NV Traffic Stats Service	<ul style="list-style-type: none"> - Historical Data - Avr. Rd. Section Speed of all traffic lanes - 9 July, 2019 - 15-min Interval (448 Obs.) - 24 hours
3. Field Survey	Continuous [High accuracy]	Actual Data	Field Survey	<ul style="list-style-type: none"> - Historical Data - Queue length of though traffic until the next origin - 9 July, 2019 - Avr. into 15-min Interval (448 Obs.) - Interval

Compare



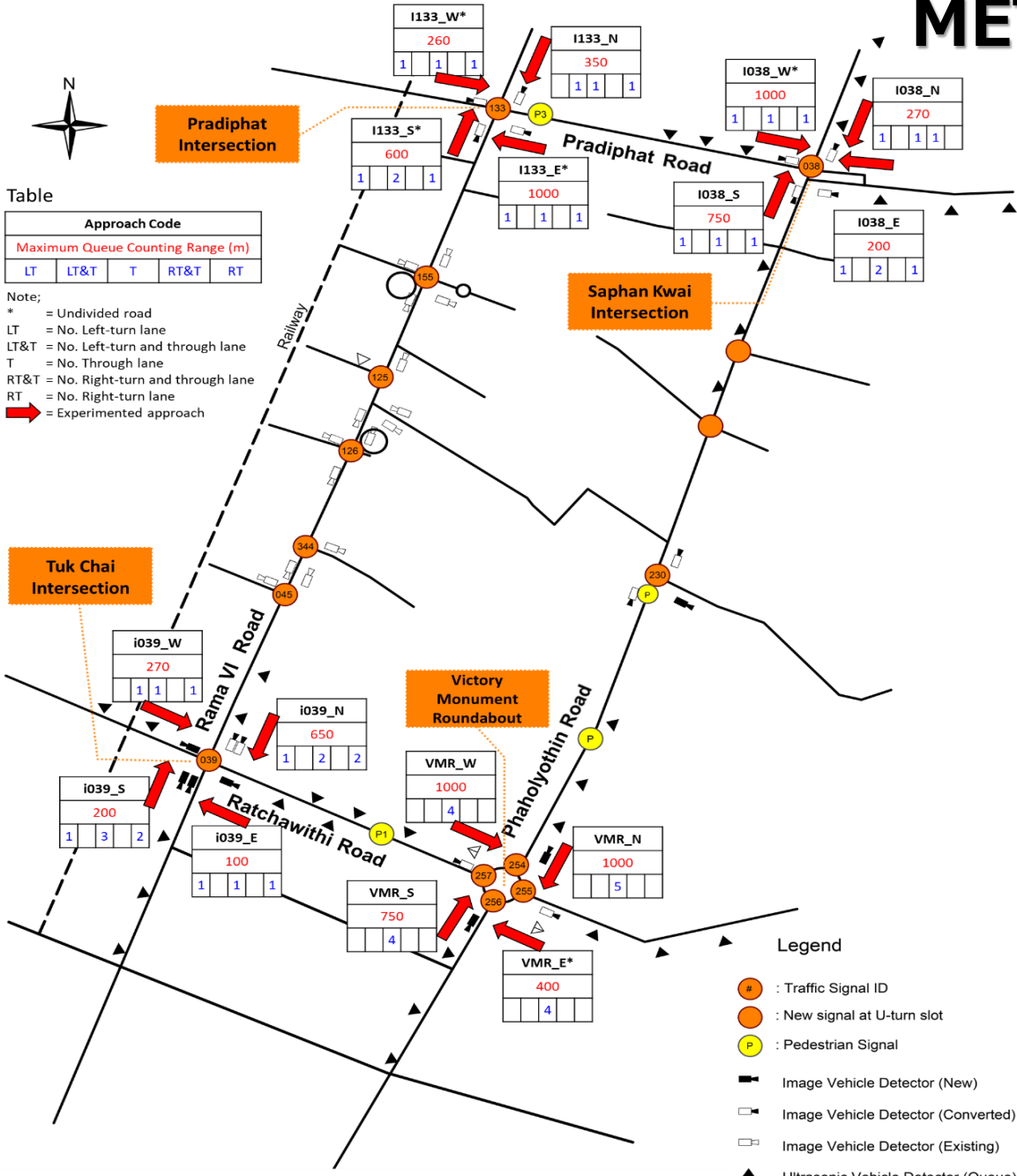


Pradiphat Intersection

Saphan Kwai Intersection

Tuk Chai Intersection

Victory Monument Roundabout



Table

Approach Code				
Maximum Queue Counting Range (m)				
LT	LT&T	T	RT&T	RT

Note;
 * = Undivided road
 LT = No. Left-turn lane
 LT&T = No. Left-turn and through lane
 T = No. Through lane
 RT&T = No. Right-turn and through lane
 RT = No. Right-turn lane
 = Experimented approach

Legend

- : Traffic Signal ID
- : New signal at U-turn slot
- : Pedestrian Signal
- : Image Vehicle Detector (New)
- : Image Vehicle Detector (Converted)
- : Image Vehicle Detector (Existing)
- : Ultrasonic Vehicle Detector (Queue)
- : Ultrasonic Vehicle Detector (Gap)
- : Ultrasonic Vehicle Detector (Existing)



Experiment Area

- **Four [4] streets:**
 1. Phaholyothin Road
 2. Rama VI
 3. Ratchawithi Road
 4. Pradiphat Road
- **Four [4] major intersections:**
 1. VMR: Victory Monument Roundabout
 2. I038: Saphan Kwai Intersection
 3. I039: Tuk Chai Intersection
 4. I133: Pradipat Intersection
- **Sixteen [16] approaches**

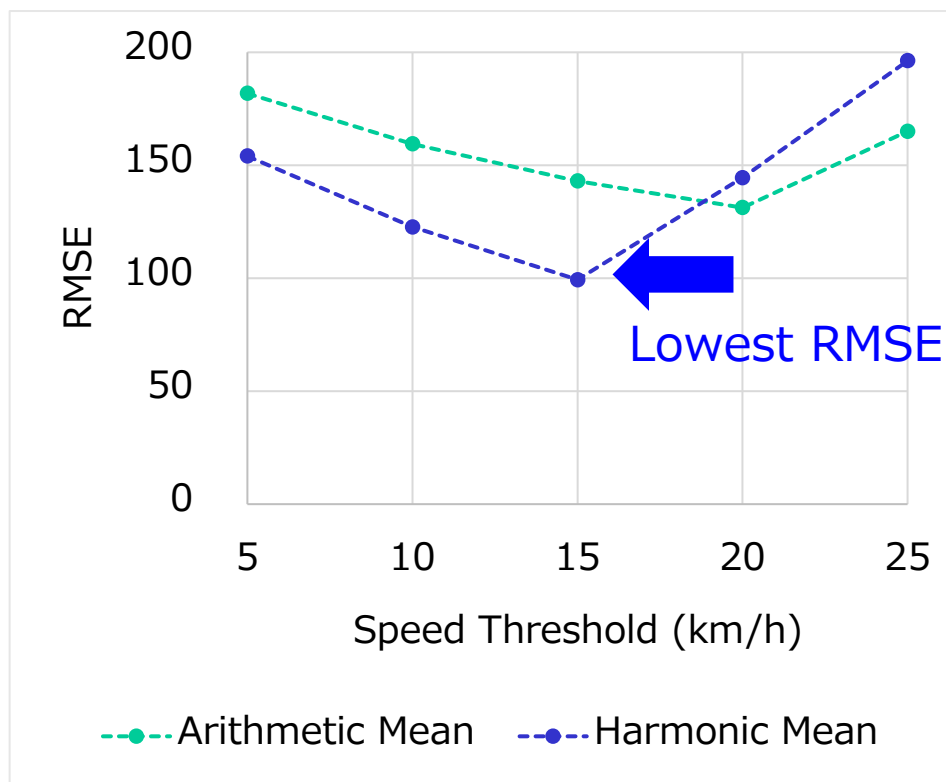
QUEUE LENGTH JUDGMENT [1/1]

How to Judge Queue Length from Probe



How to Judge Queue Length from Probe

- The average speed less than 15 km/h [Harmonic Mean]



Trialed Speed Thresholds

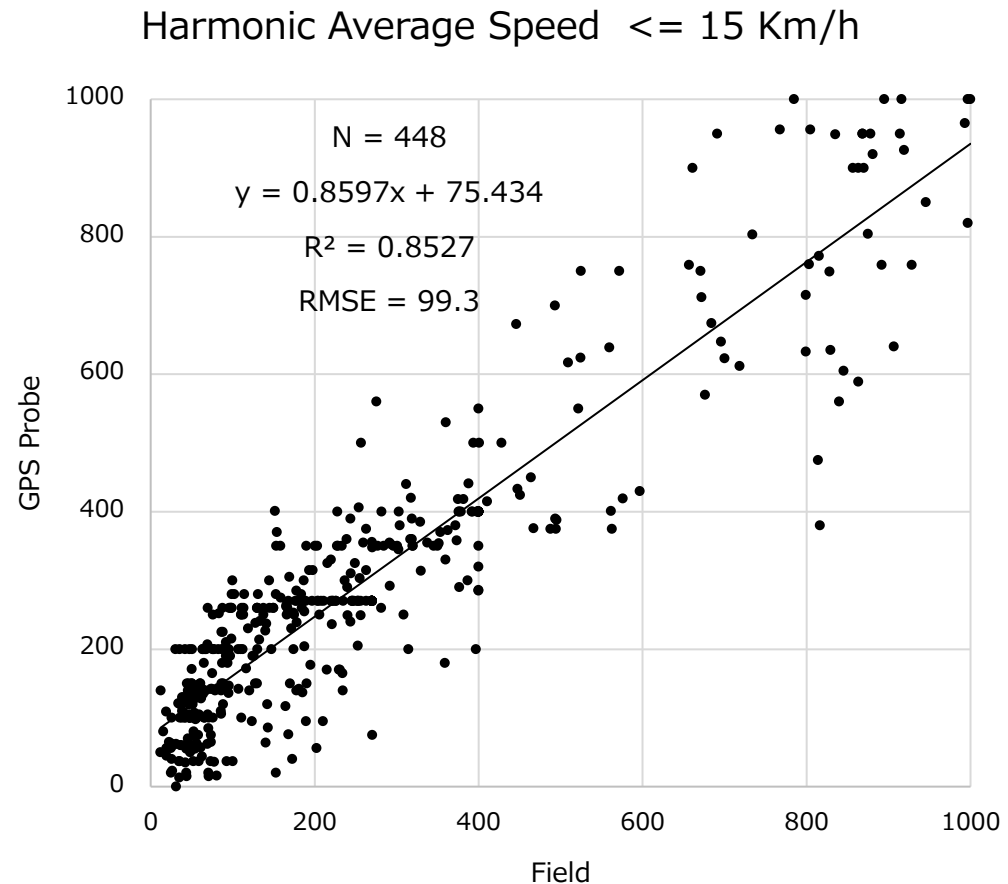


Visualization for Judgement

How to Judge Queue Length from Probe

- Lowest Root Mean Square Error [RMSE]
- $RMSE < 200m \rightarrow$ **Potentially can substitute detector data**

$$RMSE = \sqrt{\frac{\sum_{i=1}^N (Predicted_i - Actual_i)^2}{N}}$$

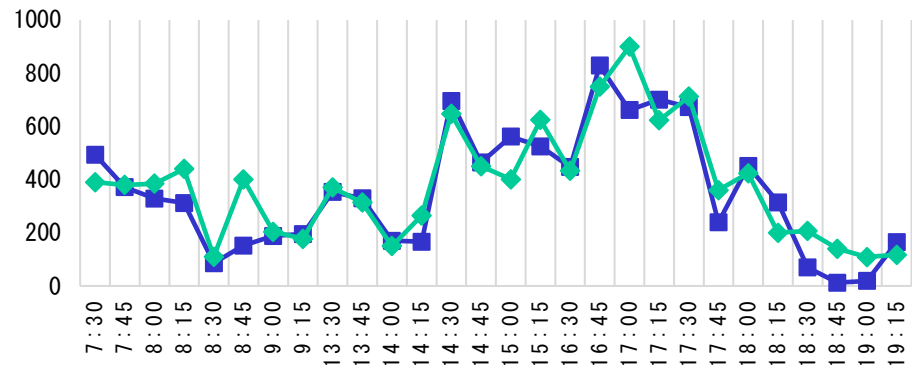


QUEUE LENGTH COMPARISON [2/9]

■ VMR : Queue length (m) from intersection by time

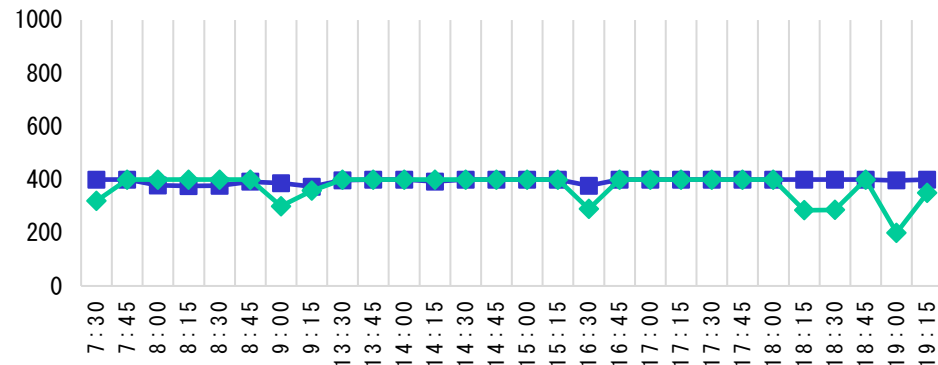
VMR_N

■ Field ◆ Probe



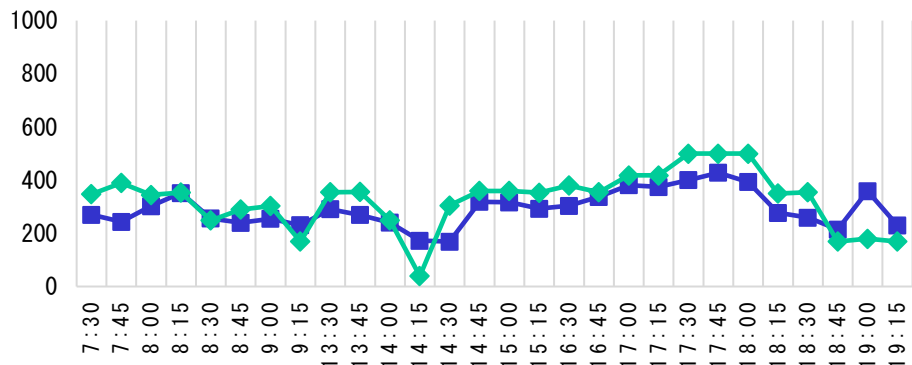
VMR_E

■ Field ◆ Probe



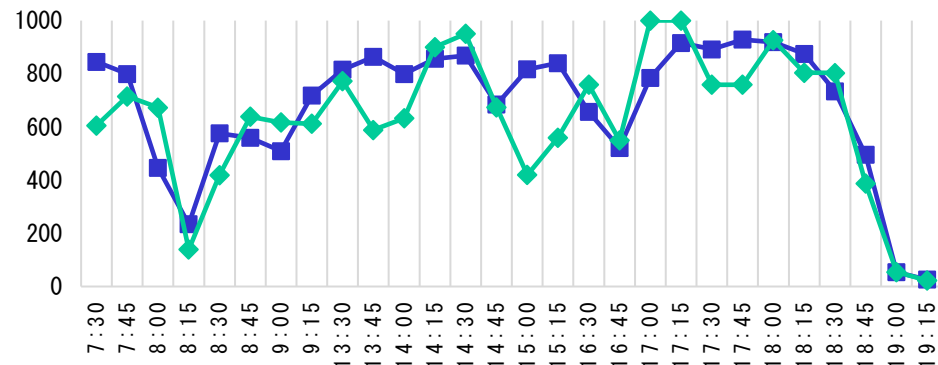
VMR_S

■ Field ◆ Probe



VMR_W

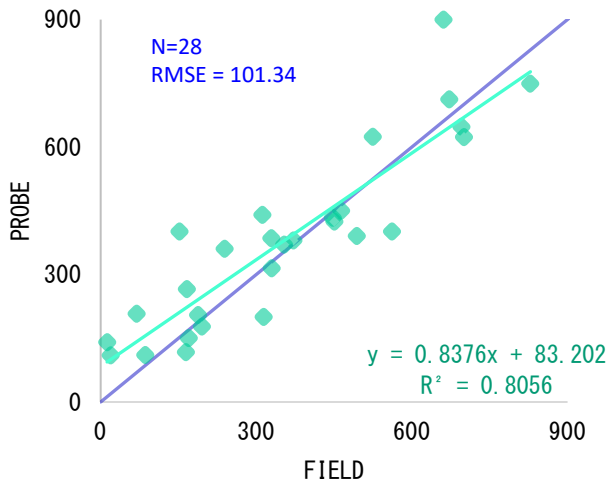
■ Field ◆ Probe



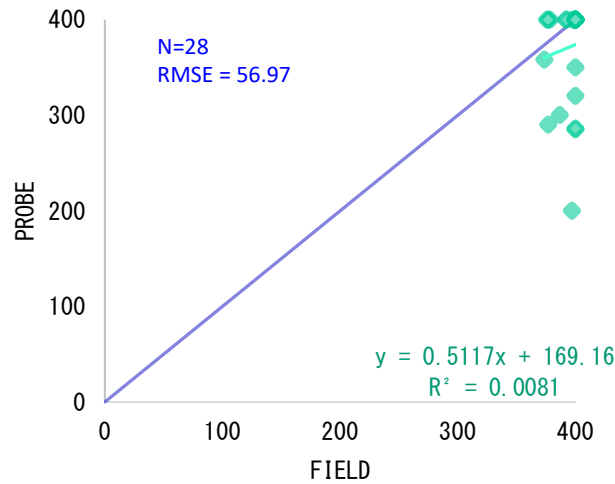
QUEUE LENGTH COMPARISON [3/9]

VMR : Comparison of queue length (m)

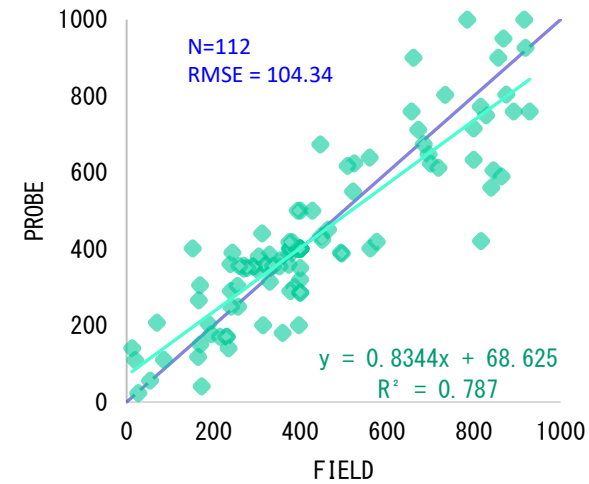
VMR_N



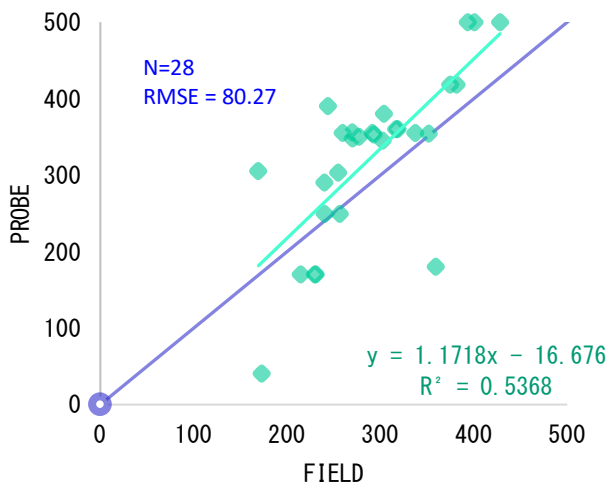
VMR_E



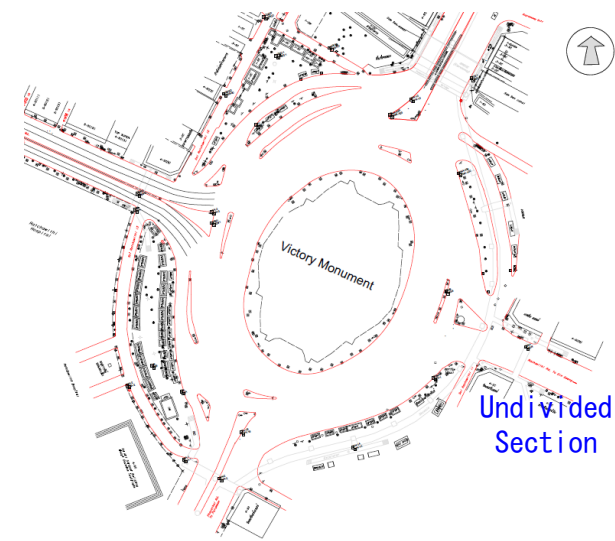
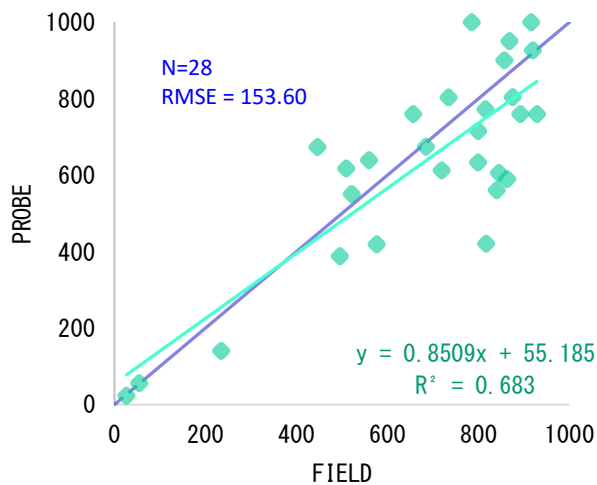
VMR_ALL APPROACH



VMR_S



VMR_W

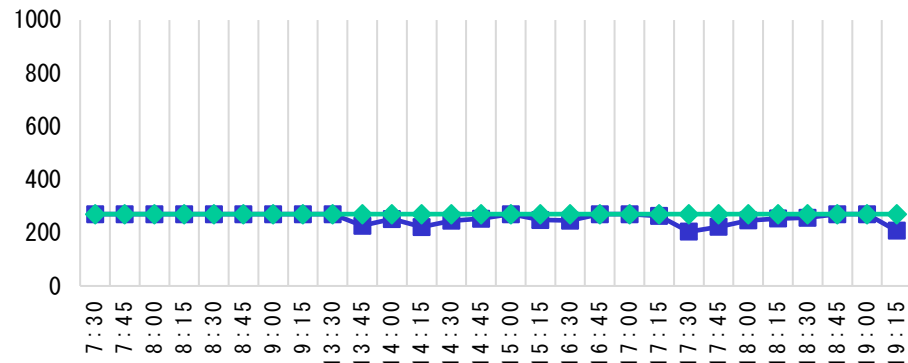


QUEUE LENGTH COMPARISON [4/9]

■ i038 : Queue length (m) from intersection by time

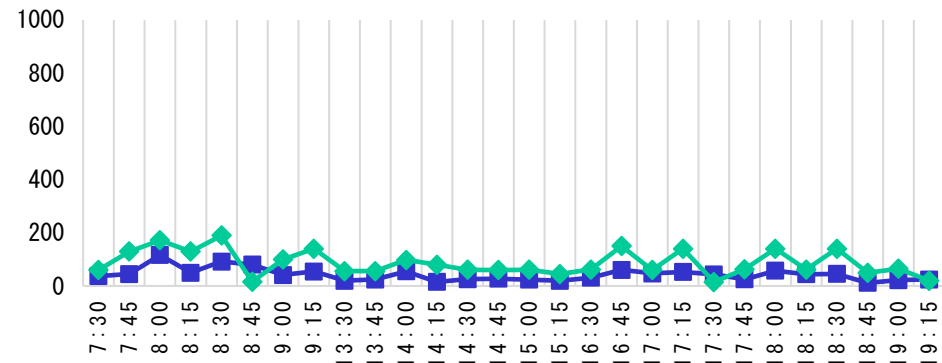
I034_N

■ Field ◆ Probe



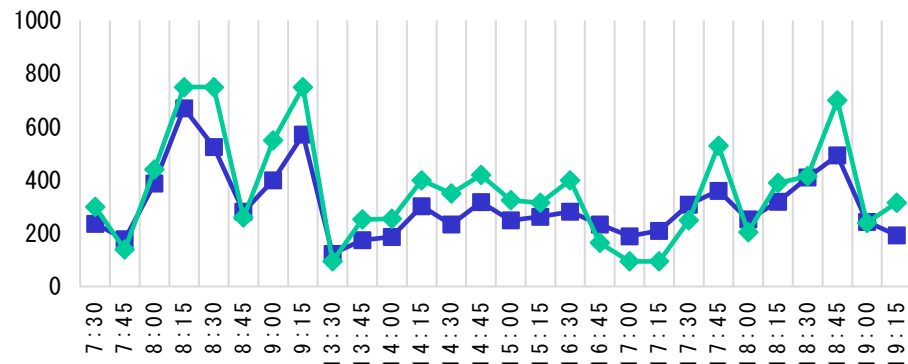
I034_E

■ Field ◆ Probe



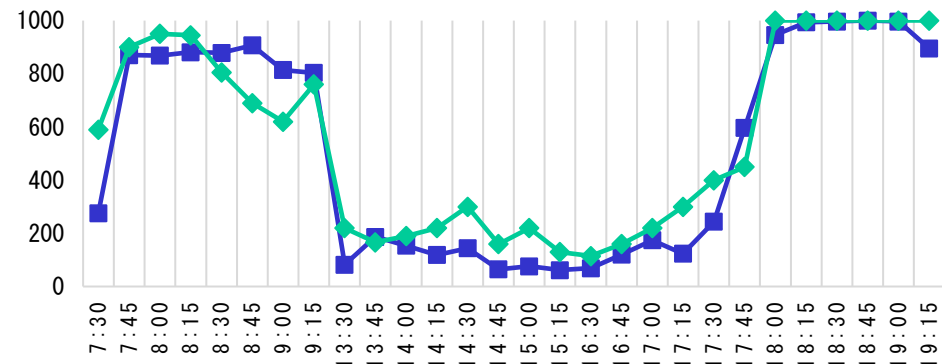
I034_S

■ Field ◆ Probe



I034_W

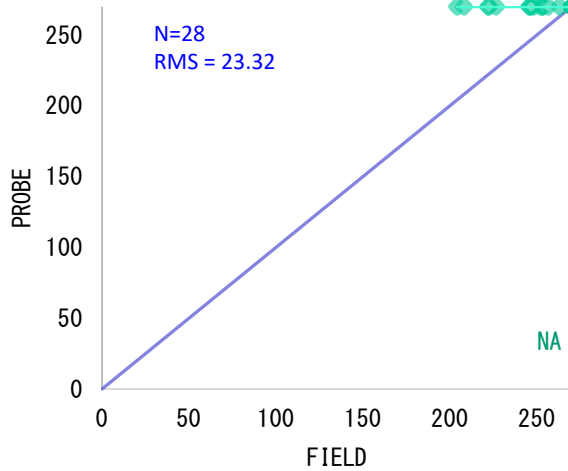
■ Field ◆ Probe



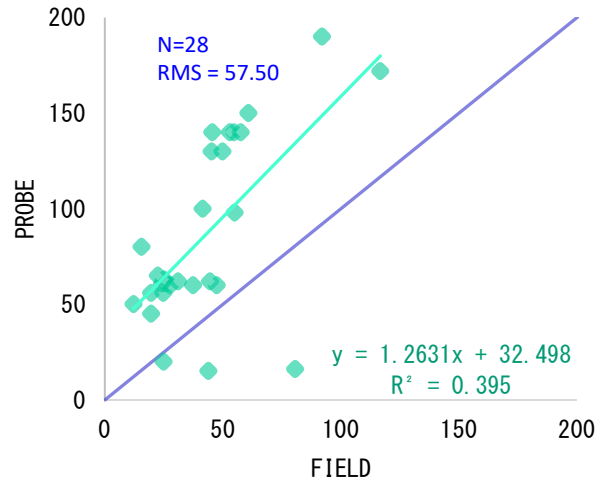
QUEUE LENGTH COMPARISON [5/9]

■ i038 : Comparison of queue length (m)

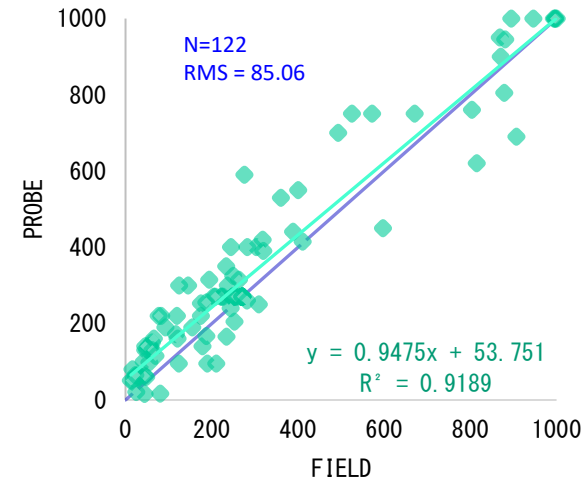
I034_N



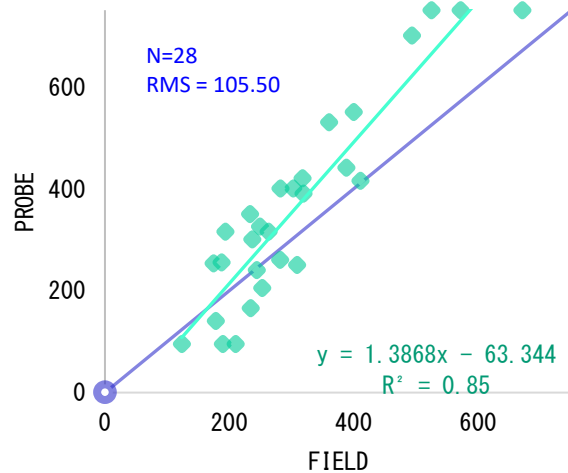
I034_E



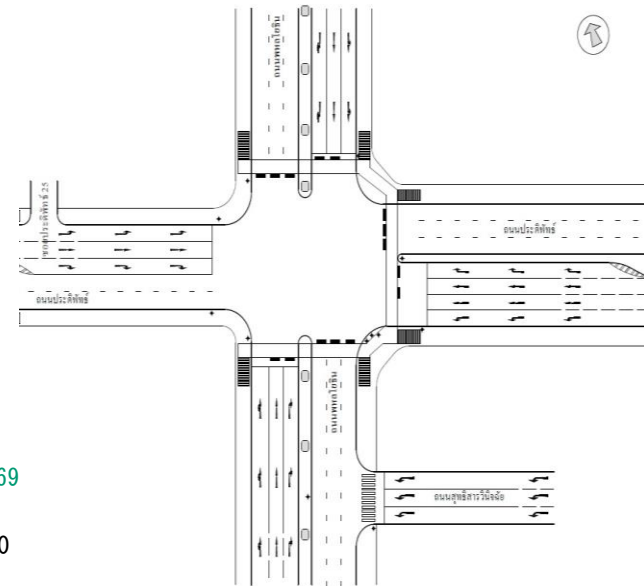
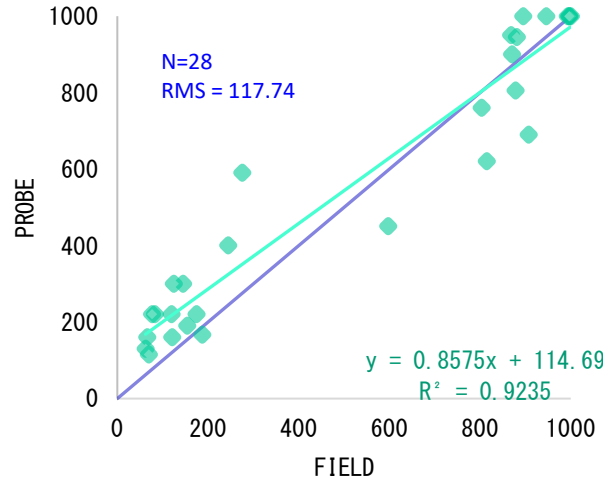
I034_A11 APPROACH



I034_S



I034_W

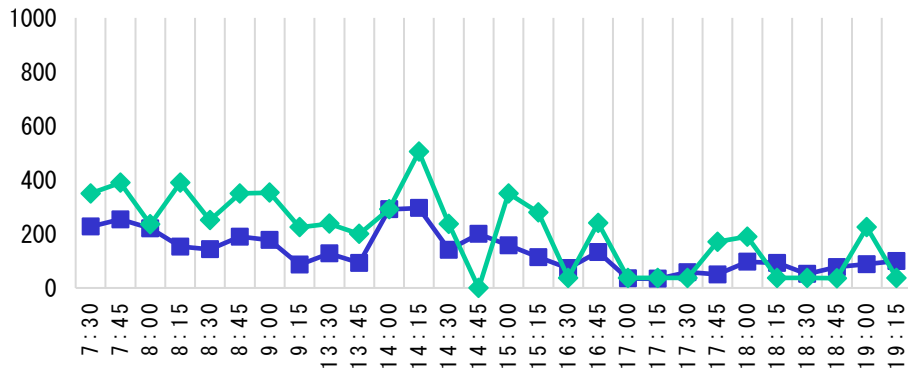


QUEUE LENGTH COMPARISON [6/9]

■ i039 : Queue length (m) from intersection by time

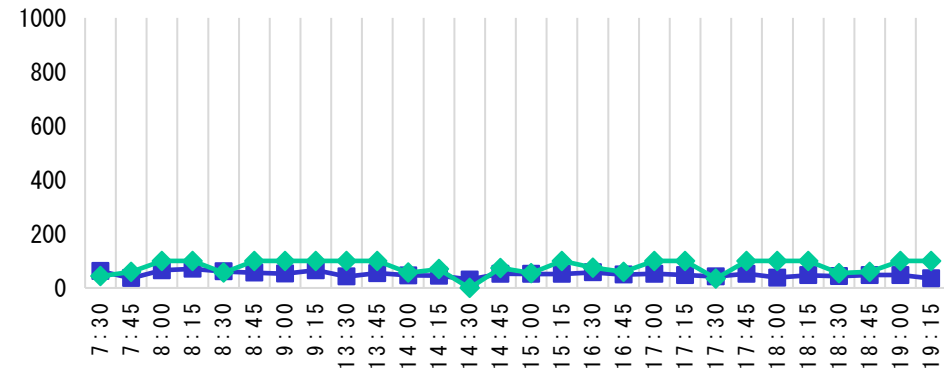
I039_N

■ Field ◆ Probe



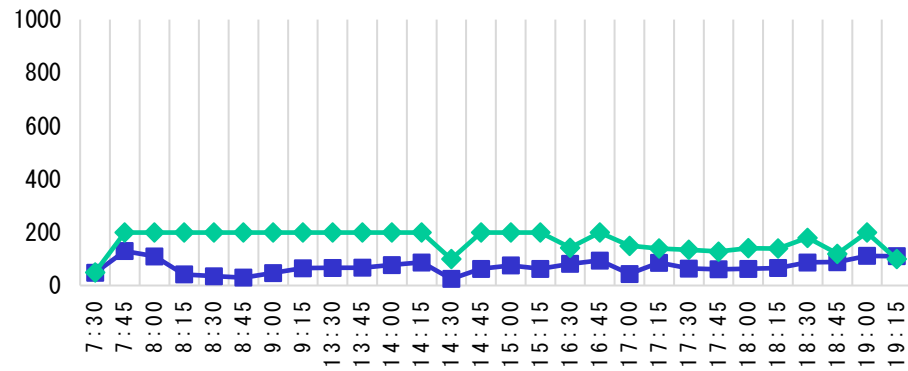
I039_E

■ Field ◆ Probe



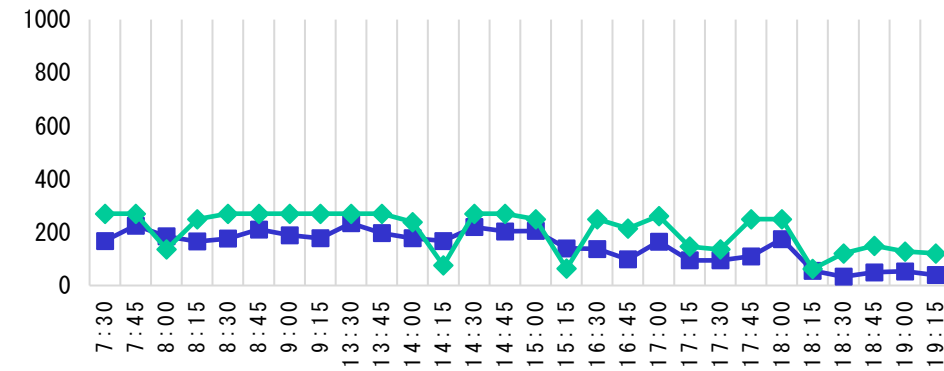
I039_S

■ Field ◆ Probe



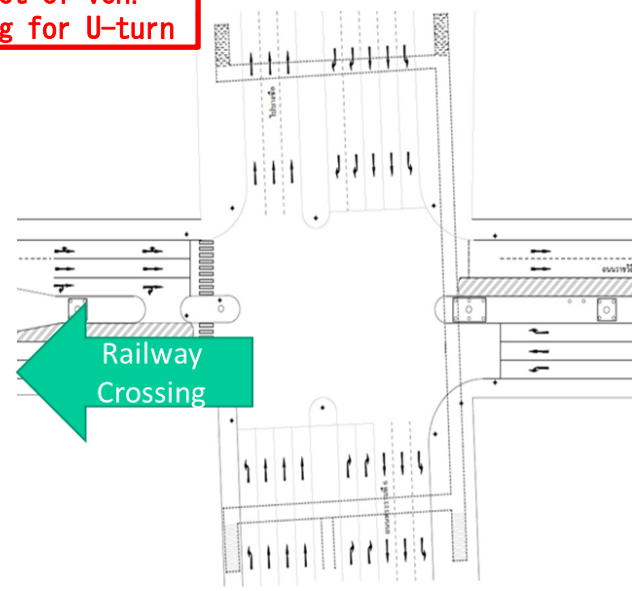
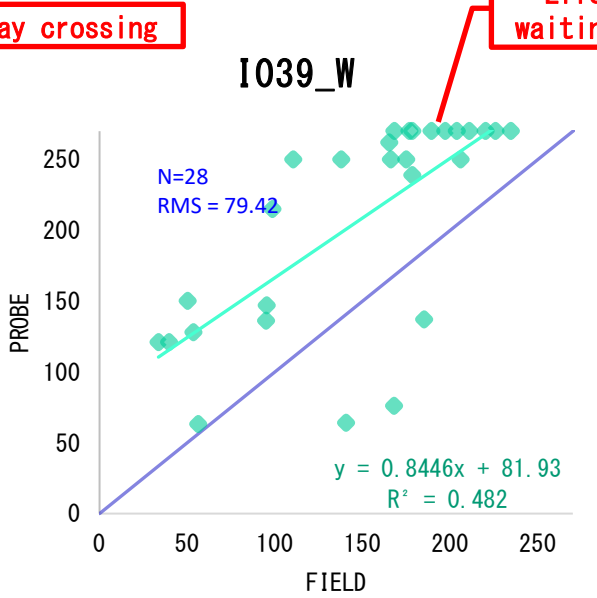
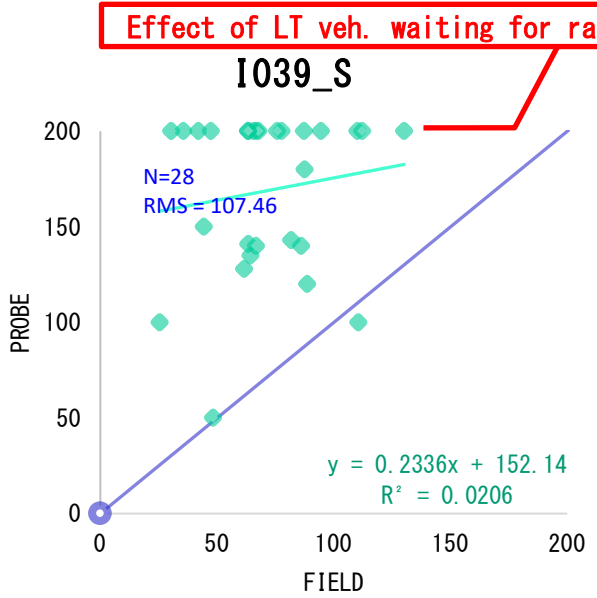
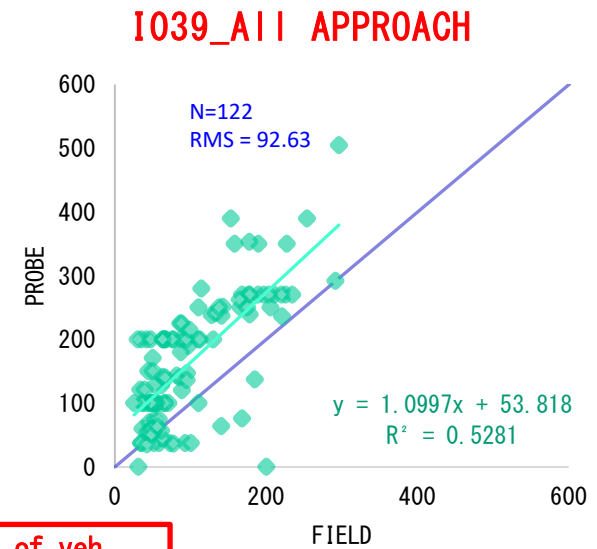
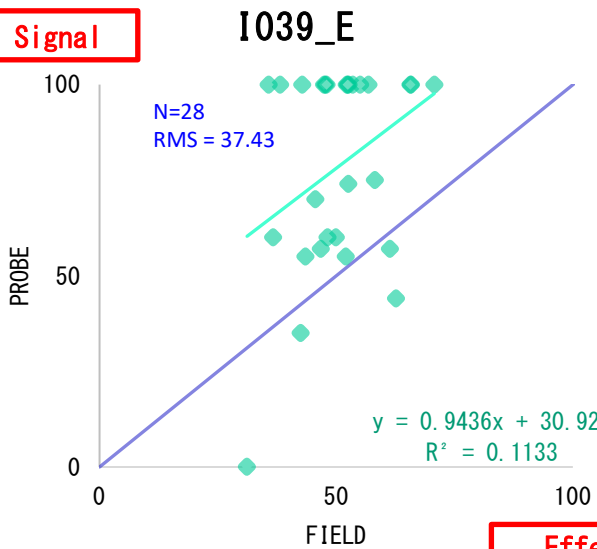
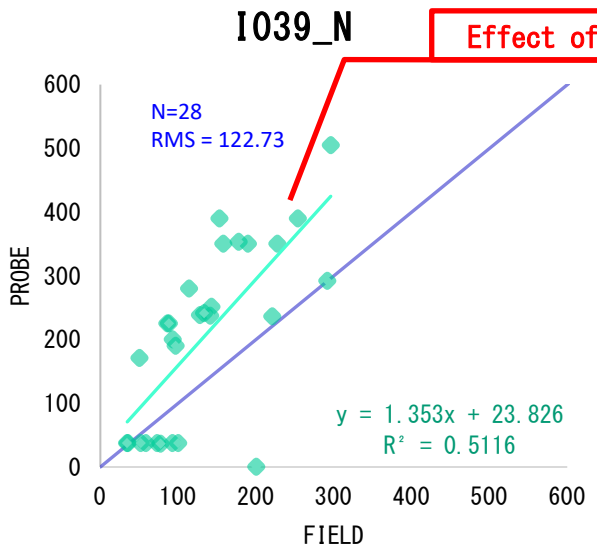
I039_W

■ Field ◆ Probe



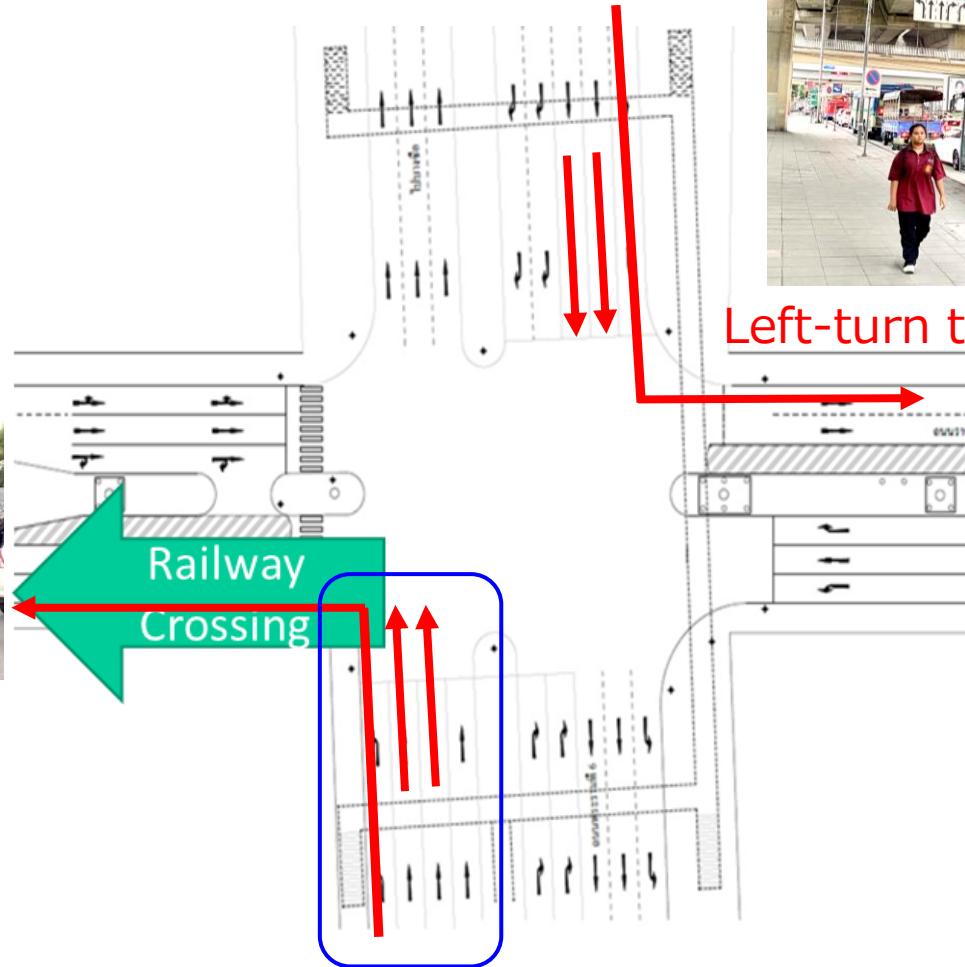
QUEUE LENGTH COMPARISON [7/9]

■ i039 : Comparison of queue length (m)



QUEUE LENGTH COMPARISON [7/9]

- i039 : Comparison of queue length (m)



Left-turn traffic light

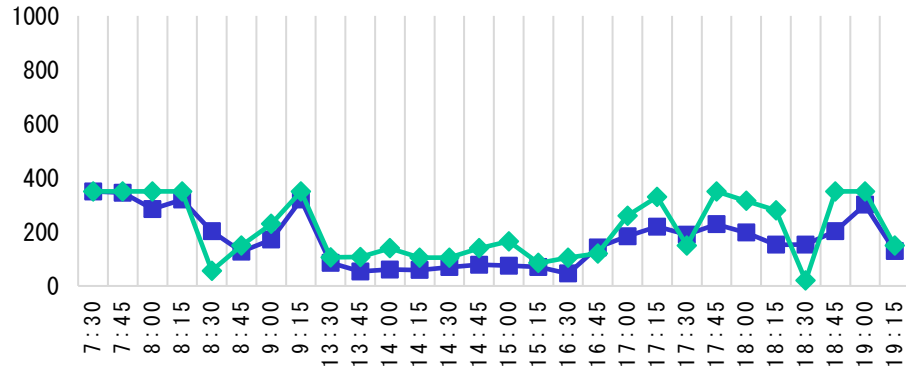
Probe GPS-derive Q was processed from all traffic lanes

QUEUE LENGTH COMPARISON [8/9]

■ i133 : Queue length (m) from intersection by time

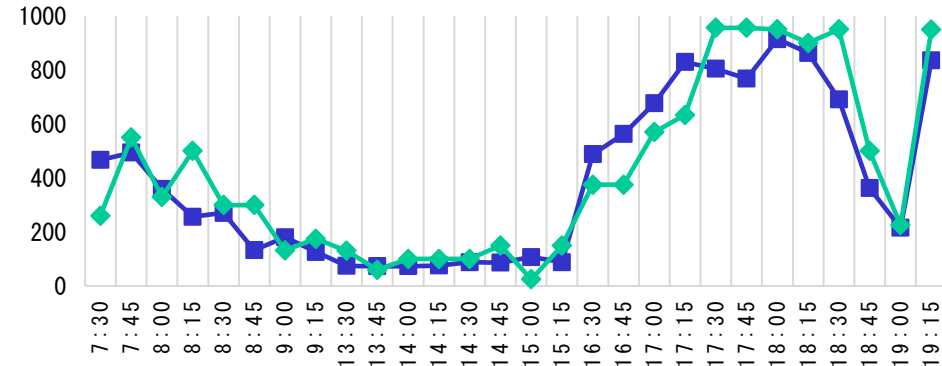
I133_N

■ Field ◆ Probe



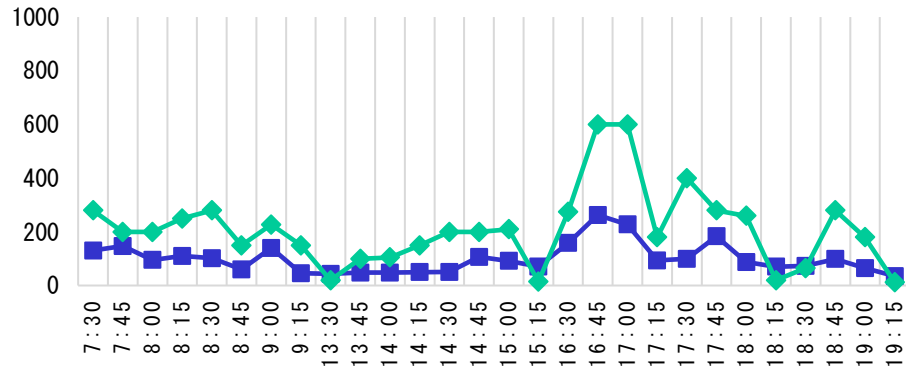
I133_E

■ Field ◆ Probe



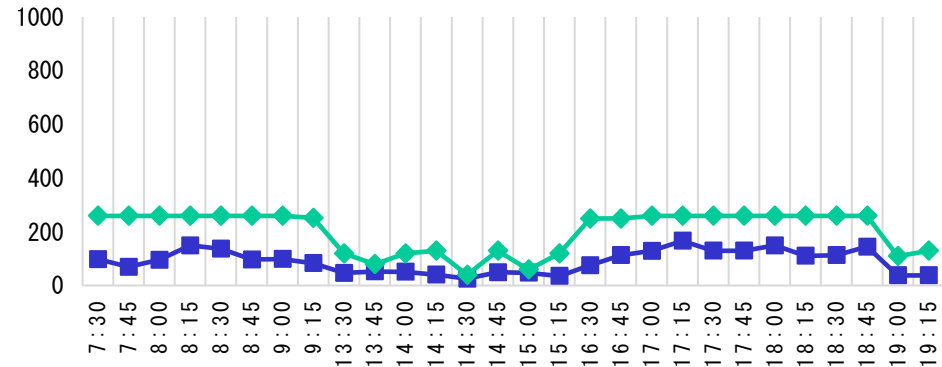
I133_S

■ Field ◆ Probe



I133_W

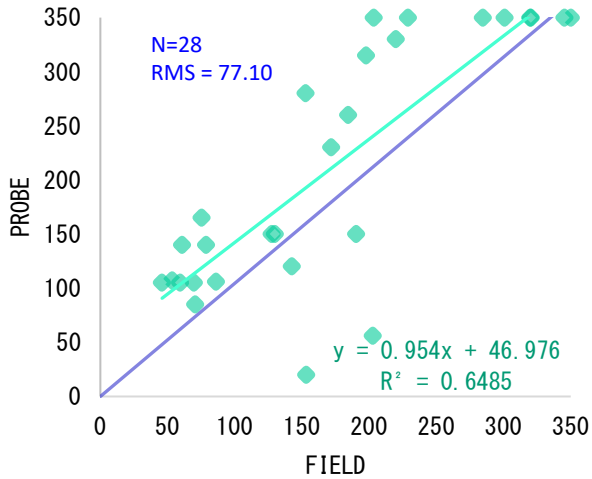
■ Field ◆ Probe



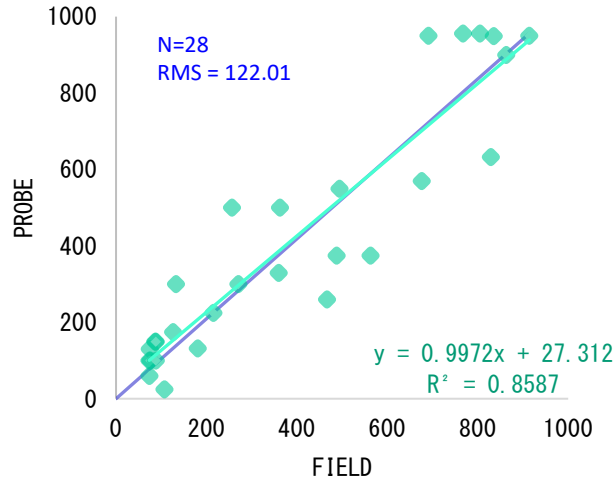
QUEUE LENGTH COMPARISON [9/9]

■ i133 : Comparison of queue length (m)

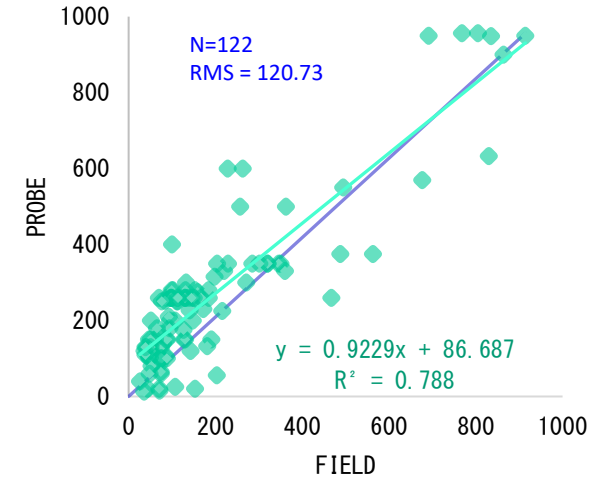
I133_N



I133_E

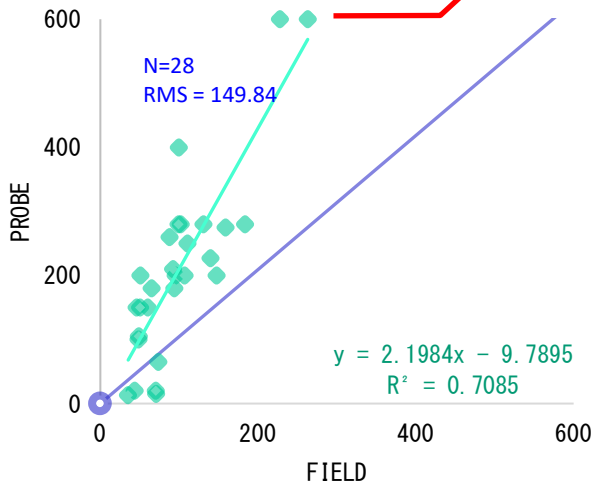


I133_A11 APPROACH



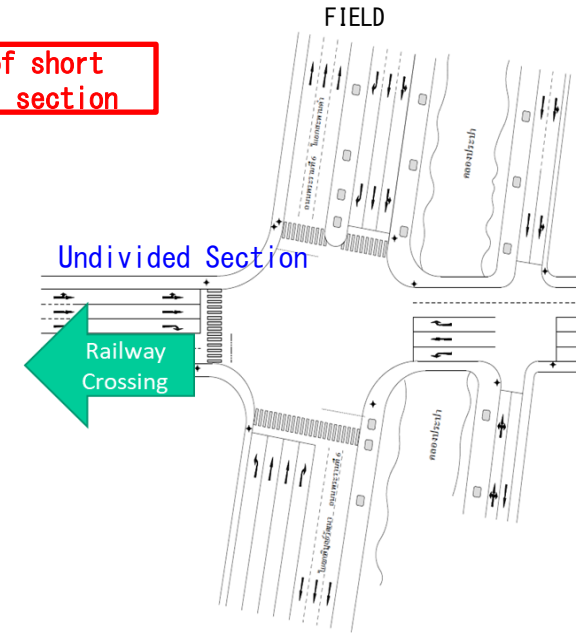
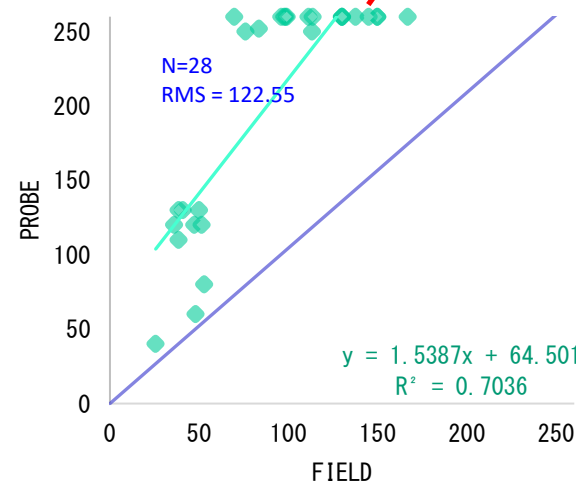
Effect of LT veh. waiting for railway crossing

I133_S



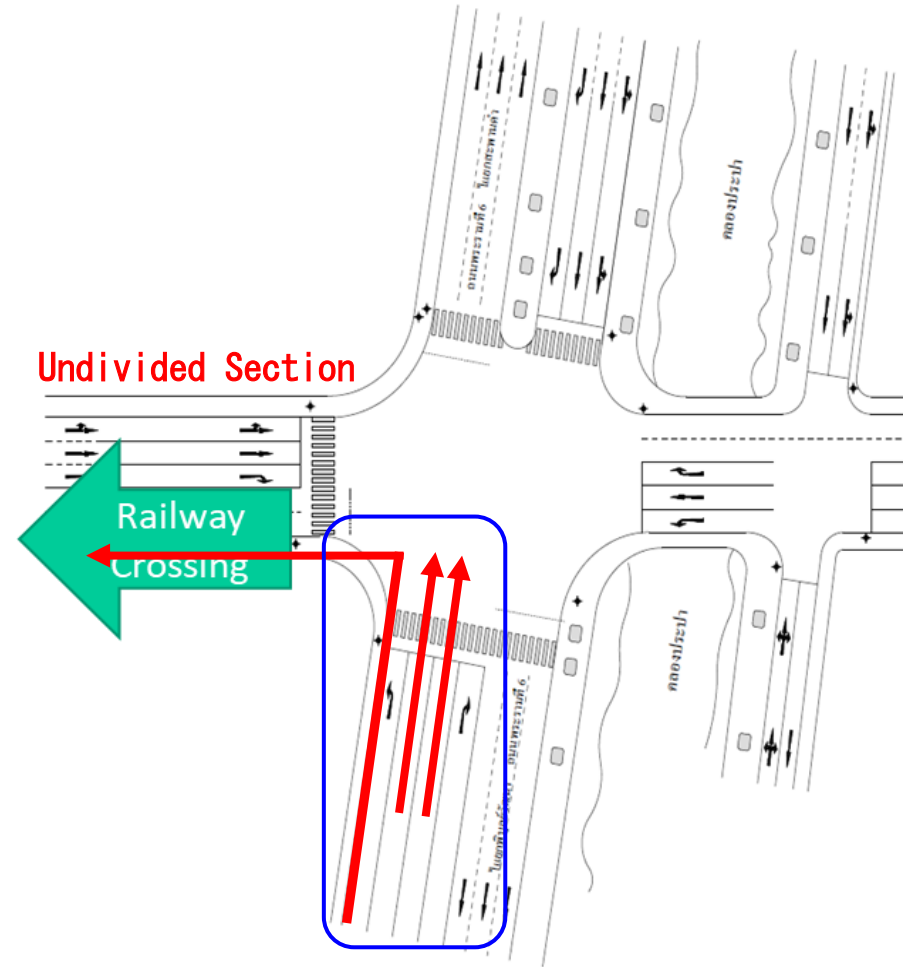
Effect of short undivided section

I133_W



QUEUE LENGTH COMPARISON [7/9]

- i133 : Comparison of queue length (m)



Probe GPS-derive Q was processed from all traffic lanes

Cause of Small Error

- Road Segment Aggregation → Unavoidable
- Difference in Avr. Speed of Each Lane ?
- GPS Noise (Ex. Undivided Road, #MT, #BUS) ?
- Intersection Type ?
- Other Factors ?



Can we address this error by estimation of adjusted value?

$$Actual_Q_i = Processed_Q_i + Adjust_Value_i \quad (1)$$

$$Adjust_Value_i = \beta_0 + \beta_1 X_1 \cdots \beta_n X_n \quad (2)$$

Actual_Q :the actual queue length observed from the field survey,
Process_Q :interpreted queue length processed from mobile GPS probe data,
 β_0 : constant value,
 β_i : the coefficient value, and
 X_i : the value of each factor, which includes;

ESTIMATION OF ADJUSTED VALUES [2/2]

Option		Note					
① Use only Probe GPS Data		<ul style="list-style-type: none"> Possible with RMSE<200m Ideal condition 					
② Incorporate Road Geometric Data		<ul style="list-style-type: none"> More complexed but BMA already has database 					
③ Include Additional Factor [Historical traffic data and signal operation in each 15-min time slice]		<ul style="list-style-type: none"> Most complexed and require most effort 					
Variable: Regression Model	Unit	Option ②		Option ③			
		Model 1		Model 2		Model 3	
		Coef.	Sig.	Coef.	Sig.	Coef.	Sig.
Number of total traffic lanes of the approach	Lane	-19.729	***	-16.308	***	-14.619	***
Intersection type	1: Roundabout, 0: Others	70.033	***	47.866	***		
Road type	1: Undivided road, 0: Others	-12.367	*			-14.242	*
Through traffic green time ratio (g/c)	%			-60.605	*	-168.236	***
Ratio of left-turn traffic volume to all traffic volume of the approach	%					-55.593	**
Large vehicle traffic (Bus and Truck) volume	Vehicle / hour			0.974	**		
Motorcycle and bicycle traffic volume	Vehicle / hour					0.132	***
Constant Value (Beta 0)		19.961		10.375		33.041	
R-squared		0.309		0.246		0.258	

CONCLUSION [1/1]

1. Probe GPS-Derived Queue Length

- Viable substitution for detector data in most cases, with a few exceptions at specific locations with notable errors

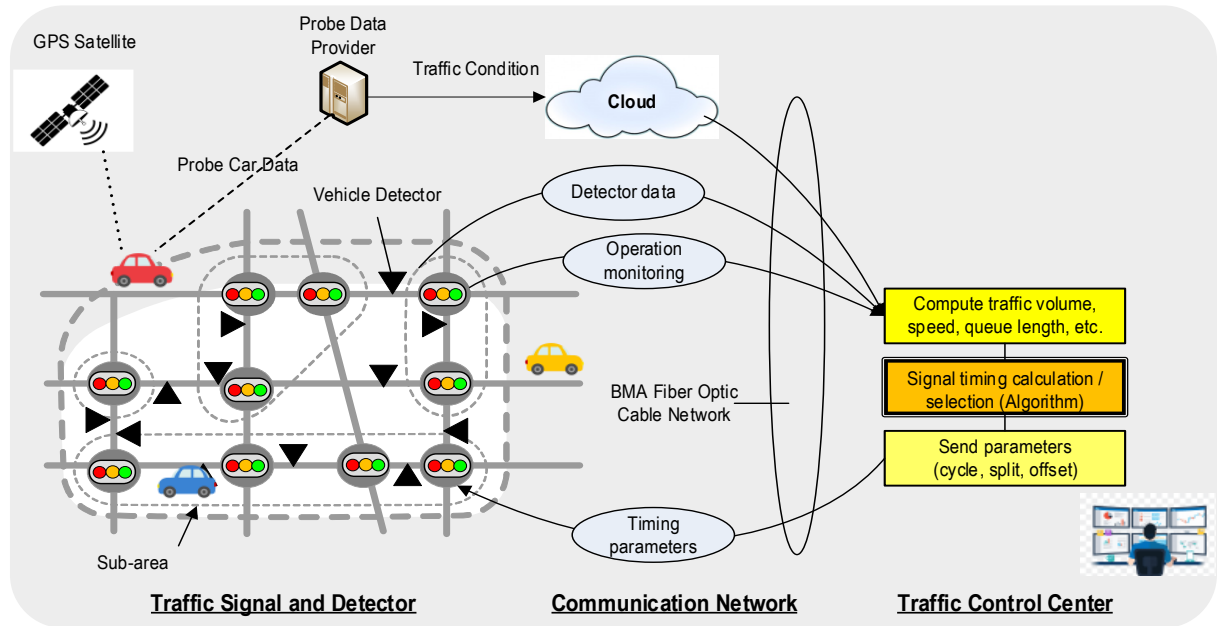
2. Recommended Approach

- Option 2 is recommended, offering effective adjustments with manageable efforts

3. Cost-Effective Solution

- Potential to minimize expenses related to detector installation and maintenance
- Enhancing the overall monitoring system

NEXT STEP [1/1]



Implementation & Proof of Concept (POC)



Experiment of Probe GPS Data

TANSAWAT Tithiwach (Presenter)

THANK YOU FOR YOUR KIND ATTENTION

Study Team

- Dr. Sarawut JANSUWAN
- Mr. Joroen BROUWER
- Mr. Seiya MATSUOKA
- Mr. Ken NISHINO
- Dr. Tetsuji MASUJIMA



Scan for more information