BANGKOK METROPOLITAN ADMINISTRATION (BMA)
ROYAL THAI POLICE (RTP)

THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

PROJECT COMPLETION REPORT

JANUARY 2025

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ALMEC CORPORATION

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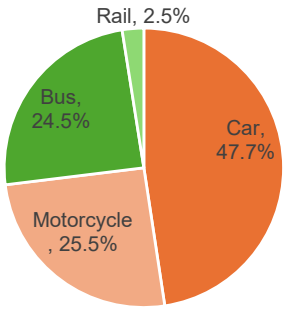
Abbreviations

ATC	area traffic control
BMA	Bangkok Metropolitan Administration
CCTV	closed-circuit television
CID	controller interface device
C/P	counterpart
DAC	Development Assistance Committee
FDF	fiber distributing frame
FOC	fiber optic cable
GDP	gross domestic product
GPS	global positioning system
GRDP	gross regional domestic product
ITS	intelligent transport system
JCC	Joint Coordinating Committee
JET	JICA Expert Team
JICA	Japan International Cooperation Agency
MODERATO	Management by Origin-Destination Related Adaptation for Traffic Optimization
MoFA	Ministry of Foreign Affairs
MoT	Ministry of Transport
OECD	Organisation for Economic Co-operation and Development
OTP	The Office of Transport and Traffic, Policy and Planning
OVIs	Objectively Verifiable Indicators
PDM	Project Design Matrix
PO	Plan of Operation
RD	Record of Discussions
RTP	Royal Thai Police
SFP	small form factor pluggable
TTD	Traffic and Transportation Department
UPS	uninterruptible power supply
VISSIM	Verkehr In Städten – SIMulationsmodell (Traffic in cities - simulation model)

Chapter 1. Project Outline

1.1 Project Background

The economic growth in Thailand has been developing steadily. In 2019 when the project began, its GDP per capita was USD7,629[1], representing an increase of approximately 1.36 times compared to its 2009 record. However, due to the impact of the COVID-19 pandemic, this figure declined to USD6,913 in 2022. The economy is now on the path to recovery, with the GDP per capita reaching USD7,172 in 2023. That year, Metropolitan Bangkok, the political and economic hub of Thailand, had a registered population of about 5.47 million[2] and a projected census-based population of approximately 9.06 million[3]. The area's gross regional domestic product (GRDP) per capita has also shown an annual growth trend of about 1%, despite the lingering effects of the COVID-19 pandemic. Additionally, the number of registered vehicles in Bangkok has grown significantly, i.e., from 8.22 million[4] in 2013 to 11.79 million in 2023, making a 1.4-fold increase over the past decade. In 2019, cars and motorcycles shared 73% of modes in Bangkok, as shown in Figure 1.1.1. While these figures highlight a thriving industrial sector, they also underscore a growing reliance on private modes, which is worsening the traffic congestion in the area. Consequently, air pollution caused by vehicles has become a pressing issue, and efforts to reduce the environmental burden are increasingly urgent.



Source: Bangkok Travel Demand Survey in 2019, Office of Transport and Traffic Policy and Planning, Ministry of Transport

Figure 1.1.1 Modal Share in Bangkok

From 2015 to 2016, JICA implemented "The Collaboration Program with Private Sector for Disseminating Japanese Technology for Operation and Maintenance of Traffic Control System for Improving Traffic Problems in Bangkok" (hereinafter referred to as "Collaboration Program"). This project introduced a coordinated traffic control system at some intersections along Rama IV Road to manage traffic, and the measure was confirmed to be effective.

Meanwhile, regional, urban, and special economic zone development is listed as one of the development strategies in the economic and social development policy of the 12th National Economic and Social Development Plan of the Thai government (2017–2021). In this development plan, an efficient and eco-friendly urbanization is one of the objectives, and the mitigation of traffic congestion, especially in Bangkok, is included as one of the measures.

[1] World Bank (https://data.worldbank.org/)
[2] Department Of Provincial Administration (https://stat.bora.dopa.go.th/stat/statnew/statMenu/newStat/sumyear.php)
[3] Official statistics registration systems (https://ubon.nso.go.th/images/staticProvince/pop_project_9.pdf)
[4] Department of Land Transport, Ministry of Transport (https://www.nesdc.go.th/nesdb_en/more_news.php?cid=156&filename=index)

Under these circumstances, the Thai government and JICA agreed to implement "The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System in the Kingdom of Thailand" (hereinafter referred to as "the Project"), aiming to reduce traffic congestion by establishing a traffic control system utilizing ITS technology.

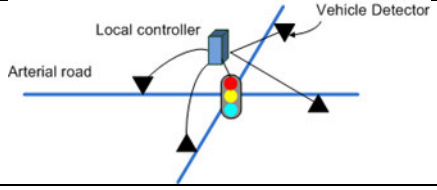
1.2 Challenges of Traffic Control in Bangkok

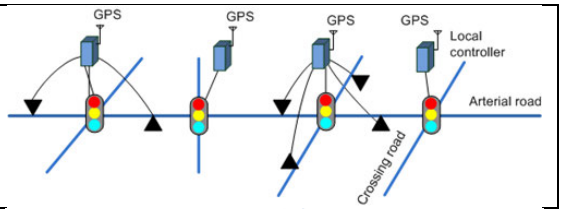
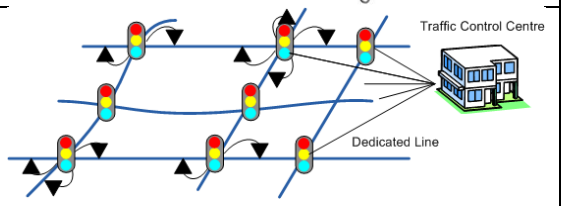
There are nearly 500 signalized intersections in Bangkok. However, most of all traffic signals at these intersections operate independently and are not synchronized with neighboring intersections. Furthermore, the traffic signals are not configured with appropriate signal parameters upon installation, nor adjusted post-installation. As a result, they operate on fixed cycles throughout the day, with no adaptation to changing traffic conditions. Traffic police officers manually operate the traffic signals to manage congestion during peak hours in the morning and evening. One contributing factor to this issue is the division of responsibilities: BMA, as the road administrator, is responsible for installing traffic signals, while RTP, as traffic administrator, is responsible for their operation. Furthermore, traffic police officers receive no formal training on manual traffic signal operation, leading to significant variability in the effectiveness of manual operation depending on the officer on duty. As a result, traffic signals across the city operate inefficiently on a broad scale. To address this situation, it is essential to consider the introduction of an Adaptive Traffic Control (ATC) system to enable signal coordination, clarify the roles of agencies responsible for the installation, operation, and maintenance of traffic signals, and enhance the technical skills required for manual signal operation. Outline of ATC system is described in Table 1.3.1.

1.3 Traffic Signal System

As mentioned above, in the Bangkok metropolitan area, traffic signals at each intersection are controlled independently. However, coordinated control was introduced for a single road section in the Collaboration Program in 2016, and an ATC system was introduced by this Project in 2023. An overview of these traffic signal control systems is provided below.

Table 1.3.1 Traffic Signal Control Systems in Bangkok Metropolitan Area

Description	Image
Isolated Signals: A system where traffic signals at each intersection are controlled independently. Each traffic light operates based on its own predefined timing, without synchronization or coordination with other intersections.	

Coordinated Signals: A method for coordinating multiple intersections by adjusting the timing of traffic signals, primarily on major roads, to enable vehicles to travel smoothly without stopping at red lights.	
ATC System: This system centrally manages multiple intersections across a wide area and dynamically adjusts the timing of traffic signals. It utilizes vehicle detectors, cameras, and AI algorithms to monitor traffic conditions in real time, ensuring optimal signal control.	

There are two types of traffic signal timing: fixed cycle and adaptive control. Fixed cycle operates based on predefined timing, while adaptive control uses sensors and other monitoring tools to adjust the timing dynamically according to traffic conditions. An example of adaptive control is illustrated in Figure 1.3.1.

In adaptive control, the green time consists of a minimum green, a unit extension, and a maximum green. The minimum green is always displayed whether a car is present or not. Just before the minimum green ends, the presence or absence of a car is determined. If a car arrives, the green time is extended by one unit green time. This extension is repeated as long as a car arrives, but once the green time reaches the maximum green, the green phase ends regardless of vehicle presence, and the next phase is displayed.

There are two methods to manage extended green time: one that shortens the duration of other phases to maintain a constant cycle time, and another that allows the cycle time to vary. The former is used when it is necessary to maintain offsets between signals in a coordinated signal or ATC system, while the latter is applied to standalone signals. Bangkok uses a different approach: A standard green time is set in advance, and the green time is either shortened or extended from that baseline.

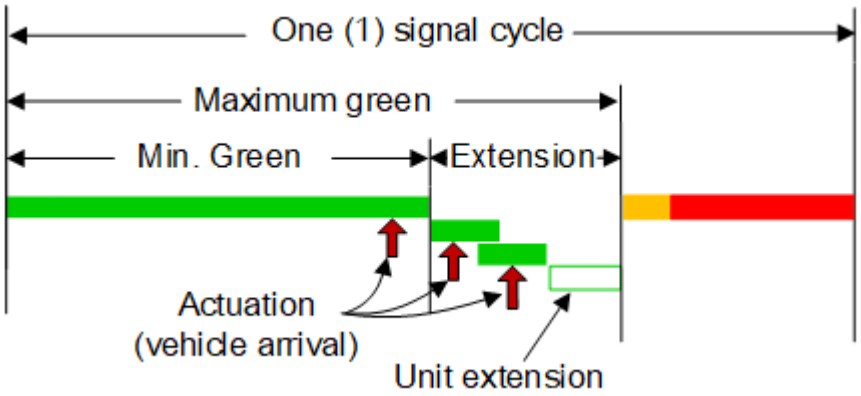


Figure 1.3.1 Image of Adaptive Control

1.4 Project Purpose

In December 2018, the Record of Discussion (hereinafter referred to as "RD"), which stipulates the framework of the Project, was signed by representatives of BMA and JICA. The RD specifies the project goal, purpose, and activities, as shown below. The RD and its amendments are provided in Annex 1.

- Overall Goal: The area covered by an ATC system is expanded, and traffic congestion and environmental condition in the area are improved.
- Project Purpose: An ATC system is established in the pilot project area, and traffic congestion in the area is improved.
- Activities and Expected Achievements: (See table below.)

Table 1.4.1 Project Activities and Expected Achievements

Expected Achievement	Outline of Activity
Output 1: Establishment of the ATC System in the Pilot Project Area	1.1 The present situation of the traffic control system, including outcomes of the Collaboration Program assisted by JICA in 2016, is reviewed and analyzed. 1.2 The pilot project area is selected. 1.3 Details of the project activities are planned, and role sharing among the participating organizations is clarified. 1.4 The information needed for installation works, including intersection drawings, communication network, and underground utilities, is collected and studied before installation of equipment for the ATC system. 1.5 Traffic volume, queue length, signal control, traffic safety, and other related issues are studied, and the amount of air pollutant in the pilot project area is estimated. 1.6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1.7 The equipment for the ATC system is installed in the pilot project area and at the traffic control center. 1.8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1.9 ATC system software is installed; database is established; and system, signal, and detector parameters are set. 1.10 Traffic management officers of BMA and Royal Thai Police receive trainings for the operation of the ATC system.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2.1 Duties and implementation structures are clarified for the organizations – BMA, RTP, and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, expansion plan, and others. 2.2 The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on-the-job training and training in Japan. 2.3 The operation and maintenance manuals of the ATC system are prepared. 2.4 Awareness campaign and public relations are conducted.

Output 3: Preparation and Utilization of the Guideline for Manual Operation of Traffic Signals	3.1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3.2 The operating guideline for manual operation of traffic signals is drafted. 3.3 Usefulness of assistant tools to support manual control of signals for the ATC system is studied, and the tool is introduced on a trial basis if required. 3.4 Trainings are conducted for BMA and RTP officers, and signals are manually operated on a trial basis based on the draft operating guideline for the manual operation of traffic signals. 3.5 The draft operating guideline is reviewed at a workshop by the BMA and RTP staff in charge of traffic signal operation, and the operating guideline is finalized.
Output 4: Drafting of short/mid-term expansion plan of the ATC system covering entire Bangkok	4.1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4.2 The situation of urban transportation, including traffic control, in Bangkok Metropolitan Area is reviewed. 4.3 The ATC system in other countries is studied. 4.4 Draft short and midterm plans for expanding the ATC system in the Bangkok Metropolitan Area are formulated 4.5 Possibility of applying state-of-the-art technologies, including probe data from individual vehicles, to Bangkok's ATC system as a long-term innovation.

Source: RD

1.5 Project Area

The Project area covers the entire Bangkok, and the pilot project area (the model area) is shown in Chapter 4.

1.6 Project Counterpart Agencies

Related local organizations are shown in the next table.

Table 1.6.1 Related Local Organizations

Classification	Institution	Overview
Implementing Organization	Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA)	BMA has a central office (16 departments) and district offices (50 district offices), and the Traffic and Transportation Department is one of the organizations in the central office. This department consists of five divisions, namely, Secretarial Division, Policy and Planning Division, Traffic Engineering Division, Traffic Technology System Division, and Transportation Division. The Traffic Engineering Division, which has Traffic System Design Division in charge of traffic signal maintenance, is directly involved in the Project. BMA's organization structure is shown in Figure 7.2.1.
Related Organizations	Traffic Police Division, Royal Thai Police (RTP)	RTP is an organization under the Thai Prime Minister's Office. The operation division IV under the Traffic Police Division of the Metropolitan Police Bureau is responsible for traffic control system in Bangkok. The

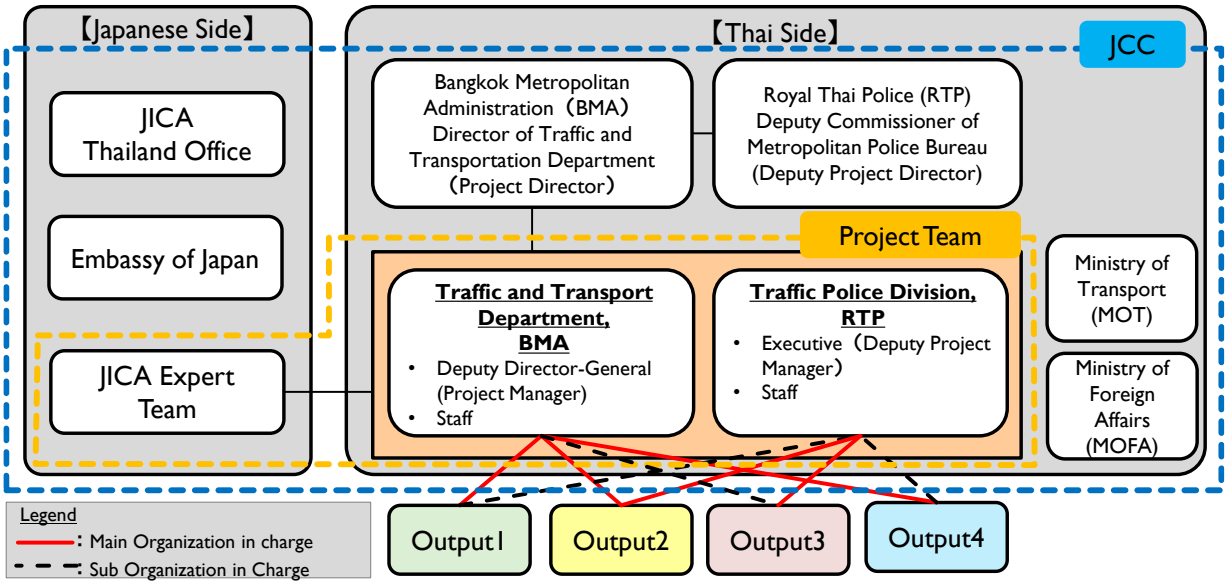
		Traffic Police Division manages traffic control using CCTV, information center, and control center; introduces new technology related to traffic control; and introduces, maintains, and manages electronic devices used by the traffic police. This division operates the traffic control system of the Project. Traffic management is the responsibility of the local police stations, which operate traffic signals manually in addition to conducting patrols and directing traffic. BMA's organization structure is shown in Figure 7.2.2.
	Department of Land Transport (DLT) of Ministry of Transport (MoT), Department of Highway (DoH), Office of Transport and Traffic Policy Planning (OTP)	They formulate transportation policies, enforce laws and regulations related to road, and maintain and manage national highways and motorways. They serve as observers in the JCC of the Project.
	Thailand International Cooperation Agency (TICA), Ministry of Foreign Affairs	TICA formulates foreign policies and strategic plans, and serves as an observer in the JCC of the Project.

Source: JET

The operation and maintenance of traffic signals is described in Chapter 5. The Bangkok Metropolitan Administration (BMA) is responsible for the installation, parameter setting, and maintenance of traffic signals, while the Royal Thai Police (RTP) is responsible for operating the traffic signals, including manual operation.

1.7 Project Implementation Structure

The project implementation structure and the list of the JCC members are shown in Figure 1.7.1 and Table 1.7.1, respectively. Project members are shown in Table 1.7.2 to Table 1.7.4. Project members from BMA and RTP were officially notified by BMA. While the names of the RTP members were already known at the beginning of the Project, personnel changes occur annually, so from March 2021 onwards, only their positions are shown. The Director General of TTD-BMA, who serves as the project director and chairman of the JCC, changed three times over the course of the Project. Mr. Panurak Klannurak held the position from the start of the project until September 2020. He was succeeded by Mr. Prapas Lueangsirinaph, who served from December 2020 to September 2022. Mr. Thaipat Tanasombatkul took over in January 2023 up to September 2024, followed by Mr. Sithiporn Somkitsan, who held the position from October 2024 up to the conclusion of the Project.



Source: JET

Figure 1.7.1 Project Implementation Structure

Table 1.7.1 JCC Members

Organization		Note
Thai	BMA-TTD	The director general of TTD serves as the JCC chairperson.
	RTP	—
	Office of Transport and Traffic Policy Planning, Ministry of Transport (MOT)	—
	Department of Highways, MOT	—
	Department of Land Transport, MOT	—
	Thailand International Cooperation Agency (TICA)	—
Japan	Embassy of Japan	—
	JICA HQ	—
	JICA Thailand Office	—
	JICA Expert Team (JET)	—

Source: JET

Table 1.7.2 Project Members from BMA's Traffic Engineering Office, Traffic and Transportation Department, as of November 2024

#	Name	Position	JCC Role
1	Mr. Sithiporn SOMKITSAN	Director General, TTD	Chairman of JCC
2	Mr. Waitaya NAVASEDTHAKUL	Director, Traffic Engineering Office, TTD	Project manager
3	Mr. Worrapoj THAMMACHART	Director, Traffic Engineering Office, TTD	Deputy project manager
4	Mr. Sayan THASANAKOSOL	Director, Traffic System Design Division, Traffic Engineering Office – TTD	Member
5	Mr. Sukhi INTHA	Chief of Traffic Sign Work Group 1, Installation and Maintenance Division, Traffic Engineering Office – TTD	Member
6	Mr. Sanan THOWADEE	Chief of Planning and Design Work Group 1, Traffic System Design Division, Traffic Engineering Office – TTD	Member
7	Mr. Chairat SUNGSAWAS	Chief of Planning and Design Work Group 2, Traffic System Design Division, Traffic Engineering Office – TTD	Member

8	Mr. Anucha AONAIM	Chief of Planning and Design Work Group 3, Traffic System Design Division, Traffic Engineering Office – TTD	Member
9	Mr. Chakaphong THIENPHITHAK	Chief of Traffic Signal Work Group, Traffic System Design Division, Traffic Engineering Office – TTD	Member
10	Mr. Bhornpravas YAMPRASERT	Electrical Technician Experienced Level, Traffic Signal Work Group, Traffic System Design Division, Traffic Engineering Office – TTD	Member
11	Mr. Nattapon MAKSRI	Electrical Technician Experienced Level, Traffic Signal Work Group, Traffic System Design Division, Traffic Engineering Office – TTD	Member
12	Mr. Akekachai PREECHAKHAM	Electrical Technician Operational Level, Traffic Signal Work Group, Traffic System Design Division, Traffic Engineering Office – TTD	Member
13	Mr. Sarawut SUKCHAREON	Civil Engineer, Professional Level (Project Study and Planning), Traffic Technology Work Group 1, Traffic System Technology Division, Traffic Engineering Office – TTD	Member
14	Mr. Aphichat CHAROENLAP	Civil Technician, Operational level, Traffic Sign Work Group1, Installation and Maintenance Division, Traffic Engineering Office – TTD	Member
15	Mr. Wasu PHOKAEW	Electrical Engineer, Practitioner Level, Traffic Signal Work Group, Traffic System Design Division, Traffic Engineering Office – TTD	Member, Secretary

Source: JET

Table 1.7.3 Project Members from RTP

#	Name	Position	Note
1	Position only	Commander of Traffic Police Division, Metropolitan Police Bureau – RTP	Project Manager
2	Position only	Deputy Commander (G.4) of Traffic Police Division, Metropolitan Police Bureau – RTP	Deputy Project Manager
3	Position only	Deputy Commander (G.6) of Traffic Police Division, Metropolitan Police Bureau – RTP	Member
4	Position only	Deputy Commander (G.7) of Traffic Police Division, Metropolitan Police Bureau – RTP	Member
5	Position only	Superintendent, General Staff Division, Traffic Police Division, Metropolitan Police Bureau – RTP	Member
6	Position only	Superintendent (G.3), Traffic Police Division, Metropolitan Police Bureau – RTP	Member
7	Position only	Superintendent (G.4), Traffic Police Division, Metropolitan Police Bureau – RTP	Member
8	Position only	Deputy Superintendent (G.3), Traffic Police Division, Metropolitan Police Bureau – RTP	Member
9	Position only	Traffic Inspector, ATC center (G.4), Traffic Police Division, Metropolitan Police Bureau – RTP	Member
10	Position only	Deputy Traffic Superintendent, Phaya Thai Police Station, Metropolitan Police Division 1, Metropolitan Police Bureau – RTP	Member
11	Position only	Traffic Inspector, Phaya Thai Police Station, Metropolitan Police Division 1, Metropolitan Police Bureau – RTP	Member
12	Position only	Deputy Traffic Inspector, Phaya Thai Police Station, Metropolitan Police Division 1, Metropolitan Police Bureau – RTP	Member
13	Position only	Deputy Traffic Superintendent, Bang Sue Police Station, Metropolitan Police Division 2, Metropolitan Police Bureau – RTP	Member
14	Position only	Traffic Inspector, Bang Sue Police Station, Metropolitan Police Division 2, Metropolitan Police Bureau – RTP	Member
15	Position only	Deputy Traffic Inspector, Bang Sue Police Station, Metropolitan Police Division 2, Metropolitan Police Bureau – RTP	Member

16	Position only	Deputy Inspector, General Staff Division, Traffic Police Division, Metropolitan Police Bureau – RTP	Member, Secretary

Source: JET

Table 1.7.4 JICA Expert Team (JET)

Name	Firm	Position
1 MASUJIMA Tetsuji	ALMEC	Project Manager/ Urban Transportation Planning
2 NISHINO Ken	ALMEC	Deputy Project Manager/ Road Planning
3 MATSUOKA Seiya	ALMEC	Traffic Control
4 SUGANUMA Atsushi	ALMEC (SET Data Service)	Traffic Signal Control
5 MURAYAMA Kiyoshi	ALMEC (MTCS)	Signal System Construction
6 ONO Yuji	ALMEC (Koutsuu Unyou Engineering)	ATC System Operation and Maintenance Management
7 WICHAIMETHAWEE Thawee	ALMEC (TKN Engineering and Technology)	Information Communication Network
8 TAKAGI Michimasa	ALMEC	Traffic Safety
9 TANSAWAT Tithiwach	ALMEC	Traffic Survey/ PR/ Project Coordination
10 KANEKO Motoko	ALMEC	Economic Analysis / Training Planning/Monitoring

Source: JET

1.8 Matters to be Taken by the Japanese Side

Summary of matters to be taken by Japanese side is shown in below.

Table 1.8.1 Summary of Matters to be Taken by Japanese Side

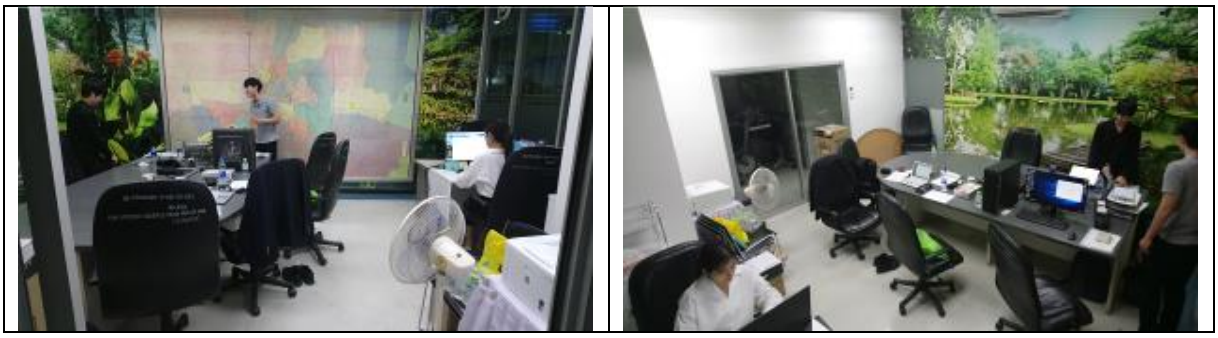
Total input from Japan	595 million JPY[5]
Receiving training in Japan	Total 12 persons of 6 officers from BMA and 6 officers from RTP (Section 3.7)
JICA Experts	90.8 person month (Table 2.2.2)
Equipment	ATC System for the pilot project 3 sets of personal computers: 1 copy machine

1.9 Matters to be Taken by the Thai Side

BMA was responsible for assignment of counterpart staffs, providing a project office, and developing traffic signals and the communication network for the pilot project. The list of counterpart staffs are presented in Table 1.7.2 and Table 1.7.3. The project office was located in the BMA Traffic and Transportation Department building, as shown in Figure 1.9.1. The

[5] The consultant cost in the total input from Japan is based on the contract amount, not the actual payment.

budget for signal development is outlined in Table 4.2.5, however, the actual disbursement remains unknown.



Source: JET

Figure 1.9.1 Photos of the Project Office

Chapter 2. Project Schedules

2.1 Implementation Schedule

Due to the impact of COVID-19, there have been delays in the progress of project activities and in securing the budget for BMA. Consequently, the contract period between JICA and JET has been adjusted as shown below.

- Original Contract : 29 Mar 2019–28 Feb 2022.
- First Amendment : 29 Mar 2019–23 Dec 2022.
- Second Amendment : 29 Mar 2019–31 Aug 2023.
- Third Amendment : 29 Mar 2019–28 Feb 2024.
- Fourth Amendment : 29 Mar 2019–28 Feb 2025.

The implementation schedule for the fourth amendment is shown in Table 2.2.1. The revised workflow is shown in Figure 2.2.1.

2.2 Staff Assignment Schedule

Due to the adjustments in the contract period and the transfer of assignment of JET members from field (Thailand) to home base (Japan) during COVID-19 travel restrictions, the number of workdays was also modified. Compared to the initial contract, the field assignment of JET members to Thailand was reduced by 1.5 person-months, while their home assignment in Japan increased by 22 person-months, resulting in a total increase of 18.3 person-months. The revised assignment plan and actual dispatch of experts are shown in Table 2.2.2 (the increase/decrease in local and domestic work will be updated in December 2024).

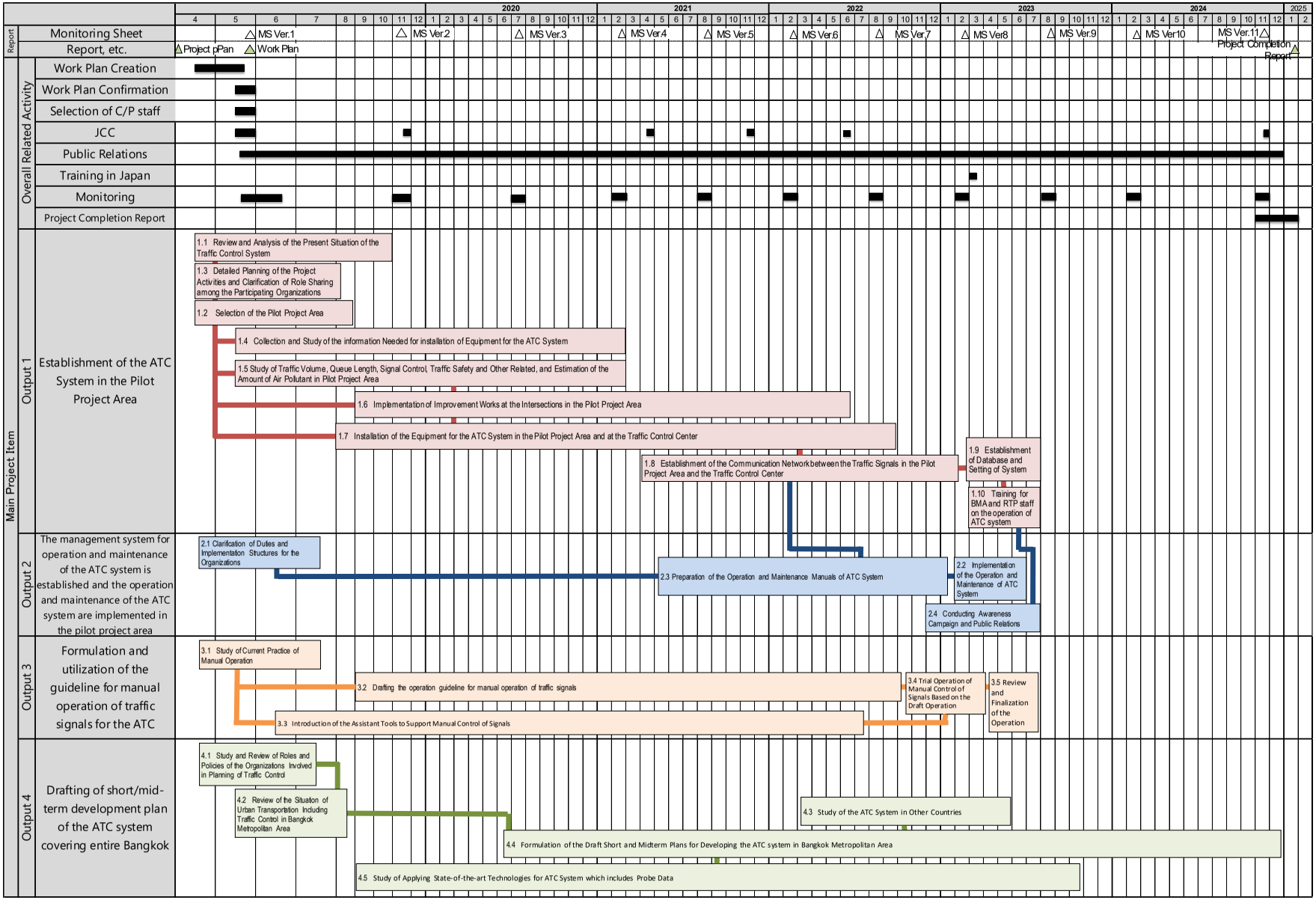
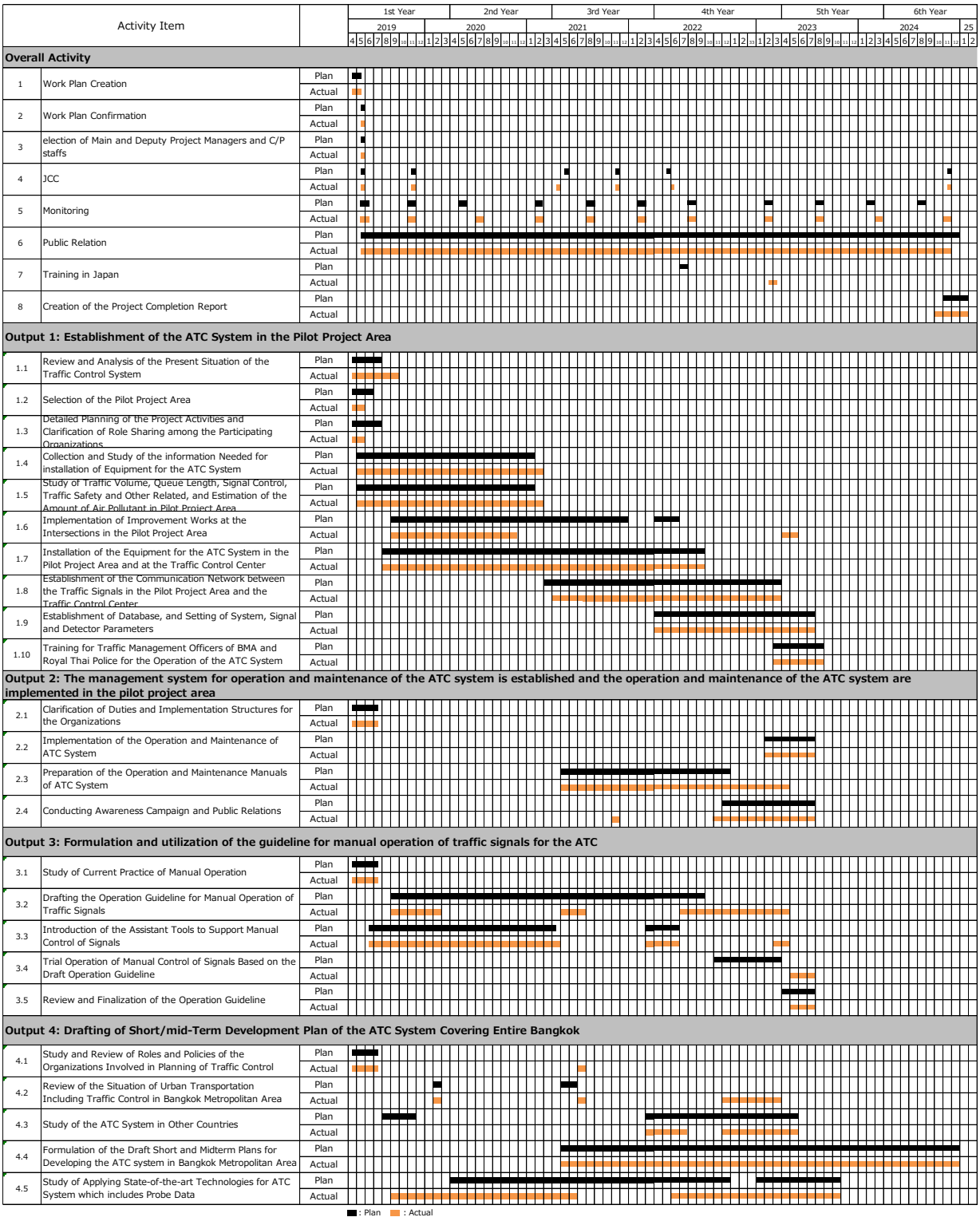


Figure 2.2.1 Project Workflow

Table 2.2.1 Project Implementation Schedule



Source: JET

Table 2.2.2 Planned and Actual Assignment of JET

Name / Position	Plan / Actual	Total Person-Month			Number of Trip						
		Thai	Japan	Total	Total	Year					
						2019	2020	2021	2022	2023	2024
MASUJIMA Tetsuji (Project Manager/ Urban Transportation Planning)	Original plan	9.50	5.00	14.50	14	4	0	3	3	2	2
	Updated plan	9.60	5.20	14.80	16	4	0	3	4	3	2
	Actual	9.60	5.20	14.80	18	4	0	3	4	3	4
NISHINO Ken (Deputy Project Manager)	Original plan	7.70	2.60	10.30	13	6	0	4	2	0	1
	Updated plan	7.60	2.75	10.35	13	6	0	4	2	0	1
	Actual	7.60	2.75	10.35	12	5	1	2	3	0	1
NISHINO Ken (Road Planning)	Original plan	1.80	0.20	2.00	0	-	-	-	-	-	-
	Updated plan	1.80	0.20	2.00	0	-	-	-	-	-	-
	Actual	1.80	0.20	2.00	2	1	0	0	1	0	0
MATSUOKA Seiya (Traffic Control)	Original plan	14.00	6.70	20.70	15	5	0	3	3	2	2
	Updated plan	14.27	8.03	22.30	17	5	0	3	3	4	2
	Actual	14.27	8.00	22.27	18	5	0	3	3	3	4
SUGANUMA Atsushi (Traffic Signal Control)	Original plan	5.00	2.20	7.20	8	3	0	0	4	1	0
	Updated plan	4.23	3.12	7.35	7	3	0	0	2	2	0
	Actual	4.23	3.15	7.38	7	3	0	0	2	2	0
MURAYAMA Kiyoshi (Signal System Construction)	Original plan	3.00	1.20	4.20	5	3	0	0	2	0	0
	Updated plan	1.53	0.60	2.13	3	3	0	0	0	0	0
	Actual	1.53	0.60	2.13	3	3	0	0	0	0	0
ONO Yuji (ATC System Operation and Maintenance Management)	Original plan	3.00	1.20	4.20	5	2	0	0	3	0	0
	Updated plan	3.40	1.45	4.85	5	2	0	0	2	1	0
	Actual	3.40	1.45	4.85	5	2	0	0	2	1	0
TAKAGI Michimasa (Traffic Safety)	Original plan	1.00	-	1.00	2	0	0	2	0	0	0
	Updated plan	0.17	-	0.17	1	0	0	1	0	0	0
	Actual	0.17	-	0.17	1	0	0	1	0	0	0
TANSAWAT Tithiwach (Traffic Survey/ PR/ Project Coordination)	Original plan	13.50	1.50	15.00	16	5	1	2	4	2	2
	Updated plan	14.80	2.75	17.55	16	5	1	2	4	2	2
	Actual	14.80	2.75	17.55	18	5	1	2	4	2	4
KANEKO Motoko (Economic Analysis / Training Planning/Monitoring)	Original plan	3.00	2.70	5.70	6	3	0	0	3	0	0
	Updated plan	1.90	3.40	5.30	6	3	0	0	3	0	0
	Actual	1.90	3.40	5.30	8	2	0	1	4	1	0
WICHAIMETHAWEE Thawee – (Information Communication Network))	Original plan	-	4.00	4.00	0	-	-	-	-	-	-
	Updated plan	-	4.00	4.00	0	-	-	-	-	-	-
	Actual	-	4.00	4.00	0	0	0	0	0	0	0
TSUCHIYA Rie (Economic Analysis/Training/Monitoring)	Original plan	-	2.00	2.00	0	-	-	-	-	-	-
	Updated plan	-	0.00	0.00	0	-	-	-	-	-	-
	Actual	-	0.00	0.00	0	0	0	0	0	0	0
Total	Original plan	61.50	29.30	90.80	84	31	1	14	24	7	7
	Updated plan	59.30	31.50	90.80	84	31	1	13	20	12	7
	Actual	59.30	31.50	90.80	92	30	2	12	23	12	13

Source: JET

Chapter 3. Overall Project Activities

3.1 Summary

The activities related to the entire Project are listed in the workflow chart as follows: creation of a work plan, selection of a project manager (PM), and counterpart (C/P) staff, holding of Joint Coordinating Committee (JCC) meetings, project monitoring, setting of indicators for the Project Design Matrix (PDM), public relations activities, training in Japan, and preparation of the project completion report (PCR). In addition, meetings of the Project Team, consisting of BMA, RTP, and JET, were held regularly to review project status and technical transfer, exchange opinions, and monitor the progress of the Project. These items are described in this chapter.

3.2 Work Plan Creation and Confirmation

JET drafted the work plan and explained it to TTD-BMA, RTP, and related agencies. The latter agreed on the project activities, and the plan was subsequently approved at the first JCC meeting which was held on 31 May 2019.

3.3 Selection of Main and Deputy Project Managers and CP Staff

The project members from the Thai side, including the Deputy PM from RTP, and C/P staff from both TTD-BMA and RTP, were announced at the first JCC meeting held on 31 May 2019 and subsequently formalized through an official notice from BMA. Although the Deputy PM and C/P staff from RTP changed annually due to personnel transfers, the same number of C/P staffers were maintained as initially planned.

3.4 Joint Coordination Committee (JCC)

JCC meetings were originally scheduled to occur every six months, but this schedule was not followed in 2020 due to COVID-19 restrictions on gatherings and meetings in Thailand. With the increased use of online conference systems, JCC meetings were held both in person and online since April 2021.

Table 3.4.1 JCC Meetings, 2019–2024

No.	Date	Main Agenda
First	31 May 2019	· Explanation, discussion, and approval of the work plan · Confirmation of the pilot project area · Confirmation of the Deputy PM and the C/P members
Second	28 Nov 2019	· Project progress · Confirmation of the ATC system for the pilot project area · Itinerary and participants to the 1st training in Japan
Third	27 Apr 2021	· Project progress · Confirmation of project members · Update on matters to be done by BMA

		· Extension of project period
Fourth	23 Nov 2021	· Project progress · Update on matters to be done by BMA and corresponding budget
Fifth	7 Jun 2022	· Update on matters to be done by BMA and corresponding budget · Extension of project period · Confirmation of the training in Japan
Sixth	29 Nov 2024	· Explanation of ATC system expansion plan · Project outputs · Project review results

Source: JET

First JCC Meeting

Second JCC Meeting

Third JCC Meeting

Fourth JCC Meeting

Fifth JCC Meeting

Sixth JCC Meeting

Source: JET

Figure 3.4.1 Photos of JCC Meetings

3.5 Monitoring

Monitoring was conducted 10 times during the Project based on the indicators in the PDM and at regular intervals: i.e., May 2019, November 2019, June 2020, February 2021, August 2021, February 2022, August 2022, February 2023, September 2023, and November 2024. Regarding the Project Design Matrix (PDM), no changes were made to the activities associated with each output. However, numerical values for the objectively verifiable indicators (OVIs) for each output, which had not been defined at project inception, were set in February 2021. To align with the proposed ATC system expansion plan, an amendment to the OVIs of the overall goal was proposed and approved in the sixth JCC meeting.

Table 3.5.1 Indicators on PDM

Narrative Summary	Objectively Verifiable Indicator	Means of Verification
Overall Goal The area covered by ATC system is expanded and traffic congestion and environmental condition in the area are improved.	1. Roadside modules including adaptive signals which are applicable to ATC system are installed. 2. Travel time along the selected routes or maximum queue lengths at sample intersections where adaptive signals are installed is reduced around 10%.	· Completion report · Survey results
Project Purpose An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	· Commissioning test of ATC system · Survey results and data from probe data or other sources · Work report of the Project
Output 1: The ATC system is established in the pilot project area.	1-1.The ATC signals are installed in 12 intersections. 1-2.The ATC center system is established.	· Successful completion of commissioning test of ATC system · Work report of the Project
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least 3 times.	· Minutes of JCC
Output 3: Operation guidelines for manual	3-1. Approximately 5 officials from RTP receive training on	· Records of workshops · Interview survey of RTP

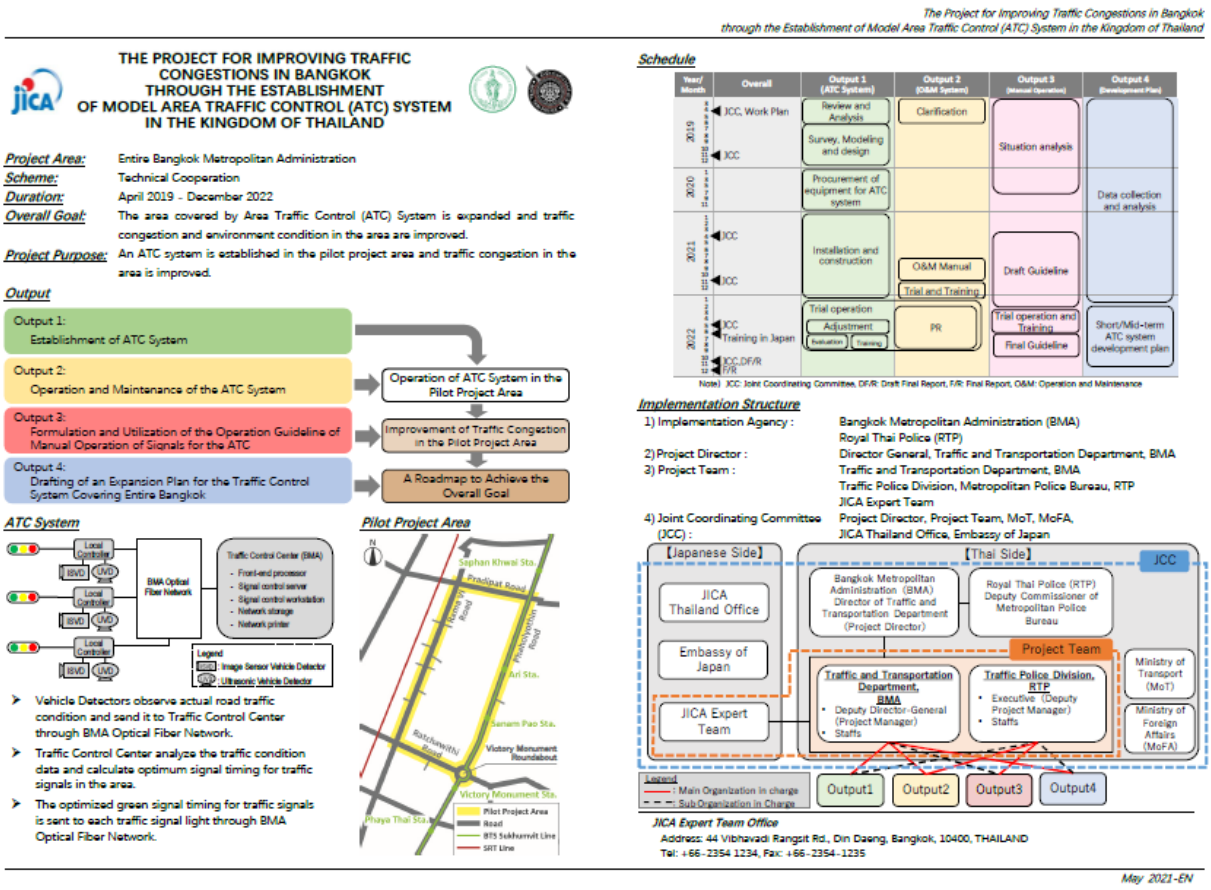
Narrative Summary	Objectively Verifiable Indicator	Means of Verification
operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	officials · Letter of acknowledgement
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.	

Source: PDM

3.6 Public Relations (PR)

(1) Project Leaflet

A leaflet was prepared in both Thai and English, briefly describing the project's purpose, activities for Outputs 1 through 4 (including the pilot project), implementation structure, and implementation schedule. Copies of the leaflet were distributed to JCC meeting participants, universities, and other parties involved in the Project.



Source: JET

Figure 3.6.1 Project Leaflet

(2) BMA's Official Website

Project activities were published on BMA's official website to promote awareness within the BMA, other government ministries and agencies, and the general public.

(3) JICA's Official Website

Project activities were published on JICA's official website[6] to promote the project, with 17 news articles released over the course of the project period.

(4) Newspapers

Through BMA's local network, the Project Team invited reporters from local TV stations and newspapers to the JCC meetings and requested that they broadcast news and publish articles. Additionally, through JICA Thailand Office's local network, the Project Team facilitated the coverage by a Japanese newspaper, resulting in an article published in the Asahi Shimbun on 5 September 2019.

(5) PR Activities for the Pilot Project

As part of public relations and awareness-raising efforts for the pilot project, the following activities were conducted together with BMA and RTP to coincide with the launch of the ATC system.

Purpose

- Inform citizens about the ATC system's overview and anticipated benefits.
- Notify road users of changes to traffic regulations in the pilot project area.

Activities

- Installation of banners in the pilot project area.
- Distribution of leaflets in the pilot project area.
- Creation of promotional videos about the pilot project and the ATC system.
- Conduct of an opening ceremony for the pilot project.

Schedule

- October 2022–March 2023: Preparation of PR materials such as leaflets, banners, and videos.
- March 2023: Finalization of PR materials.
- May–June 2023: Execution of PR activities prior to ATC system launch.
- 26 June 2023: Opening ceremony.

[6] https://www.jica.go.jp/Resource/project/thailand/028/index.html

PR Materials

Source: JET

Figure 3.6.2 Leaflet about the Pilot Project

Table 3.6.1 Design and Installation Site of Banners about the Pilot Project

Site	Design
Pedestrian Bridge	Attention
	PR

Roadside	Attention 	PR
Traffic Signal Poles, Vehicle Detectors	PR 	Decoration

Source: JET

Pedestrian Bridge

Traffic Signal Pole

Vehicle Detector

Roadside

Source: JET

Figure 3.6.3 Photos of PR Materials in the Pilot Project Area

(6) Opening Ceremony for the Pilot Project

On 26 June 2023, a ceremony to launch the pilot project was held with 120 participants, including the Governor of BMA, the Director General of TTD-BMA, the Deputy Commissioner of the Metropolitan Police Bureau of RTP, a minister from the Japanese Embassy, and the Chief Representative of JICA Thailand Office.

Group Photo

Explanation by JET

Ceremony

Live Stream by Governor of BMA
(the Governor is on the left side)

Source: JET

Figure 3.6.4 Photos of the Opening Ceremony for the Pilot Project

(7) Seminar on the Draft ATC System Development Plan

On 26 November 2024, a seminar was held to explain the draft plan on ATC system development to 30 participants including the Vice Governor Of BMA, the Director General of TTD-BMA, the Deputy Commissioner of the Metropolitan Police Bureau of RTP, a second secretary of the Japanese Embassy, and the Chief Representative of JICA Thailand Office. A panel discussion was held by representatives from TTD-BMA, RTP, JICA Thailand Office, and JET. Main comments from BMA-TTD and RTP in the panel discussion are below.

- Metropolitan Police Bureau of RTP

  RTP is in charge of traffic management in Bangkok. Peak hours require a large-scale deployment of police officers at intersections to control traffic signals and ease congestion. RTP has expressed a desire for the ATC system to cover the entire Bangkok area to help reduce the manpower required for traffic signal control and allow officers to focus on other important tasks.

- TTD-BMA

  TTD-BMA has introduced adaptive traffic signals at 72 intersections and is developing infrastructure such as the Intelligent Operating Centre (IOC) for centralized traffic data collection and real-time monitoring. BMA plans to expand the adaptive traffic signals citywide by 2026, starting with the most congested areas. The adaptive traffic signals can be upgraded and integrated with the ATC system. TTD-BMA insisted that BMA committed to expanding the ATC system in the future to improve traffic flow across the city. To address this, TTD-BMA plans to collaborate with external experts to build a skilled team for efficient system expansion. This partnership aims to enhance planning, development, and improvement, ensuring optimal operations and long-term sustainable traffic management for the city. However, the adaptive traffic signal system which BMA has introduced is different from that[7] generally used in ATC systems, which are responsive signals[8]; BMA's signals use a signal control method applicable to single intersections only, and the supplier has not disclosed to BMA the specific signal control algorithm they used.

[7] https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter9.htm#9.4

[8] https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter9.htm#9.3

Panel Discussion

Media Interview

Source: JET

Figure 3.6.5 Photos of the Seminar on the Draft ATC System Development Plan

3.7 Training in Japan

At the beginning of the Project, two training sessions in Japan were planned. However, due to the COVID-19 pandemic, the Thai side requested a postponement in 2020, resulting in the cancellation of the first session. Consequently, the training was held only once, from 27 February to 10 March 2023, as shown in Table 3.7.1.

Initially, eight participants were planned for each session, totaling 16 people. Since only one session was held, 12 participants (six each from BMA and RTP) attended, optimizing the training's efficiency.

Table 3.7.1 Plan for the 2023 Training in Japan

Date	Program	Contents
27-Feb (Mon)	Travel	Arrival in Tokyo
28-Feb (Tue)	Briefing	Orientation on the study trip
	Site visit (intersections around Hatagaya Station and roads around Shinjuku Station)	Traffic signal control and traffic management
1-Mar (Wed)	Saitama Prefectural Police	Traffic control center and operation
	Nisshin Electronics Service Co., Ltd.	Traffic control center maintenance work
	Site visit (U-turn slots near Shin-Oomiya bypass)	Traffic management at U-turn slots
2-Mar (Thu)	Pioneer Co.	Probe data utilization
	Site visit (Kishine intersection in Yokohama City)	Traffic management measures
3-Mar (Fri)	Toyo Univercity	Use of ITS for advanced and efficient road management
	Fujitsu Ltd. (Technology Hall)	Image processing for advanced traffic management and other traffic-related ITS technologies

4-Mar (Sat)	—	Free time
5-Mar (Sun)	—	Free time
6-Mar (Mon)	Site visit (Intersection traffic control)	Coordinated signals, adaptive signals, and other traffic signals
	Nippon Signal Co. Ltd.	Traffic signals, traffic safety, and automatic operation
7-Mar (Tue)	Road and Highway Bureau, Yokohama Municipal Government	Road development and maintenance, road traffic management, and traffic safety
	Sumitomo Electric Industries Ltd.	ATC system
8-Mar (Wed)	Metropolitan Expressway Co. Ltd.	Traffic management and congestion measures on metropolitan expressways
9-Mar (Thu)	JICA HQ	Wrap-up meeting
10-Mar (Fri)	Travel	Depart Tokyo

Source: JET

3.8 Project Completion Report

This report includes details of the activities conducted throughout the project period, as well as the achievement of the OVIs outlined in the PDM.

3.9 Project Team Meetings

Project team meetings were regularly held among BMA, RTP, and JET. During these meetings, the current situation is reviewed, issues are identified, and countermeasures are discussed. A summary of the project team meetings is shown in Table 3.9.1.

Table 3.9.1 Project Team Meetings, 2019–2024

No.	Date	Main Agenda
1	17 May 2019	Kick-off Meeting, Explanation and discussion on the Work Plan
2	25 Jun 2019	Location of the traffic control center
3	30 Jul 2019	Result of the traffic survey in the pilot project area, Traffic situation and issues in the pilot project area
4	4 Sep 2019	Analysis result of the traffic survey in the pilot project area
5	25 Sep 2019	Theory of traffic signal operation, Design policy of the ATC system, Operation policy of U-turn slots, The 1st training tour in Japan
6	31 Oct 2019	Analysis result of the traffic survey in the pilot project area, Participants for the 1st training tour in Japan
7	22 Nov 2019	System configuration of the ATC system for the pilot project, Contents of the 2nd JCC meeting
8	28 Jan 2020	Operation plan of the U-turn slots in the pilot project area
9	13 Feb 2020	Improvement plan of intersection in the pilot project area, Traffic signal control support tool, Program of the 1st training tour in Japan

10	27 Jan 2021	Explanation of outline of the project for new project team members. Clarification of items to be taken by BMA
11	17 Mar 2021	Explanation of micro simulation result in the pilot project area, Explanation of demonstration experiment of prob data utilization, Progress of items to be taken by BMA
12	14 Dec 2021	Monitoring of progress of the project activities, Contents of the 4th JCC meeting, ATC operation manual, Confirmation of intersection improvement plans in the pilot project area
13	5 Apr 2022	Progress of the pilot project, Explanation of traffic volume count using an image processing analysis technology, Explanation of the training tour in Japan, Contents of the 5th JCC meeting
14	5 Jul 2022	Theory of signalized intersection operation
15	30 Aug 2022	Progress of the pilot project, Procedure of road improvement for the pilot project, PR activities for the pilot project, Programs and schedule for the training tour in Japan
16	21 Dec 2022	Explanation of the survey result which was conducted in November 2022, Explanation and discussion on PR activities for the pilot project
17	20 Mar 2023	Report of the training tour in Japan, Explanation of ATC operation and maintenance manual, Discussion on priority area in the ATC expansion plan.
18	29 May 2023	Progress of the pilot project, Explanation of schedule of ATC operation training. Confirmation of program of the opening ceremony for the pilot project. Extension of the project period (extended to Feb, 2024)
19	20 Dec 2023	Report of result of the demonstration experiment of utilization of the prob data, Report of PR activities in the pilot project, Explanation of outline of the adaptive traffic signal project by BMA, Extension of the project period (extended to Feb, 2025)
20	21 May 2024	Report of implementation result of the pilot project. Explanation of outline of the draft short and midterm plans for expanding the ATC system in Bangkok Metropolitan Area.
21	17 Sep 2024	Report to the JCC members as unofficial JCC meeting. ・ Project progress and results of the pilot project ・ The draft short and midterm plans for expanding the ATC system in Bangkok Metropolitan Area ・ Celebration of retirement of Mr. Thaipat of DG of TTD

Meeting No.2

Meeting No.8

Meeting No.11

Meeting No.18

Meeting No.21

Source: JET

Figure 3.9.1 Photos of Project Team Meetings, 2019–2024

Chapter 4. Project Output 1: Establishment of the ATC System in the Pilot Project Area

4.1 Summary

An ATC system was introduced in the pilot project area, and its effectiveness in improving traffic flow was verified. An ATC system comprises several key components: vehicle detectors which monitor traffic flow within the target road network; signal control software, hosted on a server in the control center, which processes traffic flow data from the detectors and calculates optimal signal control parameters; traffic signals that operate based on commands from the control center; and a data communication system which connects all components, enabling bidirectional data exchange. Additionally, a monitoring system oversees the operation of these components, detects abnormalities, and records traffic conditions and system performance.

To successfully introduce an ATC system, a systems engineering approach is essential, requiring a comprehensive understanding of all the aforementioned system elements. The purpose of installing an ATC system in the pilot project was twofold: to gain practical experience with the process of deploying a small-scale ATC system and to evaluate its impact on traffic flow improvement.

Output 1 is composed of 10 activities and has two objectively verifiable indicators in the PDM.

Table 4.1.1 Objectively Verifiable Indicators for Output 1

1-1.	ATC signals are installed in 12 intersections.
1-2.	The ATC center system is established.

The pilot project area was selected through discussions with BMA and RTP immediately after the Project began and was agreed upon at the first JCC meeting. In the Project's first year, information collection, surveys, and designs were conducted to prepare for the introduction of the ATC system. In the second year, Genius Traffic System Co. Ltd. (hereinafter referred to as "Genius") won the bid to establish an ATC system, and a contract was signed between them and JICA Thailand Office in November 2020. The original contract period was until 10 January 2022; however, due to delays caused by the COVID-19 pandemic, it was extended to 15 December 2022, then further to 31 August 2023.

The installation of the control center and detectors by Genius, as well as the installation of traffic signals and fiber optic cables by BMA, were completed, and trial operation of the ATC system commenced on 1 March 2023. The operation evaluation was conducted using data collected from 1 March to 8 September 2023. The effectiveness of the ATC system was validated through data analysis, which demonstrated reduced queue lengths and shorter travel time for road users.

4.2 Activities

(1) Review and Analysis of the Current Traffic Control System

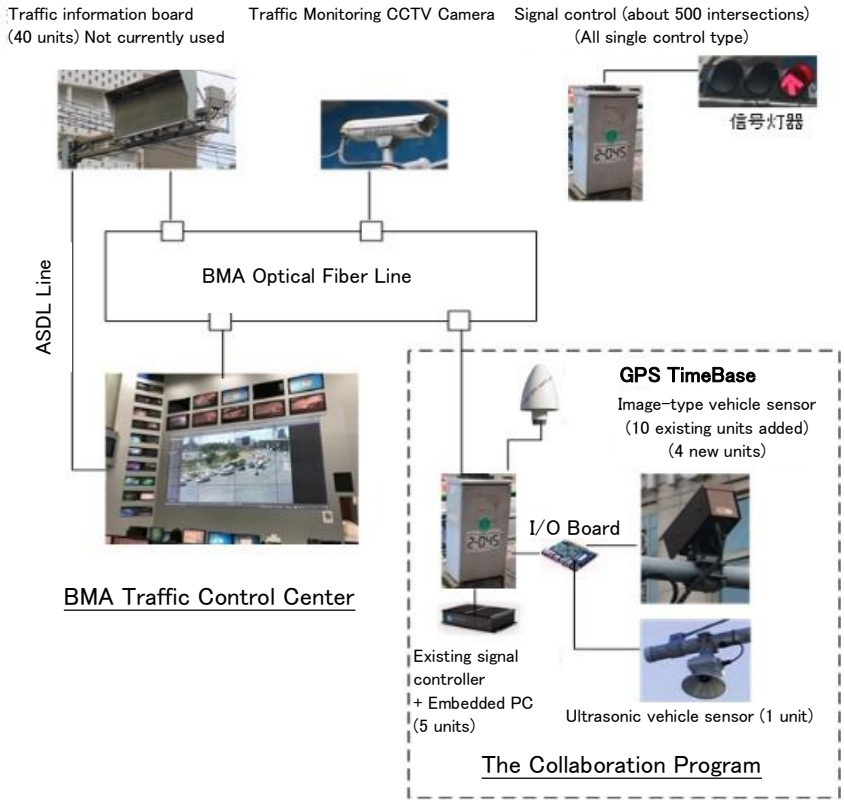
By May 2019, there were 738 traffic signals in operation in Bangkok Metropolitan Area, all operating on single control, except for six intersections which were systematized through the Collaboration Program funded by JICA: no ATC system was in place. Vehicle detectors to monitor traffic conditions were also not utilized. However, BMA had initially planned and begun implementing an ATC system in the 1990s, even preparing a control center within the BMA. However, the project was canceled midway, and the center is currently used as a traffic monitoring center using CCTV cameras. The traffic control system configuration at the Project start is shown in Figure 4.2.1.

The effectiveness of coordinated traffic signal control along a straight road section was confirmed in the Collaboration Program. Coordinated control can be achieved by adjusting the cycles and parameters of traffic signals at consecutive intersections. However, the ATC system goes further by optimizing these parameters at a central control center, which communicates with traffic signals to ensure optimal operation across a designated area. In the Project, an ATC system that had been planned but not previously implemented was developed and deployed. The Project also verified the feasibility and effectiveness of operating an ATC system in Bangkok, where roads experience heavy vehicle saturation during morning and evening peak hours.

(2) Selection of the Pilot Project Area

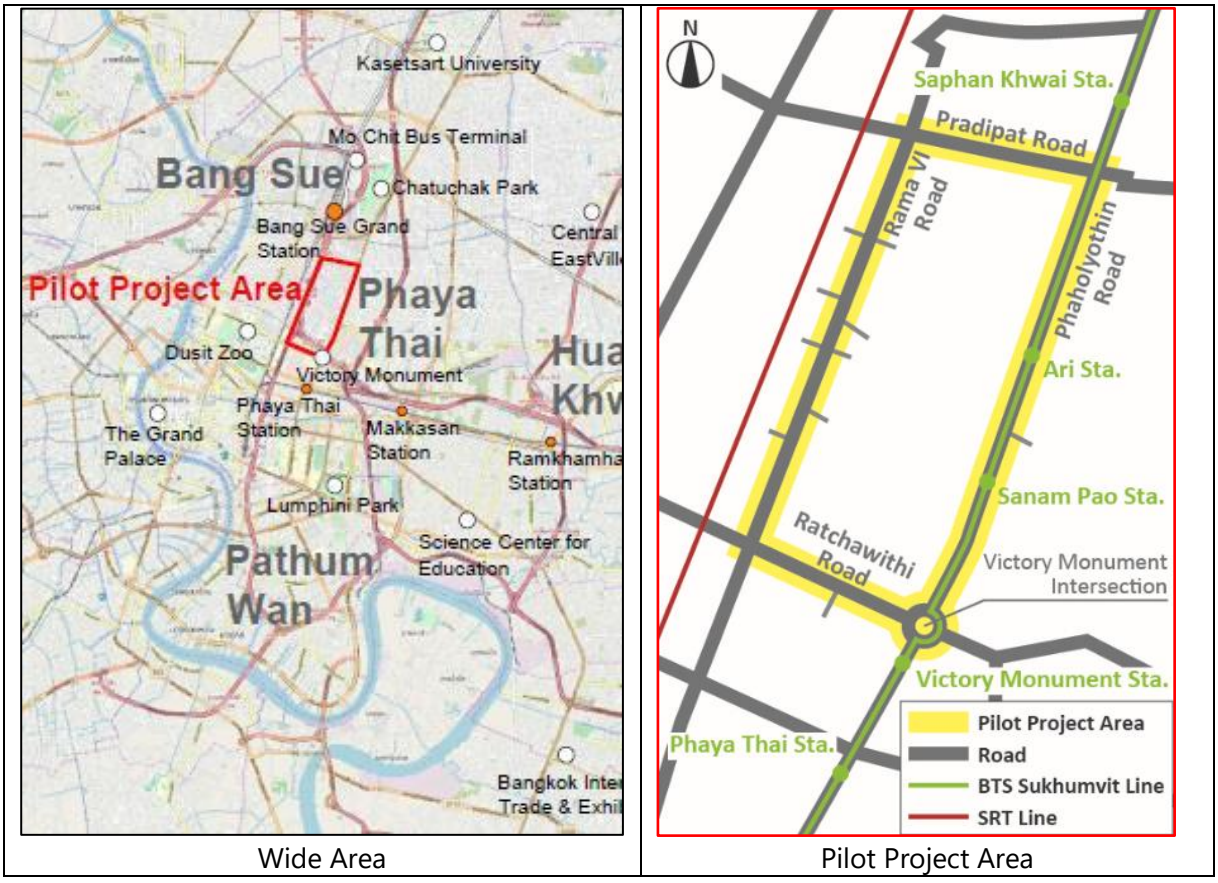
After discussions with BMA and RTP, the pilot project area was selected and approved at the first JCC meeting. The pilot project area is a road bounded by Rama VI Road, Ratchawithi Road, Phahonyothin Road, and Pradipat Road, with a circumference of approximately eight km, as shown in Figure 4.2.2.

Each road in the pilot project area typically has three lanes in each direction (ranging from two to four lanes depending on the section). There are 13 intersections with traffic signals in this area (counting Victory Monument as one intersection). Additionally, there are push-button pedestrian traffic lights at two intersections on Phahonyothin Road, one on Pradipat Road, and one on Ratchawithi Road. Of these 13 signalized intersections, traffic signals at six intersections on Rama VI Road were installed as part of the Collaboration Program which was implemented by JICA from 2015 to 2016.



Source: JET

Figure 4.2.1 Traffic Control System in BMA, 2019



Source: JET

Figure 4.2.2 Location Map of the Pilot Project Area

(3) Detailed Planning of Project Activities and Role Sharing in the Project Team

BMA and RTP are responsible for the installation and O&M of the ATC system, including the traffic signals. The division of roles among BMA, RTP, and JET was confirmed in the first JCC meeting, as shown in Table 4.2.1.

Table 4.2.1 Role Sharing in the Project

	Installation of system	Operation and maintenance	Manual operation	Planning
TTD-BMA (Installation and maintenance of ATC system)	**Main**	**Main** (Maintenance)	Sub	**Main**
Traffic Police Division of RTP (Operation of ATC system)	Sub	**Main** (Operation)	**Main**	Sub
JICA Expert Team (Technical support)	Survey, design, procurement, assist supervision, provision of trainings	Proposal of implementation structure, creation of manuals, provision of trainings, PR	Preparation of draft guidelines, study development of a support tool, provision of trainings	Provision of data, assist creation of plan

The Main organization implemented the roles, while the Sub organization supported Main by providing data and offering advice.
Source: JET

The specific roles of BMA and RTP in Project activities are explained in Table 4.2.2.

Table 4.2.2 Specific Roles of BMA and RTP in the Project

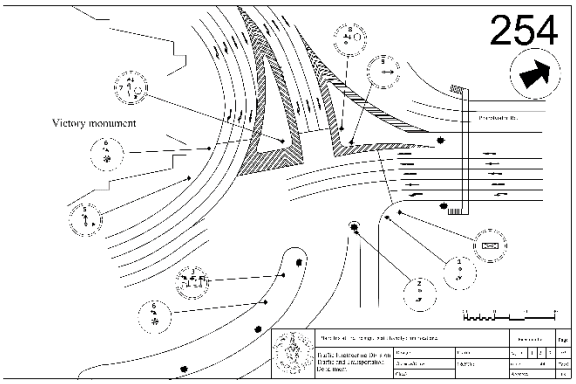
Aspect	TTD-BMA	Traffic Police Division of RTP
Installation of equipment	- Establishment of ATC center - Installation of traffic signals and vehicle detectors - Provision of communication network - Setting of traffic signal parameters	- Provision of information of traffic situation at target intersections - Advice on traffic signal operation
Operation and management	- Maintenance for traffic signals, vehicle detectors and communication network (inspection, repair)	- Promotion of understanding of signal control - Promotion of understanding of manual control
Traffic signal control	- Updating and adjustment of traffic signal parameters - Advice on manual operation to RTP	- Switching between automatic operation by ATC and manual operation by traffic police officers - Switching of signal phases and adjustment of display time for each phase during manual operation
Planning	- ATC system development planning	- Provision of information of traffic situation at target intersections

Source: JET

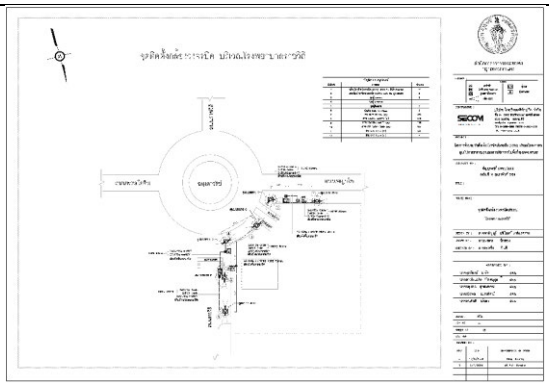
(4) Collection and Study of Information Needed for installation of Equipment for the ATC System

Necessary information and data, such as drawings of the pilot project area, were collected to confirm intersection geometry, road markings, road signs, signal device layouts, wiring

network, signal phases, and other relevant details[9]. Examples of the collected intersection drawings are shown in Figure 4.2.3.



Traffic Light Devices at Northern Part of Victory Monument Roundabout



Wiring Rout at Victory Monument Roundabout

Source: BMA

Figure 4.2.3 Drawings for Victory Monument Roundabout

As of May 2019, both BMA and RTP have traffic control centers with distinct roles. BMA's traffic control center monitors for security purposes using CCTV. Bangkok is divided into six areas, each with relay stations which send CCTV images to the traffic control center. RTP's traffic control center receives CCTV images from BMA's traffic control center, monitors traffic conditions, reports them to police stations, and provides advice on traffic operations.

As part of the Project, a dedicated control center for the ATC system was established within the Traffic and Transportation Department (TTD) of BMA, separate from the existing BMA and RTP traffic control centers. BMA plans to integrate the current traffic control center with the newly established ATC system control center in BMA building 2 in the future, creating a unified traffic control center. However, it has not yet been established as of December 2024.

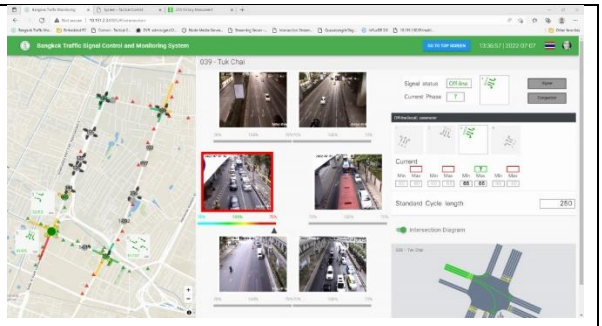
Traffic Control Center in BMA

Traffic Control Center in RTP

Source: JET

Figure 4.2.4 Photos of the Traffic Control Centers

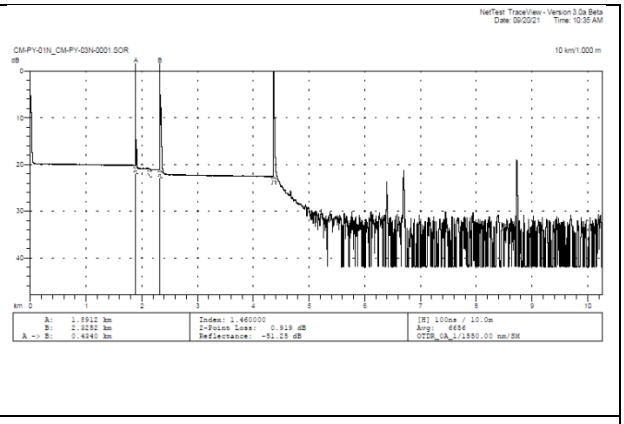
[9] Traffic Engineering Glossary (http://glossary.jste.or.jp/信号現示/): A group of multiple traffic flows passing through a signalized intersection that are given the right of way at the same time, or the time duration when they are given that right of way. Sometimes simply referred to as the signal phase.

	
Traffic Control Center for ATC System	An interface showing Traffic Light Operation and Traffic Situation

Source: JET

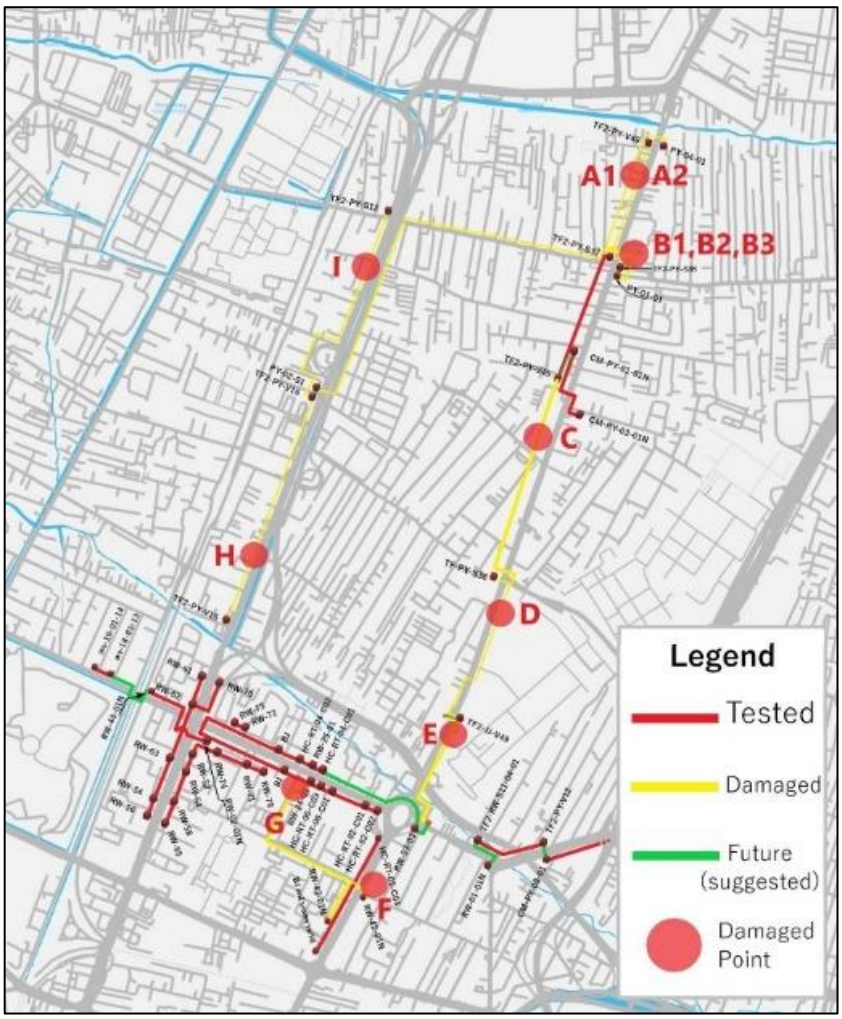
Figure 4.2.5 Traffic Control Center for the Pilot Project

BMA's fiber optic cable was used as the communication network for the pilot project. Therefore, BMA and JET surveyed the location and installation status of the splicing boxes used for branching and connecting the fiber optic cable. Additionally, during the project period, maintenance of the fiber optic cable in the pilot project area was managed by Multi, a company contracted by BMA. Multi assessed the condition of the cable using an OTDR (optical time-domain reflectometer). The Project Team observed Multi's measurement work and reviewed their assessment reports to verify the findings. Damage to the fiber optic cable was found at 12 locations, all due to missing cable segments. The repair work on the fiber optic cable was completed by the end of March 2023.

	
Measurement using OTDR	Results of OTDR Test

Source: JET

Figure 4.2.6 Situation of OTDR Test



Source: BMA and JET

Figure 4.2.7 Locations of Damaged Fiber Optic Cables

Point A: Handholes in locations with damaged cables have been filled in as part of sidewalk improvement.	Point F: Damage to the cables might have been caused by sidewalk improvement work.

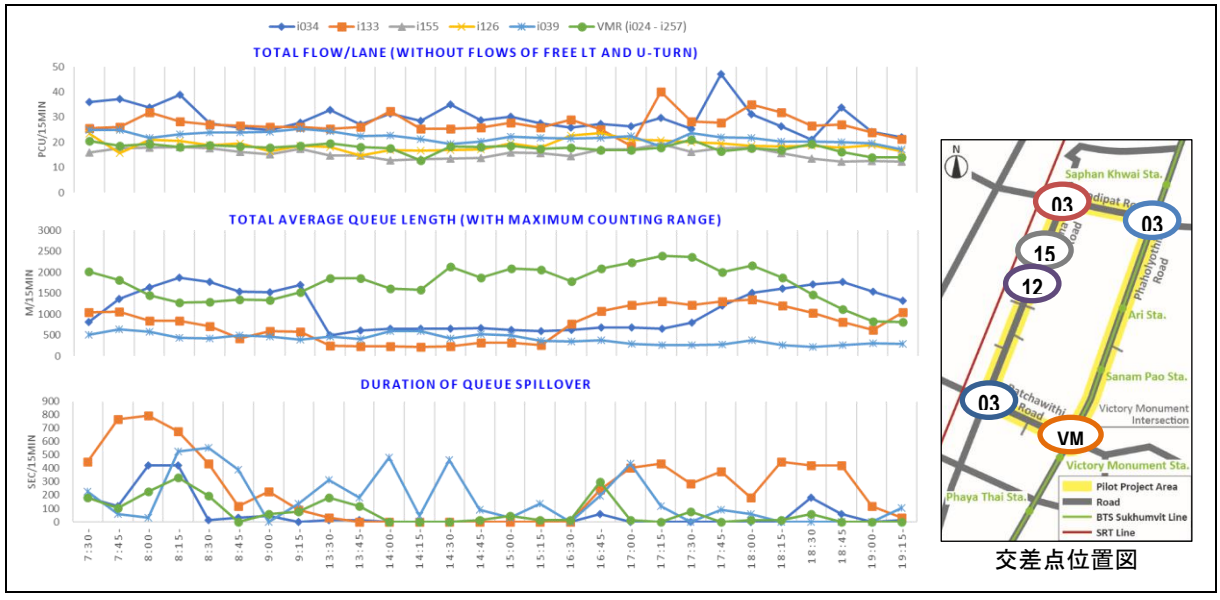
Point H: Cables may have also been damaged through contact with trees.	Point I: Handholes in locations with damaged cables have been filled in as part of sidewalk improvement.

Source: JET

Figure 4.2.8 Photos of Locations with Damaged Cables

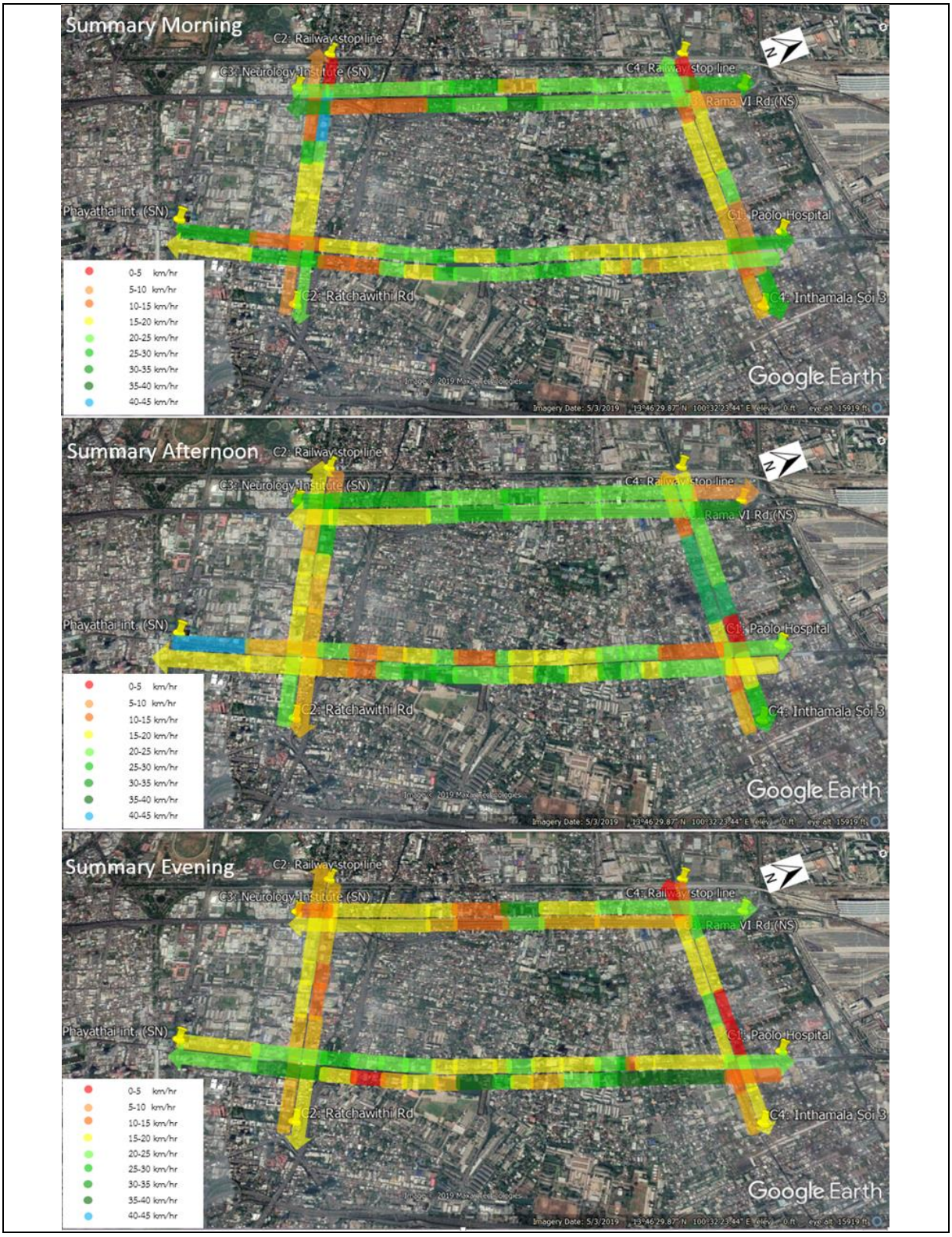
(5) Study of Traffic Volume, Queue Length, Signal Control, Traffic Safety and Other Related, and Estimation of the Amount of Air Pollutant in Pilot Project Area

A traffic survey was conducted to set signal parameters for signalized intersections in the pilot project area and established indicators for verifying the pilot project's effectiveness. The survey items included directional traffic volume count, queue lengths, travel speeds, and cycle lengths controlled by the traffic police. The survey was conducted on Tuesday, 9 July 2019, for three time periods: 7:30 AM to 9:30 AM (morning peak hour), 1:30 PM to 3:30 PM (off-peak hour), and 4:30 PM to 7:30 PM (evening peak hour). Some parts of the traffic survey results are shown in Figure 4.2.9 and Figure 4.2.10. The survey revealed that traffic congestion occurs not only during peak hours but also during off-peak hours at Victory Monument Roundabout.



Source: JET

Figure 4.2.9 Traffic Volumes, Queue Lengths, and Spillover in the Pilot Project Area, 9 Jul 2019



Source: JET

Figure 4.2.10 Travel Speeds in the Pilot Project Area, 9 July 2019

A microsimulation model was developed to predict and verify the effects of the pilot project. Models were created for four scenarios: i) current situation, ii) with signal phase improvement, iii) with road and signal phase improvement, and iv) with road improvement, signal cycle length adjustment based on traffic volume. Air pollutant emissions were

calculated for each case. For signal phase improvements, appropriate cycles and phases were established for each time period based on the directional traffic volume at each intersection. Additionally, road improvement, such as the installation of right-turn lanes and the provision of adequate waiting spaces, were implemented in alignment with the adjusted cycles and phases. Table 4.2.3 shows the estimated results of air pollutant emissions. It was confirmed that emissions decreased with improvement compared to the current situation.

Table 4.2.3 Estimated Air Pollutant Emissions by Scenario

Time	Air Pollutant	I) Current Situation	Ii) Signal Phase Improvement	iii) Road and Signal Phase Improvement	iv) Road Improvement with Signal Cycle Length Adjustment based on Traffic Volume
Morning Peak 7:30–9:30	F (gallons/PCU)	0.09	0.08	0.08	0.08
	CO (g/PCU)	6.17	5.67	5.76	5.80
	NOx (g/PCU)	1.20	1.10	1.12	1.13
	VOC (g/PCU)	1.43	1.32	1.34	1.34
	CO_2 (g/PCU)	784.01	721.47	732.37	737.20
Off Peak 13:30–15:30	F (gallons/PCU)	0.08	0.08	0.08	0.08
	CO (g/PCU)	5.85	5.59	5.93	5.66
	NOx (g/PCU)	1.14	1.09	1.15	1.10
	VOC (g/PCU)	1.36	1.30	1.37	1.31
	CO_2 (g/PCU)	743.58	710.71	753.42	720.01
Evening Peak 16:30–19:30	F (gallons/PCU)	0.09	0.08	0.08	0.08
	CO (g/PCU)	6.24	5.63	5.47	5.69
	NOx (g/PCU)	1.21	1.10	1.06	1.11
	VOC (g/PCU)	1.45	1.31	1.27	1.32
	CO_2 (g/PCU)	793.33	716.27	695.10	722.95

Note: Emission volume is calculated based on guidelines of US Federal Highway Administration.

In signal control, multiple phase patterns can be configured to manage complex traffic flows. An example is illustrated in Figure 4.2.11. I In Phase A, the green signal is first activated for all directions on both approach roads from the left and right sides, followed by a green signal exclusively for right turns on both approach roads from the left and right sides. In Phase B, the green signal is first activated for all directions on the approach road from the left side, followed by a green signal for all directions on the approach road from the right side. Determining whether phase A or phase B is safer and more efficient depends on various factors, including the traffic volume of through and right-turning vehicles, designated lane directions, driver behavior, pedestrian activity, and changes in these factors over time.

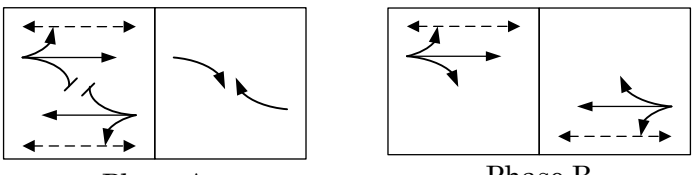


Figure 4.2.11 Signal Phases

As traffic volumes increase and intersections become more saturated, the signal cycle must

be lengthened to minimize time lost during phase changes. Conversely, excessively short signal cycles can result in wasted time and reduced signal control efficiency. However, overly long signal cycles can increase waiting times at intersections and create longer vehicle queues. Therefore, it is essential to adjust signal cycles to match the traffic conditions at each intersection to optimize safety and efficiency.

Using the above microsimulation model, training was provided to BMA and RTP staff at the 11th Project Team meeting. The session tackled the fundamental concepts of intersection and traffic signal control, fixed-period signals, sensory signal control and coordinated signal systems, ITS (vehicle detectors and dynamic traffic control), pilot project simulation results, and optimization simulation for single and coordinated signals. Additionally, a seminar was held on 18 November 2021 for BMA and RTP staff to deepen their understanding microsimulation models.

Source: JET

Figure 4.2.12 Photos of the 18 Nov 2021 Seminar on Microsimulation

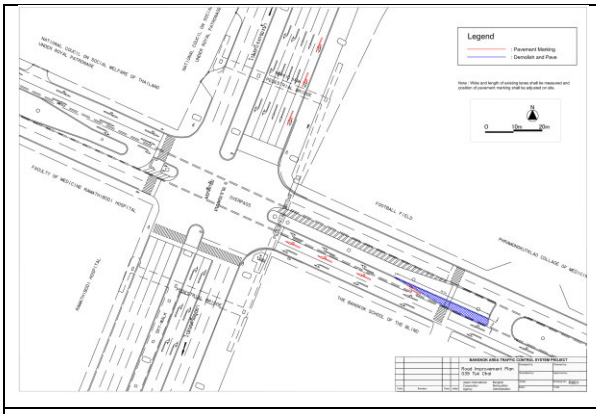
Additionally, due to the impact of COVID-19, traffic flow in the pilot project area had changed. To adjust signal parameters accordingly, a traffic volume count survey was conducted again on a Tuesday, 15 November 2022, at the four major intersections in the pilot project area. Compared to the 2019 survey, there were no significant changes in vehicle composition; however, traffic volume had decreased by approximately 5 to 30%. Using these survey results, the signal parameters were reconfigured and submitted to Genius in December 2022.

(6) Improvement of the Intersections in the Pilot Project Area

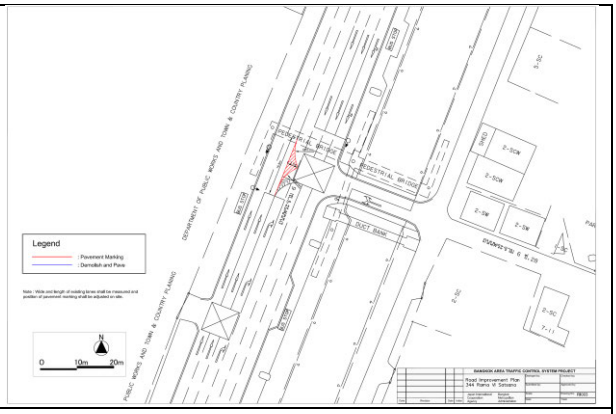
Following a review of current road drawings, a field survey was conducted to identify issues within the pilot project area, including each intersection. Key issues included the absence of scaled design drawings, mismatches between road markings and traffic flow at intersections, insufficient lengths of right-turn lanes, and congestion at U-turn slots on Phahonyothin Road.

Drawings on road markings for the intersections in the pilot project area were developed in collaboration with BMA. An example of these drawings is shown in Figure 4.2.13.

Additionally, an analysis of the U-turn slot operation on Phahonyothin Road, based on the traffic survey results, led to discussions and comparisons of multiple operations. As a result, it was decided that RTP should manage the U-turn slots based on the situation, following Case 2 as shown in Figure 4.2.14.



No.39 Tuk Chai Intersection



No.344 RamaVI Satsana Intersection

Source: BMA and JET

Figure 4.2.13 Drawings of Road Markings at Intersections

Source: JET

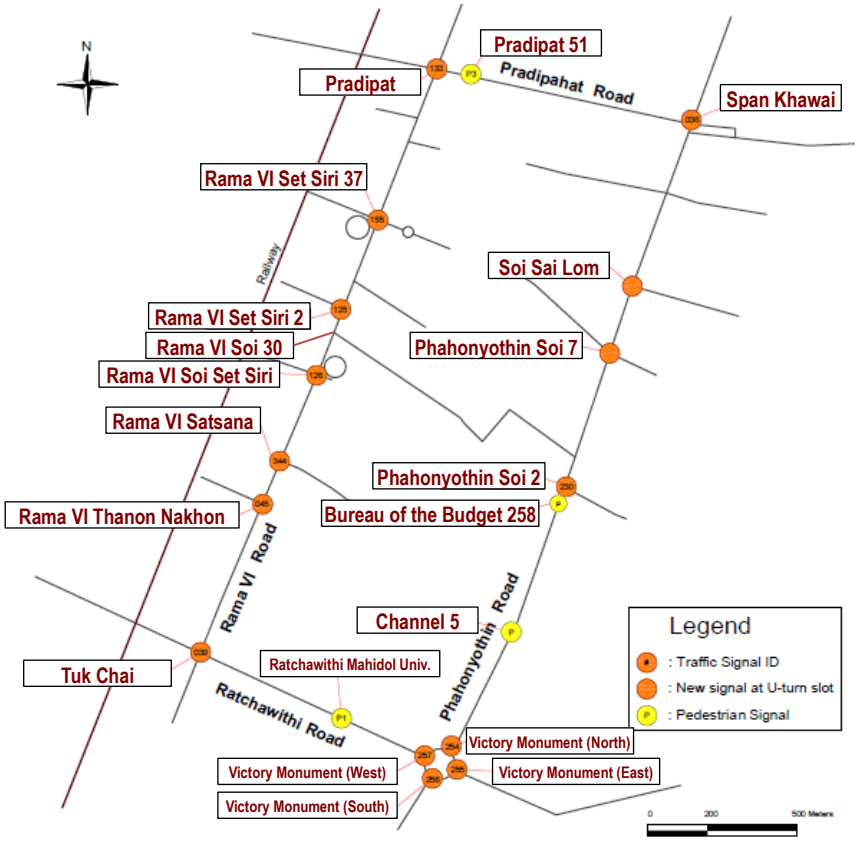
Figure 4.2.14 Operation Plan for U-turn Slots on Paholyothin Road

For the pilot project, JICA covered the cost of introducing the ATC system, while BMA funded the installation of traffic signals, improvement of intersections, and establishment of a communication network. The items covered by BMA are listed in Table 4.2.4.

Table 4.2.4 Pilot Project Expenses by BMA

Category	Item		Description
Traffic signal	Shown in Table 4.2.5		
Intersection	Rama VI Road	Tuk Chai Intersection	Road markings
		Thanon Nakhon Chaisi Intersection	Road markings
		Satsana Intersection	Road markings
		Soi Set Siri Intersection	Road markings
		Soi 30 Intersection	Road markings
		Set Siri 2 Intersection	Road markings
		Soi 37 Intersection	Road markings
		Pradipat Intersection	Road markings
	Phahonyothin Road	Span Khawai Intersection	Road markings
		Soi Sai Lom Intersection	Road markings
			Traffic lights
			Traffic sign (no straight thru, no right turn)
		Soi 7 Intersection	Road markings
			Traffic sign (no right turn)
			Prohibition of on-street vendors
		Soi 2 Intersection	Road markings
			Traffic sign (no U-turn)
Communication network	Entire pilot project area		Improvement of fiber optic cable

Source: JET



Source: JET

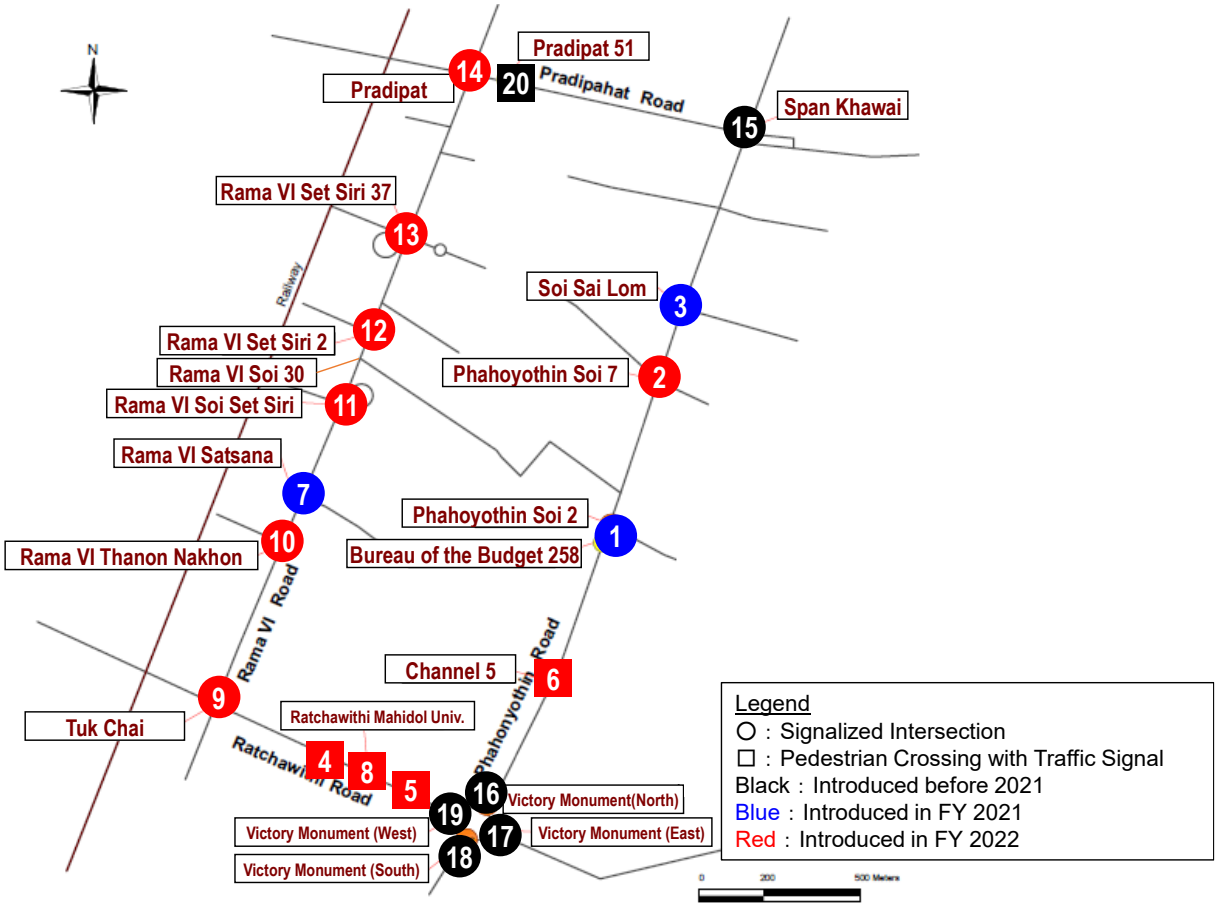
Figure 4.2.15 Location Map of Intersections in the Pilot Project Area

Although an agreement was initially reached with BMA on the items they would cover, budget allocations were adjusted due to the impact of the COVID-19 pandemic. Traffic signals at three intersections were installed using the FY2021 supplementary budget, while the remaining traffic signals were installed with the FY2022 supplementary budget by the end of March 2023. The budget breakdown for the items covered by BMA is shown in Table 4.2.5 and Figure 4.2.16. At the beginning of the project, BMA indicated that fiber optic cables were already installed in the pilot project area, eliminating the need for new installations. However, after the project commenced, it was discovered that the existing fiber optic cables had issues and could not be utilized for this project. As a result, BMA installed additional fiber optic cables in the defective sections. However, details regarding the installed sections, cable types, and core allocation including the budget were not disclosed.

Table 4.2.5 Budget Breakdown for Items covered by BMA

#	Item	Location	Amount (THB)
①	Installation of one set of intersection traffic light system	Phahonyothin Soi2	2,093,100
③	Installation of one set of intersection traffic light system	Phahonyothin Soi 8	1,799,390
⑦	Signal control device replacement	Satsana intersection (344)	369,200
Sub-total			4,261,690
Total Budget Used in FY2021			**3,861,000**
②	Installation of one set of intersection traffic light system	Phahonyothin Soi 7	2,520,036
④	Installation of pedestrian traffic lights	Phramongkutklao Hospital	2,100,366
⑤	Installation of pedestrian traffic lights	National Institute of Children	2,026,886
⑥	Replacement of pedestrian traffic lights	Channel 5	861,406
⑧	Removal of pedestrian traffic lights	Mahidol University	4,800
⑨	Installation of pedestrian traffic lights	Tuk Chai Intersection	176,850
⑩	Installation of pedestrian traffic lights	Rong Krong Nam Int. (045)	109,025
⑪	Installation of pedestrian traffic lights	Wichaiyut int. (126)	89,240
⑫	Installation of pedestrian traffic lights	Ari Samphan Int. (125)	127,545
⑬	Installation of pedestrian traffic lights	Piboon Wattana Int. (155)	203,365
⑭	Installation of pedestrian traffic lights	Pradipat Int. (133)	265,080
Sub-total			**8,484,599**
Others	Fance on sidewalk, Slope for chair wheel	Pilot project area	**4,216,401**
Total Budget Used in FY2022			**12,701,000**

Source: BMA and JET

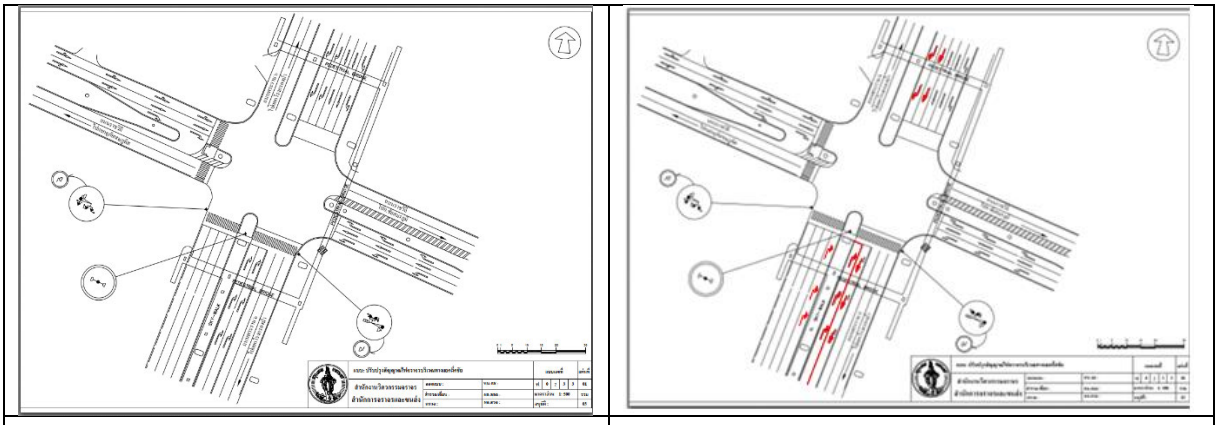


Source: BMA and JET

Figure 4.2.16 Location of Items Purchased using BMA Budget

Based on the results of the traffic survey conducted on 15 November 2022, signal parameters were reconfigured, and lane allocations for intersection approaches were set in December 2022. However, during a site observation in January 2023, JET found that the lane allocations for the north and south approaches to Tuk Chai intersection had changed by RTP. JET assessed the intersection's demand rate and the result revealed that the revised lane allocation would improve traffic flow.

To operate the ATC system with the new lane allocation, it was necessary to relocate or add sensors and traffic signals already installed. A document explaining the impact of the lane change was prepared, and discussions with BMA were held to decide whether to retain the previous or implement the new allocation. Ultimately, it was decided to proceed with the new lane allocation to enhance traffic flow.



Previous Lane Allocation	Updated Lane Allocation

Source: BMA and JET

Figure 4.2.17 Lane Allocation on South Approach to Tuk Chai Intersection

Table 4.2.6 Traffic Signal Cycle and Demand Ratio at Tuk Chai Intersection

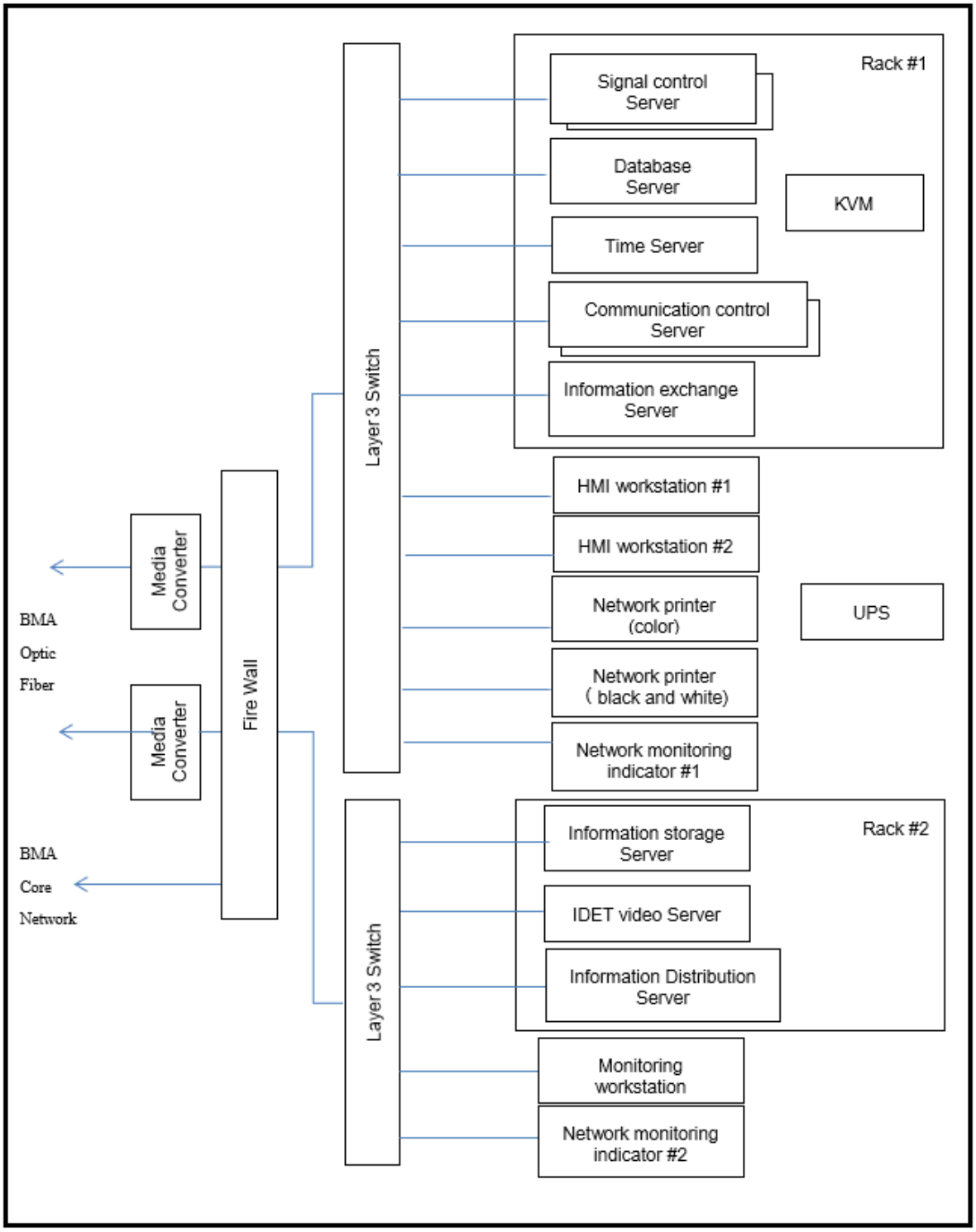
Time		Demand Ratio		Signal Cycle (second)	
		Previous	Updated	Previous	Updated
AM	7:00–8:00	0.93[1)]	0.78	240 [2)]	132
PM	17:00–18:00	0.49	0.56	57	66

1) Traffic queue occurred when the ratio exceeded 0.9.
2) Cycle time exceeded 240 seconds which was the upper limit in the analysis program.

Source: JET

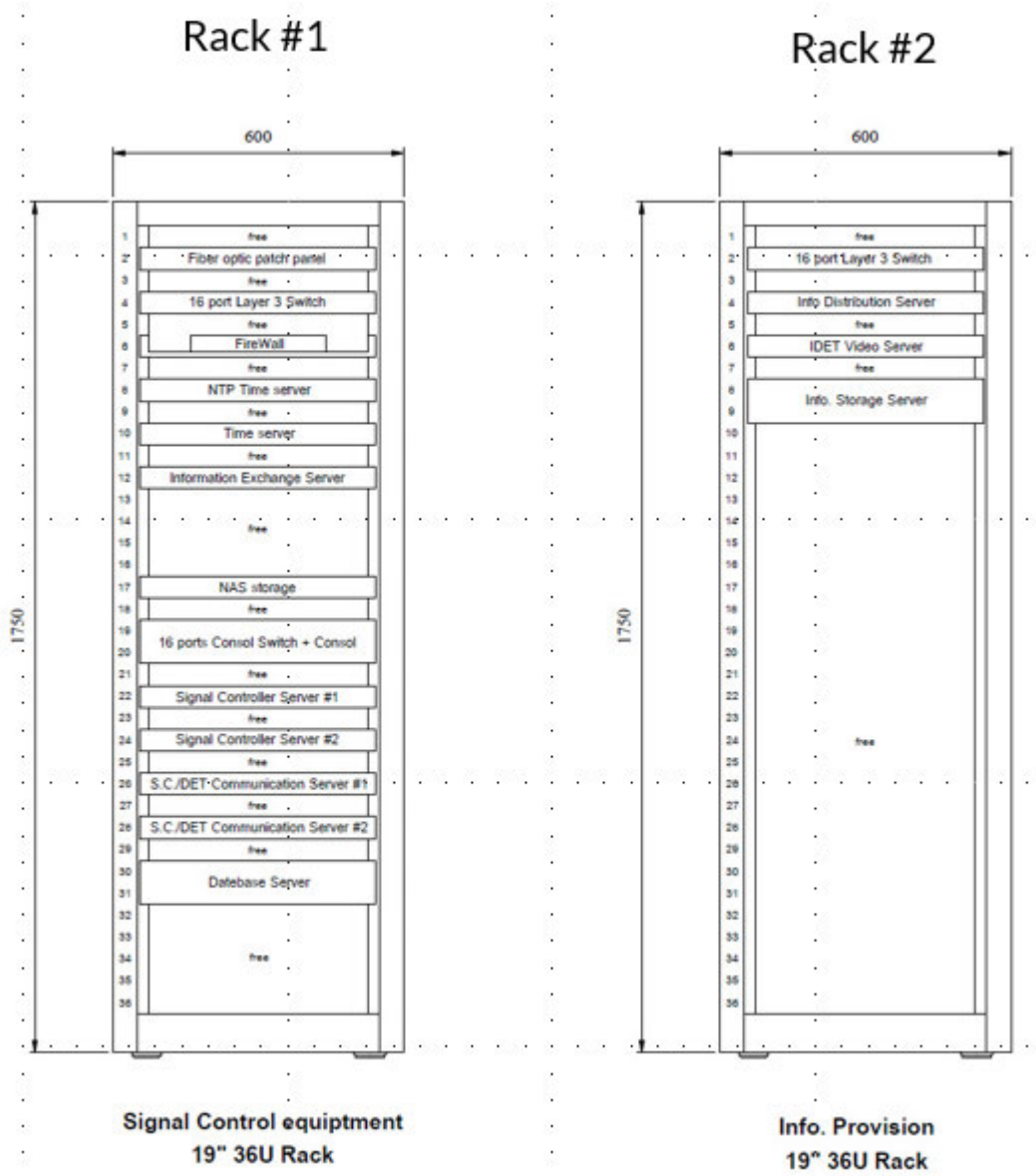
(7) Installation of ATCS Equipment in the Pilot Project Area and at the Traffic Control Center

The ATC system equipment, communication network, and control center interior were designed for the ATC system's introduction in the pilot project. The configuration diagram of the ATC system implemented in the pilot project is shown in the next figure.



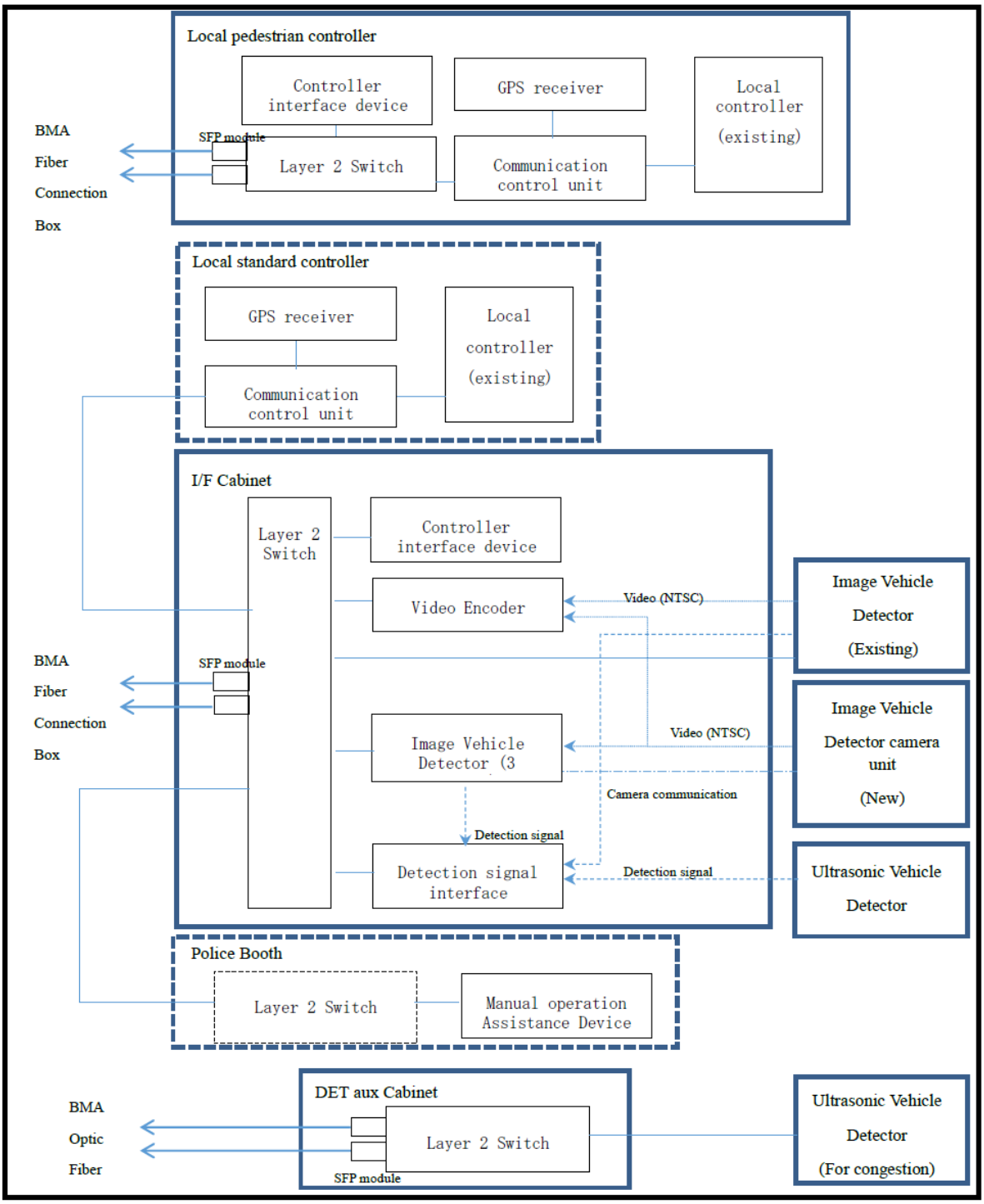
Source: Genius and Sumitomo

Figure 4.2.18 Configuration Diagram of the Traffic Control Center for the Pilot Project



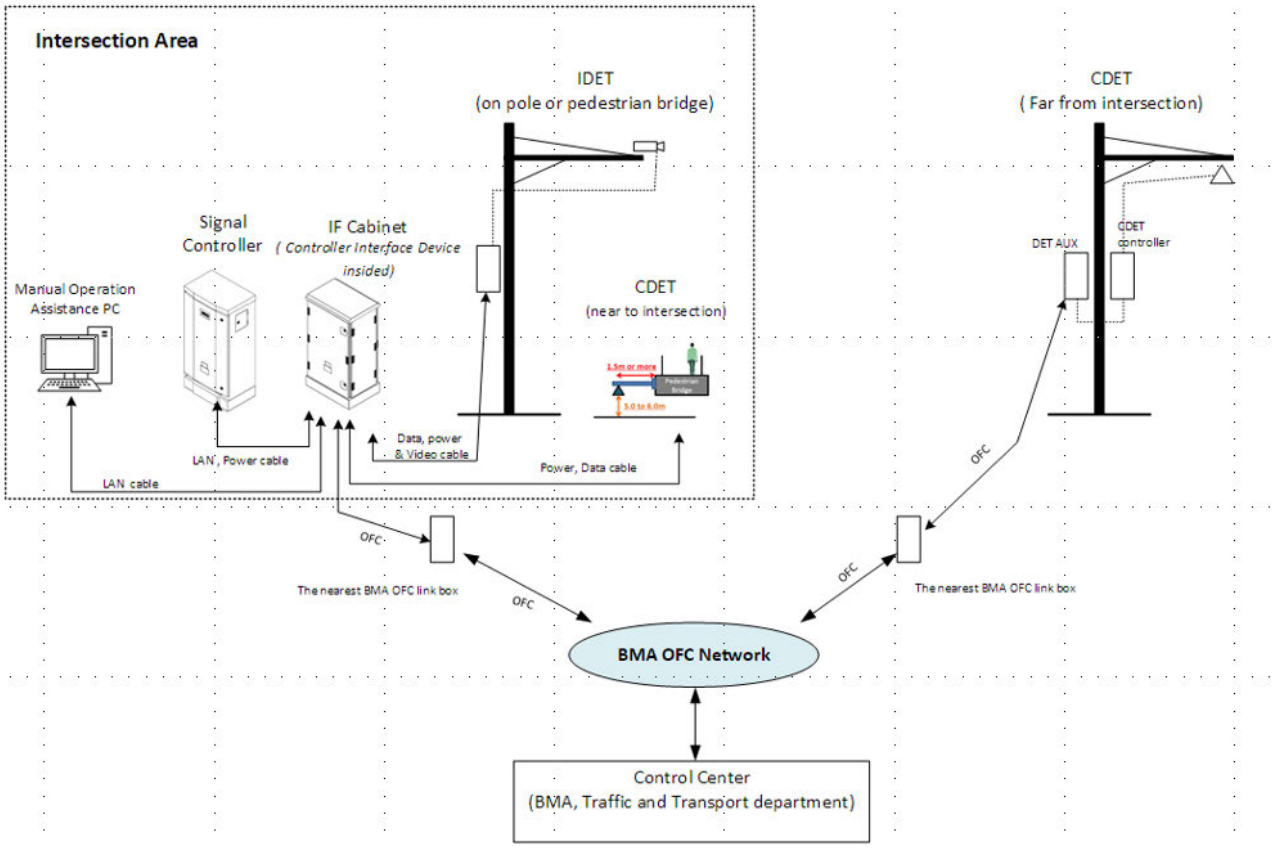
Source: Genius and Sumitomo

Figure 4.2.19 Layout of Center System Rack



Source: Genius and Sumitomo

Figure 4.2.20 Standard Configuration of Signal Control System for the Pilot Project



Source: Genius and Sumitomo

Figure 4.2.21 Standard Configuration of Devices for the Pilot Project

Source: JET

Figure 4.2.22 Location Map of Devices and Detectors in the Pilot Project Area

To introduce the ATC system as designed, JICA Thailand Office conducted a tender process to select a contractor. The tender schedule is shown in Table 4.2.7. Although the tender was delayed by about four months due to the COVID-19 pandemic, contract negotiations were completed, and an agreement was signed between JICA Thailand Office and Genius on 7 November 2020. Under the agreement, Genius was tasked with procuring the hardware for the ATC system. Meanwhile, Sumitomo Electric Industries, Ltd. (hereinafter referred to as "Sumitomo") was responsible for providing the software for the traffic control center, setting up the database, building the system, and designing and manufacturing the Controller Interface Device (CID) under a subcontract with Genius. CID serves as the interface between the existing signal control devices and the center system.

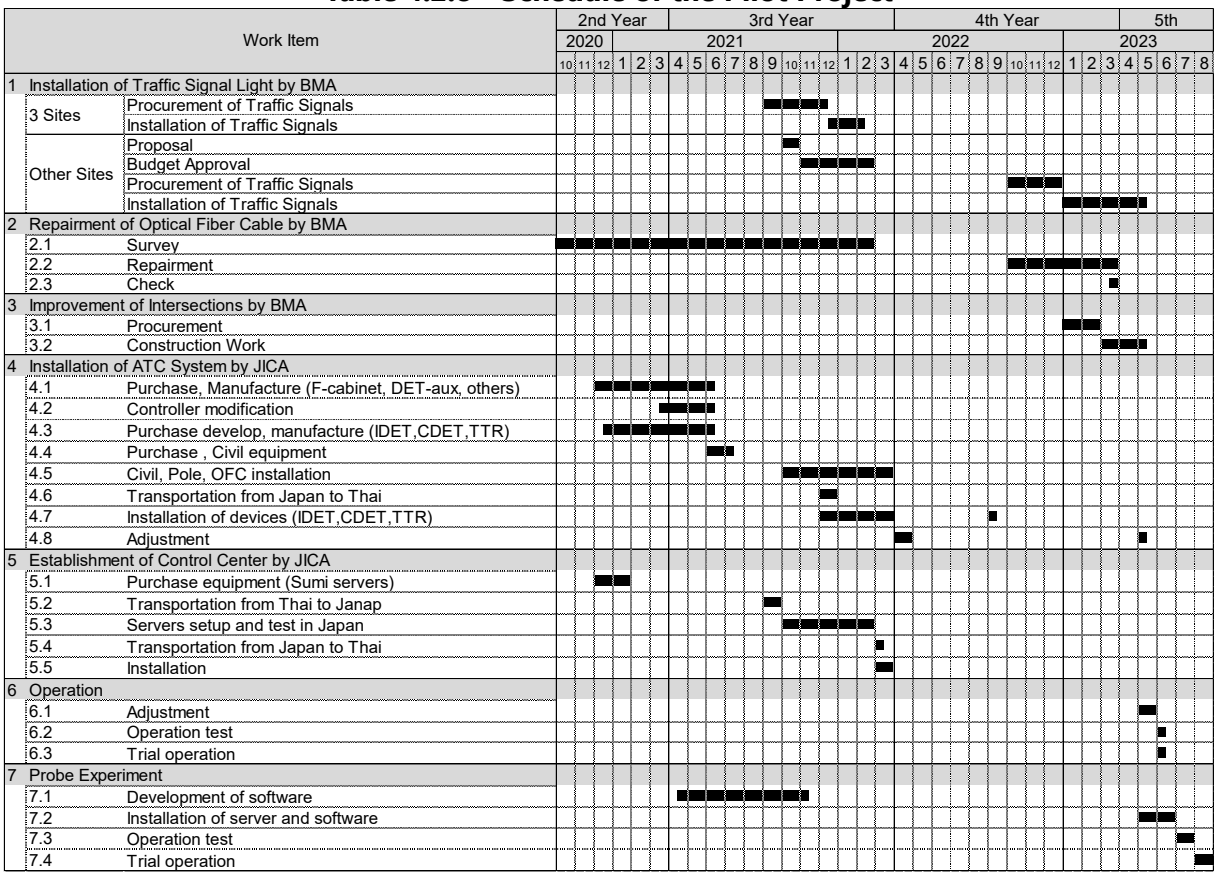
Table 4.2.7 Tender Schedule for the ATCS Contractor

Step	Schedule
Distribution of tender documents	18–29 May 2020
Submission of Expression of Interest	18–29 May 2020
Deadline for response to pre-qualification	18–29 May 2020
Questions regarding tender documents	Until 16 Jun 2020
Responses to questions	Until 26 Jun 2020
Submission of technical proposals	Until 10 Jul 2020
Evaluation of technical proposals	Until 22 Jul 2020
Tendering and screening	4 Aug 2020

Source: JET

Due to the impact of COVID-19, BMA was unable to secure the budget for its responsibilities, including the installation of traffic signals and repair and maintenance of fiber optic cables, as originally scheduled. This resulted in delays in the installation of equipment and materials. Consequently, the contract period with Genius was extended from 10 January 2021 to 15 December 2022 and, later, to 31 August 2023. The implementation schedule for the ATC system is shown in Table 4.2.8.

Table 4.2.8 Schedule of the Pilot Project



Source: JET

The lists of the equipment for the pilot project are shown below.

Table 4.2.9 Equipment for the Traffic Control Center

No	Equipment	Device	Qty/Unit
1	Signal control server		2
2	Database server		1
3	Communication control Sever		2
4	Information exchange server		1
5	Information storage server		1
6	Information distribution server		1
7	IDET video server		1
8	Time server		1
9	HMI workstation	PC	2
		Monitor	4
10	Monitoring workstation	PC	3
		Monitor	6
11	KVM console kit and KVM switch	KVM console	1
		KVM switch	1
12	Network monitoring indicator	Warning lamp	2
13	Network Printer	Color laser printer	1
		Black / White laser printer	1
14	UPS		1
15	Communication equipment	L3SW for Traffic Control Center	2
		L2SW for BMA/RTP office	2
		Media converter	2
		SFP module for BMA/RTP office	2
		Fire Wall for Traffic Control Center	1

Source: Genius and Sumitomo

Table 4.2.10 Devices for the ATC System by Site

No	Equipment	No	Intersection / Device	Sapan Khwai 038	Tuk Chai 039	Pradi pat 133	V.M. (East) 255	V.M. (North) 254	V.M. (South) 256	V.M. (West) 257	Phahol Yothin Soi 2 230	Rama6 (Existing) 155/126 045/125	Rama6 (Replace) 344	Phahol Yothing additionl 2 cont	total
				Qty.	Qty.	Qty.	Qty.	Qty.	Qty.	Qty.	Qty.	Qty.	Qty.	Qty.	
1	Signal Controller (Standard type)	1-1	Communication control unit(Embedded PC)	1	1	1	1	0	0	0	1	0	0	0	5
		1-2	GPS receiver	1	1	1	1	0	0	0	1	4	0	0	9
		1-3	Power Supply 12Vdc	1	1	1	1	0	0	0	1	0	0	0	5
2	Signal Controller (Fedestrian Type)					1-043		1-092		1-019	1-015				
		2-1	Communication control unit(Embedded PC)	0	0	1	0	0	0	1	1	0	0	0	3
		2-2	GPS receiver	0	0	1	0	0	0	1	1	0	0	0	3
		2-3	Layer 2 switch	0	0	1	0	1	0	1	1	0	0	0	4
		2-4	SFP module	0	0	2	0	2	0	2	2	0	0	0	8
		2-5	Controller interface device	0	0	1	0	1	0	1	1	0	0	0	4
		2-6	Power Supply 24Vdc (for L2-SW)	0	0	1	0	1	0	1	1	0	0	0	4
		2-7	Power Supply 12Vdc (for TTR , Embedded PC, GPS)	0	0	1	0	0	0	1	1	0	0	0	3
		2-8	Cabinet (Replacement)	0	0	1	0	0	0	1	1	0	0	0	3
3	IDET (New)	3-1	IDET camera (New) *IDET controller is installed in I/F cabinet (#8-7)	0	4	0	0	1	1	0	1	0	0	0	7
4	CDET (For Count/Gap)	4-1	CDET (for count/gap, 1 head)	0	0	0	0	0	0	1	0	0	0	0	1
		4-2	CDET (for count/gap, 2 head)	0	0	0	2	0	0	1	0	0	0	0	3
5	CDET (For congestion, far from int.)	5-1	CDET (for congestion, 1 head)	12	9	0	3	3	3	3	0	0	0	0	33
6	Detector aux cabinet	6-1	Cabinet	12	9	0	3	3	3	3	0	0	0	0	33
		6-2	Layer 2 switch	12	9	0	3	3	3	3	0	0	0	0	33
		6-3	SFP module	24	18	0	6	6	6	6	0	0	0	0	66
		6-4	Power Supply 24Vdc	12	9	0	3	3	3	3	0	0	0	0	33
		6-5	Overvoltage Protection	5	0	0	0	2	0	0	0	0	1	1	9
7	I/F Cabinet	7-1	Cabinet	1	1	1	1	1	1	1	1	0	0	0	8
		7-2	Layer 2 switch w/ 2 Optic ports	1	1	1	1	0	0	0	1	0	0	2	7
		7-3	SFP module	2	2	2	2	0	0	0	2	0	0	4	14
		7-4	Controller interface device	1	1	1	1	0	0	1	1	0	1	2	9
		7-5	Detection Signal Interface (IO2LAN)	2	3	2	1	1	1	1	2	0	1	0	14
		7-6	Built-in Image Video Detector	0	4	0	0	1	1	0	1	0	0	0	7
		7-7	Video Encoder (DVR)	1	1	1	1	1	1	1	1	0	0	0	8
		7-8	Power Supply 5Vdc	0	1	0	0	1	1	0	1	0	0	0	4
		7-9	Power Supply 12Vdc	1	1	1	1	1	1	1	1	0	0	0	8
		7-10	Power Supply 24Vdc	1	1	1	1	1	1	1	1	0	0		10
8	Manual Operation Assistance Device (For Police Booth)	8-1	PC	1	1	0	1	0	0	0	0	0	0	0	3
		8-2	Monitor	1	1	0	1	0	0	0	0	0	0	0	3

Source: Genius and Sumitomo

Regular meetings were held among TTD-BMA, Genius, Sumitomo, JICA Thailand Office, and JET to monitor project progress. An outline of these regular meetings is shown in Table 4.2.11.

Table 4.2.11 Regular Meetings on the Pilot Project, 2021–2023

No.	Date		Major Agenda
1	2021	5 Apr	・ Overall project schedule ・ Progress of items to be taken by BMA
2		19 Apr	・ Progress of ATC system development ・ Progress and budget for the items to be taken by BMA ・ Parameter setting of pedestrian signals
3		26 Apr	・ Progress of ATC system development ・ Progress and budget schedule for the items to be taken by BMA ・ Parameter setting of pedestrian signals
4		11 May	・ Procurement progress of equipment by Genius ・ Coordination between BMA and BTS ・ Progress of repairmen of fiber optical cables ・ Installation of pedestrian signals and its parameter
5		18 May	・ Coordination within BMA for installation of equipment ・ Progress of repairmen of fiber optical cables ・ Parameter setting of traffic signa parameters ・ Schedule for the demonstration experiment of utilization of prob data
6		24 May	・ Coordination with BTS for installation of the equipment ・ Progress of repairmen of fiber optical cables ・ Parameter setting of traffic signa parameters ・ IP address of BMA for the pilot project
7		1 Jun	・ Manufacturing and procurement of equipment by Genius ・ Result of the factory test ・ Progress of coordination with BTS and Police for installation of equipment ・ Progress of repairmen of fiber optical cables ・ Installation of pedestrian signals and its parameter

No.	Date		Major Agenda
8	2021	8 Jun	・ Progress of procedures to secure power for the equipment ・ Progress of repairment of fiber optical cables ・ Location of controller
9		15 Jun	・ Progress of procedures to secure power for installed equipment ・ Progress of repayment of fiber optical cables ・ Necessary number of cores in fiber optical cables
10		23 Jun	・ Progress of procedures to secure power for installed equipment ・ Progress of repayment of fiber optical cables ・ Status of procedure for installation of detectors
11		29 Jun	・ Progress of procedures to secure power for installed equipment ・ Progress of repayment of fiber optical cables ・ Necessary number of cores in fiber optical cables ・ Location of equipment connected to fiber optical cable
12		6 Jul	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of repairment of optical fiber cables ・ Necessary number of cores in fiber optical cable
13		13 Jul	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of repairment of optical fiber cables ・ Necessary number of cores in fiber optical cable ・ Impact of restrictions in Bangkok due to COVID-19 for the pilot project
14		20 Jul	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of repairment of optical fiber cables ・ Necessary number of cores in fiber optical cable
15		27 Jul	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of repairment of optical fiber cables ・ Necessary number of cores in fiber optical cable ・ Status of budget procedures in BMA
16		3 Aug	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of repairment of optical fiber cables ・ Status of budget procedures in BMA
17		10 Aug	・ Location of image sensor camera installation ・ Progress of repairment of fiber optic cables ・ Status of project extension procedures
18		17 Aug	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Payment method for the contract amount ・ Review results of the 2021 budget in BMA
19		24 Aug	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Fiber optical cable system diagram ・ Redesign of traffic signal parameters
20		31 Aug	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of repairment of optical fiber cables ・ Status of budget procedures in BMA ・ Work and cost expected to be completed by March 2022 ・ Work time and cost for redesign of the traffic signal parameter
21		7 Sep	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of survey of fiber optic cables ・ Establishment schedule of the control center ・ Status of budget procedures in BMA

No.	Date		Major Agenda
22	2021	14 Sep	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of survey of fiber optical cables ・ Schedule for additional fiber optical cable installation ・ Progress of permit procedure for use of electricity for roadside equipment
23		21 Sep	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of survey of fiber optical cables ・ Progress of construction work ・ Status of budget procedures in BMA
24		28 Sep	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of survey of fiber optical cables and a request letter from JICA ・ Progress of permit procedure for use of electricity for roadside equipment
25		5 Oct	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Procurement of materials for roadside equipment installation ・ Result of survey of fiber optical cables ・ Status of budget procedures in BMA
26		12 Oct	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of roadside equipment installation ・ Status of budget procedures in BMA
27		19 Oct	・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Amont of interim payment
28		26 Oct	・ Status of items taken by BMA ・ Result of survey of fiber optical cables and repairment work schedule
29		2 Nov	・ Available fiber optical cables ・ On-site confirmation for OTDR test ・ Progress of roadside equipment installation ・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Status of budget procedures in BMA
30		16 Nov	・ Progress of repairment of fiber optical cables ・ Progress of roadside equipment installation ・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Progress of roadside equipment installation ・ Status of MEA permit procedures for electricity use in roadside equipment ・ Status of budget procedures in BMA
31		30 Nov	・ Development of the control center ・ Fiber optical cable installation schedule ・ Progress of roadside equipment installation ・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Report on the results of on-site inspections
32		14 Dec	・ Development of the control center ・ Fiber optical cable installation schedule ・ Progress of roadside equipment installation ・ Status of permit procedures from the BMA Public Works Department for the installation of the equipment ・ Extension of the contract period between JICA and Genius ・ Report on the results of on-site inspections

No.	Date		Major Agenda
33	2022	11 Jan 2022	・ Progress of roadside equipment installation ・ Procedure of acceptance test ・ Extension of the contract period between JICA and Genius ・ Progress of traffic lights installation by BMA
34		8 Feb	・ Progress of roadside equipment installation ・ Progress of traffic lights installation by BMA ・ Schedule of the budget in FY2022
35		8 Mar	・ Progress of roadside equipment installation ・ Schedule of acceptance test for the roadside equipment and the control center ・ Additional pedestrian traffic light on Ratchawithi road ・ Progress of traffic lights installation by BMA
36		29 Mar	・ Progress of roadside equipment installation ・ IP address setting ・ Status of supplemental budget procedures in BMA
37		26 Apr	・ Progress of roadside equipment installation ・ IP address setting ・ Status of supplemental budget procedures in BMA ・ Partial payment
38		31 May	・ Progress of roadside equipment installation ・ IP address setting ・ Status of supplemental budget procedures in BMA ・ Additional cost for installation of pedestrian traffic light
39		27 Jun	・ Progress of establishment of the control center ・ Theory of traffic signal operation
40		26 Jul	・ Installation of monitoring equipment at RTP ・ Schedule of hand over of the equipment that has taken acceptance test ・ Status of supplemental budget procedures in BMA
41		30 Aug	・ Status of supplemental budget procedures in BMA ・ Implementation schedule of items taken by BMA
42		27 Sep	・ Status of supplemental budget procedures in BMA ・ Implementation schedule of items taken by BMA
43		25 Oct	・ Extension of the project period ・ Request to BMA to expedite repairment of fiber optical cables ・ Implementation of additional traffic survey ・ Outline of ATC maintenance manual ・ Outline of project PR activities
44		29 No	・ Resetting of traffic signal parameters based on additional traffic survey ・ Extension of the contract period between JICA and Genius
45		20 Dec	・ Resetting of traffic signal parameters based on additional traffic survey ・ Schedule of system test
46	2023	24 Jan	・ Impact on Tuk Chai intersection operation and installation of ATC equipment ・ Expected completion schedule of items taken by BMA
47		17 Feb	・ Impact on traffic flow at Tuk Chai intersection by operation methods ・ Expected completion schedule of items taken by BMA
48		28 Mar	・ Impact on traffic flow at Tuk Chai intersection by operation methods ・ Expected completion schedule of items taken by BMA
49		25 Apr	・ On-site traffic signal parameter setting work ・ On-site situation for the parameter setting
50		18 May	・ On-site traffic signal parameter setting work ・ On-site situation for the parameter setting
51		6 Jun	・ Issues and direction on ATC system operation ・ Training for BMA and RTP officers ・ Schedule of completion test ・ Opening ceremony of the pilot project
52		21 Jun	・ Issues and direction on ATC system operation ・ Schedule of pavement marking work by BMA ・ Training for BMA and RTP officers

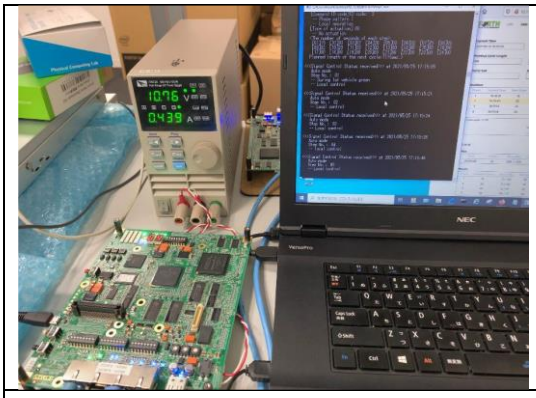
No.	Date		Major Agenda
53	2023	7 Jul	・ Progress of pavement marking work by BMA ・ Training for BMA and RTP officers by Genius ・ Submission of documents from Genius
54		18 Jul	・ Damage to fiber optical cable at Tuku Chai intersection ・ Issuance of completion test certificate
55		15 Aug	・ Progress of fiber optic cable repair work at Tuk Chai intersection ・ Invoice issuance for ATC system development ・ Final inspection of the demonstration experiment of prob data
56		29 Aug	・ Confirmation of receipt of final payment for ATC system maintenance. ・ Schedule of final payment for the demonstration experiment of prob data.
57		12 Sep	・ Warranty period of Genius ・ Duration of data provision for the probe data demonstration experiment ・ Completion certificate for the probe data demonstration experiment

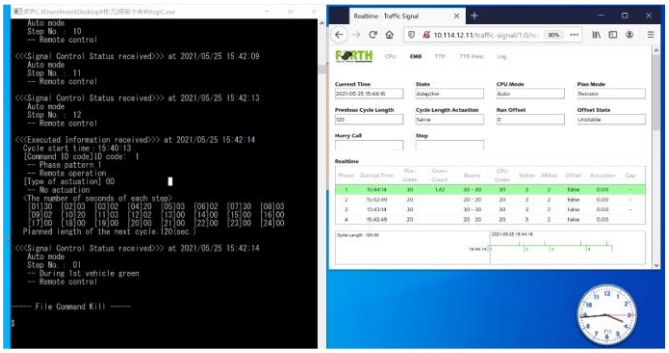
Source: JET

Major events in establishing the ATC system in the pilot project area are outlined below:

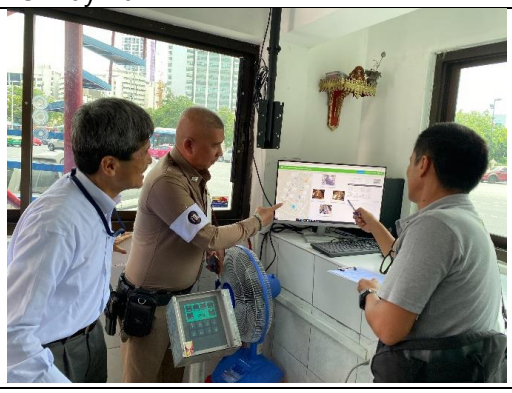
- At the commencement of ATC system equipment installation, a design briefing was held online on 4 Dec 2020, involving BMA, Genius, Sumitomo, JICA Thailand Office, and JET, during which Genius confirmed the construction details and process.
- In January 2021, the detector installation locations were confirmed both on-site and online.
- In January 2021, Genius submitted a system design manual, which met the specified requirements; an approval letter was issued on 3 February 2021.
- On 25 May 2021, the same five parties conducted an online factory inspection. A mock central system and a controller interface were set up in Japan, connected via VPN to a controller at Genius in Bangkok. This confirmed successful transmission of control commands from the central system and receipt of operational confirmation signals from the controller.
- Acceptance inspections of roadside equipment and control center equipment were conducted on 9 and 22 March 2022, respectively.
- In July 2022, signal operation monitoring and detector data collection functions were checked at the control center. It was found that while automatic control data was captured, data during manual operation was missing due to a connection issue between the embedded PC and CPU. To prevent operational issues, Genius was requested to review and enhance the software functions.
- On 8 June 2023, an acceptance test of the Manual Control Assistance Device was conducted at Tuk Chai intersection, with no issues identified.
- On 16 June 2023, an acceptance test of the central device function (software) and power supply system was conducted at the control center, with all tests completed successfully and no issues found.

The results of each inspection are shown in Annex 2.





Factory Test on 25 May 2021



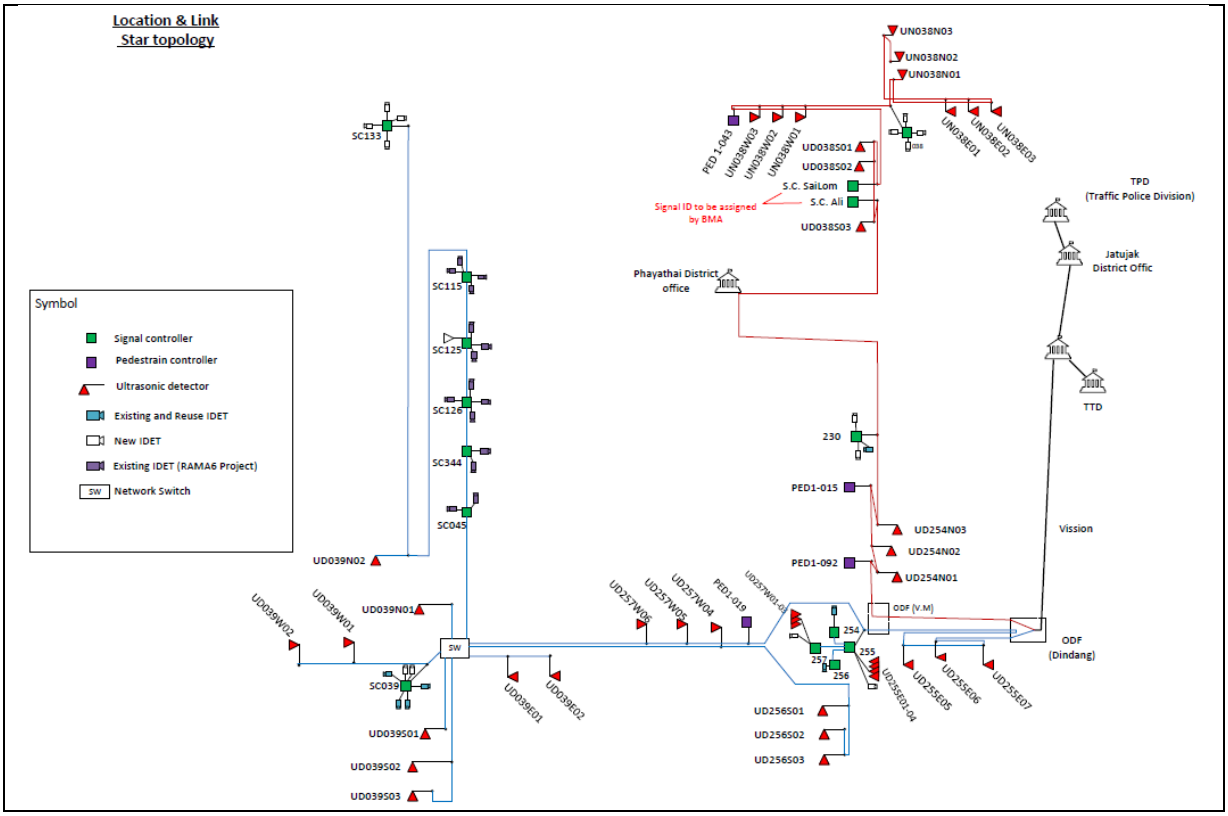
Acceptance Test for the Manual Control Assistance Device on 8 Jun 2023

Source: JET

Figure 4.2.23 Photos of Tests

(8) Establishment of the Communication Network between Traffic Signals in the Pilot Project Area and the Traffic Control Center

The BMA's fiber optic cable network was used for the ATC system in the pilot project. As mentioned above, some damaged points were identified and subsequently repaired by BMA. The branching fiber optic cables connecting the BMA's network to the traffic signals were installed under a contract between JICA Thailand Office and Genius. A diagram of the information and communication network in the pilot project area is shown in Figure 4.2.24.



Source: JET

Figure 4.2.24 Diagram of the Information and Communication Network in the Pilot Project Area

(9) Establishment of Database and Setting of System, Signal, and Detector Parameters

1) Traffic Control by ATC System

The ATC system introduced in the Project has the following signal control modes. While online traffic-responsive control is typically applied under normal circumstances, time control and flash control may be activated depending on traffic conditions or other operational requirements.

- Online (Central) Control Mode
  - Traffic-responsive control
  - Time control
  - Flash control
- Standby Mode
  - Local coordinated control
  - Local isolated control
  - Manual control
  - Flash control.
- Offline (local) Control Mode
  - Local coordinated control.
  - Local isolated control
  - Manual control
  - Flash control

Among these modes, the traffic-responsive mode dynamically adjusts control parameters based on real-time traffic conditions to ensure optimal performance. In this mode, signal parameters, including cycle length, split, and offset, are optimized by considering both traffic demand at individual approaches and congestion length. By accounting for queue length, this mode prevents issues such as upstream intersections becoming blocked or unnecessarily long queues forming when traffic demand exceeds the intersection's capacity. This approach ensures smoother traffic flow and minimizes the adverse effects of congestion.

2) Establishment of Control Center and Database

Genius established the database for the control center and configured the system on 17–28 April 2023. Sumitomo, responsible for the ATC system software under a contract with Genius, assigned their experts to assist Genius staff during establishment and adjustment. In parallel with the establishment of the database, timing parameters were adjusted to align with local traffic conditions, and the central database was updated. Traffic data, including signal operation logs, queue lengths, and detector information, were collected and checked for any defects such as data anomalies and missing data.

3) As-built Documents

As part of the ATC system installation, the contractor submitted the following as-built documents in compliance with the contract. JET subsequently reviewed the contents of these documents.

Table 4.2.12 As-built Documents for the Control Center

Code	Title	File Name (*.pdf)
1-1	Signal control server specifications	6342-ED-20-101
1-2	Database server specifications	6342-ED-20-102
1-3	Communication control server specifications	6342-ED-20-103
1-4	Information exchange server specifications	6342-ED-20-104
1-5	Information storage server specifications	6342-ED-20-105
1-6	Information distribution server specifications	6342-ED-20-106
1.7	IDET video server	6342-ED-20-107
1-8	Time server	6342-ED-20-108
1-9	HMI workstation specifications	6342-ED-20-109-rev002
1-10	Monitoring workstation specifications	6342-ED-20-110-rev002
1-11	KVM console kit and KVM switch specifications	6342-ED-20-111
1-12	Network monitoring indicator specifications	6342-ED-20-112
1-13	Network printer specifications	6342-ED-20-113
1-14	UPS specifications	6342-ED-20-114
1-15	Communications equipment specifications	6342-ED-20-115
1-16	19 inch rack specifications	6342-ED-20-116

Source: Genius

Table 4.2.13 As-built Document for Devices

Code	Title	File Name (*.pdf)
2-1	Local controller (standard) specifications	6342-ED-20-201
2-2	Local controller (pedestrian) specifications	6342-ED-20-202
2-3	IDET specifications	6342-ED-20-203
2-4	CDET specifications	6342-ED-20-204
2-5	Detector aux cabinet specification	6342-ED-20-205
2-6	I/F cabinet specifications	6342-ED-20-206
2-7	Manual operation assistance device specifications	6342-ED-20-207-rev002
2-8	Cooperation Mark Specifications	6342-ED-20-208

Source: Genius

4) Evaluation Results of ATC System by Queue Length Survey and Traffic Volume

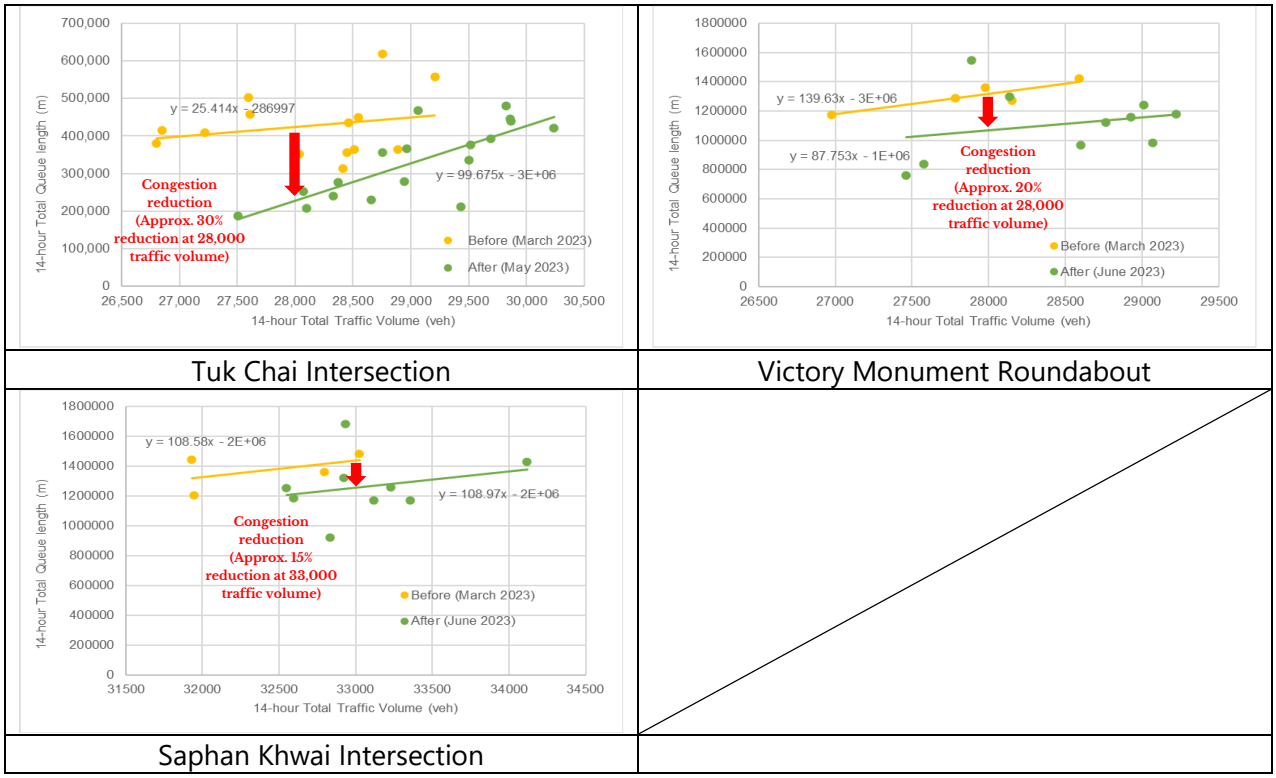
Evaluation by Actual Measurement Value

The ATC system's performance was evaluated using queue length from probe data and traffic volume from installed detectors at three intersections: Tuk Chai, Victory Monument, and Saphan Khwai. A comparison of conditions before and after the ATC system's installation showed that queue lengths decreased by 15% to 30% with the same traffic volume. Additionally, the reduction in waiting times at intersections was translated into a monetary value to reflect travel time savings. The introduction of the ATC system has significant benefits, including reductions in vehicle operating costs (VOC) and value of time (VOT). The estimated savings per weekday are THB107,355 at the Tuk Chai intersection; THB352,262 at Victory Monument; and THB169,757 at the Saphan Kwai intersection. Combined, these savings total THB163 million annually, based on 160 weekdays. The evaluation results are presented in Annex 3.

a) Total Traffic Volume and Queue Length

Figure 4.2.25 illustrates a comparison of the total traffic volume over a 14-hour period (6:00–20:00) at the three intersections, as well as the total queue lengths at each approach during the same period, before and after the introduction of the ATC system. The yellow dots represent data collected before the ATC system was introduced, while the green dots represent data collected afterward. The lines in each color indicate the corresponding trend lines.

As shown in the figure, there is some variation in the 14-hour traffic volumes both before and after the introduction of the ATC system. However, a comparison of the trend lines clearly demonstrates a reduction in congestion lengths following the implementation of the ATC system.

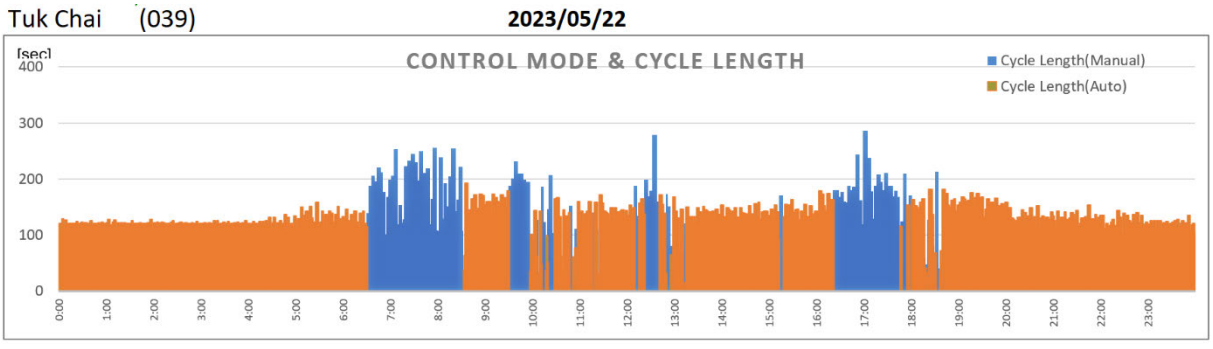


Source: JET

Figure 4.2.25 Comparison of Queue Length and Traffic Volume before and after Introduction of ATC System

b) Control Modes

Figure 4.2.26 illustrates the time progression of the control mode and the total queue length on each approach to the Tuk Chai intersection. Manual control is predominantly used during the morning peak hours (6:30–8:30) and evening hours (16:30–17:30), with occasional short applications during the day. The cycle length for manual control often exceeded 200 seconds, compared to the 100–180 seconds typically observed during automatic control.

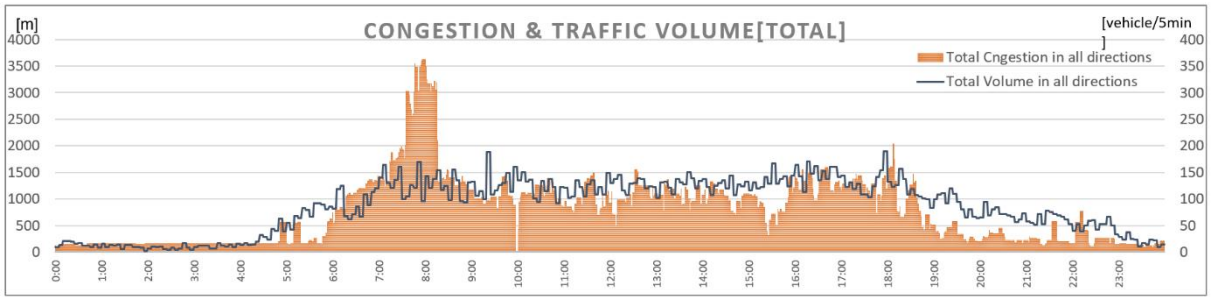


Source: JET

Figure 4.2.26 Operation Modes and Signal Cycle Lengths at Tuk Chai Intersection

Figure 4.2.27 presents the traffic volume and total queue length at the same intersection. The total queue length is notably longer around 8:00 a.m., when manual control was implemented, even though the traffic volume remains consistent before

and after. This indicates that despite similar traffic volumes, manual control is contributing to longer queue lengths, contrary to its intended purpose. This issue was explained to BMA and RTP during the training session held in June 2023.



Source: JET

Figure 4.2.27 Traffic Volumes and Queue Lengths at Tuk Chai Intersection

Evaluation by Microsimulation Model

Travel time within the pilot project area is one of the indicators in the PDM of the Project to evaluate the effectiveness of the pilot project. The pilot project area encompasses a road with a circumference of about 8 km. As the traffic flow in the area improves, more vehicles are expected to divert from other roads, making it impractical to measure identical conditions before and after the ATC system's installation. Consequently, a microsimulation model (Vissim) was used to estimate and evaluate the travel time before and after the introduction of the ATC system. The microsimulation model analyzed traffic volumes in the pilot project area where the ATC system was established. It calculated queue lengths, travel times, and air pollutant emissions for two scenarios, i.e., using the signal parameters in place prior to the ATC system's introduction and using optimal signal parameters calculated based on measured traffic volumes. The estimated travel times for the scenarios are shown in Table 4.2.14. The ATC system optimizes signal operations within the pilot project area, also affecting traffic on roads connected to it. While travel times on the outer roads of the pilot area may vary depending on the time of day, leading to occasional increases post-installation, average travel times during the morning peak, off-peak, and evening peak periods decreased by 20 to 30% in both outer and inner directions.

Table 4.2.14 Estimated Travel Times in the Pilot Project Area by Microsimulation

Target	Time	Travel Time (min)		
		Before (a)	After (b)	Rate of Change (=b/a)
Outer Loop	Morning peak hour	44.0	47.4	1.08
	Off-peak hour	50.8	33.2	0.65
	Evening peak hour	62.5	29.7	0.47
	Average	52.4	36.8	0.70
Inner Loop	Morning peak hour	54.3	38.8	0.72
	Off-peak hour	29.6	31.4	1.06
	Evening peak hour	43.7	35.7	0.82
	Average	42.5	35.3	0.83

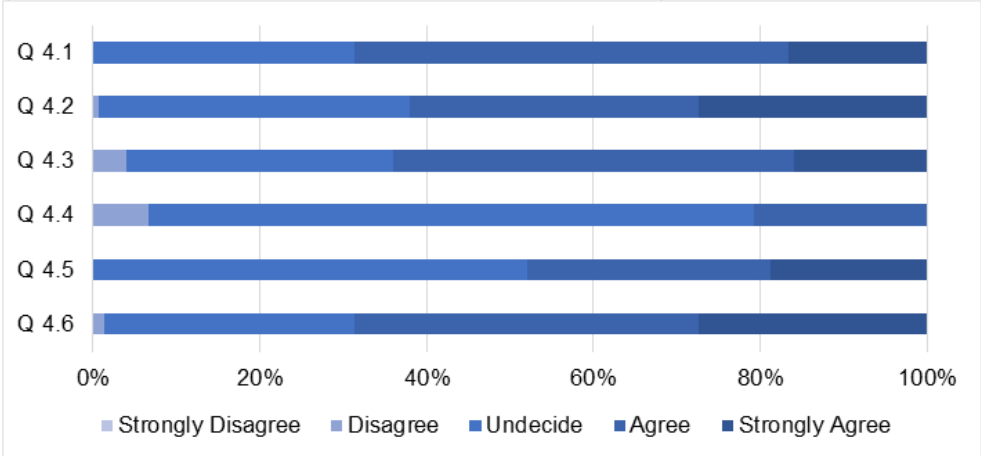
Source: JET

5) Road Users Survey Results

To evaluate the effectiveness of the ATC system, an interview survey of road users, in addition to measuring queue lengths and traffic volumes, was conducted. Residents, private company employees, and public agency employees along Phahonyothin Road in the pilot project area were asked to assess traffic conditions before and after the ATC system introduction. The respondents reported being aware of the change in signal operation (Q4.1) and perceived a reduction in queue lengths and travel times (Q4.5, Q4.6).

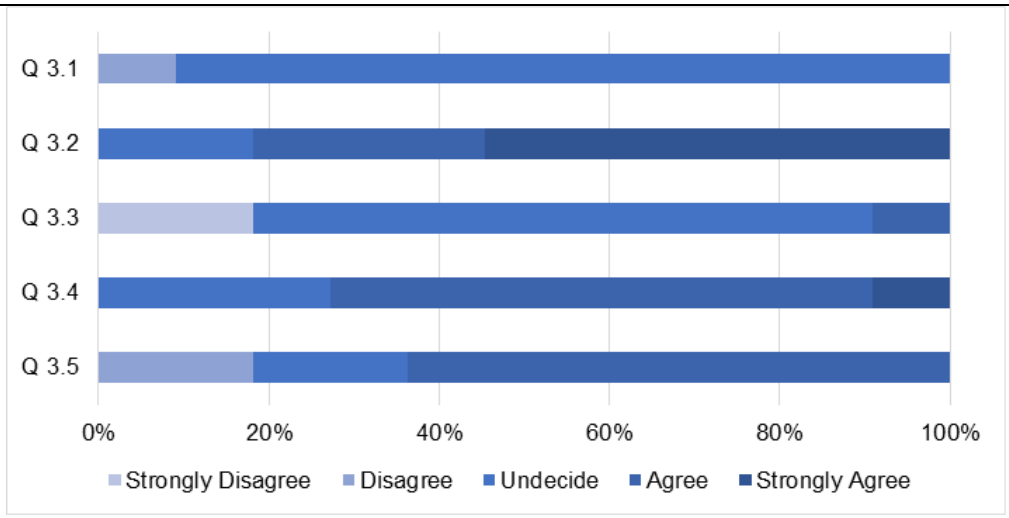
Additionally, traffic police officers responsible for traffic signal operations were asked to evaluate the need for manual intervention, a known issue, and the traffic conditions before and after the ATC system introduction. While many police officers indicated that manual operation was no longer necessary during off-peak hours (Q3.2), the majority were undecided about its necessity during peak hours (Q3.1), suggesting a need to further communicate the ATC system's effectiveness. However, a significant number of officers reported that the system allowed them to allocate time to other tasks (Q3.5), indicating the potential to reduce manual intervention. The detailed interview survey results are shown in Annex 4.

Q4.1 Did you notice any changes in traffic light operation?
Q4.2 Did you perceive coordination of green times along the traveled corridor?
Q4.3 Are you satisfied with the new cycle of traffic signals and actuated green time?
Q4.4 Did you feel the road safety improvement
Q4.5 Did you feel the reduction in queue length at intersections?
Q4.6 Did you perceive a reduction in travel time in the pilot project area?



Interview Results for Road Users

Q3.1 Did you feel about no longer manually operating traffic signals during peak hours?
Q3.2 Did you feel about no longer manually operating traffic signals during off-peak hours?
Q3.3 Did you feel that you do not need to intervene manually the traffic signal operation after the ATC system implementation?
Q3.4 Did you feel the traffic congestion improvement after the implementation of the ATC system?
Q3.5 Did your role in traffic control change, and do you have more opportunities to focus on other tasks such as traffic violation enforcement?



Interview Survey Results for Police Officers

Source: JET

Figure 4.2.28 Interview Survey Results after ATC System Installation

(10) Training for Traffic Management Officers of BMA and Royal Thai Police in Operating the ATC System

1) Training

The following manuals were created for configuring and operating the ATC system, and training based on these manuals was provided to BMA and RTP staff on 29–30 June 2023: ATC System Operation Manual (Annex 5) and Signal Timing Adjustment Procedure (Annex 6).

A total of 17 staffers participated in the training, comprising 10 from BMA and seven from RTP. The list of participants is shown below.

Table 4.2.15 BMA and RTP Trainees in ATC System Operation

Organization		Name
TTD, BMA	Director of Traffic System Design Section	Mr. Sayan THASANAKOSOL
	Experienced Electrician	Mr. Nattapol MAKSRI
	Senior Electrician	Mr. Nickson SINGHPHITAK
	Experienced Electrician	Mr. Soonthorn SRIPANG
	Experienced Electrician	Mr. Noppasil PANCHAMA
	Experienced Electrician	Mr. Pairoj SUWANMANOP
	Operational Electrician	Mr. Aekkachai PREECHAKAM
	Operational Civil Engineer	Mr. Nattakrit METHISAKULMAS
	Experienced Electrician	Mr. Surachai THAISAKUL
	Experienced Electrician	Mr. Bhornpravas YAMPRASERT
RTP	Traffic Inspector, Traffic Police Division (TPD)	Pol. Maj. Chaiya WERUWANARAK
	Deputy Inspector, Traffic Engineering 3, Section 4, TPD	Pol. Lt. Warot AUIKHAM
	Deputy Inspector, Traffic Engineering 3, Section 4, TPD	Pol. Lt. Noppakit TOHNGEW
	Traffic Squad Leader, Bang Sue Police Station	Pol. Sgt. Pornchai KAEWHANG
	Traffic Squad Leader, Phaya Thai Police Station	Pol. Snr. Sgt. Maj. Somboon KRUEATHI
	Traffic Squad Leader, Phaya Thai Police Station	Pol. Snr. Sgt. Maj. Sadej SITHISARAKOO
	Suppression Squad Leader, Phaya Thai Police Station	Pol.Cpl. Pornphitak BOONLUECHA

Source: JET

2) Study on Introducing a New Traffic Volume Count System in Bangkok

The Victory Monument Roundabout, which is included in the pilot project area, is a large ring road, making it challenging to capture directional traffic volume using roadside traffic surveys, which are necessary for traffic control. Additionally, traffic signal parameters in Bangkok are set often without conducting traffic volume surveys, contributing to traffic congestion. Under this situation, a verification traffic volume count using CCTV cameras and image processing technology was conducted. This method counts traffic volume for each combination of entry and exit roads by processing camera images. Specifically, a video covering the entire ring road was recorded from a high floor of a nearby hospital, allowing vehicles to be recognized and tracked from entry to exit. From June to July 2021, 10 scenarios based on time of day and weather conditions were set, as shown in Table 4.2.16, and videos of traffic volume were recorded. Based on these images, JET assessed the feasibility of using image analysis technology for traffic volume measurement.

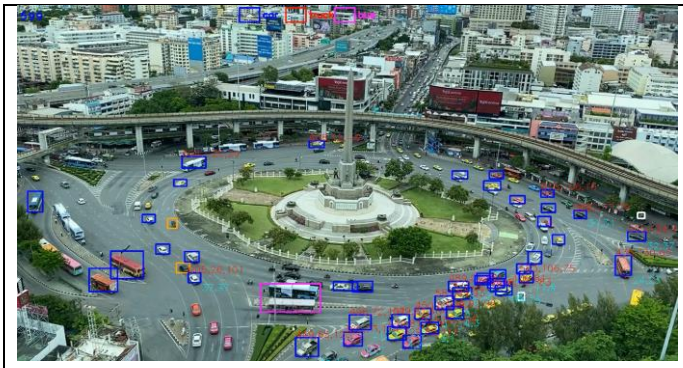
Table 4.2.16 Verification Cases of Image Processing Analysis

Weather	Morning (M)	Day time (D)	Evening (E)	Night (N)
Sunny (S)	MS	DS	ES	NS
Cloud (C)	MC		EC	NC
Rain (R)	MR		ER	NR

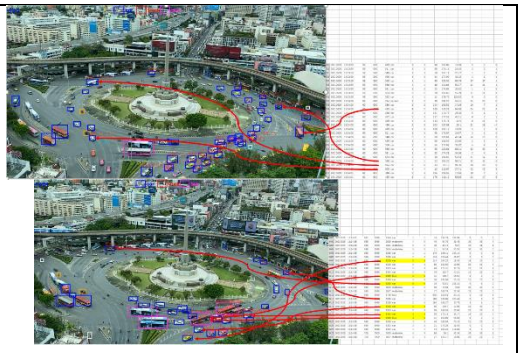
MS: Morning-Sunny, MC: Morning-Cloud, MR: Morning-Rain, DS: Day time-Sunny, ES: Evening-Sunny, EC: Evening-Cloud, ER: Evening-Rain, NS: Night-Sunny, NC: Night-Cloud, NR: Night-Rain

Source: JET

Verification was conducted using vehicle recognition (the ability to recognize vehicles) and tracking (following recognized vehicles from entry to exit). Vehicle recognition was effective during bright daytime conditions but proved difficult in low-light nighttime conditions. For tracking, vehicles at the bottom of the screen were successfully tracked more frequently than those at the top, where greater distance and smaller vehicle shapes led to tracking failures. To improve accuracy, AI training data was increased, and analysis parameters were adjusted, By September 2022, the system achieved 95% recognition accuracy for passenger cars. While recognizing and tracking larger vehicles and motorcycles remains challenging, the high accuracy for passenger cars, which make up the majority of the target vehicles, confirmed the system's potential for measuring traffic volume at other intersections. After introducing the ATC system, further adjustments were made to improve measurement accuracy based on pre-existing images. However, a second round of video recording and vehicle counting post-installation revealed lower accuracy due to a slight shift in the camera's angle and the inclusion of construction vehicles, highlighting the need for adjustments tailored to each specific viewing angle. The results of this verification, along with findings from the study on system configuration for full-scale implementation in BMA, are detailed in Annex 7.



Recognition (Rectangles show recognized vehicles)



Tracking

Source: Fujitsu Limited

Figure 4.2.29 Example of Verification (Case of Day Time - Sunny)

Chapter 5. Project Output 2: Establishment of a Management System to Implement the O&M for the ATC System in the Pilot Project Area

5.1 Summary

In Output 2, the division of roles between BMA and RTP was clarified, and the necessary manuals were developed to enable the ATC system to be effectively operated and maintained beyond the Project's completion.

To sustain the effectiveness of the ATC system, an appropriate O&M framework must be established. Traffic signal phases and cycles need to be regularly reviewed and adjusted to accommodate changes in road conditions or traffic demand. In the event of equipment failure, prompt action is necessary to minimize disruptions. The control center enables real-time monitoring of traffic conditions and equipment operation, making it essential to utilize these capabilities effectively. Achieving this requires the preparation of O&M manuals, the allocation of sufficient personnel to operate and maintain the system, and the provision of appropriate training to ensure staff can perform their roles effectively and efficiently.

Output 2 is composed of four activities and has three objectively verifiable indicators in the PDM.

Table 5.1.1 Objectively Verifiable Indicators for Output 2

2-1. Approximately 10 officials from BMA and RTP receive training in the operation and maintenance the of ATC system.
2-2. ATC operation and maintenance guidelines are made available.
2-3. An awareness campaign is conducted at least 3 times.

The implementation structure for the O&M of the ATC system was confirmed with BMA and RTP immediately after the Project began. Although the ATC system control center was established in BMA as part of the pilot project, BMA plans to relocate the control center to another location within its facilities in the future. JET developed O&M manuals and provided training to BMA and RTP staff. Furthermore, JET conducted public relations and awareness-raising activities in conjunction with the ATC system's launch.

5.2 Activities

(1) Clarification of Duties and Implementation Structures for the Organizations

The roles of BMA and RTP in the O&M of the ATC system were clarified in the first JCC meeting, as shown in Table 5.2.1. It was agreed then that BMA would remain responsible for the maintenance of the ATC system even after the operation of traffic signals at

intersections is transferred to RTP.

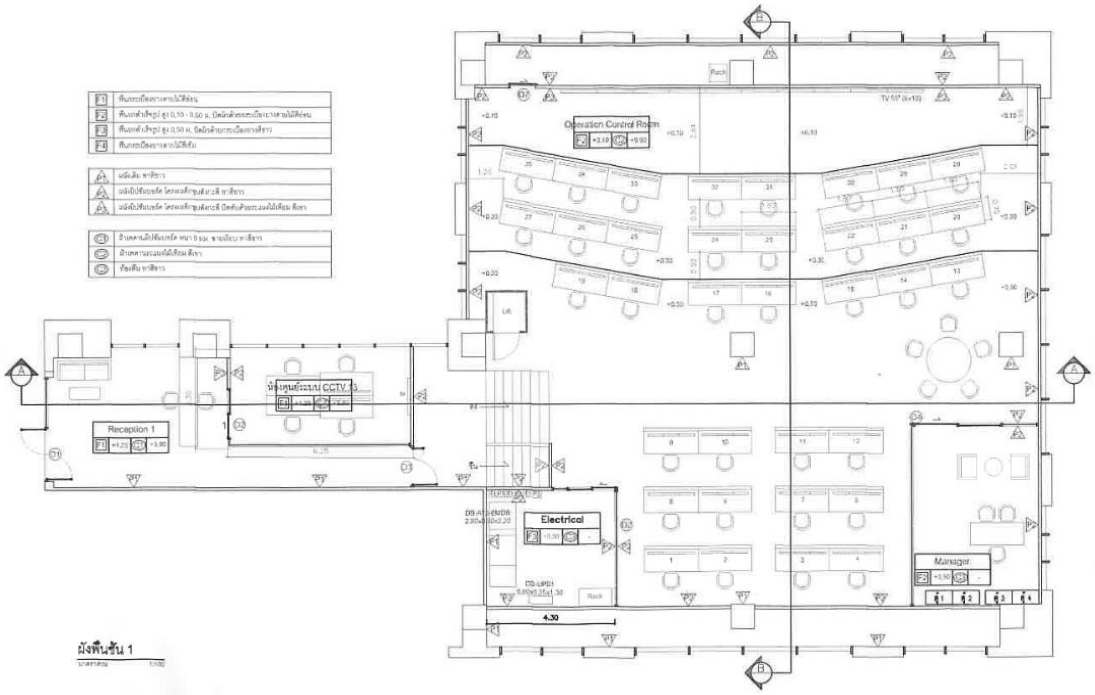
There is a basic agreement between BMA and RTP stating that BMA is responsible for the installation and modification of traffic signals, while RTP operates them. When installing traffic signals, suppliers commissioned by BMA install the equipment and configure parameters according to BMA's instructions. If necessary, RTP request parameter changes to BMA.

Table 5.2.1 Post-project Role Sharing between BMA and RTP

Task	BMA	RTP
Installation of equipment (control center and roadside equipment)	●	-
Setting of parameters for control center and traffic signals	●	-
Preparation of operation manual	●	●
Operation of ATC system at Control Center	●	-
Operation of ATC system at intersection	-	●
Manual operation of signals at intersection	-	●
Maintenance of system (control center, OFC net, and roadside equipment)	●	-
Planning and design of ATC system expansion	●	-

Source: JET

The ATC system control center for the pilot project was established in the office of BMA's Traffic and Transportation Division, but it will be relocated to the first floor of BMA2 building, which, as of November 2024, was still unfinished. BMA needs to complete the interior construction work for the control center. Since the current design is not specifically intended for a traffic control center, JET advised BMA to redesign the space by considering the placement of equipment, number of personnel to man the center, each staffer's role, the design of the wall map, and provisions for visitors.



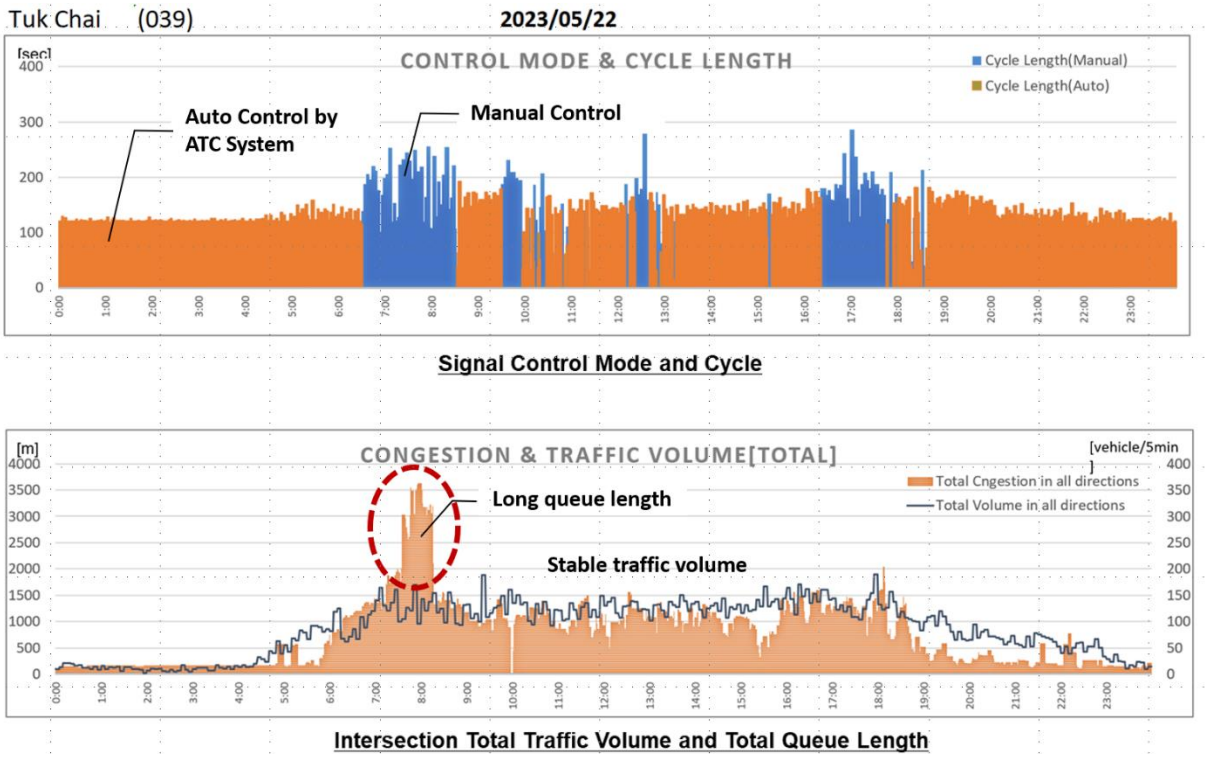
Source: BMA

Figure 5.2.1 Layout Plan for the New Traffic Control Center in BMA2 Building

(2) Implementation of the Operation and Maintenance of ATC System

It has been agreed that RTP would be responsible for operating the ATC system in the pilot project area, while BMA would handle its maintenance. Using the O&M manual mentioned in the next section, training was conducted for BMA and RTP staff on 20 and 30 June 2023.

Despite the ATC system's installation, RTP continues to manually operate traffic signals during morning and evening peak hours. Data analysis shows that compared to ATC-controlled signal operation, manual operation leads to longer signal cycles and subsequently longer queue lengths. Figure 5.2.2 shows the survey results of the relations among signal operation mode, cycle length, traffic volume, and queue length. With the same traffic volume, extended signal cycles increase queue lengths and total waiting times, making manual control inefficient. Although BMA and JET have requested RTP to cease manual operation at JCC and other meetings, it has continued throughout the project period. One likely reason for this is the lack of a clearly defined division of duties among traffic police officers stationed at intersections. These officers often rely on long-standing customs and manage traffic flow independently, which inadvertently leads to longer signal cycles and increased congestion lengths.



Source: JET

Figure 5.2.2 Relation among Signal Operation Modes, Cycle Lengths, Traffic Volumes, and Queue Lengths

(3) Preparation of the O&M Manuals for the ATC System

To ensure proper and continuous operation of the ATC system, the following O&M manuals were developed. These manuals were based on standards and manuals in Japan and the management contract used by BMA. The contents of these manuals (excluding the operations manual) were explained to BMA and RTP during the 12th Project Team meeting held on 6 July 2021, and to BMA personnel on 21 October 2022. Training was conducted in June 2023 as described above, with participants as listed in Table 4.2.15.

- ATC System Maintenance Manual (Annex 8): Specifies the overall maintenance work scope and defines the roles and responsibilities of the client and the contractor.
- Special Conditions of Contract for ATC System Maintenance (Annex 9): Specifies the specific contractual terms and conditions applicable to the maintenance agreement.
- Technical Specifications for ATC System Maintenance (Annex 10): Defines the technical standards and specifications required for maintenance activities.
- ATC System Maintenance (Annex 11): Provides an overview of the maintenance work organization, contract structure, work content, and includes a checklist for reference.
- ATC System Operations Manual (Annex 5): Guidelines for control center operations defining the roles and functions of the control center, its operational structure, the processes for collecting and providing traffic information, and the responsibilities of

the staff regarding the ATC system.

In Traffic and Transportation Department[10] of BMA, Traffic Engineering Division is responsible for traffic control equipment, including traffic signals and the ATC system, while Traffic Technology Division[11] oversees CCTV cameras and fiber optic cable networks. Both divisions outsource the maintenance of their equipment and facilities to external private companies. Currently, BMA is reviewing the proposals outlined in the manual but has not yet implemented them, as it is necessary to evaluate the responsibilities of each division and the terms of existing maintenance contracts with the maintenance companies.

The contents of these manuals are shown below.

ATC System Maintenance Manual

1. Purpose
2. Definition of terms
3. Person in charge of management…Who is legally in charge?
4. Person in charge of management
5. Maintenance work and management system
6. Proper management
7. Inspection by contractor
8. Work area safety
9. Traffic signal failure report

Special Conditions of Contract for ATC System Maintenance

1. General obligations
1.1 Contractor's responsibility
1.2 Works to be done by the contractor
1.3 Contractor's employees
1.4 Contractor's equipment
1.5 Laws to comply
1.6 Responsibility for damage claims
1.7 Temporary suspension of work
2. Measurement and payment
2.1 Work hours
2.2 Preventive maintenance
2.3 Corrective maintenance
2.4 Accident repair
2.5 System modification
2.6 Maintenance and repair records

[10] https://division.bangkok.go.th/dotat/WebEng/TheTrafficEngineeringDivision.html
[11] https://division.bangkok.go.th/dotat/WebEng/TheTrafficTechnologyDivision.html

2.7 Liquidated damage

3. Contract renewal

4. Cost adjustment

4.1 Escalation

4.2 Foreign spare parts

4.3 Currency conversion

Technical Specifications for ATC System Maintenance

1. General

1.1 General requirement

1.2 Definition

1.3 Scope of work

1.4 Signal turn-off and signal on flash

2. Preventive maintenance of control center equipment

2.1 General

2.2 Monthly inspection/servicing

2.3 Quarterly and bi-annual inspection/servicing

3. Preventive maintenance of field equipment

3.1 Monthly inspection of signal equipment

3.2 Quarterly inspection of vehicle detector

3.3 Quarterly and bi-annual inspection of field equipment

4. Schedule and check lists

4.1 Schedule for preventive maintenance

4.2 Check list

5. Corrective maintenance and accident repair

5.1 Response and service times

5.2 Rehabilitation of pre-existing defects

5.3 Fault reporting and work order

5.4 System modification

6. Spare parts and consumables

6.1 Spare parts inventory

6.2 Payment for spare parts

7. Work area safety and traffic safety

ATC System Operations Manual

1. General

1.1 Introduction

1.2 Vision

1.3 Mission

1.4 Definition of terms

2. Function and services
3. Organizational setup
3.1 Coverage area of pilot system
3.2 Organizational setup for system operation
3.3 Operational improvement
4. Collection of traffic information
5. Reporting of traffic information
5.1 Reporting and notification of traffic information
5.2 Instructions by the person in charge of operations
6. Provision of traffic information
6.1 Provision of traffic information
6.2 Operation of the traffic information facility
7. Guidelines for employees
8. ATC center work system
8.1 Service system
8.2 Working hours
8.3 Allocation of working hours (example)
8.4 Assignment of shift work (example)
8.5 Work plan
8.6 Daily report

(4) Conduct of Awareness-raising and Public Relations Campaign

With the ATC system's operation introducing changes in lane allocation and signal timing, road users in the pilot project area, who are accustomed to previous traffic patterns, may need time to adjust to the new system. To prepare them, the Project Team conducted advance notifications and public relations (PR) activities. During the 15th Project Team meeting, BMA and RTP suggested using banners, roadside signs, and electronic bulletin boards and recommended providing notices one month before the operation started. Consequently, the Project Team issued notices and prepared PR materials in preparation for the ATC system's launch. A list of media used for awareness-raising and public relations is shown in Table 5.2.2.

Table 5.2.2 PR Activities and Materials

Item	Objective	Location	No.
Banner A	Notice of the commencement of ATC operation	Pedestrian bridges, Sidewalks	13 spots
Banner B	Notice of the ATC system	Pedestrian bridges, Sidewalks	25 spots

Sign	Notice of both of the ATC system and the commencement of ATC operation	Traffic lights, Detectors	18 spots
Hand Sanitizer	Ditto	Distribute	-
Leaflet	Ditto	Online	-
Short movie	Ditto	Online	-

Source: JET

Source: JET

Figure 5.2.3 Image of PR Materials

An opening ceremony was held on 26 June 2023 to launch the ATC system in the pilot project area. The ceremony was chaired by Bangkok Governor, Mr. Chachart Sittiphun, and

attended by over 120 representatives from BMA, RTP, the Minister-Counsellor of the Embassy of Japan (EOJ), the Chief Representative of JICA Thailand Office, other relevant organizations, research institutes, and media outlets. The ceremony received extensive media coverage, and the Governor of Bangkok live-streamed the event on his Facebook page.

Group Photo with Representatives

Group Photo with BMA, RTP, EOJ, JICA, JET

Explanation of ATC System by a JICA Expert

Explanation by Minister of EOJ

Source: JET

Figure 5.2.4 Photos of the Opening Ceremony

Chapter 6. Project Output 3: Formulation and Utilization of a Guidebook on Manual Operation of ATC Traffic Signals

6.1 Summary

For Output 3, a manual operation support tool was integrated into the ATC system introduced in the pilot project. This tool aims to facilitate a gradual transition from the manual operation of traffic signals by traffic police officers to automated control. Additionally, guidelines were developed to help them understand the fundamentals of manual operation.

Traffic police officers are stationed at major intersections in Bangkok and frequently operate traffic signals manually while also monitoring traffic. While manual signal operation may be necessary in emergency situations, such as accidents, it is generally ineffective for managing daily congestion, as evidenced by measurement results at the intersections in the pilot project area (Figure 6.2.2). To address this, a guidebook was prepared for traffic police officers, explaining the characteristics and limitations of manual operation and outlining the appropriate conditions for its use. Furthermore, training sessions were conducted to enhance their understanding of and proficiency in manual operation.

The guidelines clarify the purpose of manual operation, highlighting its advantages and limitations to eliminate unnecessary and inefficient practices. They emphasize that manual operation should only be applied in situations where it is genuinely necessary. The manual operation support tool, a monitor installed at traffic police stations where officers manually operate traffic signals, provides real-time traffic information and displays the optimal timing for signal changes. This tool assists officers in executing manual operations more effectively while also enhancing their understanding of the ATC system's benefits and functionality.

Output 3 is composed of five activities and two objectively verifiable indicators in the PDM.

Table 6.1.1 Objectively Verifiable Indicators for Output 3

3-1. Approximately 5 officials from RTP receive training in manual signal operation.
3-2. Manual operation based on the guidelines is implemented at intersections in the pilot project area.

The status of manual traffic signal operation by traffic police officers was reviewed through Project Team meetings and determined through interviews with police officers assigned in the pilot project area. Additionally, the interface of the manual operation support tool for traffic signals, installed as part of the Project, was discussed in these meetings, and the tool was developed as part of the ATC system procurement for Output 1. The *Guideline for Manual Operation of Traffic Signals* was prepared together with the development of the ATC system.

6.2 Activities

(1) Study of Current Practice of Manual Operation

The manual operation of traffic signals by traffic police officers was assessed through observation of signal cycles during this mode and through interviews with them. Key findings are as follows:

- At most intersections, traffic police officers manually operate traffic signals only during morning and evening peak hours. However, at intersections with heavy traffic demand, such as Victory Monument Roundabout, manual operation is done throughout the day.
- There are no official guidelines or training in the manual operation of traffic signals.
- Traffic police officers do not have sufficient knowledge or experience of traffic engineering, relying solely on intuition when carrying out manual operation.
- Traffic police officers monitor vehicle queue lengths on each approach using CCTV cameras and adjust the green light duration from the police box at the intersection.
- The primary goal of manual operation is to prevent congestion from spilling over into adjacent intersections.
- The maximum signal cycle length during peak hours is set at 12 minutes.
- Traffic police officers believe that manual operation can manage higher traffic volume than automatic operation.

(2) Drafting the Guidelines for the Manual Operation of Traffic Signals

JET provides BMA and RTP with explanations on the transition from manual operation to automation, as well as the principles of traffic signal control based on traffic engineering using the *Guidelines for Manual Operation of Traffic Signals* which was created in this Project.

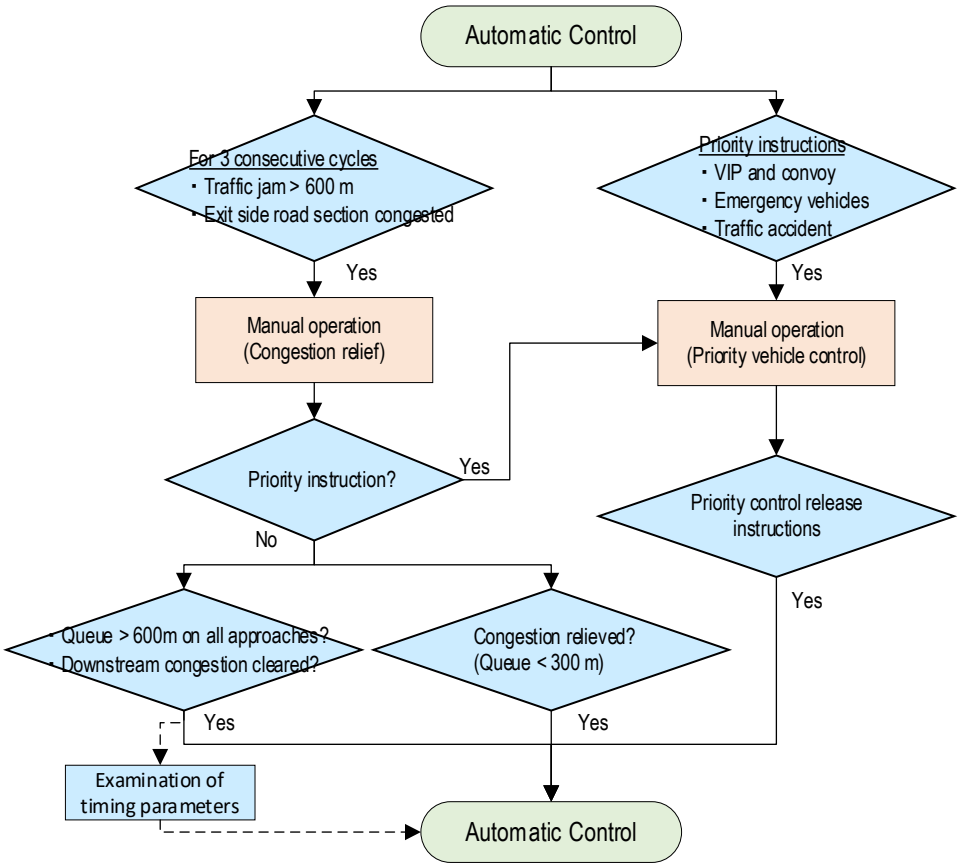
Currently, traffic signals are manually operated by traffic police officers during morning and evening peak hours. If the ATC system is fully automated, traffic police officers need not be deployed to the intersections immediately, However, although the timing of the signal phase change will be calculated by the control center once the ATC system is introduced, a gradual transition from manual to automatic control was proposed. This phased approach was accepted by RTP during the Project Team meeting.

BMA previously attempted to introduce the ATC system, but a key issue arose: "Traffic police officers were unable to freely operate traffic signals during emergencies." To facilitate acceptance, a gradual transition is proposed from manual to automatic operation, allowing traffic police officers to observe the ATC system's effects while retaining some manual control in the pilot project. While the theory of traffic signal control suggests that shorter signal cycles improve efficiency, some RTP officers expressed skepticism about its applicability in Bangkok. Consequently, the *Guidelines for Manual Operation of Traffic Signals* include foundational theories to align with the knowledge and perspectives of RTP officers. The guidelines comprise a summary and a part focused on single intersections. The

following guidelines and manual were created:

- Guidelines for Manual Operation of Traffic Signal (Annex 12): Provides detailed instructions on the purpose, benefits, implementation procedures, precautions, and step-by-step manual operation at specific intersections.
- Manual Control Analysis (Annex 13): Summarizes the analysis results of traffic signal operations, including comparisons of automatic and manual control durations, phase splits, and maximum green times, based on operation records enabled by the introduction of the ATC system.

The procedure for manual operation of traffic signals is detailed in Chapter 3 of the *Guidelines for Manual Operation of Traffic Signal*s, as outlined below.



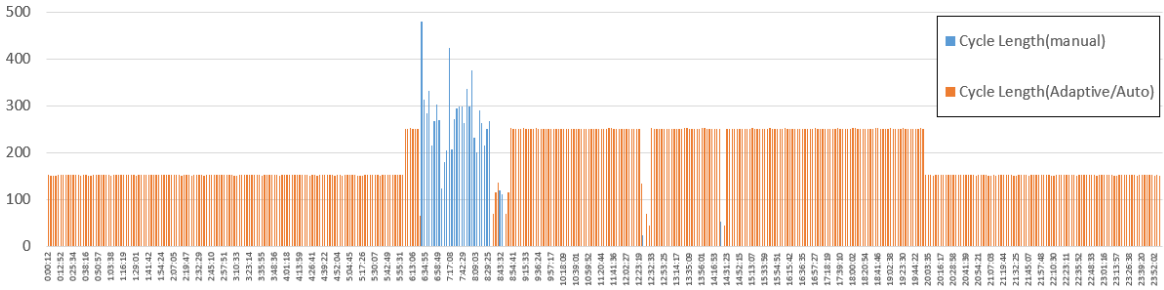
Source: JET

Figure 6.2.1 Procedure for Manual Operation of Traffic Signals

In the Manual Control Analysis, the Project Team focuses on Chai intersection and Victory Monument Roundabout, examining the status of signal control, including manual operation, actual automatic and manual signal cycles, aspect and split, longest green time, and queue length. In this context, automatic control refers to the time-based control by the signal controller before the implementation of ATC control.

As an example, Figure 6.2.2 displays data on the signal cycle length at Tuk Chai intersection on Monday, 1 August 2022. Based on the figure, during automatic control (indicated in red), only two cycle lengths are set, i.e., one for nighttime and one for daytime, indicating limited

responsiveness to the considerable fluctuations in traffic volume throughout the day. In contrast, during manual control (indicated in blue), the signal cycle varies significantly from one cycle to the next. Typically, during peak hours with heavy traffic, traffic volume does not fluctuate greatly from cycle to cycle. Therefore, frequent cycle length adjustments during these times may not result in efficient or stable control.



Source: JET

Figure 6.2.2 Traffic Signal Cycles at Tuk Chai Intersection, 1 August 2022

In August 2021, a clash between demonstrators and police resulted in attacks on several police boxes in Bangkok, with some set on fire. All police boxes in the pilot project area were also damaged, with their interiors destroyed. However, the traffic signal controllers, which were installed outside the police boxes at all but one intersection were undamaged and continued to operate normally. In the Project, manual operation support tools were installed inside the police boxes to assist manual control. Following repairs to all police boxes in the pilot project area in early 2023, the manual operation support tool was installed as planned.

Police Box at Victory Monument Roundabout
(CCTV monitors were taken away)

Burned Police Box
(Outside the pilot project area)

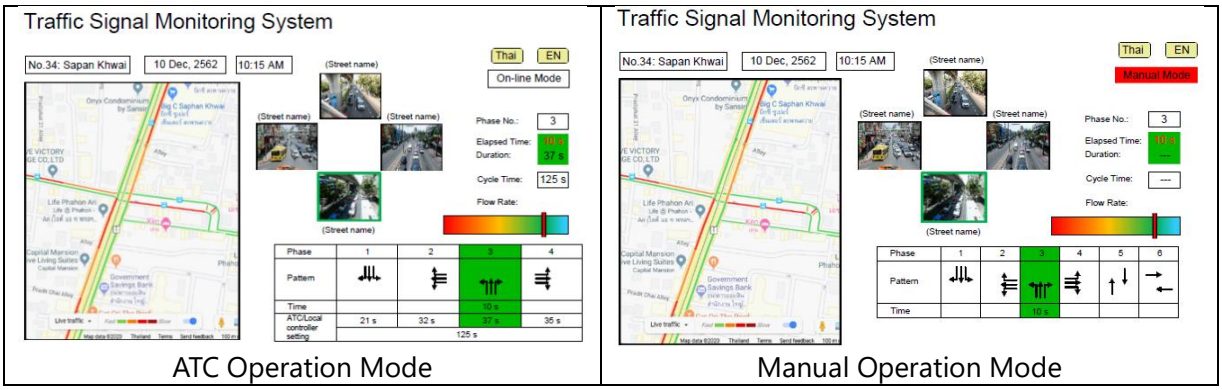
Source: JET

Figure 6.2.3 Police Box in the Pilot Project Area after the December 2021 Clash with Demonstrators

(3) Introduction of Support Tools to Aid in Manual Control of Signals

Given the RTP's current traffic management system, it is not practical to completely abolish manual operation of traffic signals by traffic police officers, except in cases of abnormal traffic conditions. To enable more efficient manual operation when necessary, support tools to aid in manual control of signals were installed in traffic police boxes at major

intersections. This tool allows traffic police officers to monitor traffic conditions, operating status of traffic signals, and optimal timing for signal changes. Its aim is to minimize the duration of manual operation and reduce inefficiencies associated with manual operation. The procurement of the tool was included as part of the ATC system installation package. Since the interface for this tool differs depending on whether the ATC system or manual operation is used, separate monitor screens were designed for each mode. This tool, along with the ATC system, was deployed in the pilot project area. Starting in June 2022, the control center began operating a system that monitors the operating status of traffic lights, CCTV camera footage, and related traffic data. Simultaneously, the manual operation support tool was installed at the target traffic police stations and became operational.



ATC Operation Mode　　Manual Operation Mode

Source: Genius and Sumitomo

Figure 6.2.4　Interface of Manual Operation Support Tool

(4) Trial Operation of Manual Control of Signals based on the Draft Operating Guidelines

In June 2023, a session was held to explain system usage to RTP and BMA staff, followed by trial operation. RTP officers noted the advantage of being able to view camera images and queue lengths when operating the system manually.

(5) Review and Finalization of the Operating Guidelines

The guidelines and manual were finalized after a review by RTP and BMA.

Chapter 7. Project Output 4: Preparation of a Short- and Medium-term Plan on ATC System Development for Bangkok Metropolitan Area

7.1 Summary

In Output 4, a draft development plan for an ATC system for the entire Bangkok was prepared, building on the system verified by the pilot project.

Output 4 is composed of five activities and one objectively verifiable indicator in the PDM.

Table 7.1.1 Objectively Verifiable Indicator for Output 4

4-1. The short and midterm plan is acknowledged as an official draft plan on ATC system development for BMA.

A short/midterm ATC system development plan was created taking into account BMA's budgeting schedule, related traffic and transportation plans, and lessons from study results on the use of probe data in this Project. .

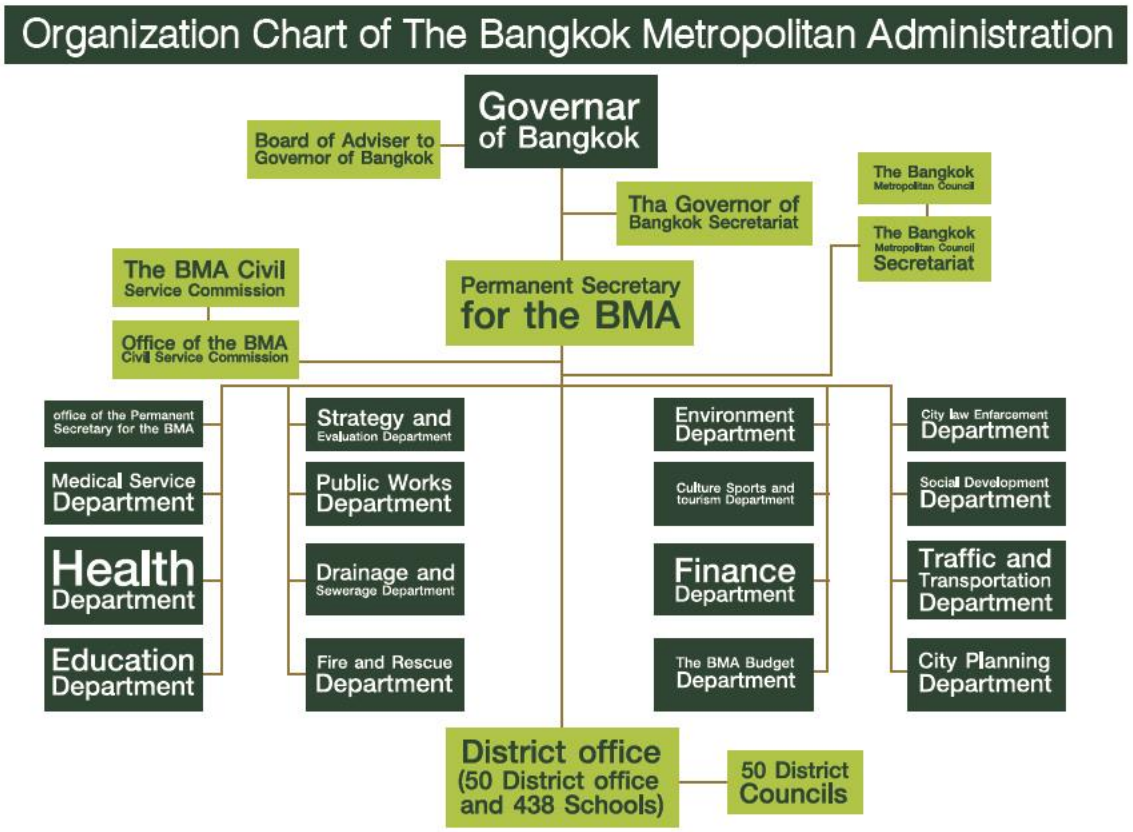
7.2 Activities

(1) Review of Roles and Policies of Organizations Involved in Planning of Traffic Control

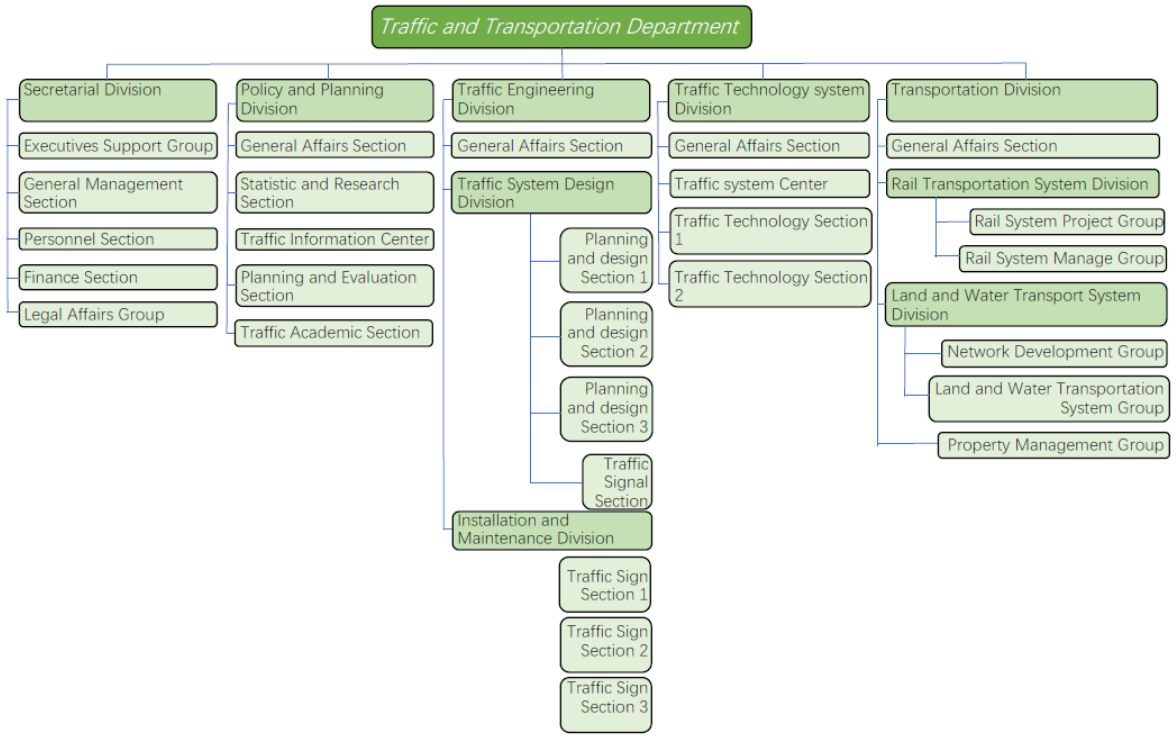
1) Organizational Structures of BMA and RTP

The organizational structures of BMA and RTP are shown in Figure 7.2.1 and Figure 7.2.2, respectively. In Bangkok, traffic signals and associated equipment are managed by the Traffic System Design Division under BMA's Traffic and Transportation Department (TTD), which is the main counterpart of this Project. For the pilot project, TTD's Traffic Technology System Division handled the installation and maintenance of the fiber optic cables required for the ATC system.

Meanwhile, signal operation in Bangkok falls under the Traffic Police Division of RTP's Metropolitan Police Bureau. For the pilot project, the Phayathai Police Station and Bang Sue Police Station were both responsible for the ATC system's operation.



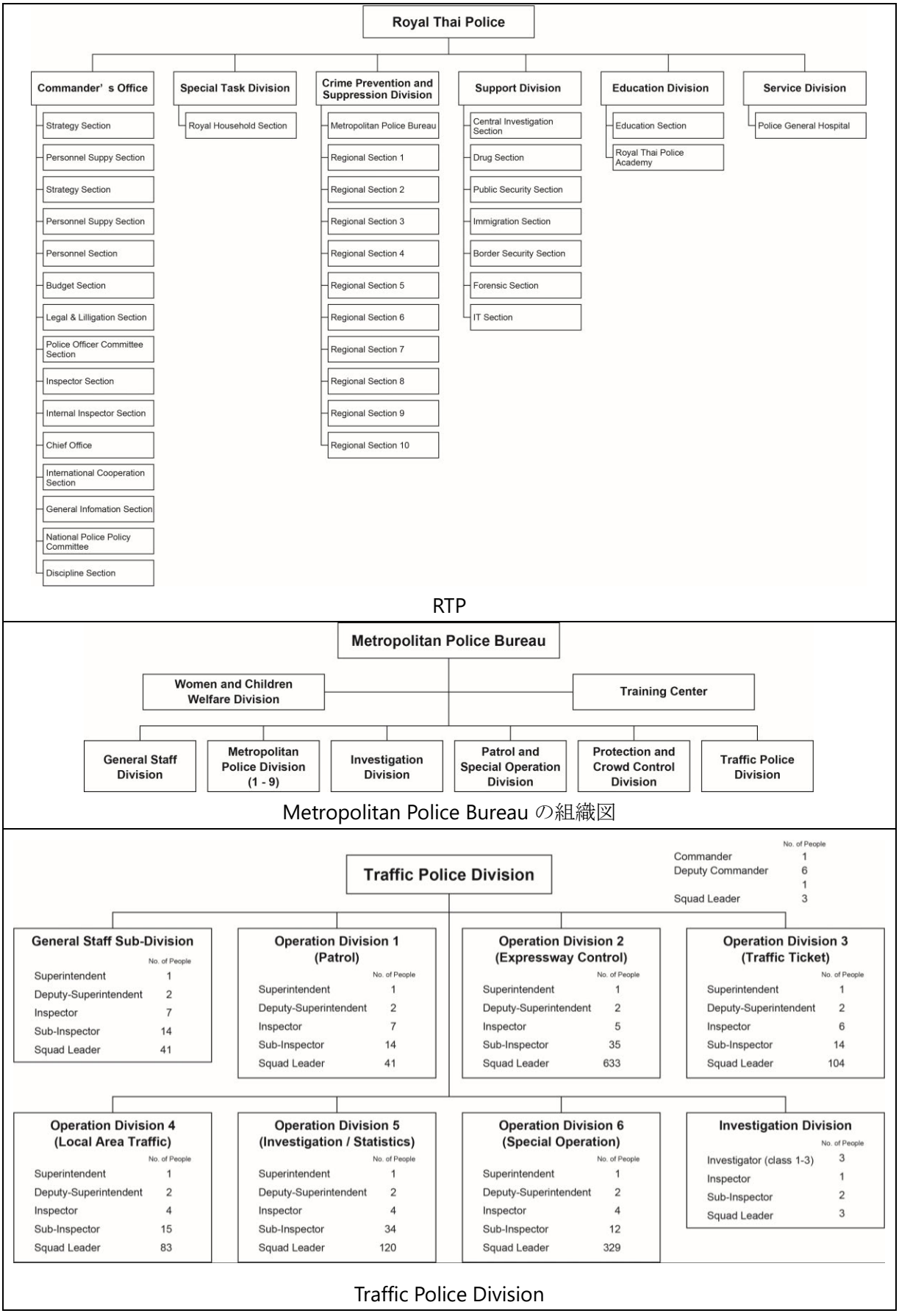
BMA



Traffic and Transport Department

Source: BMA

Figure 7.2.1 Organizational Structure of BMA and TTD



Source: RTP

Figure 7.2.2 Organizational Structure of RTP

2) Traffic Signalization Projects by BMA

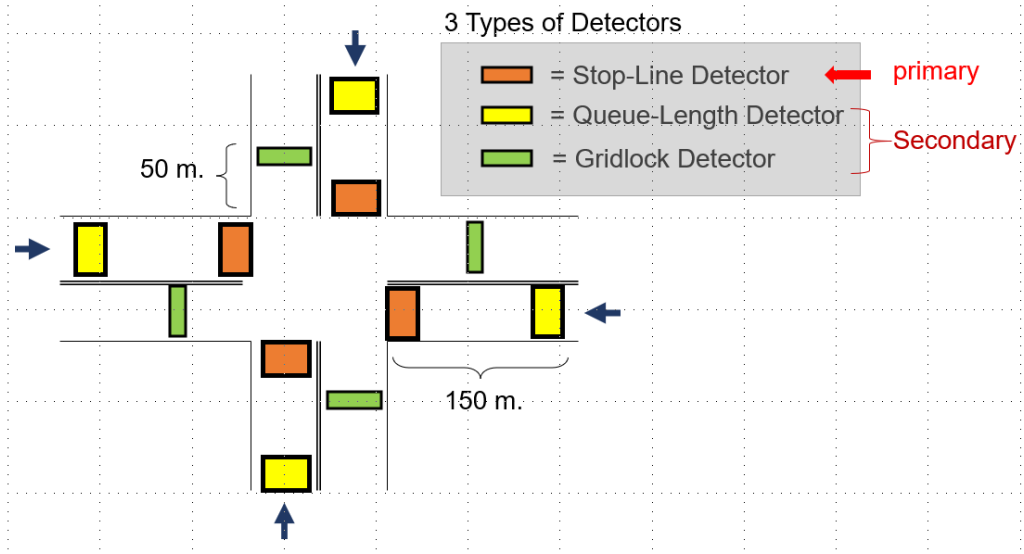
The BMA introduced a traffic signal called adaptive traffic signal[12] in 2009. These signals are believed to employ sensory control at individual intersections using loop-type sensors. The green time for each signal phase is calculated based on the last three cycles of the value obtained by multiplying the occupancy measured by the loop detectors installed near and upstream of the intersection. However, the details of how data from vehicle detectors related to multiple signals phases are processed and how they are handled in the event of a detector malfunction are unknown. According to its effectiveness analysis report, the average delay time for each signal phase was used as an effect indicator, but the method for measuring the delay time was not provided. According to the BMA, a total of 70 intersections were equipped with Adaptive Traffic Signals by 2013.

In fiscal year 2024 (October 2023–September 2024), BMA introduced what they refer to as adaptive traffic signals at 72 intersections, although the exact control mechanism has not been disclosed. Specifically, this system uses CCTV cameras to capture vehicle license plates and estimate travel times between two points by matching license plates captured at upstream and downstream locations near the intersection. Signal control is then based on these estimations. However, it is unclear how the system addresses challenges, such as reading license plates at night or during heavy traffic congestion when vehicle distances are minimal. Additionally, these traffic signals are designed for individual intersections and are not integrated with adjacent intersections.

BMA plans to install adaptive traffic signals at 100 intersections in the fiscal year 2026. However, this expansion is contingent on the effectiveness of the adaptive traffic signals introduced in fiscal year 2024. According to BMA, the supplier of these signals will conduct the effectiveness checks, and results are expected by January 2025.

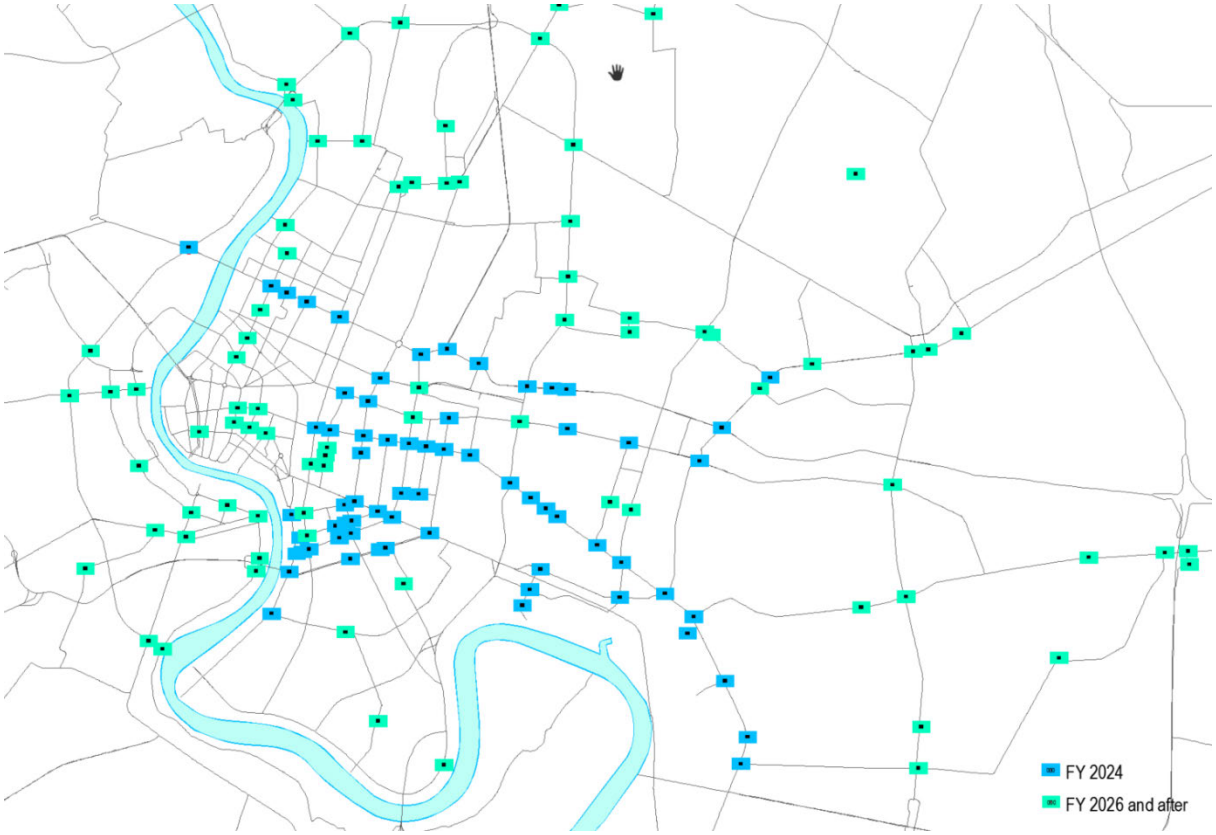
The technical specifications provided in the tender documents for the planned procurement refer to adaptive traffic signals but do not include any explanation or details about the control algorithm. According to BMA, sensors will be installed near intersections and approximately 150 meters upstream. Data from these sensors will be processed by a device attached to the signal controller and used to adjust signal control parameters.

[12] https://www.jstage.jst.go.jp/article/eastpro/2011/0/2011_0_404/_pdf



Source: BMA

Figure 7.2.3 Location of Detectors for Adaptive Signals



Source: BMA

Figure 7.2.4 Location Map of Planned Adaptive Signals

3) Other Traffic Signalization Projects in Bangkok

There are three traffic signalization projects implemented in Bangkok---two ongoing and another recently completed.

Table 7.2.1 Traffic Signalization Projects in Bangkok

Project Name	PO	Contractor	Outline
ATC Improvement Planning Project	BMA	AMP Consultants Ltd.	· Formulation of basic policy on and implementation plan for an ATC system · Formulation of basic policy on ATC system development and planning for development in four phases · Plan to implement the first phase as a pilot project · Final report to be completed in November 2021 (shown in Figure 7.2.5)
Artificial Intelligent Traffic System for Modern Cities Around Kasetsart University	Ministry of Transport	Kasetsart University	· AI-based traffic signal control for 14 signalized intersections · On February 2, 2022, BMA, RTP Metropolitan Police, and Kasetsart University signed an MOU to investigate technological improvements to traffic control systems, utilize resources among the three parties, conduct pilot projects, and continue projects.
Rama 4 Model	BMA PPP (Public-private partnership)	MOT, BMA, Metropolitan Police Bureau, Toyota Mobility Foundation, Chulalongkorn University	· Traffic improvement plans were analyzed using various data collected from RAMA 4, a major arterial road in Bangkok.

Source: JET summarize information from various sources

The projects mentioned above were implemented independently of this project after its commencement, with no significant collaboration between them. While many agencies recognize the need to improve traffic operations, including signalized intersections, this JICA project took the lead by demonstrating the effectiveness of the ATC system through a pilot project. Additionally, it developed a draft of the ATC system development plan, which has likely provided a significant impetus for improving traffic operations in the Bangkok Metropolitan Area. An outline of these projects is as follows:

ATC Improvement Planning Project

This project, commissioned by BMA independently of this JICA project, has the following objectives:

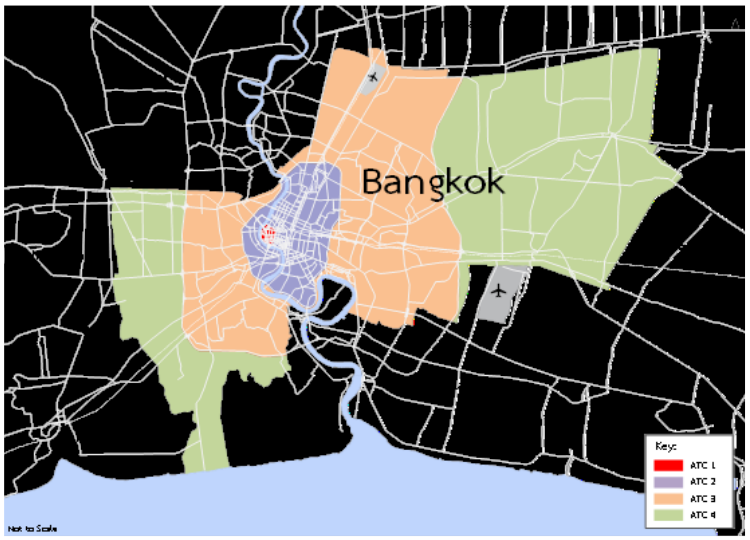
- To study and analyze the existing traffic issues around the junctions;
- To formulate a plan for improving and developing a traffic management system at intersections; and
- To prepare for the implementation of a traffic management system as part of a pilot project.

The proposed pilot project encompasses 22 intersections in Bangkok, with the overall system comprising the following subsystems:

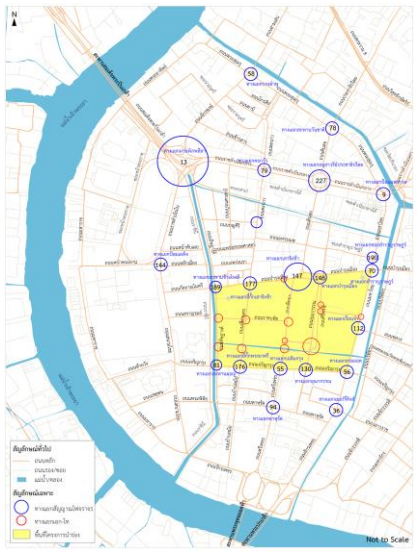
1) System
2) Traffic signalization
3) Artificial intelligence (AI)
4) Closed circuit television
5) Variable message sign
6) Journey time monitoring
7) Air quality measurement
8) Display and visualization system
9) Data analysis and visualization
10) Enforcement and compliance system

This project is being procured under a design-build bidding system, where the winning contractor is responsible for both designing and constructing the system. Consequently, there are no specific regulations regarding the type of ATC system to be implemented, and the evaluation method for proposals remains an issue. The project budget is THB620 million, with a timeline of 1.5 years for design and an additional 1.5 years for construction.

While this project incorporates numerous traffic and signal-related terms, the content remains largely conceptual, indicating a lack of in-depth knowledge and experience regarding ATC systems. This raises concerns about the project's feasibility. For instance, automatic license plate recognition is proposed as a means to assess traffic conditions, despite the fact that no ATC system has yet implemented this technology in practice. Additionally, there is no mention of the algorithms that would be used to optimize signal control parameters, which is a critical component of any effective ATC system.



ATC System Expansion Plan in Four Phases



Location of Phase 1

Source: ATC Improvement Planning Project

Figure 7.2.5 ATC Improvement Planning Project

<u>Artificial Intelligent Traffic System for Modern Cities around Kasetsart University</u>

BMA, RTP's Metropolitan Police Bureau, and Kasetsart University have collaborated on a study funded by the Thai government to enhance traffic control system technologies. The three parties have signed an MOU valid until February 2027, under which Kasetsart

University is responsible for conducting technical research, while BMA and RTP will jointly implement the pilot project. The findings from the research will be shared with both BMA and RTP. As of now, the results of the research have not yet been submitted.

Rama 4 Model

This traffic management project was conducted over three and a half years starting in November 2019 by the Ministry of Transport, BMA, Metropolitan Police Bureau, Chulalongkorn University, and the Toyota Foundation. It focused on a 16-kilometer section of Rama 4, a major arterial road in Bangkok. The project was fully funded by the Toyota Foundation and achieved three main outcomes:

- Effective use of traffic data through visualization;
- Identification of the root causes of traffic congestion and implementation of appropriate measures; and,
- Accumulation and dissemination of knowledge gained through the project.

For the first objective, the project utilized CCTV cameras, Bluetooth devices, and traffic data provided by Grab to visualize the traffic situation. Regarding the second objective, three congestion sites along Rama 4 were identified. Specific measures were proposed and implemented to alleviate congestion in each area, resulting in improved traffic conditions across all three hotspots. Finally, for the third objective, the project demonstrated the effectiveness of data-driven traffic management, providing valuable insights for future initiatives.

(2) Review of Urban Transportation in Bangkok Metropolitan Area

Taking into account the urban structure and socio-economic situation of the Bangkok Metropolitan Area, information was gathered on vehicle ownership, the status of road infrastructure and railway network development, related plans, the status of traffic control system development, modal share, and other relevant factors. The main related plans are outlined in Table 7.2.2.

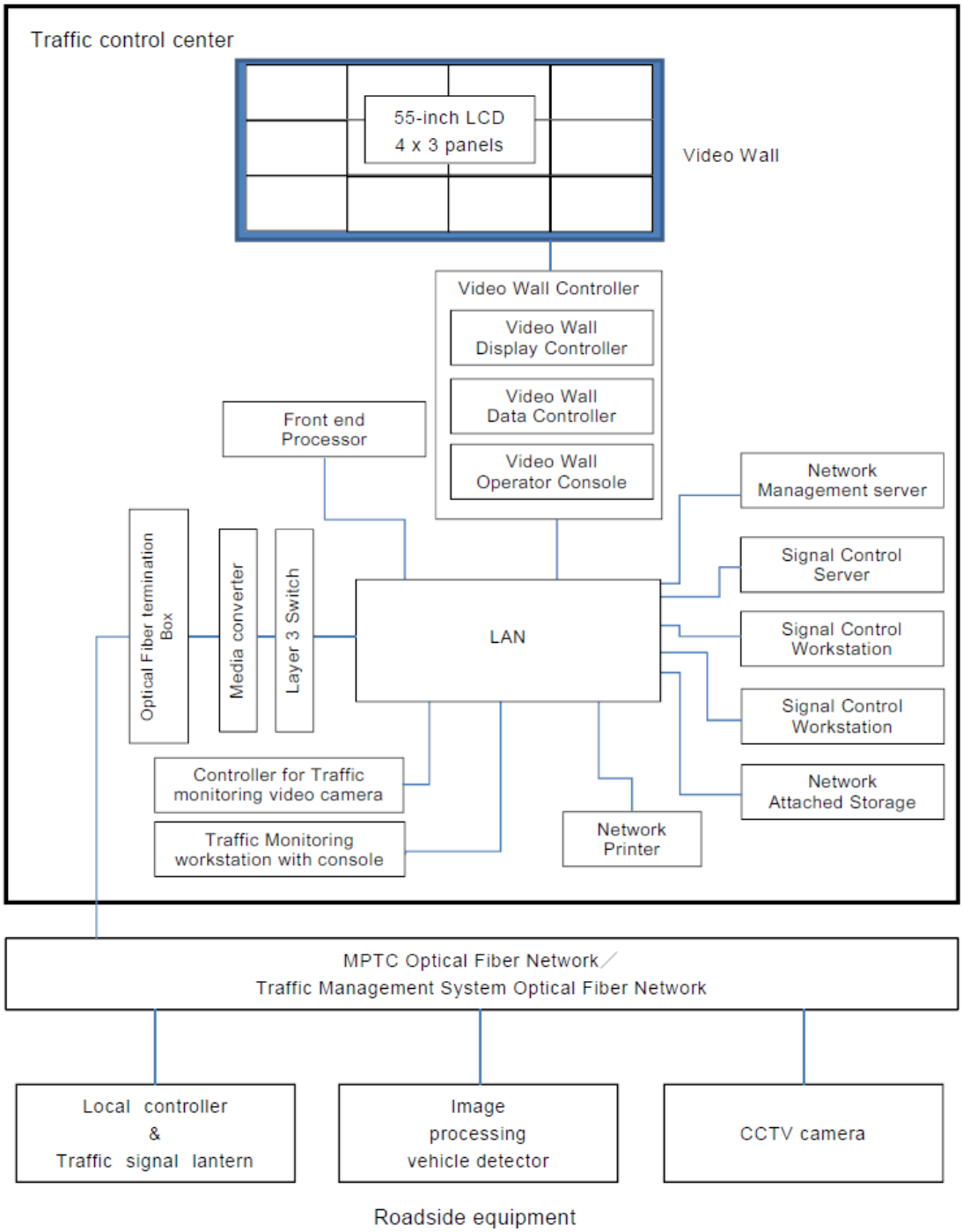
Table 7.2.2 Major Transportation-related Plans

Name of Plan	Organization
Transportation Infrastructure Development Strategy of Thailand (2015-2022)	OTP, MOT
Intelligent Transport System Master Plan (2012 – 2017)	OTP, MOT
ITS Development Plan	OTP, MOT
Study of Intelligent Transport System Development Master Plan in Bangkok Metropolitan Region	OTP, MOT

Note: JET summarized the information collected from various sources.

(3) Study of ATC Systems in Other Countries

The ATC system installed in Phnom Penh, Cambodia, was reviewed, and its issues were summarized. The ATC system in Phnom Phen was established through a Japanese grant aid project and developed by a Japanese private company. The O&M manuals for this project were prepared with reference to the operating practices in Phnom Pehn.



Source: The Project for Development of Traffic Management System in Phnom Penh

Figure 7.2.6 System Configuration of Phnom Penh's ATC System

Table 7.2.3 ATC System Equipment in Phnom Penh's ATC System (Control Center)

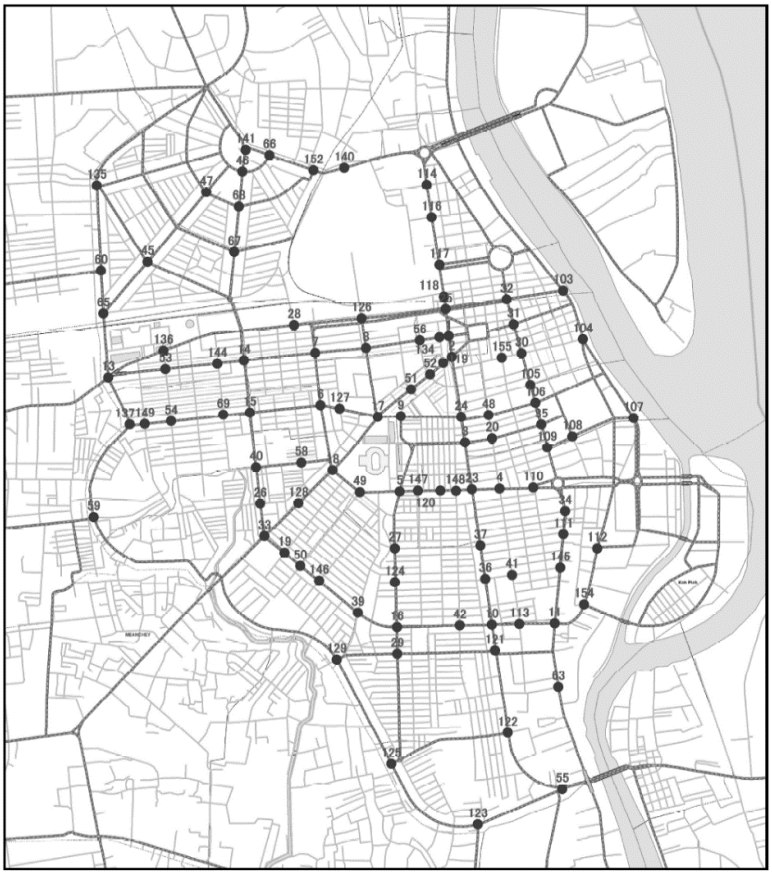
Item No.	Description	Quantity	Unit
1-1	Network management server	1	set
1-2	Signal control server	1	set
1-3	Signal control workstation	2	set
1-4	Network attached storage	1	set
1-5	Front-end processor	1	set
1-6	Network printer	1	set
1-7	Video wall	1	set
1-8	Video wall controller	1	set
1-9	Traffic monitoring workstation with console	1	set
1-10	Vehicle detector data processing software	1	set
1-11	Signal control software	1	set
1-12	Equipment operation monitoring software	1	set
1-13	Human-machine interface	1	set
1-14	Statistics software(	1	set
1-15	Database software	1	set
1-18	Uninterruptible power supply	1	set
1-19	Controller for traffic monitoring video camera	1	Set
1-20	Layer 3 switch	1	set
1-21	Layer 2 switch	2	set
1-22	Media converter	2	set
1-23	Generator	1	set

Source: The Project for Development of Traffic Management System in Phnom Penh

Table 7.2.4 ATC System Equipment in Phnom Penh's ATC System (Local Devices)

Item No.	Description	Quantity	Unit
2-1	Local controller (standard and large)	100	set
2-2	Layer 2 switch	102	Set
2-3	Media converter	2	set
2-4	Signal lantern (vehicle and pedestrian)	1745	set
2-5	Vehicle detector	180	set
2-6	Traffic monitoring video camera	26	set

Source: The Project for Development of Traffic Management System in Phnom Penh



Source: The Project for Development of Traffic Management System in Phnom Penh

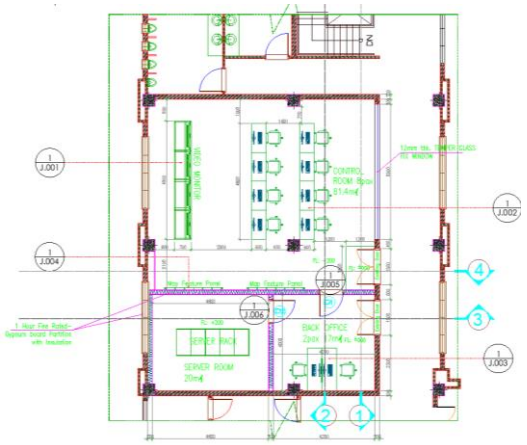
Figure 7.2.7 Location of Intersections Connected to ATC System in Phnom Phem

The location of intersections connected to the ATC system are shown in Figure 7.2.7, and photos and the layout of the control center in Phnom Penh are shown in Figure 7.2.8. On-site observations and interviews with relevant parties identified the O&M issues in Phnom Penh's ATC system (Table 7.2.5).

Table 7.2.5 O&M Issues in Phnom Penh's ATC System

· The officers responsible for O&M are local employees of JET who initially managed the detailed design and construction of the ATC system. They are well-acquainted with the system's specifications and operation.
· Consequently, the staff at the ATCS control center can make system adjustments beyond regular operations, such as modifying signal control parameters.
· Maintenance and operation manuals, along with as-built drawings for the system and its components, have been provided by the system supplier and are available on site.
· However, there are frequent incidents where vehicles damage signal control devices, signal lamps, vehicle detectors, and/or mounting poles. This issue occurs because vehicles are often parked on sidewalks in Phnom Penh.
· Since the equipment is manufactured in Japan and the poles are sourced from Thailand, repairs cannot be done readily due to budget constraints and logistical issues, often necessitating emergency measures to address damage.

Source: JET

	
Control Center	Layout Plan of the Control Center

Source: The Project for Development of Traffic Management System in Phnom Penh

Figure 7.2.8 Photos of the Control Center in Phnom Phen

(4) Formulation of the Draft Short and Midterm Plans for Developing the ATC System in Bangkok Metropolitan Area

1) Considerations

The draft ATC System Development Plan was prepared based on the following considerations:

a) Developing a system tailored to Bangkok's road network and traffic conditions;
b) Maximizing the use of existing facilities and resources;
c) Ensuring sustainable O&M; and,
d) Planning a phased expansion.

2) Coverage Area

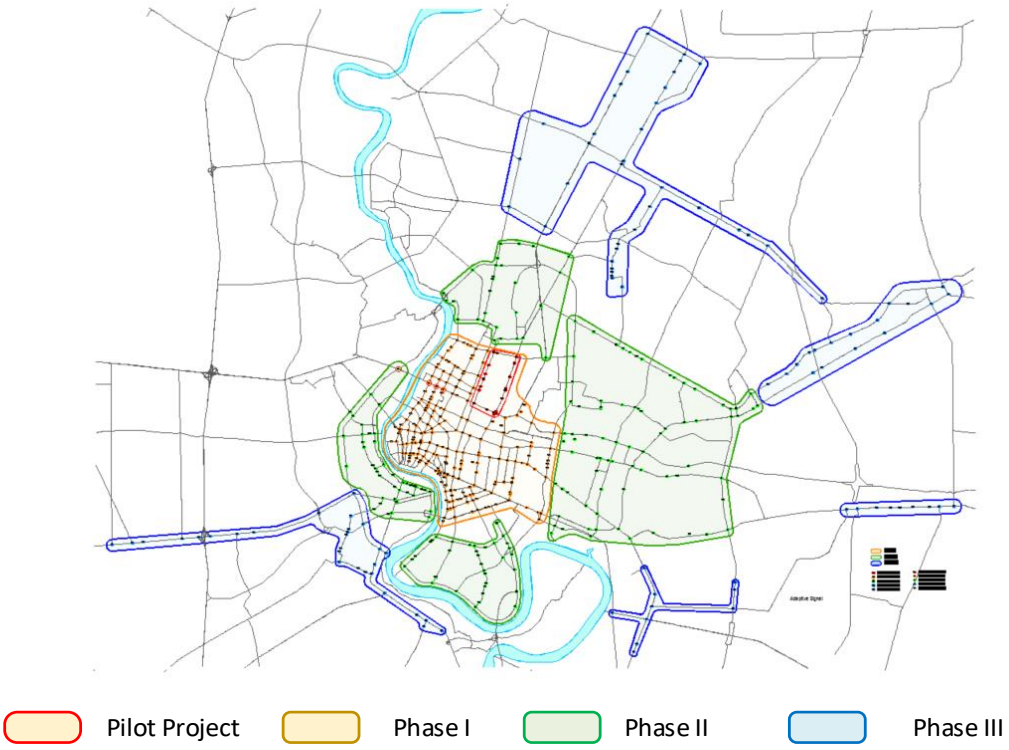
As of September 2023, there were 539 intersection signals and 321 pedestrian signals in Bangkok. The plan is to develop the system in three phases, since it is not realistic to incorporate all these signals into the ATC system at once due to budget and time constraints. In each phase, 100 to 200 signals will be converted to ATC over 1.5 to 2 years. The first phase will cover central Bangkok, with the second and third phases expanding the system toward the periphery. The planned number of signals and coverage for each phase are shown in Table 7.2.4. Since all these signals are located on major roads, it would be desirable to operate them more efficiently by systematizing them with an ATC system. For comparison, Tokyo has approximately 16,000 traffic signals, half of which, around 8,000, are operated by an ATC system. The remaining 8,000 are isolated signals, primarily installed on roads other than major roads where the need for signal systematization is minimal. These signals are operated

to be primarily aimed at enhancing traffic safety.

Table 7.2.6 Number of Existing Traffic Signals and Phased Expansion

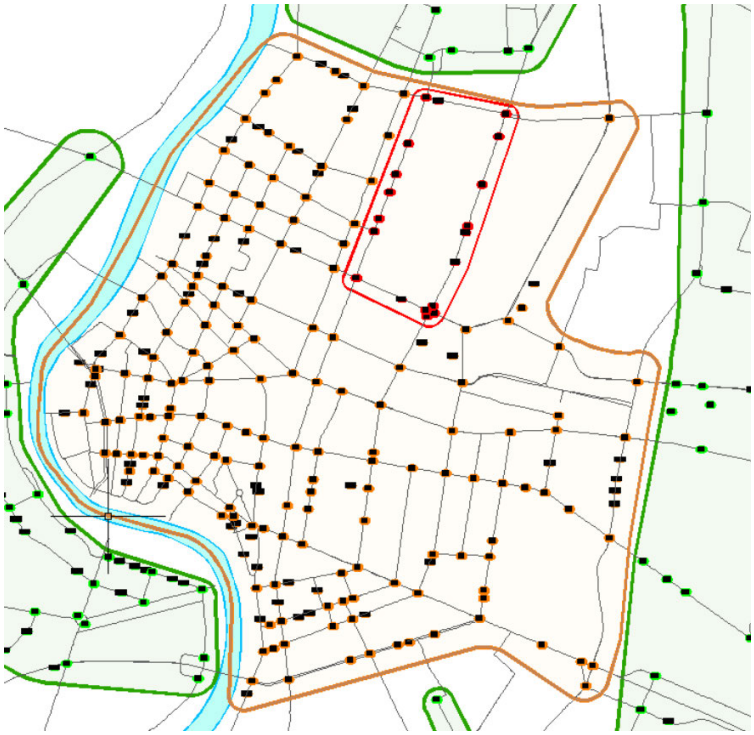
Location	No. of Existing Traffic Signals	Traffic Signals Connected to ATC System				
		Pilot Project	Phase 1	Phase 2	Phase 3	Total
Intersections	541	15	159	135	83	392
Pedestrian Crossings	323	4	51	44	18	117
Total	864	19	210	179	101	509

Source: BMA and JET



Source: BMA and JET

(a) Entire Coverage Area



Source: BMA and JET

(b) Phase 1 Coverage Area

Figure 7.2.9 ATC System Coverage Area

3) Function and Configuration of the ATC System

The proposed ATC system includes the following five core functions:

a) Assessing traffic conditions

The ATC system operates and adjusts signal control based on traffic conditions, which requires accurate traffic data. Traditionally, vehicle detectors, such as ultrasonic sensors, loop detectors, and CCTV cameras, have been used. In the Project, the usefulness of traffic situation data from probe cars was examined. The findings revealed that the queue lengths observed on site closely matched those calculated using vehicle probe data. A detailed comparison between the queue lengths measured by probe data and those observed on site is provided in the next section, which discusses the use of cutting-edge technology, including vehicle probe data, in the ATC system. However, implementing vehicle probe data presents challenges. These include the high cost of data acquisition and the lack of redundancy from relying on a single data source. Additionally, since vehicle probe data is typically acquired through subscription, it is crucial to determine whether recurring costs can be accommodated within the BMA's budget. The feasibility of applying vehicle probe data to the ATC system is described in the next section. In this Project, the method for monitoring traffic conditions will not be predetermined. Instead, it is proposed that

bidders' methodologies be reviewed and evaluated during the system bidding process.

b) Controlling traffic signals in real time

This function involves an algorithm that adjusts and optimizes the signal display times based on traffic conditions obtained from vehicle detectors. Although various methods have been applied in practice, the specifics of these algorithms are generally not disclosed. In recent years, the focus of signal control has expanded beyond reducing vehicle travel time to include additional priorities, such as integrating bus and bicycle lanes and enhancing pedestrian safety at crossings. Consequently, it is recommended not to specify a particular signal control algorithm. Instead, a review and selection process based on bidders' proposals should be conducted during the procurement process.

c) Monitoring system status

The hardware, software, and communication systems of the ATC system require continuous monitoring. In the event of a fault, an alarm should sound to enable prompt corrective action.

d) Building a database

The ATC system manages both static data (e.g., controller and vehicle detector information) and dynamic data (e.g., traffic conditions, equipment operational status, and fault records). An efficient database system capable of managing various types of data online is required.

e) Communicating data between the center and roadside equipment

In an ATC system, signal controllers operate based on commands from the traffic control center, and it is also essential to relay their operating status back to the center. Traffic condition data collected by vehicle detectors is also transmitted to the center to support signal control. A fiber optic cable network is used for this data communication.

4) Traffic Control Center

A traffic control center will be established on the first floor of the BMA2 building. The necessary space has already been secured, and the general layout is shown in Figure 7.2.10. However, the internal layout needs to be considered as it is not necessary to have as many staff as shown in the diagram.

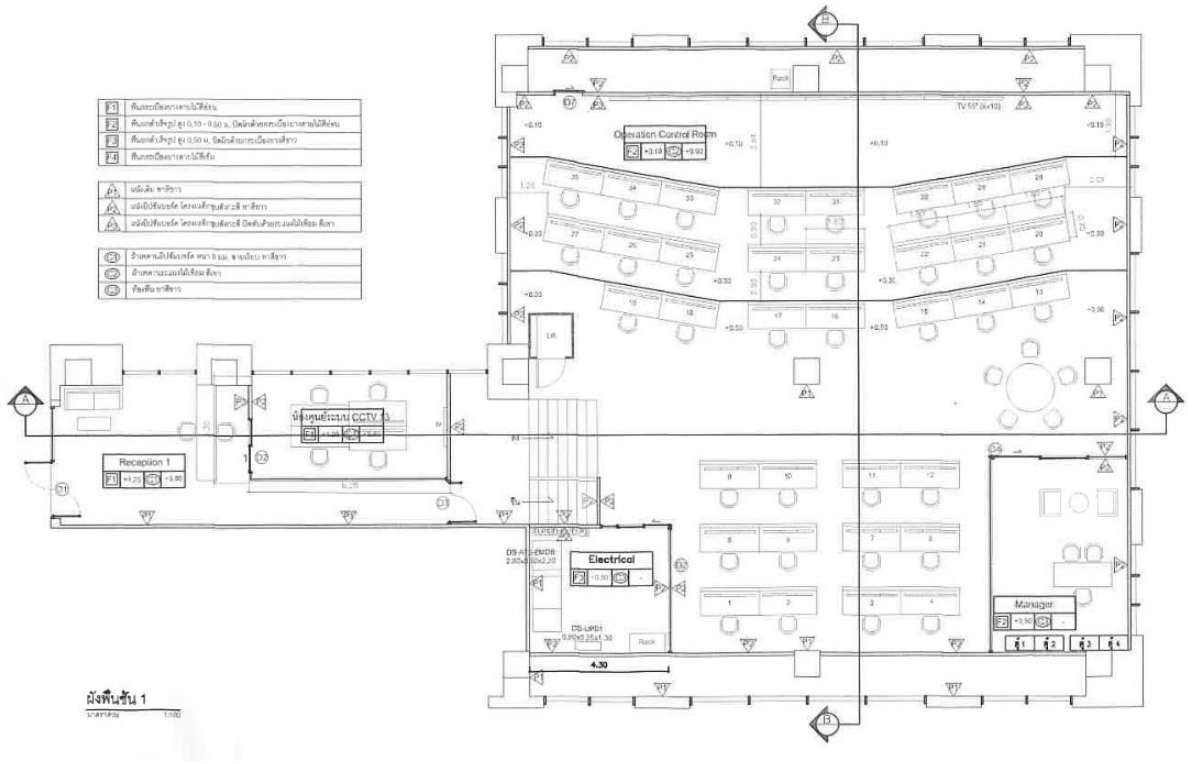
The general layout of the planned control center is as follows:

Location: First floor of the BMA2 building

Area: 18m x 18m (324m^2)

Layout: Refer to Figure 7.2.10

Machine room: To be determined or integrated as part of the control room.



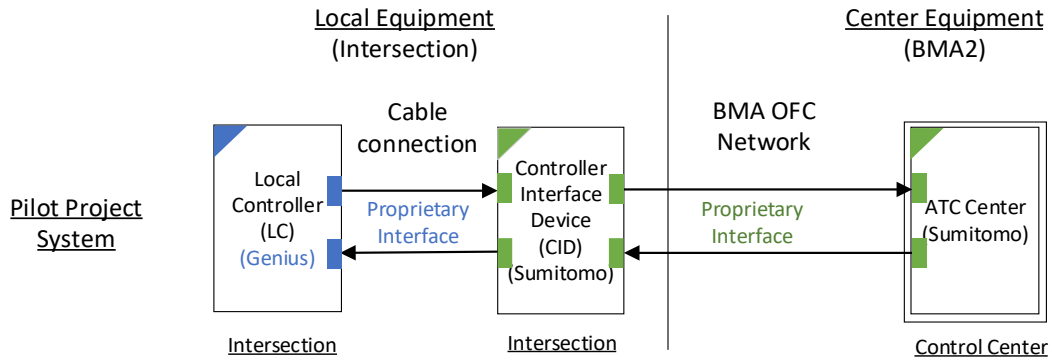
Source: BMA

Figure 7.2.10 Layout Plan for the New Traffic Control Center in BMA2 Building (same with Figure 5.2.1)

5) Configuration and Interface of the ATC System in the Pilot Project

In the pilot project, the signal controllers at the intersections were manufactured by Genius, while Sumitomo handled the control center equipment, software, database, and interface devices (controller interface devices or CIDs) which connect to Genius signal controllers. The configuration diagram is shown in Figure 7.2.11. Specifics about data transmission between signal controllers and CIDs, as well as between CIDs and the control center (including data content, transmission and reception timing, error countermeasures and processing, etc.) have not been disclosed to the Project Team by the two contractors.

It is assumed that commands from the control center to CIDs follow the indication step units commonly used in Japan (independently controlling green, yellow, and red lights). In contrast, Genius's traffic signals are controlled as sets of green, yellow, and red, with this difference reconciled through the CIDs.



Source: JET

Figure 7.2.11 Configuration of the ATC System for the Pilot Project

6) System Development Plans

BMA has been introducing adaptive traffic signals starting from fiscal year 2024. The planned ATC system will primarily utilize adaptive traffic signals; however, the use of other signal controllers will also be considered if they offer advantages in terms of functionality or overall costs, including maintenance expenses.

There are three potential approaches to develop the ATC system for BMA.

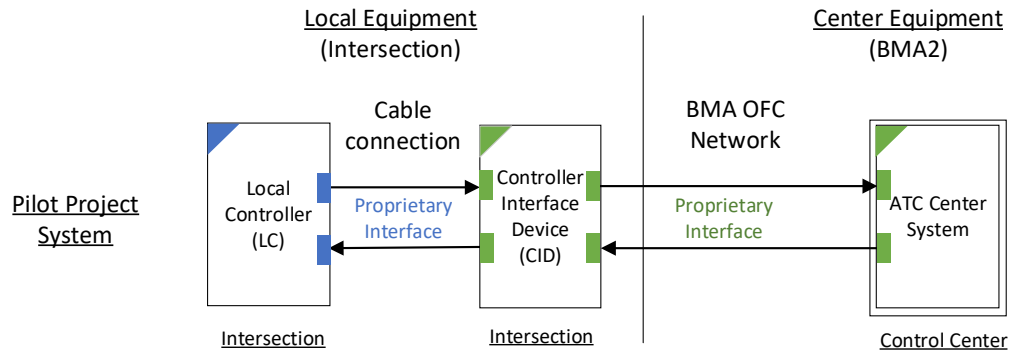
Table 7.2.7 Alternative Cases of ATC System Development

Option A:	The current system will be expanded to increase the number of traffic signals that can be controlled.
Option B:	CIDs will be introduced to connect the adaptive signals introduced by BMA to the planned control center to be established in BMA2 building. The ATC center system will be developed as part of this initiative.
Option C:	All signal control devices and a control center will be replaced with new equipment.

Source: JET

Option A

Option A is will simply expand the existing system.



Source: JET

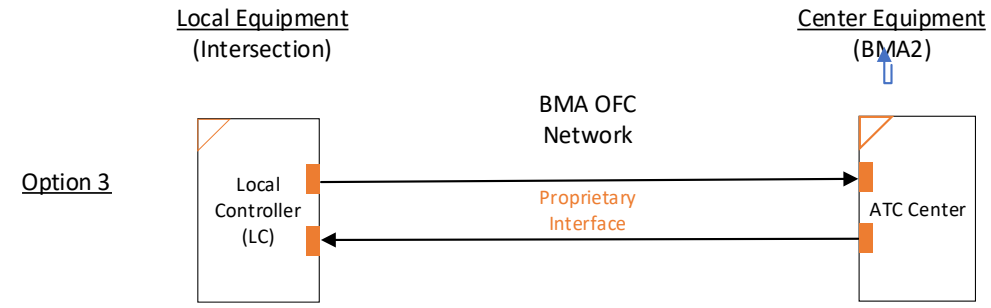
Figure 7.2.12 System Configuration for Option A (Same as the Pilot Project System)

The interfaces between the signal controllers and the CIDs used in the pilot project, as well as between the CIDs and the control center, have not been disclosed to the Project Team. Therefore, unless the provider of the pilot system's central system discloses the specifications of the central equipment, software, database, and CID, the pilot ATC system cannot be expanded in its current form.

Pros · No need to develop new hardware, software, communication protocols, or databases. · The reliability of the CID and communication protocols has already been verified. · Short construction time since no new development is required.
Cons · Unless details of the existing ATC system are disclosed, only the current providers of the hardware and software can implement this expansion. · The factors mentioned above could substantially reduce competitiveness during the bidding process.

Option B

Option B involves replacing all signal controllers and the control center with new equipment.



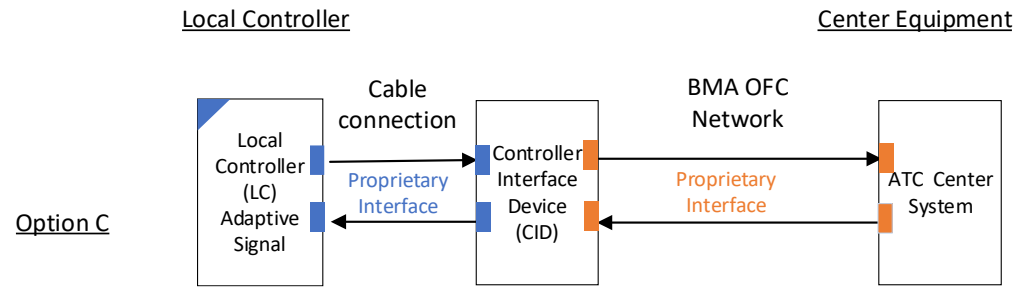
Source: JET

Figure 7.2.13 System Configuration for Option B

Pros · Minimal technical risks and short construction period, as a proven ATC system is introduced. · Open bidding process allows participation from any signaling system manufacturer. · Project timeline is shortened since no new development is needed.
Cons · Existing facilities cannot be used. · Updating all equipment and software will incur high costs. · If the system will be provided by a supplier outside Thailand, future maintenance, operation, and expansion may present challenges.

Option C

An additional device, the CID, will be integrated into the existing adaptive signals to enable connectivity to the new ATC center.



Source: JET

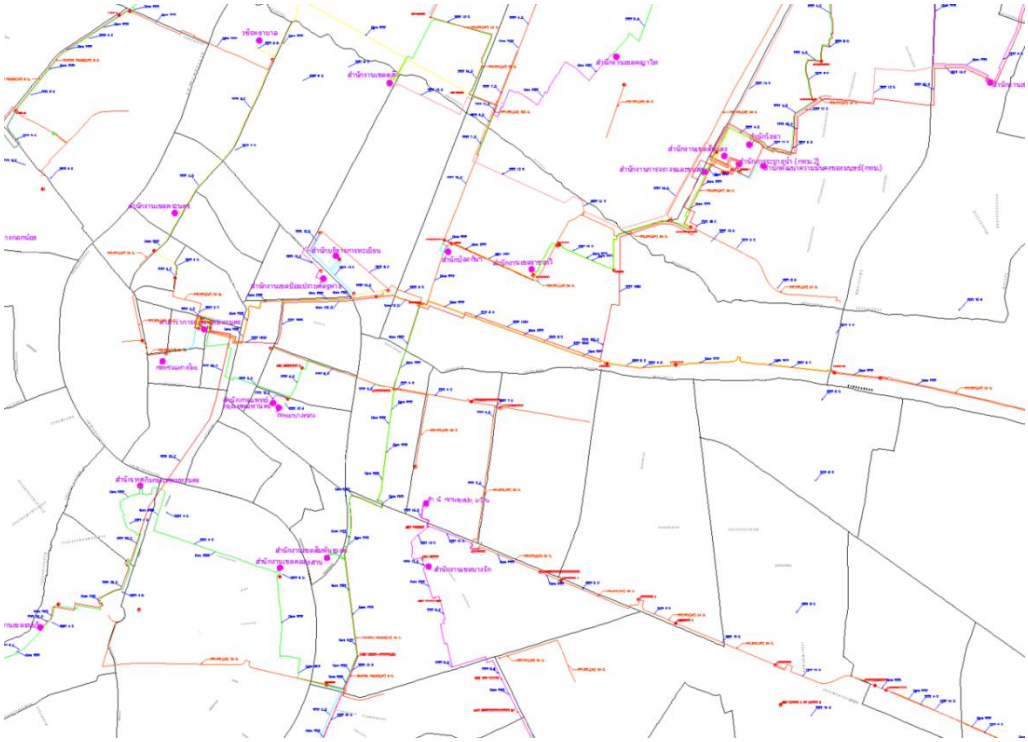
Figure 7.2.14 System Configuration for Option C

Pro · The cost of the controller can be reduced by utilizing the existing adaptive signals.
Cons · The ATC system will feature a new configuration, requiring the technical feasibility to be guaranteed at the time of bidding. · Developing and producing the additional CID will increase costs and may extend the project timeline. · The data processing function and hardware of the vehicle detectors in the existing adaptive signals cannot be utilized. · The progress of the ATC project and its target intersections will depend on the ongoing s installation project being implemented by the BMA. · The feasibility of the system will be influenced by the intentions and cooperation of the existing adaptive signal manufacturer. · Consideration is needed on whether to disclose the specifications of the existing adaptive signal during the bidding process or require bidders to develop an interface with the adaptive signal in advance and submit their bids.

According to BMA regulations, ATC system procurement must be conducted through competitive bidding. Therefore, it is preferable to allow participation in any of the options above and leave the system configuration to the supplier's discretion. However, the ATC system must have a proven track record.

7) Fiber Optic Cable Network

In the ATC system, data is exchanged between the central device in the control center and the CIDs installed at intersections and along roadsides. A data communication network is essential for this purpose. The pilot ATC system utilized an existing fiber optic cable (FOC) network owned and operated by BMA. However, the condition of the cables was unknown in many areas, leading to unforeseen additional cabling needs (Figure 4.2.7 and Figure 4.2.8). Furthermore, while BMA's fiber optic network covers most of the Bangkok metropolitan area, there are no drawings for connection changes made during maintenance or additional installations, and the communication speed is significantly slower than that of a standard fiber optic network.



Source: BMA

Figure 7.2.15 BMA's Fiber Optic Cable Network (A part of the Network)

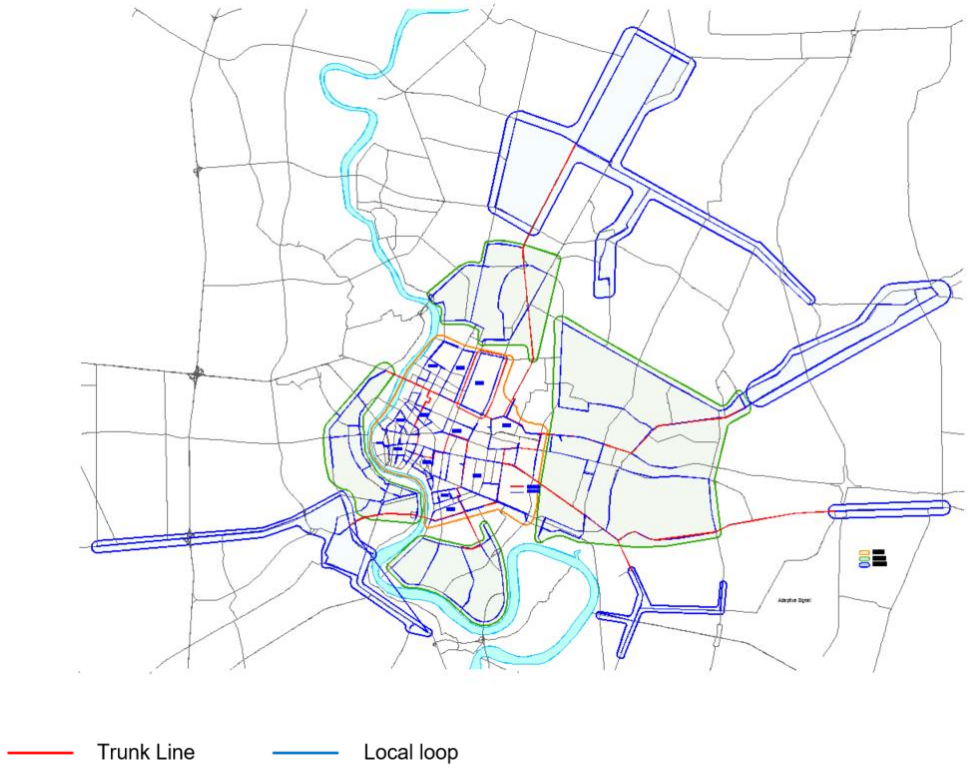
Given the above situation, the draft ATC development plan includes the installation of new fiber optic cables. The estimated length and route of the proposed FOC network are shown in Table 7.2.8, Figure 7.2.16, and Figure 7.2.17.

Table 7.2.8 Length of FOC Network

(unit: km)

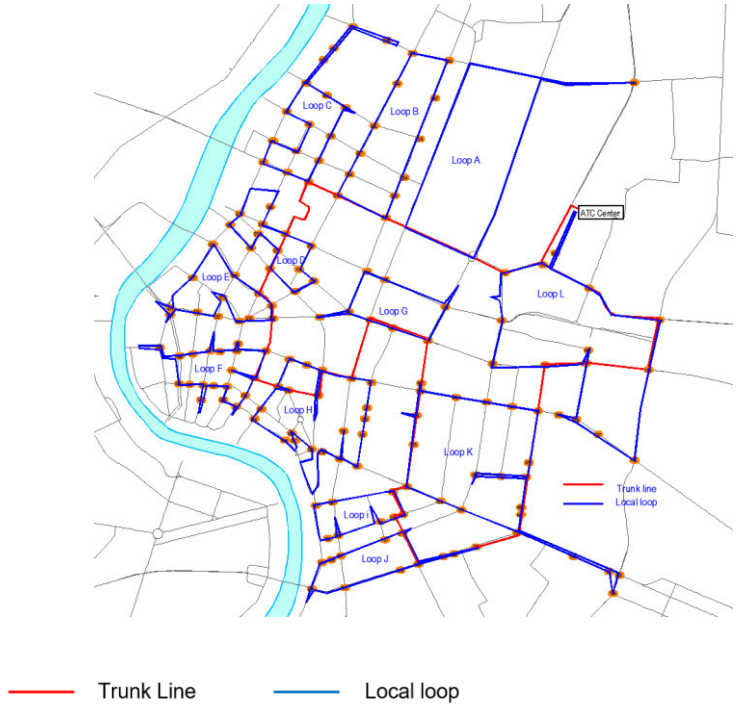
Type	No. of Core	Phase 1	Phase 2	Phase 3	Total
Trunk line	12C	27.9	26.9	29.2	86.6
Local loop	4C	95.6	154.2	134.3	384.1

Source: BMA and JET



Source: BMA and JET

Figure 7.2.16 Planned FOC Network for Bangkok Metropolitan Area



Source: BMA and JET

Figure 7.2.17 Planned FOC Network for Bangkok Metropolitan Area under Phase 1

8) Project Cost

The cost estimates for each phase are shown in Table 7.2.9 and Table 7.2.10. The following conditions were applied to the estimates:

- A new ATC system will be introduced, with the option for the contractor to propose whether to expand the pilot ATC system or to develop a new one.
- A new type of traffic signal will be introduced, as the existing signal controller has functional limitations.
- The choice of vehicle detector type (loop, ultrasonic, CCTV camera) will be left to the contractor.
- The cost of laying fiber optic cables will be estimated separately for reasons described below.
- The O&M costs of the ATC system are not included.
- Although the project has a long-term scope, the estimate is based on current prices.

Table 7.2.9 Project Cost (Excluding Laying of FOCs)

Item No.	Description	Amount (THB)			
		Phase 1	Phase 2	Phase 3	Total
A	System Design	965,000			965,000
B	Documentation	850,000	160,000	160,000	1,170,000
C	Training	828,000	828,000	828,000	2,484,000
D	Traffic control center equipment	3,464,330	405,250	229,500	4,099,080
E	Remote monitoring system	243,770			243,770
F	Traffic control center software	8,997,000	3,774,000	1,818,000	14,589,000
G	Local controller	66,666,180	88,865,982	50,142,258	205,674,420
H	Vehicle detector	128,200,835	108,878,040	66,873,230	303,952,105
I	Communication equipment at Center	124,430	75,030		199,460
J	Optical fiber cable				
K	Spare parts and maintenance equipment	425,000	260,000	260,000	945,000
Total for Items A through K		**210,764,545**	**203,246,302**	**120,310,988**	**534,321,835**
	Overhead (10%)	21,076,455	20,324,630	12,031,099	53,432,184
	VAT (7%)	16,228,870	15,649,965	9,263,946	41,142,781
Grand Total		**248,069,869**	**239,220,897**	**141,606,033**	**628,896,800**

Source: JET

According to interviews with BMA and contractors responsible for installing and

maintaining fiber optic cables for existing CCTV cameras, network and connection diagrams are created when new cables are laid. However, diagrams are not maintained for changes to connections due to maintenance work or additional installations. As a result, it is proposed that when an ATC system is introduced, it should not rely on existing fiber optic networks, and new installations should be planned.

Additionally, the communication speed required for the ATC system is 10 kbit/s or less, which is significantly slower than the typical speed of a fiber optic network (several Gbit/s). Therefore, once fiber optic cables are installed for the ATC system, they could be repurposed for other uses.

Table 7.2.10 Project Cost of Laying FOCs

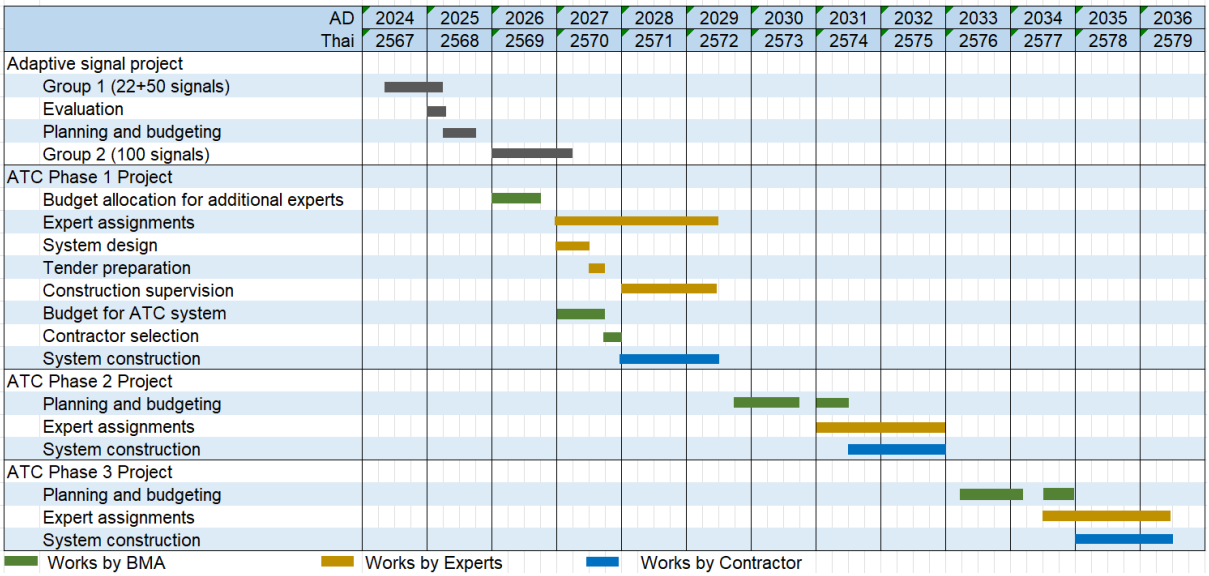
Item No.	Description	Amount (THB)			
		Phase 1	Phase 2	Phase 3	Total
J	Fiber Optic Cable	430,000,000	704,120,000	675,350,000	1,809,460,000
	Overhead (10%)	43,000,000	704,120,000	675,350,000	180,947,000
	Tax (7%)	33,110,000	54,217,240	52,001,950	139,329,190
	Total	**506,110,000**	**828,749,240**	**794,886,950**	**2,129,746,190**

Source: BMA and JET

9) Schedule

The expected project schedule is shown in Table 7.2.11. The ATC system will be introduced in three phases. The first phase is planned to begin in 2025, following budget approval; the second phase will commence in 2028; and the third phase is scheduled to start in 2032. The Short- and Medium-Term Development Plan for the ATC System is shown in Appendix 14. JET assumed that a new FOC network will need to be installed due to the uncertain condition of the existing network. Given the significant capital investment required, JET recommends to first proceed with the signal conversion of major intersections to the adaptive mode. These priority intersections can then be connected to the newly procured or improved ATC system to mitigate traffic congestion at the earliest time possible.

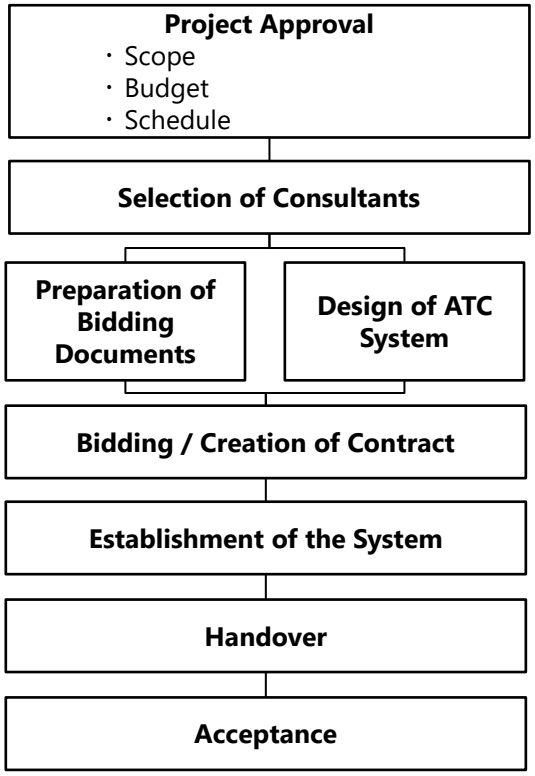
Table 7.2.11 Tentative Schedule of ATC System Development



Source: BMA and JET

10) Implementation of the ATC System Development Project

The implementation flow to develop the ATC system is shown in Figure 7.2.18.



Source: JET

Figure 7.2.18 Implementation Flow for ATC System Development

Use of Consultants

The design of the ATC system, supplier selection, and construction management will require experts with experience in ATC systems. Additionally, the design and construction of the ATC system demands a wide range of expertise in traffic engineering, computer systems, data communications, project management, and construction management. As BMA lacks experts with the necessary knowledge and experience in these fields, the use of consultants is essential for project implementation.

The consultants' responsibilities include the following:

- Project management
- Detailed design of the ATC system
- Project cost estimation
- Preparation of bidding documents
- Assistance in contractor selection
- System construction and construction management
- Receipt inspection
- Technology transfer

Two-Envelope Bidding

The bidding process should preferably be a two-envelope process, in which technical proposals and price bids are submitted in separate envelopes at the same time. In this case, technical proposals are reviewed first, and the price bids of bidders who meet the technical requirements are then opened. The contract is awarded to the bidder offering the lowest price among those who qualify. However, based on previous interviews with BMA, it appears that BMA (specifically TTD) has no experience with the two-envelope process, and it remains unclear whether this method can be adopted.

11) Budgeting Process in BMA

The annual budgeting process for BMA is outlined in Table 7.2.12. A fiscal year in Thailand runs from October to September of the following year. Each department is required to prepare its budget proposals for the upcoming fiscal year within three months of the fiscal year's start.

Table 7.2.12 Budgeting Process of the Bangkok Metropolitan Administration

Month	Process
Oct–Dec	· Creation of budget estimates by each division/department
Jan–Apr	· Examination of budget estimates from each division/department by Bangkok

	Budget Bureau (BBB)
May	· Deliberation in committees and BMA administrators
Jun	· Preparation of budget proposal in BMA
Jul–Aug	· Review and approval by BMA Council · Signing of the budget proposal by BMA Governor
Sep	· Explanation and submission of the budget proposal by the BMA Council to the Royal Institution · Approval by the Royal Institution of BMA's budget proposal

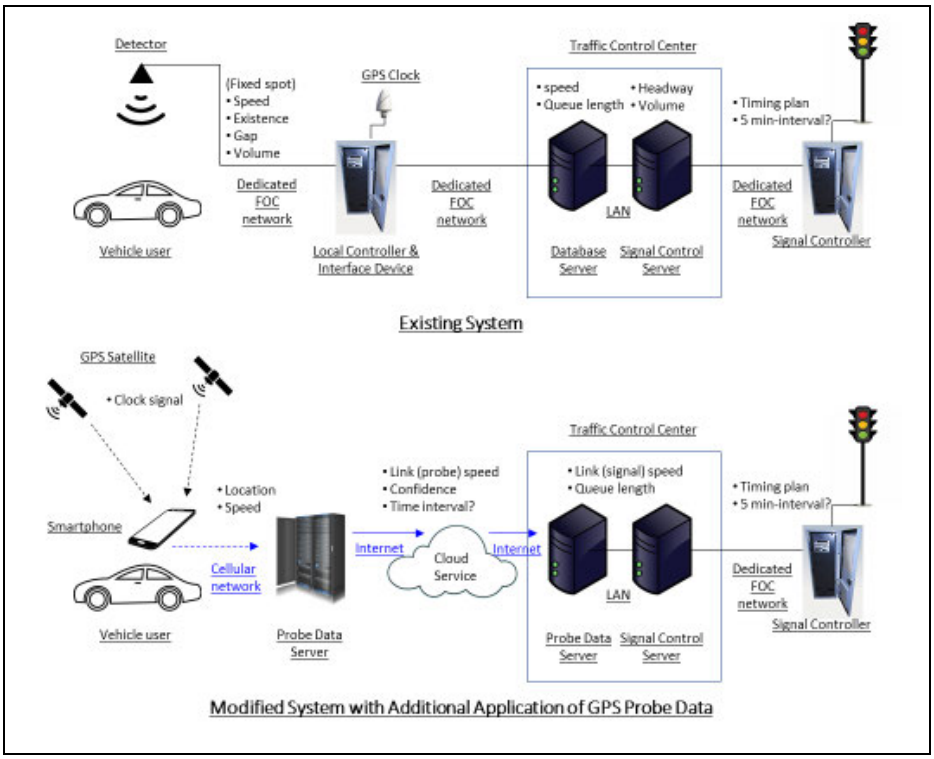
Source: JET

(5) Study of Applying Advanced ATC System Technologies which includes Probe Data

The Project Team studied the use of vehicle probe data in the operation of the ATC system to reduce O&M costs. The advantages are as follows:

- Existing detectors only capture traffic conditions at specific fixed locations, while probe data can provide traffic information in the entire target area.
- The number of detectors required can be reduced, lowering both installation and maintenance costs.

On the other hand, utilizing probe data for traffic signal control requires verifying the unit time, section length, and accuracy of the provided data. Additionally, signal control cannot rely on probe data if the continuity of data provision is not guaranteed, necessitating the use of at least two data sources to ensure reliability. Furthermore, the continuous purchase of probe data presents challenges, not only in terms of cost but also in determining whether BMA can manage recurring charges. In experimenting with probe data, the data was provided by TomTom through Sumitomo, which developed the ATC system. However, the cost of obtaining the data was not revealed due to a non-disclosure agreement (NDA) between Sumitomo and TomTom, leaving no information for the Project Team to base a budget on.



Source: JET

Figure 7.2.19 Adoption of Detector and Probe Data for Traffic Signal Operation

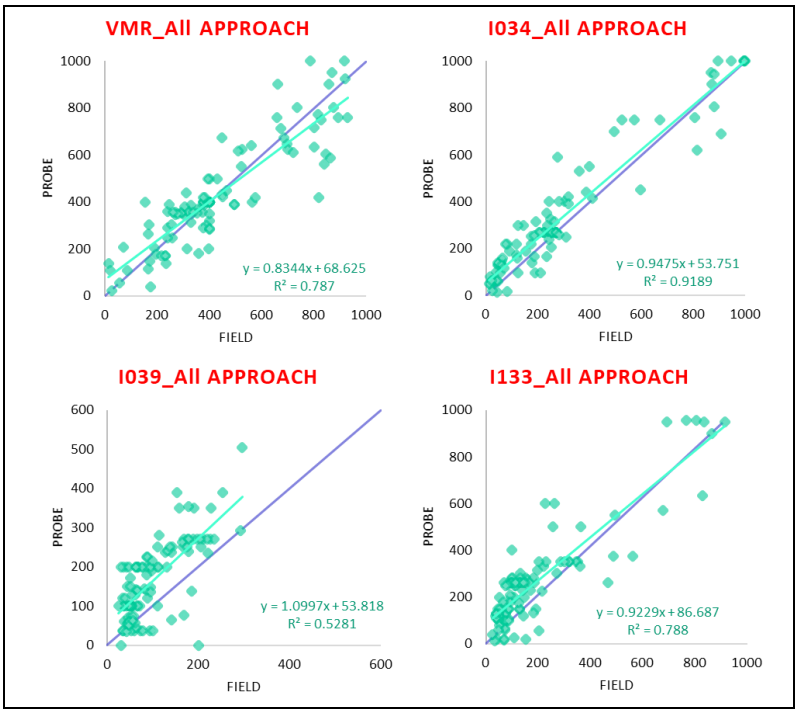
Two sources of probe data in Bangkok were found: commercial vehicle probe data managed by MOT's Department of Land Transport (DLT) and smartphone location data from TomTom. The specifications of probe data from DLT and TomTom are shown in Table 7.2.13. BMA and JET discussed with both DLT and TomTom regarding data provision. However, considering the time required for DLT to provide the data, the bias in the number of data samples and vehicle types, and the one-minute data acquisition frequency, which is approximately the same as the traffic signal cycle, it was decided, after consultation with BMA, to conduct the demonstration experiment using TomTom's data.

Table 7.2.13 Specifications of Probe Data which can be Used in Bangkok

Item	DLT	TomTom
Area	Entire Bangkok (Entire Thailand)	Entire Bangkok (Entire Thailand)
Data Source	Freight vehicle: 170,000 vehicles Bus: 73,000 vehicles	Personal navigation device users (iPhone 等)
Sample Number	Taxi: 20,000 vehicles (different system from freight and bus)	Undisclosed
Data Collection	Mobile phone line / internet	Mobile phone line / internet
Data Processing	Private, 127 providers	TomTom Live Service
Data Transmission	Undeveloped (need to be developed)	TomTom Live Service
Frequency	Every minute	Undisclosed
Delay/Real Time	A few minutes delay	Real time
Segment Length	Non (raw data)	About 200 m

Source: JET

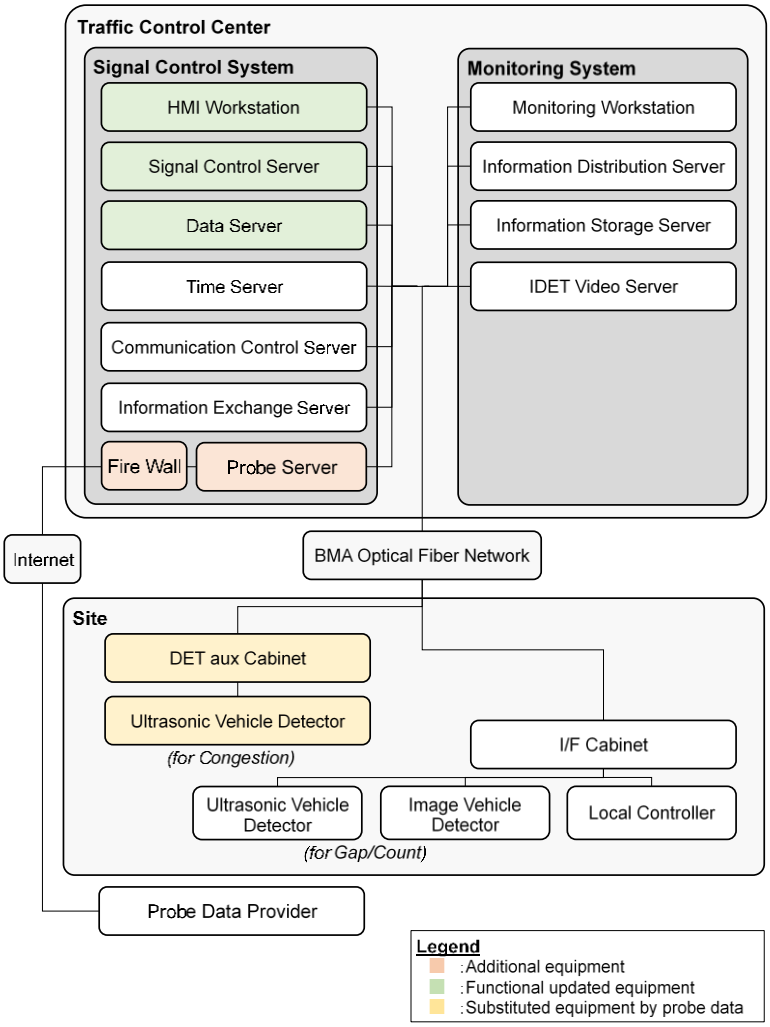
To assess the applicability of TomTom's probe data, the Project Team compared the queue lengths recorded during a field survey on 9 July 2019 with those calculated from TomTom's probe data on the same day. The results are shown in Figure 7.2.20. Generally, if the error between the actual measured value and the calculated value is within 250 m, which is the typical interval of detectors in Bangkok, this value is acceptable for signal control performance. In the comparison, the error remained within 250 m, showing a high correlation with the observed value. Consequently, the Project Team concluded that probe data is applicable in setting signal control parameters.



Source: JET

Figure 7.2.20 Comparison of Queue Lengths from Survey Data and Probe Data

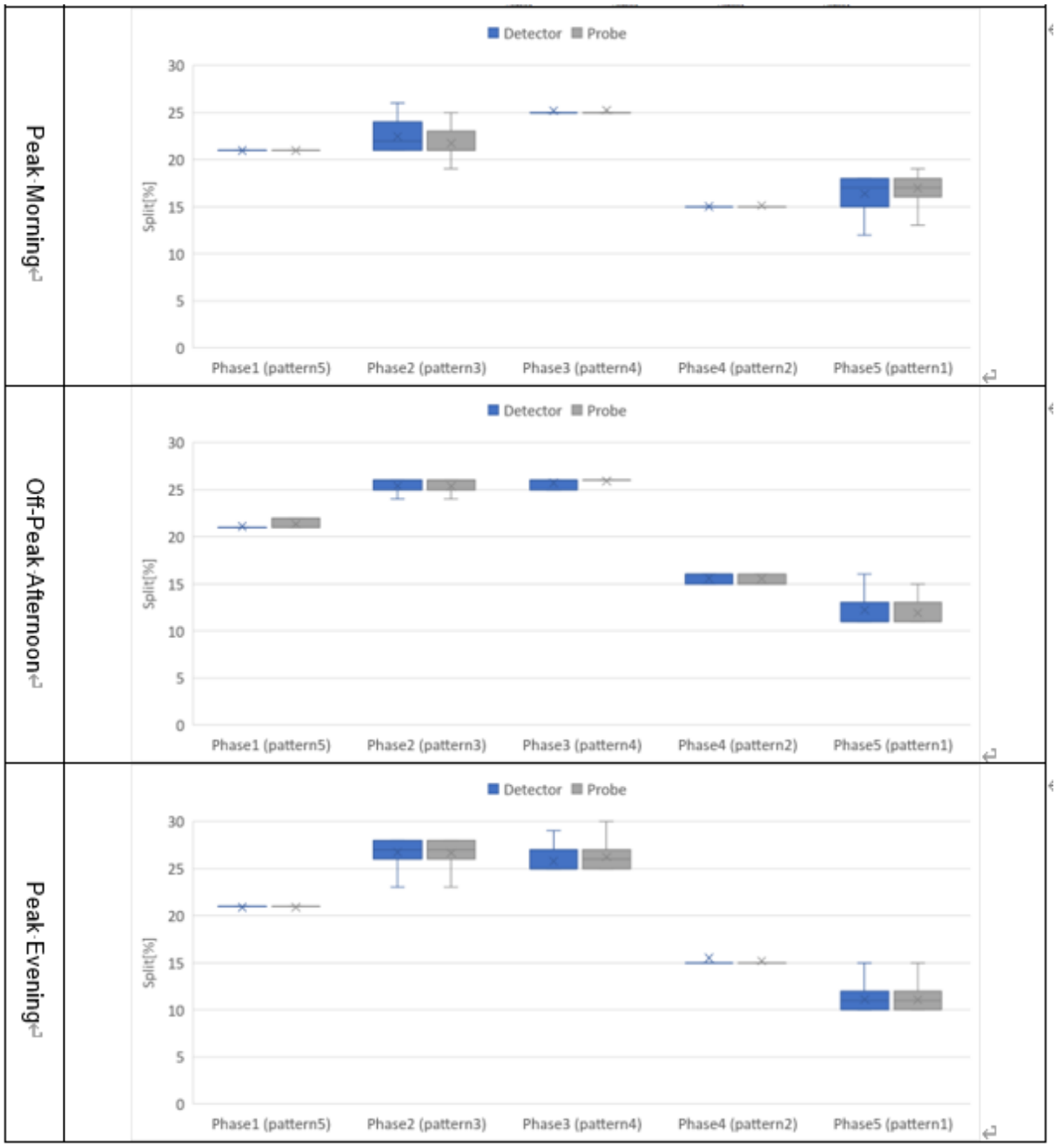
A demonstration on integrating probe data with the ATC system was conducted in this pilot project for this JICA project. The demonstration workflow is illustrated in Figure 7.2.21. Following the introduction and adjustment of the ATC system, the probe data experiment, which was subcontracted to Genius, was conducted in May 2023.



Source: JET

Figure 7.2.21 Workflow of Using Probe Data in the ATC System

The feasibility of using probe data in the ATC system was verified for three intersections in the pilot project area using recorded data from 29 May to 8 September 2023. The queue lengths indicated by the probe data showed the same trend as those measured by the detectors, confirming that signal operation using probe data performed at a comparable level to detector-based control. This demonstrated the feasibility of using probe data for signal control as an alternative to detectors. The results of the probe data experiment are shown in Annex 15 (Probe Data Experiment of the ATC System).



Source: JET

Figure 7.2.22 Comparison between Prob Data and Detector Data for Traffic Signal Operation

For the probe data demonstration, section-specific speed data provided by TomTom was used. The use of vehicle probe data would be considered when there are multiple data sources and continuous and sufficiently reliable data provision can be guaranteed. Therefore, other data providers were explored to diversify data sources and mitigate the impact of rising data costs. In Thailand, the DLT under the Ministry of Transport manages commercial vehicle probe data. Although the Project Team requested DLT for data multiple times since 2019 and submitted a joint request with JICA in September 2022, DLT was

unable to provide the needed sample data. Therefore, the Project Team reviewed the specifications of probe data from various private organizations, with alternative sources listed in Table 7.2.14.

Table 7.2.14 Probe Data Providers

Source	Organization/ Business (Brief)	Detail
DLT	Public/ Regulator of transportation operators	Real-time GPS log data (raw data) for every 60 sec from mounted GPS devices on approx. 70,000 buses and 400,000 trucks.
ITIC	Non-profit foundation/ Traffic data collection, traffic monitoring service	Real-time GPS log data (raw data) for every 5 min from mounted GPS devices on approx. 10,000 taxis and 80,000 trucks.
Grab	Private/ Taxi booking platform application	Real-time GPS log data (raw data) for every 5 sec from Grab application of taxi drivers.
Toyota Tsusho Nexty Electronics (Thailand) Co. Ltd.	Private/ Maps connected services, navigation software, application platform, route planning API, traffic monitoring service, traffic management solution	Real-time GPS log data (raw data) from mounted GPS devices on approx. 130,000 cars and 10,000 taxis, and 380,000 TSquare application users.
TomTom N.V.		Real-time GPS log data (for internal use) and processed data for traffic monitoring, such as average road segment speed, from processed data received from GPS data vendors (vender list is undisclosed).
Waze		
Here We Go		

Source: JET

The historical budget of TTD-BMA and the share of traffic control equipment and facility, including traffic signals, are shown in Table 7.2.15. The budget for traffic control equipment and facilities ranges from approximately THB100 million to THB400 million per year, and it was increased in 2024 to support the introduction of adaptive traffic signals.

Table 7.2.15 BMA Budget related to Traffic Safety Facility

Fiscal Year	Traffic and Transportation Department (Million THB)	Traffic Control Equipment and Facility (Million THB)
2017	3,925	138
2018	3,469	159
2019	3,036	Unknown
2020	4,327	366
2021	2,897	243
2022	4,133	130
2023	3,126	102
2024	3,275	396

Source: BMA

Chapter 8. Project Review

8.1 Objectives

The objectives of the project review are as follows:

- Confirm the project's performance and level of achievement based on indicators reflected in the Project Design Matrix (PDM).
- Analyze the project using six evaluation criteria: relevance, coherence, effectiveness, efficiency, impact, and sustainability.
- Identify factors that promoted or hindered the implementation process.
- Extract lessons that can be applied to similar projects.
- Confirm the activity plans of counterparts for achieving the overall goal after project completion.

8.2 Method

The project review was conducted through an examination of existing documents, questionnaires, and interviews with counterparts and experts. Of the six evaluation criteria, coherence, relevance, effectiveness, and efficiency were assessed based on the current situation and the degree of achievement at the Project's conclusion, while impact and sustainability were evaluated based on the current situation and the anticipated outlook following project implementation.

8.3 Outputs and Achievements

(1) Evaluation Indicators for Each Output

Output 1: The ATC system is established in the pilot project area.

- Indicator 1-1: The ATC signals are installed in 12 intersections.

  All 12 signalized intersections in the pilot project area have been connected to the ATC system. JET designed the ATC system, JICA Thailand Office handled procurement, BMA installed the traffic signals and fiber optic cables, and RTP was responsible for its operation. Although some activities were delayed due to the impact of COVID-19, a completion inspection in June 2023 confirmed that all inspections were successful and that the system functioned as expected. As of January 2025, all traffic signals and equipment introduced through this pilot project continue to operate as intended.

- Indicator 1-2: The ATC center system is established.

  A control center was established, featuring the introduction of software and the construction of a database. Traffic signals, sensors, signal controllers, and interface devices (CIDs) were manufactured and installed. The control center and CIDs were

connected through an FOC network, and the traffic signals at intersections linked to the ATC system commenced operation.

Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.

- Indicator 2-1: Approximately 10 officials from BMA and RTP receive training in operation and maintenance of ATC system.

  It was agreed that RTP would be responsible for operating the ATC system in the pilot project area, while BMA would handle maintenance. Using the O&M manual described below (Indicator 2-2), a total of 17 individuals (10 from BMA and 17 from RTP) participated in the training sessions held on 20 and 30 June 2023. The list of training participants is shown in Table 4.2.15.

- Indicator 2-2: The ATC operation and maintenance guidelines are made available.

  Four manuals were prepared as O&M guidelines for the ATC system: the "ATC System Maintenance Manual," "Special Conditions of Contract for Area Traffic Control System Maintenance," "Technical Specifications for Area Traffic Control System Maintenance," and "ATC System Maintenance Work." Explanations were provided to BMA and RTP at the 12th Project Team meeting held on 6 July 2021 and to BMA personnel on 21 October 2022. Training, as mentioned above, was conducted in June 2023.

- Indicator 2-3: Awareness campaign is conducted at least 3 times.

  Public relations and awareness-raising activities were conducted alongside the launch of the ATC system. User awareness activities were implemented through three channels: 1) roadside advertising, 2) handouts, and 3) online platforms. Additionally, an opening ceremony was held to mark the start of the ATC system's operation, serving as a PR and awareness event for stakeholders. The ceremony was covered by multiple media outlets and live-streamed on the Bangkok Metropolitan Governor's Facebook page, also reaching general users as part of the awareness campaign.

Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.

- Indicator 3-1: Approximately 5 officials from RTP receive training in manual signal operation

Guidelines for the manual operation of traffic signals were developed along with the "Manual Control Analysis." Using these guidelines, seven RTP staff and 10 BMA staff were trained in manual traffic signal operation in June 2023. The participants were the same as those listed under Indicator 2-1.

- Indicator 3-2: Manual operation based on the guideline is implemented at intersections in the pilot project area.

  The traffic signal manual operation support tool was installed at police boxes at the Victory Monument Roundabout and Tuk Chai intersection, after which operation commenced. In Bangkok, manual operation of traffic signals often increases cycle length, which can result in longer queues. To mitigate this, the guidelines recommended shorter cycle lengths, and the support tool displays the appropriate timing for traffic signal adjustments accordingly. When RTP staff manually operate the traffic signals, they use the camera images and queue length information displayed on the support tool to determine the optimal timing for signal phase changes, performing manual operations in line with the guidelines. However, traffic police officers manually operated the traffic lights in the pilot project area even when BMA requested them to operate under automatic control after the introduction of the ATC system. That said, the frequency and duration of manual operations gradually decreased. Awareness of the inefficiency of manual operation has been growing within RTP. The Deputy Commissioner of the Metropolitan Police commented: "Police officers should focus on patrols and enforcement rather than manually operating traffic signals, and we hope that the development of the ATC system will enable this shift."

Output 4: A draft ATC system development plan covering entire Bangkok is prepared.

- Indicator 4-1: The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.

  The draft short- and medium-term ATC system development plan was formulated and presented at a seminar held on 26 November 2024. It was subsequently submitted and approved at the 6th JCC meeting on 29 November 2024. BMA secures budgets annually to improve traffic signalization and traffic control systems as required, but there is no formal mechanism to establish such plans as official development strategies. Consequently, the draft plan on short- and medium-term ATC system development will not be positioned as an official plan within BMA but will serve as a reference for budget allocation within the organization.

(2) Evaluation Indicators for the Project Purpose

Project Purpose: An ATC system is established in the pilot project area and traffic congestion in the area is improved.

- Indicator 1: The ATC system in the pilot project area is commissioned.

  As outlined in the activities of Output 1 in Chapter 4, traffic signals at 12 intersections in the pilot project area were connected to the ATC system. Furthermore, as outlined in Output 2 in Chapter 5, while manual operation by RTP is still ongoing, the implementing agencies, BMA and RTP, have acquired an understanding of the system's O&M methods and continue to manage the system. As a result, the ATC system in the pilot project was completed and is still operational.

- Indicator 2: Travel time is reduced approximately 10% along the routes in the pilot project area.

  As described in the activities of Output 1 in Chapter 4, the improved traffic flow in the target area led to an increase in vehicles diverting from other roads, making it impractical to measure identical conditions before and after implementation. Therefore, a microsimulation model was used to estimate and evaluate travel times before and after the introduction of the ATC system. Results showed a reduction in travel time by an average of 20% to 30% across three time periods: morning peak, off-peak, and evening peak (Table 4.2.14).

  The ATC system's effectiveness was also evaluated using queue length and traffic volume data obtained from vehicle detectors and probe data at three intersections: Tuk Chai, Victory Monument, and Saphan Khwai. A comparison of conditions before and after the ATC system introduction showed a 15% to 30% reduction in queue lengths under the same traffic volume (Figure 4.2.25). Additionally, in user interviews, 50% of respondents reported a reduction in queue lengths, and 70% reported a reduction in travel time (Figure 4.2.28).

- Indicator 3: Approximately 10 officials from BMA and RTP are available to operate ATC system.

  As described in Indicator 2-1 of Output 2, a total of 17 staffers from BMA and RTP received training in the operation and maintenance of the ATC system. These trained staffers are now actively involved in the system’s O&M. Given the frequent annual staff transfers at RTP, the organization plans to use the guidelines developed in this project for internal training purposes.

8.4 Project Evaluation Results

Project evaluation was conducted using the six criteria established by the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD) and for which a five-point scale was applied: high, relatively high, medium, relatively low, and low.

(1) Relevance

The relevance of this Project is rated as "high."

Thailand's Policy: In Thailand, the number of registered vehicles has increased 1.7 times over the past decade due to steady economic development, resulting in severe traffic congestion and related air pollution issues in the Bangkok Metropolitan Area. Currently, signalized intersections in Bangkok operate independently without coordination, and police officers manually control traffic signals during peak hours, further exacerbating congestion. Alleviating congestion at these intersections is therefore crucial, and the BMA has been considering the introduction of an ATC system since the 1990s. Additionally, BMA is promoting the Adaptive Traffic Signal Project alongside the development of the ATC system in this project, making congestion alleviation at signalized intersections a top priority for BMA and aligning with Thai policy. Thailand's National Economic and Social Development Plan for 2023–2027 aims to transform the country into a circular economy and a low-carbon society. Reducing air pollutant emissions by alleviating traffic congestion through the development of an ATC system aligns with this goal.

External Conditions: The external condition for achieving the Project's purpose is the continuation of BMA's policy to improve traffic congestion using an ATC system. This policy remains unchanged, and BMA has already begun developing adaptive signals as part of its preparations for implementing a full ATC system.

Beneficiary Needs: Road transportation is a daily necessity for Bangkok residents, and the ATC system introduced in the pilot project for this JICA project, with plans for expansion across BMA, directly addresses the needs of road users. Easing traffic congestion will lead to shorter travel times and improved logistics efficiency, benefiting Bangkok residents and Thailand as a whole.

Advantages of Japan's Cooperation: While ATC systems are widely developed globally, those in Europe and the United States are often not designed for operation under highly congested conditions. In contrast, the Japanese ATC system was specifically developed to manage severe urban congestion, making it well-suited to Bangkok’s conditions. Supported by JICA, the Japanese ATC system has been successfully implemented across Asia and Africa, allowing Japan to apply its expertise in adapting its systems to suit the

unique conditions of various cities, which provides a strong advantage in cooperation. Additionally, this Project demonstrated the use of probe data as an alternative to vehicle detectors for measuring queue length. The demonstration confirmed the feasibility of operating an ATC system using probe data as input. The results showed that this setup can significantly reduce the installation and maintenance costs of roadside equipment. The software for the center system with such functions, as well as the compatibility between Thai-made roadside equipment and the center system, was developed by Japanese manufacturers. This represents a technical achievement that highlights the value of Japanese cooperation.

(2) Coherence

The coherence of this Project is rated as "high."

Japan's ODA Policy: Japan's development cooperation policy for Thailand emphasizes three priority areas: "sustainable economic development and addressing a maturing society," "addressing common issues within the ASEAN region," and "providing third-country support." Mitigating severe urban traffic congestion is a common challenge within the ASEAN region that directly affects sustainable economic development and societal well-being. This Project was established based on the results of the Collaboration Program conducted from 2015 to 2016. It involves implementing a pilot project in areas that include signalized intersections targeted in the Collaboration Program, demonstrating strong continuity and alignment with past initiatives. The introduction of the ATC system in Bangkok has already contributed to reducing traffic congestion. Furthermore, this success positions Thailand to share the technology as a solution to common traffic issues in the ASEAN region, thereby extending support to third countries. These activities align with Japan's ODA policy. From the perspective of the SDGs, alleviating traffic congestion contributes to "sustainable urban development," while reducing air pollutant emissions through improved traffic management addresses "concrete measures against climate change."

JICA's Other Projects: JICA's infrastructure initiatives in Thailand include support for capacity building in road transport, such as the "Project for Capacity Development on Tunnel Project Management in Thailand" and the "Project on Capacity Improvement for Road Traffic Safety Institutions and Implementation in Thailand" They also include public transport development support, such as the " Project for enhancing capacity of formulation of the Second Mass Rapid Transit Master Plan in Bangkok Metropolitan Region " and the " Mass Transit System Project in Bangkok (Red Line) " All these projects aim to develop smooth and safe transport infrastructure and are highly relevant to this ATC initiative.

(3) Effectiveness

The effectiveness of this Project is rated as "relatively high."

Congestion Relief: In the pilot project area, a comparison of traffic conditions before and after the ATC system introduction showed a 15% to 30% reduction in queue length with the same traffic volume. Additionally, in user interviews, 50% of respondents reported a decrease in congestion, and 70% noted shorter travel times. These results indicate that congestion relief was achieved to a noticeable extent, demonstrating a high degree of goal attainment.

Expansion to the Entire Bangkok Metropolitan Area: The ATC system became operational at 12 intersections in the pilot project area, and its effectiveness was confirmed. Additionally, the draft ATC system development plan for the entire Bangkok Metropolitan Area received approval from the JCC, indicating a high degree of goal achievement for this Project. The success of this effort will largely depend on the future actions and commitment of the BMA.

(4) Efficiency

The efficiency of this Project is rated as "moderate."

JICA Expert Team Input: The Project was implemented through cooperation among BMA, RTP, and JET. Project activities were delayed due to the COVID-19 pandemic beginning in 2020, which necessitated remote operations and additional resources. The delay in project activities is attributed to delays in securing the budget for BMA's portion of the pilot project. Additionally, the increase in inputs is due to the increased administrative work required as a result of the project period being extended. The Project was initially planned to be implemented in 34 months with a total cost of JPY370 million. Due to the pandemic's impact, the implementation period was extended to 70 months, approximately twice the planned duration, and the total project cost rose to JPY586 million or about 1.6 times the original budget. Despite these challenges, the Project achieved the intended results, resulting in a "moderate" efficiency rating. The increase in project costs was primarily attributed to the additional input from JET and the rise in the commissioning fee for the probe data demonstration, which was driven by inflation and fluctuations in the Thai currency.

Procurement of ATC System Installation: Genius was contracted to install the ATC system in the pilot project area. With extensive experience in installing traffic signals and fiber optic cables in Bangkok, Genius executed the installation efficiently.

(5) Impact

The impact of this Project is rated as "high."

Economic Effects: The mitigation of congestion at intersections in the pilot project area resulted in shorter travel times for road users and reduced travel costs for passing vehicles. The economic benefits were estimated to be significant, amounting to THB107,355 per day at Tuk Chai intersection and THB352,262 per day at Saphan Khwai intersection (shown in Annex 13), indicating a high economic impact.

Reduction in Air Pollutant Emissions: The reduction in air pollutant emissions resulting from the introduction of the ATC system in the pilot project area and the alleviation of traffic congestion was estimated through simulation as shown in Table 4.2.3. The results indicated that carbon dioxide (CO_2) and volatile organic compound (VOC) emissions decreased by 6% during morning peak hours, 3% during off-peak hours, and 9% during evening peak hours, reflecting a significant environmental impact.

Improved Police Deployment Efficiency: At major intersections in Bangkok, police officers operate traffic signals manually. With citywide implementation of an ATC system, the need for manual operation would be eliminated, allowing officers to be redeployed to other essential tasks, such as traffic control and enforcement in high-congestion areas, thus greatly enhancing deployment efficiency.

Achievability of the Overall Goal: The Project aimed to establish an ATC system in the pilot project area to mitigate traffic congestion, with the overall goal of expanding the ATC system to reduce traffic congestion and air pollutant emissions across a larger area. The mitigation of traffic congestion and reduction of air pollutant emissions in the pilot project area were confirmed. If the ATC system expansion proceeds, these benefits, along with the anticipated economic advantages, are expected to increase. The first stage of the expansion, involving the installation of adaptive signals at more intersections, is currently being promoted by BMA. Given adequate budget allocation, the feasibility of achieving the overall goal is considered high. Additionally, the pilot project demonstrated that roadside units manufactured by a Thai company could be successfully connected to the center system via CIDs. This confirms the potential for connecting adaptive signals to the center system in the future, enabling further development into a fully functional ATC system.

(6) Sustainability

The sustainability of this Project is rated as "moderate."

Implementation of the Development Plan: Although the draft ATC system development plan was approved by the JCC, completing the system across the entire Bangkok Metropolitan Area is expected to take approximately 10 years. This will require sustained budget and continuous implementation within BMA, both of which will also be influenced

by political factors and policies. Therefore, it is recommended that BMA personnel incorporate the development plan into their regular responsibilities, with external parties continuing to advocate for its progress. BMA policies are strongly influenced by the priorities of the governor. With a gubernatorial election scheduled for 2026, there is a risk that these policies could shift under a new administration. If the incoming government does not approve the necessary budget for implementing the development plan after 2026, this could potentially lead to delays or even the cancellation of the plan.

Training and Support for BMA Engineers: While training and technology transfer were provided to BMA and RTP staff during project activities, they currently lack sufficient knowledge and experience to independently expand and develop the ATC system. Specifically, they lack the technical expertise required to make informed decisions regarding contractor selection and system design for expansion. Therefore, ongoing support is essential, including training engineers specifically in ATC systems and dispatching experts to assist until BMA engineers are fully prepared. For the ATC system introduced in the pilot project, implementing software updating and connecting new traffic signals will be challenging not only for BMA but also for local engineers. To overcome these challenges, it is crucial to adopt a bidding and contracting strategy. This should include provisions for training engineers and ensuring maintenance management support within the procurement contract, potentially involving local private companies to strengthen technical capacity.

8.5 Lessons and Issues

(1) Conduct of Project Team Meetings

Two organizations, BMA and RTP, are involved as Project Team members. Recognizing the challenges of coordinating activities across different organizations, JET proposed in the first JCC meeting the conduct of regular Project Team meetings. Although these meetings were initially suspended due to the impact of COVID-19, upon resumption they served as a valuable forum for sharing updates on project activities and facilitating collaboration between BMA and RTP, contributing to the Project's smooth progress from the outset.

(2) Relationship Building among Project Team Members

At the beginning of the Project, there were concerns about whether BMA and RTP could effectively collaborate on joint activities. Immediately after the Project began, BMA provided RTP with a detailed explanation of project objectives and held the Project Team meetings at RTP's office, which helped both organizations align and advance project activities.

Additionally, during the 2023 training in Japan, key decision-makers, including the Director of BMA and the Deputy Commissioner of Metropolitan Police Bureau from RTP, along with

those involved in day-to-day project work, such as the Section Chief and staff of the Traffic Engineering Section, and personnel from the Traffic Police Department and Bang Sue and Phaya Thai police stations, actively participated and exchanged views over their two-week stay. On the final day, an action plan was formulated to address challenges in improving traffic flow in Bangkok, emphasizing the importance of BMA and RTP cooperation, and clarifying the specific roles each organization should undertake. Since the training, participating members have remained actively engaged in the Project, significantly contributing to its progress by establishing a collaborative framework with the police in the pilot project area and facilitating discussions on post-JICA ATC implementation at BMA.

The training in Japan also proved invaluable for aligning the counterparts' and JET's expectations. By carefully selecting participants, thoughtfully structuring the program, and providing time for in-depth discussions, the training contributed substantially to effective project management.

(3) Capacity Development of Counterparts

In a similar JICA project, titled "The Project for the Improvement of Traffic Control in Kampala City," it was noted that measures, such as providing technical guidance to multiple counterparts and distributing copies of various manuals, are necessary to prevent interruptions in O&M due to staff turnover. Although there were no resignations in this Project, RTP staff were reassigned annually. Therefore, drawing on the lessons from the Kampala project, a manual was created and training sessions were conducted based on this manual for relevant BMA and RTP personnel.

(4) Activities during COVID-19 Pandemic

The global impact of the COVID-19 pandemic led to significant restrictions on travel and activities for Japanese experts in Bangkok, the cancellation of training in Japan for Thai counterparts, and delays in securing budgets for the BMA for the pilot project. Although BMA was responsible for installing traffic signals and laying fiber optic cables, the originally planned budget could not be secured on schedule due to COVID-19 countermeasures. This resulted in delays in the implementation of the pilot project and necessitated an extension of the project period. This situation was unforeseen at the Project's inception and caused considerable delays in budget allocation. However, BMA made efforts to address these challenges by pursuing supplementary budgets. As a result, the project period was extended by three years, enabling the completion of all originally planned activities.

(5) Manual Operation of Traffic Signals by Police

Even after the ATC system was established in the pilot project area, traffic police officers continued to manually operate traffic signals. The roles of BMA and RTP are distinct, with

BMA responsible for facility maintenance and RTP for operation. Although training was provided to both organizations, it appears that RTP did not fully understand the effectiveness of automatic control. Towards the end of the Project, reports indicated that high-ranking RTP officials began to recognize the benefits of automatic control and instructed staff to reduce manual operation. However, gaining such understanding took considerable time.

(6) Proposals on Traffic Control System in Bangkok

1) Transition from Manual to Automatic Control of Traffic Signals

Data analysis following the launch of ATC system operations confirmed that automatic control is more effective than manual control in reducing queue lengths. However, manual control was still implemented during peak morning and evening hours. Key findings associated with manual control identified in this project are the following:

- Manual control is less efficient at managing traffic compared to automatic control.
- In manual control, signal parameters (cycles and splits) vary each time, resulting in inconsistent traffic conditions (traffic volume and vehicle queue). This variability prevents a clear understanding of the relationship between signal parameters and traffic conditions, making it difficult to design optimal signal control.
- Without understanding the relationship between signal parameters and traffic conditions, even automatic control systems cannot operate optimally. This would fail to alleviate traffic congestion and could lead to continued reliance on manual control.

However, discontinuing manual control immediately poses challenges, including constraining emergency response and retraining or reassigning police officers currently performing manual operation. Therefore, a gradual transition to automatic control is planned. At the same time, a smooth and rapid transition is crucial for the successful expansion of the ATC system. To facilitate this transition, the following is proposed: Analyze the data accumulated in the ATC system, including traffic volumes, queue lengths, and cycle splits during manual control. While this Project has captured the current state of manual control, a comprehensive analysis of its impact on traffic volume and congestion is still needed to better reveal the limitations of manual control and inform decision making as to the appropriate improvement measures.

2) Development of the Road Network

Traffic congestion occurs at major intersections in Bangkok, where many traffic signals use multi-phase control, allocating separate green phases to each approach direction. This approach, likely due to the high volume of right-turning and U-turning vehicles, has led to an increased number of phases, causing heavy saturation at intersections.

While Bangkok has many expressways and trunk roads, numerous connecting roads are dead-ends (*soi*). Additionally, the presence of median strips on trunk roads limits opportunities for right turns and merging, inevitably creating significant U-turn traffic.

Consequently, there are few fully accessible intersections, and the limited road network connectivity forces right-turning and U-turning vehicles to concentrate at signalized intersections and median openings, creating bottlenecks.

To address these issues, it is essential to improve street connectivity by reducing dead-ends, developing additional trunk roads, and installing traffic signals on these roads. These improvements will reduce the demand for right turns at signalized intersections and help alleviate intersection saturation in the long term.

3) Strengthening of Inter-Agency Cooperation in Traffic and Signal Control

At certain locations, push-button traffic signals are deactivated during peak morning and evening hours. While BMA initially installed these traffic signals to enhance pedestrian safety and prevent accidents, it is unclear whether RTP, which manages their operation, turns them off to prioritize smoother traffic flow. This practice, however, compromises pedestrian safety during times of high foot traffic.

One reason for this operational issue is the division of responsibilities: BMA is responsible for installing traffic signals and setting signal parameters (automatic control), while RTP manages traffic operations, including manual signal control. As a result, traffic signal installation and traffic management are handled by different agencies. While some level of coordination between the two is assumed, the increasing number of traffic signals and the need for more complex and advanced signal control in the future make it essential to clarify authority over signal control.

Additionally, push-button traffic signals in Thailand reportedly lack systemized or interlocking functionality, which may explain why some are turned off during peak hours. However, as the ATC system expands in the future, systemized control—particularly for closely located push-button traffic signals—will be crucial. Therefore, it is necessary to develop this functionality to ensure effective and safe traffic signal operation.

4) Promotion of Pedestrian Safety

In Thailand, pedestrian crossing signals change directly from green to red without a flashing green phase, increasing the risk of pedestrians being stranded mid-crossing. Additionally, some areas lack pedestrian signals, and in places with push-button signals, the crossing time is often set to a minimum. These signals are also sometimes deactivated, further compromising pedestrian safety.

As a tourism-driven country, Thailand should prioritize pedestrian safety from an international perspective, ensuring safe crossing options for tourists, the elderly, persons with disabilities, and other vulnerable road users. However, while introducing a flashing green phase for pedestrian signals could enhance safety, it will also require waiting for the flashing phase to finish during manual control, reducing flexibility in signal timing. This constraint could present challenges for manual signal operation and potentially deter the implementation of flashing green lights.

5) Control of Left-Turning Vehicles

In Japan, when continuous left turns are permitted, several structural measures are often implemented outside of signal control, including:

- Installation of dedicated left-turn lanes,
- Provision of merging lanes for safe integration with traffic coming from the right on a green light, and
- Safety measures for pedestrians crossing paths with left-turning vehicles.

In Bangkok, such structural adjustments are seldom made. As a result, the safety of merging left-turning vehicle and pedestrian traffic is often overlooked. Continuous left-turn permissions can be feasible in areas with low traffic volume and sufficient space, but in Bangkok's highly saturated traffic environment, giving left-turning vehicles unconditional priority complicates intentional, citywide traffic management.

To enhance traffic flow control and safety, it is necessary to review current left-turn practices. This includes reassessing continuous left-turn permissions and considering the implementation of dedicated left-turn arrow signals, particularly as the ATC system expands. These adjustments would contribute to more effective traffic management and improved pedestrian safety throughout the city.

6) Reduction of Total Traffic Volume

Bangkok faces chronic traffic congestion during peak morning and evening hours, primarily due to high traffic demand. To improve traffic flow, sustained efforts to reduce overall traffic volume are essential. Currently, many government offices, businesses, hospitals, hotels, and other facilities with parking are located along main roads, which are heavily used by commuter vehicles during peak hours.

Future efforts to reduce urban traffic volume should focus on transportation demand management (TDM) strategies, such as promoting ride-sharing, particularly for commuter traffic. Prompt implementation of these measures will help alleviate congestion and contribute to a smoother, more efficient urban transportation system.

7) Introduction and Maintenance of Fiber Optic Cables

The maintenance of BMA's fiber optic cables is outsourced to private companies under contract. However, the pilot project revealed that many cables are damaged, and the current usage and available capacity of the fiber optic cables are not effectively managed. To facilitate the development of an ATC system across Bangkok in the future, it is crucial to enhance the management capabilities for fiber optic infrastructure. Alternatively, instead of BMA being solely responsible for installing and maintaining the fiber optic cables, it could consider utilizing private FOC networks, as is done in Japan and other countries.

8.6 Conclusion

Although COVID-19 impacted the Project by causing delays and extending the project period, the objectives and outcomes were successfully achieved, and the implementation process remained appropriate. The Project demonstrated particularly high effectiveness and impact in the DAC's six-point project review. Based on the ATC system expansion plan developed within this Project, it is anticipated that BMA and RTP will collaborate to expand and implement the ATC system throughout the Bangkok Metropolitan Area.

Annex

#	Document Name
1	Record of Discussions
	1-1 Record of Discussions, December 13, 2018
	1-2 Minutes of Meetings for Amendment of the Record of Discussions, January 31, 2022
	1-3 Minutes of Meetings for Amendment of the Record of Discussions, December 15, 2022
	1-4 Minutes of Meetings for Amendment of the Record of Discussions, September 29, 2023
	1-5 Minutes of Meetings for Amendment of the Record of Discussions, August 30, 2024
2	Inspection Documents for ATC System Installation Work
	2-1 Factory Test Plan and Report
	2-2 On-site Inspection Record (Local Controller, Image Vehicle Detector and Ultrasonic Vehicle Detector)
	2-3 On-site Inspection Record (Acceptant Test of Center System)
	2-4 On-site Inspection Record (Installation Work of Local Controller, Image Vehicle Detector and Ultrasonic Vehicle Detector)
	2-5 Inspection Report of Installation Work Completion
3	Evaluation of the Benefit of the ATC System
4	A Study on ATC System Perception and Awareness
5	ATC System Operation Manual
6	Signal Timing Adjustment Procedure
7	Study Result of Utilization of Image Processing Technology for Traffic Volume Count in Bangkok
8	ATC System Maintenance Manual
9	Special Condition of Contract for Area Traffic Control System Maintenance
10	Technical Specifications for Area Traffic Control System Maintenance
11	ATC System Maintenance Work
12	Guidelines for Manual Operation of Traffic Signal
13	Manual Control Analysis
14	Draft of ATC System Development Plan
15	Probe Data Experiment of the ATC System

Annex 1

Record of Discussions

1-1. Record of Discussions, December 13, 2018

RECORD OF DISCUSSIONS

FOR

THE PROJECT FOR IMRPOVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

AGREED UPON BETWEEN

BANGKOK METROPOLITAN ADMINISTRATION,

ROYAL THAI POLICE

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

December 13, 2018

Based on the minutes of meetings on the Detailed Planning Survey for the Project for Improving traffic congestions in Bangkok through the establishment of model Area Traffic Control (ATC) System (hereinafter referred to as "the Project") signed on 14th June 2018 between Director General of Traffic and Transportation Department of Bangkok Metropolitan Administration of the Kingdom of Thailand (hereinafter referred to as "the Counterpart") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with the Counterpart and relevant organizations to develop a detailed plan of the Project.

The purpose of this record of discussions (hereinafter referred to as "the R/D") is to establish a mutual agreement for its implementation by all parties and to agree on the detailed plan of the Project as described in the followings and the Annexes, which will be implemented within the framework of the Agreement on Technical Cooperation signed on 5th November 1981 (hereinafter referred to as "the Agreement") and the Note Verbales exchanged on 18th May 2018 between the Government of Japan and the Government of Thailand.

The Counterpart will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of the Kingdom of Thailand.

All parties also agreed that the Project will be implemented in accordance with the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), unless other arrangements are agreed in the R/D.

The R/D is delivered at Bangkok as of the day and year first above written. The R/D may be amended by a minutes of meetings between all parties, except the plan of operation to be modified in monitoring sheets. The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.

Ms. Katsura Miyazaki
Chief Representative
Japan International Cooperation Agency
Thailand Office

Mr. Somchai Dechakorn
Deputy Director General,
Acting Director General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Annex 1 Main Points Discussed
Annex 2 Project Design Matrix (PDM)
Annex 3 Plan of Operation (PO)
Annex 4 Implementation Structure
Annex 5 List of Proposed Members of Joint Coordinating Committee

Annex 1

MAIN POINTS DISCUSSED

1. **Framework of the Project**
   The Project Design Matrix (hereinafter referred to as "PDM") and Plan of Operation (hereinafter referred to as "PO") attached to R/D as the Annex 2 and Annex 3 respectively shall be used as a monitoring and management tool of the Project. The PDM and PO will be reviewed and revised flexibly whenever the necessity arises.

2. **Duration of the Project**
   Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.

3. **Joint Coordinating Committee (JCC)**
   Both sides have agreed that the Joint Coordinating Committee (hereinafter referred to as "JCC") comprising of the authorities concerned will be established, and chaired by the Director General of Traffic and Transportation Department of BMA. The proposed members of the JCC are described in Annex 5 of the draft R/D. The first JCC will be convened within six months of the commencement of the Project to approve the first version of the PDM and PO. JCC will meet at least once a year and whenever necessity arises.

4. **Counterpart Personnel**
   Both sides agreed that the necessary counterpart personnel described in the PDM of the R/D will be assigned by the respective organizations and informed to JICA before signing of R/D.

6. **Sharing of responsibilities on establishment of Area Traffic Control System as a pilot project**
   Both sides agreed that the establishment of Area Traffic Control System shall be implemented under the sharing of responsibilities described as Attachment 1.

7. **Provision of benefits and facilities**
   Thai side agrees to provide the following benefits and facilities:
   (1) Office space in the building of BMA for the Project members with office furniture and utilities such as internet connection, electricity, air conditioner and so on;
   (2) Necessary data and information for the Project;
   (3) Permission of access for JICA Experts to the project sites; and
   (4) Identification cards for JICA Experts if necessary
   (5) Budget allocation for personnel, operation and activities for implementation of the Project, including the pilot project, personnel costs, local traveling costs and daily subsistence allowance for counterpart personnel, and other recurrent cost.

Japanese side agrees to provide following inputs to the Thai side.
(1) Experts
(2) Counterpart trainings in Thailand and Japan
(3) Necessary equipment for the project activities
(4) Expenses related to Japanese experts' activities

8. Environmental and Social Considerations

With regard to the Section 10.1 of the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

Attachment 1 Sharing of responsibilities

Attachment 01

Responsibility Sharing Matrix

Items		JICA	TICA	BMA	RTP
1. **Plan, Design**					
1-1	Map with Existing Signals			✓	
1-2	Traffic Survey	✓			
1-3	Detail Design of Civil Works	✓			
1-4	Detail Design of Electrical Works	✓			
1-5	Detail Design of Communication Network & ATC System	✓			
2. Construction					
2-1	Procurement of ATC System Equipment	✓			
2-2	Tax Exemption for Importing Equipment		✓		
2-3	Installation of Equipment for Intersections and Control Center	✓			
2-4	Civil Works at Intersections (Lane Markings, Road Signs, etc.)			✓	
2-5	Electrical Works (Wiring Ducts, Handholes, Poles, etc.)	✓			
2-6	Communication Network Works (From intersections to nearest BMA access point)	✓			
2-7	CommunicationTrunk Line			✓	
3. Maintenance, Operation					
3-1	Power Cost			✓	
3-2	Maintenance of ATC System			✓	
3-3	Operation of ATC System			✓	✓
3-4	Usage of Existing Cameras for Traffic Detectors			✓	✓
3-5	One Year Warranty for Equipment and Works	✓			
4. Evaluation					
4-1	Analysis and Evaluation on Pilot Project (including Traffic Survey)	✓			

Draft Project Design Matrix

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System

Version 0
Annex 2

Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Thirty-four (34) months, Project Site: Bangkok

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall Goal			
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources	
Project Purpose			
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced XX% along the routes in the pilot project area. 3. XX officials from BMA and RTP are available to operate ATC system .	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.
Outputs			
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in XX intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. XX officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least XX times.	• Minutes of JCC	
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	3-1. XX officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement	
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.		

Activities	Inputs		
	The Japanese Side	**The Thailand Side**	Human resources and budget necessary for the Project is provided by the responsible organizations. Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.			

3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			Preconditions Conditions are satisfied to begin the Project as indicated in the Record of Discussion.

Remark:

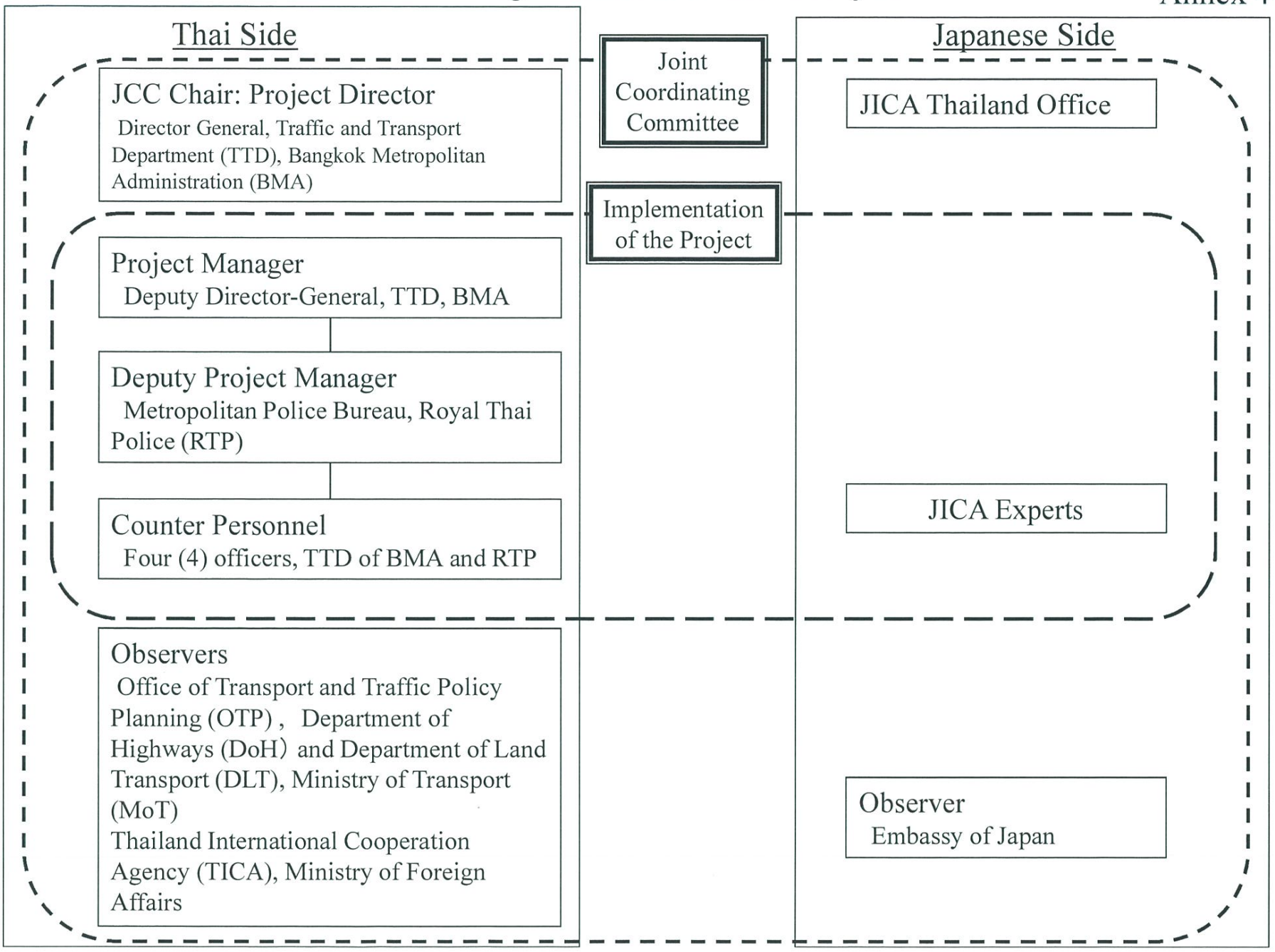
Tentative Plan of Operation

Annex 3

No.	Activities		1st year				2nd year				3rd year			
			I	II	III	IV	I	II	III	IV	I	II	III	IV
	Joint Coordination Committee		■	■		■		■				■		
	Submission of Monitoring Sheet/Completion Report			■	■		■		■		■		■	
	Post-project Monitoring		(Ex-post evaluation three (3) years after the project completion, in principle)											
1	Output 1: Establishment of the ATC system													
1-1	The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance the traffic control system, is reviewed and analyzed.	1	1											
1-2	The pilot project area is selected.	1	1											
1-3	Details of the project activities are planned, and demarcation among the participating organizations is clarified.	1	1											
1-4	The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system.	1.5	1.5											
1-5	The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area.	4	4											
1-6	Based on the above studies, improvement works are implemented at the intersections in the pilot project area.	2			2									
1-7	The equipment for the ATC system is installed in the pilot project area and the traffic control center.	4							4					
1-8	The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center.	1.5							1.5					
1-9	The database is established, and system, signal and detector parameters are adjusted.	3								3				
2	Output 2: Operation and maintenance of the ATC system													
2-1	Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others.	1		1										
2-2	The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on-the-job training and training in Japan.	2					0.5				2			
2-3	The operation and maintenance guidelines of ATC system are prepared.	3					3							
2-4	Awareness campaign and public relations are conducted.	0.5									0.5			
3	Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC													
3-1	Current practice of manual operation is studied through interviews with traffic police officers and observations.	1	1											
3-2	The operation guideline for manual operation of traffic signals is drafted.	1		1										
3-3	Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required.	1									1			
3-4	Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals,	1									1			
3-5	The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized.	1										1		
4	Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok													
4-1	Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed.	1	1									1		
4-2	The situation of urban transportation in Bangkok Metropolitan Area is reviewed.	1	1									1		
4-3	The traffic control system in the other countries is studied.	1			1									
4-4	The draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated.	2											2	
4-5	Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.	1						1						

Organization chart of the Project

Annex 4



Annex 5

List of Proposed Members of Joint Coordination Committee

(1) Project Team
1) Project Director (Chairperson of JCC)
   Director General of Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA)
2) Project Manager
   Deputy Director-General, TTD, BMA
3) Deputy Project Manager
   Metropolitan Police Bureau, Royal Thai Police (RTP)
4) Counterpart Personnel from BMA and RTP
5) JICA Experts

(2) Observer Members of the Thai side
1) Officials from Office of Transport and Traffic Policy Planning (OTP), Ministry of Transport (MOT)
2) Officials from Department of Highways (DoH), MOT
3) Officials from Department of Land Transport (DLT), MOT
4) Officials from Thailand International Cooperation Agency (TICA), Ministry of Foreign Affairs (MOFA)

(3) Members of the Japanese side
1) Chief Representative and other staffs, JICA Thailand Office
2) Representatives, JICA Headquarters

(4) Observer Members of the Japanese Side
1) Officials of the Embassy of Japan

(5) Others
The JCC can invite any related persons to discuss specific issues if necessary.

1-2. Minutes of Meetings for Amendment of the Record of Discussions, January 31, 2022

MINUTES OF MEETING
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
BANGKOK METROPOLITAN ADMINISTRATION,
ROYAL THAI POLICE
FOR
AMENDMENT OF THE RECORD OF DISCUSSIONS ON
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK
THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC)
SYSTEM

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), Bangkok Metropolitan Administration (hereinafter referred to as "BMA") and Royal Thai Police (hereinafter referred to as "RTP") hereby agree that the Record of Discussions on the Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System signed on December 13th, 2018 is amended as follows;

1. Annex.1 Main Points Discussed

Before	Amended Version
2. Duration of the Project Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.	**2. Duration of the Project** Both sides agreed that the duration of the Project is forty-four (44) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended. The duration may be further amended (shortened or extended) depending on the COVID-19 situation.	

Annex1: Record of Discussions (signed on December 13th 2018)
Annex2: Amended Project Design Matrix

This amendment is effective as of April 27, 2021 when the extension of the Project duration was approved by the JCC committee members.

Bangkok, January 31 , 2022

Mr. MORITA Takahiro
Chief Representative
Thailand Office
Japan International Cooperation Agency

Mr. Prapas Lueangsirinapha
Director-General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

RECORD OF DISCUSSIONS

FOR

THE PROJECT FOR IMRPOVING TRAFFIC CONGESTIONS
IN BANGKOK THROUGH THE ESTABLISHMENT
OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM
IN
THE KINGDOM OF THAILAND

AGREED UPON BETWEEN

BANGKOK METROPOLITAN ADMINISTRATION,

ROYAL THAI POLICE

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

December 13, 2018

Ms. Katsura Miyazaki
Chief Representative
Japan International Cooperation Agency
Thailand Office

Mr. Somchai Dechakorn
Deputy Director General,
Acting Director General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Annex 1 Main Points Discussed
Annex 2 Project Design Matrix (PDM)
Annex 3 Plan of Operation (PO)
Annex 4 Implementation Structure
Annex 5 List of Proposed Members of Joint Coordinating Committee

Annex 1

MAIN POINTS DISCUSSED

1. **Framework of the Project**
   The Project Design Matrix (hereinafter referred to as "PDM") and Plan of Operation (hereinafter referred to as "PO") attached to R/D as the Annex 2 and Annex 3 respectively shall be used as a monitoring and management tool of the Project. The PDM and PO will be reviewed and revised flexibly whenever the necessity arises.

2. **Duration of the Project**
   Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.

3. **Joint Coordinating Committee (JCC)**
   Both sides have agreed that the Joint Coordinating Committee (hereinafter referred to as "JCC") comprising of the authorities concerned will be established, and chaired by the Director General of Traffic and Transportation Department of BMA. The proposed members of the JCC are described in Annex 5 of the draft R/D. The first JCC will be convened within six months of the commencement of the Project to approve the first version of the PDM and PO. JCC will meet at least once a year and whenever necessity arises.

4. **Counterpart Personnel**
   Both sides agreed that the necessary counterpart personnel described in the PDM of the R/D will be assigned by the respective organizations and informed to JICA before signing of R/D.

6. **Sharing of responsibilities on establishment of Area Traffic Control System as a pilot project**
   Both sides agreed that the establishment of Area Traffic Control System shall be implemented under the sharing of responsibilities described as Attachment 1.

7. **Provision of benefits and facilities**
   Thai side agrees to provide the following benefits and facilities:
   (1) Office space in the building of BMA for the Project members with office furniture and utilities such as internet connection, electricity, air conditioner and so on;
   (2) Necessary data and information for the Project;
   (3) Permission of access for JICA Experts to the project sites; and
   (4) Identification cards for JICA Experts if necessary
   (5) Budget allocation for personnel, operation and activities for implementation of the Project, including the pilot project, personnel costs, local traveling costs and daily subsistence allowance for counterpart personnel, and other recurrent cost.

Japanese side agrees to provide following inputs to the Thai side.
(1) Experts
(2) Counterpart trainings in Thailand and Japan
(3) Necessary equipment for the project activities
(4) Expenses related to Japanese experts' activities

8. **Environmental and Social Considerations**
With regard to the Section 10.1 of the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

Attachment 1 Sharing of responsibilities

Responsibility Sharing Matrix

Items		JICA	TICA	BMA	RTP
1. **Plan, Design**					
1-1	Map with Existing Signals			✓	
1-2	Traffic Survey	✓			
1-3	Detail Design of Civil Works	✓			
1-4	Detail Design of Electrical Works	✓			
1-5	Detail Design of Communication Network & ATC System	✓			
2. Construction					
2-1	Procurement of ATC System Equipment	✓			
2-2	Tax Exemption for Importing Equipment		✓		
2-3	Installation of Equipment for Intersections and Control Center	✓			
2-4	Civil Works at Intersections (Lane Markings, Road Signs, etc.)			✓	
2-5	Electrical Works (Wiring Ducts, Handholes, Poles, etc.)	✓			
2-6	Communication Network Works (From intersections to nearest BMA access point)	✓			
2-7	CommunicationTrunk Line			✓	
3. Maintenance, Operation					
3-1	Power Cost			✓	
3-2	Maintenance of ATC System			✓	
3-3	Operation of ATC System			✓	✓
3-4	Usage of Existing Cameras for Traffic Detectors			✓	✓
3-5	One Year Warranty for Equipment and Works	✓			
4. Evaluation					
4-1	Analysis and Evaluation on Pilot Project (including Traffic Survey)	✓			

Draft Project Design Matrix

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System

Version 0
Annex 2

Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Thirty-four (34) months, Project Site: Bangkok

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall Goal			
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources	
Project Purpose			
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced XX% along the routes in the pilot project area. 3. XX officials from BMA and RTP are available to operate ATC system .	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.
Outputs			
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in XX intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. XX officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least XX times.	• Minutes of JCC	
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	3-1. XX officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement	
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.		

Activities	Inputs		
	The Japanese Side	**The Thailand Side**	Human resources and budget necessary for the Project is provided by the responsible organizations. Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.			

3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			Preconditions Conditions are satisfied to begin the Project as indicated in the Record of Discussion.

Remark:

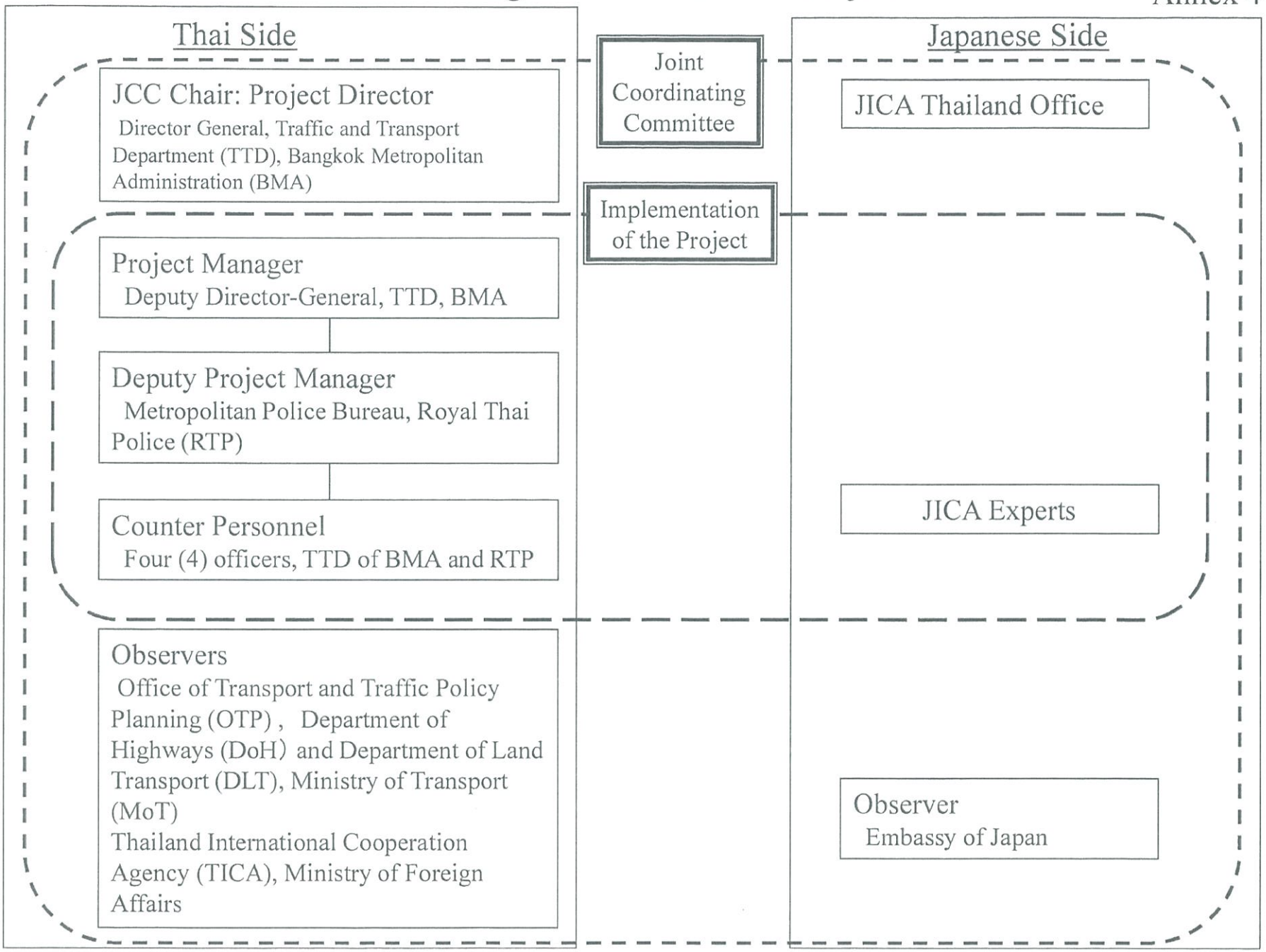
Tentative Plan of Operation

Annex 3

No.	Activities		1st year				2nd year				3rd year			
			I	II	III	IV	I	II	III	IV	I	II	III	IV
	Joint Coordination Committee		■	■		■	■	■				■		
	Submission of Monitoring Sheet/Completion Report			■	■		■		■		■		■	
	Post-project Monitoring		(Ex-post evaluation three (3) years after the project completion, in principle)											
1	Output 1: Establishment of the ATC system													
1-1	The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance the traffic control system, is reviewed and analyzed	1	1											
1-2	The pilot project area is selected	1	1											
1-3	Details of the project activities are planned, and demarcation among the participating organizations is clarified.	1	1											
1-4	The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system	1.5	1.5											
1-5	The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area.	4	4											
1-6	Based on the above studies, improvement works are implemented at the intersections in the pilot project area	2			2		2							
1-7	The equipment for the ATC system is installed in the pilot project area and the traffic control center	4							4					
1-8	The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center	1.5							1.5					
1-9	The database is established, and system, signal and detector parameters are adjusted	3								3				
2	Output 2: Operation and maintenance of the ATC system													
2-1	Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others	1		1										
2-2	The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on-the-job training and training in Japan	2					0.5				2			
2-3	The operation and maintenance guidelines of ATC system are prepared	3					3							
2-4	Awareness campaign and public relations are conducted	0.5									0.5			
3	Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC													
3-1	Current practice of manual operation is studied through interviews with traffic police officers and observations	1	1											
3-2	The operation guideline for manual operation of traffic signals is drafted	1		1										
3-3	Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required	1									1			
3-4	Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.	1									1			
3-5	The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized	1										1		
4	Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok													
4-1	Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed	1	1									1		
4-2	The situation of urban transportation in Bangkok Metropolitan Area is reviewed.	1	1									1		
4-3	The traffic control system in the other countries is studied	1			1		1							
4-4	The draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated	2											2	
4-5	Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles	1						1						

Organization chart of the Project

Annex 4



Annex 5

List of Proposed Members of Joint Coordination Committee

(1) Project Team
1) Project Director (Chairperson of JCC)
   Director General of Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA)
2) Project Manager
   Deputy Director-General, TTD, BMA
3) Deputy Project Manager
   Metropolitan Police Bureau, Royal Thai Police (RTP)
4) Counterpart Personnel from BMA and RTP
5) JICA Experts

(2) Observer Members of the Thai side
1) Officials from Office of Transport and Traffic Policy Planning (OTP), Ministry of Transport (MOT)
2) Officials from Department of Highways (DoH), MOT
3) Officials from Department of Land Transport (DLT), MOT
4) Officials from Thailand International Cooperation Agency (TICA), Ministry of Foreign Affairs (MOFA)

(3) Members of the Japanese side
1) Chief Representative and other staffs, JICA Thailand Office
2) Representatives, JICA Headquarters

(4) Observer Members of the Japanese Side
1) Officials of the Embassy of Japan

(5) Others
The JCC can invite any related persons to discuss specific issues if necessary.

Project Monitoring Sheet I (Revision of Project Design Matrix)

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System
Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Forty-four (44) months
Project Site: Bangkok

Date: 27th Apr 2021

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources		-	-
Project Purpose					
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.	-	-
Outputs					
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in 12 intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.	• The supplier of ATC system was selected.	• Activities on Output 1 is around a half year delayed due to COVID-19.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least 3 times.	• Minutes of JCC		-	• Activities on Output 2 is around a half year delayed due to COVID-19.
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation	3-1. Approximately 5 officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement		-	• Activities on Output 3 is around a half year delayed due to COVID-19.

guidelines are used for signal control during peak hours.	intersections in the pilot project area.				
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.			• The experiment of utilization of car probe data for operation of ATC system have been planned.	Activities on Output 4 is around a half year delayed due to COVID-19.

Activities	Inputs		Important Assumption
	The Japanese Side	The Thailand Side	· Human resources and budget necessary for the Project is provided by the responsible organizations. · Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	**Preconditions** · Conditions are satisfied to begin the Project as indicated in the Record of Discussion.
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared.			

2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals. 3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			**Issues**
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			

1-3. Minutes of Meetings for Amendment of the Record of Discussions, December 15, 2022

MINUTES OF MEETING
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
BANGKOK METROPOLITAN ADMINISTRATION,
ROYAL THAI POLICE
FOR
AMENDMENT OF THE RECORD OF DISCUSSIONS ON
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK
THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC)
SYSTEM

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), Bangkok Metropolitan Administration (hereinafter referred to as "BMA") and Royal Thai Police (hereinafter referred to as "RTP") hereby agree that the Record of Discussions on the Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System signed on December 13th, 2018 is amended as follows;

1. Annex.1 Main Points Discussed

Before	Amended Version
2. Duration of the Project Both sides agreed that the duration of the Project is forty-four (44) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.	**2. Duration of the Project** Both sides agreed that the duration of the Project is fifty-two (52) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), and the distribution of BMA budget, some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended.	

2. Annex.2 Project Design Matrix

Before	Amended Version
2. Period of Project forty-four (44) months	**2. Period of Project** fifty-two (52) months
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), and the distribution of BMA budget, some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended.	

× Jirasant K. × T. Thaiphat

3. Annex.3 Plan of Operation

Before	Amended Version
2. Period of Project As attached Annex1 of this Minutes of Meeting	**2. Period of Project** As attached Annex3 of this Minutes of Meeting
Reason: Because of the extension of the duration of the Project, the schedule of the Project activities needs to be modified.	

Annex1: Record of Discussions (signed on December 13th 2018)
Annex2: Amended Project Design Matrix
Annex3: Amended Plan of Operation
Annex4: Minutes of Meeting for Record of Discussion amendment (signed on January 31th 2022)
Annex5: Minutes of Meeting for 5th JCC

This amendment is effective as of June 7, 2022 when the extension of the Project duration was approved by the JCC committee members.

Bangkok, December 15 , 2022

SUZUKI Kazuya
Chief Representative
Japan International Cooperation Agency
Thailand Office

× T. Thaiphat

Director-General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

× Jirasunt K.

Pol.Maj.Gen. Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

RECORD OF DISCUSSIONS

FOR

THE PROJECT FOR IMRPOVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

AGREED UPON BETWEEN

BANGKOK METROPOLITAN ADMINISTRATION,

ROYAL THAI POLICE

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

December 13, 2018

Based on the minutes of meetings on the Detailed Planning Survey for the Project for Improving traffic congestions in Bangkok through the establishment of model Area Traffic Control (ATC) System (hereinafter referred to as "the Project") signed on 14th June 2018 between Director General of Traffic and Transportation Department of Bangkok Metropolitan Administration of the Kingdom of Thailand (hereinafter referred to as "the Counterpart") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with the Counterpart and relevant organizations to develop a detailed plan of the Project.

The purpose of this record of discussions (hereinafter referred to as "the R/D") is to establish a mutual agreement for its implementation by all parties and to agree on the detailed plan of the Project as described in the followings and the Annexes, which will be implemented within the framework of the Agreement on Technical Cooperation signed on 5th November 1981 (hereinafter referred to as "the Agreement") and the Note Verbales exchanged on 18th May 2018 between the Government of Japan and the Government of Thailand.

The Counterpart will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of the Kingdom of Thailand.

All parties also agreed that the Project will be implemented in accordance with the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), unless other arrangements are agreed in the R/D.

The R/D is delivered at Bangkok as of the day and year first above written. The R/D may be amended by a minutes of meetings between all parties, except the plan of operation to be modified in monitoring sheets. The minutes of meetings will be signed by authorized persons of each side who may be different from the signers of the R/D.

Ms. Katsura Miyazaki
Chief Representative
Japan International Cooperation
Agency
Thailand Office

Mr. Somchai Dechakorn
Deputy Director General,
Acting Director General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Annex 1 Main Points Discussed
Annex 2 Project Design Matrix (PDM)
Annex 3 Plan of Operation (PO)
Annex 4 Implementation Structure
Annex 5 List of Proposed Members of Joint Coordinating Committee

Annex 1

MAIN POINTS DISCUSSED

1. **Framework of the Project**
   The Project Design Matrix (hereinafter referred to as "PDM") and Plan of Operation (hereinafter referred to as "PO") attached to R/D as the Annex 2 and Annex 3 respectively shall be used as a monitoring and management tool of the Project. The PDM and PO will be reviewed and revised flexibly whenever the necessity arises.

2. **Duration of the Project**
   Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.

3. **Joint Coordinating Committee (JCC)**
   Both sides have agreed that the Joint Coordinating Committee (hereinafter referred to as "JCC") comprising of the authorities concerned will be established, and chaired by the Director General of Traffic and Transportation Department of BMA. The proposed members of the JCC are described in Annex 5 of the draft R/D. The first JCC will be convened within six months of the commencement of the Project to approve the first version of the PDM and PO. JCC will meet at least once a year and whenever necessity arises.

4. **Counterpart Personnel**
   Both sides agreed that the necessary counterpart personnel described in the PDM of the R/D will be assigned by the respective organizations and informed to JICA before signing of R/D.

6. **Sharing of responsibilities on establishment of Area Traffic Control System as a pilot project**
   Both sides agreed that the establishment of Area Traffic Control System shall be implemented under the sharing of responsibilities described as Attachment 1.

7. **Provision of benefits and facilities**
   Thai side agrees to provide the following benefits and facilities:
   (1) Office space in the building of BMA for the Project members with office furniture and utilities such as internet connection, electricity, air conditioner and so on;
   (2) Necessary data and information for the Project;
   (3) Permission of access for JICA Experts to the project sites; and
   (4) Identification cards for JICA Experts if necessary
   (5) Budget allocation for personnel, operation and activities for implementation of the Project, including the pilot project, personnel costs, local traveling costs and daily subsistence allowance for counterpart personnel, and other recurrent cost.

Japanese side agrees to provide following inputs to the Thai side.
(1) Experts
(2) Counterpart trainings in Thailand and Japan
(3) Necessary equipment for the project activities
(4) Expenses related to Japanese experts' activities

8. Environmental and Social Considerations

With regard to the Section 10.1 of the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

Attachment 1 Sharing of responsibilities

Attachment 01

Responsibility Sharing Matrix

Items		JICA	TICA	BMA	RTP
1. Plan, Design					
1-1	Map with Existing Signals			✓	
1-2	Traffic Survey	✓			
1-3	Detail Design of Civil Works	✓			
1-4	Detail Design of Electrical Works	✓			
1-5	Detail Design of Communication Network & ATC System	✓			
2. Construction					
2-1	Procurement of ATC System Equipment	✓			
2-2	Tax Exemption for Importing Equipment		✓		
2-3	Installation of Equipment for Intersections and Control Center	✓			
2-4	Civil Works at Intersections (Lane Markings, Road Signs, etc.)			✓	
2-5	Electrical Works (Wiring Ducts, Handholes, Poles, etc.)	✓			
2-6	Communication Network Works (From intersections to nearest BMA access point)	✓			
2-7	CommunicationTrunk Line			✓	
3. Maintenance, Operation					
3-1	Power Cost			✓	
3-2	Maintenance of ATC System			✓	
3-3	Operation of ATC System			✓	✓
3-4	Usage of Existing Cameras for Traffic Detectors			✓	✓
3-5	One Year Warranty for Equipment and Works	✓			
4. Evaluation					
4-1	Analysis and Evaluation on Pilot Project (including Traffic Survey)	✓			

Draft Project Design Matrix

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System

Version 0
Annex 2

Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Thirty-four (34) months. Project Site: Bangkok

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall Goal			
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources	
Project Purpose			
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced XX% along the routes in the pilot project area. 3. XX officials from BMA and RTP are available to operate ATC system .	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.
Outputs			
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in XX intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. XX officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least XX times.	• Minutes of JCC	
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	3-1. XX officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement	
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.		

Activities	Inputs		
	The Japanese Side	The Thailand Side	Human resources and budget necessary for the Project is provided by the responsible organizations. Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.			

3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			Preconditions Conditions are satisfied to begin the Project as indicated in the Record of Discussion.

Remark:

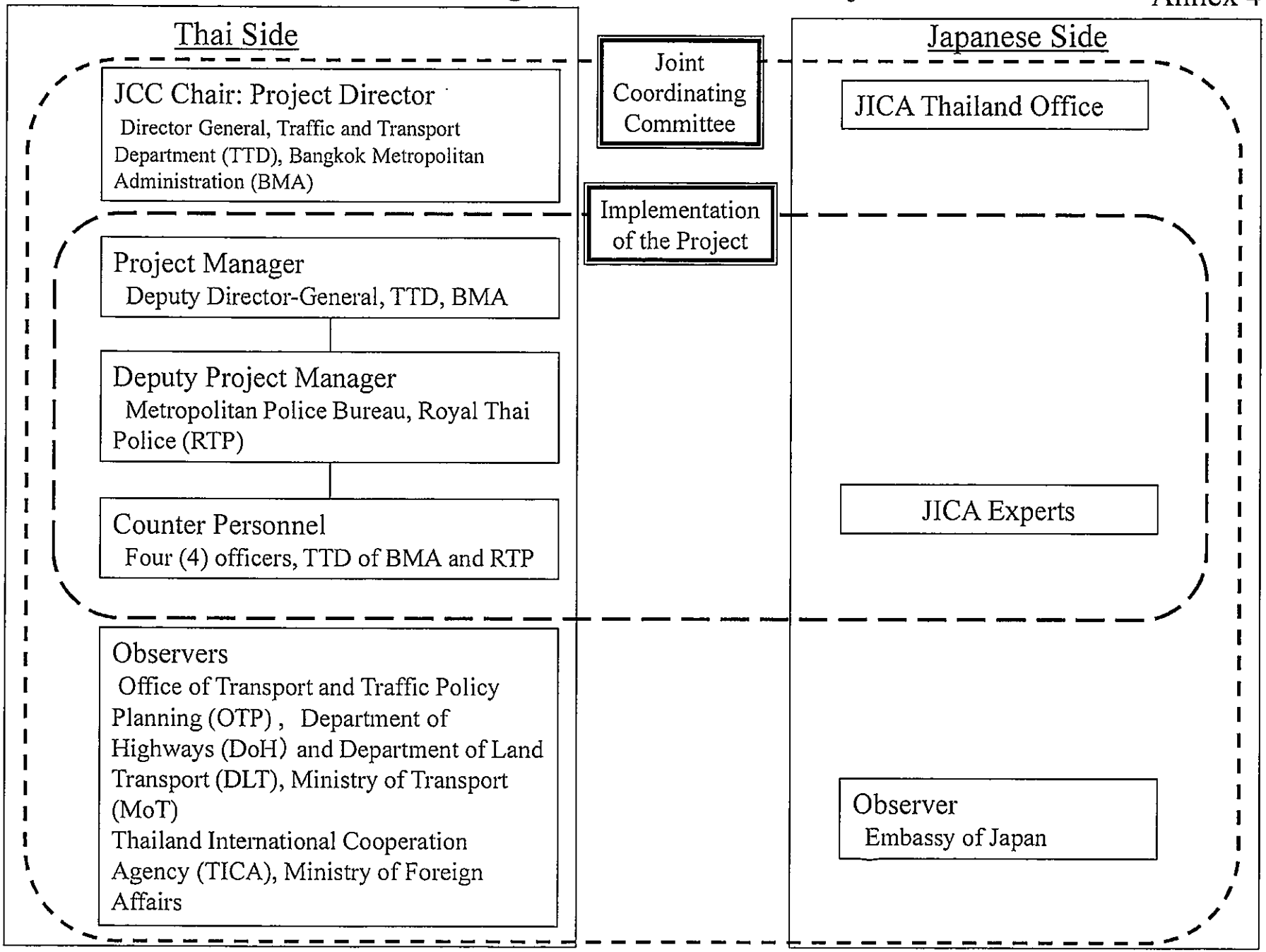
Tentative Plan of Operation

Annex 3

No.	Activities		1st year				2nd year				3rd year			
			I	II	III	IV	I	II	III	IV	I	II	III	IV
	Joint Coordination Committee		1	1	1	1	1	1	1			1		
	Submission of Monitoring Sheet/Completion Report			1	1		1		1		1		1	
	Post-project Monitoring		(Ex-post evaluation three (3) years after the project completion, in principle)											
1	Output 1: Establishment of the ATC system													
1-1	The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance the traffic control system, is reviewed and analyzed.	1	1											
1-2	The pilot project area is selected	1	1											
1-3	Details of the project activities are planned, and demarcation among the participating organizations is clarified.	1	1											
1-4	The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system	1.5	1.5											
1-5	The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area.	4	4											
1-6	Based on the above studies, improvement works are implemented at the intersections in the pilot project area	2			2		2							
1-7	The equipment for the ATC system is installed in the pilot project area and the traffic control center.	4							4					
1-8	The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center	1.5							1.5					
1-9	The database is established, and system, signal and detector parameters are adjusted	3								3				
2	Output 2: Operation and maintenance of the ATC system													
2-1	Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others	1		1										
2-2	The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on-the-job training and training in Japan	2					0.5				2			
2-3	The operation and maintenance guidelines of ATC system are prepared	3							3					
2-4	Awareness campaign and public relations are conducted	0.5									0.5			
3	Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC													
3-1	Current practice of manual operation is studied through interviews with traffic police officers and observations.	1	1											
3-2	The operation guideline for manual operation of traffic signals is drafted	1		1										
3-3	Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required	1									1			
3-4	Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.	1									1			
3-5	The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized	1										1		
4	Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok													
4-1	Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed.	1	1									1		
4-2	The situation of urban transportation in Bangkok Metropolitan Area is reviewed.	1	1									1		
4-3	The traffic control system in the other countries is studied	1			1		1							
4-4	The draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated	2											2	
4-5	Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.	1												

Organization chart of the Project

Annex 4



Annex 5

List of Proposed Members of Joint Coordination Committee

(1) Project Team
1) Project Director (Chairperson of JCC)
   Director General of Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA)
2) Project Manager
   Deputy Director-General, TTD, BMA
3) Deputy Project Manager
   Metropolitan Police Bureau, Royal Thai Police (RTP)
4) Counterpart Personnel from BMA and RTP
5) JICA Experts

(2) Observer Members of the Thai side
1) Officials from Office of Transport and Traffic Policy Planning (OTP), Ministry of Transport (MOT)
2) Officials from Department of Highways (DoH), MOT
3) Officials from Department of Land Transport (DLT), MOT
4) Officials from Thailand International Cooperation Agency (TICA), Ministry of Foreign Affairs (MOFA)

(3) Members of the Japanese side
1) Chief Representative and other staffs, JICA Thailand Office
2) Representatives, JICA Headquarters

(4) Observer Members of the Japanese Side
1) Officials of the Embassy of Japan

(5) Others
The JCC can invite any related persons to discuss specific issues if necessary.

Project Monitoring Sheet I (Revision of Project Design Matrix)

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System
Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: fifty-two (52) months
Project Site: Bangkok

Version 7
Date: 31st Aug 2022

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources		-	-
Project Purpose					
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.	-	-
Outputs					
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in 12 intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.	• The roadside equipment and the control center equipment have been installed.	• Installation of traffic signal lanterns and establishment of optical fiber network by BMA have been delayed., but BMA have secured the budged.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least 3 times.	• Minutes of JCC		• Draft of the ATC operation and maintenance manual was explained and confirmed.	-
Output 3: Operation guidelines for manual operation of traffic signal are	3-1. Approximately 5 officials from RTP receive training on manual signal	• Records of workshops • Interview survey of RTP		-	-

developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	officials • Letter of acknowledgement			
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.			-	The experiment of utilization of car probe data for operation of ATC system might be delayed due to delay of Output 1.

Activities	Inputs		Important Assumption
	The Japanese Side	The Thailand Side	· Human resources and budget necessary for the Project is provided by the responsible organizations. · Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	**Preconditions** · Conditions are satisfied to begin the Project as indicated in the Record of Discussion.
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others.			

2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals. 3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			**Issues**
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			

Project Monitoring Sheet II (Revision of Plan of Operation)

Version 7

Project Title: The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System in the Kingdom of Thailand

Dated: 31st August 2022

Inputs	Year / Month (2019 – 2023)	Remarks	Monitoring	
Expert				
1 Project Manager/Urban Transportation Planning	Plan / Actual		no issues	-
2 Deputy Project Manager	Plan / Actual		ditto	-
3 Road Planning	Plan / Actual		ditto	-
4 Traffic Control	Plan / Actual		ditto	-
5 Traffic Signal Control	Plan / Actual		ditto	-
6 Signal System Construction	Plan / Actual		ditto	-
7 ATC System Operation and Maintenance Management	Plan / Actual		ditto	-
8 Traffic Safety	Plan / Actual		ditto	-
9 Traffic Survey/IHL/Project Coordination	Plan / Actual		ditto	-
10 Information Communication Network	Plan / Actual		ditto	-
11 Economic Analyst/Training Planning/Monitoring	Plan / Actual		ditto	-
12 Economic Analyst/Training Planning/Monitoring (D Frame)	Plan / Actual		ditto	-
Training				
Training in Japan	Plan / Actual		The study tour in 2021 was canceled.	The study tour is planned in February 2023.

Note: Assignment in Japan also recorded as actual inputs. Total planned inputs have not been changed.

Outputs / Activities	Year / Month (2019 – 2023)	Responsible Organization: Japan	Responsible Organization: Thailand	Achievements	Issue & Countermeasures
Output 1: Establishment of the ATC system					
1-1 The present situation of the traffic control system, including outcomes of the project invested by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed	Plan / Actual				
1-2 The pilot project area is selected	Plan / Actual				
1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified	Plan / Actual				
1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system	Plan / Actual			The confirmation survey for existing Optical Fiber Cable conduct in the pilot project area is behind schedule	BMA have been preparing the survey report and BMA will repair the damaged points of Optical Fiber Cable.
1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area	Plan / Actual				
1-5-1 Traffic volume, queue length, traffic safety and other relevant issues in pilot project area are studied	Plan / Actual				
1-5-2 The effect of ATC system introduction and amount of air pollutants is estimated by traffic micro simulation	Plan / Actual				
1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area	Plan / Actual				
1-6-1 Intersection improvement is designed	Plan / Actual				
1-6-2 Based on the above design, improvement works are implemented for intersections in the pilot project area	Plan / Actual				
1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center	Plan / Actual			The installation work is behind schedule, due to delay at installation of traffic signal hardware and optical fiber network by BMA	BMA have secured the budgeted. Extension of the project period have been agreed.
1-7-1 ATC system, signal and communication network is designed	Plan / Actual				
1-7-2 The equipment for the ATC system is procured	Plan / Actual				
1-7-3 The equipment for the ATC system is installed in the pilot project area and the traffic control center	Plan / Actual				
1-8 The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center	Plan / Actual				
1-9 The database is established, and system, signal and detector parameters are adjusted	Plan / Actual				
1-9-1 The database is established, and system, signal and detector parameters are adjusted	Plan / Actual				
1-9-2 The operation of the ATC system is evaluated	Plan / Actual				
1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system	Plan / Actual				
Output 2: Operation and maintenance of the ATC system					
2-1 Duties and responsibilities of the organizations for the operation and maintenance of the ATC system, including BMA, RTP and companies to be contracted for maintenance, which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system management, future expansion plan, and others, are clarified	Plan / Actual			-	-
2-2 The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on the job training and training in Japan	Plan / Actual			-	-
2-3 The operation and maintenance guidelines of ATC system are prepared	Plan / Actual			-	-
2-4 Awareness campaign and public relations are conducted	Plan / Actual			-	-
Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC					
3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations	Plan / Actual			-	-
3-2 The operation guideline for manual operation of traffic signals is drafted	Plan / Actual			-	-
3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced on trial basis if required	Plan / Actual			This activity is included in Activity 1-7-3.	-
3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals	Plan / Actual			-	-
3-5 The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized	Plan / Actual			-	-
Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok					
4-1 Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed	Plan / Actual			-	-
4-2 The situation of urban transportation in Bangkok Metropolitan Area is reviewed	Plan / Actual			-	-
4-3 The ATC system in the other countries is studied	Plan / Actual			-	-
4-4 A draft short and midterm plan for expansion the ATC system in Bangkok Metropolitan Area is formulated	Plan / Actual			-	-
4-5 Possible long term innovation of area transport control in Bangkok are studied applying state of art technologies which includes probe data from individual vehicles	Plan / Actual			The activity is behind schedule, due to delay of Activity 1-7.	Extension of the project period have been agreed

Monitoring Plan	Year / Month (2019 – 2023)	Remarks	Issue	Solution
Monitoring				
Joint Coordinating Committee	Plan / Actual		-	-
Submission of Monitoring Sheet	Plan / Actual		-	-
Post project Monitoring	Plan: Ex post evaluation (Three (3) years after the project completion, in principle) / Actual		-	-
Reports/Documents				
Project Plan/Work Plan	Plan / Actual		-	-
Project Completion Report	Plan / Actual		-	-

Note: Extension of the project duration was agreed in the 3rd JCC. So, this plan of operation is prepared based on the extended schedule.

× Jirasuk K. × T. Thaiphat

MINUTES OF MEETING
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
BANGKOK METROPOLITAN ADMINISTRATION,
ROYAL THAI POLICE
FOR
AMENDMENT OF THE RECORD OF DISCUSSIONS ON
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), Bangkok Metropolitan Administration (hereinafter referred to as "BMA") and Royal Thai Police (hereinafter referred to as "RTP") hereby agree that the Record of Discussions on the Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System signed on December 13th, 2018 is amended as follows;

1. Annex.1 Main Points Discussed

Before	Amended Version
2. Duration of the Project Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.	**2. Duration of the Project** Both sides agreed that the duration of the Project is forty-four (44) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended. The duration may be further amended (shortened or extended) depending on the COVID-19 situation.	

Annex1: Record of Discussions (signed on December 13th 2018)
Annex2: Amended Project Design Matrix

This amendment is effective as of April 27, 2021 when the extension of the Project duration was approved by the JCC committee members.

Bangkok, January 31 , 2022

Mr. MORITA Takahiro
Chief Representative
Thailand Office
Japan International Cooperation Agency

Mr. Prapas Lueangsirinapha
Director-General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

RECORD OF DISCUSSIONS

FOR

THE PROJECT FOR IMRPOVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

AGREED UPON BETWEEN

BANGKOK METROPOLITAN ADMINISTRATION,

ROYAL THAI POLICE

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

December 13, 2018

宮崎 桂

Ms. Katsura Miyazaki
Chief Representative
Japan International Cooperation
Agency
Thailand Office

Mr. Somchai Dechakorn
Deputy Director General,
Acting Director General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Annex 1 Main Points Discussed
Annex 2 Project Design Matrix (PDM)
Annex 3 Plan of Operation (PO)
Annex 4 Implementation Structure
Annex 5 List of Proposed Members of Joint Coordinating Committee

Annex 1

MAIN POINTS DISCUSSED

1. **Framework of the Project**
   The Project Design Matrix (hereinafter referred to as "PDM") and Plan of Operation (hereinafter referred to as "PO") attached to R/D as the Annex 2 and Annex 3 respectively shall be used as a monitoring and management tool of the Project. The PDM and PO will be reviewed and revised flexibly whenever the necessity arises.

2. **Duration of the Project**
   Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.

3. **Joint Coordinating Committee (JCC)**
   Both sides have agreed that the Joint Coordinating Committee (hereinafter referred to as "JCC") comprising of the authorities concerned will be established, and chaired by the Director General of Traffic and Transportation Department of BMA. The proposed members of the JCC are described in Annex 5 of the draft R/D. The first JCC will be convened within six months of the commencement of the Project to approve the first version of the PDM and PO. JCC will meet at least once a year and whenever necessity arises.

4. **Counterpart Personnel**
   Both sides agreed that the necessary counterpart personnel described in the PDM of the R/D will be assigned by the respective organizations and informed to JICA before signing of R/D.

6. **Sharing of responsibilities on establishment of Area Traffic Control System as a pilot project**
   Both sides agreed that the establishment of Area Traffic Control System shall be implemented under the sharing of responsibilities described as Attachment 1.

7. **Provision of benefits and facilities**
   Thai side agrees to provide the following benefits and facilities:
   (1) Office space in the building of BMA for the Project members with office furniture and utilities such as internet connection, electricity, air conditioner and so on;
   (2) Necessary data and information for the Project;
   (3) Permission of access for JICA Experts to the project sites; and
   (4) Identification cards for JICA Experts if necessary
   (5) Budget allocation for personnel, operation and activities for implementation of the Project, including the pilot project, personnel costs, local traveling costs and daily subsistence allowance for counterpart personnel, and other recurrent cost.

Japanese side agrees to provide following inputs to the Thai side.
(1) Experts
(2) Counterpart trainings in Thailand and Japan
(3) Necessary equipment for the project activities
(4) Expenses related to Japanese experts' activities

8. **Environmental and Social Considerations**
With regard to the Section 10.1 of the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

Attachment 1 Sharing of responsibilities

Responsibility Sharing Matrix

Items	JICA	TICA	BMA	RTP
1. Plan, Design				
1-1 Map with Existing Signals			✓	
1-2 Traffic Survey	✓			
1-3 Detail Design of Civil Works	✓			
1-4 Detail Design of Electrical Works	✓			
1-5 Detail Design of Communication Network & ATC System	✓			
2. Construction				
2-1 Procurement of ATC System Equipment	✓			
2-2 Tax Exemption for Importing Equipment		✓		
2-3 Installation of Equipment for Intersections and Control Center	✓			
2-4 Civil Works at Intersections (Lane Markings, Road Signs, etc.)			✓	
2-5 Electrical Works (Wiring Ducts, Handholes, Poles, etc.)	✓			
2-6 Communication Network Works (From intersections to nearest BMA access point)	✓			
2-7 CommunicationTrunk Line			✓	
3. Maintenance, Operation				
3-1 Power Cost			✓	
3-2 Maintenance of ATC System			✓	
3-3 Operation of ATC System			✓	✓
3-4 Usage of Existing Cameras for Traffic Detectors			✓	✓
3-5 One Year Warranty for Equipment and Works	✓			
4. Evaluation				
4-1 Analysis and Evaluation on Pilot Project (including Traffic Survey)	✓			

Draft Project Design Matrix

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System

Version 0
Annex 2

Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Thirty-four (34) months, Project Site: Bangkok

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall Goal			
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources	
Project Purpose			
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced XX% along the routes in the pilot project area. 3. XX officials from BMA and RTP are available to operate ATC system .	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.
Outputs			
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in XX intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. XX officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least XX times.	• Minutes of JCC	
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	3-1. XX officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement	
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.		

Activities	Inputs		
	The Japanese Side	The Thailand Side	
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	Human resources and budget necessary for the Project is provided by the responsible organizations. Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.			

3-5 The draft operation guideline is reviewed through the workshop with concerned officials. and the operation guideline is finalized.			
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			Preconditions Conditions are satisfied to begin the Project as indicated in the Record of Discussion.

Remark:

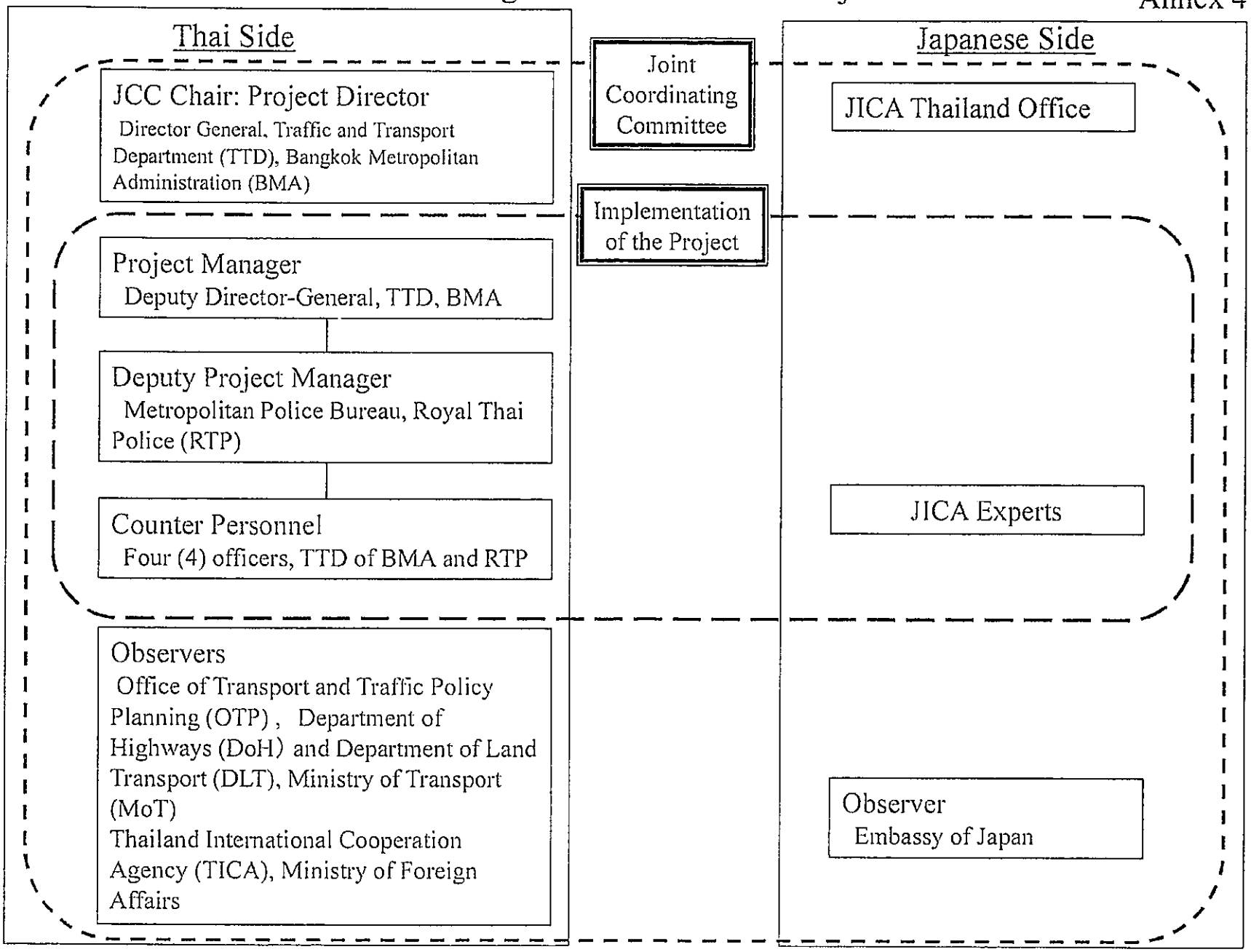
Tentative Plan of Operation

Annex 3

No.	Activities		1st year				2nd year				3rd year			
			I	II	III	IV	I	II	III	IV	I	II	III	IV
	Joint Coordination Committee													
	Submission of Monitoring Sheet/Completion Report													
	Post-project Monitoring		(Ex-post evaluation three (3) years after the project completion, in principle)											
1	Output 1: Establishment of the ATC system													
1-1	The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance the traffic control system, is reviewed and analyzed	1												
1-2	The pilot project area is selected	1												
1-3	Details of the project activities are planned, and demarcation among the participating organizations is clarified	1												
1-4	The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system	1.5												
1-5	The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area.	4												
1-6	Based on the above studies, improvement works are implemented at the intersections in the pilot project area	2												
1-7	The equipment for the ATC system is installed in the pilot project area and the traffic control center	4												
1-8	The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center	1.5												
1-9	The database is established, and system, signal and detector parameters are adjusted	3												
2	Output 2: Operation and maintenance of the ATC system													
2-1	Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control system maintenance, traffic data analysis, system improvement, future expansion plan, and others	1												
2-2	The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on-the-job training and training in Japan	2												
2-3	The operation and maintenance guidelines of ATC system are prepared	3												
2-4	Awareness campaign and public relations are conducted	0.5												
3	Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC													
3-1	Current practice of manual operation is studied through interviews with traffic police officers and observations	1												
3-2	The operation guideline for manual operation of traffic signals is drafted	1												
3-3	Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required	1												
3-4	Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals	1												
3-5	The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized	1												
4	Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok													
4-1	Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed	1												
4-2	The situation of urban transportation in Bangkok Metropolitan Area is reviewed.	1												
4-3	The traffic control system in the other countries is studied	1												
4-4	The draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated	2												
4-5	Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles	1												

Organization chart of the Project

Annex 4



Annex 5

List of Proposed Members of Joint Coordination Committee

(1) Project Team
1) Project Director (Chairperson of JCC)
   Director General of Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA)
2) Project Manager
   Deputy Director-General, TTD, BMA
3) Deputy Project Manager
   Metropolitan Police Bureau, Royal Thai Police (RTP)
4) Counterpart Personnel from BMA and RTP
5) JICA Experts

(2) Observer Members of the Thai side
1) Officials from Office of Transport and Traffic Policy Planning (OTP), Ministry of Transport (MOT)
2) Officials from Department of Highways (DoH), MOT
3) Officials from Department of Land Transport (DLT), MOT
4) Officials from Thailand International Cooperation Agency (TICA), Ministry of Foreign Affairs (MOFA)

(3) Members of the Japanese side
1) Chief Representative and other staffs, JICA Thailand Office
2) Representatives, JICA Headquarters

(4) Observer Members of the Japanese Side
1) Officials of the Embassy of Japan

(5) Others
The JCC can invite any related persons to discuss specific issues if necessary.

Project Monitoring Sheet I (Revision of Project Design Matrix)

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System
Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Forty-four (44) months
Project Site: Bangkok

Date: 27th Apr 2021

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources		-	-
Project Purpose					
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.	-	-
Outputs					
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in 12 intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.	• The supplier of ATC system was selected.	• Activities on Output 1 is around a half year delayed due to COVID-19.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least 3 times.	• Minutes of JCC		-	• Activities on Output 2 is around a half year delayed due to COVID-19.
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation	3-1. Approximately 5 officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement		-	• Activities on Output 3 is around a half year delayed due to COVID-19.

guidelines are used for signal control during peak hours.	intersections in the pilot project area.				
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.			• The experiment of utilization of car probe data for operation of ATC system have been planned.	Activities on Output 4 is around a half year delayed due to COVID-19.

Activities	Inputs		Important Assumption
	The Japanese Side	The Thailand Side	· Human resources and budget necessary for the Project is provided by the responsible organizations. · Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared.			**Preconditions** · Conditions are satisfied to begin the Project as indicated in the Record of Discussion.

2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals. 3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			Issues
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			

MINUTES OF MEETING
OF
THE FIFTH JOINT COORDINATING COMMITTEE (JCC) MEETING
FOR
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

In accordance with the Record of Discussions (RD) for the Project signed on 13th December 2018, the Fifth JCC Meeting was convened on 7th June 2022 at the conference room of Bangkok Metropolitan Administration (BMA), attended by Thai and Japanese members.

The meeting was started with the opening remarks made by the chairman, Mr. Thaiphat TANASOMBATKUL, Deputy Director-General of Traffic and Transportation Department (TTD) of BMA, Pol. Col. Suebsod SINGHASENI, Superintendent Section 4 of Traffic Police Department (TPD), Metropolitan Police Bureau (MPB), Royal Thai Police (RTP), and Mr. Hiroo TANAKA, Director-General for Infrastructure Management Department, Japan International Cooperation Agency (JICA).

In the meeting, the project progress and confirmation items were presented by the Project Team represented by JICA Expert Team (JET) and TTD-BMA. The participants then made comments and clarifications. Finally, the discussion was summarized and the meeting was adjourned with the closing remarks made by Mr. Thaiphat TANASOMBATKUL.

As a result of the discussion, the following major agreements were made:

1. As for the implementation of the Pilot Project of Area Traffic Control (ATC), the remaining tasks and the status of the additional allocation budget of BMA in the fiscal year of 2022 were confirmed. It was agreed that all member organizations will try to accelerate the implementation of the Pilot ATC Project.

2. The second extension of the project period was agreed upon as below (1) and the RD amended in April 2021 was further amended as below (2).

   (1) Original: April 2019 to February 2022 (RD signed on 13th December 2018)

   Extension (1st): April 2019 to December 2022 (RD amended in April 2021)

   Extension (2nd): April 2019 to August 2023

   (2) Second Amendment of RD

   Annex 1 Main Points Discussed

Before (RD amended in April 2021)	Amended version
2. Duration of the Project Both sides have agreed that the duration of the Project is forty-four (44) months from the date of the first arrival of the JICA experts to Thailand based on the	2. Duration of the Project Both sides have agreed that the duration of the Project is fifty-two (52) months from the date of the first arrival of the JICA experts to Thailand based on the

framework of the Project.	framework of the Project.

Annex 2 Project Design Matrix (PDM)

Before (RD amended on 27 April 2021)	Amended version
Period of Project: Forty-four (44) months	Period of Project: Fifty-two (52) months

3. It was confirmed that the schedule of the training program in Japan is shifted to approximately February 2023 considering the extension of the Project and the travel restrictions due to Covid-19. JICA requested BMA to accelerate authorization and implementation of the budget in aspect of the training program implementation because one of the purposes of the training is to learn the Japanese practices of operation and management of ATC System, comparing with ATC system operated in pilot project.

ANNEX 1 List of Participants
ANNEX 2 Presentation Material on the Overall Project Progress
ANNEX 3 Presentation Material on the Progress of the Pilot ATC Project and Matters to be done by BMA
ANNEX 4 Minutes of Meeting for Amendment of the Record of Discussion signed on 31JAN 2022

7th June 2022
Bangkok, Thailand

Mr. Prapas LUEANGSIRINAPHA
Project Director,
Traffic and Transportation Department,
Bangkok Metropolitan Administration

Mr. Takahiro MORITA
Chief Representative,
Thailand Office,
Japan International Cooperation Agency

Pol. Maj. Gen Jirasunt KAEWSAENGAKE
Deputy Commissioner,
Metropolitan Police Bureau,
Royal Thai Police

for
Dr. Tetsuji MASUJIMA
Project Manager,
The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System in the Kingdom of Thailand

Annex 1

The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System in the Kingdom of Thailand

The 5th Joint Coordination Committee (JCC)

Attendance List
Date/Time: 7rd June 2020, 13.30 - 15.30 (TST), 15.30 - 17.
Venue: Conference room 108 - 01, 8th Floor,Thani Nopparat Building, BMA 2

No.	Name	Organization	Position	Note
Thai Side: JCC Member				
1	Mr. Thaiphat TANASOMBATKUL	TTD	Deputy Director General	
2	Pol.Col. Suebsod SINGHASENI	TPD,MPB,RTP	Superintendent section 4	
3	Mr. Apiwat CHOTISANGAS	DOH, MOT	Civil Engineer, Experience Level	
4	Mr. Mussawa SOMJAIKID	DLT, MOT	Representative of Director General	
5	Mrs. Arunee HIAM	TICA	Director of Interantional Cooperation Division	Remote
6	Ms. Chanthip MAKKHAM	BMTA	Director of Bangkok Mass Transit Authority Division	
7	Mr. Thosapol SUPAREE	TTD,MPB,RTP	Director of Traffic Engineering Division	
8	Mr. Chakrapong TIENPITAK	TTD,MPB,RTP	Chief of Traffic Signal Section	
Thai Side: Project Team Member				
1	Pol. Maj. Wattana PETCHARATH	TPD,MPB,RTP	Inspector section 4	
2	Pol.Capt. Natthakrit CHITTIBOONSAP	Bang Sue Police Station	Sub-Traffic Inspector	
3	Pol.Lt. Warot AUIKHAM	TPD,MPB,RTP	Sub-Traffic Inspector, Traffic Engineering Division, Section 4	
4	Pol.Capt. Warawut KHOBKHUN	TPD,MPB,RTP	Sub-Inspector, Administration Division	
5	Mr. Akekachai PREECHAKAM	Traffic Signal Section,Traffic System Design Division,TTD	Electrical Technician (Operational Level)	
6	Mr. Wasu PHOKAEW	Traffic Signal Section,Traffic System Design Division,TTD	Electrical Engineer (Practitioner Level)	
Japanese Side, JCC Member				
1	Mr. Hiroo TANAKA	JICA Headquarter	Infrastructure Management Department	
2	Ms. Aya YOSHIDA	JICA Headquarter	Infrastructure Management Officer, Transportation Group, Infrastructure Management Department	
3	Mr. Tomohiro KOZONO	JICA Headquarter	Infrastructure Management Officer, Transportation Group, Infrastructure Management Department	Remote
4	Shuntaro KAWAHARA	JICA Headquarter	Infrastructure Management Officer, Transportation Group, Infrastructure Management Department	Remote
5	Mr. Hideaki IWASE	JICA Thailand Office	Representative	Remote
6	Ms. Suphak SUESUTTHIKUL	JICA Thailand Office	Program Officer	
Japanese Side, Project Team Member				
1	Dr. Tetsuji MASUJIMA	JICA Expert Team	Team Leader / Urban Transportation Planning	
2	Mr. Ken NISHINO	JICA Expert Team	Deputy Team Leader / Road Planning	
3	Mr. Seiya MATSUOKA	JICA Expert Team	Traffic Control	Remote
4	Mr. Yuji ONO	JICA Expert Team	ATC System Operation and Maintenance Management	Remote
5	Mr. Atsushi SUGANUMA	JICA Expert Team	Traffic Signal Control	Remote
6	Mr. Motoko KANEKO	JICA Expert Team	Economic Analysis / Training Planning / Monitoring	Remote
7	Dr. Tithiwach TANSAWAT	JICA Expert Team	Traffic Survey/ PR/ Project Coordination	
8	Mr. Pakorn PHIMMAHA	JICA Expert Team	Assistant Engineer	
9	Ms. Kanchana UBOL	JICA Expert Team	Secretary	

BMA Bangkok Metropolitan Administration
BMTA Bangkok Mass Transit Authority
DoH Department of Highways
JICA Japan International Cooperation Agency
MoT Ministry of Transport
MPB Metropolitan Police Bureau
OTP Office of Transport and Traffic Policy
RTP Royal Thai Police
TICA Thailand Incentive and Convention Association
TPD Taffic Police Devision
TTD Trafic and Transportation Department

THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

The 5th Joint Coordinating Committee (JCC)

= Overall Project Progress =

7th June 2022

JICA Expert Team

Topics

1. Outline of the Project
2. Project Progress
3. Project Period
4. Activities Schedule from now
5. Matters to be confirmed

1. Outline of the Project

■ 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

An ATC system is established in the pilot project area and traffic congestion in the area is improved.

■ Expected Outputs

Output 1: An **ATC system** is established in the pilot project area.

Output 2: The **management system for operation and maintenance** of the ATC system is established and it is implemented in the pilot project area.

Output 3: **Operation guidelines for manual operation of traffic signal** are developed for the intersections under the ATC system, and they are used for signal control during peak hours.

Output 4: A **draft ATC System development plan** covering entire Bangkok is prepared.

1. Outline of the Project

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

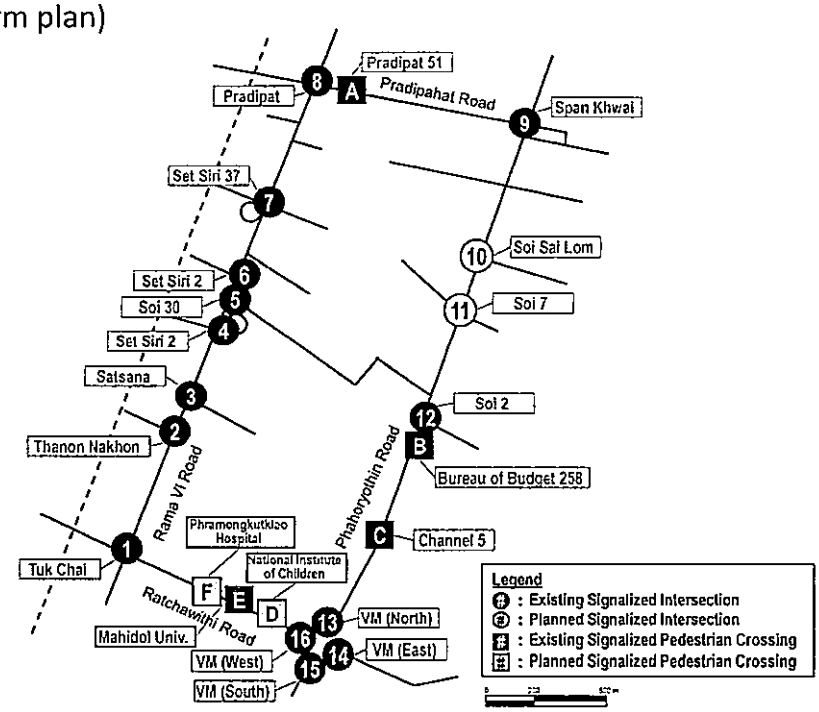
■ Pilot Project Area

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

Existing traffic signal system:

- 11 signalized intersections
- 4 pedestrian signals

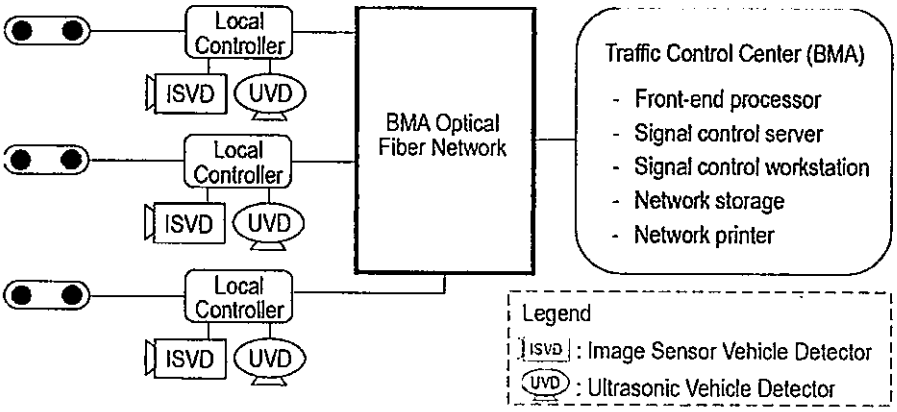
Location of Pilot Project Area



1. Outline of the Project

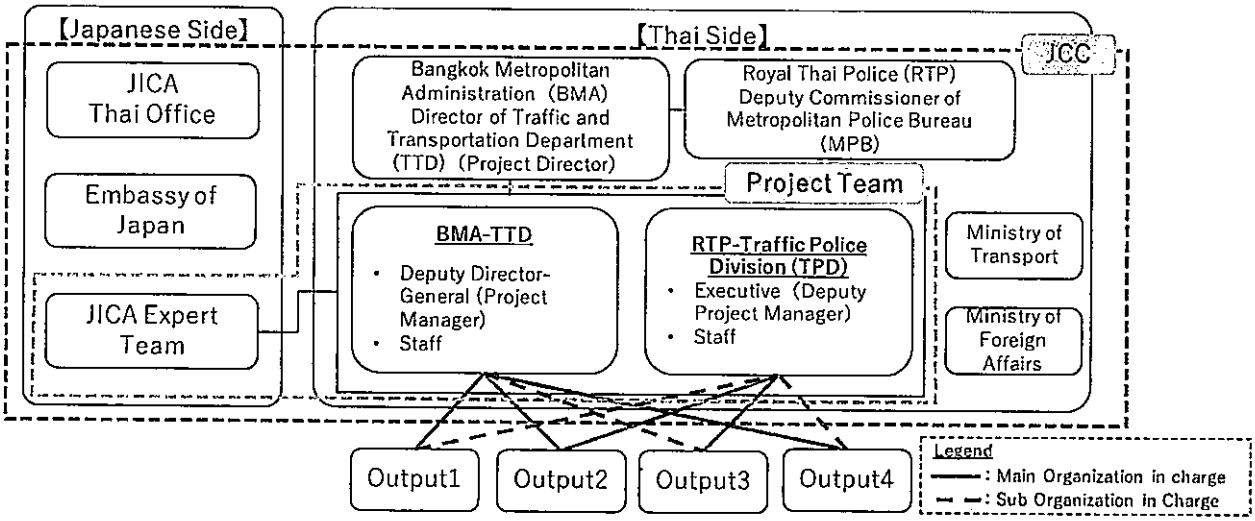
■ ATC System

- 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.



1. Outline of the Project

■ Implementation Structure

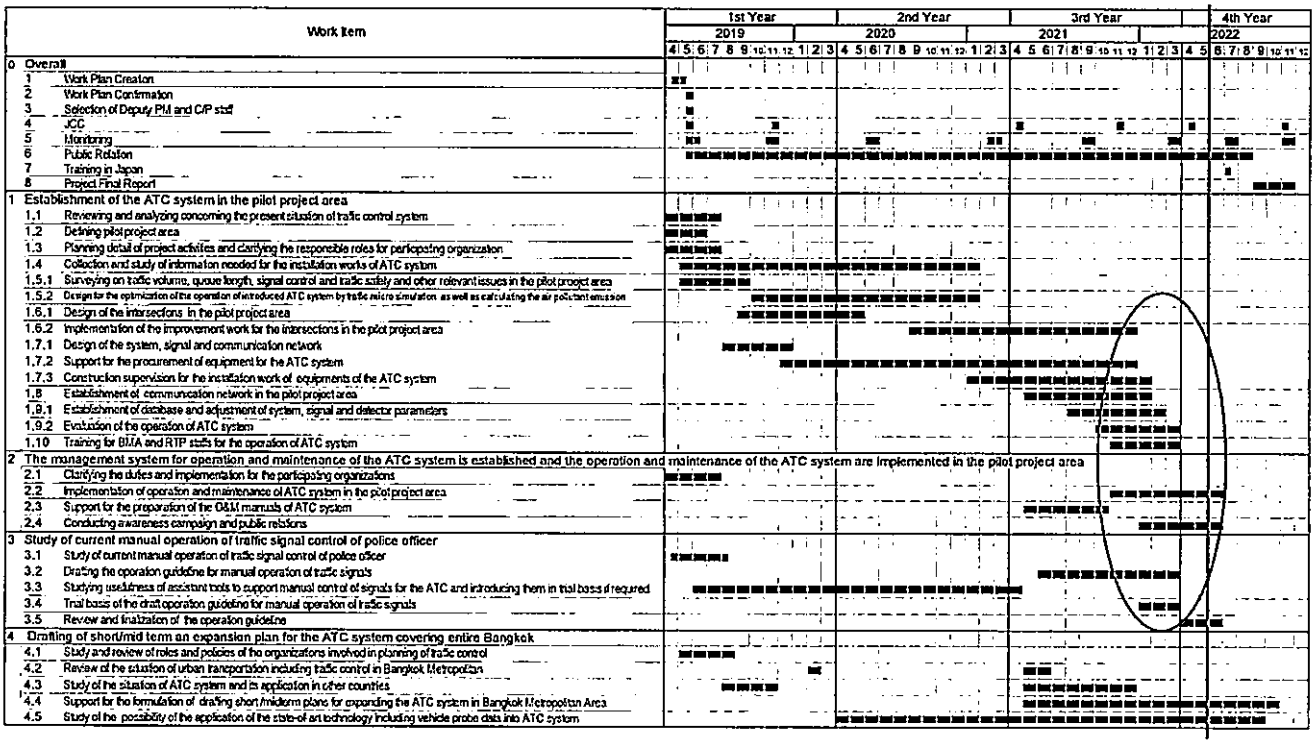


	Output 1 (Establishment of ATC)	Output 2 (Operation and Maintenance)	Output 3 (Traffic Signal Manual Operation)	Output 4 (Expansion Plan)
BMA-TTD	Installation	Maintenance	Installation	Planning
RTP-TPD	Advice for design	Operation	Manual Operation	Advice

1. Outline of the Project

■ Project Schedule (extended in April 2021)

Delays in the implementation of the Pilot Project due to Covid-19 and BMA's procurement of traffic signals and FOC network, etc.



2. Project Progress

■ Overall Activities

- JCC (Joint coordinating Committee)
  - 1st JCC (5th May 2019): The work plan, the pilot area, the implementation organization and project team member were confirmed.
  - 2nd JCC (28th November 2019): The design of ATC system was confirmed.
  - 3rd JCC (27th April 2021): Extension of the project period and matters to be done by BMA were confirmed.
  - 4th JCC (23rd November 2021): The critical tasks to complete the Pilot Project and Provisional schedule of Japan Training Tour were confirmed.
- Monitoring
  - Monitoring have been carried out and the monitoring sheet version 1 to 6 had been submitted so far.
- Public Relation
  - Activities have been posted on both of BMA and JICA's website.
- Project Team Meeting
  - Project team meeting had been organized monthly but postponed after the 3rd JCC due to COVID-19. Thereafter, it is organized when there are topics that need to be discussed.

2. Project Progress

■ Output 1 (Establishment of ATC System in the Pilot Area)

- ➢ A experimental study of traffic volume count using image processing technology has been done. [1.5]
- ➢ Installation work of equipment for the ATC system was almost done. [1.7]

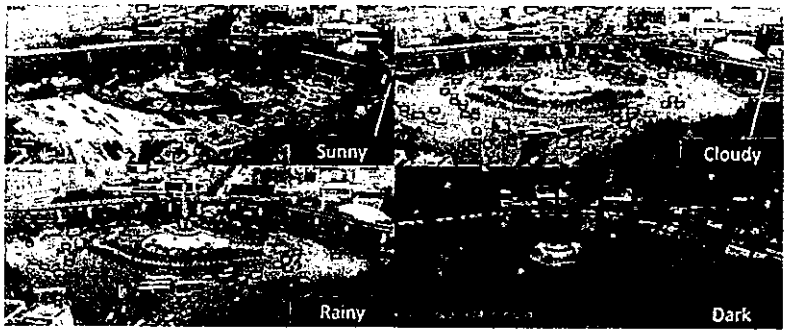
	Activity	Progress
Review and Analysis	1.1 Review of present situation	Done
	1.2 Selection of the pilot area	Done
	1.3 Clarification of role sharing	Done
	1.4 Data collection	Done
	1.5 Traffic survey and analysis	On-going
Design	1.6 Design of ATC system	On-going
Installation	1.7 Installation of equipment	On-going
	1.8 Establishment of communication network	On-going
	1.9 Establishment of software and database	On-going
Training	1.10 Operation training for BMA and RTP officers	Not yet

Bangkok ATC Project (BATCP)

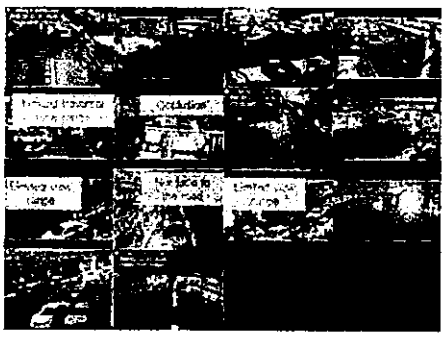
2. Project Progress

■ Output 1 (Establishment of ATC System in the Pilot Area)

- ➢ Activity 1.5: Traffic Survey and analysis
  - The experimental study to count the directional traffic volume at VMRA using the image processing technology has been done in ten weather/time cases.
  - The result shows that directional traffic volume can be counted during the daytime (even in cloudy condition), but it is difficult during nighttime.
  - The result can be used for an adjustment of signal parameters.
  - The study recommended to utilize this technology to count traffic volume at other intersections in BMA where CCTV is equipped.



(1) Vehicle Recognition and Tracking



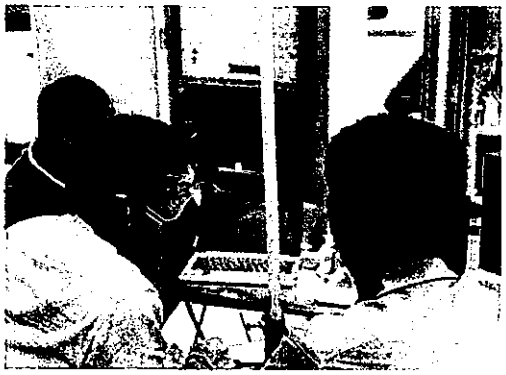
(2) Example of Existing CCTV Camera view

2. Project Progress

■ Output 1 (Establishment of ATC System in the Pilot Area)

➢ Activity 1.7: Installation of equipment

- BMA, JICA, Contractor (Genius) and JET have held 38 times of periodical meeting so far.
- Factory test was completed and approved in June 2021.
- ATC Roadside Equipment and Control Center Acceptance Test were conducted in 9th and 22nd Mar 2022, and the results were acceptable .



(1) ATC Road Site Equipment Acceptance Test

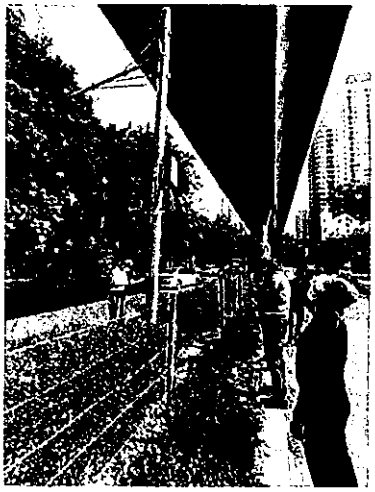
(2) Area Traffic Control Center Acceptance Test

2. Project Progress

■ Output 1 (Establishment of ATC System in the Pilot Area)

➢ Activity 1.7: Installation of equipment

- Phase 1 of traffic signals installation which includes Phaholyothin Soi 2, Phaholyothin Soi 8 and Satsana Intersection was completed.
- Installation of the detectors and poles were completed.



ATC Field Equipment checking and confirmation

2. Project Progress

■ Output 2 (Establishment of Management System for Operation and Maintenance (O&M) for the ATC System)

➢ O&M manuals were drafted by JET and being discussed among the Project Team. [2.3]

Activity	Progress
2.1 Clarification of duties	Done
2.2 Implementation of O&M in the pilot area	Not yet
2.3 Preparation of the O&M manual	On-going
2.4 Conduction of public relations campaign	Not yet

2. Project Progress

■ Output 2 (Establishment of Management System for Operation and Maintenance (O&M) for the ATC System)

➢ Activity 2.3: Preparation of the O&M manual

- The operation and maintenance manuals were drafted by JET based on Japanese manual and current manuals of BMA, and being discussed among the Project Team..

ATC System Operation Manual (draft)

ATC System Operation Manual (draft) 1
1 General 2
1 1 Introduction 2
1 2 Mission 2
1 3 Vision 2
1 4 Definition 2
2 Function and Services 3
3 Operation 3
3 1 Daily system operation 3
3 2 Backoffice system review and improvement 4
3 3 Coordination with other agencies 5
3 4 Personnel 6
3 5 Hour of operation and staffing 6
3 6 Security procedure 7
3 7 Maintenance checklist 7
4 Reporting of Traffic Information 7
4 1 Reporting and notification of traffic information 7
4 2 Instructions by the person in charge of operation 8
5 Provision of Traffic Information 8
5 1 Provision of traffic information 8
6 Guidelines for Employees 8
Traffic Information Reporting (Notification) Criteria 10
ATC Center Activity Daily Report 12

ATC System Maintenance Manual (Draft)

Maintenance Manual (Draft) 1
1 Purpose 2
2 Definition of Terms 2
2 1 Traffic signals and associated equipment 2
2 2 ATC system equipment 2
3 Person in charge of management Who is legally in charge? 2
4 Person in charge of management 2
5 Maintenance and management system 3
5 1 Relevant organizations 3
5 2 Work system 3
6 Proper management 3
6 1 Responsibility 3
6 2 Monitoring 3
6 3 Inspection 4
6 4 Special inspection 4
7 Inspections by contractors 4
7 1 Daily inspection (system check) Inspection by center staff? 4
Traffic Signal Failure Repair Report 10

2. Project Progress

■ Output 3 (Development of Traffic Signal Manual Operation)

➢ Preparation of manuals was started. [3.2]

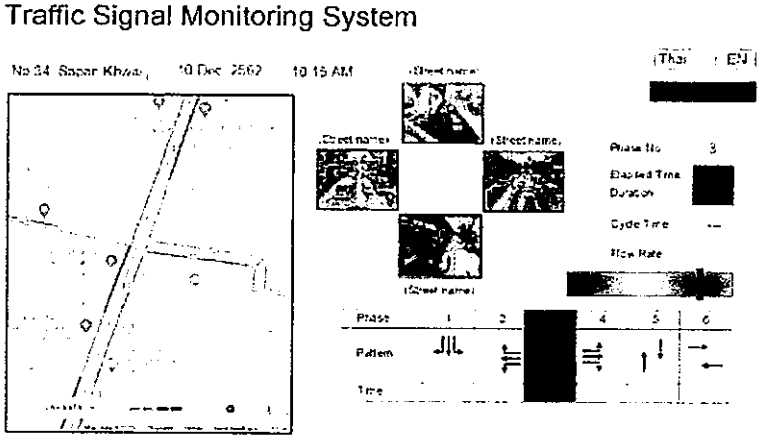
Activity	Progress
3.1 Study on current manual operation of traffic signal	Done
3.2 Drafting of the manual operation guideline	On-going
3.3 Study on assistant tool for the manual operation	Done
3.4 Trail of the draft guideline	Not yet
3.5 Finalization of the guideline	Not yet

2. Project Progress

■ Output 3 (Development of Traffic Signal Manual Operation)

➢ Activity 3.2: Drafting of the manual operation guideline

- The operation and maintenance manual is under preparation based on Japanese manual and current manuals of BMA.



Screen layout: manual control (tentative)

2. Project Progress

■ Output 4 (Preparation of a draft ATC Development Plan)

- Information of road network and location of signalized intersections and other data in Bangkok were collected and being studied. [4.2]

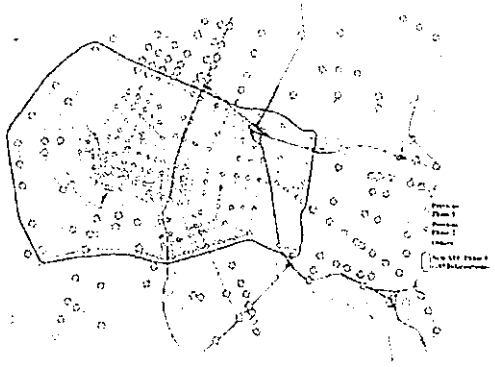
Activity	Progress
4.1 Review of roles and policies of traffic control in BKK	Done
4.2 Review of existing situation of urban transport in BKK	On-going
4.3 Study of the situation of ATC system in other countries	On-going
4.4 Draft of short and mid term expansion plan	Not yet
4.5 Study of application of the state-of-art technology (probe data)	On-going

2. Project Progress

■ Output 4 (Preparation of a draft ATC Development Plan)

- Activity 4.2: Review of existing situation of urban transport in BMA

Traffic Signals in BMA



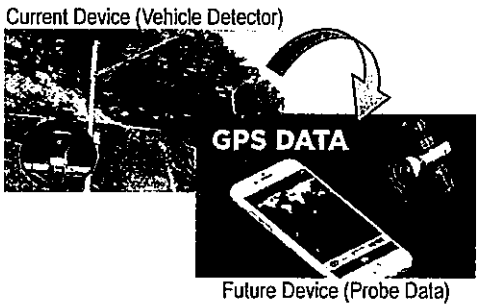
Proposed Coverage for ATC Plan in 2004

2. Project Progress

■ Output 4 (Preparation of a draft ATC Development Plan)

➢ Activity 4.5

- Applicability of probe data was confirmed by comparing the queue length from both of site survey and prove data.
- An experimental test has been planned and will be conducted when the Pilot ATC system is in operation.



Comparison of Queue Length at VMRA by Site Survey and Probe Data

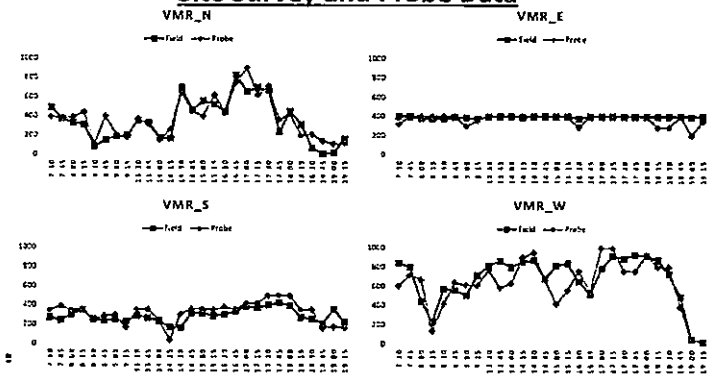
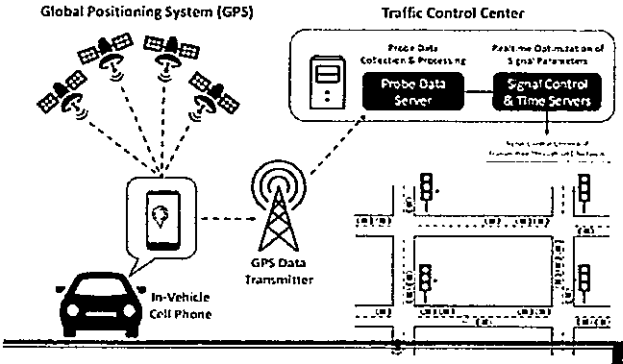


Image of Utilization of Probe Data



3. Project Period

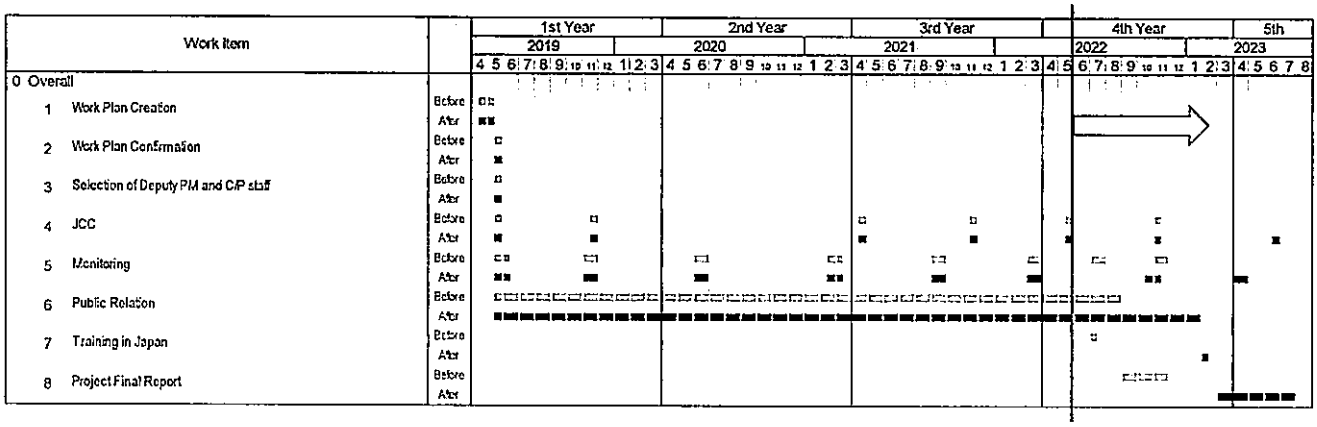
- The progress of the Pilot Project has been delayed due to Covid-19 and BMA's procurement of traffic signals and FOC network, etc.
- In order to adjust the project schedule with the implementation of the Pilot Project, additional 8 months extension of the project period is proposed.

Item	Project Period
Original	From April 2019 to February 2022 (34 months)
Extended in April 2021 (approved in 3rd JCC)	From April 2019 to December 2022 (44 months)
Proposed	From April 2019 to August 2023 (52 months)

3. Activities Schedule from now

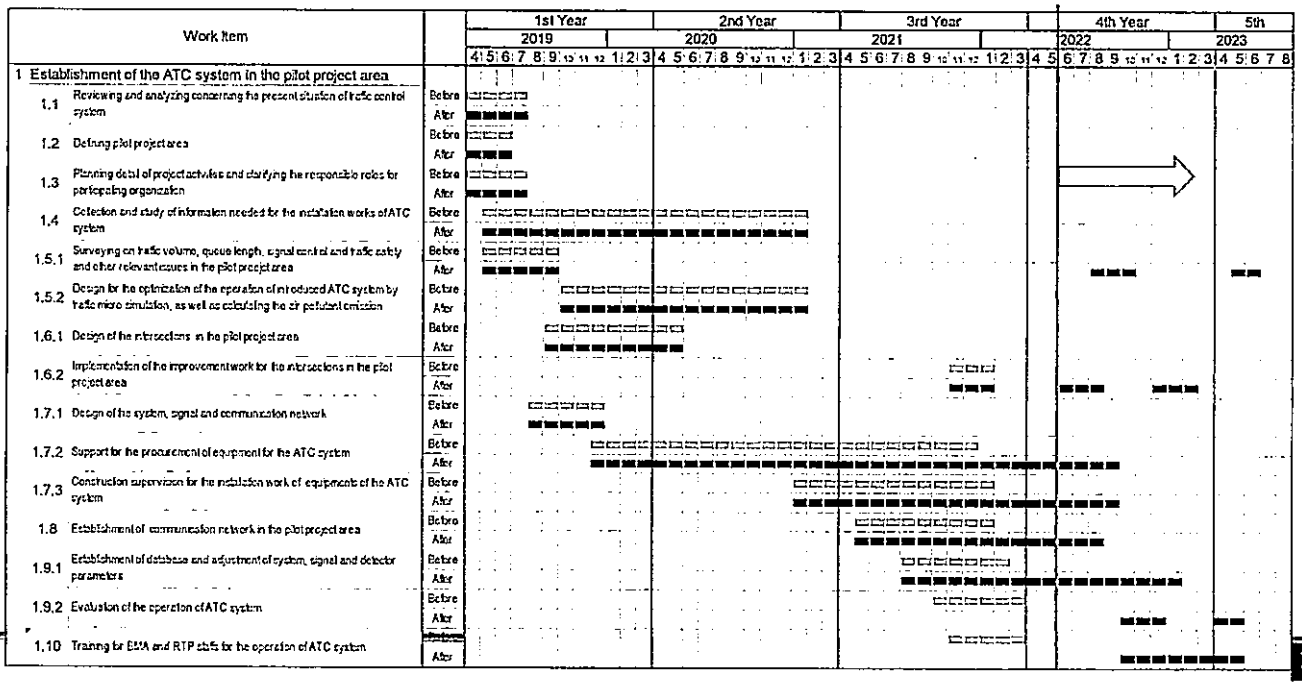
■ Overall Activities

- ➢ JCC and Project Monitoring
  - The next JCC (6th) is scheduled in November 2022.
  - Project Monitoring is carried out every 6-month.
- ➢ Training Program
  - Rescheduled to February 2023 in consideration of the travel restriction due to Covid-19.



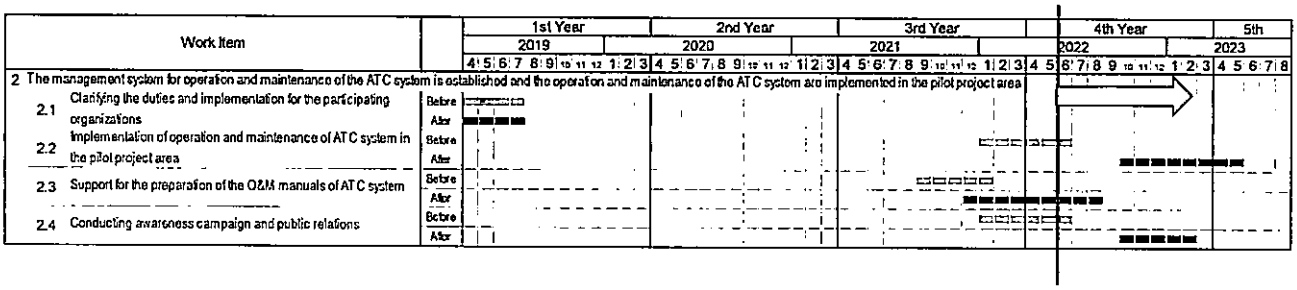
■ Output 1 (Establishment of ATC System in the Pilot Area)

- ➢ Traffic survey (before/after) will be conducted for the adjustment of phasing plan and project evaluation. [1.5]
- ➢ Improvement work of intersections will be continued. [1.6]
- ➢ Installation of the ATC system will be continued.[1.7 - 1.9]
- ➢ The training will be carried out during trial operation of the ATC system. [1.10]



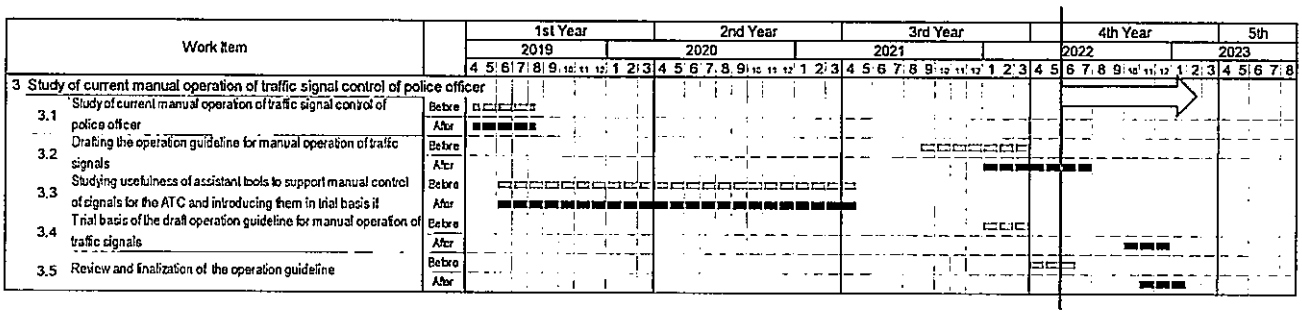
■ Output 2 (Establishment of O&M Management System)

- O&M training will be implemented during installation work and operation of the ATC system. [2.2]
- The O&M manual will be prepared by mid 2022. [2.3]
- Public relations campaign will be implemented same timing with operation of the ATC system. [2.4]



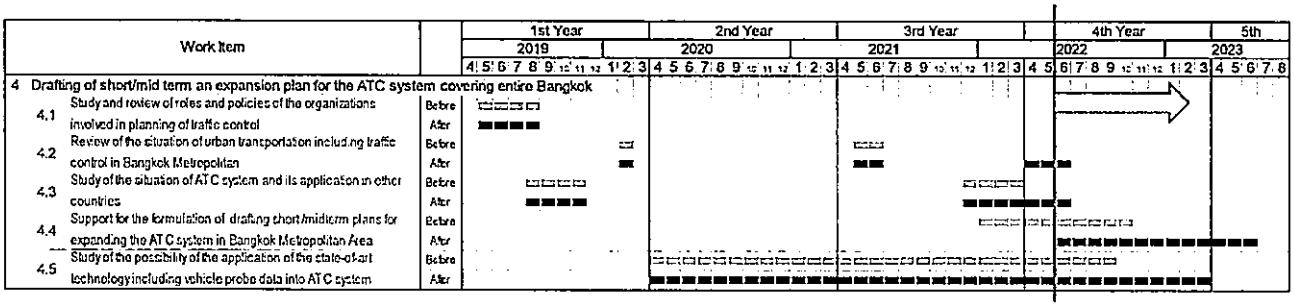
■ Output 3 (Development of Traffic Signal Manual Operation)

- The draft manual operation guideline will be prepared in parallel with installation of the ATC system. [3.2]
- Trial of manual operation of traffic signal using the guideline will be implemented with the operation of the ATC system. [3.4]
- The guideline will be finalized by the end of 2022. [3.5]



■ Output 4 (Preparation of a draft ATC Development Plan)

- The review of the existing urban tra sport situation in BMA and the study of ATC systems in other countries will be done by mid 2022. [4.2 - 4.3]
- The short and mid term ATC system expansion plan will be finalized in 2023. [4.4]
- The software and equipment for the experiment of utilization of probe data was started. The experiment will be implemented by the end of 2022. [4.5]



5. Matters to be confirmed

1. To **accelerate the implementation of Pilot ATC Project**:
   - ➢ Remaining tasks
   - ➢ BMA's Additional Allocating Budget of 2022

2. To **extend the Project Period up to August 2023**, considering the delay in the implementation of Pilot ATC Project.

3. To conduct the **Training Program in Japan in February 2023**, considering the travel restrictions due to Covid-19.

Thank you for your attention

THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

PROGRESS OF THE ATC PILOT PROJECT AND MATTERS TO BE DONE BY BMA

7 JUNE 2022

TRAFFIC AND TRANSPORTATION DEPARTMENT,
BANGKOK METROPOLITAN ADMINISTRATION

1

2

OUTLINE

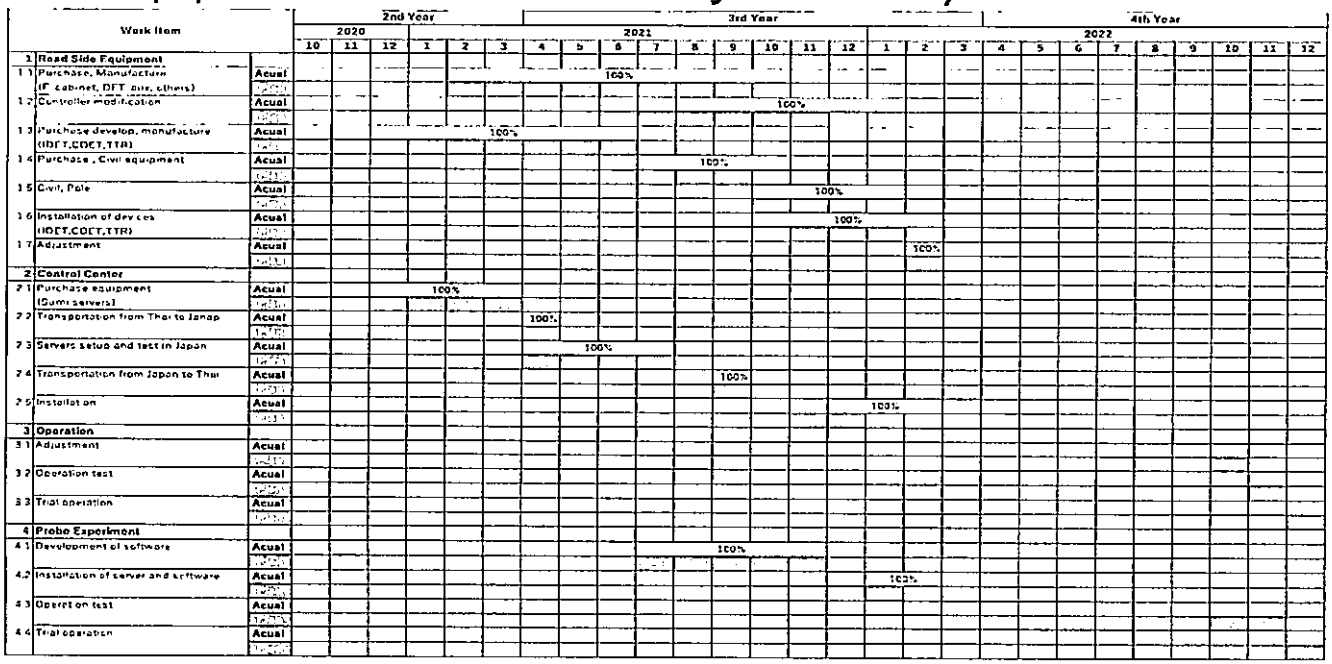
1. Progress of the Implementation of ATC Pilot Project
2. Progress of Matters to be Done by BMA

1. PROGRESS OF THE IMPLEMENTATION OF ATC PILOT PROJECT

[redacted]

1. PROGRESS OF THE IMPLEMENTATION OF ATC PILOT PROJECT

☐ Equipment Installation Plan for JICA ATC System



1. PROGRESS OF THE IMPLEMENTATION OF ATC PILOT PROJECT

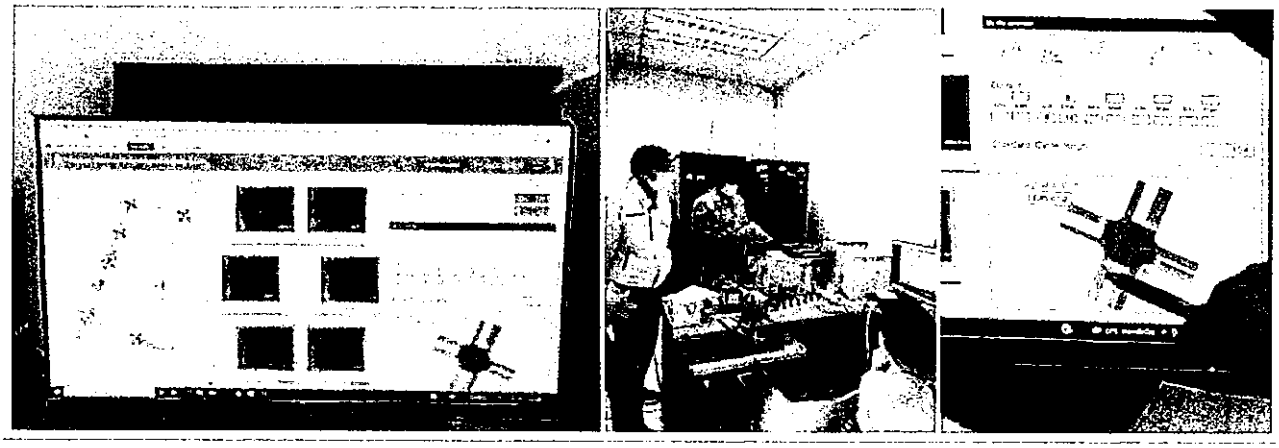
ATC Road Site Equipment Acceptance Test

- Conducted in 9 Mar 2022
- To ensure that Local Controller, Image Detector, and Ultrasonic Detector are working properly as designed.
- Location: Phaholyothin Soi 2 intersection, Phaholyothin Rd.

1. PROGRESS OF THE IMPLEMENTATION OF ATC PILOT PROJECT

Area Traffic Control Center Acceptance Test (Tuk Chai)

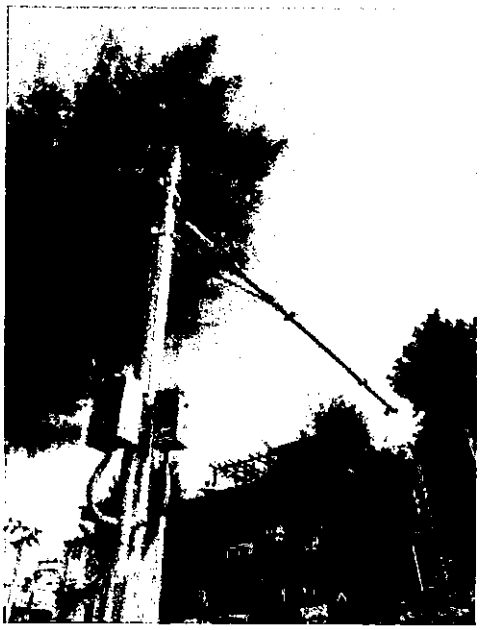
- Conducted in 22 Mar 2022
- To ensure the coordination between Loca l Controller and Vehicle Detectors with ATC Control Center at TTD
- Location: Building 2, Traffic and Transportation Department.



1. PROGRESS OF THE IMPLEMENTATION OF ATC PILOT PROJECT

☒ Progress of the Installation of Detector (completed)

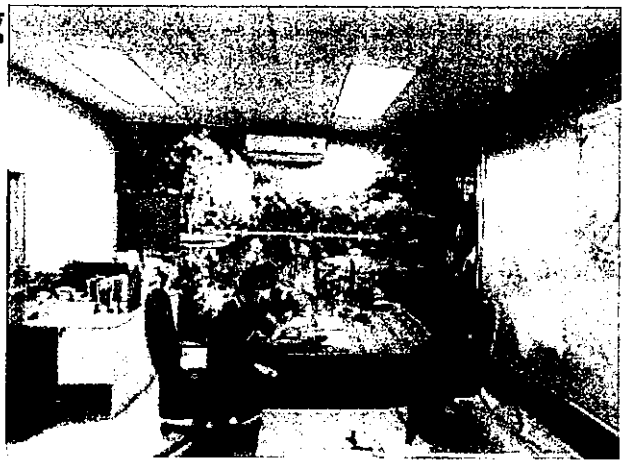
Construction		2021					2022		
		8	9	10	11	12	1	2	3
1 Pole	Plan								
	Actual			100%					
2 Arm	Plan								
	Actual			100%					
3 IF Cabinet	Plan								
	Actual					100%			
4 CDET (Tuk Chai)	Plan								
	Actual					100%			
5 CDET (Saphan Kwai)	Plan								
	Actual					100%			
6 CDET (V.M)	Plan								
	Actual					100%			
7 IDET (New)	Plan								
	Actual					100%			
8 IDET (Existing)	Plan								
	Actual			100%					
9 Traffic Signal Controller	Plan								
	Actual			100%					



1. PROGRESS OF THE IMPLEMENTATION OF ATC PILOT PROJECT

<u>Organize Weekly/Monthly Meeting</u>

- ☐ For Project Monitoring and Steering
- ☐ Participants
  - BMA
  - JICA Thailand Office
  - JICA Expert Team
  - Contractor
- ☐ From April ~ Current (38 Times)
- ☐ To be continued until the completion of the implementation

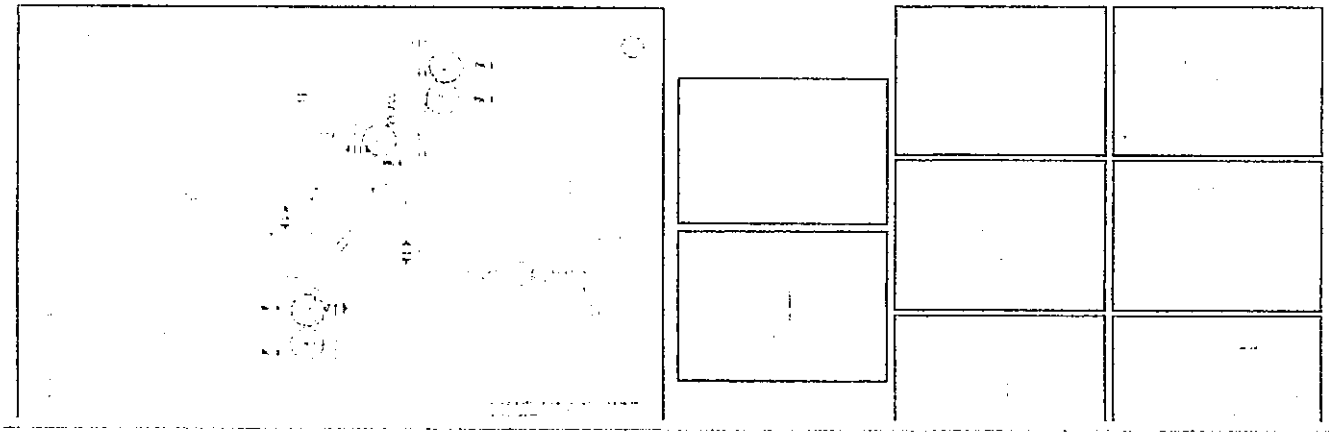


2. PROGRESS OF TASKS TO BE DONE BY BMA

2. PROGRESS OF MATTERS TO BE DONE BY BMA

1) Approval for the Electricity Connection in the Pilot Project Area

Organization	The Metropolitan Electricity Authority (MEA)
Coordination	Support for permanently connect electricity to the traffic counter devices in the project area
Progress (Aug 21~Current)	- Completed the power connection 8 sites from the total 9 sites.



2. PROGRESS OF MATTERS TO BE DONE BY BMA

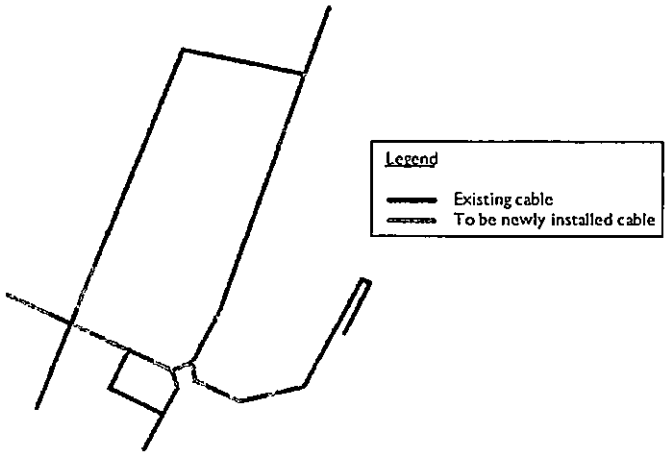
2) Provision of trunk-line Fiber Optical Cable (FOC)

- Provided available cores of existing FOC with OTDR test result (95% Completed)
- Planned to additionally install FOC in the missing sections (by budget for Installation and remove of traffic signal lanterns Phase 2; in the next slide)

FOC to be additionally installed

	From Network Switch	To Network Switch	Number of core
1	RW-01-01N	TF2-RW-S11	4
2	TF2-PY-V12	CM-PY-09-01	4
3	ODF V.M.	J. Ratchawithi Soi 8	4
4	J. Ratchawithi Soi 8	RW-03-03	2
5	RW-03-03	HC-RT-04-C01	2
6	BJ	RW-72	4
7	RW-73	NW-SW (Tuk Chai)	4
8	NW-SW (Tuk Chai)	RW-62	6
9	NW-SW (Tuk Chai)	RW-02-01N	6
10	RW-02-01N	RW-81	4
11	RW-44-01N	สถ-18-01-13	4
12	RW-02-01N	RW-74	4
13	HC-RT-02-C02	HC-RT-02-C03	2
14	TF2-PY-V45	CM-PY-01-01N	4
15	RW-61	TF2-PY-V15	2
16	PY-01-01N	TF2-PY-S38	2
17	J. Phayathai Hosp.	TF2-JJ-V49	2
18	ODF Din Daeng	TF2-RW-S11	4

Fiber optic route for ATC system



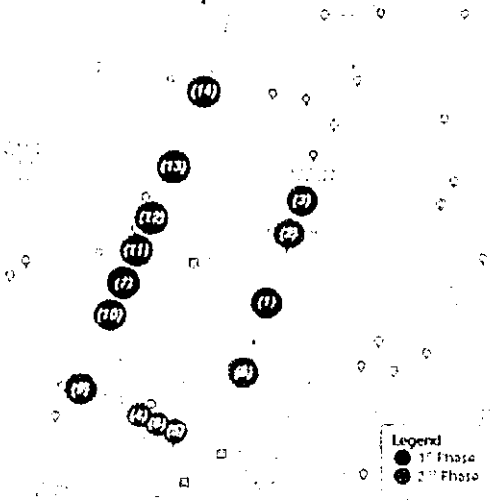
2. PROGRESS OF MATTERS TO BE DONE BY BMA

3) Installation and exchange of traffic signal lanterns

- Phase 1 [3 Locations]
  - Received 3.81 M THB (Additional Allocating Budget of 2021)
  - Completed on 24h Mar 2022
- Phase 2 [11 Locations]
  - In process of requesting Additional Allocating Budget of 2022
  - Expected to be completed bybeginning of Feb 2023

Additional Allocating Budget of 2021		
No.	Category	Location
1	Installation of Traffic Signal Light	Phahonryothin Soi 2 (230)
3	Installation of Traffic Signal Light	Phahonryothin Soi 8
7	Installation of Traffic Signal controller and equipment	Satsana Intersection (344)
Additional Allocating Budget of 2022		
No.	Category	Location
2	Installation of Traffic Signal Light	Phaholyothin Soi 7
4	Installation of Pedestrian Traffic Signal Light	Phramongkutklao Hospital
5	Installation of Pedestrian Traffic Signal Light	National Institute of Children
6	Relocation of Pedestrian Traffic Signal Light	Channel 5
8	Removing Pedestrian Traffic Signal Light	Mahidol University
9	Installation of Pedestrian Traffic Signal Light	Tuk Chai Intersection
10	Installation of Pedestrian Traffic Signal Light	Rong Krong Nam Int. (045)
11	Installation of Pedestrian Traffic Signal Light	Wichaiyut int. (126)
12	Installation of Pedestrian Traffic Signal Light	Ari Samphan Int. (125)
13	Installation of Pedestrian Traffic Signal Light	Piboon Wattana Int. (155)
14	Installation of Pedestrian Traffic Signal Light	Pradipat Int. (133)

Installation phase and location



2. PROGRESS OF MATTERS TO BE DONE BY BMA

☐ The Work Plan of Matters under the Responsibility of BMA

Items	2020		2021											2022											2023										
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1. Communication network (OFC Network)																																					
2. Installation of traffic signals																																					
2.2 Additional Allocating Budget of 2021																																					
Proposal																																					
Consideration of proposal - Budget Approval																																					
Procurement																																					
Implement																																					
2.3 Additional Allocating Budget of 2022																																					
Proposal																																					
Consideration of proposal - Budget Approval																																					
Procurement																																					
Implement																																					
3. Road physical improvement																																					
4. Comtrol center renovation																																					
Fixed IP Adress for communication with external probe server																																					

(Implement parallel with item 2)

Thank you

for your kind attention

MINUTES OF MEETING
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
BANGKOK METROPOLITAN ADMINISTRATION,
ROYAL THAI POLICE
FOR
AMENDMENT OF THE RECORD OF DISCUSSIONS ON
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK
THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC)
SYSTEM

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), Bangkok Metropolitan Administration (hereinafter referred to as "BMA") and Royal Thai Police (hereinafter referred to as "RTP") hereby agree that the Record of Discussions on the Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System signed on December 13th, 2018 is amended as follows;

1. Annex.1 Main Points Discussed

Before	Amended Version
2. Duration of the Project Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.	**2. Duration of the Project** Both sides agreed that the duration of the Project is forty-four (44) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended. The duration may be further amended (shortened or extended) depending on the COVID-19 situation.	

Annex1: Record of Discussions (signed on December 13th 2018)
Annex2: Amended Project Design Matrix

This amendment is effective as of April 27, 2021 when the extension of the Project duration was approved by the JCC committee members.

Bangkok, January 31, 2022

Mr. MORITA Takahiro
Chief Representative
Thailand Office
Japan International Cooperation Agency

Mr. Prapas Lueangsirinapha
Director-General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

RECORD OF DISCUSSIONS

FOR

THE PROJECT FOR IMRPOVING TRAFFIC CONGESTIONS IN BANGKOK THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM IN THE KINGDOM OF THAILAND

AGREED UPON BETWEEN

BANGKOK METROPOLITAN ADMINISTRATION,

ROYAL THAI POLICE

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

December 13, 2018

Ms. Katsura Miyazaki
Chief Representative
Japan International Cooperation
Agency
Thailand Office

Mr. Somchai Dechakorn
Deputy Director General,
Acting Director General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen.Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Annex 1 Main Points Discussed
Annex 2 Project Design Matrix (PDM)
Annex 3 Plan of Operation (PO)
Annex 4 Implementation Structure
Annex 5 List of Proposed Members of Joint Coordinating Committee

Annex 1

MAIN POINTS DISCUSSED

1. **Framework of the Project**
   The Project Design Matrix (hereinafter referred to as "PDM") and Plan of Operation (hereinafter referred to as "PO") attached to R/D as the Annex 2 and Annex 3 respectively shall be used as a monitoring and management tool of the Project. The PDM and PO will be reviewed and revised flexibly whenever the necessity arises.

2. **Duration of the Project**
   Both sides have agreed that the duration of the Project is thirty-four (34) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.

3. **Joint Coordinating Committee (JCC)**
   Both sides have agreed that the Joint Coordinating Committee (hereinafter referred to as "JCC") comprising of the authorities concerned will be established, and chaired by the Director General of Traffic and Transportation Department of BMA. The proposed members of the JCC are described in Annex 5 of the draft R/D. The first JCC will be convened within six months of the commencement of the Project to approve the first version of the PDM and PO. JCC will meet at least once a year and whenever necessity arises.

4. **Counterpart Personnel**
   Both sides agreed that the necessary counterpart personnel described in the PDM of the R/D will be assigned by the respective organizations and informed to JICA before signing of R/D.

6. **Sharing of responsibilities on establishment of Area Traffic Control System as a pilot project**
   Both sides agreed that the establishment of Area Traffic Control System shall be implemented under the sharing of responsibilities described as Attachment 1.

7. **Provision of benefits and facilities**
   Thai side agrees to provide the following benefits and facilities:
   (1) Office space in the building of BMA for the Project members with office furniture and utilities such as internet connection, electricity, air conditioner and so on;
   (2) Necessary data and information for the Project;
   (3) Permission of access for JICA Experts to the project sites; and
   (4) Identification cards for JICA Experts if necessary
   (5) Budget allocation for personnel, operation and activities for implementation of the Project, including the pilot project, personnel costs, local traveling costs and daily subsistence allowance for counterpart personnel, and other recurrent cost.

Japanese side agrees to provide following inputs to the Thai side.
(1) Experts
(2) Counterpart trainings in Thailand and Japan
(3) Necessary equipment for the project activities
(4) Expenses related to Japanese experts' activities

8. **Environmental and Social Considerations**
With regard to the Section 10.1 of the "Basic Principles for Technical Cooperation" published in December 2016 (hereinafter referred to as "the BP"), the Project is likely to have minimal adverse impact on the environment and society under the 'JICA Guidelines for Environmental and Social Considerations (April 2010)'.

Attachment 1 Sharing of responsibilities

Attachment 01

Responsibility Sharing Matrix

Items	JICA	TICA	BMA	RTP
1. Plan, Design				
1-1 Map with Existing Signals			✓	
1-2 Traffic Survey	✓			
1-3 Detail Design of Civil Works	✓			
1-4 Detail Design of Electrical Works	✓			
1-5 Detail Design of Communication Network & ATC System	✓			
2. Construction				
2-1 Procurement of ATC System Equipment	✓			
2-2 Tax Exemption for Importing Equipment		✓		
2-3 Installation of Equipment for Intersections and Control Center	✓			
2-4 Civil Works at Intersections (Lane Markings, Road Signs, etc)			✓	
2-5 Electrical Works (Wiring Ducts, Handholes, Poles, etc.)	✓			
2-6 Communication Network Works (From intersections to nearest BMA access point)	✓			
2-7 CommunicationTrunk Line			✓	
3. Maintenance, Operation				
3-1 Power Cost			✓	
3-2 Maintenance of ATC System			✓	
3-3 Operation of ATC System			✓	✓
3-4 Usage of Existing Cameras for Traffic Detectors			✓	✓
3-5 One Year Warranty for Equipment and Works	✓			
4. Evaluation				
4-1 Analysis and Evaluation on Pilot Project (including Traffic Survey)	✓			

Draft Project Design Matrix

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System

Version 0
Annex 2

Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Thirty-four (34) months, Project Site: Bangkok

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption
Overall Goal			
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources	
Project Purpose			
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced XX% along the routes in the pilot project area 3. XX officials from BMA and RTP are available to operate ATC system	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained
Outputs			
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in XX intersections 1-2. The ATC center system is established	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained Communication network is prepared in a timely manner by BMA
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area	2-1. XX officials from BMA and RTP receive training of operation and maintenance of ATC system 2-2. The ATC operation and maintenance guidelines are made available 2-3. Awareness campaign is conducted at least XX times	• Minutes of JCC	
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours	3-1. XX officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area	• Records of workshops • Interview survey of RTP officials	
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.	• Letter of acknowledgement	

Activities	Inputs		
	The Japanese Side	The Thailand Side	
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system. Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted. Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	Human resources and budget necessary for the Project is provided by the responsible organizations. Majority of the counterpart personnel trained by the Project is retained in their respective positions.

3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized. Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles	Preconditions Conditions are satisfied to begin the Project as indicated in the Record of Discussion.

Remark.

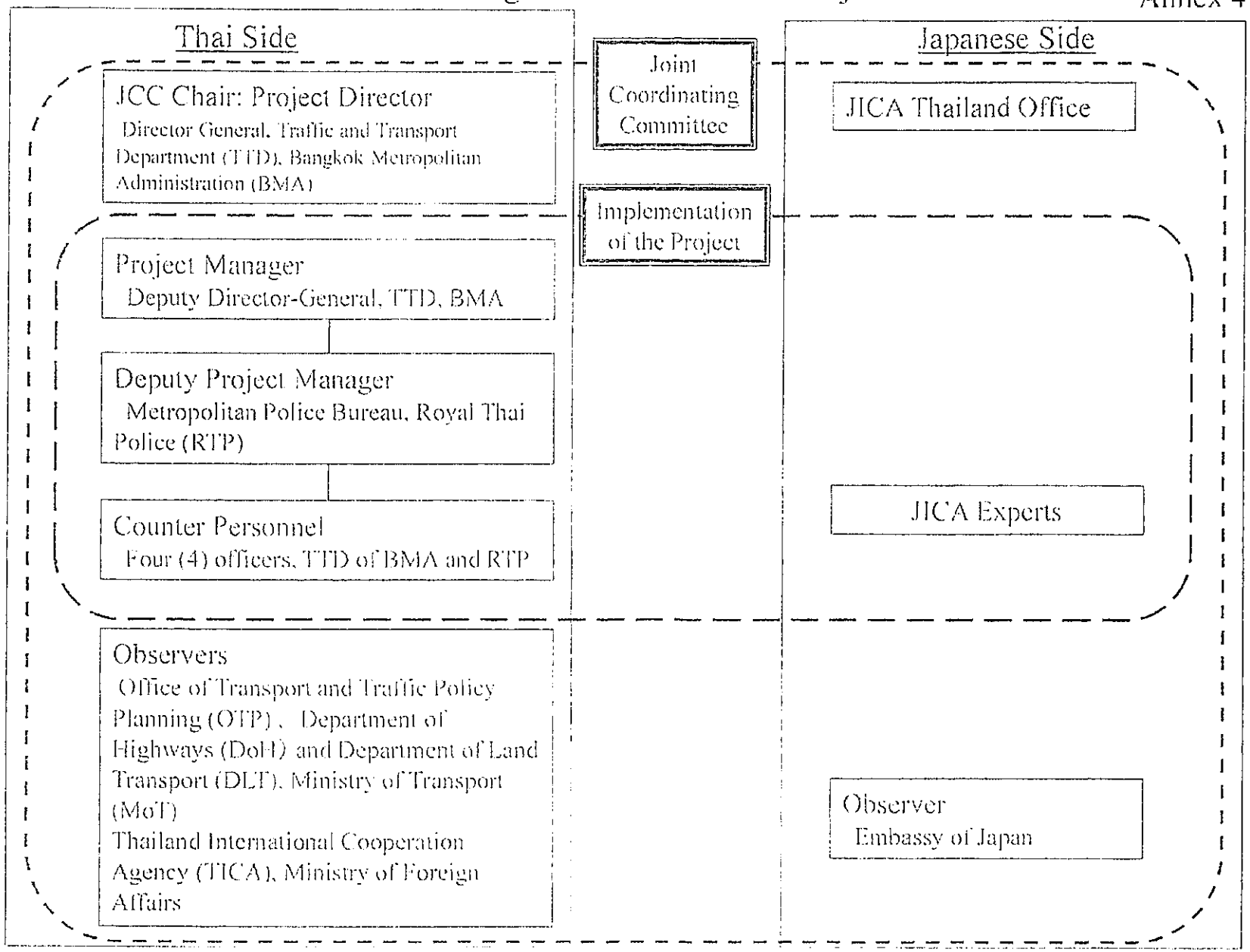
Annex 3

Tentative Plan of Operation

No.	Activities	1st year				2nd year				3rd year			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
	Joint Coordination Committee												
	Submission of Monitoring Sheet/Completion Report												
	Post-project Monitoring	If ex-post evaluation needs (3) years after the project completion, in principle											
1	Output 1 Establishment of the ATC system												
1-1	The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance the traffic control system, is reviewed and analyzed												
1-2	The pilot project area is selected												
1-3	Details of the project activities are planned, and demarcation among the participating organizations is clarified												
1-4	The information needed for installation works, including intersection, existing communication network, and surroundings utilities is collected and studied before installation of equipment for the ATC system												
1-5	The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollution is estimated in pilot project area												
1-6	Based on the above studies, improvement works are implemented at the intersections in the pilot project area												
1-7	The equipment for the ATC system is installed on the pilot project area and the traffic control center												
1-8	The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center												
1-9	The database is established, and system, signal and detector parameters are inputted												
2	Output 2 Operation and maintenance of the ATC system												
2-1	Duties and implementation structures are clarified for the organizations - BMA, RTP and consultants to be contracted to maintenance - which are involved in traffic surveillance, traffic control system maintenance, traffic data analysis, system improvement, future expansion plan, and others												
2-2	The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on-the-job training and training in Japan												
2-3	The operation and maintenance guidelines of ATC system are prepared												
2-4	Awareness campaign and public relations are conducted												
3	Output 3 Formulation and utilization of the operation guidance of manual operation of signals for the ATC												
3-1	Current practice of manual operation is studied through interviews with traffic police officers and observations												
3-2	The operation guideline for manual operation of traffic signals is drafted												
3-3	Usefulness of assistive tools to support manual control of signals for the ATC is studied, and the tool is introduced, in the basic if required												
3-4	Trainings are conducted for BMA and RTP officers and signals are manually operated on trial basis based on the draft operation guidance for manual operation of traffic signals												
3-5	The draft operation guideline is reviewed through workshop with concerned officers, and the operation guidance is finalized												
4	Output 4 Drafting of an expansion plan for the traffic control system covering entire Bangkok												
4-1	Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed												
4-2	The situation of urban transportation in Bangkok Metropolitan Area is reviewed												
4-3	The traffic control system in the other countries is studied												
4-4	The draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated												
4-5	Possible long term innovation of area transport control in Bangkok are studied applying state of art technologies which include probe data from and about vehicles												

Organization chart of the Project

Annex 4



Annex 5

List of Proposed Members of Joint Coordination Committee

(1) Project Team
1) Project Director (Chairperson of JCC)
   Director General of Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA)
2) Project Manager
   Deputy Director-General, TTD, BMA
3) Deputy Project Manager
   Metropolitan Police Bureau, Royal Thai Police (RTP)
4) Counterpart Personnel from BMA and RTP
5) JICA Experts

(2) Observer Members of the Thai side
1) Officials from Office of Transport and Traffic Policy Planning (OTP), Ministry of Transport (MOT)
2) Officials from Department of Highways (DoH), MOT
3) Officials from Department of Land Transport (DLT), MOT
4) Officials from Thailand International Cooperation Agency (TICA), Ministry of Foreign Affairs (MOFA)

(3) Members of the Japanese side
1) Chief Representative and other staffs, JICA Thailand Office
2) Representatives, JICA Headquarters

(4) Observer Members of the Japanese Side
1) Officials of the Embassy of Japan

(5) Others
The JCC can invite any related persons to discuss specific issues if necessary.

Project Monitoring Sheet I (Revision of Project Design Matrix)

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System
Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Forty-four (44) months
Project Site: Bangkok

Date: 27th Apr 2021

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources		-	-
Project Purpose					
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.	-	-
Outputs					
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in 12 intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.	• The supplier of ATC system was selected.	• Activities on Output 1 is around a half year delayed due to COVID-19.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least 3 times.	• Minutes of JCC		-	• Activities on Output 2 is around a half year delayed due to COVID-19.
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation	3-1. Approximately 5 officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement		-	• Activities on Output 3 is around a half year delayed due to COVID-19.

guidelines are used for signal control during peak hours.	intersections in the pilot project area.				
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.			• The experiment of utilization of car probe data for operation of ATC system have been planned.	Activities on Output 4 is around a half year delayed due to COVID-19.

Activities	Inputs		Important Assumption
	The Japanese Side	The Thailand Side	· Human resources and budget necessary for the Project is provided by the responsible organizations. · Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	**Preconditions** · Conditions are satisfied to begin the Project as indicated in the Record of Discussion.
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared.			

2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals. 3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			Issues
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			

1-4. Minutes of Meetings for Amendment of the Record of Discussions, September 29, 2023

MINUTES OF MEETINGS
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
BANGKOK METROPOLITAN ADMINISTRATION,
ROYAL THAI POLICE
FOR
AMENDMENT OF THE RECORD OF DISCUSSIONS ON
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK
THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC)
SYSTEM

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), Bangkok Metropolitan Administration (hereinafter referred to as "BMA") and Royal Thai Police (hereinafter referred to as "RTP") hereby agree that the Record of Discussions on the Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System signed on December 13th, 2018 is amended as follows;

1. Annex.1 Main Points Discussed

Before	Amended Version
2. Duration of the Project Both sides agreed that the duration of the Project is fifty-two (52) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.	**2. Duration of the Project** Both sides agreed that the duration of the Project is fifty-eight (58) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), and the distribution of BMA budget, some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended.	

2. Annex.2 Project Design Matrix

Before	Amended Version
2. Period of Project fifty-two (52) months	**2. Period of Project** fifty-eight (58) months
Reason: Because of the global spread of the coronavirus disease 2019 (COVID-19), and the distribution of BMA budget, some of the project activities have been suspended. In order to achieve the project purpose after the project team resume the activities, project duration needs to be extended.	

Jirawat K. T. Thaiphat

3. Annex.3 Plan of Operation

Before	Amended Version
2. Period of Project As attached Annex1 of this Minutes of Meeting	**2. Period of Project** As attached Annex3 of this Minutes of Meeting
Reason: Because of the extension of the duration of the Project, the schedule of the Project activities needs to be modified.	

Annex1: Amended Project Design Matrix

Annex2: Amended Plan of Operation

Annex3: Minutes of Meetings for Record of Discussion amendment (signed on December 15th, 2022)

Annex4: Minutes of Meetings for Project Team Meeting (signed on May 29th, 2023)

Bangkok, September 29 , 2023

K. Suzuki

Mr. SUZUKI Kazuya
Chief Representative
Thailand Office
Japan International Cooperation Agency

T. Thaiphat

Mr. Thaiphat Tanasombatkul
Director-General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Jirasunt K.

Pol.Maj.Gen. Jirasunt Kaewsaengake
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Project Monitoring Sheet I (Revision of Project Design Matrix)

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System
Implementing Agency: Bangkok Metropolitan Administration (BMA)
Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: fifty-eight (58) months
Project Site: Bangkok

Version 8
Date: 1st June 2023

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal					
The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources		-	-
Project Purpose					
An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.	-	-
Outputs					
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in 12 intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.	• The roadside equipment and the control center equipment have been installed.	• Installation of traffic signal lanterns and establishment of optical fiber network by BMA have been delayed., but BMA have secured the budged.
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted at least 3 times.	• Minutes of JCC		• Draft of the ATC operation and maintenance manual was explained and confirmed.	-
Output 3: Operation guidelines for manual operation of traffic signal are	3-1. Approximately 5 officials from RTP receive training on manual signal	• Records of workshops • Interview survey of RTP		-	-

developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	officials • Letter of acknowledgement			
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.			-	The experiment of utilization of car probe data for operation of ATC system might be delayed due to delay of Output 1.

Activities	Inputs		Important Assumption
	The Japanese Side	**The Thailand Side**	· Human resources and budget necessary for the Project is provided by the responsible organizations. · Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center. 1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved (7) Others as required	**Preconditions** · Conditions are satisfied to begin the Project as indicated in the Record of Discussion.
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance – which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others.			

2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals. 3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			**Issues**
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			

Project Monitoring Sheet II (Revision of Plan of Operation)

Version 8

Project Title: The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System in the Kingdom of Thailand

Dated: 1st June 2023

Inputs	Year / Month 2019	2020	2021	2022	2023	2024	Remarks	Monitoring	
Expert									
1 Project Manager/Urban Transportation Planning	Plan / Actual							no return	-
2 Deputy Project Manager	Plan / Actual							ditto	-
3 Road Planning	Plan / Actual							ditto	-
4 Traffic Control	Plan / Actual							ditto	-
5 Traffic Signal Control	Plan / Actual							ditto	-
6 Signal System Construction	Plan / Actual							ditto	-
7 ATC System Operation and Maintenance Management	Plan / Actual							ditto	-
8 Traffic Safety	Plan / Actual							ditto	-
9 Traffic Survey/FR/Project Coordination	Plan / Actual							ditto	-
10 Information Communication Network	Plan / Actual							ditto	-
11 Economic Analyst/Training Planning/Monitoring	Plan / Actual							ditto	-
12 (Economic Analyst/Training Planning/Monitoring (D Thana)	Plan / Actual							ditto	-
Training									
Training in Japan	Plan / Actual							ditto	

Note: Assignment in Japan also recorded as actual inputs. Total planned inputs have not been changed

Outputs / Activities	2019	2020	2021	2022	2023	2024	Responsible Organization: Japan	Responsible Organization: Thailand	Achievements	Issue & Countermeasures
Output 1: Establishment of the ATC system										
1 1 The present situation of the traffic control system, including outcome of the project installed by JICA in 2016 for expressway and in ordinance the traffic control system is answered and analyzed	Plan / Actual									
1 2 The pilot project area is selected	Plan / Actual									
1 3 Details of the project activities are planned, and demarcation among the participating organizations is clarified	Plan / Actual									
1 4 The volume alone needed for installation works, as taking interruption drawings, maintenance manual, and underground utilities is collected and studied before installation of equipment for the ATC system	Plan / Actual									
1 5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area	Plan / Actual									
1 5 1 Traffic volume, queue length, traffic safety and other relevant issues in pilot project area are studied	Plan / Actual									
1 5 2 The effect of ATC system introduction and amount of air pollutants is estimated by traffic micro simulation	Plan / Actual									
1 6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area	Plan / Actual									
1 6 1 Intersection improvement is designed	Plan / Actual									
1 6 2 Based on the above design, improvement works are implemented for intersections in the pilot project area	Plan / Actual									
1 7 The equipment for the ATC system is installed in the pilot project area and the traffic control center	Plan / Actual								The installation work is behind schedule due to delay of installation of traffic signal systems and optical fiber network by BMA.	BMA have secured the budgeted. Extension of the project period will be discussed.
1 7 1 ATC system, signal and communication network is designed	Plan / Actual									
1 7 2 The equipment for the ATC system is procured	Plan / Actual									
1 7 3 The equipment for the ATC system is installed in the pilot project area and the traffic control center	Plan / Actual									
1 8 The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center	Plan / Actual									
1 9 The database is established, and system, signal and detector parameters are adjusted	Plan / Actual									
1 9 1 The database is established, and system, signal and detector parameters are adjusted	Plan / Actual									
1 9 2 The operation of the ATC system is evaluated	Plan / Actual									
1 10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system	Plan / Actual									
Output 2: Operation and maintenance of the ATC system										
2 1 Roles and responsibilities are agreed to by organizations (BMA, RTP and consultants) to be involved in maintenance - which are involved in traffic surveillance, traffic control system maintenance, traffic data analysis, system improvement, lane management, and others	Plan / Actual								-	-
2 2 The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on the job training and training in Japan	Plan / Actual								-	-
2 3 The operation and maintenance guidelines of ATC system are prepared	Plan / Actual								-	-
2 4 Awareness campaign and public relations are conducted	Plan / Actual								-	-
Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC										
3 1 Current practice of manual operation is studied through interviews with traffic police officers and observations	Plan / Actual								-	-
3 2 The operation guideline for manual operation of traffic signals is drafted	Plan / Actual								-	-
3 3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required	Plan / Actual								This activity is included in Activity 3 7 1.	-
3 4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals	Plan / Actual								-	-
3 5 The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized	Plan / Actual								-	-
Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok										
4 1 Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed	Plan / Actual								-	-
4 2 The situation of urban transportation in Bangkok Metropolitan Area is reviewed	Plan / Actual								-	-
4 3 The ATC system in the other countries is studied	Plan / Actual								-	-
4 4 A draft short and mid-term plan for expanding the ATC system in Bangkok Metropolitan Area is formulated	Plan / Actual								-	-
4 5 Possible long term introduction of area transport control in Bangkok are studied applying state of art technologies which includes probe data from individual vehicles	Plan / Actual								The activity is behind schedule, due to delay of Activity 1 7	Extension of the project period will be discussed.

Monitoring Plan	2019	2020	2021	2022	2023	2024	Remarks	Issue	Solution
Monitoring									
Joint Coordinating Committee	Plan / Actual								
Submission of Monitoring Sheet	Plan / Actual								
Post project Monitoring	Plan / Actual	(3 x joint evaluation three (3) years after the project completion, in principle)							
Reports/Documents									
Project Plan/Work Plan	Plan / Actual							-	-
Project Completion Report	Plan / Actual							-	-

Note: Extension of the project duration was agreed in the 3rd JCC. So, this plan of operation is prepared based on the extended schedule.

× Jirasant S. × T. Thaiphat

1-5. Minutes of Meetings for Amendment of the Record of Discussions, August 30, 2024

MINUTES OF MEETING
BETWEEN
JAPAN INTERNATIONAL COOPERATION AGENCY
AND
BANGKOK METROPOLITAN ADMINISTRATION,
ROYAL THAI POLICE
FOR
AMENDMENT OF THE RECORD OF DISCUSSIONS ON
THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK
THROUGH THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC)
SYSTEM

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), Bangkok Metropolitan Administration (hereinafter referred to as "BMA") and Royal Thai Police (hereinafter referred to as "RTP") hereby agree that the Record of Discussions on the Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control (ATC) System signed on December 13th, 2018 is amended as follows;

1. Annex.1 Main Points Discussed

Before	Amended Version
2. Duration of the Project Both sides agreed that the duration of the Project is fifty-eight (58) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.	**2. Duration of the Project** Both sides agreed that the duration of the Project is seventy (70) months from the date of the first arrival of the JICA experts to Thailand based on the framework of the Project.
Reason: BMA are scheduled to procure and introduce the adaptive control traffic system in FY2024 and Draft of master plan for ATC expansion should be revised to reflect and consider the BMA new plan of procurement traffic system and the project duration needs to be extended for that.	

2. Annex.2 Project Design Matrix

Before	Amended Version
2. Period of Project fifty-eight (58) months	**2. Period of Project** seventy (70) months
Reason: BMA are scheduled to procure and introduce the adaptive control traffic system in FY2024 and Draft of master plan for ATC expansion should be revised to reflect and consider the BMA new plan of procurement traffic system and the project duration needs to be extended for that.	

T. Thaiphat

Annex1: Amended Project Design Matrix
Annex2: Amended Plan of Operation
Annex3: Minutes of Meeting for Record of Discussion amendment (signed on September 29, 2023)
Annex4: Minutes of Meeting for ATC Project Team Meeting (signed on December 20, 2023)

This amendment is effective as of 20th DEC 2023 when the extension of the Project duration was approved by the JCC committee members.

Bangkok, August 30 , 2024

K. Suzuki

Mr. SUZUKI Kazuya
Chief Representative
Thailand Office
Japan International Cooperation Agency

T. Thaiphat

Mr. Thaiphat Tanasombatkul
Director-General
Traffic and Transportation Department
Bangkok Metropolitan Administration
Kingdom of Thailand

Pol.Maj.Gen. Thawat Wongsanga
Deputy Commissioner
Metropolitan Police Bureau
Royal Thai Police
Kingdom of Thailand

Project Monitoring Sheet I (Revision of Project Design Matrix)

Project Title: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System
Implementing Agency: Bangkok Metropolitan Administration (BMA)

Version 10
Date: 20th December 2023

Target Group: Officers in charge of traffic signal control in BMA and Royal Thai Police (RTP)
Period of Project: Seventy (70) months
Project Site: Bangkok

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumption	Achievement	Remarks
Overall Goal The area covered by Area Traffic Control (ATC) system is expanded and traffic congestion and environmental condition in the area are improved.	1. The ATC signals are increased to XX intersections under the expansion plan. 2. Travel time is reduced by XX% along the selected routes in the ATC area. 3. Maximum queue length is reduced XX% at the key ATC intersections.	• Annual reports and statistics from BMA, RTP and other relevant organizations • Survey results and data from probe data or other sources		-	-
Project Purpose An ATC system is established in the pilot project area and traffic congestion in the area is improved.	1. The ATC system in the pilot project area is commissioned. 2. Travel time is reduced Approximately 10% along the routes in the pilot project area. 3. Approximately 10 officials from BMA and RTP are available to operate ATC system.	• Commissioning test of ATC system • Survey results and data from probe data or other sources • Working report of the Project	BMA's policy to improve the traffic congestion, using ATC system is maintained.	• The ATC system in the pilot project area has been commissioned. • Travel time has been reduced approximately 30% along the routes in the pilot project area. • 12 officials of BMA and 15 officials of RTP are able to operate ATC system.	-
Outputs					
Output 1: The ATC system is established in the pilot project area.	1-1. The ATC signals are installed in 12 intersections. 1-2. The ATC center system is established.	• Successful completion of commissioning test of ATC system • Working report of the Project	The implementation structure of the Project is sustained. Communication network is prepared in a timely manner by BMA.	• Commissioning test of ATC system was successful completed. • The ATC center system has been established.	-
Output 2: The management system for operation and maintenance of the ATC system is established and the operation and maintenance of the ATC system are implemented in the pilot project area.	2-1. Approximately 10 officials from BMA and RTP receive training of operation and maintenance of ATC system. 2-2. The ATC operation and maintenance guidelines are made available. 2-3. Awareness campaign is conducted	• Minutes of JCC		• 9 officials of BMA and 7 officials of RTP received the training of operation and maintenance of ATC system. • The ATC operation and maintenance manual was prepared and will be submitted to the next JCC meeting for	-

	at least 3 times.			approval. • Awareness campaign was conducted by 3 approaches of a ceremony, signboards at site and a short movie.	
Output 3: Operation guidelines for manual operation of traffic signal are developed for the intersections under the ATC system, and the operation guidelines are used for signal control during peak hours.	3-1. Approximately 5 officials from RTP receive training on manual signal operation. 3-2. Manual operation based on the guideline is implemented at intersections in the pilot project area.	• Records of workshops • Interview survey of RTP officials • Letter of acknowledgement		• 7 officials of RTP received the training of manual signal operation. • Interview survey of RTP was conducted and the report was prepared. • The guideline for manual operation of traffic signal was prepared.	-
Output 4: A draft ATC system development plan covering entire Bangkok is prepared.	4-1. The short and midterm plan is acknowledged as an official draft plan of ATC system development of BMA.			-	-

Activities	Inputs		Important Assumption
	The Japanese Side	The Thailand Side	· Human resources and budget necessary for the Project is provided by the responsible organizations. · Majority of the counterpart personnel trained by the Project is retained in their respective positions.
Activities for Output 1 Establishment of the ATC system in the pilot project area 1-1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance of the traffic control system, is reviewed and analyzed. 1-2 The pilot project area is selected. 1-3 Details of the project activities are planned, and demarcation among the participating organizations is clarified. 1-4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system. 1-5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area. 1-6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area. 1-7 The equipment for the ATC system is installed in the pilot project area and the traffic control center. 1-8 The communication network is established between the traffic signals in the pilot project area and the traffic control center.	(1) Experts (2) Training in Japan (3) Necessary Equipment (4) Expenses related to the Japanese experts' activities	(1) Human Resources • Project Director • Project Manager • Counterpart Personnel (2) Project office and working facilities (space for workshop, space in the traffic control center, and others) (3) Costs for preparing, connecting and operating the communication network (4) Costs for improving the intersections (5) Local costs for the project implementation including electricity, water, communication, local travel costs for the counterpart personnel (6) Coordination with organizations involved	

1-9 The database is established and system, signal and detector parameters are adjusted. 1-10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system.		(7) Others as required	
Activities for Output 2 Establishment of management system for operation and maintenance of the ATC system 2-1 Duties and implementation structures are clarified for the organizations - BMA, RTP and companies to be contracted for maintenance - which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others. 2-2 The operation and maintenance of ATC system are implemented and knowhow is transferred through on-the-job training and training in Japan. 2-3 The operation and maintenance manuals of ATC system are prepared. 2-4 Awareness campaign and public relations are conducted.			**Preconditions** · Conditions are satisfied to begin the Project as indicated in the Record of Discussion.
Activities for Output 3 Formulation and utilization of the operation guideline for manual operation of traffic signals for the ATC 3-1 Current practice of manual operation is studied through interviews with traffic police officers and observations. 3-2 The operation guideline for manual operation of traffic signals is drafted. 3-3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required. 3-4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals. 3-5 The draft operation guideline is reviewed through the workshop with concerned officials, and the operation guideline is finalized.			**Issues**
Activities for Output 4 Drafting of an expansion plan for the ATC system covering entire Bangkok 4-1 Roles and policies of the organizations involved in planning of traffic control are studied and reviewed. 4-2 The situation of urban transportation including traffic control in Bangkok Metropolitan Area is reviewed. 4-3 The ATC system in the other countries is studied. 4-4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated. 4-5 Possible long term innovation of area transport control in Bangkok are studied applying state-of-art technologies which includes probe data from individual vehicles.			

Project Monitoring Sheet II (Revision of Plan of Operation)

Version 9

Project Title: The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System in the Kingdom of Thailand

Dated: 20th December 2023

Inputs		Year / Month	Remarks	Monitoring
		2019 (Apr–Dec) / 2020 (Jan–Dec) / 2021 (Jan–Dec) / 2022 (Jan–Dec) / 2023 (Jan–Dec) / 2024 (Jan–Dec) / 2025 (Jan–Feb)		
Expert				
1 Project Manager/Urban Transportation Planning	Plan / Actual			
2 Deputy Project Manager	Plan / Actual			
3 Road Planning	Plan / Actual			
4 Traffic Control	Plan / Actual			
5 Traffic Signal Control	Plan / Actual			
6 Signal System Construction	Plan / Actual			
7 ATC System Operation and Maintenance Management	Plan / Actual			
8 Traffic Safety	Plan / Actual			
9 Traffic Survey/PR/Project Coordination	Plan / Actual			
10 Information Communication Network	Plan / Actual			
11 Economic Analysis/Training Planning/Monitoring	Plan / Actual			
12 Economic Analysis/Training Planning/Monitoring (D frame)	Plan / Actual			
Training				
Training in Japan	Plan / Actual			

Note: Assignment in Japan also recorded as actual inputs. Total planned inputs have not been changed.

Outputs / Activities		2019 (Apr–Dec) / 2020 (Jan–Dec) / 2021 (Jan–Dec) / 2022 (Jan–Dec) / 2023 (Jan–Dec) / 2023 (Jan–Dec) / 2024 (Jan–Feb)	Responsible Organization: Japan	Responsible Organization: Thailand	Achievements	Issue & Countermeasures
Output 1: Establishment of the ATC system						
1.1 The present situation of the traffic control system, including outcomes of the project assisted by JICA in 2016 for operation and maintenance the traffic control system, is reviewed and analyzed	Plan / Actual					
1.2 The pilot project area is selected	Plan / Actual					
1.3 Details of the project activities are planned, and demarcation among the participating organizations is clarified	Plan / Actual					
1.4 The information needed for installation works, including intersection drawings, communication network, and underground utilities is collected and studied before installation of equipment for the ATC system	Plan / Actual					
1.5 The traffic volume, queue length, signal control, traffic safety and other relevant issues are studied, and amount of air pollutant is estimated in pilot project area	Plan / Actual					
1.5.1 Traffic volume, queue length, traffic safety and other relevant issues in pilot project area are studied	Plan / Actual					
1.5.2 The effect of ATC system introduction and amount of air pollutants is estimated by traffic micro simulation	Plan / Actual					
1.6 Based on the above studies, improvement works are implemented at the intersections in the pilot project area	Plan / Actual					
1.6.1 Intersection improvement is designed	Plan / Actual					
1.6.2 Based on the above design, improvement works are implemented for intersections in the pilot project area	Plan / Actual					
1.7 The equipment for the ATC system is installed in the pilot project area and the traffic control center	Plan / Actual					
1.7.1 ATC system, signal and communication network is designed	Plan / Actual					
1.7.2 The equipment for the ATC system is procured	Plan / Actual					
1.7.3 The equipment for the ATC system is installed in the pilot project area and the traffic control center	Plan / Actual					
1.8 The communication network is established between the traffic signals in the intersections in the pilot project area and the traffic control center	Plan / Actual					
1.9 The database is established, and system, signal and detector parameters are adjusted	Plan / Actual					
1.9.1 The database is established, and system, signal and detector parameters are adjusted	Plan / Actual					
1.9.2 The operation of the ATC system is evaluated	Plan / Actual					
1.10 Traffic management officers at BMA and Royal Thai Police receive trainings for operation of the ATC system	Plan / Actual					
Output 2: Operation and maintenance of the ATC system						
2.1 Duties and implementation structures are clarified for the organizations (BMA, RTP and companies to be contracted for maintenance, which are involved in traffic surveillance, traffic control, system maintenance, traffic data analysis, system improvement, future expansion plan, and others)	Plan / Actual					
2.2 The operation and maintenance of the ATC system are implemented, and knowhow is transferred through on the job training and training in Japan	Plan / Actual					
2.3 The operation and maintenance guidelines of ATC system are prepared	Plan / Actual					
2.4 Awareness campaign and public relations are conducted	Plan / Actual					
Output 3: Formulation and utilization of the operation guideline of manual operation of signals for the ATC						
3.1 Current practice of manual operation is studied through interviews with traffic police officers and observations	Plan / Actual					
3.2 The operation guideline for manual operation of traffic signals is drafted	Plan / Actual					
3.3 Usefulness of assistant tools to support manual control of signals for the ATC is studied, and the tool is introduced in trial basis if required	Plan / Actual					
3.4 Trainings are conducted for BMA and RTP officers and signals are manually operated on a trial basis based on the draft operation guideline for manual operation of traffic signals	Plan / Actual					
3.5 The draft operation guideline is reviewed through workshop with concerned officials and the operation guideline is finalized	Plan / Actual					
Output 4: Drafting of an expansion plan for the traffic control system covering entire Bangkok						
4.1 Roles and policies of the organizations involved in planning of urban transportation are studied and reviewed	Plan / Actual					
4.2 The situation of urban transportation in Bangkok Metropolitan Area is reviewed	Plan / Actual					
4.3 The ATC system in the other countries is studied	Plan / Actual					
4.4 A draft short and midterm plan for expanding the ATC system in Bangkok Metropolitan Area is formulated	Plan / Actual					
4.5 Possible long term innovation of area transport control in Bangkok are studied applying state of art technologies which includes probe data from individual vehicles	Plan / Actual					

Monitoring Plan		2019 (Apr–Dec) / 2020 (Jan–Dec) / 2021 (Jan–Dec) / 2022 (Jan–Dec) / 2023 (Jan–Dec) / 2023 (Jan–Dec) / 2024 (Jan–Feb)	Remarks	Issue	Solution
Monitoring					
Joint Coordinating Committee	Plan / Actual				
Submission of Monitoring Sheet	Plan / Actual				
Post-project Monitoring	Plan / Actual	(Ex-post evaluation three (3) years after the project completion, in principle)			
Reports/Documents					
Project Plan/Work Plan	Plan / Actual				
Project Completion Report	Plan / Actual				

T. Thaiphat

Annex 2

Inspection Documents for ATC System Installation Work

2-1. Factory Test Plan and Report

Area Traffic Control System
for
The Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System in the Kingdom of Thailand

Factory Test Plan and Report between CID(Sumitomo) and Local Controller(Genius)

May. 2021
Genius Traffic System Co., Ltd

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No.12 17
No.13 18
No.14 19

1. Date, Place, Participants

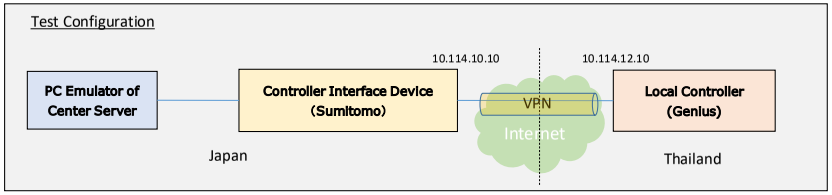
Date: 13:10 - 15:00 (Thaikand time) on May 25th, 2021

Place and Participants:

(1) Genius R&D Office in Bangkok
BMA: Mr. Chakrapong TIRNPITAK, Mr. Wasu PHOKAEW
JET: Mr. Pakorn PHIMMAHA
Genius: Mr, Janwit SRIHARUKSA, Athikhom NILNAKKHARA, Mr.Panumas UNHASUT

(2) Sumitomo (Osaka Office): Mr. Masazumi HORIE, Mr. Takehiko KATO, Mr. Atsushi FURUTA, Mr. Tatsuya ASAI
Sumitomo (Tokyo Office): Mr. Hajime SAKAKIBARA

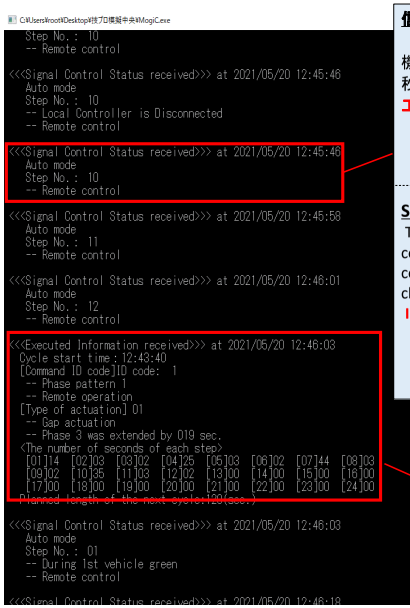
(3) On-line (Teams):
JET: Mr. Ken NISHINO, Mr.Seiya MATSUOKA, Dr. Tithiwach TANSAWAT
Mr. Atsushi SUGANUMA, Mr. Yuji ONO



模擬中央PC画面　PC Emulator of Center Server

CIDから受信した、信号機情報を表示します。
工場試験では、「信号動作状態情報」と「信号制御実行情報」の２つの情報を確認します。

Displays the local controller information received from CID.
In the factory test, two types of information are
checked: "Signal control status" and "Executed information".



信号動作状態情報
信号制御機の現在の動作状態を表す情報です。信号制御機のステータスが変化した時と、ステータスに変化がなく30秒経過した時に、CIDから送信します。
工場試験では、以下のステータスを確認します。
・動作モード：遠隔動作/単独動作/手動動作
・ステップ番号
・GG異常

Signal Control Status
This information is the current operating status of the local controller. This is sent by CID when the status of the signal controller changes or when 30 seconds have passed without a change in status.
In the factory test, the following statuses are checked.
・Operation mode : Remote / Local / Manual
・Step number
・Green conflict

信号制御実行情報
信号機の前サイクルの動作履歴を表す情報です。信号機の１サイクルの動作が終了した時に、CIDから送信します。
工場試験では、以下の情報を確認します。
・前サイクル開始時刻
・動作モード：遠隔動作/単独動作/手動動作
・ギャップ感応、リコール制御の実行有無
・ギャップ感応による青時間の変動秒数
・各ステップの実行秒数

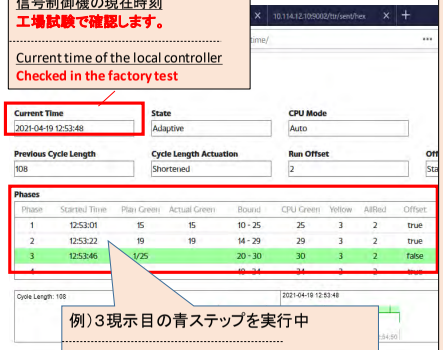
Executed Information
This information is the operation history of the previous cycle of the local controller. This is sent by the CID when a cycle operation of the local controller has been completed.
In the factory test, the following information are checked.
・Start time of the previous cycle
・Operation mode : Remote / Local / Manual
・Whether or not gap actuation and recall control were operated
・The number of seconds of green time variation due to gap actuation
・The number of seconds of each step

信号制御機モニタ画面　Local Controller Monitor

信号制御機の動作状態のリアルタイムモニタ画面です。
日本の模擬中央PCのWEBブラウザから、オンライン接続して確認することができます。

Real-time monitoring screen of the local controller's operating status.
We can connect and check online from the web browser of PC for center server emulator in Japan.

信号制御機の現在時刻
工場試験で確認します。
Current time of the local controller
Checked in the factory test



例）3現示目の青ステップを実行中

Example) Local controller is operating the green step of Phase3.

信号制御機の動作状況
実行中の信号機サイクルの情報を表示します。以下の情報が表示されます。
このうち、工場試験で確認するものを赤字で記します。
・実行中の現示
　実行中の現示は色付きで表示されます。
　ステップが進むごとに　緑⇒黄⇒赤　と色が変化します。
・現示開始時刻 (Started Time)
　各現示の実行を開始した時刻です。
・予定青秒数(Plan Green)
　各現示の実行予定の青ステップの秒数です。
・実行青秒数(Actual Green)
　各現示の実際に実行された青ステップの秒数です。
・ギャップ感応幅 (Bound)
　各現示でギャップ感応動作によって変動可能な青ステップ秒数の範囲です。
・CPU 青秒数(CPU Green)
　CPUに設定される青秒数です。青秒数の最大値が設定されます。
・黄秒数(Yellow)
　各現示の黄色ステップの秒数です。
・全赤秒数(AllRed)
　各現示の全赤ステップの秒数です。
・オフセット調整可否(Offset)
　各現示でのオフセット調整の可否です。

Operating status of local controller
Displays cycle information of the local controller that is being executed. The following information is displayed.
The items to be checked in the factory test are marked in red.
・Current phase
　The phase under execution is displayed in color.
　The color changes from green to yellow to red as each step progresses.
・Started Time
　The time when the execution of each phase started.
・Plan Green
　The number of seconds of green step to be executed for each phase.
・Actual Green
　The number of seconds of green step actually executed for each phase.
・Bound
　The range of the number of the seconds of green step that can be varied by gap actuation.
・CPU Green
　The number of seconds of green step to be set for the CPU.
　The maximum number of seconds of green second will be set.
・Yellow
　The number of seconds of yellow step for each phase.
・AllRed
　The number of seconds of allred step for each phase.

●Test Plan

Creation Date	21-05-21

<Phase pattern>

▪ Other than recall control

Phase No.	Phase 1			Phase 2			Phase 3			Phase 4		
Step No.	1	2	3	4	5	6	7	8	9	10	11	12
Vehicle Signal 1												
Vehicle Signal 2												
Vehicle Signal 3												
Vehicle Signal 4												
Step time	15	3	2	20	3	2	25	3	2	30	3	2

▪ Recall Control

Phase No.	Phase 1				Phase 2	
Step No.	1		2	3	4	5
Vehicle Signal						
Pedestrian Signal						
Step time	● Wait	10 (Vehicle countdown)	3	2	10	5

Correspondence to "Employer's Requirement" 1.13.1 Factory test (2) Test item	Test No.	Test Order	Test Items	Points to be checked	Test procedure	(CID) Acceptance criteria on CID side	Result	Acceptance criteria on local controller side	Result
Start-up procedure of local controller and controller interface device	**1**	1st	Start-up procedure of local controller and CID	Start the local controller on Thai side and CID on Japanese side at the same time, and check the following 1. Local controller starts local control (operation based on its own settings, not on a central command). 2. emulator of center server starts to receives the operation status of the local controller.	・[Japanese side]Start CID from the power off state (coordinating timing with local controller). ・[Thailand side]Start local controller from the power off state(coordinating timing with CID).	After the startup of CID, emulator of center server starts to receives the operation status of the local controller.	OK	After startup, local controller starts local control based on its own settings.	OK
Automatic re-start after power interruption	**2**	2nd	Automatic re-start of CID after power interruption	Ater power interrunption of CID, CID automatically restart and emulator of center server starts to receives the operation status of the local controller.	[Japanese side]Unplug CID from the power outlet once and then turn it on again.	After the restart of CID, emulator of center server starts to receives the operation status of the local controller.	OK	None	N/A
Clock and calendar	**3**	4th	Tha clock function of CID	1. CID has clock function. 2. The time of CID and the time of local controller is the same.	[Japanese side] 1. Check the time of CID by connecting the console of CID. 2. Access the online monitor of the local controoler and compare the time of local controller with the time of CID.	The time of CID and the time of local controller is the same in procedure 2.	OK	None	N/A
	4	5th	Time adjustment from center	By time adjustment command from emulator of center server, the time of local controller and CID is adjusted to the time of emulator of center server.	[Japanese side] 1.Set the time of the emulator of center server as the time deviated from the local controller. 2.Send time adjustment command from emulator of center server while checking the time of local controller and CID.	After sending time adjustment command in procedure 2, the time of local controller and CID is adjusted to the time of emulator of center server.	OK	None	N/A
Phase timing plan reception and execution	**5**	6th	Central remote control in accordance with signal control command form center.	Local controller operates according to the phase timing plan sent from emulator of center server.	[Japanese side] Send signal control command specifing remote operation from the emulator of center server.	1. Center simulaor receives the operation status of "remote operation" of the local controller from the next cycle after sending the remote operation command. 2. After the end of the next cycle in which emulator of center server sent the remote command, the center sumulator receives the cycle execution information with the contents of the sent remote command.	OK	In the next cycle after receiving the remote command, the local controller operates in the number of step seconds according to the received command.	OK
Time-of-day control	**6**	7th	Phase timing plan change from center	Local controller accepts the change of signal control command from emulator of center server.	[Japanese side] Send signal control command that specifies the different number of seconds of steps from test No.5 from the emulator of center server.	After the end of the next cycle in which emulator of center server sent the remote command, the center sumulator receives the cycle execution information with the contents of the newest sent remote command.	OK	In the next cycle after receiving the remote command, the local controller operates in the number of step seconds according to the newest received command.	OK

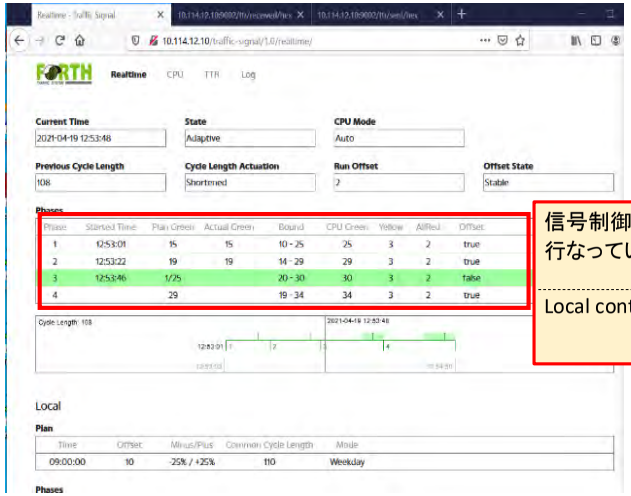
Correspondence to "Employer's Requirement" 1.13.1 Factory test (2) Test item	Test No.	Test Order	Test Items	Points to be checked	Test procedure	(CID) Acceptance criteria on CID side	Result	Acceptance criteria on local controller side	Result
Actuation and recall if provided using vehicle detector simulator	**7**	8th	Gap actuation	Local controller operates the green step terminating by gap actuation and emulator of center server receives the result of the actuation.	(1) [Japanese side] Send signal control command that specifies gap actuation from emulator of center server. (2) [Thai side] In the next cycle after receiving the command, input the vehicle detection signal before the adaptive green step, and terminate the detection signal during the adaptive green step.	After the end of the next cycle in which emulator of center server sent the remote command, the center sumulator receives the cycle execution information with the contents of green step terminating by gap actuation.	OK	After the vehicle detection signal is terminated, the adaptive green step is terminated after the unit green time has passed.	OK
Manual control	**8**	14th	Recall control （Stopping type recall）	Local controller operates stopping type recall control and emulator of center server receives the result.	(1) [Thai side] Set the local controller to stop type recall mode. (2) [Japanese side] Send signal control command that specifies recall control from emulator of center server. (3) [Thai side] In the next cycle after receiving the command, the pedestrian pushbutton is pressed after waiting one minute at the waiting step.	1. While the local controller is stopping at the waiting step, the emulator of center server continues to receive the operating status of the 1st step periodically (at 30-second intervals).. 2. After the pedestrian button is pressed, emulator of center server receives the operating status of after the 2nd step. 3.After the cycle is ended, the emulator of center server receives the cycle execution information with the contents of the recall operation.	OK	1.Local controller stops at the waiting step (vehicle: green, pedestrian: red) until the pedestrian button is pressed. 2. After the pedestrian button is pressed, the pedestrian green phase is indicated.	OK
	9	9th	Nortification of the start of manual operation	emulator of center server receives the notification that local controller has stated manual operation.	[Thai side] Start the manual opeartion of local controller	Center simulaor receives the operation status of "manual operation" of the local controller.	OK	The local controller switches to manual operation mode.	OK
	10	10th	Manual operation	1. Manual control of local controller by the operator is possible. 2.While the local controller is operating manual control, emulator of center server continues to receive the notification of the manual operation.	[Thai side] The operator switches the signal phase by manual control.	Center simulaor continues to receive the operation status of "manual operation" of the local controller periodically (at 30-second intervals).	OK	The signal phase of the local controller is switched according to the operator's operation.	OK
	11	11th	Nortification of the canceling of manual operation	emulator of center server receives the notification that local controller has canceled manual operation.	[Thai side] Cancel the manual opeartion of local controller	"Manual operation" is eliminated from the operational status of the operation status received by the emulator of center server.	OK	The local controller cancels manual operation and switches to normal operation.	OK
Green conflict detector	**12**	12th	Nortification of the occurrence of green conflict abnormality to center	emulator of center server receives tha notification that green conflict has occered on local contoller.	[Thai side] Cause green conflict at local controller.	Center simulaor receives the operation status of "green conflict" of the local controller.	OK	Local controller detects green conflict and the switches to flash operation.	OK
	13	13th	Nortification of the recovery from green conflict to normal operation to center.	emulator of center server receives tha notification that local controller has recovered from green conflict to normal operation.	[Thai side] Recovery the local controller from green conflict to normal operation.	"Green conflict" is eliminated from the operational status of the operation status received by the emulator of center server.	OK	The Local controller terminates flashing operation and switches to normal operation.	OK
Power supply test (low voltage side only)	**14**	3rd	Low voltage test of CID	Specification Voltage: DC12V±10% CID operates with the power supply of DC12V minus 10 percent,	[Japanese side]Reduce the supply voltage of the CID from 12 VDC to 10.8 VDC.	Even if the supply voltage drops to 10.8V, the CID does not turn off and the simulated center continues to receive the operation status.	OK	None	N/A

・No.1

●確認画面 (Screen to be confirmed)

模擬中央に「Signal Control Status received」と表示されること

"Signal Control Status received" in the emulator of center server.

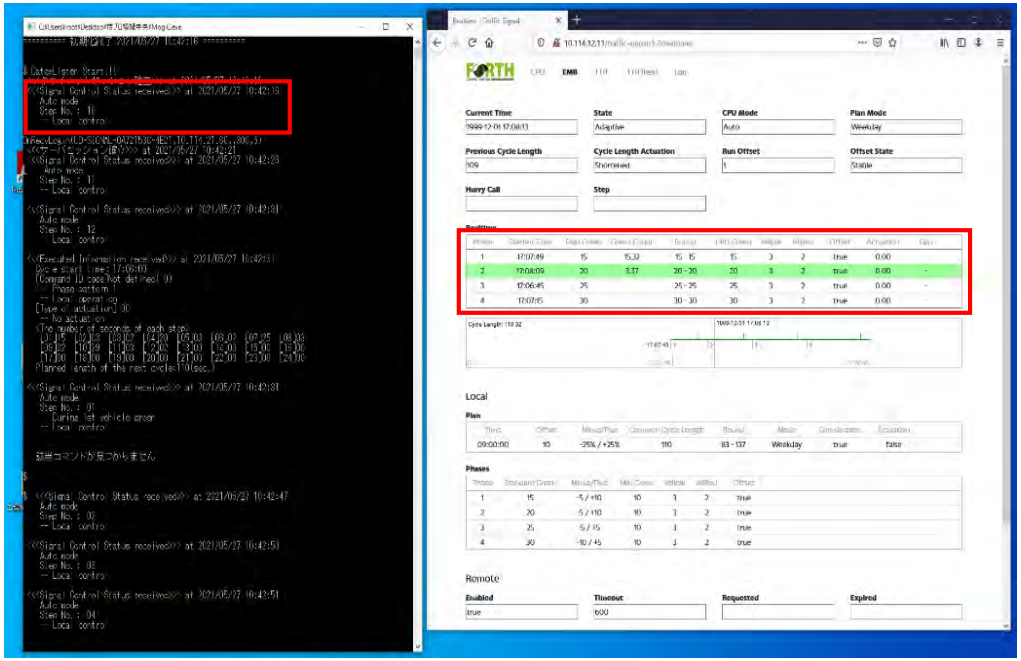


信号制御機がサイクル動作を行なっていること

Local controller is in cyclic operation.

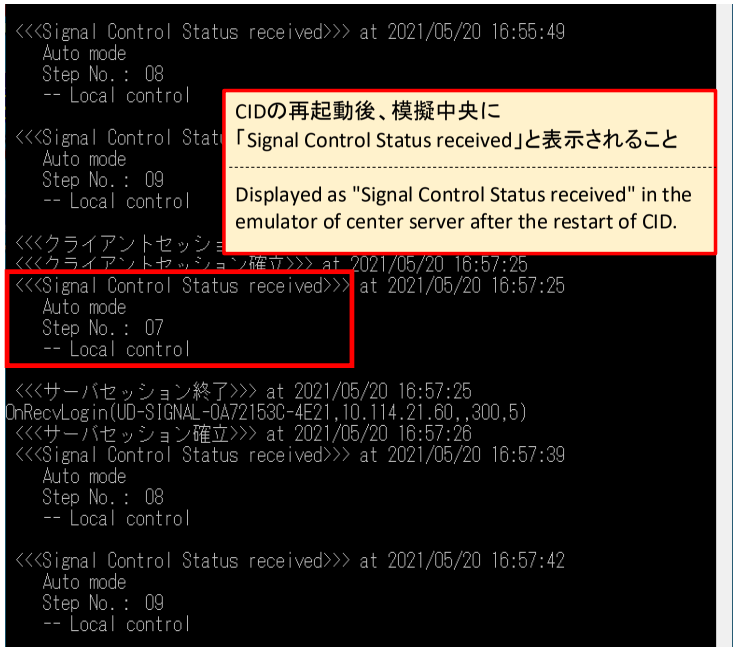
●合格確証 (Confirmed screen)

※ Since we missed taking screenshot on the day of the factory test, we retested at a later date to take screenshot.



・No.2

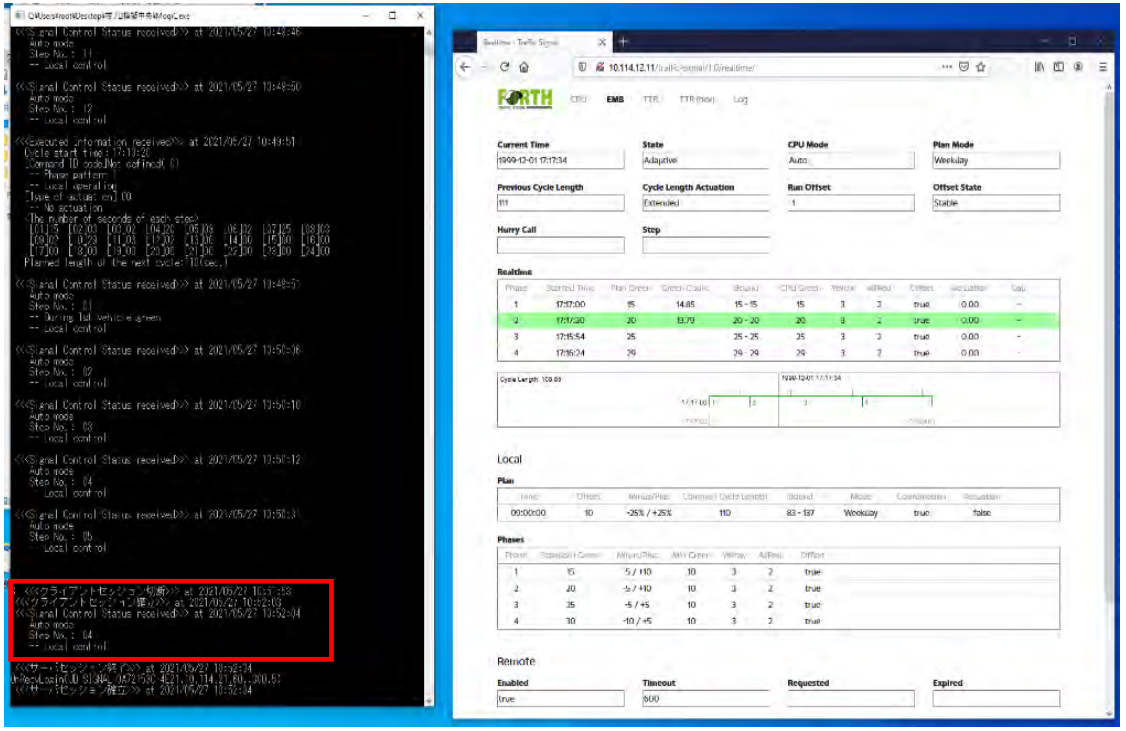
●確認画面 (Screen to be confirmed)




```
<<<Signal Control Status received>>> at 2021/05/20 16:55:49
   Auto mode
   Step No. :  08
   -- Local control

<<<Signal Control Stat
   Auto mode
   Step No. :  09
   -- Local control

<<<クライアントセッシ
<<<クライアントセッション確立>>> at 2021/05/20 16:57:25
<<<Signal Control Status received>>> at 2021/05/20 16:57:25
   Auto mode
   Step No. :  07
   -- Local control

<<<サーバセッション終了>>> at 2021/05/20 16:57:25
OnRecvLogin(UD-SIGNAL-0A72153C-4E21,10.114.21.60,,300,5)
<<<サーバセッション確立>>> at 2021/05/20 16:57:26
<<<Signal Control Status received>>> at 2021/05/20 16:57:39
   Auto mode
   Step No. :  08
   -- Local control

<<<Signal Control Status received>>> at 2021/05/20 16:57:42
   Auto mode
   Step No. :  09
   -- Local control
```

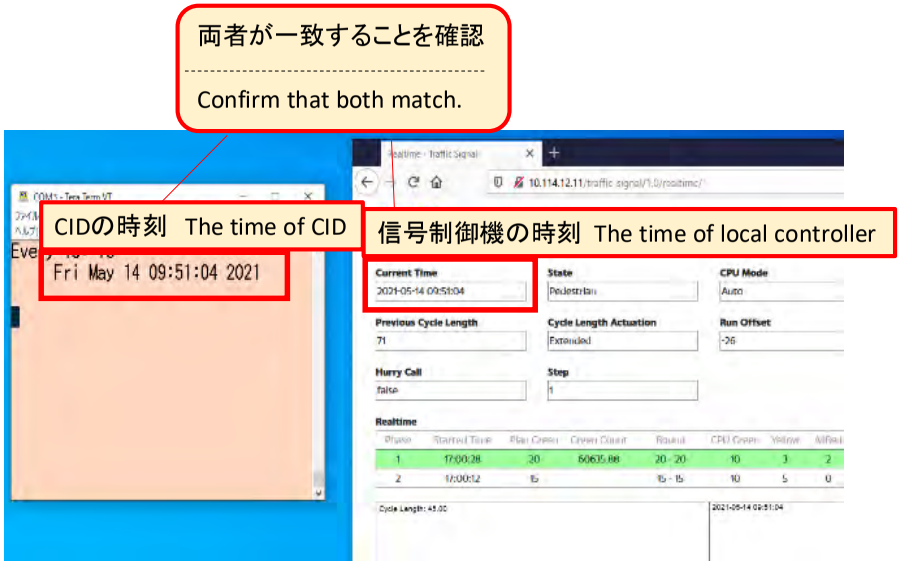
●合格確証 (Confirmed screen)

※ Since we missed taking screenshot on the day of the factory test, we retested at a later date to take screenshot.



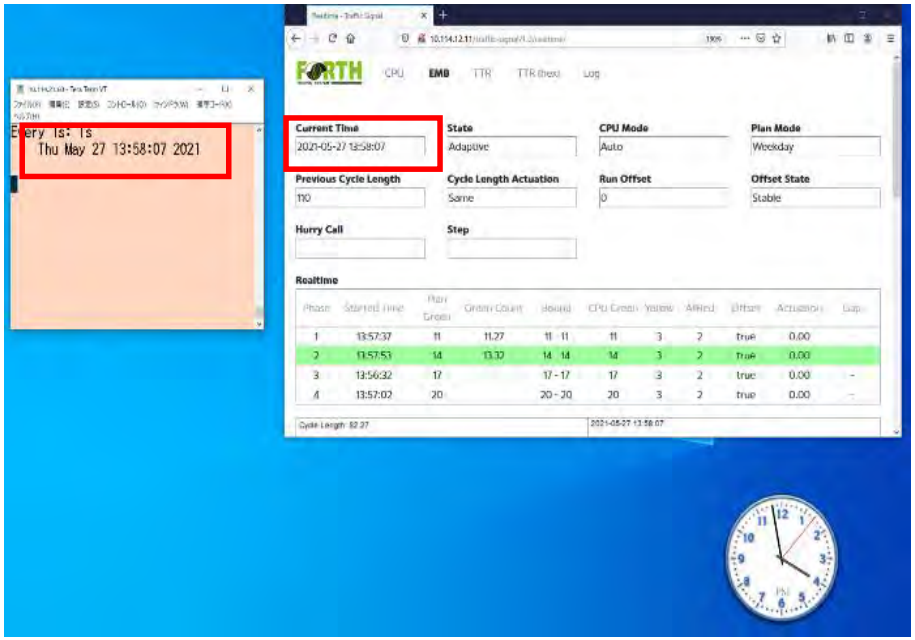
・No.3

●確認画面 (Screen to be confirmed)



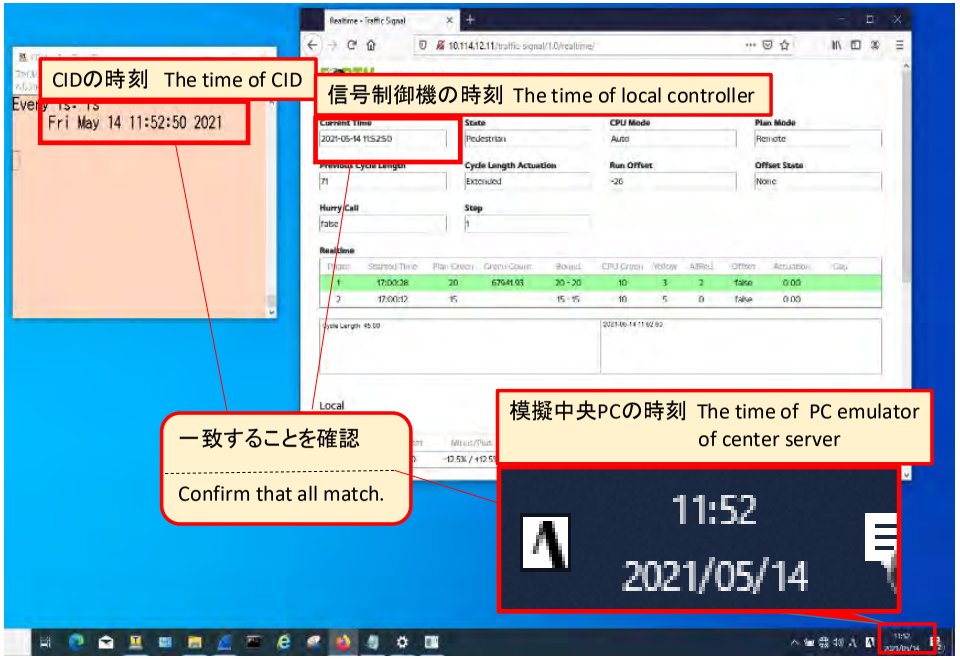
●合格確証 (Confirmed screen)

※ Since we missed taking screenshot on the day of the factory test, we retested at a later date to take screenshot.



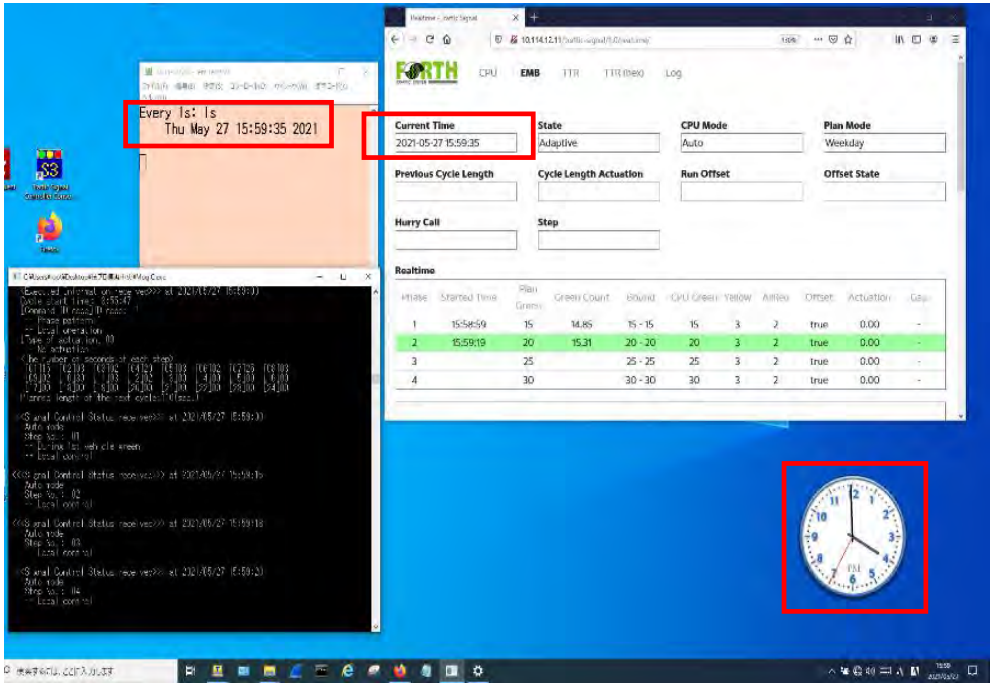
・No.4

●確認画面 (Screen to be confirmed)



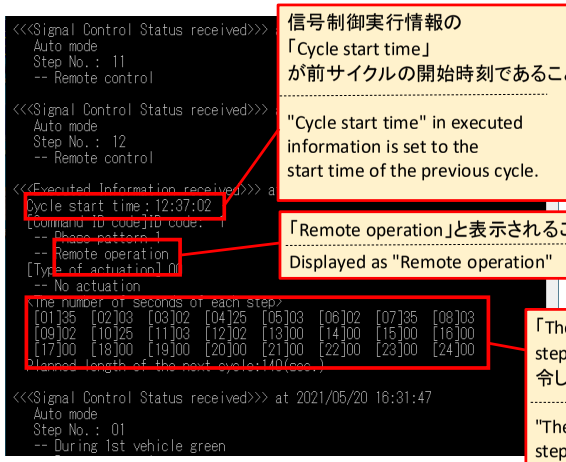
●合格確証 (Confirmed screen)

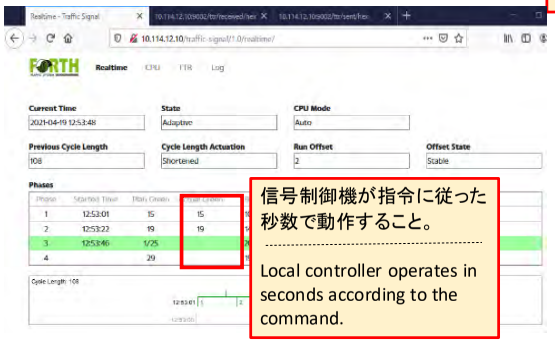
※ Since we missed taking screenshot on the day of the factory test, we retested at a later date to take screenshot.



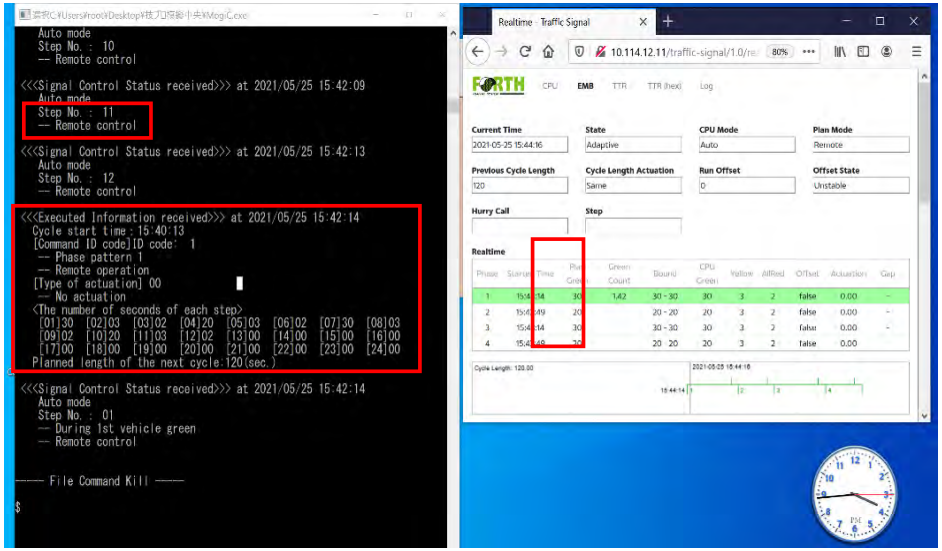
・No.5

●確認画面 (Screen to be confirmed)

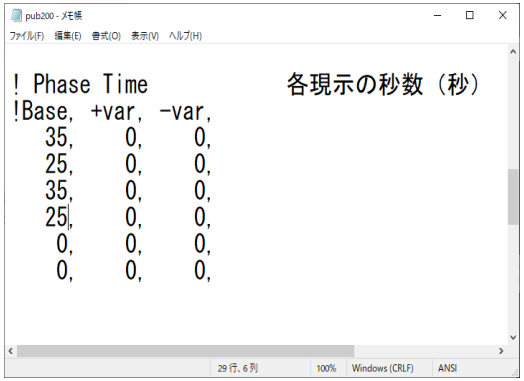




●合格確証 (Confirmed screen)



Phase time parameter from center



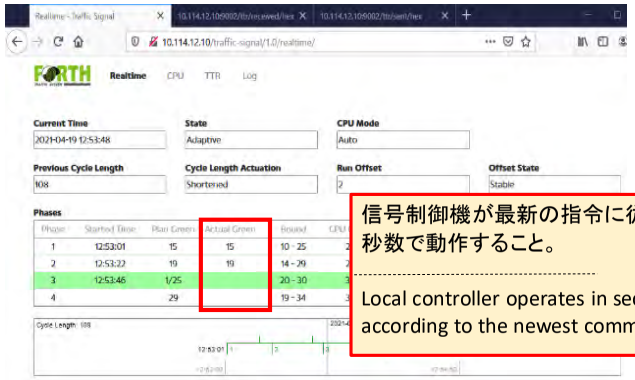
・No.6

●確認画面 (Screen to be confirmed)

```
$  <<<Signal Control Status received>>> at 2021/05/20 16:36:06
    Auto mode
    Step No. :  12
    -- Remote control

<<<Executed Information received>>> at 2021/05/20 16:36:08
  Cycle start time : 12:41:43
  [Command ID code]ID code:  1
    -- Phase pattern 1
    -- Remote operation
  [Type of actuation] 00
    -- No actuation
  <The number of seconds of each step>
   [01]30  [02]03  [03]02  [04]20  [05]03  [06]02  [07]30  [08]03
   [09]02  [10]20  [11]03  [12]02  [13]00  [14]00  [15]00  [16]00
   [17]00  [18]00  [19]00  [20]00  [21]00  [22]00  [23]00  [24]00
  Planned length of the next cycle:120(sec.)
```

「The number of seconds of each step」の各ステップの秒数が、最新の指令内容の通りであること。

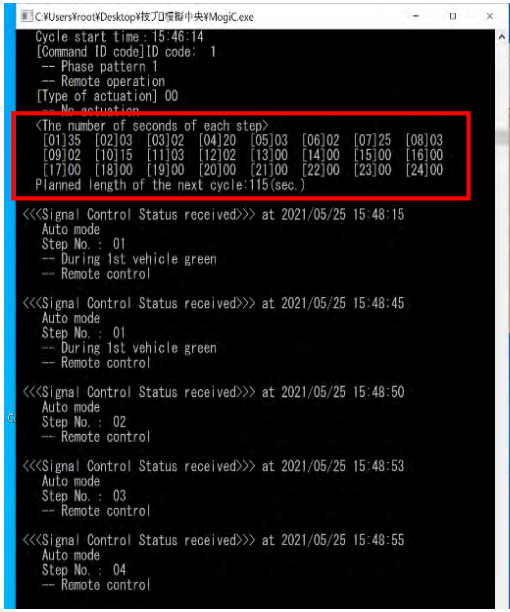
"The number of seconds of each step" is as specified in the newest command.

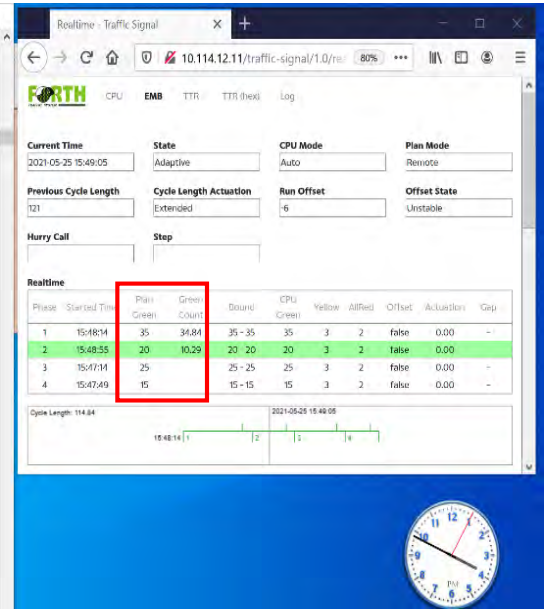


信号制御機が最新の指令に従った秒数で動作すること。

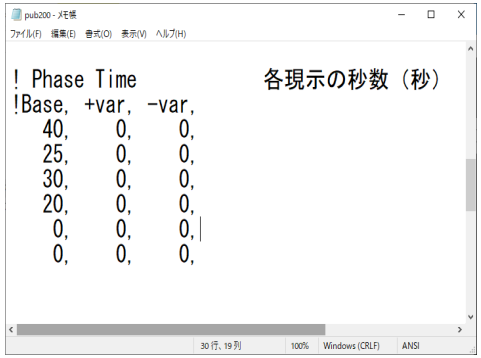
Local controller operates in seconds according to the newest command.

●合格確証 (Confirmed screen)



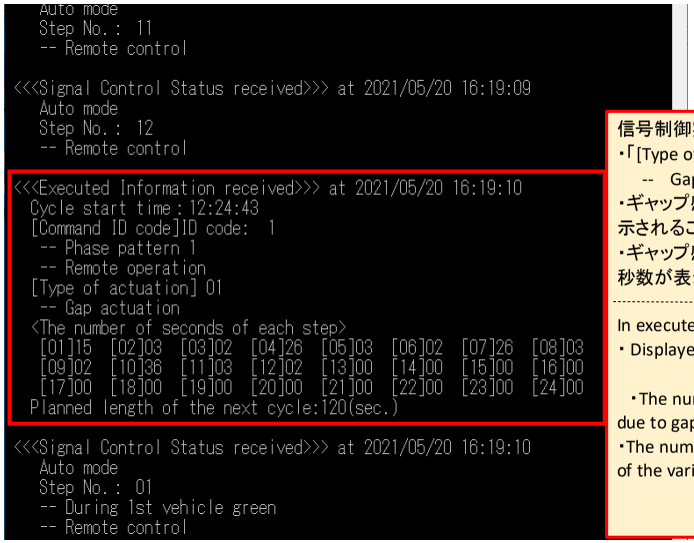


Phase time parameter from center



・No.7

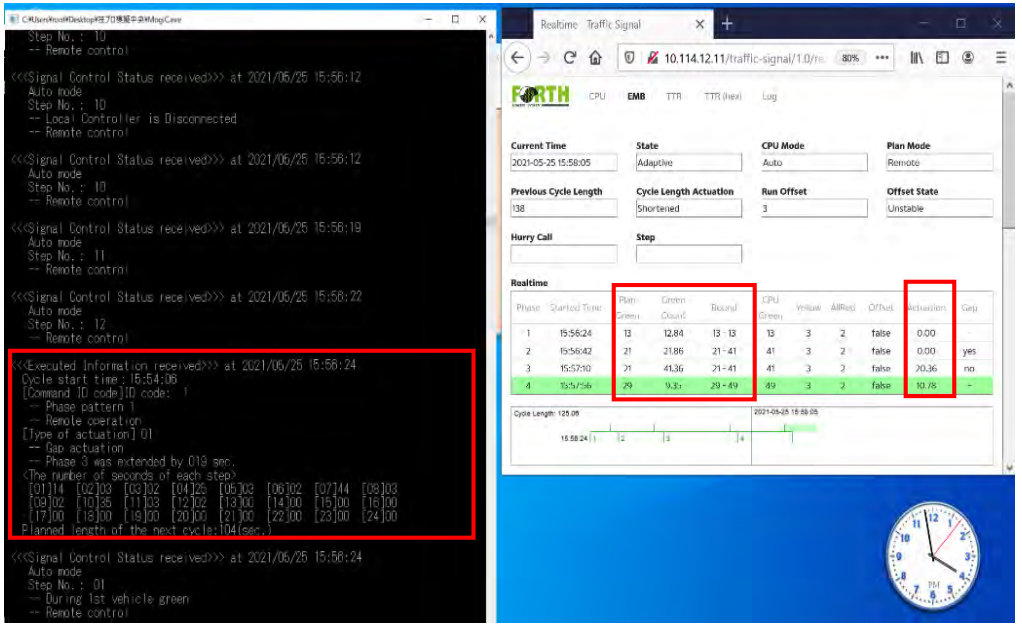
●確認画面 (Screen to be confirmed)

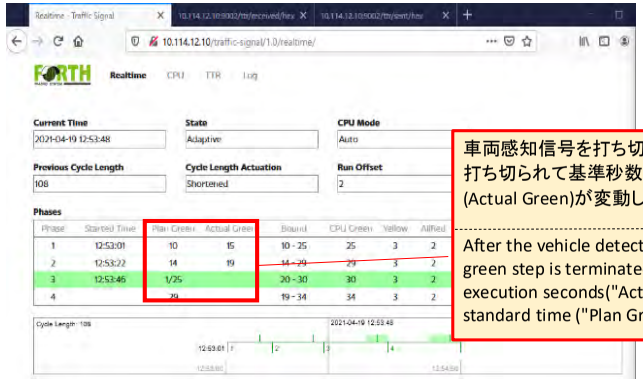


信号制御実行情報で
・「[Type of actuation] 01
-- Gap actuation 」と表示されること。
・ギャップ感応動作による青時間の変動秒数が表示されること。
・ギャップ感応動作で変動した結果の各ステップの秒数が表示されること。

In executed information,
・Displayed as "[Type of actuation] 01
-- Gap actuation"
・The number of seconds of green time variation due to gap actuation is displayed.
・The number of seconds of each step of the result of the variation in gap actuation is displayed.

●合格確証 (Confirmed screen)



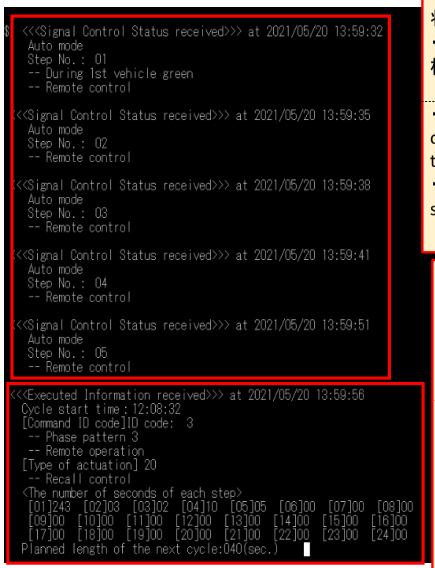


車両感知信号を打ち切った後に、感応青ステップが打ち切られて基準秒数(Plan Green) から実行秒数(Actual Green)が変動していること。

After the vehicle detection signal is terminated, the green step is terminated and the number of execution seconds("Actual Green") varies from the standard time ("Plan Green").

・No.8

●確認画面 (Screen to be confirmed)



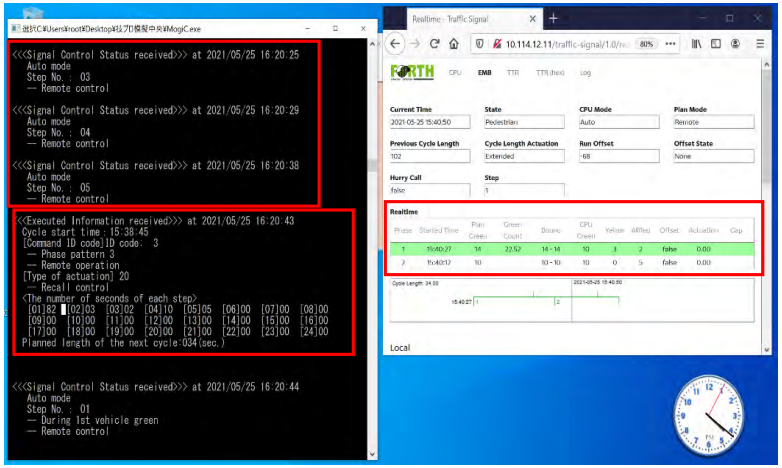
・信号制御機が待機ステップで待機中は、1ステップ目の動作状態を、模擬中央が30秒間隔で受信しつづけること。
・歩行者ボタンが押された後、2ステップ目以降の動作状態を、模擬中央が受信すること。

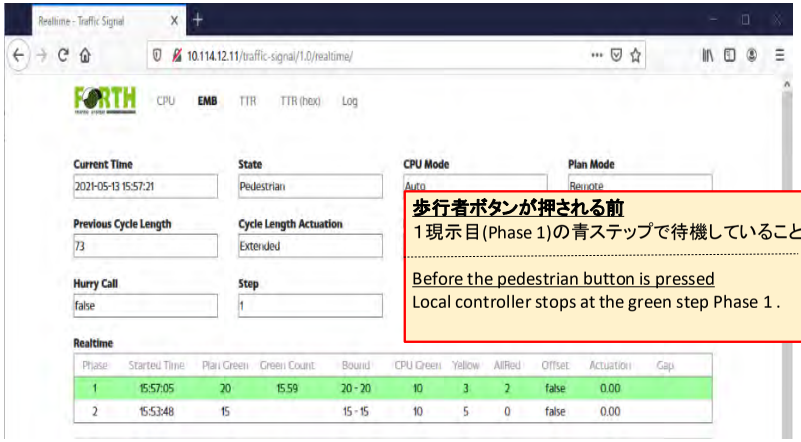
・While local controller is stopping at the waiting step, simulator of center server continues to receive the signal control status of the 1st step at 30-second intervals.
・After the pedestrian button is pressed, simulator of center server receives the signal control status of after the 2nd step.

・歩行者ボタンが押されてサイクルが終了した後、模擬中央が信号制御実行情報を受信すること。
・「[Type of actuation] 20
-- Recall control」と表示されること。
・リコール制御の結果の各ステップの秒数が表示されること。(待機ステップは停止していた秒数であること)

・After the pedestrian button is pressed and the cycle is ended, emulator of center server receives executed information.
・Displayed as「[Type of actuation] 20
-- Recall control」
([Type of actuation] 20
-- Recall control)
・The number of seconds of each step of the result of the recall control is displayed. (For the waiting step, the number of seconds the step was waiting is displayed.

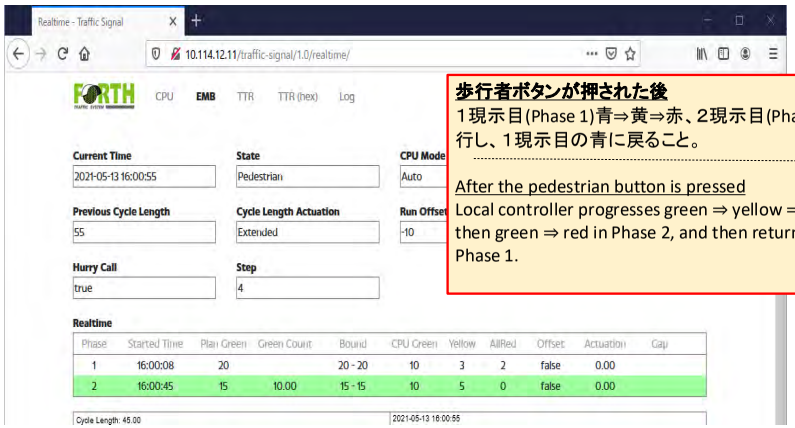
●合格確証 (Confirmed screen)





歩行者ボタンが押される前
1現示目(Phase 1)の青ステップで待機していること。

Before the pedestrian button is pressed
Local controller stops at the green step Phase 1 .

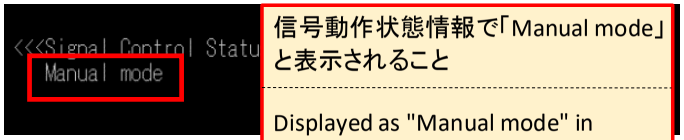


歩行者ボタンが押された後
1現示目(Phase 1)青⇒黄⇒赤、2現示目(Phase 2)青⇒赤と進行し、1現示目の青に戻ること。

After the pedestrian button is pressed
Local controller progresses green ⇒ yellow ⇒ red in Phase 1, then green ⇒ red in Phase 2, and then returns to green in Phase 1.

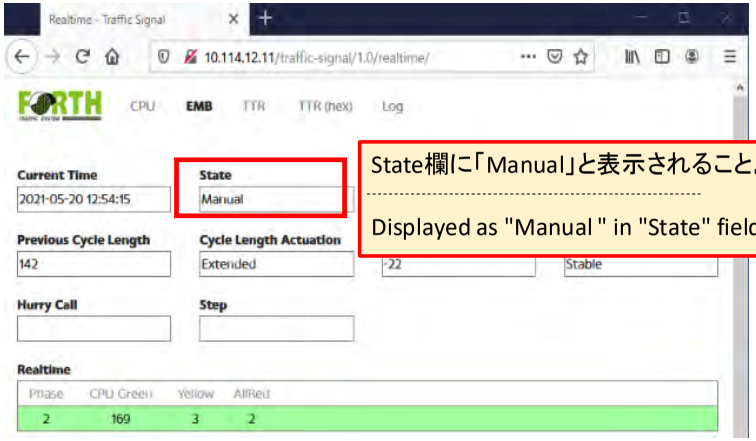
・No.9

●確認画面 (Screen to be confirmed)



信号動作状態情報で「Manual mode」と表示されること

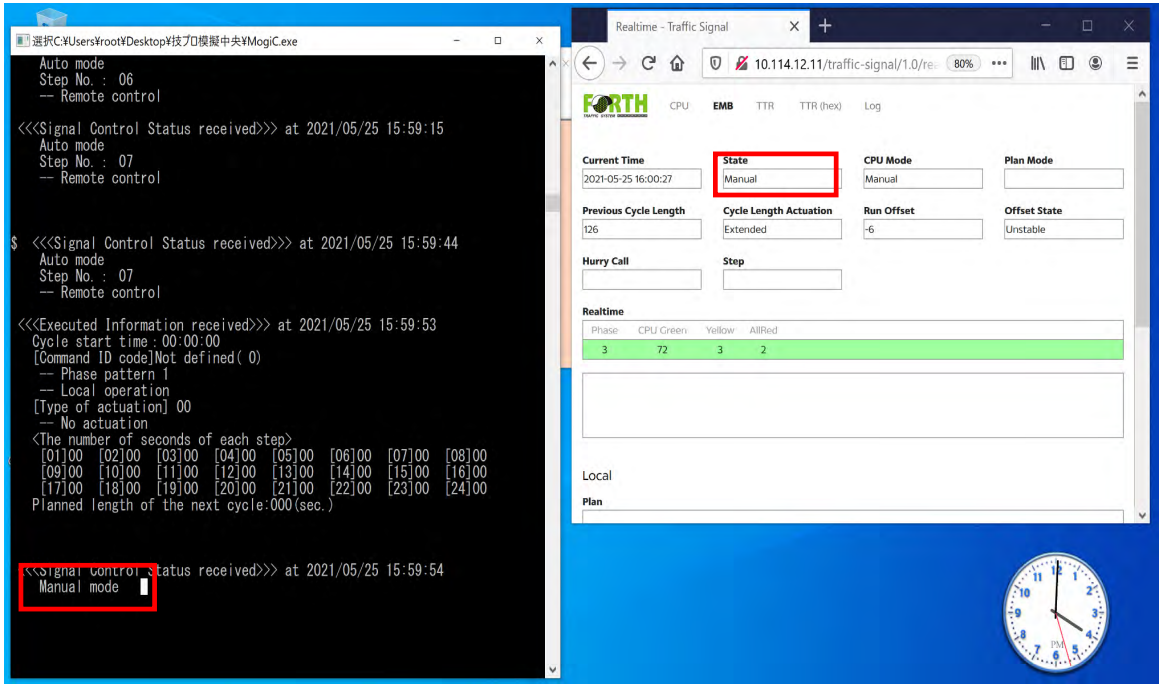
Displayed as "Manual mode" in signal control status.



State欄に「Manual」と表示されること。

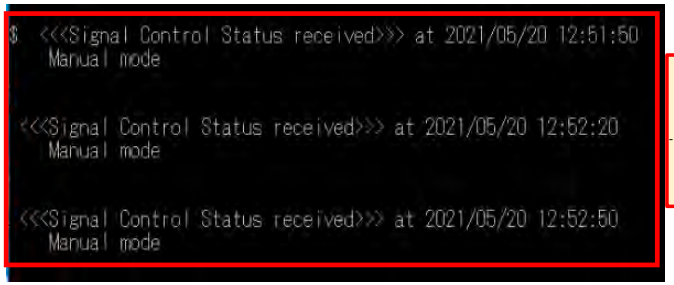
Displayed as "Manual " in "State" field.

●合格確証 (Confirmed screen)



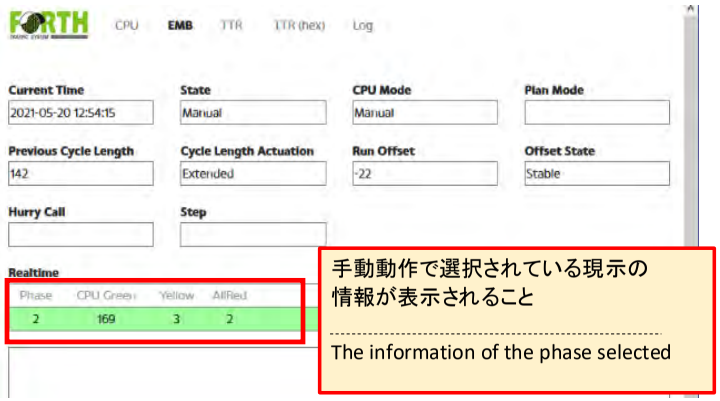
・No.10

●確認画面 (Screen to be confirmed)



30秒間隔で、「Manual mode」の
信号動作状態情報が表示されること

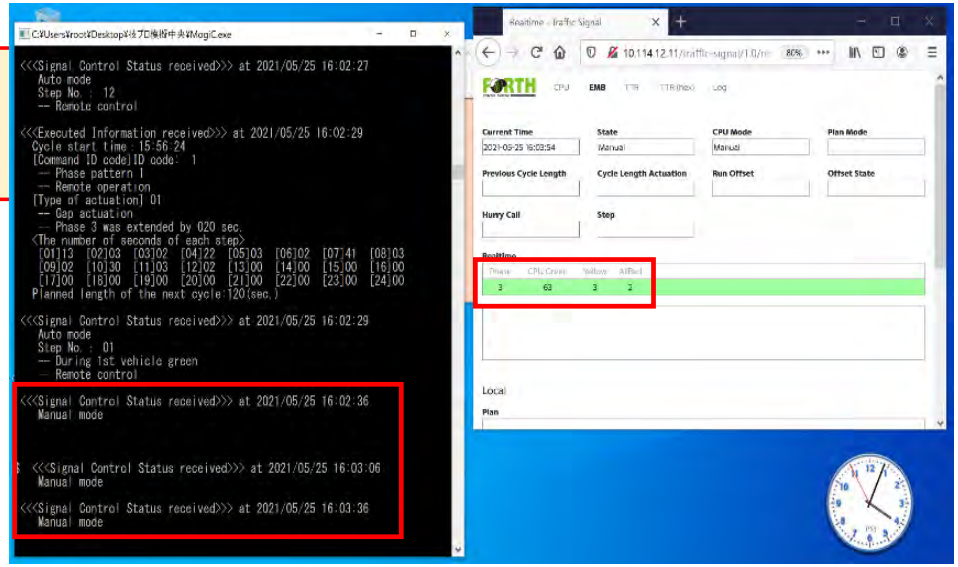
Signal control status of "Manual mode"
is displaed at 30-second intervals.



手動動作で選択されている現示の
情報が表示されること

The information of the phase selected

●合格確証 (Confirmed screen)

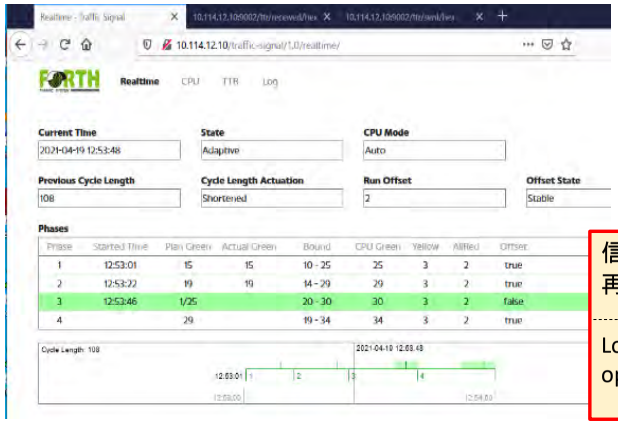


・No.11

●確認画面 (Screen to be confirmed)

信号動作状態情報で「Auto mode」と表示されること

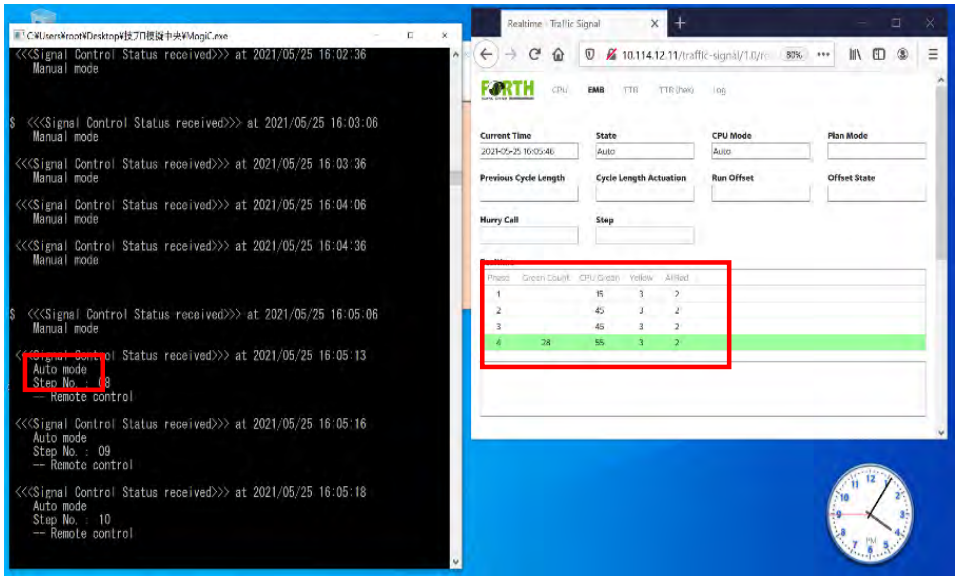
Displayed as "Auto mode" in signal control status.



信号制御機がサイクル動作を再開していること

Local controller resumes cyclic operation.

●合格確証 (Confirmed screen)

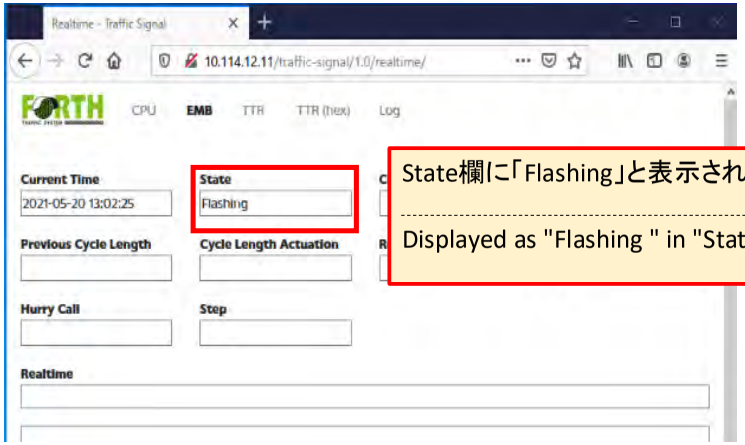


・No.12

●確認画面 (Screen to be confirmed)

信号動作状態情報で「Green conflict」と表示されること

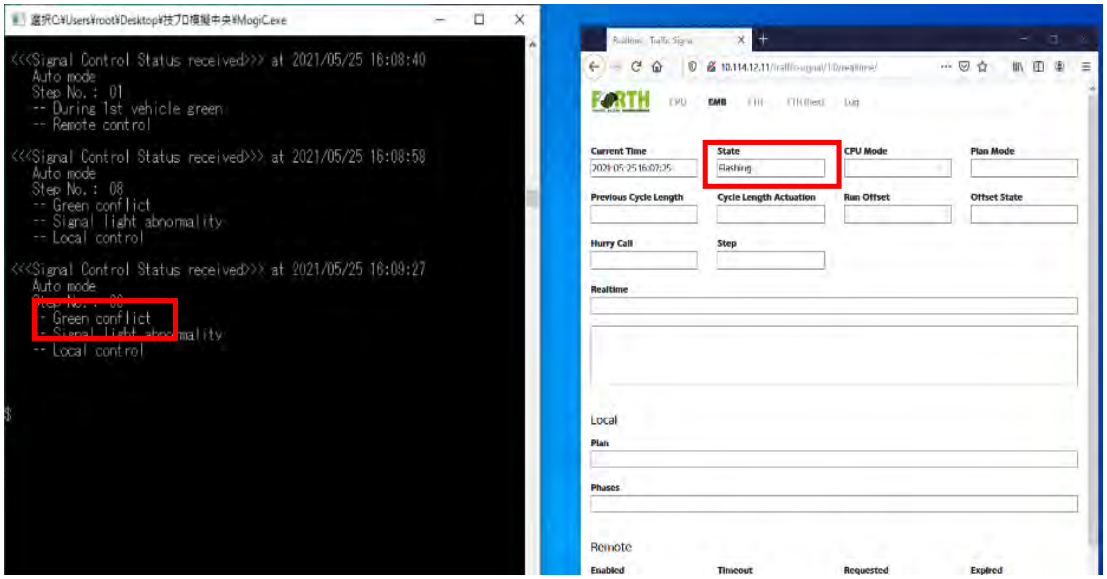
Displayed as "Green conflict" in signal control status.



State欄に「Flashing」と表示されること。

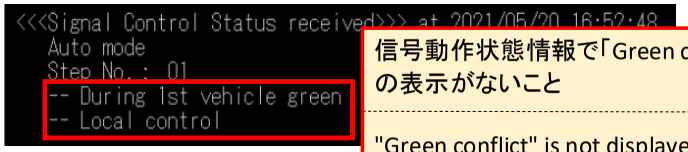
Displayed as "Flashing " in "State" field.

●合格確証 (Confirmed screen)



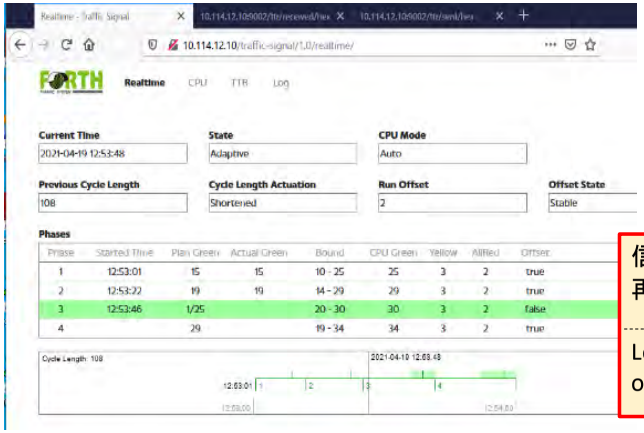
・No.13

●確認画面 (Screen to be confirmed)



信号動作状態情報で「Green conflict」の表示がないこと

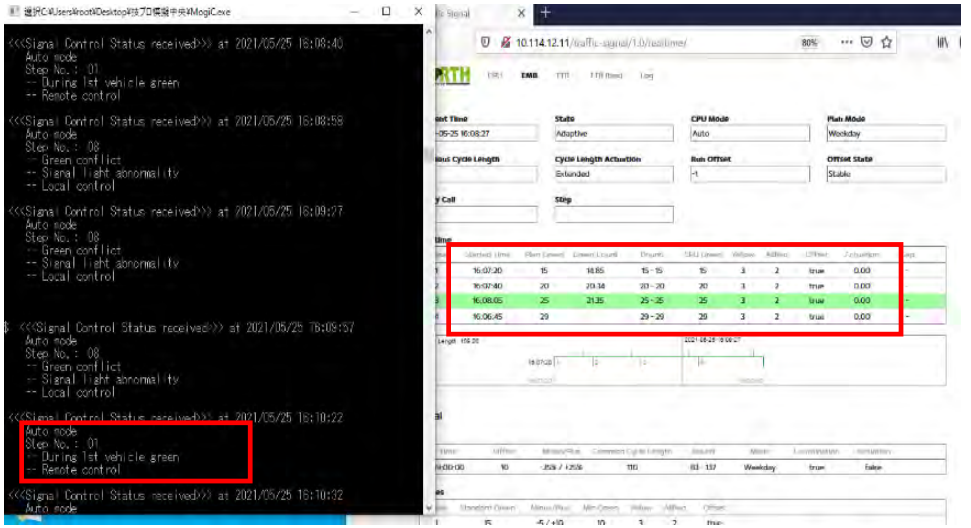
"Green conflict" is not displayed in signal control status.



信号制御機がサイクル動作を再開していること

Local controller resumes cyclic operation.

●合格確証 (Confirmed screen)



・No.14

●確認画面 (Screen to be confirmed)

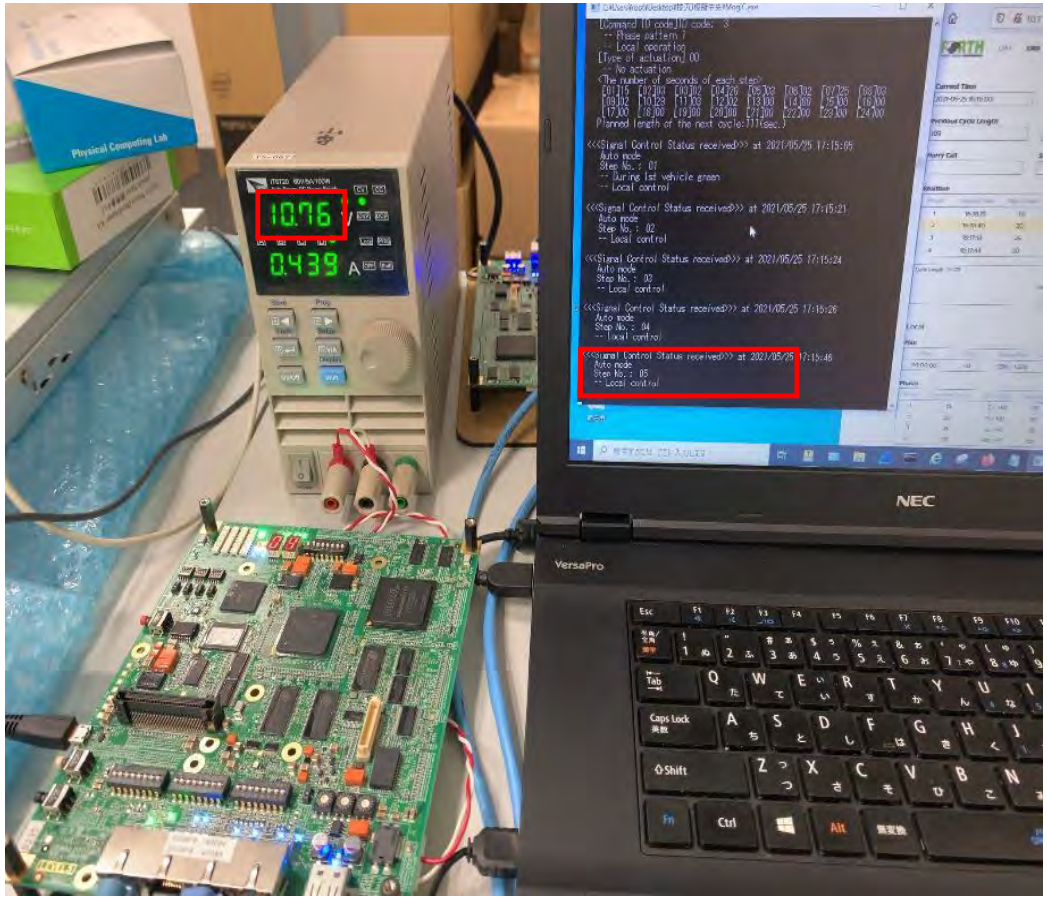
```
<<<Signal Control Status received>>> at 2021/05/20 16:52:48
   Auto mode
   Step No. :  01
   -- During 1st vehicle green
   -- Local control

<<<Signal Control Status received>>> at 2021/05/20 16:53:03
   Auto mode
   Step No. :  02
   -- Local control

<<<Signal Control Status received>>> at 20
   Auto mode
   Step No. :  03
   -- Local control

<<<Signal Control Status received>>> at 20
   Auto mode
   Step No. :  04
   -- Local control

<<<Signal Control Status received>>> at 2021/05/20 16:53:27
   Auto mode
   Step No. :  05
   -- Local control
```

CIDの電源電圧が10.8Vになっても、模擬中央が信号動作状態情報を受信しつづけること

Emulator of center server continues to receive signal control status even when the supply voltage of the CID drops to 10.8V.

●合格確証 (Confirmed screen)

※ We retested after the factory test to get the confirmation image including the supply voltage.



2-2. On-site Inspection Record

(Local Controller, Image Vehicle Detector and Ultrasonic Vehicle Detector)

On-site Inspection Record (Local Controller, Image Vehicle Detector and Ultrasonic Vehicle Detector)

1. Summary of Test

Test Type:	Test on completion for a portion of works (Roadside acceptance test)
Contractor:	Genius traffic system Co., Ltd
Date & Time:	9 March 2022, 1:00 - 3:00 p.m.
Test Site:	Local controller test at Paholyothin Soi2 intersection
	Image detector test at Paholyothin Soi2
	Ultrasonic detector test at ID254W03 (in font of GETs office)
Reference:	C. Employer's Requirements 1.13.4 Test on Completion for a portion of works
Results:	All tests were successfully conducted
Remark:	All lanterns cables must be disconnected from the local controller for safety reason.
	Phase sequence operation can be observed from LED indicators on the local controller pane.

2. Test Items and Results

2.1. Function and performance

Group	Location	Item	Test Case	Points to be checked	Result (Pass/Fail)	Note
1) Local controller	Paholyothin Soi 2 intersection	1.1	Start-up procedure	Refer to System design manual (page 40) Anytime main power is applied or restored after an interruption, the start-up procedure is initiated as follows: • Flashing Amber for about five (5) seconds for all vehicle signals. • Display all red for about five (5) seconds for all vehicle signals. • Start normal operation and display green to the main street in local isolated mode and establish communication with the central system. • If communication is established within three (3) cycles, start pick-up procedure. Otherwise, switch to local coordinated mode.	Pass	
		1.2	Automatic re-start after power interruption	Refer to 1.1	Pass	
		1.3	Clock and Calendar	Clock and Calendar correction.	Pass	
		1.4	Phase timing plan	Phase timing plan operation.	Pass	
		1.5	Time-of-day control	Time-of-day can be set.	Pass	
		1.6	Actuation	Actuation operation.	Pass	
		1.7	manual control	Manual control mode operation	Pass	
		1.8	Green conflict	Green conflict protection.	Pass	

2) Image Detector	Paholyothin Soi2 intersection	2.1	Sensing Area	Check sensing area for vehicle detection	Pass	
		2.2	Vehicle detection	Image detector can detect vehicle when they pass the sensing area.	Pass	• Some motorcycles were not detected.*/ • Detector does not distinguish motorcycle and car.*/
		2.3	Automatic restart after power interruption	Image detector can restart automatically when power interruption event occur.	Pass	
3) Ultrasonic detector	UD254W03 at Infront of GETs office	3.1	Sensing Area & Vehicle detection	Specify sensing area . Detector can detect a vehicle that pass the area.	Pass	
		3.2	Automatic restart after power interruption	Ultrasonic detector can restart automatically when power interruption event occur.	Pass	

*/: Detection of motor cycle is not required in the Employer's Requirements.

Contractor	Consultant	JICA Thailand Office

2-3. On-site Inspection Record

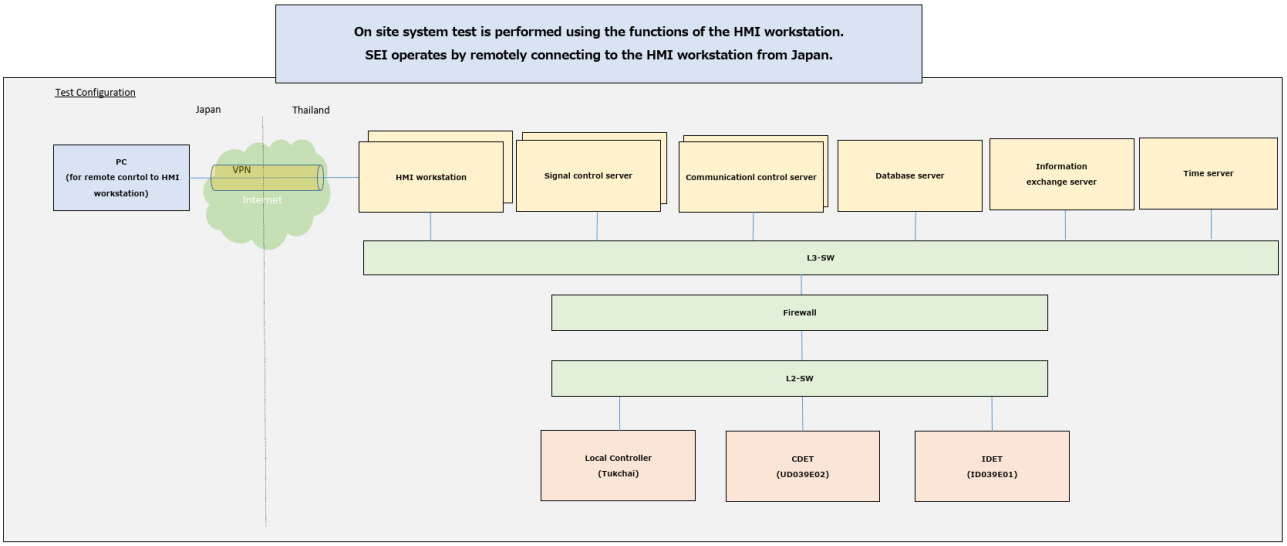
(Acceptant Test of Center System)

On-site Inspection Record (Acceptant Test of Center System)

1. Summary of Test

Test Type:	Test on completion for onsite system test. (Center Side Acceptant Test).		
Contractor:	Genius traffic system Co., Ltd		
Date & Time:	22 March 2022, 1:00 - 3:00 p.m.		
Test Site:	Control room at Traffic and Transportation Department (TTD)		
Reference:	B. Condition of Contract	7.2	Inspection on Delivery by the Employer
	C. Employer's Requirements	1.13.2	On site System test
Results:	All tests were successfully conducted		
Remark:	Target intersection: Tukchai		

2. Test System Configuration



3. Test Items and Results

3.1 Signal Controller & Vehicle Detector

Correspondence to "Employer's Requirement" 1.13.2 On site system test	Test number	Test item	Poit to be check	Result	Note
Drop-off and pickup	1	Remote Control Command	The local controller status becomes online after sending Remote control command from HMI workstation.	pass	
	2	Local Control Command	The local controller status becomes offline after sending Local control command from HMI workstation.	pass	
Data exchange	3	Cycle length change from center and execution information reception	The local controller operates at the cycle length intervented from HMI workstation. Center server receives the cycle execution information.	pass	
	4	Manual operation	Center server receives the notification that local controller has stated manual operation.	pass	
	5	Time adjustment from center	The time of Center server and the time of local controller is the same.	pass	
	6	Status Intervention from center	The local controller status becomes flashing after sending Status Intervention from HMI workstation.	pass	
Alarm reception	7	Signal light abnormality	Center server receives the notification that Signal light abnormality has occurrred on rhe local controller.	pass	
	8	MPU Abnormality(Disconnection between CID and Local controller)	Center server receives the notification that MPU Abnormality(Disconnection between CID and Local controller) has occurrred on the local controller.	pass	
Disconnection of communication and recovery	9	Disconnection of communication and recovery	The local controller status becomes offline after communication is disconnect. The local controller status becomes online after communication is recoverd .	pass	
Data reception	10	Detector data reception	Center server receives detector data.	pass	
Disconnection of communication and recovery	11	Disconnection of communication and recovery	Detector status becomes abnormality after communication is disconnect. After the connection is rescovered, detector abnormality disappears and Center server receives detector data.	pass	
Alarm reception	12	Detector abnormality	Detector status becomes abnormality when error has occurrred on the detector.	pass	

3.2 Information Provision system

Screen	Item	Test Items		Points to be checked	Result (Pass/Fail)	Note
Top Screen (Map Page)	1.1	Language selection		Change the language displayed in the program to Thai / English.	Pass	
	1.2	Signal control status		The intersection position in map shows the color of the signal control status.	Pass	
	1.3	IDET on map	IDET status	Show IDET location on the map. The color of IDET indicates the status. - Yellow color: Normal status - Black color: Error status	Pass	
	1.4		IDET video	Show live video streaming.	Pass	
	1.5		IDET information	Show detector information page.	Pass	
	1.6	CDET on map	CDET status	Show CDET location on the map. The color of CDET indicates the status - Green color : Normal status - Red color : Error status	Pass	
	1.7		CDET video	Show "No video"	Pass	
	1.8		CDET information	Show detector information page	Pass	
	1.9	Current phase		Shows the current phase of the intersection on the map.	Pass	
	1.10	Congestion line		Show congestion line on map. Congestion line changes color according to level. The length of the line changes according to the queue length value.	Pass	
	1.11	Intersection page		The program will display the intersection page of the selected intersection.	Pass	
Intersection Page	2.1	Show intersection name Show map section		Show intersection name. The map section shows the device status like a "map page".	Pass	
	2.2	Video in intersection page		Shows live video streaming of the intersection.	Pass	
	2.3	Flow rate indicator		Shows the flow rate indicator of the intersection.	Pass	
	2.4	Intersection diagram		Show intersection diagram in intersection page.	Pass	
	2.5	Current Phase Elapsed time indicator		Show current phase of the intersection. Show elapsed time indicator of the intersection.	Pass	
	2.6	Phase sequence diagram		Show phase sequence diagram of the intersection.	Pass	
	2.7	Congestion form		Show the congestion length graph for each route of the intersection.	Pass	

Contractor	Seiya MATSUOKA Consultant	JICA Thailand Office

2-4. On-site Inspection Record

(Installation Work of Local Controller, Image Vehicle Detector and Ultrasonic Vehicle Detector)

On-site Inspection Record (Installation Work of Local Controller, Image Vehicle Detector and Ultrasonic Vehicle Detector)

1. Summary of Test

Test Type: Test on completion for a portion of works (Roadside acceptance test)

Contractor: Genius traffic system Co., Ltd

Date & Time: 7 and 8 April, 13:00 - 16:30 p.m.

Test Site: All installation locations of local controller, image vehicle detector, and ultrasonic vehicle detector in the project area

Reference: C. Employer's Requirements 1.13.4 Test on Completion for a portion of works

Results: All installation works were found acceptable with minor defects to be corrected by the Contractor

Remark:

2. Test Results

2.1. New ultrasonic detector

Seq	Int. Code	Intersection	App.	Use	Det type	Code	Pass/Fail	Remarks
1	254	Victory Monument (North)	North	Queue	Ultrasonic	UD254N01	Pass	
2				Queue	Ultrasonic	UD254N02	Pass	A cover bolt is missing.
3				Queue	Ultrasonic	UD254N03	Pass	No cable protection
4	255	Victory Monument (East)	East	Count/gap	Ultrasonic	UD255E01	Pass	
5				Count/gap	Ultrasonic	UD255E02	Pass	
6				Count/gap	Ultrasonic	UD255E03	Pass	
7				Count/gap	Ultrasonic	UD255E04	Pass	
8				Queue	Ultrasonic	UD255E05	Pass	
9				Queue	Ultrasonic	UD255E06	Pass	
10				Queue	Ultrasonic	UD255E07	Pass	
11	256	Victory Monument (South)	South	Queue	Ultrasonic	UD256S01	Pass	

12				Queue	Ultrasonic	UD256S02	Pass	
13				Queue	Ultrasonic	UD256S03	Pass	Bolt for window cover missing
14	257	Victory Monument (West)	West	Count/gap	Ultrasonic	UD257W01	Pass	
15				Count/gap	Ultrasonic	UD257W02	Pass	
16				Count/gap	Ultrasonic	UD257W03	Pass	Conduit is not suitably fixed to connection box
17				Queue	Ultrasonic	UD257W04	Pass	
18				Queue	Ultrasonic	UD257W05	Pass	Cable not properly protected
19				Queue	Ultrasonic	UD257W06	Pass	
20	039	Tuk Chai	North	Queue	Ultrasonic	UD039N01	Pass	
21				Queue	Ultrasonic	UD039N02	Pass	Loose cable
22			East	Queue	Ultrasonic	UD039E01	Pass	
23				Queue	Ultrasonic	UD039E02	Pass	
24			South	Queue	Ultrasonic	UD039S01	Pass	
25				Queue	Ultrasonic	UD039S02	Pass	Bolt hole on base plate for anchor bolt too large
26				Queue	Ultrasonic	UD039S03	Pass	
27			West	Queue	Ultrasonic	UD039W01	Pass	Attachment metal not galvanized
28				Queue	Ultrasonic	UD039W02	Pass	
29	038	Saphan Kwai	North	Queue	Ultrasonic	UD038N01	Pass	Cabinet door does not close tightly
30				Queue	Ultrasonic	UD038N02	Pass	Cable must be tied
31				Queue	Ultrasonic	UD038N03	Pass	
32			East	Queue	Ultrasonic	UD038E01	Pass	
33				Queue	Ultrasonic	UD038E02	Pass	Cable must be tied, Rust on attachment
34				Queue	Ultrasonic	UD038E03	Pass	Cable must be tied, Rust on attachment
35			South	Queue	Ultrasonic	UD038S01	Pass	
36				Queue	Ultrasonic	UD038S02	Pass	
37				Queue	Ultrasonic	UD038S03	Pass	Cable must be tied
38			West	Queue	Ultrasonic	UD038W01	Pass	Cable must be tied
39				Queue	Ultrasonic	UD038W02	Pass	

40				Queue	Ultrasonic	UD038W03	Pass	Cable must be tied

2.2. Existing ultrasonic detector

Seq	Int. Code	Intersection	App.	Use	Det type	Code		Remark
1	125	Rama VI Soi Set Siri 2	West	Count/gap	Ultrasonic	UD125W01	Pass	

2.3. New image detector

Seq	Code	Intersection	App.	Use	Det type	Code	Pass/Fail	Remark
1	254	Victory Monument (N)	North	Count	Image	ID254N01	Pass	Cable protection to be provided
2	256	Victory Monument (S)	South	Count	Image	ID256S01	Pass	Cable protection to be provided
3	039	Tuk Chai	East	Count	image	ID039E01	Pass	
4			South	Count	image	ID039S01	Pass	Cable protection to be provided
5			South	Count	image	ID039S02	Pass	Cable protection to be provided
6			West	Count	image	ID039W01	Pass	Rubber cap to be provided
7	230	Phaholyothin 2	East	Count	image	ID230E01	Pass	Cable protection to be provided

2.4. Existing camera converted to image detector

Seq	Code	Intersection	App.	Use	Det type	Code		Remark
1	255	Victory Monument (E)	East	Count	Image	ID255E01	Pass	
2	257	Victory Monument (W)	West	Count	Image	ID257W01	Pass	
3	038	Sphan Kwai	North	Count	image	ID038N01	Pass	
4			East	Count	image	ID038E01	Pass	
5			South	Count	image	ID038S01	Pass	
6			West	Count	image	ID038W01	Pass	
7	039	Tuk Chai	North	Count	image	ID039N01	Pass	
8			North	Count	image	ID039N02	Pass	
9	133	Pradipahat	North	Count	Image	ID133N01	Pass	Cover open hole
10			East	Count	Image	ID133E01	Pass	
11			South	Count	Image	ID133S01	Pass	

12			West	Count	Image	ID133W01	Pass	
13	230	Phaholyothin 2	North	Count	Image	ID230N01	Pass	
14			South	Count	Image	ID230S01	Pass	

2.5. IF cabinet and signal controller

Seq	Code	Intersection	Approach	Pass/Fail	Remark
1	254	Victory Monument	Nort	Pass	OFC cable inside cabinet to be fixed
2	255	Victory Monument	East	Pass	OFC cable inside cabinet to be fixed
3	256	Victory Monument	South	Pass	OFC cable inside cabinet to be fixed
4	257	Victory Monument	West	Pass	OFC cable inside cabinet to be fixed
5	039	Tukchai		Pass	
6	133	Padipat		Pass	
7	039	Sapan kwai		Pass	

2.6. Pedestrian controller

Seq	Code	Intersection	Approach	Pass/Fail	Remark
1	1-043	Near Pradipat		Pass	
2	1-015	Near Paholyothin Soi2		Pass	
3	1-092	TV.5		Pass	
4	1-019	Mahidol U.		Pass	

Seiya Matsuoka

Contractor | Consultant | JICA Thailand Office

2-5. Inspection Report of Installation Work Completion

Inspection Report of Installation Work Completion

Project Name: Project for Improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System in Kingdom of Thailand

Equipment: Control Center System and Software

Location: Control Room at BMA 2

Date of Inspection: 16 June, 2023

Test Results:

	Test Item	Employer's Requirements	Result
1.	Central control and monitoring		
1.1	Change-over of Signal control server	4.2.1	✓
1.2	Control confirmation (1)	4.2.2	✓
1.3	Control confirmation (2)	4.2.2	✓
2.	Traffic information gathering and processing		
2.1	Gathering of detector information	4.3.1	✓
2.2	Validity check of detector information (1)	4.3.3 (1)	✓
2.3	Validity check of detector information (2)		✓
3.	System operation monitoring		
3.1	Status monitoring of signal control server equipment	4.4.2	✓
3.2	Alarm	4.10.5	✓
3.3	Fail history record	4.4.2 (3)	✓
4.	Human-Machin Interface (HMI)		
4.1	4.1 Status display of Local control on map		
4.1.1	Off-line	4.2.2 (3)	✓
4.1.2	On-line	4.2.2 (1)	✓
4.2	Traffic condition display of detector information		
4.2.1	Detector failure and communication error	4.5.8	✓
4.2.2	Detector recovery when power up.	4.5.8	✓
4.3	Equipment monitoring		
4.3.1	Indication on map	4.5.8	✓
4.3.2	History	4.5.8	✓
4.4	Report		
4.4.1	Daily report	4.6.2	✓
4.4.2	Monthly report	4.6.2	✓

Continued on next page

	Test Item	Employer's Requirements	Result
5.	Data recording and reporting		
5.1.5	5-minute volume, occupancy, speed, and status of system detector	4.4.3	✓
6.	Access control		
6.1	History of intervention	4.8	✓
7.	Remote monitoring		
7.1	Remote monitoring	4.5.9	✓
8.	Power coordinating equipment		
8.1	Function on commercial power fail – switch off	4.10.7	✓
	Function on commercial power fail – switch on	4.10.7	✓
8.2	Bypassing function	4.10.7	✓
8.3	Voltage and frequency	4.10.7	✓

Detailed procedure and screen shots are presented in the attachments.

Contractor:	Genius Traffic System Co., Ltd.	Consultant:	ALMEC Corporation
Title:	Project Manager	Title:	Traffic Control
Name:	Janwit Sriharuksa	Name:	Seiya Matsuoka
Signature:		Signature:	

Attachments:

1. Test on Completion Procedure Center System
2. Test on Completion Screen Photo

Annex 3

Evaluation of the Benefit of the ATC System

Evaluation of the Benefit of the ATC System

OBJECTIVE

The objective of this report is to evaluate the benefit of the Area Traffic Control (ATC) system implemented in the Pilot Project area. The study aims to analyze the magnitude of the benefit by comparing the traffic congestion situation before and after the implementation of the ATC system. The evaluation will provide valuable insights for the large-scale introduction of ATC system to Bangkok.

METHODOLOGY

The methodology for evaluating the benefit of the ATC system follows the steps explained below. It is noted that ATC system is capable of automatically counting the number of vehicles and measuring the queue length.

1. **Comparison of Congestion Lengths**: The study compares congestion lengths before and after the implementation of the ATC system at the same traffic volume to remove bias. This comparison aims to determine if congestion lengths were reduced after the ATC system was turned on.

2. **Benefit Calculation**: The benefit calculation involves the calculation of total waiting time in the queue before and after the implementation of the ATC system. The waiting time is then converted into a monetary value using factors such as the value of time (VOT) and vehicle operating cost (VOC). The analysis compares the case without the ATC system (in March 2023) to the case with the ATC system (in May 2023).

■ Data Used

- **Case Study**:
  1. Tuk Chai Intersection,
  2. Victory Monument Roundabout (VMR)
  3. Saphan Kai Intersection
- **Queue Length**: Measured by vehicle detectors (unit: 1-minute average in meter) and processed Probe GPS data
- **Traffic Volume of Through Traffic Lane**: Counted by vehicle detectors (unit: 5-minute total in vehicle)
- **Data Set**: Refer to Table 1 for the specific dates used in the analysis.

Table 1: Data set used in the analysis

	Condition:	**Before**	**After**
	6:00-20:00 weekday	**3/1-3/24**	**5/2-5/31**
Tuk Chai	Queue Length (Detector)	○	○
	Traffic Volume	○	○
	Condition:	**Before**	**After1**
	6:00-20:00 weekday	**3/27-3/31**	**6/19-6/30**
Victory Monument	Queue Length (Probe GPS)	○	○
	Traffic Volume	○	○
Saphan Khwai	Queue Length (Probe GPS)	○	○
	Traffic Volume	○	○

Source: Study Team
Note: ○ = Data is available; National holiday was not counted as weekday

■ Benefit Calculation Method

The benefit calculation follows the following steps:

1. **Calculation of Total Waiting Time**: The total waiting time was calculated by summing up the queue length in every time-slice from 6:00 to 20:00 as demonstrated in Figure 1. The average queue length in each 1-minute time-slice was used for the analysis.

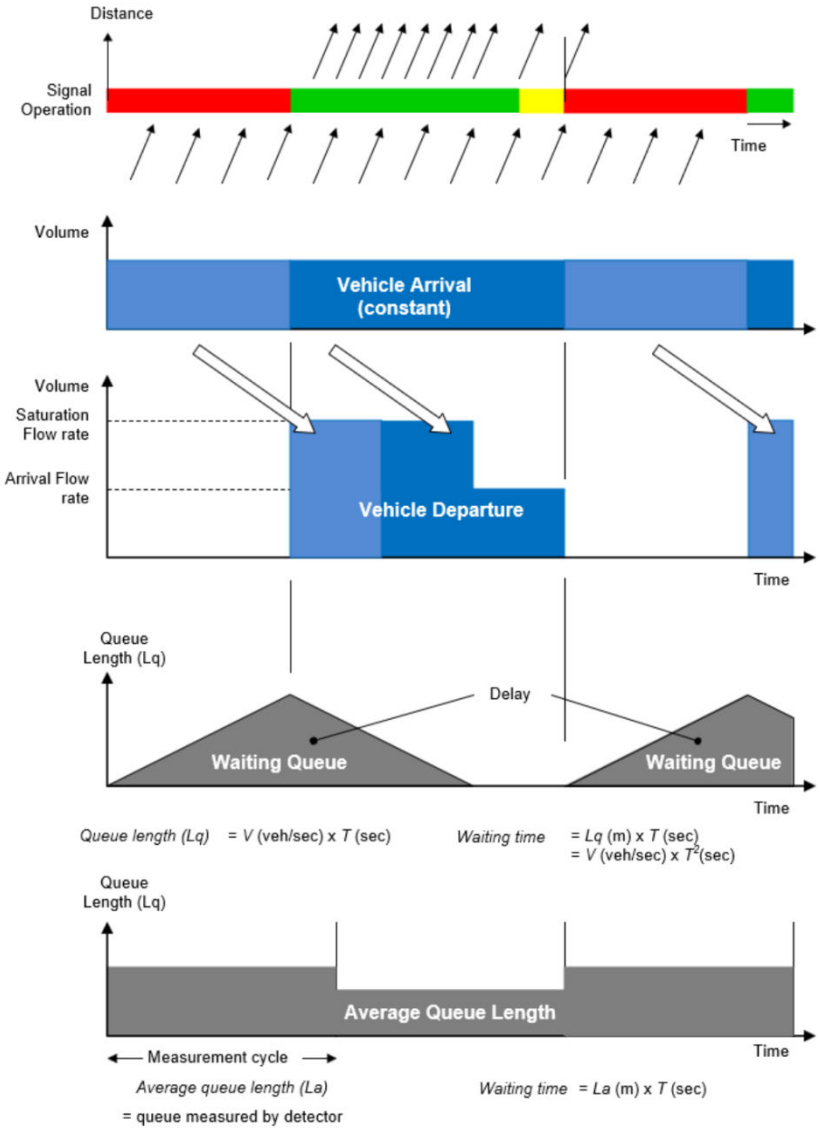


Figure 1: Waiting time calculation

2. **Determination of Total Number of Vehicles**: The 1-minute average queue length was divided by the average headway of 8 meters to determine the average total number of vehicles (cars) waiting in the queue for each 1-minute interval (unit: veh/lane).

3. **Approximation of Total Vehicles per Approach**: The total number of vehicles waiting in the queue for each 1-minute interval was multiplied by the number of lanes in each approach to estimate the total number of vehicles waiting in the queue per approach. The closure of the reversible lane in the S approach of Tuk Chai intersection from 5:00 to 10:00 was taken into account.

4. **Estimation of Total Vehicle Operating Cost (VOC)**: The total number of vehicles waiting in the queue for each 1-minute interval was multiplied by the idling VOC at 0 km/h (THB/veh/min) as provided in Table 2.

Table 2: Average VOC at Idling: C Segment Car (1500-2200 cc)

Item	Value	Unit
ES (Total engine displacement)	1.85	L
IFC=ES*0.6 (Idling Fuel Consumption)	1.11	L/h
GC (Gasohol 91 Cost on 2023/07/11)	35.78	THB/L
VOC = IFC*GC	39.72	THB/h

Source: Calculator Academy, YUKON, PTTOR

5. **Calculation of Value of Time (VOT)**: The total number of vehicles waiting in the queue for each 1-minute interval was multiplied by the VOT (THB/veh/min) as calculated using the average wage rate method, considering the average wage rate, total working hours, and car occupancy rate. Refer to Table 3 for the specific values used in the calculation.

Table 3: Average VOT: Average wage rate method

Item	Value	Unit
Average Income of Bangkok Metropolitan Citizen	22,343	THB/m
Number of working hour per day	8	h/day
Number of working day per month	22	day/m
VOT (Wage / Total working hour)	126.95	THB/h
Average car occupancy on weekdays	1.15	Per/veh
VOT per vehicle	2.43	THB/veh/min

Source: NSO, Kijmanawat et al.

RESULT

■ Reduction of Queue length

As depicted in Figures 2 through 4, total traffic volume vs. queue length graphs at Tuk Chai Intersection, VMR, and Saphan Kwai Intersection demonstrate notable reductions in queue length with the same traffic volume. At Tuk Chai Intersection, the ATC system operation obviously reduces queue lengths, especially during periods of lower traffic volume. However, the difference under saturated traffic conditions with high volume remain inconclusive. On the other hand, for VMR and Saphan Kwai Intersection, significant reductions in queue lengths are observed across various traffic conditions.

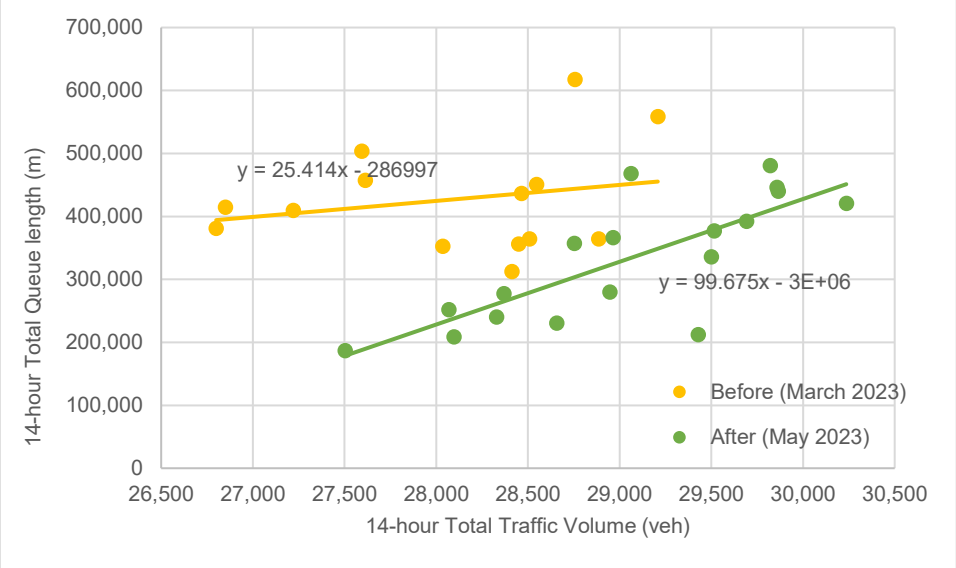


Figure 2: The comparison of queue lengths before and after the implementation of the ATC system at Tuk Chai Intersection

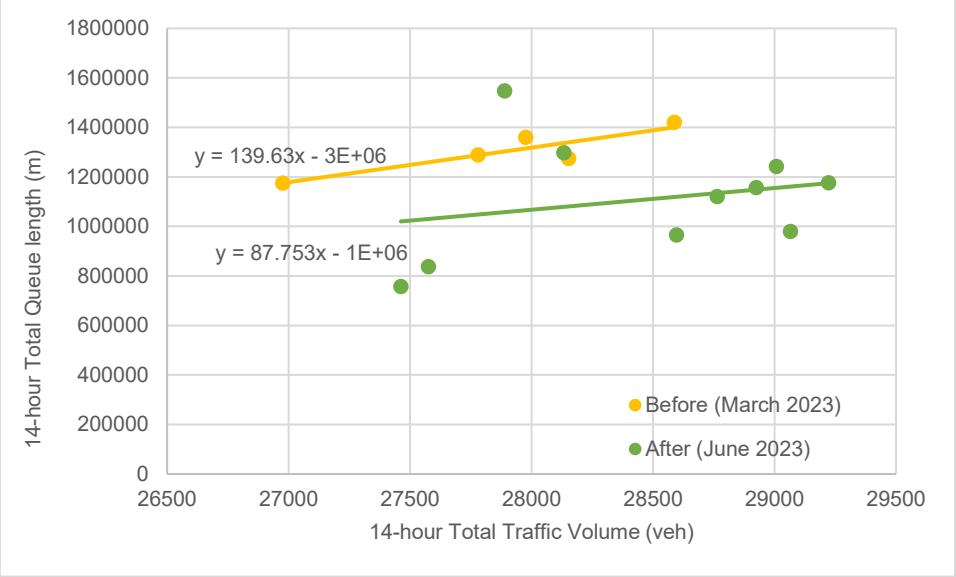


Figure 3: The comparison of queue lengths before and after the implementation of the ATC system at Victory Monument Roundabout

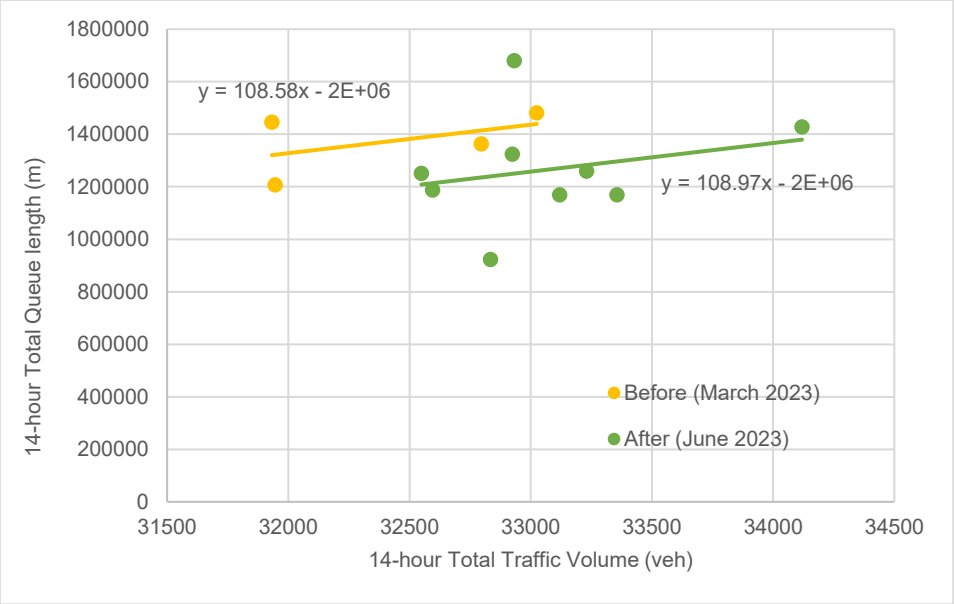


Figure 4: The comparison of queue lengths before and after the implementation of the ATC system at Saphan Kwai Intersection

■ Benefit of ATC system

The reduction in queue lengths due to the implementation of the ATC system has been quantified in terms of economic benefits, as depicted in Figures 5 through 7. This benefit estimation consists of reduced vehicle operating costs (VOC) and the value of time (VOT). Notably, the ATC system implementation yielded substantial economic gains, with average benefits of 107,355 THB (per weekday) at Tuk Chai Intersection, 352,262 THB at VMR, and 169,757 THB at Saphan Kwai Intersection. When considering all three locations collectively, the ATC system within the Pilot Project area could potentially save over approximately 163 million Baht per year[1] in economic losses.

[1] Assuming 260 weekdays a year

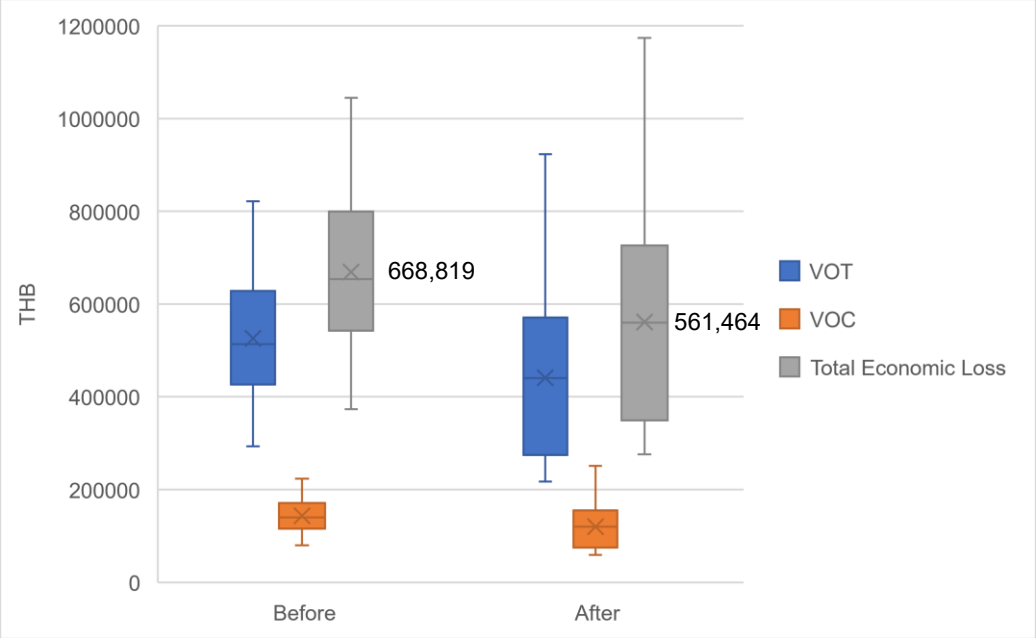


Figure 5: The comparison of the economic loss before and after the implementation of the ATC system at Tuk Chai Intersection

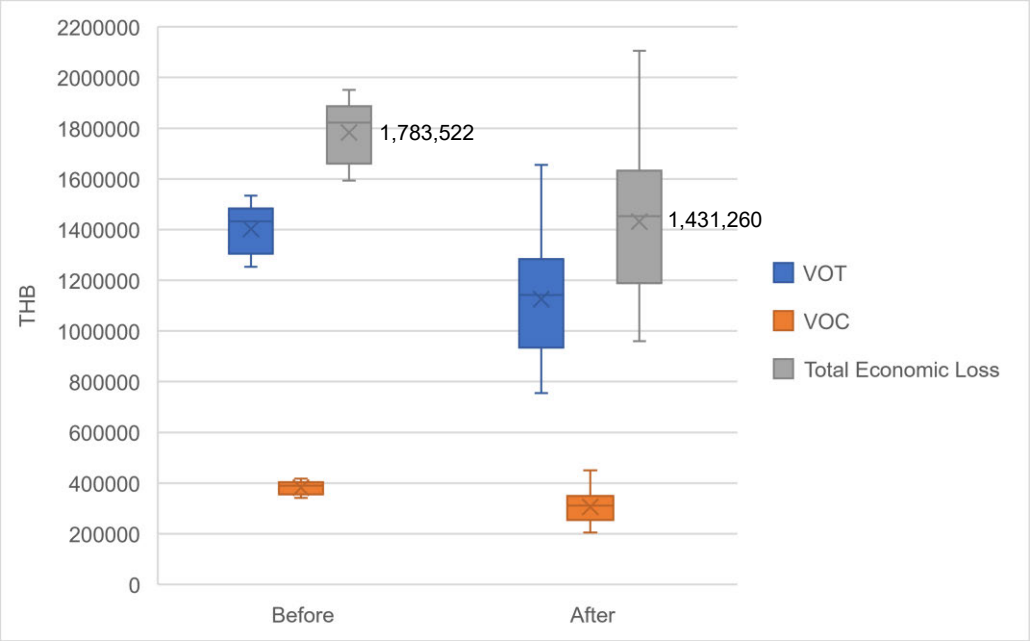


Figure 7: The comparison of the economic loss before and after the implementation of the ATC system at Victory Monument Roundabout

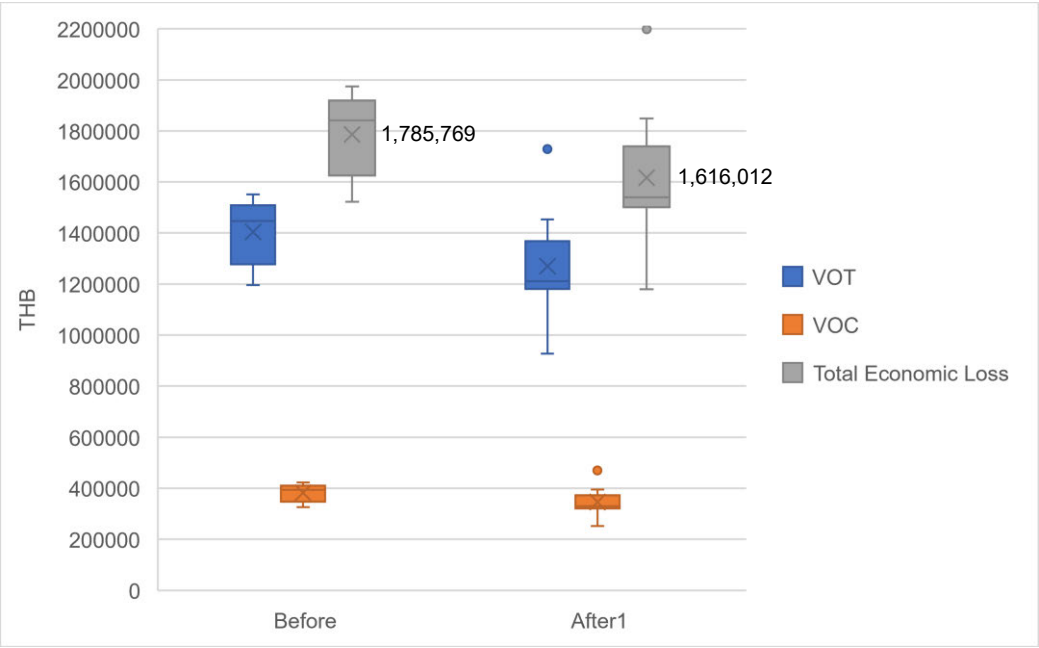


Figure 6: The comparison of the economic loss before and after the implementation of the ATC system at Saphan Kwai Intersection

Annex 4

A Study on ATC System Perception and Awareness

FINAL REPORT

FOR

A STUDY ON ATC SYSTEM PERCEPTION AND AWARENESS

UNDER

THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS IN BANGKOK TROUGH

THE ESTABLISHMENT OF MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM

NOVEMBER 23, 2023

TEAM OF LOCAL STAFFS

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1. Introduction

The establishment of a Model Area Traffic Control (ATC) system in Bangkok is part of "The Project for Improving Traffic Congestions in Bangkok Through the Establishment of Model Area Traffic Control (ATC) System" (BATCP), a collaborative effort between the Japan International Cooperation Agency (JICA), the Bangkok Metropolitan Administration (BMA), and the Royal Thai Police (RTP). This comprehensive project was initiated in 2019 to address the persistent traffic congestion issues in the city.

One of the key initiatives within the project is the implementation of the ATC system in the Pilot Project area, encompassing 13 signalized intersections and 4 pedestrian crossings along major roads, including Rama VI Road, Ratchawithi Road, Phaholyothin Road, and Pradipat Road (Figure 1-1). The ATC system relies on advanced vehicle detectors, such as Ultrasonic detectors and converted CCTV cameras with image processing technology, to monitor real-time traffic conditions. This data is transmitted to the Traffic Control Center through BMA Optical Fiber Network, where traffic conditions are analyzed to optimize signal timing for the area's traffic signals. The optimized signal timings are then sent back to each traffic signal light via the BMA Optical Fiber Network. The ultimate goal of the ATC system is to alleviate traffic congestion and reduce the workload of traffic police who manually operate traffic signals during peak hours.

After meticulous installation, setup, and fine-tuning, the ATC system was fully operational in May 2023, ready to serve the road users in the Pilot Project area. To validate the effectiveness of the newly implemented ATC system, a Proof of Concept (POC) has been initiated to assess the perceptions of road users and traffic police who operate the traffic signals. The questionnaire survey will gather feedback from both parties before and after the ATC system's implementation.

Additionally, an important aspect of the project is promoting awareness and understanding among the citizens of Bangkok. Therefore, a Public Relations (PR) activity has been planned to disseminate information about the ATC system project. The PR team will create compelling PR video content, showcasing positive feedback and experiences from road users. The content will be promoted through various Social Media channels to reach a wider audience.

This study has two primary objectives, with distinct parts for each:

1. Conduct the Questionnaire Survey to Evaluate the Perception of Road Users and Traffic Police in the Newly Implemented ATC System which is explained in Section 2.
2. Undertake the Public Relations (PR) Activity by Creating and Promoting PR Videos through Social Media Channels which is explained in Section 3.

With these objectives, we aim to not only assess the efficacy of the ATC system but also raise awareness and understanding of this transformative initiative among the population of Bangkok.

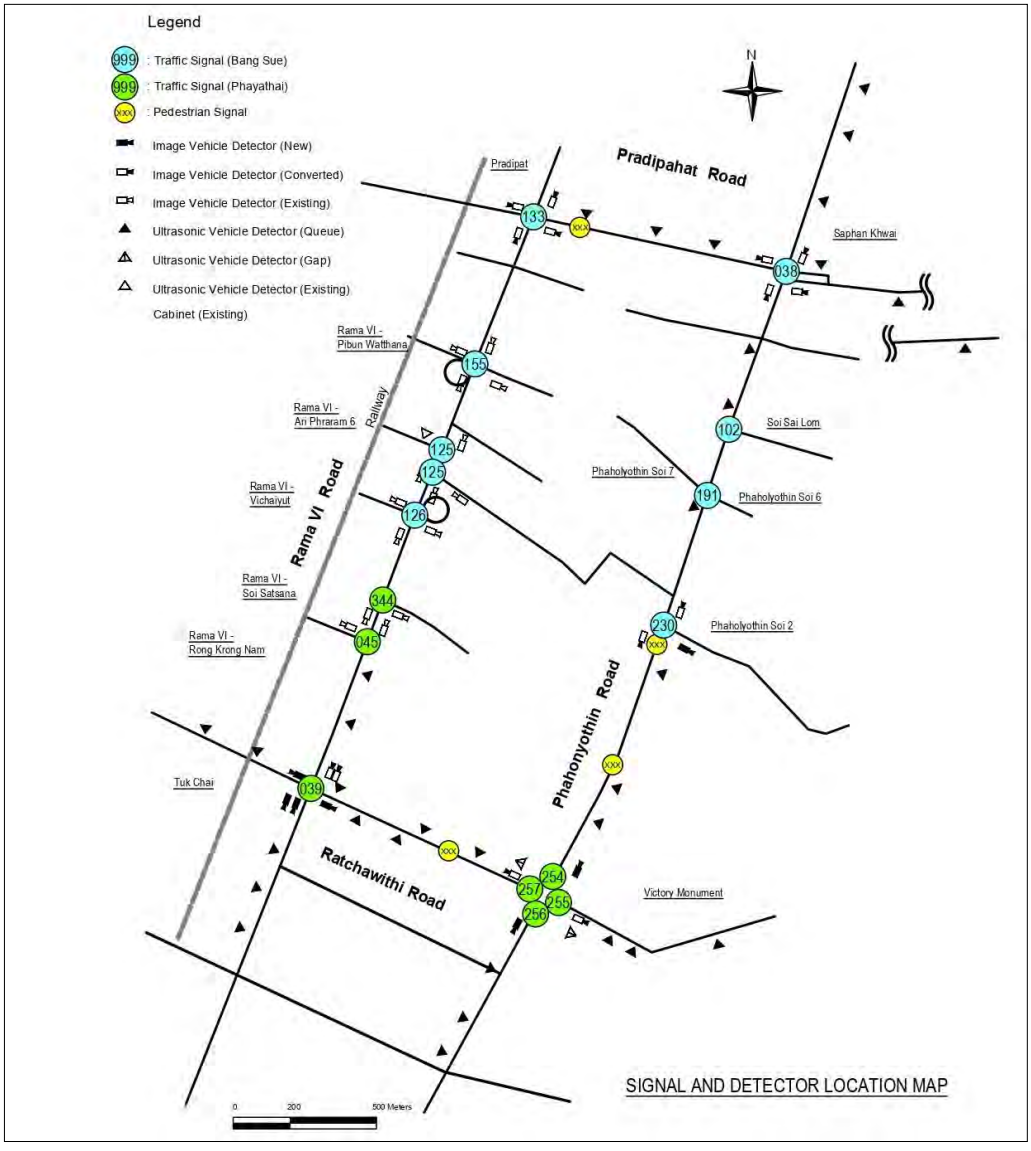


Figure 1-1 The Pilot Project Area

2. The Questionnaire Survey to Assess the Perceptions

2.1 Objective

The objective of this survey is to gather feedback from officers, both from private and public sectors, and who reside near the pilot project area. The survey aims to assess their perceptions before and after the implementation of the Area Traffic Control (ATC) system in terms of travel time reduction, queue length, new installed operating traffic lights along Phaholyothin Road, changes in the cycle of traffic signals and actuated green time, coordinated green times along the corridor (especially on Rama 6 Road), and safety improvements due to road marking enhancements and U-turn closures.

Additionally, we plan to collect feedback from the police stations, specifically Phayathai Station and Bang Sue Station, regarding their experience manually operating traffic signals during peak hours, frequency of manual intervention after the ATC system implementation, and their impressions on traffic congestion improvement as the system automates signal control. Furthermore, we will inquire about their opportunities to focus on other tasks such as traffic violation enforcement, as the ATC system takes over the traffic signal operation.

2.2 Survey Methodology

Questionnaire A (See Attachment 1): Officers and residents in the Pilot Project area

- Obtain permission from organizations and residents reside near the Pilot Project area to conduct the interview survey.
- During the interviews, explain the outline of the Pilot Project to all respondents (use project PR leaflet and video in Attachment 2 to explain the outline).
- Collect socio-demographic and transport information from respondents and request respondents to compare their experiences before and after the implementation of the ATC system using specified questions.
- Target to collect responses from at least 150 individuals, ensuring a diverse sample based on socio-demographic factors and travel destination proportions.
- Record video footage during the interview at least 10 clips (1 person per 1 clip) for creating the PR video footage which will be used in section 3.
- Encode the collected data into an Excel format.
- Analyze the descriptive statistics and summarize the main findings.

Questionnaire B (See Attachment 2): Police Officers at Phayathai and Bang Sue Stations

- Schedule appointments with all police officers responsible for operating the traffic signals in the Pilot Project area, covering all shifts.
- Conduct a review of the Pilot Project's outline with all police officers according to the project PR leaflet.
- Collect data from each police officer using the questionnaire and ask them to compare the situation before and after the implementation of the ATC system using specified questions.
- Record video footage during the interviews at least 5 clips for creating the PR video footage which will be used in section 3.
- Encode the collected data into an Excel format and submit it to the First Party for analysis.
- Analyze the descriptive statistics and summarize the main findings into a report to be submitted to the First Party.

2.3 Data Collection

The interview survey was conducted according to the well-planned schedule, which is presented in Table 2-1. The surveyors conducted in-depth interviews with officers, residents, and traffic police at the police boxes located within the designated Pilot Project area. To ensure a thorough understanding of the participants' perspectives, the surveyors engaged in thoughtful and insightful conversations, capturing their responses in video footage. This approach facilitated candid and open discussions, enabling the participants to express their opinions freely and honestly.

The visual representations in Figure 2-1 demonstrate the dedication and enthusiasm of both the surveyors and the respondents. The engaged atmosphere during the survey sessions reflects the commitment of the survey team to collect accurate and valuable data, capturing the firsthand experiences and opinions of the participants.

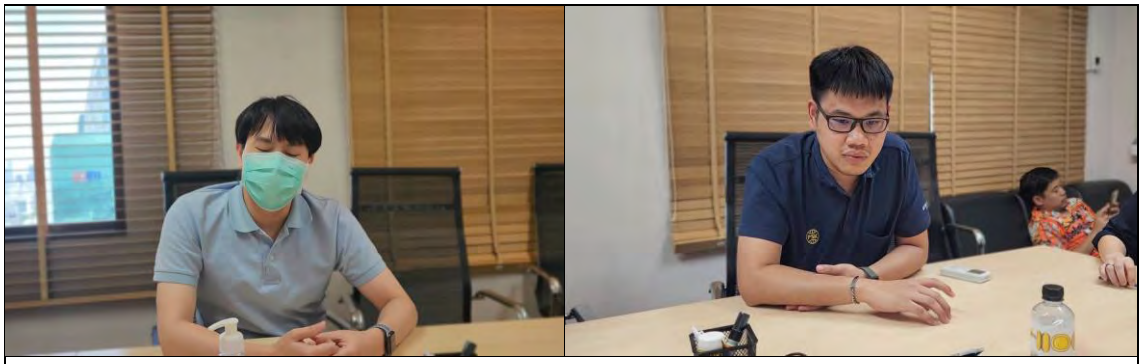
Overall, the survey implementation followed the predetermined schedule with precision and efficacy. The data collected during these interviews will form a crucial part of the comprehensive analysis of the perception and impact of the ATC system in the Pilot Project area.

Table 2-1 Survey Implementation Schedule

Target	Survey Dates
Traffic Polices	7/26, 7/27, 8/3, 8/17, 8/18
Officers and Residents	8/14~8/18, 8/23~8/25

Confidential Policy

- As part of the commitment to protect the privacy and confidentiality of the respondents, all personal information and individual responses was treated with the utmost care and kept strictly private. The data collected during the interview surveys was securely stored and accessible only to authorized personnel involved in the study.
- The surveyors were fully committed to ensuring that the respondents' willingness to contribute to the Public Relations (PR) efforts was taken into account and duly respected.
- If any video footage captured during the interview surveys was being considered for use in the PR video, the surveyors obtained explicit permission from the respondents beforehand.



Officer of private sector

Government staff

Resident

Police officer

Figure 2-1 The Atmosphere During the Interview

3. Result and Findings for the Questionnaire Survey for Officers and Residents in the Pilot Project Area

3.1 Descriptive Statistic

A total of one hundred and fifty individuals comprising residents living and officers working within the Pilot Project Area were interviewed for this study. The interviews encompassed a range of aspects, including sociodemographic information, transport-related details, and perceptions concerning the newly installed Area Traffic Control (ATC) system. The data collected from these interviews has been meticulously summarized as follows.

- Socio-demographic of total respondent
  The distribution of respondents' gender and age is depicted in Figure 3-1 and Figure 3-2, respectively. The gender ratio is almost equal, with 53% male and 47% female respondents. The majority of respondents fall within the 25-34 years age range, followed by the 35-44 years age group. Notably, respondents of various ages are included, showcasing diversity in the sample (Figure 3-2).

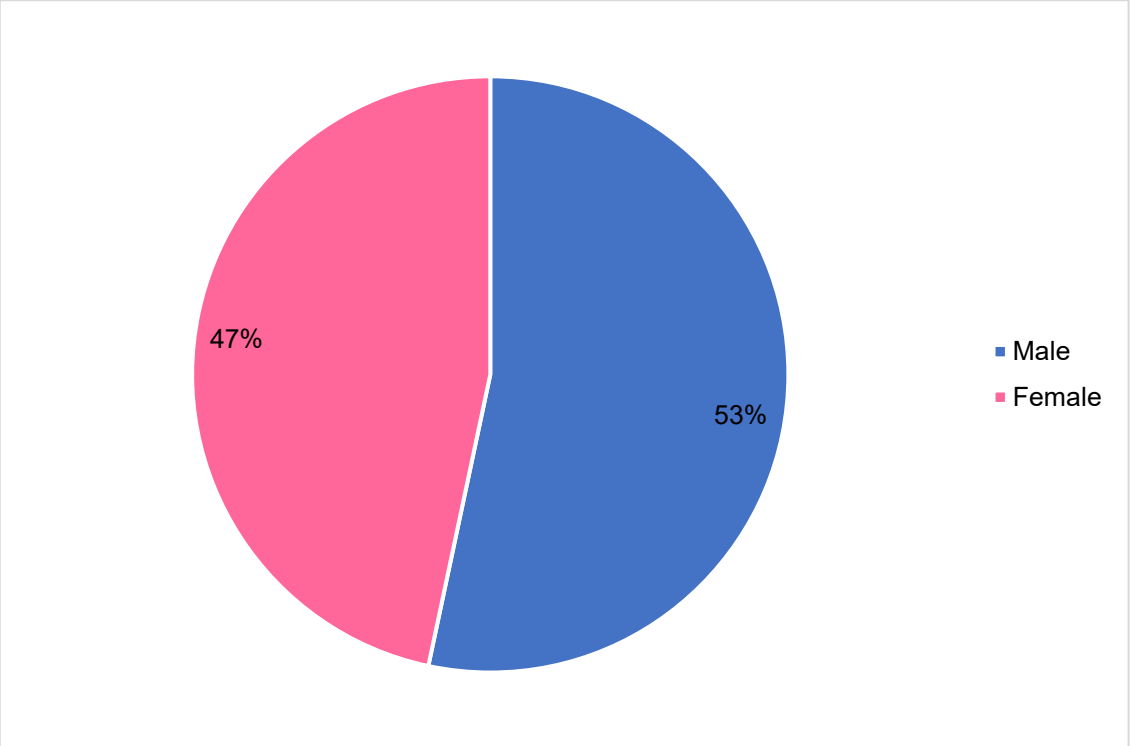


Figure 3-1 Proportion of Gender of Officers and Residents Sample

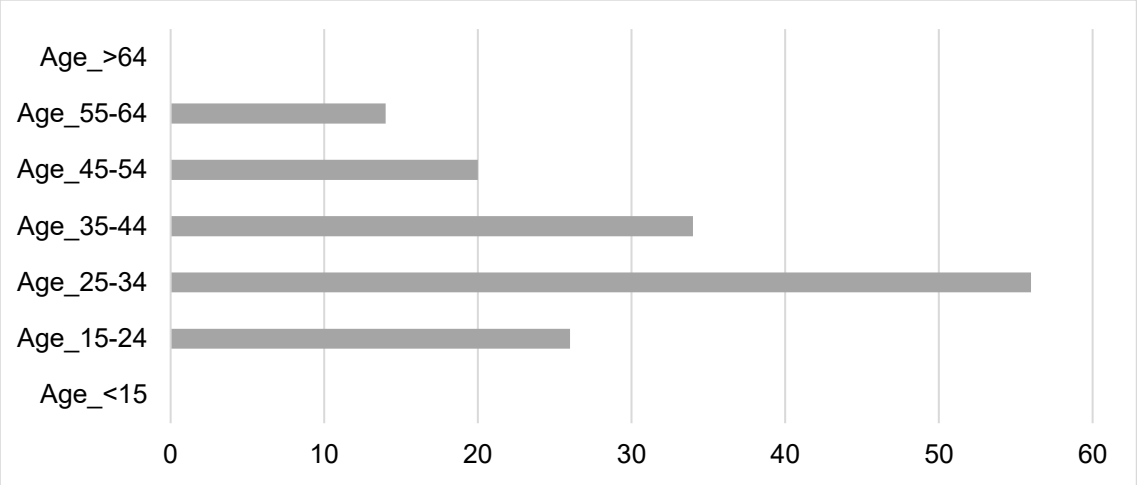


Figure 3-2 Age Distribution of Officers and Residents Sample

- Occupation:

  Figure 3-3 illustrates the distribution of occupation among the respondents. The majority (44%) are employed in private companies, followed by government officers (28%). Students constitute 11% of the sample, and freelancers and housewives/husbands account for 13%. This diverse occupation distribution represents the variation within the sample.

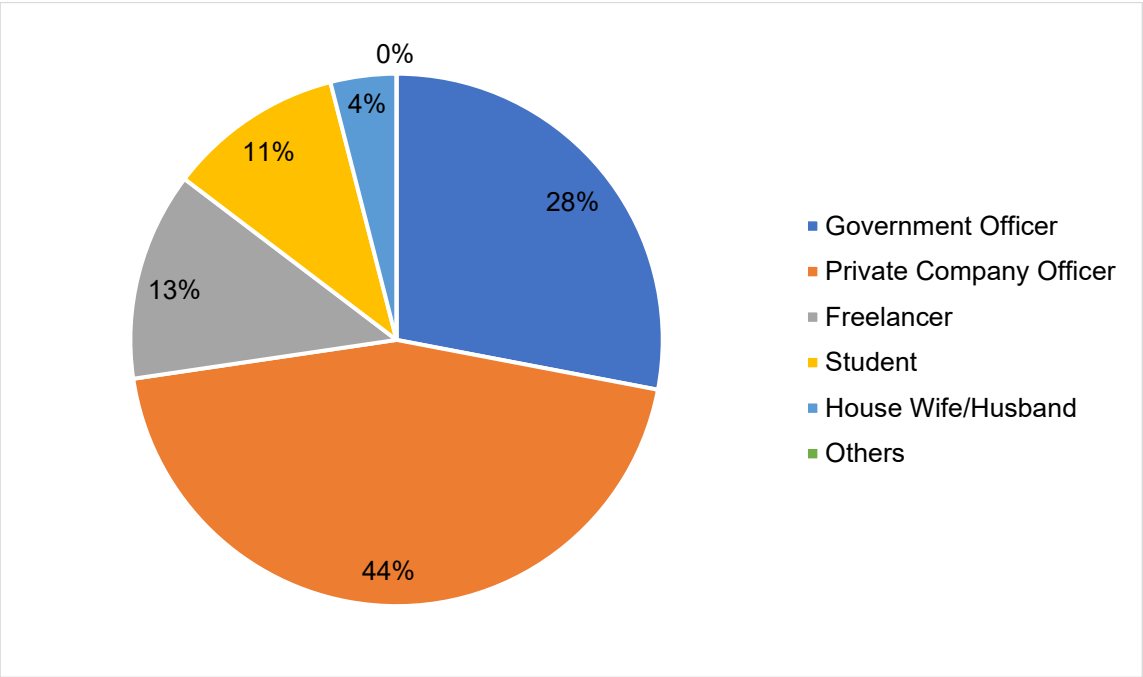


Figure 3-3 Proportion of Occupation of Officers and Residents Sample

- Transport information

  The mode share of respondents is depicted in Figure 3-4. The most prominent mode shareis medium-sized vehicles (42% car drivers, 10% car passengers, 3% taxi, and 5% van). This is followed by large-sized vehicles (21% bus) and small-sized vehicles (15% motorcycle rider and 4% motorcycle passenger), as shown in Figure 3-5.

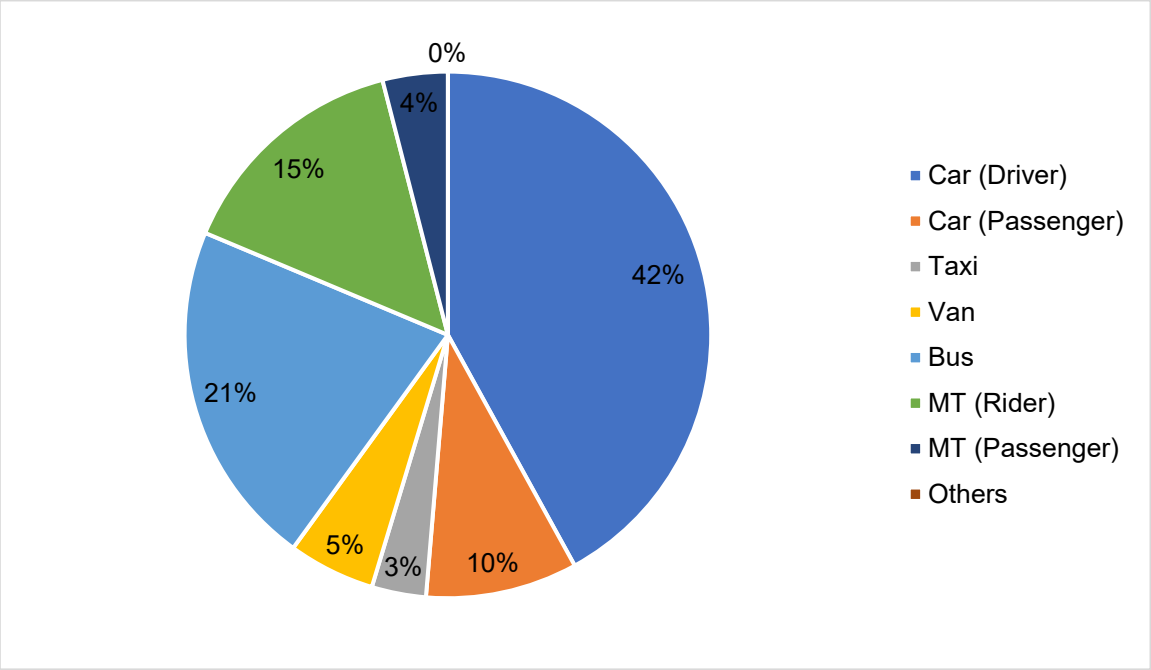


Figure 3-4 Mode Share of Officers and Residents Sample

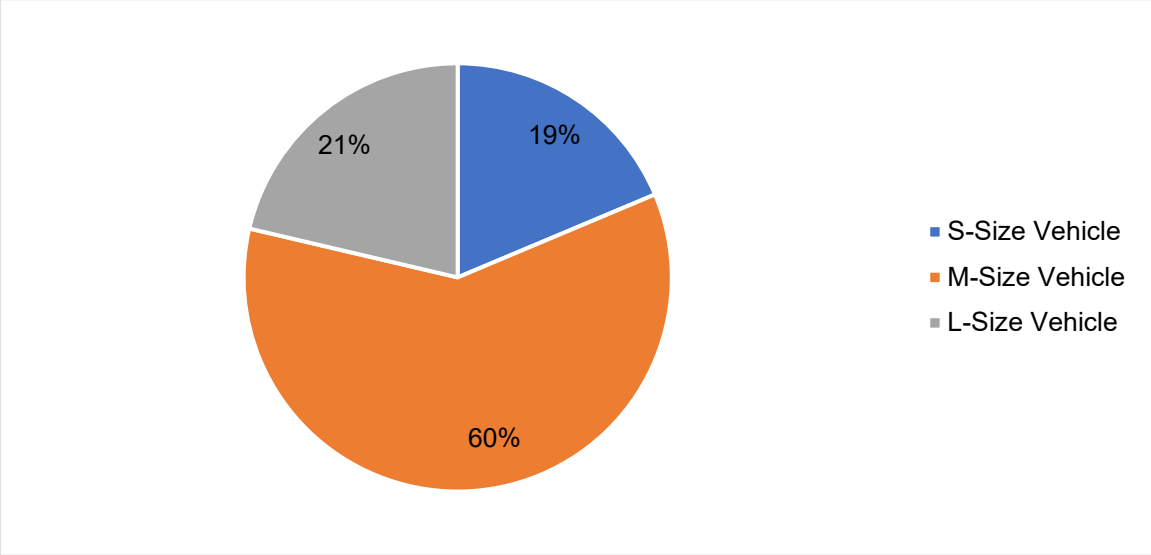


Figure 3-5 Proportion of Vehicle Size of Officers and Residents Sample

- Duration of frequent trip

  Figure 3-6 illustrates the distribution of travel duration during peak morning, off-peak, and peak evening hours. Approximately 26% of respondents travel during both morning and evening peak hours, signifying balanced travel patterns during these times.

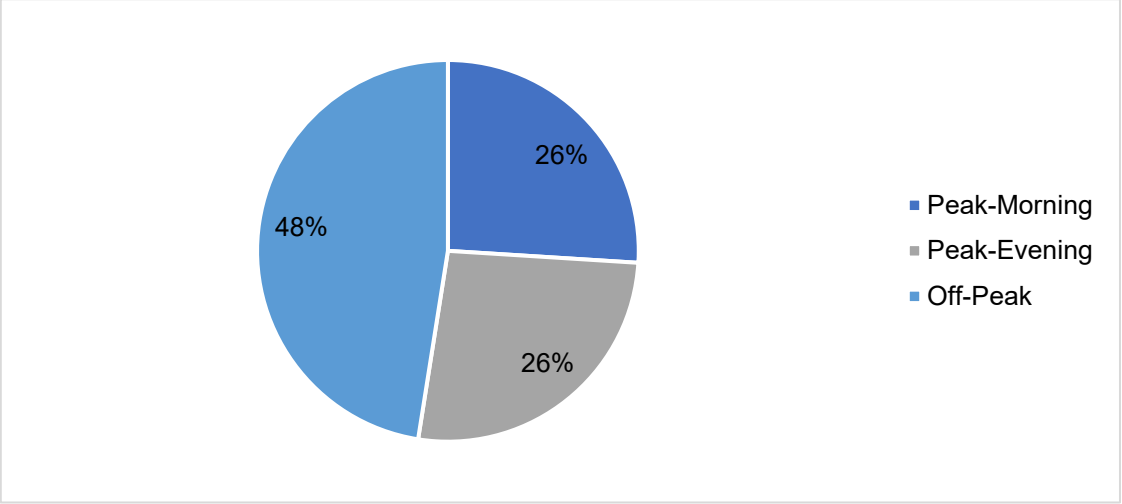


Figure 3-6 Proportion of Travel Duration of Officers and Residents Sample

- Proportion of travel route

  Figure 3-7, Figure 3-8, and Figure 3-9 depict the number of approaches, roads, and U-turn slots traveled by respondents. For Phaholyothin Road, VMR is the most traversed intersection, particularly the North approach. Saphan Kwai Intersection (I038) and the adjacent intersection (i191) also have high demand. On Rama 6 Road, many intersections are traveled by respondents, with Rama 6 Road showing a higher ratio due to its multiple intersections.

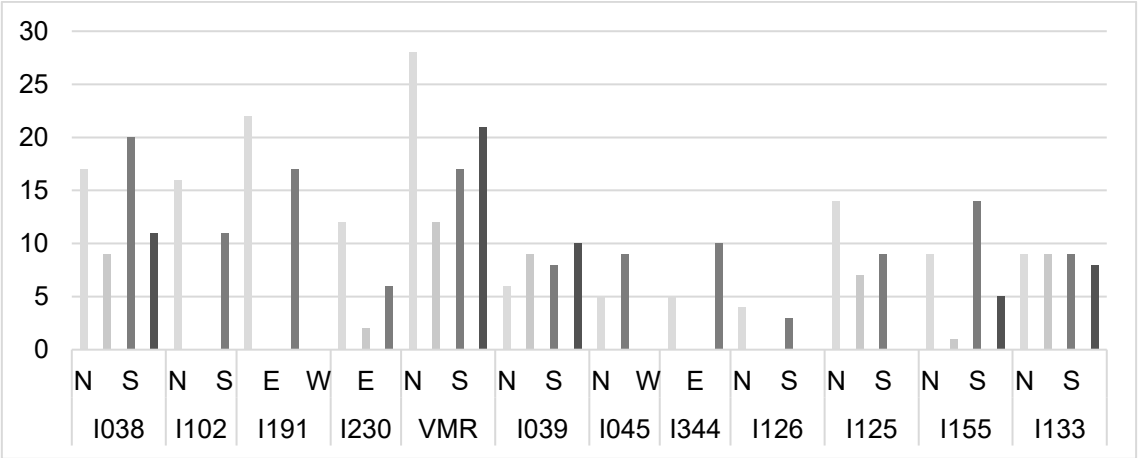


Figure 3-7 Number of Approach Travelled by Officers and Residents Sample

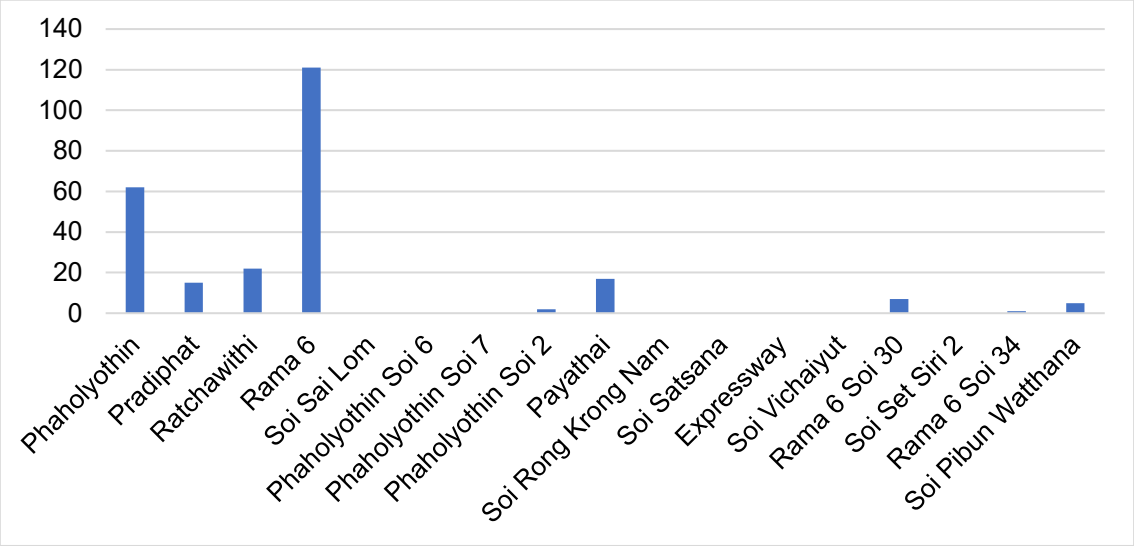


Figure 3-8 Number of Road Travelled by Officers and Residents Sample

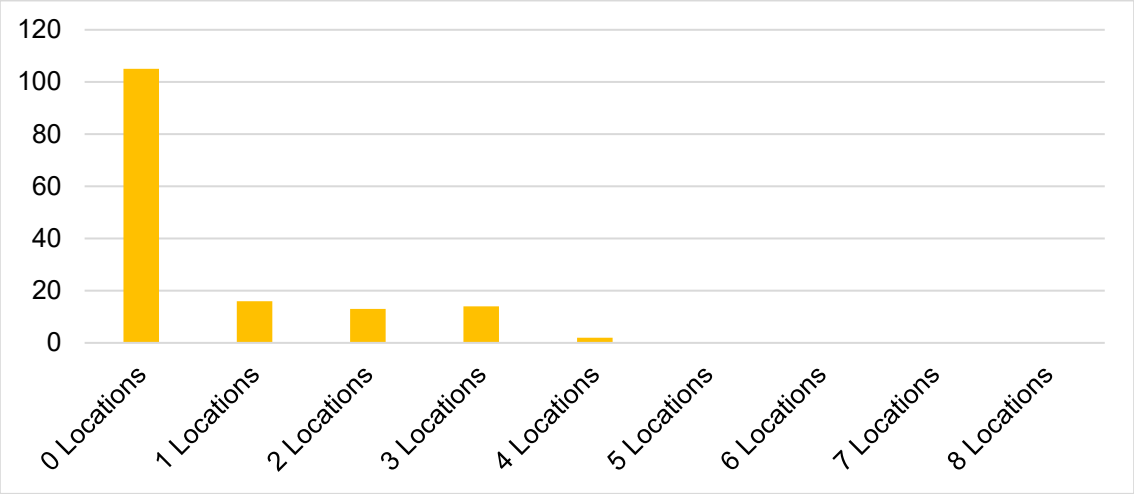


Figure 3-9 Number of U-turn Slot Travelled by Officers and Residents Sample

- Perception

  As mentioned in the questionnaire from the questions ask respondents about the satisfaction degree to the ATC system as below.

  - 4.1 Did you notice any changes in traffic light operation?
  - 4.2 Did you perceive coordination of green times along the traveled corridor?
  - 4.3 Are you satisfied with the new cycle of traffic signals and actuated green time?
  - 4.4 Did you feel the road safety improvement
  - 4.5 Did you feel the reduction in queue length at intersections?
  - 4.6 Did you perceive a reduction in travel time in the pilot project area?

Figure 3-10 showcases respondents' perception of the newly installed ATC system. From the average scores depicted in Figure 3-11, respondents perceived changes in traffic light operation (average score of 3.85; Q4.1), coordination of green times (average score of 3.89; Q4.2), and reductions in queue length (average score of 3.67; Q4.5) and travel time (average score of 3.95; Q4.6). However, the improvement in road safety received the lowest score (average score of 3.14: Q4.4), possibly due to the primary focus of the ATC system on traffic signal management.

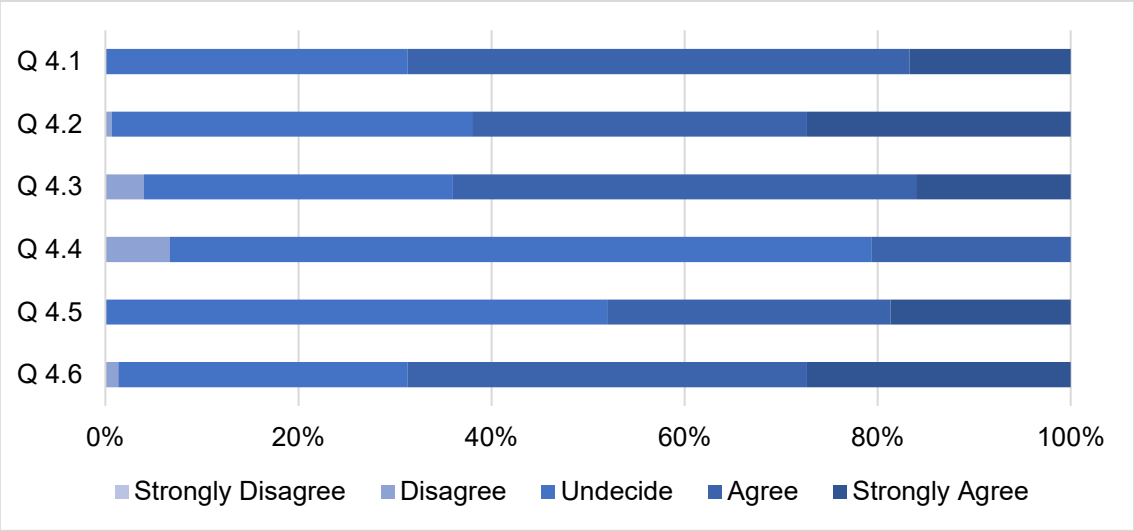


Figure 3-10 Perception to Newly Installed ATC System of Officers and Residents Sample

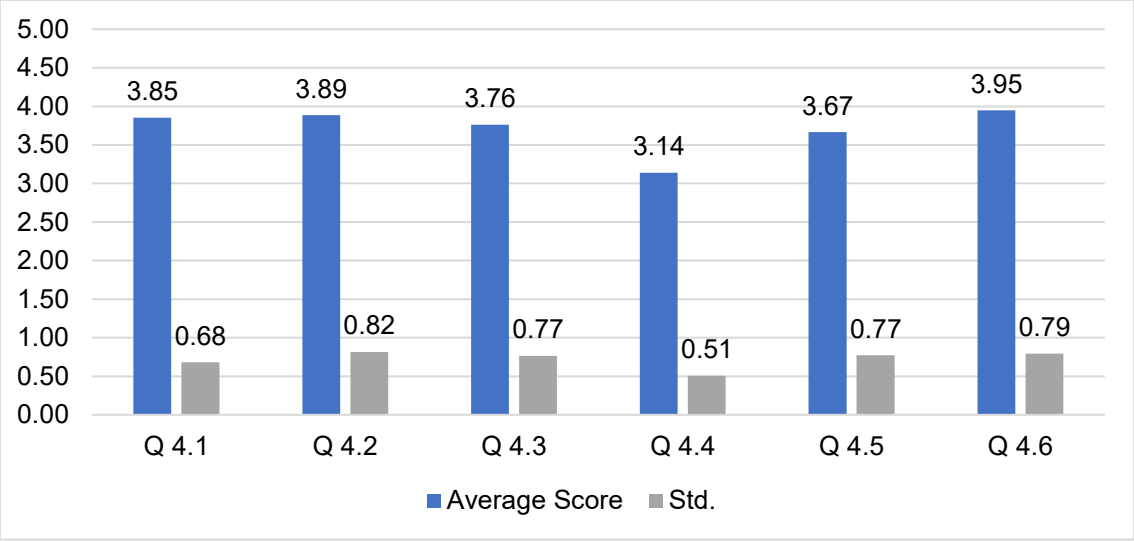


Figure 3-11 Average Score of Perception to Newly Installed ATC System of Officers and Residents Sample

3.2 Trialed Correlation and Insights of Officer and Resident Sample

A correlation test was conducted among various factors of the officer and resident sample, as summarized in Table 3-1. The findings include:

Table 3-1 The Correlation Test Among Factors of Officer and Resident Sample

Factor		Q4.1	Q4.2	Q4.3	Q4.4	Q4.5	Q4.6
Q4.1		1.00					
Q4.2		0.22	1.00				
Q4.3		0.73	0.28	1.00			
Q4.4		-0.08	0.17	0.05	1.00		
Q4.5		0.46	0.16	0.58	0.22	1.00	
Q4.6		0.61	0.19	0.64	0.14	0.67	1.00
Gender (1 Male, 0 Female)		0.07	-0.11	0.02	-0.06	0.10	0.04
Age (Year)		0.04	-0.01	0.05	-0.08	0.11	0.03
Occupation	Government Officer	0.16	-0.08	0.16	-0.06	0.17	0.19
	Private Company Officer	-0.06	0.03	-0.12	0.18	0.01	-0.04
	Freelancer	-0.04	0.10	0.01	-0.03	0.06	-0.03
	Student	0.04	-0.06	0.08	-0.14	-0.21	-0.06
	House Wife/Husband	-0.21	0.03	-0.20	-0.06	-0.18	-0.20
Travel Duration	Peak-Morning	0.03	-0.11	-0.01	0.02	-0.01	0.01
	Peak-Evening	0.02	-0.19	0.05	-0.01	0.08	0.14
	Off-Peak	-0.05	0.31	-0.04	-0.01	-0.08	-0.16
Travel Mode	Car_Driver	0.26	0.00	0.09	0.03	0.33	0.28
	Car_Passenger	0.00	0.19	0.10	0.09	0.20	0.20
	Taxi	-0.01	0.03	0.01	-0.05	-0.11	-0.03
	Van	-0.21	-0.15	-0.16	-0.07	-0.21	-0.21
	Bus	0.02	-0.07	0.04	-0.18	-0.20	-0.05
	MT_Rider	-0.24	-0.13	-0.19	0.11	-0.21	-0.31
	MT_Passenger	-0.01	0.24	0.06	0.08	0.00	-0.07
Travel Route	Phaholyothin	0.02	0.03	-0.04	0.12	0.10	0.01
	Pradiphat	-0.03	0.10	0.08	0.04	0.14	0.16
	Ratchawithi	0.01	-0.01	0.01	-0.15	-0.09	-0.07
	Rama 6	0.09	0.28	0.05	0.10	0.23	0.18

- Motorbike (MT) users tend not to feel much difference, possibly due to their ability to maneuver through traffic. However, few MT passengers perceive good coordination on Rama 6 Road.
- People traveling on Rama 6 Road during off-peak hours perceive better coordination due to the proximity of intersections and fewer access points obstructing traffic flow.
- Passengers of vans, taxis, and buses do not significantly perceive differences, as their focus may be diverted to other activities such as playing smartphone during boarding.
- Car drivers tend to feel phase, travel time, and queue length reductions, as

they are more attentive when driving.

- Respondents who feel queue length reduction also tend to perceive travel time reduction and satisfaction with the new signal phases.
- Housewives and husbands tend not to perceive much difference, possibly due to their use of buses, taxis, and vans, focusing on other activities.

Notably, there is no clear trend in the improvement of road safety perception. Gender and age trends are also inconclusive. The effect of each road on perception is more prominent, particularly in terms of the coordination of green times on Rama 6 Road.

4. Result and Findings for the Questionnaire Survey for Police

4.1 Descriptive Statistic

The study involved eleven police officers from seven different locations of police boxes, including VMR, i038, i039, i133, i155, i344, and i045. These officers were interviewed to gather insights into their roles, perceptions of the newly installed ATC system, and recommendations for its improvement. Figure 4-2 presents the average duration of previous manual traffic signal operation at each location. The summarized descriptive statistics of the police respondents are as follows:

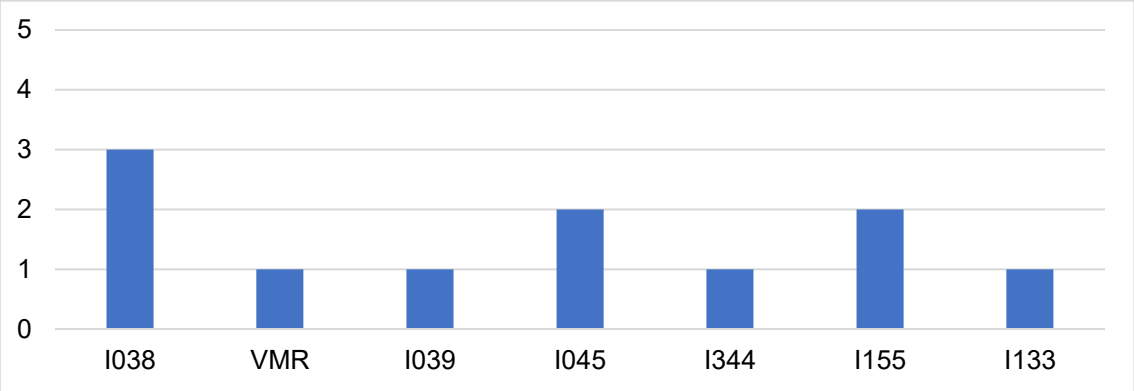


Figure 4-1 Number of Police Categorized by Location in charge

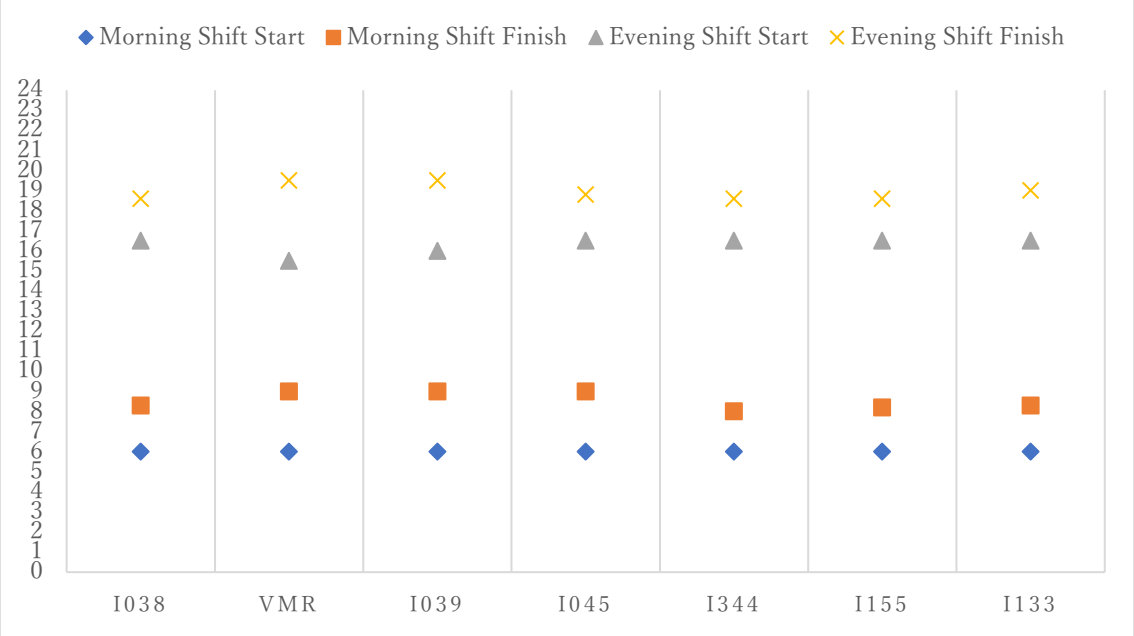


Figure 4-2 The Average Duration of Previous Manual Traffic Signal Operation of Police Categorized by Locations

- Police information

  Figure 4-3 reveals that police officers from various ranks were assigned to control traffic signals during peak hours. Figure 4-4 indicates that a majority of those engaged in traffic signal operations were senior officers aged over 45 years.

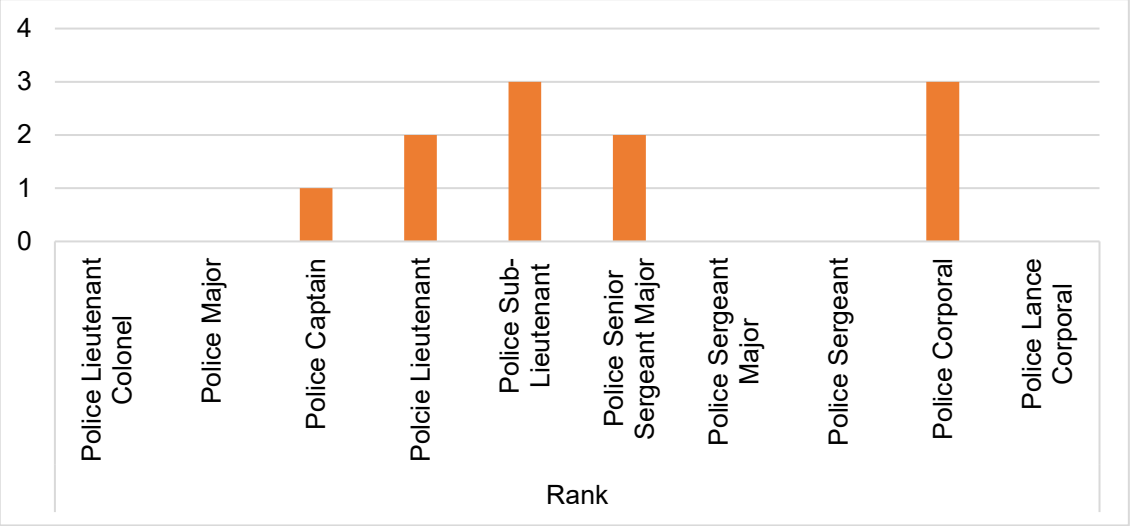


Figure 4-3 Level of Police Sample

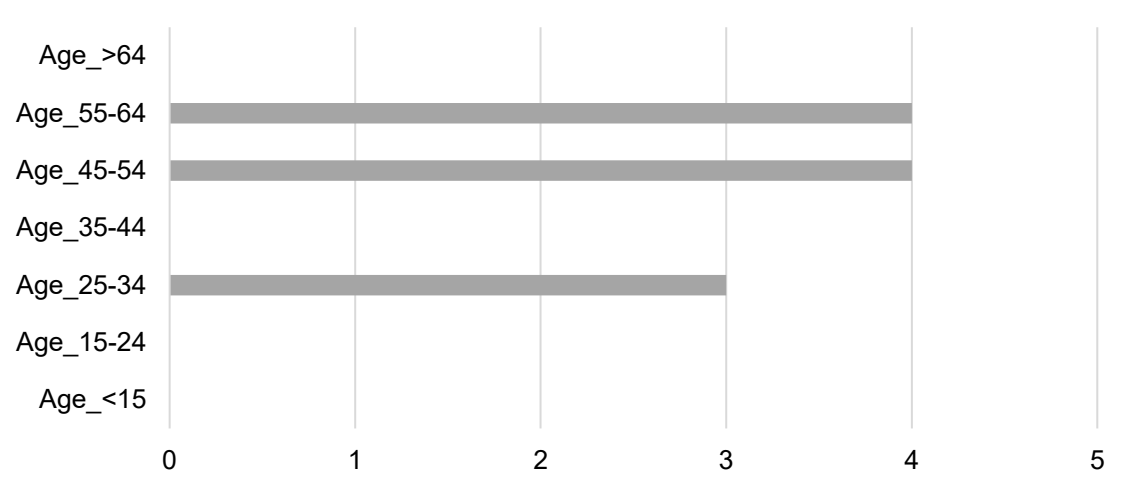


Figure 4-4 Age Distribution of Police Sample

- Traffic Signal Operation

  Most police respondents (Figure 4-5) possessed extensive experience in traffic signal control, with over 55% having more than five years of experience. Figure 4-6 highlights that VMR had the highest average controlling experience, followed by i045 and i155.

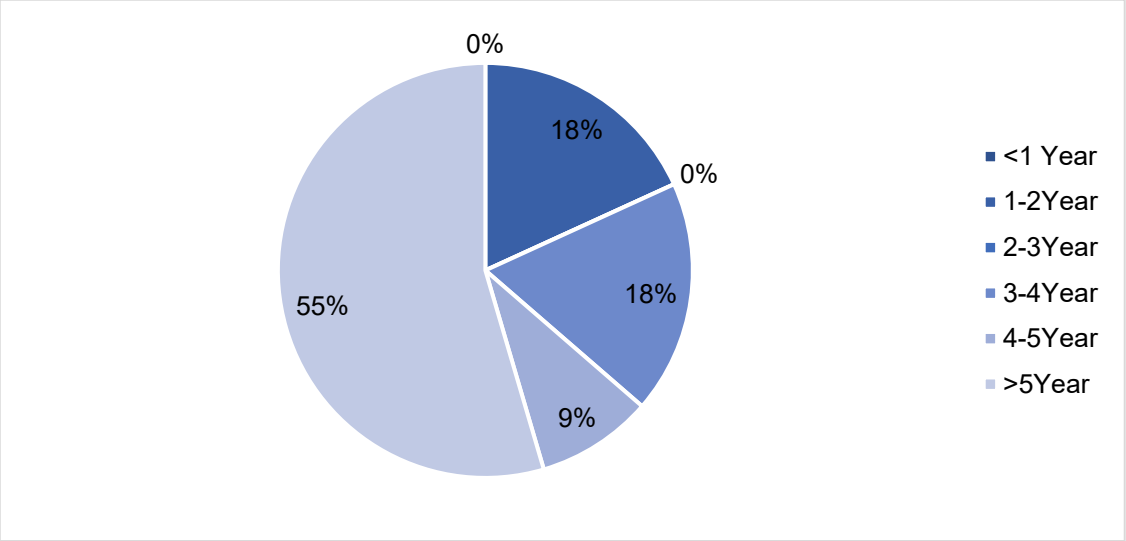


Figure 4-5 Traffic Signal Control Experience at the Location in Charge

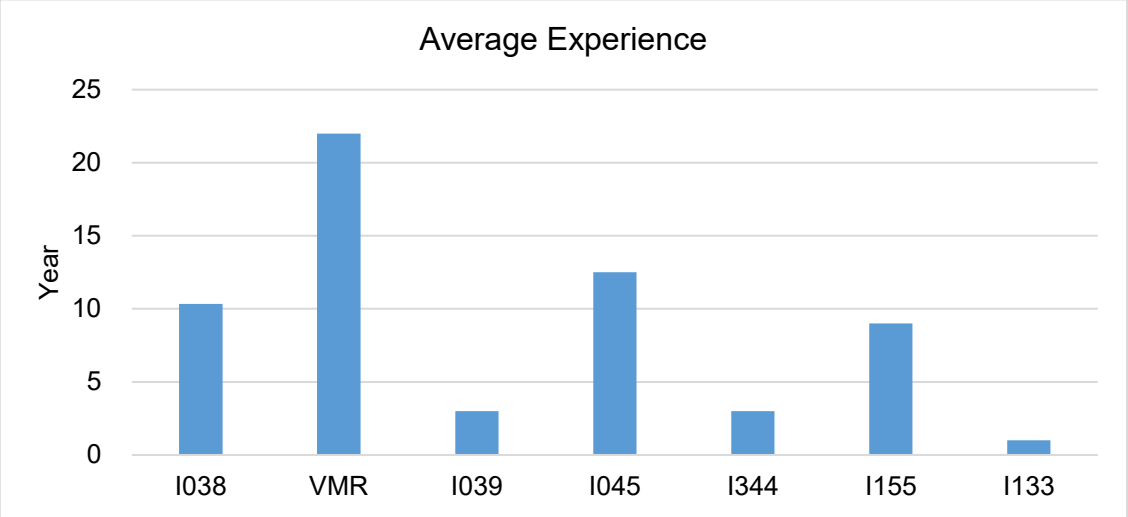


Figure 4-6 Average Experience of Traffic Signal Control at each Location in Charge

- Familiarity with ATC System

  As shown in Figure 4-7, In terms of the familiarity with the ATC system and traffic engineering, most of police have fair level and some of them rarely got the information of ATC system before. On the other hand, few of them who participated in the meeting and training program before tend ho have higher score in this aspect. Referring to Figure 4-8 and categorizing by location, it becomes evident that police officers at VMR and i133 demonstrated the highest levels of familiarity with the ATC system and traffic engineering.

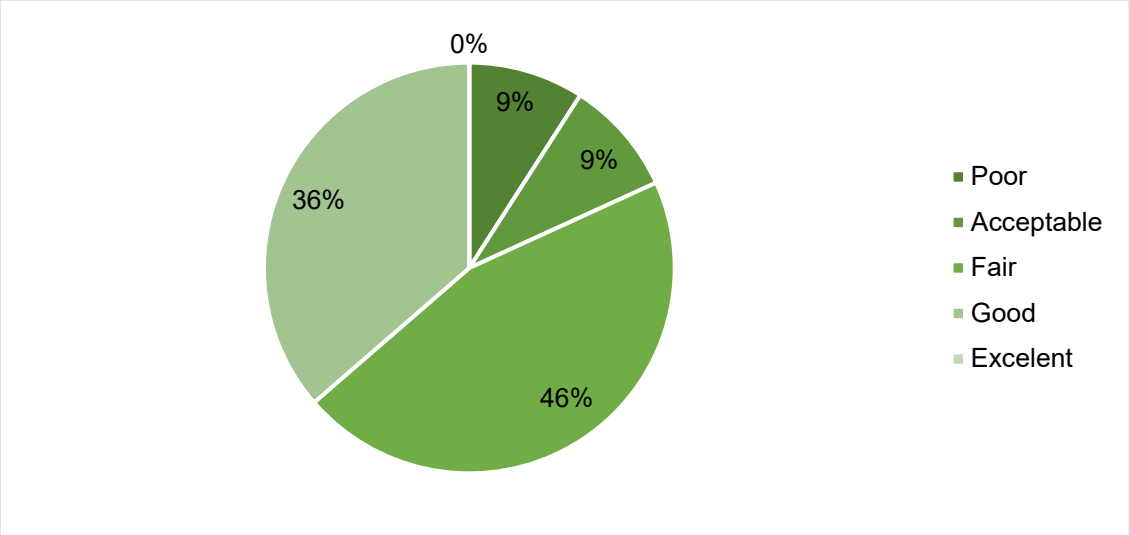


Figure 4-7 Familiarity with the ATC System and Traffic Engineering

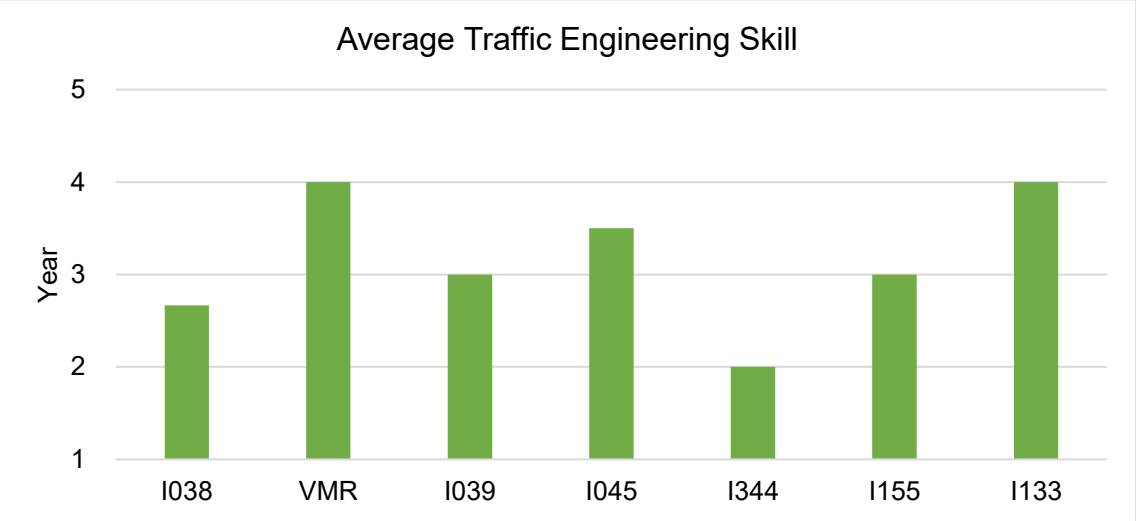


Figure 4-8 Familiarity with the ATC System and Traffic Engineering of Police Categorized by Location

- Perception

  As mentioned in the questionnaire from the questions ask respondents about the satisfaction degree to the ATC system as below.

  · 3.1 Did you feel about no longer manually operating traffic signals during peak hours?

  · 3.2 Did you feel about no longer manually operating traffic signals during off-peak hours?

  · 3.3 Did you feel that you do not need to intervene manually the traffic signal operation after the ATC system implementation?

- 3.4 Did you feel the traffic congestion improvement after the implementation of the ATC system?
- 3.5 Did your role in traffic control change, and do you have more opportunities to focus on other tasks such as traffic violation enforcement?

Respondents' perception of the newly installed ATC system was assessed through various questions. Figure 4-9 indicates that many police staff felt relieved from manually operating traffic signals during off-peak hours, resulting in a higher satisfaction score (average score of 4.36; Q3.2) compared to peak hours (average score of 2.91; Q3.1). Officers also expressed satisfaction (average score of 3.45; Q3.5) with the ability to focus on other tasks while the system operated. While some still favored manual operation (average score of 2.73; Q3.3), many felt an improvement in traffic congestion (average score of 3.82; Q3.4).

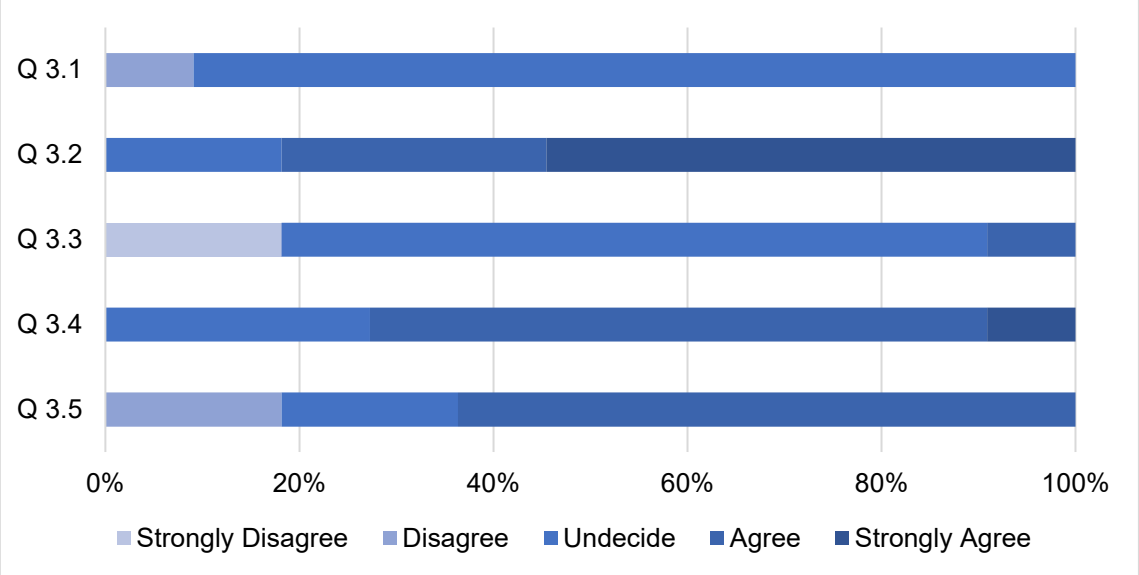


Figure 4-9 Perception to Newly Installed ATC System of Officers and Residents Sample

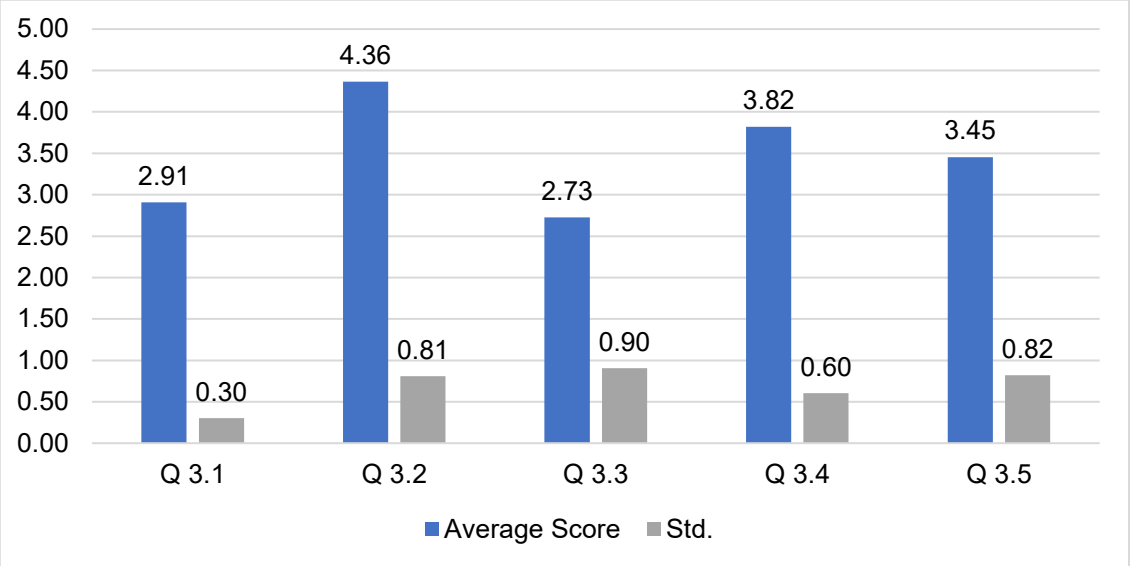


Figure 4-10 Average Score of Perception to Newly Installed ATC System of Officers and Residents Sample

4.2 Correlation and Insights of Police Sample

A correlation test was conducted among different factors within the police sample, yielding insightful findings summarized in Table 4-1. These include:

- Familiarity of the ATC system and traffic engineering had a positive significant impact on satisfaction scores.
- Degree of satisfaction tended to be higher during off-peak hours for individuals at Rama 6 and VMR, except for i045 and i344, which the police at those location showed lower familiarity to the ATC system and traffic engineering.
- Saphan Kwai intersection during rush hours experienced relatively lower satisfaction levels.
- Pradiphat Intersection demonstrated the highest satisfaction regarding traffic improvement and workload reduction.
- Police officers with 1-2 years of experience were more satisfied during off-peak hours.
- Very experienced officers exhibited higher satisfaction during peak hours and workload reduction due to their extensive experience and familiarity with traffic engineering.
- High satisfaction in one aspect often led to satisfaction in others, reflecting the interconnected nature of different elements.

Table 4-1 The Correlation Test Among Factors of Police Sample

Factor		Q3.1	Q3.2	Q3.3	Q3.4	Q3.5
Q3.1		1.00				
Q3.2		0.56	1.00			
Q3.3		0.63	0.83	1.00		
Q3.4		0.45	0.76	0.82	1.00	
Q3.5		0.59	0.78	0.86	0.79	1.00
Age (Year)		0.50	-0.08	-0.01	-0.28	0.04
Operation Location	I038	-0.52	-0.02	-0.28	-0.16	-0.09
	VMR	0.10	0.26	0.10	0.10	-0.18
	I039	0.10	0.26	0.10	0.10	0.22
	I045	0.15	-0.22	0.15	-0.26	0.03
	I344	0.10	-0.56	-0.63	-0.45	-0.59
	I155	0.15	0.08	0.15	0.15	0.33
	I133	0.10	0.26	0.47	0.65	0.22
Experience of Traffic Signal Control at the location	<3Year	0.15	0.39	0.42	0.56	0.33
	3-4Year	0.15	-0.22	-0.40	-0.26	-0.27
	4-5Year	-1.00	-0.56	-0.63	-0.45	-0.59
	>5Year	0.35	0.19	0.35	0.03	0.30
Familiarity with ATC System and Traffic Engineering		0.73	0.74	0.85	0.73	0.72

5. Public Relations Activity by Creating and Promoting PR Videos

5.1 Objective

The objective of the PR plan is to create awareness and promote the benefits of the ATC system. This was achieved by utilizing video footage from interviews and collaborating with influencers to reach a wider audience. The step of this activity is shown below.

5.2 PR Methodology

Video Footage during the Interview Survey

- Utilize recorded videos from the interview surveys to create compelling PR video footage showcasing the positive feedback from road users regarding the ATC system.
- Select the most impactful clips and speakers from the interview recordings to effectively highlight the advantages of the ATC system.
- Ensure a diverse representation in the video, including different ages, genders, and occupations, including officers and police personnel.
- Coordinate to promote the video on the social media platforms of the Traffic and Transportation Department (TTD) and Bangkok Metropolitan Administration (BMA).

Influencer Collaboration

- Approach and coordinate with influencers to create content promoting the ATC system.
- Categorize them into mid-tier and macro influencers based on their follower count and hire influencers as specified in the provided Table 5-1.

Table 5-1 Number of Influencer Use

Level	Chanel	Followers	Number
Macro	Facebook	Approx. more than 1,000,000	1
Micro	TikTok	40,000-100,000	4

- Provide influencers with possible content options shown in Table 5-2

Table 5-2 The Contents

No.	Topic	Content
(1)	Control Center	- The atmosphere of the operation of traffic control center
(2)	Police box	- Reduction in manual operation of traffic signals by the police - Monitoring screen at VMR police box
(3)	Roadside equipment	- Detector (Ultrasonic, CCTV Camera) - PR Banner and decoration (Traffic signal, Detector pole, Pedestrian crossing)
(4)	Coordinated green time	- The coordinate green time along RAMA6 Rd.
(5)	Actuated control	- Actuated green time for turning right vehicles, with the green light or right turn lane immediately cut when the gap between vehicles turning right becomes large.

- Support to collaborate influencer to ensure the created content aligns with the objectives and goals.
- Assign influencers to promote the video clips through their social media channels.
- Evaluate the effectiveness of the influencer's clips.

5.3 Result of the PR Activities

Part A: Video Footage during the Interview Survey

During the interview surveys, video clips were recorded from various respondents, including residents, officers, and traffic police, to capture their valuable feedback on the newly implemented ATC system in the pilot project area. These recorded clips were skillfully compiled to create a compelling PR video footage, totaling @@ minutes in duration. The details of clips used in the PR video footage is shown in the Table 5-3. Additionally, the video was uploaded to promoted in the Chanel in Table 5-4.

Table 5-3 The details of clips used in the PR video footage

Respondent Type	Clip length	Language
Officer and resident	3:11	Thai with English Subtitle
Police	2:08	Thai with English Subtitle

Table 5-4 Social media channels for PR video footage promotion

Channel Name	Type	Organization in charge	Date of Promotion
TTD	Facebook	TTD, BMA	To be decided by TTD
BMA	Facebook	BMA	To be decided by BMA
Thailand Smart City Expo	Expo	Digital Economy Promotion Agency (DEPA) and JICA	November 23, 2023

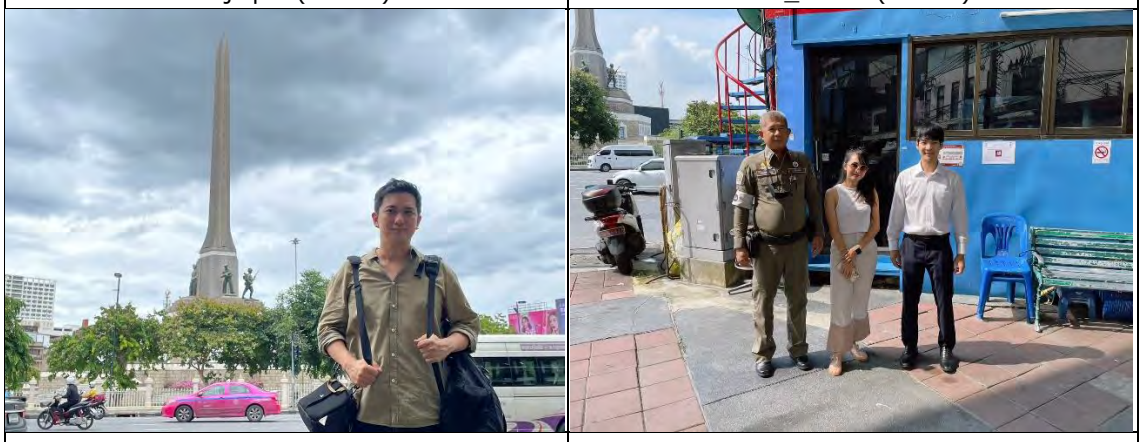
Part B: Influencer Collaboration to Promote the Pilot Project

In parallel to the PR video footage, influencer collaboration was initiated to further promote the pilot project and raise awareness about the ATC system. A team of 5 influencers were engaged to create captivating content to highlight specific aspects of the ATC system's benefits. Each influencer was carefully selected based on their reach and relevance to the target audience.

The influencers enthusiastically generated engaging content based on the provided topics in Table 5-2, such as improved traffic signal coordination, reduced manual signal operation, and actuated green time for turning vehicles. Figure 5-1 shows the atmosphere during the production of video clips. In total, Influencer list and detail of clips is shown in Table 5-5 and Table 5-6.

Drama-addict (FB)

Phajaipai (TikTok) | Tina_Janeti (TikTok)



Onthewayjourney (TikTok) | Ampairkongkaew (TikTok)

Figure 5-1 The Atmosphere During Video Clips Production

These influencers played an important role in sharing their content across their respective social media channels, amplifying the reach and impact of the promotional efforts. The response to the influencer-led promotions was measured, and the effectiveness of each influencer's content was evaluated to gauge the overall impact of the campaign as shown in the Table 5-7.

Table 5-5 Influencer list and detail of clips

Channel Name	Type	Followers / Likes	Date of Production
Drama-addict	Facebook	3.2M / 3 M	13/09/2023
Phajaipai	TikTok	101.2K / 2.1M	12/09/2023
Tina_Janeti	TikTok	38.9K / 1.7 M	13/09/2023
Onthewayjourney	TikTok	134.2K / 1.9M	14/09/2023
Kikstorystorjai	TikTok	37K / 857K	13/09/2023
Ampairkongkaew	TikTok	30.5K / 2.3 M	05/10/2023

Table 5-3 The details of clips used in the PR video footage

Channel	length	Dialog (EN)
Drama-addict	3:29	· Let's follow me to see something interesting. · It is the pilot project of the Area Traffic Control system. · Currently, Bangkok Metropolitan Administration has cooperated with the Traffic Police Division and JICA. · The pilot project is aimed at improving traffic congestion in Bangkok. · Traffic signals in the pilot area are controlled automatically by the ATC system, which covers four main intersections. It sounds interesting,right? Let's see! · Ok, let's see. · As we know, there are a large number of vehicles in Bangkok. Reducing the amount of time spent traveling by car by five to ten minutes is such a positive thing. · Firstly, we thought that road users felt nothing. When we conducted questionnaires in the pilot area, we were surprised by the results. · Over 50% of road users feel that traffic flow is quite smoother when driving through the pilot area. · The green signal is always optimized. Road users just wait for 1-2 signal phases. It is better than usual. · This is a Flow Rate. · It is when cars are running with the appropriate gap and speed. This flow rate can be shown at its maximum at 100%. · As you can see, the algorithm will not produce a lengthy sequence of green signals when there is a change in the distance between cars because fewer cars are passing through the intersection. · As you can see here, the green signal is calculated for just a few seconds, then the phase changes. · The system has already been set up. It will not generate a green signal for just 3 seconds. · When there are no cars, the green signal will last for 13 seconds. · When there are many cars, it will last just 29 seconds. · In order to optimize the signal, the system itself also learns from current traffic conditions. · As a result, it can modify optimum signal intervals. · Its aim is to operate with 100% of flow rate. · Is this an intertwined case? · Exactly, it is the intertwined, however, mostly we just let it be. · Mostly, we just let it run automatically. · How was the situation prior to JICA implementing the ATC initiative into action? · We manually operated all day, from early morning until 8 -9 PM. · It is a roundabout, not an intersection. The roundabout gets tangled when cars cannot manage to complete it. · In a roundabout, cars will become intertwined. Cars cannot be released while they are blocked. · Yes, that is what I am trying to tell you. · Police response times to traffic control may be shortened if the technology is extended throughout the Bangkok area. It really helps, in my opinion. · It should be expanded in all Bangkok area.

		· For example, we have to switch to manual operation when the lengthy queue length blocks the flow of traffic heading to Phaya Thai because the system has not been implemented in Phaya Thai area yet. · Din Daeng area has not been implemented too. · However, Tuk Chai heading to Victory Monument is fine, because the intersections have already been linked by the ATC system. · Sapankhwai intersection is also operated automatically. · Previously, police have to operate manually allday from AM to PM. · See you again if anything interesting comes up. Bye Byeee See yaaa
Phajaipai	1:34	· The issue with travelling in Bangkok that we face every day is that there are many vehicles, which leads to a traffic bottleneck. · Whether going out, going to work, or going to create content, we have to encounter traffic jams like this, guys. · There are numerous signals in Bangkok, but the roads are heavily congested with vehicles. · However, this issue will eventually become better and today I'm gonna take you guys to know a good project. · which is known as "The Bangkok Area Traffic Control Project". · This project has just launched on June 26th,2023. · Bangkok Metropolitan Administration Led by Governor Chatchat collaborating with the Royal Thai Police with support from JICA, the project was implemented to improve traffic congestion in Bangkok applying an Area Traffic Control system or ATC system to provide optimal signal for traffic condition in real time. · Currently, this system is operating in the pilot project area, covering traffic signals in 13 intersections and 4 pedestrian crossing signals located on 4 main roads. · Alright, now I'll take you to see how the ATC system works. · Here, the one you are seeing is called an ultrasonic detector. · It will detect vehicles and traffic congestion. · The detected data will then be transmitted to a central control center for analysis and real-time signal control adjustment at each intersection. Super cool! · The system's operation will shorten waiting times and will promote a smoother traffic flow. · Bangkok Metropolitan Administration plans to expand the system in other intersections throughout Bangkok. Consequently, traffic conditions in Bangkok will be improved.
Tina_Janeti	0:46	· I've traveled a lot in Bangkok and been living in here for almost 2 years now. · I saw a lot of things change. · Guys, this is a new traffic signal system which the Bangkok Metropolitan Administration has collaborated with the Royal Thai Police and JICA. · They solve the traffic congestion by implementing an Area Traffic Control system. · The pilot area covers 13 intersections on 4 main roads. · You can see information on this notice. · Have you guys ever seen a cone-shaped device like this? · This one is called an Ultrasonic Detector, which detects traffic volume and real-time traffic conditions. It also analyzes traffic data and optimizes traffic signals at that time. · It's so lit! The traffic jam will be shorter! · This is a pedestrian signal which also connected to traffic signal system. · People strolling in Bangkok, like me, no longer have to worry about crossing the street, guys. Life is much better now!

Onthewayjourney	0:33	· I can feel the winds of change. “How good is the Intelligent Traffic Signal introduced by Governor Chadchart?” · Bangkok collaborates with the Royal Thai Police and JICA, Japanese Official Agency to establish the intelligent traffic signal system. · It can reduce queue length by around 30%. · and help save an estimated 30-90 million baht per intersection per year. · It starts piloting in 4 main roads and 13 intersections · AI will calculate automatically. · Traffic signals will be optimized depending on traffic conditions. · AI will calculate to make all 13 intersections linked together. · Outside traffic conditions will be transmitted to the control center in real time. · Traffic police don’t need to manually control the signal. · And the Bangkok Metropolitan Administration intends to implement it throughout the city in the future.
Kikstorystorjai	1:05	· Today I’m gonna do a one-day Vlog with me. · My day starts in the afternoon today. I'm gonna find a cafe to work at there to change my working environment. · I'm driving to the Pradipat area today. Guys, I feel very strange while driving. There is no traffic on Rama 6 Road. At every intersection, I got green signals. It's like a lucky day when we're driving and there aren't any traffic jams. · Wait, I think I'm lucky today because I'm wearing a lucky color. · But actually, this is not my lucky guys. This road has an Area Traffic Control (ATC) system installed. The ATC system collects traffic data in the area using ultrasonic vehicle detectors and CCTV cameras. · These devices will monitor traffic conditions in real time. It's really cool, guys. · As a Bangkok resident, I’m happy to see advanced technology being used in our city. · Café review
Ampairkongkaew	0:39	· The Area Traffic Control system has been piloted · By the cooperation among BMA, RTP and JICA. · The system will detect traffic condition in real time via sensors. · Traffic volume will be transmitted to the control center for signal optimization. · The project area covers 13 intersections at Phaholyothin road, Rama 6 road, Ratchavithi road and Pradiphat road. · And BMA plans to expand the project into other intersections to improve traffic congestion.

Table 5-7 The evaluation of Engagement with the PR video of each influencer

Channel Name	Link	Date of Publication	Date of Evaluation	No. Views	No. Like	No. Share	No. Comment (+/N/-)	Summary of Comment
Drama-addict	https://fb.watch/oaC3NMOL3N/	November 7, 2023	November 14, 2023	132k	1,449	60	62 (47/10/5)	Overview of people who liked this post: Praise the project. Praise AI. I want this project to be developed in many places in Bangkok. People have wanted to see this for a long time. I want this kind of development to help people in many points. As for the negative comments, they're about other areas, why they didn't do it. Only do this area.
Phajaipai	https://vt.tiktok.com/ZSNUnY4xF/			32k	533	5	7 (5/1/1)	Overall, people admiring this project have only one negative comment, which is not related to the project.
Tina_Janeti	https://vt.tiktok.com/ZSNUW8WnJ/			15k	125	1	3 (2/1/0)	I like the system, but motorists still need to be careful about road safety, and there are no negative comments.
Ontheway journey	https://vt.tiktok.com/ZSNUWev3J/			70k	1,387	91	115 (78/25/12)	Overview of people who liked this post admires the project and feels that since this project, it really helps improve the road a lot. You can feel it; you do not just think about it. As for the negative comments, they are more about the governor. For example, claiming that it was Mr. Aswin's work.
Kikstoryst orjai	https://vt.tiktok.com/ZSNUnTPqs/			17k	132	4	0	NA
Ampairkongkaew	https://vt.tiktok.com/ZSNUnTPqs/			28k	1342	2	3 (0/2/1)	Wait to see if it will work and recommend doing a one-way road.

Note: +, N, - refer to No. Positive, neutral, and negative comments, respectively. The posted clips are still ongoing after the date of evaluation.

5.4 Summary the PR Activity

The PR video footage, a result of collaborative efforts, effectively conveyed overwhelmingly positive feedback from both road users and traffic police regarding the newly implemented ATC system in the pilot project area. Anticipation for the expansion of the ATC system was expressed by both police and road users, highlighting the expectation of larger positive effects with a broader system implementation. The clips were featured at the Thailand Smart City Expo in Bangkok and are planned for publication on TTD and BMA's PR platforms.

The collaboration with influencers significantly raised awareness about the system's benefits, showcasing its role in improving traffic conditions and enhancing the overall commuting experience in Bangkok. Particularly successful clips from the “Drama-addict” Facebook page and “Onthewayjourney” TikTok page garnered substantial engagement with 132k and 70k views, over 1000 likes, 60 and 91 shares, and 62 and 115 comments, predominantly positive in nature. Comments frequently praised the project and AI, with net users expressing the sentiment that Bangkok should have had this system long ago. Negative comments were rare and mostly unrelated to the project, often suggesting recommendations like creating one-way roads.

ATTACHMENT 1

QUESTIONNAIRE A: OFFICERS & RESSIDENTS

1. Socio Demographic

1.1 Gender: ☐ Male ☐ Female

1.2 Age: _____ Years

1.3 Occupation:
- ☐ Governmental officer
- ☐ Private company officer
- ☐ Freelance, part time job or private business
- ☐ Student
- ☐ House Wife/Husband
- ☐ Others (_____)

1.4 Consent for video record ☐ Yes ☐ No

2. Transport Information (Final mode: Officers)

2.1 Destination: _____ Company/Office

Address (filled by surveyor): _____ Soi/Station
_____ Sub-district
_____ District

2.2 Final transport mode (excluding non-motorized mode):
- ☐ Car (Driver)
- ☐ Car (Passenger)
- ☐ Taxi
- ☐ Bus/Van
- ☐ Motorcycle (private)
- ☐ Motorcycle (Passenger)
- ☐ Others (_____)

2.3 Origin: _____ Soi/Station
_____ Sub-district
_____ District

2.4 Origin for the final transportation mode (if respondent changes mode):
_____ Soi/Station
_____ Sub-district
_____ District

2.5 Travel time from origin to destination: From: _____ To: _____

2.6 Travel route:

2.6.1 Please draw your travel route in the Pilot Project area in the provided map

2.6.2 Signalized intersections you travel pass (filled by surveyor)

☐ 1st (Int. code: _____) ☐ 2nd (Int. code: _____)
☐ 3rd (Int. code: _____) ☐ 4th (Int. code: _____)
☐ 5th (Int. code: _____) ☐ 6th (Int. code: _____)

2.6.3 How many u-turn slot you travel pass (filled by surveyor)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Others (_____ loc.)

3. Transport Information (First mode: Residents)

3.1 Origin (Please mark on map): _____ Soi/Station
_____ Sub-district
_____ District

3.2 First transport mode (excluding non-motorized mode):

☐ Car (Driver)
☐ Car (Passenger)
☐ Taxi
☐ Bus/Van
☐ Motorcycle (private)
☐ Motorcycle (taxi)
☐ Others (_____)

3.3 Destination: _____ Soi/Station
_____ Sub-district
_____ District

3.4 Destination for the next transportation mode (if respondent changes mode):
_____ Soi/Station
_____ Sub-district
_____ District

3.5 Travel time from origin to destination: From: _____ To: _____

3.6 Travel route:

3.6.1 Please draw your travel route in the Pilot Project area in the provided map

3.6.2 Signalized intersections you travel pass (filled by surveyor)

☐ 1st (Int. code: _____) ☐ 2nd (Int. code: _____)
☐ 3rd (Int. code: _____) ☐ 4th (Int. code: _____)
☐ 5th (Int. code: _____) ☐ 6th (Int. code: _____)

3.6.3 How many u-turn slot you travel pass (filled by surveyor)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ Others (_____ loc.)

4. Experiences Before and After the Implementation of the ATC System in May 2023

4.1 Did you notice any changes in traffic light operation?
☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree
How: _____

4.2 Did you perceive coordination of green times along the traveled corridor?
☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree
How: _____

4.3 Are you satisfied with the new cycle of traffic signals and actuated green time?
☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree
How: _____

4.4 Did you feel the road safety improvement, including road markings and U-turn closures?
☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree
How:_____

4.5 Did you feel the reduction in queue length at intersections?
☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree
How: _____

4.6 Did you perceive a reduction in travel time in the pilot project area?
☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree
How: _____

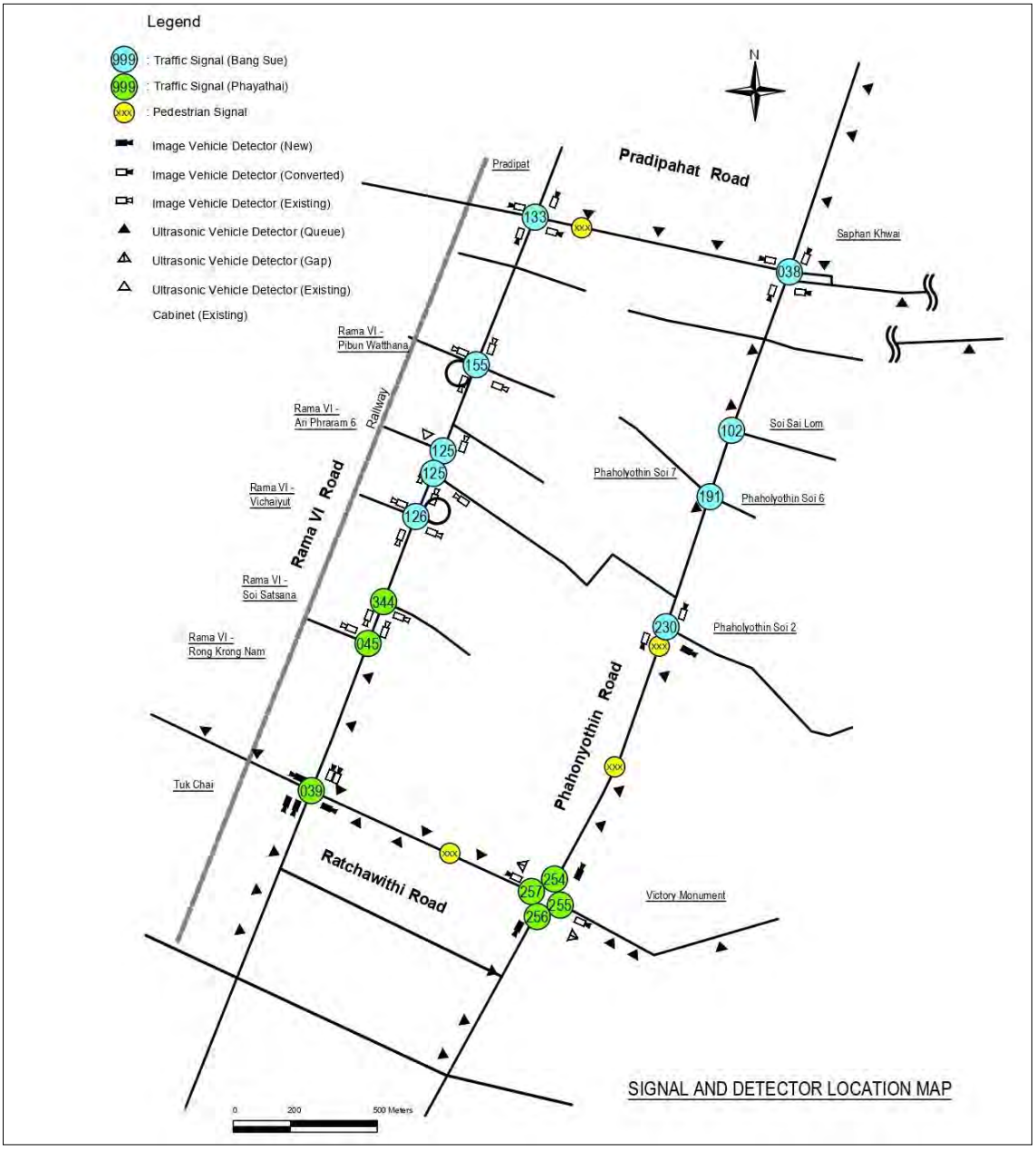


Figure for drawing the travel path

ATTACHMENT 2

QUESTIONNAIRE A: PLICE OFFICERS

1. Socio Demographic

1.1 Rank/Name: _____

1.2 Gender: ☐ Male ☐ Female

1.3 Age: _____ Years

1.4 Consent for video record ☐ Yes ☐ No

1.5 Degree of knowledge related to traffic engineer and ATC system

☐ Very Familiar ☐ Familiar ☐ Fair ☐ Slightly Unfamiliar ☐ Unfamiliar

2. Traffic Operation Assignment

2.1 Location: _____ Intersection (Int. code: _____)

2.2 Experience: _____Month _____ Year

2.3 The latest shift:

☐ Mon (From: _____ To: _____ (Total: _____ hr.)

☐ Tue (From: _____ To: _____ (Total: _____ hr.)

☐ Wed (From: _____ To: _____ (Total: _____ hr.)

☐ Thu (From: _____ To: _____ (Total: _____ hr.)

☐ Fri (From: _____ To: _____ (Total: _____ hr.)

☐ Sat (From: _____ To: _____ (Total: _____ hr.)

☐ Sun (From: _____ To: _____ (Total: _____ hr.)

3. Experiences before and after the implementation of the ATC system in May 2023

3.1 Did you feel about no longer manually operating traffic signals during peak hours?

☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree

How: _____

3.2 Did you feel about no longer manually operating traffic signals during off-peak hours?

☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree

How: _____

3.3 Did you feel you do not need to intervene manually the traffic signal operation after the ATC system implementation?

☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree

Reason: _____

3.4 Did you feel the traffic congestion improvement after the implementation of the ATC system?

☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree

How: _____

3.5 Did your role in traffic control change, and do you have more opportunities to focus on other tasks such as traffic violation enforcement?

☐ Strongly Agree ☐ Agree ☐ Undecide ☐ Disagree ☐ Strongly Disagree

How: _____

Annex 5

ATC System Operation Manual

ATC System Operation Manual (draft)

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1 General

1.1 Introduction

A model Area traffic control (ATC) system is being constructed under the JICA assisted project entitled “The Project for improving Traffic Congestions in Bangkok through the Establishment of Model Area Traffic Control System in the Kingdom of Thailand”, for which Traffic and Transportation Department (TTD), Bangkok Metropolitan Administration (BMA) is a counterpart of the project. As TTD is an organization responsible for installation and operation of traffic signal and associated equipment in Bangkok Metropolitan Area, TTD will also be in charge of operation and maintenance of the model ATC system.

The model ATC system covers a small rectangular area surrounded by Rama IV Road, Phaholyothin Road, Ratchawithi Road and Pradiphat Road in the central Bangkok, where 15 standard signals and 4 pedestrian signals are installed and controlled by the system. The center system is installed at BMA 2 compound located in Din Daeng.

The system is expected to expand and will cover the central business district (CBD) area in Bangkok in phased installation. It has been already agreed between BMA and Royal Thai Police (RTP) that when the system is expanded (Phase I system), the control center will be established in RTP and RTP will be in charge of system operation. The maintenance of the system will, however, remain the task of the BMA.

This operation manual has been prepared to provide a guidance for operating ATC system for both model system and the Phase I system. Timely understanding of the traffic condition and prompt action on the operation are required for the efficient and effective operation of ATC system regardless of the organization that operates the system.

1.2 Vision

The vision for establishing ATC system is set as “To create efficient and safe road traffic environment for all modes of transportation including pedestrians.”

1.3 Mission

The mission of the Traffic Control Center is 1) to monitor the traffic on the road network through vehicle detectors, CCTV cameras, and communication systems, 2) to apply signal timings most suitable for the prevailing traffic conditions, 3) to provide road users with the traffic condition and related information, 4) to act as command center in case of incident, abnormal traffic condition and at the time of disaster, and 5) ensure the safety of road users of any modes under both normal condition and in case of incident.

1.4 Definition of terms

The meaning of the terms in this manual shall be defined as follows:

(1) Traffic information

Traffic information is the information necessary for the safe and efficient passage of vehicles that is provided by the road administrator or traffic management organization to road users in accordance with the provisions of the Road Traffic Law.

(2) Traffic Obstruction Information

Information on traffic obstructions, which refers to the impossibility of passing, prohibition of passing, and restriction of passing on roads due to natural disasters, abnormal weather, traffic accidents, road construction, and other reasons.

(3) Road use event information

Information on the use of roads for the purposes other than traffic such as facility construction, work on roads, or the holding of events, etc.

(4) Traffic congestion information

Traffic congestion information refers to the Information on traffic congestion caused by excessive concentration of traffic, road construction, traffic accidents, bad weather condition, etc.

The criteria for level of congestion by road classification.

Table 1: Definition of Congestion (Example, to be setup)

Road classification	Speed for "light congestion"	Speed for “heavy congestion”
Suburban expressways and freeways	More than 40 km/h but 60 km/h or less	not more than 40 kilometers per hour
Urban expressways and freeways	More than 20 km/h but not more than 40 km/h	not more than 20 kilometers per hour
Other roads	More than 10 km/h but less than 20 km/h	10 kilometers per hour or less

(Note) "Suburbs" refers to areas outside of urban areas, and "urban areas" refers to areas that have formed or are expected to form urban areas.

(5) Area Traffic Control (ATC) System

The term "ATC system" refers to a system that undertakes integrated and systematic collection, analysis, and provision of traffic information, operation of traffic signals with the timing parameters suitable for prevailing traffic condition, provision of traffic information through various media, and issuance commands to police officers for regulating traffic.

(6) ATC System Facilities

ATC system facilities mean the devices, equipment, and other facilities including communication devices comprising ATC system.

(7) Traffic information provision facilities

Traffic information provision facilities mean the facilities that provide traffic information, such as radio and television broadcasting, newspapers, telephone inquiries, variable message signs, and web site.

2 Function and Services

The Bangkok ATC System Center (hereinafter referred to as the "ATC Center") shall perform the following tasks:

(1) Management and coordination of traffic flow.

(2) Gathering, analysis, and provision of traffic information to public.

(3) Control and operation of traffic control facilities

(4) Other matters related to traffic control.

3 Organizational setup

Different organizational setup is required for the ATC system operation. The pilot system will be operated by BMA as the center system is located in BMA2. When the coverage area of the system is expanded and the center system is relocated to RTP, RTP will be in charge of system operation, while BMA will take care of the maintenance.

3.1 Coverage area of pilot system

The pilot system operates the small number of equipment (local controller and vehicle detector) in the area as shown in Pilot Project System Location Map attached.

3.2 Organizational setup for system operation

The pilot ATC system will be operated and managed by BMA until the system is expanded and first phase system is completed. Upon completion of the first phase system, the system operation will be transferred to RTP, while maintenance of the system remains as BMA's responsibility.

BMA will be responsible for its operation and maintenance of the pilot ATC system. The organizational setup will be as shown in Figure 1. The pilot ATC system will operate without any staff stationed at the center except at the time of abnormal traffic as the number of signals under the system is small. Daily inspection and confirmation of normal operation through the human-machine interface (HMI) workstation will be undertaken by the Executive Engineer. Should any malfunction occur, the Executive Engineer will report the incident to his/her superior and appropriate action will be taken depending on the nature of the incident.

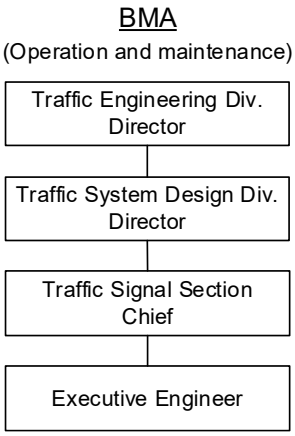


Figure 1: Operation and Maintenance Setup for Pilot Project

Once the system is expanded and more signals are added to the system under the Phase I system, responsibility of system operation will be transferred to RTP together with the relocation of the center system. The suitable number of staff will station at the center during the day time.

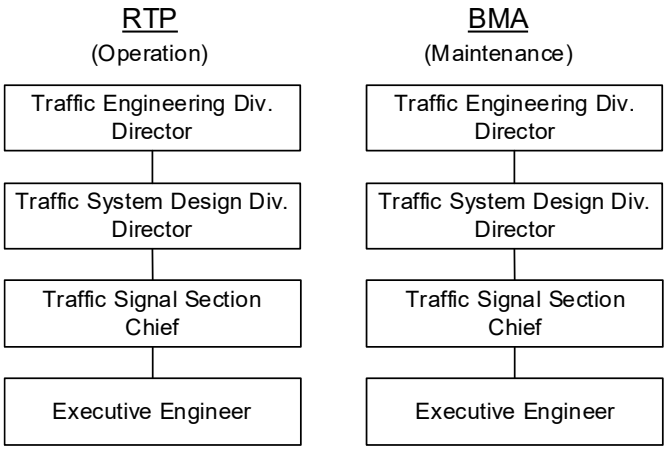


Figure 2: Operation and Maintenance Setup for Phase 1 system

3.3 Operational Improvement

Since the conditions of roads and traffic are constantly changing with time, it is necessary to constantly check and readjust the traffic signal phasing and timing parameters to ensure that they are appropriate for the traffic at any given time. For this reason, the person in charge of the operation of the system must proactively conduct periodic and systematic surveys and analyses of the system.

4 Collection of traffic information

One of the major tasks of ATC Center is the collection of traffic condition data and information. For this purpose, the following works must be carried out:

(1) The person in charge of operations is required to collect traffic information in a comprehensive manner by making effective use of traffic control facilities and by working closely with the traffic police at intersection, road administrators, and other relevant organizations.

(2) Internet application such as Google Maps, Apple Maps, TSquare Traffic[1] can be a source of traffic condition information.

(3) The person in charge of operations shall analyze and organize the collected traffic information for effective use as traffic management data.

5 Reporting of Traffic Information

5.1 Reporting and notification of traffic information

(1) When it is recognized that a traffic hazard or traffic jam has occurred or is likely to occur, or when a road is used for the purpose other than traffic, the Chief of District Police, etc. shall promptly report it to the person in charge of the operation by using the Traffic Information Report Form (Appendix Form 1) in accordance with the Traffic Information Reporting Standards (Table 4) and also report to the head of the relevant department. However, if the situation is urgent, the report may be made by telephone, SMS or other means.

(2) In the event that a traffic hazard or traffic jam has occurred or is likely to occur, and intervention deems necessary, the police officer shall take necessary measures

[1] https://tsquare.rtic-thai.info/en/home-2/

such as measures to ease congestion or prevent danger, and then promptly report the situation to the person in charge of the operation and the head of the relevant department.

5.2 Instructions by the person in charge of operations

(1) The person in charge of operations shall take necessary measures to eliminate traffic disturbances or traffic congestion, if deemed necessary, in response to the report mentioned in 5.1 above. In this case, if it is deemed urgent, he or she may directly instruct the police officer assigned to the scene to take necessary measures such as traffic control and manual operation of traffic signals.

(2) When the person in charge of operations directly instructs a police officer assigned to the scene to take the necessary measures described in (1) above, he or she shall promptly notify the head of the relevant department of the details.

6 Provision of Traffic Information

6.1 Provision of traffic information

(1) The person in charge of operation shall analyze and organize the collected traffic information, and if it is deemed necessary, shall provide accurate and appropriate traffic information by actively operating traffic information facilities.

(2) The person in charge of the operation shall work closely with road administrators to coordinate traffic information with road information, and provide traffic information to the media and other related organizations.

(3) The person in charge of the operation shall endeavor to provide accurate and appropriate traffic information in response to inquiries about traffic information.

6.2 Operation of the Traffic Information Facility

(1) The operation of the traffic information facilities shall be performed by the person in charge of the operation.

(2) The chief of police, etc. shall request the person in charge of the operation when it is deemed necessary to display something different from the normal display on the traffic information board for special reasons.

(3) When the person in charge of the operation receives the request as described in (2) above, the person in charge of the operation shall display the information on the traffic information board according to the request, if it is deemed necessary.

7 Guidelines for Employees

ATC Center staff shall pay attention to the following matters to ensure proper work:

(1) To accurately grasp the road conditions and traffic volume in and around the area under jurisdiction, and to take effective measures to relieve traffic congestion.

(2) To collect and provide accurate road traffic information without failing, verify and confirm normal operation of the ATC system functions.

(3) To be proficient in the operation of ATC system equipment and to make efforts to improve their skills.

(4) Handle the various devices in the ATC center with care and make efforts to maintain their functions.

8 ATC Center Work System

8.1 Service System

The employees working at the ATC Center (hereinafter referred to as "employees") shall be assigned to regular or shift work.

8.2 Working hours

The working hours of personnel on regular duty shall be ___ hours and ___ minutes per week, and those on shift duty shall be ___ hours and ___ minutes per week, averaged over 3 weeks.

8.3 Allocation of Working Hours (Example)

The following table shall apply to the allocation of working hours, etc. for employees.

Table 2 Allocation of working hours (Example)

Items / Shift		Working hours	Working time		Rest time
			Start time	End time	
Regular shift		7 hours 45 minutes	8:30 a.m.	5:15 p.m.	1 hour
Shift work	Duty day	15 hours 30 minutes	8:30 a.m.	8:30 a.m. Next day	8 hours 30 minutes
	Day shift day	7 hours 45 minutes	8:30 a.m.	5:15 p.m.	1 hour

Notwithstanding the above, the person in charge of operations may change the start and end times of work when necessary.

8.4 Assignment of shift work (Example)

Shift work shall be divided into on-duty, off-duty, and day shifts, and shall be assigned as follows:

Table 3: Shift Schedule (Example)

Week		Week 1									Week 2						Week 3					
Day		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	A		S	D		W	D		W	D		W	D		W	D		W	D		W	D
	B		W	D		S	D		W	D		W	D		W	D		W	D		W	D
	C	D		W	D		W	D		S	D		W	D		W	D		W	D		
	D	D		W	D		W	D		W	D		S	D		W	D		W	D		
	E	W	D		W	D		W	D		W	D		W	D		S	D		W	D	
	F	W	D		W	D		W	D		W	D		W	D		W	D		S	D	

Legend: D: Duty day, Blank: off-duty, W: weekly day off, S: day shift day

8.5 Work Plan

The operation manager shall develop a work plan and give instructions to the employees.

Table 4: Traffic Information Reporting (Notification) Criteria

Type of information	Reporting (notification) criteria	Reporting destination
Traffic obstruction information	- when a total traffic ban is implemented - When two-way traffic, alternating one-way traffic, or lane restrictions are required. - When traffic is prohibited or restricted except for emergency vehicles due to disasters, etc. - When prohibiting or restricting the passage of vehicles other than those under guard or protection.	Superintendent of the concerned police station and road administrator
Road use information	- In the event that construction work, etc., is to be carried out that will result in a total prohibition of traffic (including prohibition of traffic on one side of a separated section). - In the case of construction work that requires two-way traffic, alternating one-way traffic, or lane restrictions, and congestion or traffic jams of two kilometers or more are expected to occur.	
Traffic congestion information	- When traffic congestion of two kilometers or more occurs or is expected to occur. - other cases in which the cause or form of the traffic jam is unique and is expected to have a large social impact	

Form No. 1

Day: _____ Month: _____ Year: _____

Attention:

Head of Police Station

Traffic Information Report

Information Type	☐ Traffic obstruction ☐ Road use ☐ Traffic congestion				
Date and time of occurrence (period)	From: ____ day _____ month ____ Year, (Dow) _____ hour _____minute Until: ____ day _____ month ____ Year, (Dow) _____ hour _____minute				
Location (section)	Road type	☐ Expressway ☐ National road ☐ Prefectural road ☐ Others			
	Route Name: Route (direction).				
Regulation details	Start	___ mon. __ day __hr. __ min	Duration	____ Hr. ___ min	
	End	___ mon. __ day __hr. __ min			
Cause, contents, etc.					
Detour	Yes/No	Route name	Road		
Requested actions					
Reference					

Reference:

ATC Center Activity Daily Report

Month ____ Day ___ Year ____, Weather ____

Person in charge

Duty	Rank	Name
Day time		
Day time		
Day time		

Duty	Rank	Name
Day time		
Day time		
Day time		

Traffic information collection

Police		No. of cases
Road administrator	National	
	Provincial	
	City	
Fire station		

Traffic information provision

Police		No. of cases
Road administrator	National	
	Provincial	
	City	
Fire station		
Telephone inquiry	General public	
	In-house	
	Others	
Broadcasting station	TV	
	Radio	

Defect

Malfunction	Signal	
	Camera	
	Signboard	
Damage	Signal	
	Camera	
	Signboard	

Abnormal Event

Outline	Response
1. Traffic accident Time of occurrence: Location: Outline of accident:	- Inform TV station and radio station - Instruct police at site to report the congestion situation timely

Road Obstruction Report

Seq.	Time	Location	Event	Congestion	Remarks
1.	14:00-17:00 One lane closure	__ road, eastbound ___ intersection	Road construction	EB: 0.6 km	
2.	11:00 – 12:00 One lane closure	__ road, eastbound ___ int. - ___ int	Demonstration	NB: 1.0 km SB: 0.3 km	

Items to be hand-over

Other matters

Pilot Project System Location Map

Annex 6

Signal Timing Adjustment Procedure

Signal Timing Adjustment Procedure (Draft)

1. Introduction

Signal timing adjustment procedure is developed based on the practices used in Bangkok. Since signals are often operated manually in Bangkok, it is not appropriate to apply the same signal timing adjustment procedure adopted in Japan, where manual control is rarely applied. Signal adjustment procedure for Bangkok is prepared taking into account the manual signal operation.

2. Signal Operation Issues

Automatic control is commonly applied at the large cities in Japan and other developed countries where many signals must operate in coordination each other. Manual control is applied only at the time of exceptional situation like event or accident. Under automatic control, signal parameters are adjusted within a certain range. As a result, pattern and degree of traffic conditions are generally similar every day. Because of the similarity of daily traffic conditions, it is easy to identify change in traffic pattern and problems in signal operation.

In Bangkok, the parameters change frequently and irregularly due to manual control, making it difficult to determine whether traffic congestion is caused by the problem at the intersection operating in manual control, or by the signal operation at an adjacent intersection. Such situation makes it difficult to identify the true cause of congestion, not to mention the improvement measures.

3. Signal Timing Adjustment Procedure

The general procedure of signal timing adjustment is shown below. It takes the steps of issue identification, new signal timing development, new signal timing implementation, and review and evaluation of effectiveness. If the new timing implemented is judged not as effective as expected, different timing parameters will be developed and implemented.

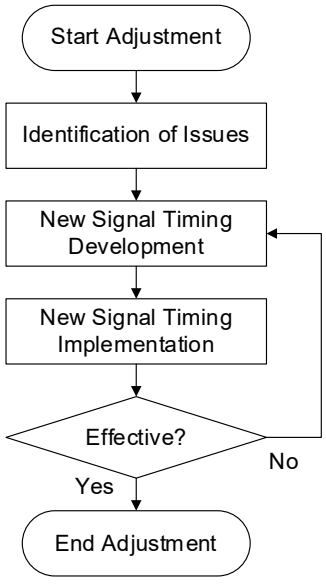


Figure 1 Signal Timing Adjustment Procedure

4. Proposed Signal timing adjustment procedure in Bangkok

Because manual control is frequently implemented to handle the prevailing traffic situation In Bangkok, it is difficult to identify fundamental issues that cause congestion. In addition, since the signal timing parameters under manual control varies significantly and without any pattern, same operation cannot be repeated under manual control. For this reason, it is not possible to verify the effectiveness of the manual operation implemented.

The timing parameter adjustment procedure that takes frequent manual control in Bangkok into consideration is proposed below.

(1) Define clearly the objective of manual control

Specify the traffic flow that should be prioritized at intersection during the morning and evening peak hours when the intersection is saturated or nearly saturated. The acceptable range of congestion must also be defined. This control policy should be applied consistently regardless of whether manual or automatic control is adopted.

(2) Identify the problems of the timing parameter under automatic control as compared with the timing parameters applied under manual control operations

Case 1: Longer green time is applied to the main road by manual control

Issue: Green time under automatic control is not long enough to accommodate demand and congestion worsens.

Solution: Increase green time for main road under automatic control

Case 2: Shorter green time is given to the secondary road by manual control as compared with automatic control.

Issue: Because there is excessive green time for the secondary roads under automatic control.

Solution: Decrease the split for the secondary road

Manual control is used not only to make up for the inefficiency of signal operation but also to identify the issues associated with automatic control. At the same time, it provides bases to improve automatic control.

(3) Feedback manual control results to automatic control

In order to improve the efficiency of automatic control, the review results of manual control must be reflected to the parameters used by automatic control. The time when automatic control is applied must be gradually extended replacing manual control. To achieve this, it is necessary to record and analyze the manual control timing parameters.

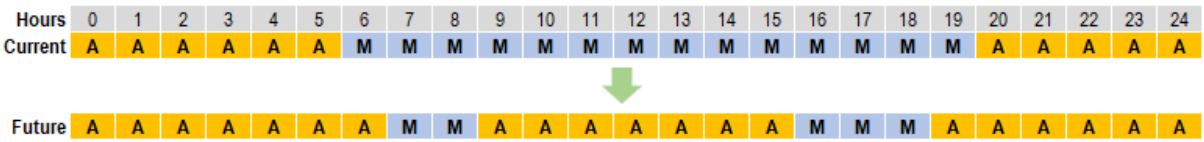


Figure 2 Transition to Automatic Control (image)

5. Additional Note for Signal Timing Parameter

In preparing timing parameter, consideration must be given to the following:

(1) When traffic demand exceeds traffic capacity, congestion cannot be avoided. Signal operation under such circumstances should be made in such a way that congestion on all approaches is balanced.

(2) Signal timing parameters are designed based on hourly traffic volume. Thus, there would be a case of too long or too short green time due to variation of traffic volume. It is necessary to observe the traffic condition for at least several cycles before judging the adequacy of the cycle time.

Annex 7

Study Result of Utilization of Image Processing Technology for Traffic Volume Count in Bangkok

Study on Utilization of Image Processing Technology for Traffic Volume Count in Bangkok

1. Objective

Image processing technology has been increasingly utilized for traffic management in recent years. Numerous software applications employing image processing technology for traffic volume counting have been developed.

Victory Monument Roundabout (VMR) is included in the pilot project area where the ATC system has been introduced. VMR is a large-scale roundabout with a 200 m diameter, and it is difficult to count directional traffic volume manually. Traffic volume data is necessary for parameter setting for traffic lights at intersections and traffic management and planning. However, BMA does not have traffic volume data for most of the intersections and the roads in Bangkok. On the other hand, closed-circuit television (CCTV) cameras have been installed at many intersections and road sections in Bangkok, and the data from the cameras are sent to the control center in BMA and RTP for monitoring purposes.

Under this situation, the project team carried out a study on the utilization of image processing technology for traffic volume counting at VMR, and other intersections and road sections in Bangkok.

2. Outline of the Study

This study is composed with following 3 items.

1) Verification study on directional traffic volume count at VMR using image processing technology
2) Utilization of the Image Processing Analysis Technology in Bangkok
3) Establishment of Traffic Data Collection System in Bangkok

3. Verification Study on Directional Traffic Volume Count at VMR Using Image Processing Technology

3.1. Flow of the Study

Some cased of traffic flow at VMR were recorded by a video camera as the first step. A prototype AI software was used to analyze recorded movies to count directional traffic volume at VMR as the second step. Directional traffic volume obtained through image processing analysis and manual count was then compared to verify the accuracy of the image processing analysis result as the third step.

Step 1: Video record at VMR

Step 2: Image processing analysis using AI software

Step 3: Comparison of directional traffic volume between the image processing analysis and

manual count

3.2. Video Record and Analysis Cases

A toll building of Rajvithi Hospital is located on the west side of VMR, and movies of traffic flow in VMR were recorded from the building by a camera.

The accuracy of image processing analysis is affected by weather condition and brightness. Therefor, following 10 cases of traffic flow were recorded by camera and analyzed. Traffic flow of three type of vehicles, car, large vehicle and motorcycle, were recorded. The video recording was conducted in June 2021.

Table 3.1 Cases for Analysis

	Morning	Day Time	Evening	Night
Sunny	MS	DS	ES	NS
Cloudy	MC		EC	NC
Rainy	MR		ER	NR

Figure 3.1 Location of Camera for Video Record

3.3. Evaluation Indicators

Two indicators, the identification of vehicles and the tracking of vehicles, were used to evaluate accuracy of traffic count using image processing technology.

Table 3.2 Evaluation Items

Indicator	Description
Vehicle Identification	The image processing analysis software identifies vehicles and assigns an ID number to each vehicle. The number of identified vehicles by the software was compared with the number of manually counted vehicles.
Vehicle Tracking	The identified vehicles are tracked from an entry leg to an exit leg. The number of tracked vehicles within the identified vehicles were counted.

3.4. Evaluation Result

Two indicators of the vehicle identification and the vehicle tracking were used to evaluate accuracy of traffic count using image processing technology.

The vehicle identification functioned well during the daytime but was not effective during the night due to lower brightness. The vehicle tracking functioned effectively, although some vehicles at the upper and left sides of the monitor were not tracked due to their small size in the recorded footage.

A summary of the evaluation results and the evaluation result of each case are shown below.

Table 3.3 Evaluation Result

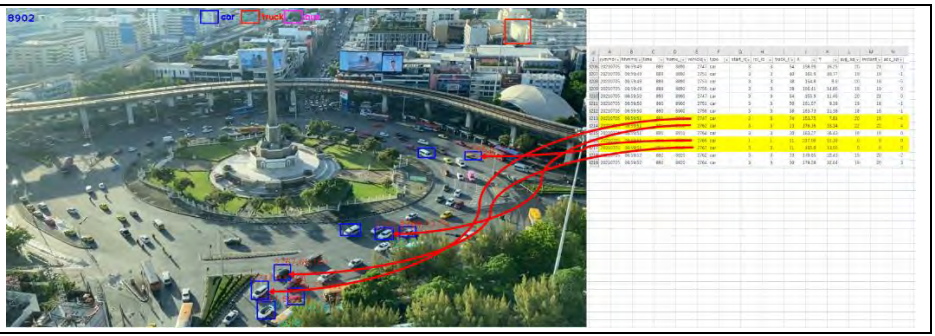
	Morning	Day Time	Evening	Night
Sunny	I: Average T: Good	I: Good T: Good	I: Good T: Good	I: Poor T: Poor
Cloudy	I: Good T: Good		I: Good T: Good	I: Poor T: Poor
Rainy	I: Average T: Good		I: Average T: Good	I: Poor T: Poor

Notte: “I” means the vehicle identification, “T” means the vehicle tracking

(1) Morning Sunny (MS)

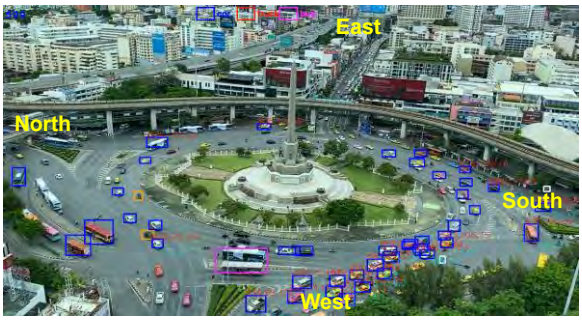
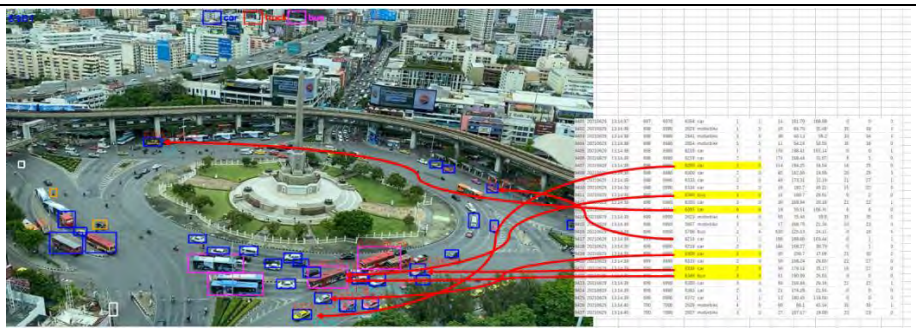
- Vehicles at the south and west leg were identified. Only few percentages of vehicles were identified at the east and north leg due to sunlight from a low position.
- The majority of identified vehicles were successfully tracked.

Identification	

Tracking	

(2) Daytime Sunny (DS)

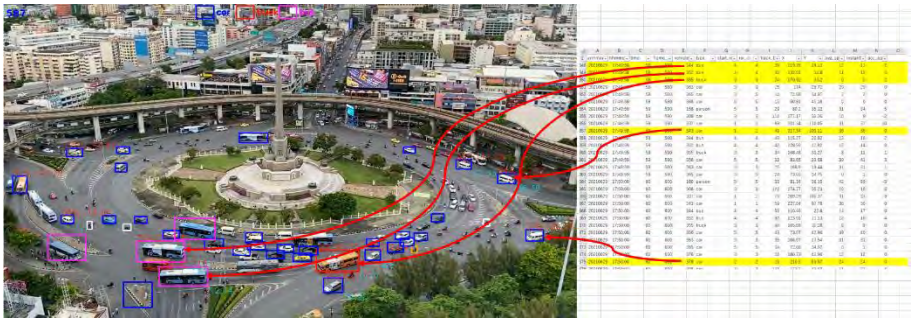
- The majority of vehicles were identified. Some vehicles at the north and east leg were not identified.
- The majority of identified vehicles were successfully tracked.

Identification	
Tracking	

(3) Evening Sunny (ES)

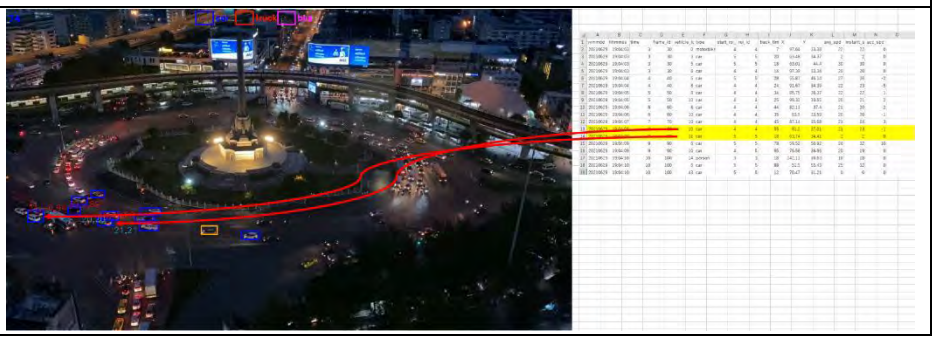
- The majority of vehicles were identified. Some vehicles at the north and east leg were not identified.
- The majority of identified vehicles were successfully tracked.

Identification	

Tracking	

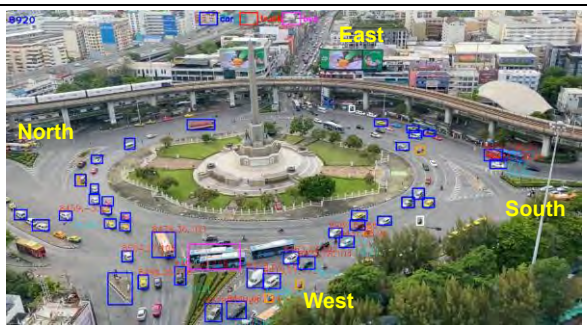
(4) Night Sunny (NS)

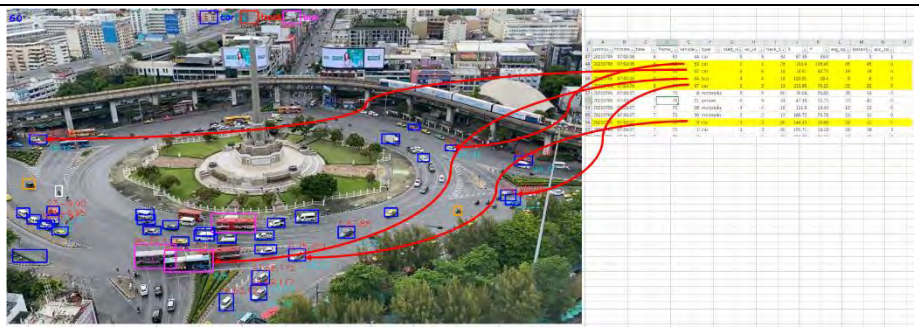
- The majority of vehicles were not identified due to low brightness, except for some vehicles at the north leg.
- The majority of identified vehicles were not tracked due to low brightness.

Identification	
Tracking	

(5) Morning Cloudy (MC)

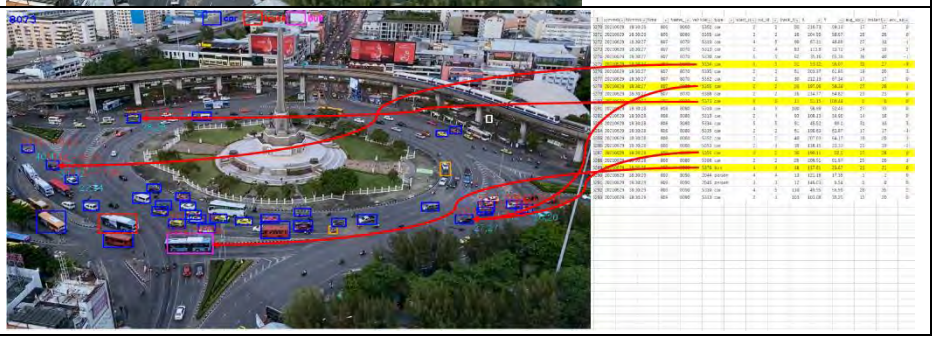
- The majority of vehicles were identified. Some vehicles at the north and east leg were not identified.
- The majority of identified vehicles were successfully tracked.

Identification	

Tracking	

(6) Evening Cloudy (EC)

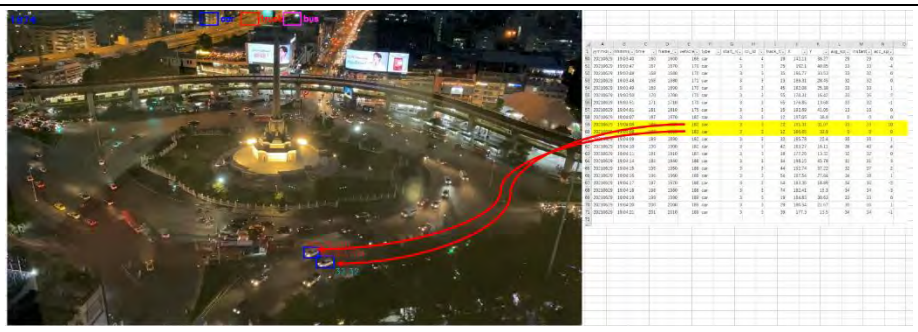
- The majority of vehicles were identified. Some vehicles at the north and east leg were not identified.
- The majority of identified vehicles were successfully tracked.

Identification	
Tracking	

(7) Night Cloudy (NC)

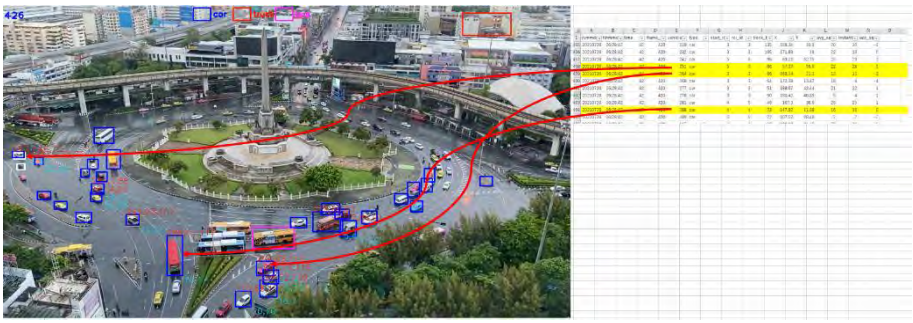
- The majority of vehicles were not identified due to low brightness, except for some vehicles at the west leg.
- The majority of identified vehicles were not tracked due to low brightness.

Identification	

Tracking	

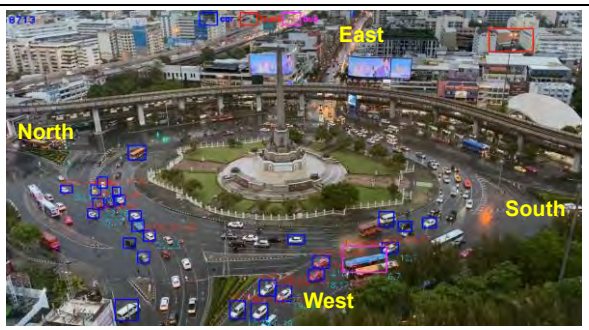
(8) Morning Rainy (MR)

- Vehicles at the south and west legs, as well as vehicles exiting to the north leg, were identified. However, some vehicles at the east leg and some vehicles entering from the north leg were not identified.
- The majority of identified vehicles were successfully tracked.

Identification	
Tracking	

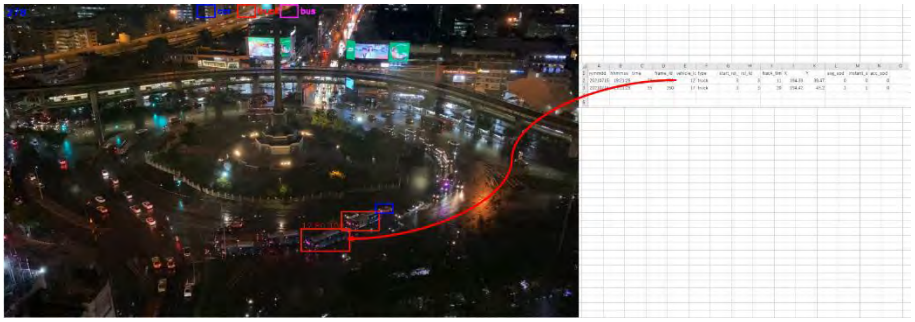
(9) Evening Rainy (ER)

- Vehicles at the south and west leg, as well as vehicles exiting to the north leg were identified. However, some vehicles at the east leg and some vehicles entering from the north leg were not identified.
- The majority of identified vehicles were successfully tracked.

Identification	
Tracking	

(10) Night Rainy (NR)

- The majority of all vehicles were not identified due to low brightness.
- The majority of identified vehicles were not tracked due to low brightness.

Identification	
Tracking	

(11) Vehicle Identification Rate

The vehicle identification rate was studied by comparing the number of identified vehicles by the software with the manual count in a sunny daytime case. There is room for improvement in the identification of large vehicles and motorcycles; however, this low accuracy is caused by the angle of the camera. Since VMR is a large-scale roundabout and most vehicles are recorded at a very small size, accuracy tends to decrease. On the other

hand, the accuracy of the identification of passenger cars is high, and passenger cars constitute the majority of vehicles.

Table 3.4 Vehicle Identification Rate

Type of Vehicle	Manual (a)	Software (b)	Rate (= b / a)
Passenger Car	419	401	95.7%
Large Vehicle	14	41	292.8%
Motorcycle	300	105	35%

4. Utilization of the Image Processing Analysis Technology in Bangkok

4.1. Challenges

Traffic volume count data can be used for traffic management and traffic planning. However, the Bangkok Metropolitan Administration (BMA) has been conducting traffic volume counts only on some roads in Bangkok annually. There is a significant number of CCTV cameras on roads in Bangkok, primarily used for monitoring. If the BMA collects traffic volume count data using CCTV cameras and AI software, it will assist the BMA in mitigating traffic congestion in Bangkok.

4.2. Conditions for Traffic Volume Count by CCTV Cameras

It is assumed that various types of CCTV cameras have been used in Bangkok, and the camera angles also vary by location. The necessary conditions for traffic counting using CCTV cameras are outlined below.

(1) Specification of Cameras

It is recommended to create specifications for CCTV cameras and establish a standardized framework. Examples of specifications are provided below.

- Hardware (night vision, PTZ control, etc.)
- Shooting (resolution, bit rate, frame rate, etc.)
- Stream (H.264-TS/TTS, MPEG2-PS, etc.)
- Security
- Network (video transmission method from the field the center)

(2) Setting of Cameras

The detected area, height, angle, and other parameters should be verified before the cameras are set.

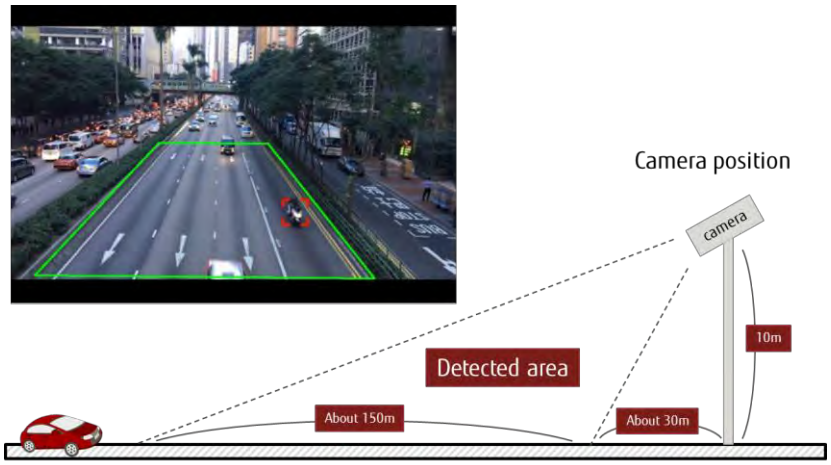
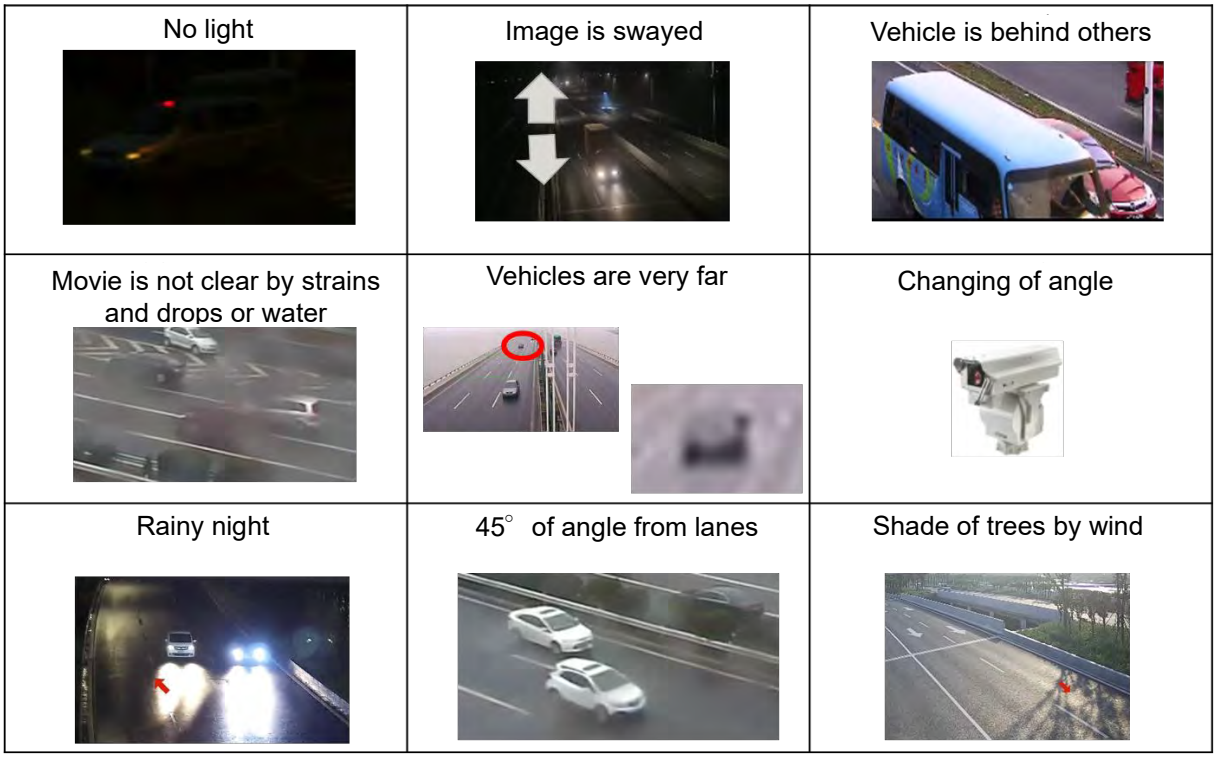


Figure 4.1 Check Point for Setting of Cameras

Cameras should not be placed in the following situations.



Images from existing cameras provided by BMA were assessed for their suitability for traffic counting, as demonstrated below.

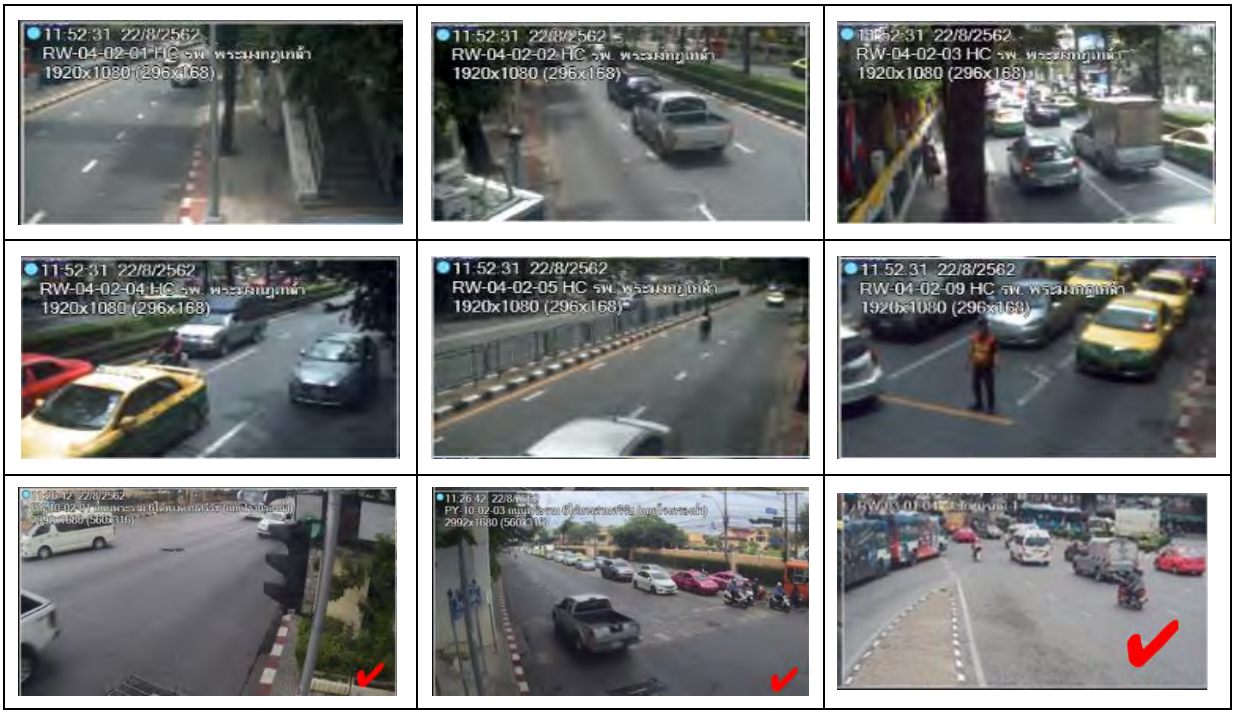


Figure 4.2 Available Angle of Image

Limited view range

Limited view range

Limited view range

Limited view range

Obstacle of view

Obstacle of view

Not face to the road

Not face to the road

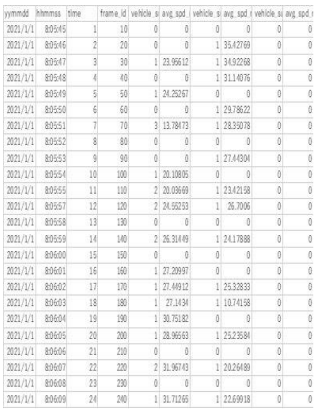
Obstacle of view

Figure 4.2 Unavailable Angle of Image

4.3. Utilization of Image Processing Technology

The following data can be collected using CCTV cameras and AI software. The data is exported in text format.

- Number of vehicles
- Average travel speed
- Sudden deceleration
- Over speeding vehicle
- Lane change
- Traffic situation such as congestion



yymmdd	hhmmss	time	frame_id	vehicle_si	avg_spd_i	vehicle_si	avg_spd_i	vehicle_si	avg_spd_i
2021/1/1	80545	1	10	0	0	0	0	0	0
2021/1/1	80546	2	20	0	0	1	35.42769	0	0
2021/1/1	80547	3	30	1	23.99512	1	34.92268	0	0
2021/1/1	80548	4	40	0	0	1	31.14076	0	0
2021/1/1	80549	5	50	1	24.25267	0	0	0	0
2021/1/1	80550	6	60	0	0	1	29.78622	0	0
2021/1/1	80551	7	70	3	13.78473	1	28.35078	0	0
2021/1/1	80552	8	80	0	0	0	0	0	0
2021/1/1	80553	9	90	0	0	1	27.44304	0	0
2021/1/1	80554	10	100	1	20.10805	0	0	0	0
2021/1/1	80555	11	110	2	20.03649	1	23.42158	0	0
2021/1/1	80557	12	120	2	24.55253	1	26.7006	0	0
2021/1/1	80558	13	130	0	0	0	0	0	0
2021/1/1	80559	14	140	2	26.31449	1	24.17888	0	0
2021/1/1	80600	15	150	0	0	0	0	0	0
2021/1/1	80601	16	160	1	27.29997	0	0	0	0
2021/1/1	80602	17	170	1	27.44912	1	25.32833	0	0
2021/1/1	80603	18	180	1	27.1434	1	10.74198	0	0
2021/1/1	80604	19	190	1	30.75182	0	0	0	0
2021/1/1	80605	20	200	1	28.96563	1	25.23584	0	0
2021/1/1	80606	21	210	0	0	0	0	0	0
2021/1/1	80607	22	220	2	31.96743	1	20.26489	0	0
2021/1/1	80608	23	230	0	0	0	0	0	0
2021/1/1	80609	24	240	1	31.71265	1	22.69918	0	0

The collected data can be utilized for traffic management and planning purposes.

Figure 4.3 Image of Utilization of the Data

5. Establishment of Traffic Data Collection System in Bangkok

Following data shall be collected to make traffic planning and traffic management in BMA.

Table 5.1 Proposed Items which Shall be Collected

Item	Outline
Traffic Volume Count	Traffic volume count by type of vehicles by 5 min interval. This data is used for traffic management and road planning.
Travel Speed	Average travel speed on target sections. This data is able to show congestion situation and it will be utilized to make countermeasures to mitigate congestion.
Vehicle Trajectory	Vehicle trajectory on target sections. This data is able to show vehicle position in the road section. Risks of traffic accident are able to be identified.

Proposed system structure is shown in below.

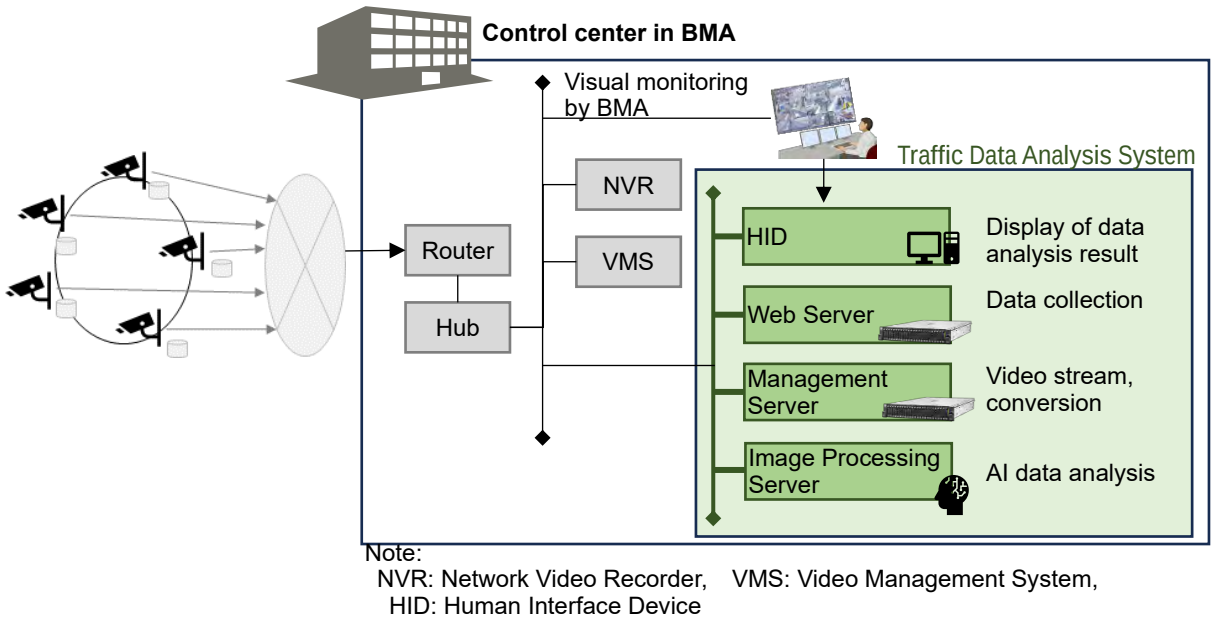


Figure 5.1 Proposed System Structure for Traffic Data Analysis in BMA

Annex 8

ATC System Maintenance Manual

ATC System Maintenance Manual (Draft)

ATC System Maintenance Manual (Draft) 1
1 Purpose 2
2 Definition of Terms 2
2.1 Traffic signals and associated equipment 2
2.2 ATC system equipment 2
3 Person in charge of management... Who is legally in charge? 2
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7.4 Special Inspection 6
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1 Purpose

The purpose of this manual is to provide the necessary information for the proper management of traffic signals and related equipment.

The purpose of maintenance is to prevent failures from occurring, and to restore functionality as soon as possible.

To prevent failures, it is important to consider the reliability of the equipment at the design, manufacturing, and construction stages, and at the same time, statistical analysis of failures should be fed back to improve equipment, construction methods, and materials. Periodic inspections are necessary to prevent breakdowns from occurring, and the inspection cycle, items to be inspected, and inspection methods must be specified and planned. In the event of a malfunction, it is important that police officers first take measures such as traffic control at the scene, and in parallel, repair the malfunction as soon as possible.

2 Definition of Terms

The terms used in this manual have the following meanings.

2.1 Traffic signals and associated equipment

Traffic signals, and ATC system equipment (as defined in Road Traffic Law?)

2.2 ATC system equipment

ATC System Equipment refers to the equipment at ATC Control Center such as server, workstation, wall map, disk storage, and other equipment comprising the central system, and the terminal equipment such as vehicle detectors, CCTV cameras, and traffic information boards.

In the draft the organization following organization is assumed:

Manager (in charge of management)

|_ Director (in charge of management) ___ Staff

|_ Manager (in charge) Person in charge ___ Staff

3 Person in charge of management... **Who is legally in charge**?

(1) A Manager shall be responsible for the management of ATC System management.

(2) The person responsible for the management of the ATC system shall be (position).

(3) The person in charge of the management of traffic signals, etc. shall handle general administrative work for the proper maintenance and management of traffic signals, etc.

(4) The person in charge of management shall organize, store, and utilize the ledger of each signal equipment created by the BMA at the time of installation of traffic signals.

4 Person in charge of management

(1) A person in charge of management shall be appointed in ____ office (section).

(2) The person in charge of management shall be the head of the ____ office (section).

(3) The staff in charge of management shall assist the manager in charge of management and handle administrative work related to the management of traffic signals, etc. in the area under his/her jurisdiction.

(4) When the person in charge of management recognizes the necessity of relocating or improving traffic signals, he or she shall investigate the current situation and report it to the person in charge of management.

5 Maintenance work and management system

5.1 Type of maintenance works

Maintenance work is not only the repair of defective part, it involves other works as illustrated in Figure 1. Preventive Maintenance is carried out at a regular interval to confirm the normal operation of the equipment, while corrective maintenance and accident repair are the works to be done when any trouble or irregularity is found in the operation of the system. The difference between corrective maintenance and system modification is that the former is applied to the malfunction caused by wear and tear, abnormal environmental condition, and act of God, for which no one is responsible. Accident repair is the case that an equipment or part of it is damaged by the traffic accident or other act by a third party. Repair work is required for these cases and, in the case of accident repair, the cost of repair is to be paid by the person or party who caused the damage.

It is noted that the contractor or supplier of the equipment that becomes defective is not responsible for the defect after the defect liability period has been expired.

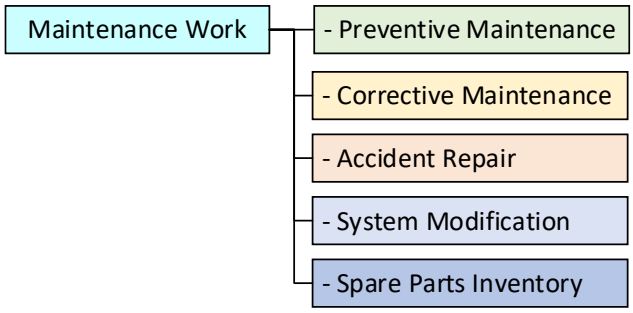
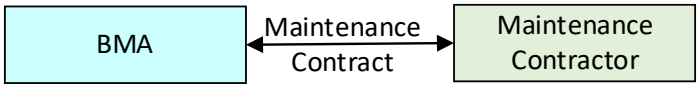


Figure 1: Components of Maintenance Work

5.2 Role sharing between BMA and Maintenance Contractor

Although Royal Thai Police is in charge of operation of ATC system, Traffic Engineering Division (to be confirmed) is responsible for the maintenance of the system. It is recommended to hire a maintenance contractor who carries out actual maintenance works, while Maintenance work is managed and supervised by TED. The works to be carried out by two parties are illustrated as shown in .



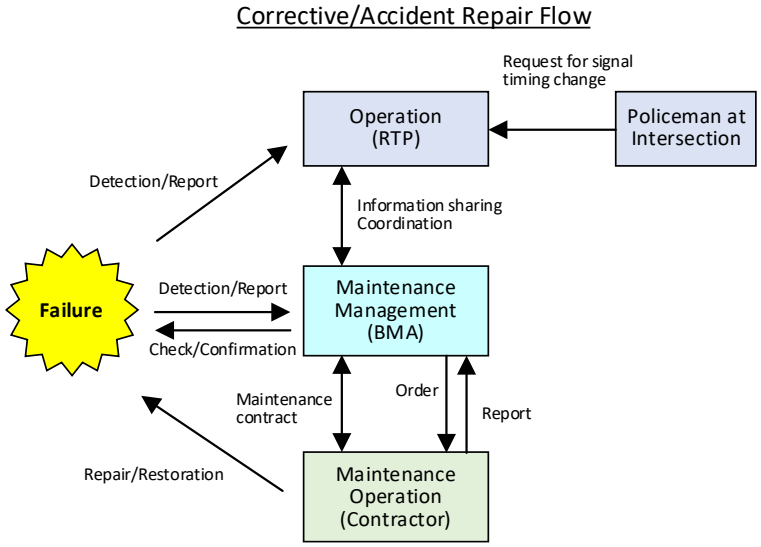
Maintenance management
- Maintenance planning
- Budgeting and accounting
- Maintenance work supervision
- Quality and reliability analysis

Maintenance execution
- Inspection and checking
- Defect / damage repair
- Minor modification
- Spare part inventory

Figure 2 Role Sharing between BMA and Maintenance Contractor

5.3 Corrective/Accident Repair

Maintenance and management of traffic signals, etc. shall be carried out in cooperation with related organizations. Each organization will have the tasks assigned to them.



5.4 Work system

(To be confirmed) Should be considered after confirming the details of the work system and maintenance contract

6 Proper management

6.1 Responsibility

The person in charge of the management of traffic signals, etc. shall ensure that the person in charge of the management of traffic signals, etc. is always aware of the condition of the traffic signals, etc., so that the effectiveness of the traffic signals, etc. is not impaired due to damage, failure, or other reasons.

6.2 Monitoring

The person in charge of management shall always monitor the actual traffic conditions, and if the signal cycle, etc., does not conform to the actual traffic conditions, he/she shall work with the traffic police (RTP) and other related organizations to make improvements as soon as possible.

6.3 Inspection

The person in charge of management shall periodically patrol traffic signals, etc. in the area under his/her jurisdiction at least once a year and conduct a comprehensive inspection of visibility, damage to pillars, locking of control devices, etc., based on the Inspection Points for Traffic Signals, etc. (Appendix Form No. 0).

6.4 Special inspection

The person in charge of management shall conduct a special inspection in the following cases. In this case, the special inspection shall be conducted based on the inspection points for traffic signals, etc.

(1) When a lightning strike, windstorm, flood, or other disaster occurs and it is deemed necessary

(2) When the person in charge of management deems it necessary.

7 Inspections by contractors

In order to ensure appropriate maintenance and management of traffic signals, etc., the person in charge shall entrust the following inspections, etc. to traffic signal maintenance companies.

(Confirmation) In Japan, it is common to contract with different companies for central maintenance and terminal maintenance.

7.1 Daily inspection (system check): Inspection by center staff

Control center (ATC system center): Check for abnormalities in ATC system equipment based on information obtained from the control center (ATC system center?), and perform based on a checklist. If any abnormality or preventive measures are judged to be necessary, report to the person in charge of management and ask for instructions.

Inspection method	Inspection	Frequency
Status Monitoring through HMI	central equipment status	3 times/day
	Signal Status	3 times/day
	Vehicle Detector Status	3 times/day
Report Outputs through HMI	Local controller malfunction daily report	Once a day
	Abnormal traffic data daily report	Once a day
	Detector malfunction daily report	Once a day
	Center unit event daily report	Once a day

7.2 Periodic Inspection

Periodic inspection refers to such periodical works like inspection, cleaning, and replacement of parts that have operating life to maintain the functions of ATC system equipment. Detailed inspections should be conducted in detail that cannot be confirmed in daily inspections. If

preventive measures are judged necessary as a result of the inspection, replacement of maintenance materials, electrical or mechanical adjustment, or rework shall be performed.

Method	Items inspected	Frequency
Detailed inspection	Control center system equipment	4 times / year
	Field equipment	4 times / year
Report output by system	Local controller malfunction monthly report	4 times / year
	Abnormal traffic data monthly report	4 times / year

(notes) Inspection schedule must be set according to actual conditions in Bangkok

Details of inspection items and method are under preparation

7.3 Temporary Maintenance

Regardless of the cause of the failure, the ATC system equipment shall be repaired and the operational constants shall be modified in the event of a failure or a possible failure.

Only for damage that occurs between 5:15 p.m. on weekdays and 8:30 a.m. on the following day, or on Saturdays, Sundays, or holidays, the system operator shall visit the site to investigate the damage and report on it. If simple restoration is possible, it will be carried out based on instructions.

(Confirmation) Review will be made when working hours and staff are defined.

7.4 Special Inspection

Special inspections shall be conducted when the person in charge recognizes the need for special inspections of traffic signals, etc., due to lightning, strong wind or flood, or other reasons. The results of the inspection shall be reported within three months of receiving the instruction.

7.5 Failure Repair

When a malfunction occurs, inspection and repair shall be carried out immediately. However, in principle, the scope of repair shall be adjustment of equipment based on the results of various inspections, replacement of failed (damaged) parts with supplied parts, installation, modification, and reinforcement of equipment, etc., and emergency measures to avoid danger such as ensuring traffic safety.

Scope of repair (example)

- Replacement of broken bulbs in signal lights and replacement with LED bulbs
- Correcting the direction of signal lights and vehicle detector arms
- Replacement of push button boxes (excluding piping) and vehicle detector heads
- Correction of slack in signal cables
- Replacement of the base and installation of a temporary controller due to the failure of the signal controller
- Reinforcement of concrete pillars when symptom of broken waveform is detected
- Temporary measures when ground wire is exposed

- Emergency measures for controller damaged by incident, etc.

A repair report should be prepared for each failure repair, and statistical analysis of the failure and the maintenance history of the equipment should be recorded.

If any other repairs (including base repair by the manufacturer) are required, immediately report to the person in charge of management for instructions.

8 Work Area Safety

The maintenance contractor shall pay utmost attention to the work area safety and traffic safety during the maintenance work. When working on or near the maintenance site, all persons shall wear the proper personal protective equipment including but not limited to hardhat and reflective safety vest. Slipper, sandal and open toe shoes shall be slowed.

Obstructions and excavations in the work area shall be adequately fenced and guarded at all times and proper traffic control devices shall be installed to protect the workers and the public. Particular attention shall be paid to the positioning of traffic barriers and traffic cones. Unnecessary blocking of traffic lanes shall not be permitted.

Adequate traffic control devices shall be in place before work begins and all such devices shall be removed immediately when the work is completed. As work progresses, warning devices which were appropriate at one time but are no longer applicable shall be removed or moved to proper location immediately.

Signs, lights, barriers and other traffic control devices shall be maintained in good order and in the correct position day and night. Signs shall be neat, clear and legible at all times.

8.1 Notes

(1) Preparation of maintenance plan

The maintenance contractor for traffic signals, etc. shall prepare an annual maintenance implementation plan immediately after the contract is concluded and obtain approval from the person in charge of management.

(2) Reporting of results

The results of the maintenance work shall be compiled on a monthly basis in the prescribed format and reported to the person in charge by the 10th of the following month.

No.	Type of maintenance	Maintenance report
1.	Daily inspection	1. Dily check list
2.	Periodic inspection (center system equipment)	2. Regular maintenance sheet (center)
3.	Periodic inspection (field equipment)	3. Regular maintenance sheet (field)
4.	Extra inspection	4. Failure repair sheet
5.	Additional inspection	3. Regular maintenance sheet
6.	Defect repair	4. Failure repair sheet

(3) Equipment to be maintained (to be confirmed)

All equipment comprising the ATC system should be subject to maintenance.

(4) Control Center System Equipment

No	Equipment	Device	Qty/Unit
1	Signal control server		2
2	Database server		1
3	Communication control Sever		2
4	Information exchange server		1
5	Information storage server		1
6	Information distribution server		1
7	IDET video server		1
8	Time server		1
9	HMI workstation	PC	2
		Monitor	4
10	Monitoring workstation	PC	3
		Monitor	6
11	KVM console kit and KVM switch	KVM console	1
		KVM switch	1
12	Network monitoring indicator	Warning lamp	2
13	Network Printer	Color laser printer	1
		Black / White laser printer	1
14	UPS		1
15	Communication equipment	L3SW for Traffic Control Center	2
		L2SW for BMA/RTP office	2
		Media converter	2
		SFP module for BMA/RTP office	2
		Fire Wall for Traffic Control Center	1
16	19 inch rack	36U、 19inch rack	2

(5) Field Equipment

No	Equipment	Device
1	Local Controller (Standard type)	Communication control unit (Embedded PC + Software)
		GPS receiver
		Power Supply (12Vdc)
2	Local Controller (Pedestrian Type)	Communication control unit (Embedded PC + Software)
		GPS receiver
		Layer 2 switch
		SFP module

		Controller interface device (CID)
		Power Supply (24Vdc)
		Power Supply (12Vdc)
		Outdoor Cabinet (replacement)
3	IDET	IDET camera
4	CDET	CDET(For Count/Gap)
		CDET(For congestion、 far from int。)
5	Detector aux cabinet	Cabinet
		Layer 2 switch
		SFP module
		Power Supply (24Vdc)
		Overvoltage Protection
6	I/F Cabinet	Cabinet
		Layer 2 switch
		SFP module
		Controller interface device (CID)
		Detection Signal Interface
		Built-in IDET
		Video Encoder (DVR)
		Power Supply (5 Vdc)
		Power Supply (12 Vdc)
		Power Supply (24 Vdc)
7	Manual Operation Assistance Device	PC
		Monitor

(List of equipment and device to be confirmed.)

Inspection Check List

Inspection category	Items inspected
Signal display time	1. Is the signal cycle appropriate? 2. 2. Is the green (green arrow) signal too short or wasted? 3. Can pedestrians cross the street within the green time? 4. Is there traffic congestion in only one direction? 5. The signal display method compatible with traffic flow and not dangerous? 6. Is there a need for right-turn arrows, separation of pedestrians and vehicles, etc.? 7. Is the signal display method compatible with other traffic regulations? 8. Is there a need for coordination and synchronization with adjacent traffic signals? 9. Does the car stop at the next traffic signal even though it started on green? 10. Is there a need to implement or eliminate flashing operation (to ensure visibility)? 11. Are yellow and all red lights too short (or too long)?
Pole	1. Are there any leaning, cracks, corrosion of pole, or loosening of the foundation? 2. Are there any obstacles to pedestrian or vehicular traffic?
Signal lantern, variable message sign, traffic sign, etc.	1. Is there a risk of falling? 2. Is there any corrosion or damage to the control unit, lights, etc.? 3. Is it facing the wrong direction? 4. Is visibility obscured by trees, advertisements, etc.? 5. Is the lens damaged or discolored?
Overhead cable	1. Is there any danger of the cable hanging down? 2. Is it in contact with other structures? 3. Is the protective cover attached properly?
Vehicle detector	1. Is the sensor head installed in the center of the vehicle's travel position? 2. Does the sensor operate normally? 3. Semi-actuation in low volume, full/semi-actuation, etc.
Pedestrian pushbutton	1. Does the pushbutton operate normally? 2. Does the response light (please wait a moment) light up? 3. is there any problem in the direction of installation or operation?
Others	1. Is the controller’s ID marked clear? 2. Are the pipes and fittings deformed or damaged? 3. Is the door of the controller securely closed and locked?

(Confirmation) Inspection items must reflect the situation in Bangkok.

Traffic Signal Failure Repair Report

Received on (1)	__ year ___ month ___ day ___ hr. ___ min.	Reception No.	
Location	_____ Police District _____ intersection	Signal ID	
Reported by		Received	
Details of failure	01 All lantern off 02 Partial lantern off 03 Partial LED off 04 Flashing operation 05 No phase change 06 Abnormal display 07 Out of coordination 08 Others (specify) ( )	11 Central system failure 12 Detector failure 13 CCTV failure 14 Others ( )	21 Lantern displacement 22 Damaged vehicle lantern 23 Damaged ped lantern 24 Damaged signal pole 25 Damaged cable 26 Others ( )
Person dispatched			
Time dispatched		Time arrived	
Time completed (2)		Elapsed time (2)-(1)	
Cause and work accomplished			
Parts replaced	Name, type, quantity		
Controller model	(Manufacturer, model, quantity, etc.)		
Completion reported	___ month ___ day ___ hr. ___ min.	Reported by Section and name	
Input to maintenance system	___ month ___ day ___ hr. ___ min.	Input by (section, name)	

Annex 9

Special Condition of Contract for Area Traffic Control System Maintenance

Special Conditions of Contract
For Area Traffic Control System Maintenance

1. General Obligations 1
1.1 Contractor's Responsibility 1
1.2 Works to be done by the Contractor 1
1.3 Contractor's Employees 1
1.4 Contractor's Equipment 1
1.5 Laws to Comply 1
1.6 Responsibility for damage claims 1
1.7 Temporary Suspension of Work 1
2. Measurement and Payment 1
2.1 Work Hour 1
2.2 Preventive Maintenance 1
2.3 Corrective Maintenance 2
2.4 Accident Repair 2
2.5 System Modification 2
2.6 Maintenance and Repair Records 2
2.7 Liquidated Damage 2
3. Contract Renewal 3
4. Cost Adjustment 3
4.1 Escalation 3
4.2 Foreign Spare Parts 3
4.3 Currency Conversion 3

Special Conditions of Contract
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2.7 Liquidated Damage 2
3. Contract Renewal 3
4. Cost Adjustment 3
4.1 Escalation 3
4.2 Foreign Spare Parts 3
4.3 Currency Conversion 3
5. Interpretation 3

Special Conditions of Contract for Area Traffic Control System Maintenance

1. General Obligations

1.1 Contractor's Responsibility

The Contractor shall, subject to the provision of the Contract, and with due care and diligence assume full responsibility for the maintenance work in accordance with the Technical Specifications and to the satisfaction of the Engineer and his duly authorized representative.

1.2 Works to be done by the Contractor

The Contractor shall provide maintenance services for area traffic control system and associated equipment under this Contract. The scope of the maintenance works and the technical requirements to the Contractor are specified in the Technical Specifications for the Traffic Control System Maintenance.

1.3 Contractor's Employees

The Contractor shall provide and employ its own competent personnel who are skilled in the maintenance of traffic control system and associated equipment covered under this contract. The number of qualified employees shall at least meet with his maintenance proposal submitted by the Contractor in his Tender.

1.4 Contractor's Equipment

The Contractor is required to own or lease equipment, tools, shop facilities, and vehicles necessary in undertaking the maintenance contract. The available equipment shall meet at least the requirements of his maintenance proposal submitted by the Contractor in his Tender.

1.5 Laws to Comply

The Contractor shall comply with all national laws, city ordinances, and all government regulations, in so far as they are binding upon or affect the parties hereto, the work, or those engaged thereon, and obtain all required licenses and permits, and be responsible for all damages to persons or properties which may occur in connection with the execution of the work.

1.6 Responsibility for damage claims

The Contractor shall indemnify the BMA against all loses and claims to any person or property which may arise out of or in consequence of the execution of the maintenance works, except injuries or damage resulting from any act or neglect of the Engineer or his authorized representatives.

1.7 Temporary Suspension of Work

The Engineer or his authorized representatives shall have the authority to suspend the work wholly or in part, by written order, for such period as he may deem necessary due to adverse weather, conditions considered unsuitable for the proper prosecution of work, or for failure on the part of the Contractor to perform any provision of the specifications of the Contract. The Contractor shall immediately comply with such order as directed.

2. Measurement and Payment

2.1 Work Hour

Work hour shall be classified as either Regular Time or Over Time. Regular Time hours shall be from 7:00 A.M. to 7:00 P.M. from Monday through Friday except National Holidays. All other work hours shall be classified as Over Time.

2.2 Preventive Maintenance

The Contractor shall provide all labor, spare parts, tool, shop facilities, equipment, materials, and service vehicles necessary to perform preventive maintenance as defined in the Specifications.

Compensation for monthly inspections and shorter interval shall be made monthly and compensation for quarterly and bi-annual inspections shall be made quarterly at the rates therefor based on the appropriate unit price schedule.

2.3 Corrective Maintenance

The Contractor shall provide all labor, spare parts, tool, shop facilities, equipment, materials, and service vehicles necessary to perform corrective maintenance as defined in the Specifications. Compensation for this work shall be made monthly at the rates therefor based on the appropriate unit price schedule subject to deduction of liquidated damages prescribed in Section 3.7.

Under normal situations where the equipment being maintained is fully operational, the Contractor shall be conclusively presumed to have undertaken the corrective maintenance work and shall be entitled to the payment therefor.

2.4 Accident Repair

Repair of pre-existing defects and damages due to accidents, vandalism, act of God, and pavement failures shall be billed monthly as extra work chargeable to contract contingency amount.

Except where the work involved an item included in the unit price schedule or for which a cost of repair has been mutually agreed upon between the Contractor and the BMA prior to commencement of the work, a separate itemized invoice, indicating the actual labor (hours per employment classification), material, equipment units used, spare parts, and applicable rates, shall be prepared for each repair work and submitted to the BMA. Costs of spare parts shall be supported by supplier's invoice.

Where the work involved an item included in the unit price schedule or for which a cost of repair has been mutually agreed upon between the Contractor and the BMA prior to commencement of the work, the unit price or the agreed upon price therefor, subject to adjustment of foreign spare part cost as provided below, shall apply regardless of the actual labor and material used.

2.5 System Modification

System modifications work shall be billed as extra work. Compensation for this work shall be based on cost estimates provided by the Contractor to the BMA prior to authorization to proceed. Where the work involved an item included in the unit price schedule, the unit price therefor shall apply. The BMA reserves the right to seek competitive bids to perform the modification work.

System modification work shall not be done without a written authorization from the Engineer.

2.6 Maintenance and Repair Records

Compensation for record keeping as required in the Specifications is considered included in the various pay items for maintenance and repair work and no separate payment shall be made therefor.

2.7 Liquidated Damage

Subject to exceptions as provided in Section 5.1, "Response and Service Times" and Section 6, "Spare Parts and Consumables" of the Technical Specifications for Traffic Control System Maintenance, the Contractor shall be assessed liquidated damages for failure to effect permanent repair within the specified time limit. Liquidated damages shall be deducted from payment due the Contractor.

The amount of liquidated damage under various failure conditions shall be as specified below:

(1)	Shutdown of the central control system:	Baht 2,000/day
(2)	Disconnection of central control system and all local controllers:	Baht 1,500/day
(3)	Signal on flash or totally inoperative:	Baht 500/day
(4)	Signal operating in off-line:	Baht 200/day/signal
(5)	Knocked down signal pole:	Baht 200/day/pole

(6)	Defective vehicle or pedestrian signal head:	Baht 200/item
(7)	Defective pedestrian pushbutton, vehicle detector sensor and vehicle detector unit:	Baht 200/detector

3. Contract Renewal

The BMA shall have the right to extend the Contract on a year by year basis to a maximum of four (4) years. If the BMA elects to extend the Contract, the unit prices for the various items of work shall be adjusted according to Section 4.1 "Escalation" of this Special Conditions of Contract.

4. Cost Adjustment

4.1 Escalation

One year from the effective date of the Contract and each anniversary thereafter for the duration of the contract, the unit rates paid for maintenance and repair shall be increased or decreased in direct proportion to the increase or decrease in the Consumer Price Index (CPI). The CPI shall be the CPI for Bangkok for all wage earners. The Contractor shall submit to the Engineer a minimum of one month prior to the anniversary date a revised unit price schedule and supporting CPI information.

4.2 Foreign Spare Parts

Adjustment for Foreign Spare Part Cost - The Unit Cost Rates for Accident Repair in the Bid Schedule shall be adjusted if use of foreign spare part(s) is necessary and there is a five percent (5%) or more increase in the foreign exchange rate between the time of bid opening and the time the spare part is actually used. The adjustment will be made only if the Contractor submits in writing a request for adjustment, concurrent with the submittal of the monthly invoice or billing, supported by supplier's invoice and foreign exchange rates data. Likewise, if there is a five percent (5%) or more decrease in the foreign exchange rate, the BMA shall be entitled to a reduction in the foreign spare parts costs.

4.3 Currency Conversion

Currency conversion for foreign spare part costs shall be based on the reference rate published by Bank of Thailand on the date shown on the supplier's invoice.

5. Interpretation

If an ambiguity or discrepancy is found in the documents comprising contract documents, the Engineer shall issue any necessary clarification or instruction.

Annex 10

Technical Specifications for Area Traffic Control System Maintenance

Technical Specifications

For Area Traffic Control System Maintenance

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Annex 1: List of Equipment for Maintenance
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Technical Specifications

For Area Traffic Control System Maintenance

1. General

1.1. General Requirement

The purpose of the Maintenance Contract (hereinafter referred to as Contract) is to keep the signal and related equipment in operation in the manner originally intended, that is to facilitate the orderly movement of traffic with due regard for the safety of life, limb, and property of motorists and pedestrians and prolong the useful life of the equipment. Therefore, time is of the essence and repair must be done in a timely and satisfactory manner.

The tenderer shall be required to submit with his tender the outline proposals for maintenance of the traffic control system under this Contract.

The Contractor shall be furnished with manuals and drawings of the traffic control system and related equipment produced for and applicable to the system and equipment covered by the Contract prior to the commencement of maintenance. Unless otherwise specified, the standards for equipment and equipment performance and system shall be in accordance with these documents.

The requirements described herein shall be considered the minimum standards to be followed for the maintenance and repair of all traffic control system covered under this Contract.

1.2. Definition

The following meaning shall apply throughout this documentation unless expressed otherwise elsewhere.

1) Traffic Control System

All traffic signal control equipment and computer software operated by the BMA including all field equipment, communication equipment and equipment located in the control center.

2) Communication lines

Optical fiber cable network that connects control center equipment and roadside equipment and network device forming the communication network. Cables and communication devices are not covered by the contract except those that were installed particularly for traffic control system.

3) Engineer

The Engineer designated as such by the BMA to be in charge of the implementation of the maintenance work for the purpose of liaison, coordination and supervision.

4) Clean

Removal of dirt, insects, foreign matters, stains of metal surface necessary to prevent corrosion.

5) Check

Checking the equipment operation and physical condition and make adjustments or minor repair, clean and oil moving mechanism, secure mounting, and restore water or fuel levels as necessary.

6) Inspect

The term “inspect” shall have the same meaning as “check”.

7) Foreign Spare Parts

Spare parts which are manufactured in foreign countries and are not regularly available in the Kingdom of Thailand.

1.3. Scope of Work

Except where otherwise specified in this specification, the Contractor shall furnish all labor, spare parts, tools, shop facilities, equipment, material, service vehicles, and perform all works necessary to maintain in good working manner all traffic control system and associated equipment covered under this Contract.

Maintenance services shall be provided to all traffic control system and its components except communication line not installed for signal system. The control center equipment, intersection signals, vehicle detectors and CCTV camera to be maintained under this Contract are listed in the Annex 1.

The various classifications of maintenance and repair work and related services to be performed by the Contractor include the following:

(1) Preventive Maintenance

The work to be done consists of monthly inspection and cleaning, and quarterly or bi-annual checking, cleaning, routine replacement or overhaul of parts as recommended by the manufacture, and servicing of various system components and related equipment. Minor deficiencies uncovered during the performance of preventive maintenance shall be corrected immediately and all adjustment, tuning and calibration necessary to keep the equipment in the best operating condition shall be performed.

Any problems which require further attention or use of spare part(s) shall be recorded on the appropriate fault report form and corrected according to the provisions for corrective maintenance or accident repair as appropriate.

(2) Corrective Maintenance

The work to be done consists of correcting malfunctions resulting from equipment deterioration and failure under normal operating condition.

(3) Accident Repair

The work to be done consists of repairing damage to the equipment due to accidents, vandalism, act of God, pavement failures, and construction activities of other contractors or third parties and includes cleanup of debris, erecting necessary warning and safety devices, and connection of temporary equipment if required to ensure the safety of the public.

(4) System Modifications

The work to be done consists of minor modification to the system and the intersection facilities to improve system operation or to conform to new operational requirements. The work shall be done as directed by the Engineer.

(5) Consultations

The Contractor shall provide technically competent representative who shall be available to the BMA to provide a consultation service at no additional cost to the BMA. The scope of consultation shall include cost estimates and explanation of functional and operational characteristics of the system and equipment.

(6) Maintenance and Repair Records

The Contractor shall maintain the comprehensive records of all maintenance and repair activities and spare parts consumption. The records shall include, as a minimum, maintenance check lists, fault reports, spare parts receiving and consumption records, and work orders.

1.4. Signal Turn-off and Signal On Flash

The Contractor shall notify the Engineer in advance of any signal or vehicle detector “turn-off/on” or signal “on flash” necessitated by his maintenance activities.

2. Preventive maintenance of Control Center Equipment

2.1. General

Preventive maintenance of the control center shall cover all equipment necessary for the operation of the traffic control system in the control center including all associated power supply and air conditioning equipment.

2.2. Monthly Inspection/Servicing

All control center equipment covered under the Contract shall be inspected, cleaned, and adjusted as required, and checked for functional deficiencies either through test operation, use of test programs, inspection of indicator lamps, indication on the monitor, or other manufacture recommended procedures.

2.3. Quarterly and Bi-annual Inspection/servicing

Various equipment and/or components and their operations shall be checked and serviced every three (3) or six (6) months. Routine replacement or overhaul of equipment or equipment components as recommended by the manufacture shall be done as part of the quarterly and bi-annual inspection/servicing work.

3. Preventive Maintenance of Field Equipment

3.1. Monthly Inspection of Signal Equipment

Each intersection and pedestrian signal shall be inspected monthly. As a minimum, the following shall be performed:

1) Walk the intersection or crosswalk and visually inspect all signal heads and pedestrian pushbutton for proper operation, alignment, and damages.
2) Observe and check for proper operation of the signals.
3) Check all hand-hole covers, riser pipes and poles for damages.

3.2. Quarterly Inspection of Vehicle Detector

Each vehicle detector shall be inspected quarterly. For the purpose of the maintenance contract, vehicle detector shall include all vehicle detectors installed for the traffic control system.

1) Walk the vehicle detector site and visually inspect the detector sensor. For each loop coil, check for pavement or sealant failure, if any. For overhead sensor, check for sensor position and angle and its proper operation, if any. Any damages or pending failure shall be reported immediately to the Engineer.
2) Check proper operation of vehicle detector by confirming on state of detection indicator on the vehicle detector unit when vehicle passes through detection area.
3) Check all hand-hole cover, riser pipe and poles for damage.

3.3. Quarterly and Bi-Annual Inspection of Field Equipment

All cabinets, controllers, lanterns, poles, footings, hand-holes, riser pipes, vehicle detectors, and communication equipment shall be inspected every three (3) or six (6) months. Routine replacement and overhaul of equipment or equipment components shall be done as part of the quarterly and bi-annual inspection/servicing work.

4. Schedule and Check Lists

4.1. Schedule for Preventive Maintenance

The Contractor shall submit to the Engineer a complete schedule for all preventive maintenance work under this Contract within two weeks of receiving the Notice to Proceed. The schedule shall be in sufficient detail to indicate which part of the monthly inspections and items of inspection are to be performed in each week and which part of the quarterly and bi-annual inspections and items of inspection are to be performed in each month and the number of maintenance technicians to be assigned.

The Contractor will be required to revise the schedule if the work load and the man-power assignment are unbalanced or unrealistic. Failure to submit an acceptable schedule within one month of receiving order to proceed shall be sufficient cause for suspension of the Contract and/or withholding of payments due the Contractor.

4.2. Check List

The Contractor shall design and develop suitable check lists for use in the preventive maintenance work. The format of the forms shall be subject to the approval of the Engineer. Sample forms are attached to this Specifications as Annex 2 as reference.

The dates of inspection shall be recorded in the check lists. The Contractor is required to submit a copy of all check lists every three (3) months and as requested by the Engineer at any time. The Contractor is also required to keep an up-to-date check list in each controller and detector cabinet, and in the control center.

Failure to maintain or submit the check lists shall be sufficient cause for suspension of the Contract and/or withholding of payments due to the Contractor.

5. Corrective Maintenance and Accident Repair

5.1. Response and Service Times

Corrective maintenance and accident repair shall be provided on a 24-hour a day, 7-days a week basis. Immediate action shall be taken to safeguard the public at any time a signal operation becomes partly or totally inoperative from any cause whatever.

The Contractor shall provide the Engineer with a telephone number for receiving service calls. The telephone shall be manned 24-hours a day, 7-days a week. All fault reports must be recorded on a suitable Fault Report Form immediately upon receiving the call.

The maximum response time, i.e. the elapsed time from receiving notification to arriving at the affected site, shall be as follows:

(1) Emergency Signal Repairs	Day (06:00 to 20:00):	2-hours
	Night (20:00 to 06:00):	4-hours
(2) Other Repairs	24 hours	

The following shall be classified as Emergency Signal Repairs:

1) Signal on flash
2) Signal blackout not caused by power outage
3) Any faults other than power outage which has or will cause two or more local controllers to be dropped off-line
4) Failures of the uninterrupted power supply system in the control center, if any.
5) Failure of any equipment which has or will cause the central traffic control system to shut down or be rendered inoperative
6) Any failure which is determined by the Engineer or the Police to pose immediate hazard to the public

If the fault cannot be permanently repaired immediately, a temporary repair or remedial measure sufficient to safeguard the safety of the public shall be taken by the Contractor, and the Engineer shall be so notified.

Permanent repairs shall be completed as soon as possible, and in all cases within 72-hours of notification unless unusual circumstance exists. Shortage of spares shall not be considered as unusual circumstances except the unavailability of foreign spare parts that the Contractor is not required to stockpile as provided in Section 6 “Spare Parts and Consumables”.

Failure to meet the response time requirements by the Contractor shall be sufficient cause for BMA to authorize repairs to be completed by others and deduct the cost of such repair from payments due the Contractor.

Failure to effect permanent repairs within the specified time period by the Contractor shall at BMA’s discretion result in liquidated damages being assessed. Repetitive failure shall be sufficient cause for BMA to cancel the Contract.

5.2. Rehabilitation of Pre-existing Defects

The Contractor shall be responsible for correcting pre-existing defects.

Immediately after the issuance of the Notice to Proceed, the BMA will provide the Contractor with a list of currently known pre-existing defects. Within fourteen (14) calendar days of receiving said list, the Contractor shall submit to the Engineer a detailed schedule and cost estimates for the restoration of the pre-existing defects in the said list. The restoration work shall then proceed as directed by the Engineer. Where additional diagnostic or testing is required before completing the cost estimate, the Contractor shall so inform the Engineer and perform the diagnostic or testing as directed by the Engineer.

In addition to BMA supplied list of pre-existing defects, the Contractor shall identify all other pre-existing defects during the first monthly preventive maintenance inspection and, within thirty (30) calendar days of completing the inspections, submit to the Engineer a list of all pre-existing defects, indicating in detail nature of the defect, and work and estimated cost required to correct each pre-existing defect, and a schedule to carry out the restoration work. The restoration work shall then be completed as directed by the Engineer.

5.3. Fault Reporting and Work Order

Each and every corrective maintenance and accident repair work must be documented on the appropriate fault report form and work order form by the Contractor. A copy of completed work order forms must be submitted with the monthly invoice. No payment will be made without submitting the completed work order forms. The fault reports shall be kept in a log book and shall be made available to Engineer upon request at any time.

The Contractor shall design and develop suitable forms of Fault Report and Work Order, and submit to the Engineer for his approval. Sample forms are attached as Annex 3 as reference.

5.4. System Modification

The Contractor shall modify the intersection facilities, vehicle detector, and corresponding modification for the central signal control system under the direction of Engineer. The necessary documents and drawings with instruction will be furnished by the Engineer to the Contractor.

The possible system modification work includes the following:

Newly installation, relocation, modification and removal of intersection facilities including signal controller, lantern, vehicle detector and related incidental materials.

Modification of preset parameters in the central signal control system corresponding to the newly installation, relocation, modification and removal of intersection signal and vehicle detector.

Modification of preset parameters in the existing central signal control system and signal controller including signal phasing plan, signal timing plan, time-of-day control plan, other necessary preset parameters, and lantern wiring modification, if necessary.

Modification of preset parameters in the existing vehicle detector and/or readjustment of sensitivity and detection zone.

Modification of preset parameters in the central signal control system corresponding to the modification of existing intersection signal and vehicle detector.

6. Spare Parts and Consumables

6.1. Spare Parts Inventory

The Contractor is required to maintain an inventory of spare parts and consumables sufficient to effect the maintenance and repair work as recommended by the system and equipment manufacturer except that the Contractor is not required to maintain an inventory of foreign spare parts which were not needed during the last 12-month period.

The list of inventories of spare parts and consumables shall be subject to the approval of the Engineer.

The Contractor will be allowed up to three (3) months, from date of Notice to Proceed, to build up his inventory of foreign spare parts. During this time, the BMA will loan its foreign spare parts, if available, to the Contractor on an as needed basis in order to complete the work. The Contractor shall procure on-loan spare parts by himself and shall be returned in kind to BMA within 60 days or as soon as possible.

Beginning the fourth month of the contract, the Contractor shall be fully responsible for furnishing all needed inventory of spare parts and consumables. The repair works shall be carried out normally using contractor’s inventory. The Contractor shall procure used spare parts and consumables in a timely manner and shall replenish his inventory constantly.

6.2. Payment for Spare Parts

The Contractor shall be paid the actual costs plus a five percent (5%) handling charge of the spare parts used and procured for the maintenance and repair works. The Contractor shall provide the BMA with a detailed list of the used and procured spare parts together with a copy of the supplier's invoices and receipts of taxes and duties paid.

Upon termination of the Contract, all unused spare parts shall become the property of the BMA. The Contractor shall provide the BMA with a detailed list of the unused spare parts.

Failure by the Contractor to effect permanent repair within the specified time limit due to inadequate spare part inventory, except those which are not required to be maintained in the inventory, shall not relieve the Contractor from being assessed liquidated damages as specified in the Section 2.7 "Liquidated Damages" of Special Conditions of Contract for Traffic Control System Maintenance unless the unavailability of spare parts is due to circumstances which are beyond the control of the Contractor.

7. Work Area Safety and Traffic Safety

The Contractor shall pay utmost attention to the work area safety and traffic safety during the maintenance work. When working on or near maintenance work site, all persons shall wear the proper personal protective equipment including but not limited hardhat and reflective safety vest. Slipper, sandal and open toe shoes shall not be allowed.

Obstruction and excavations in the work areas shall be adequately fenced and guarded at all times and proper traffic control devices shall be installed to protect the workers and the public. Particular attention shall be paid to the positioning of traffic barriers and traffic cones. Unnecessary blocking of traffic lanes shall not be permitted.

Adequate traffic control devices shall be in place before work begins and all such devices shall be removed immediately when the work is completed. As work progresses, warning

devices which were appropriate at one time but are no longer applicable shall be removed or moved to proper location immediately.

Signs, lights, barriers and other traffic control devices shall be maintained in good order and in the correct position day and night. Signs shall be neat, clear and legible at all times.

Compensation for meeting the requirements of this section shall be included in the Contract Price and no separate payments will be made therefor.

Annex 1: List of Equipment for Maintenance

1-1 List of Control Center Equipment for Maintenance

Seq.	ID	Name	Description	Remarks

1-2: List of Traffic Signal for Maintenance

Seq.	Int. ID	Name	Type	Remarks

1-3: List of Vehicle Detector for Maintenance

Seq.	Det. ID	Location	Type	Remarks

1-4: List of Camera for Maintenance

Seq.	Camera ID	Location	Type	Remarks

Annex 2: Hardware Check List （To be prepared）

1. Control Center Equipment

   Signal control server
   Database server
   Communication control server
   Information storage server
   IDet video server
   Information distribution server
   Time server
   KVM console
   Network status indicator
   HMI workstation
   Monitoring work station
   L3 switch
   L2 switch
   Media converter
   UPS

2. Remote monitoring system

   Monitoring workstation
   Manual control assistance device

3. Field Equipment

   Controller Interface Device (CID)
   L2 switch
   Media converter

4. Vehicle Detector

   Image sensor detector (IDet)
   Video encoder
   L2 SW
   Ultrasonic vehicle detector (UDet)
   Detector interface

Annex 3: Fault Report and Work Order Form (To be prepared)

Annex 11

ATC System Maintenance Work

THE PROJECT FOR IMPROVING TRAFFIC CONGESTIONS
IN BANGKOK THROUGH THE ESTABLISHMENT OF
MODEL AREA TRAFFIC CONTROL (ATC) SYSTEM
IN THE KINGDOM OF THAILAND

ATC System Maintenance

21 October, 2022

JICA Expert Team

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ATC System Maintenance

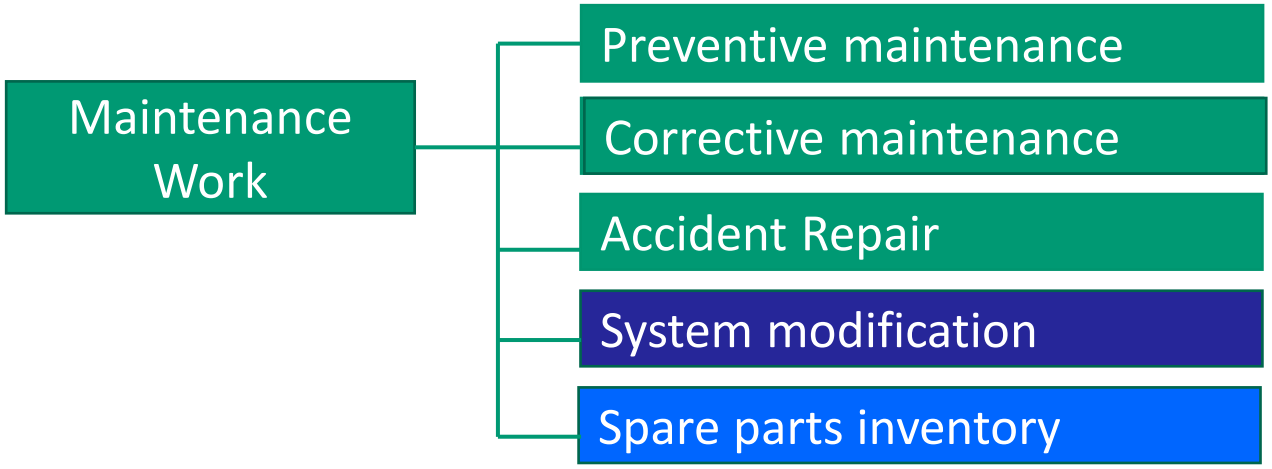
1. Maintenance Work Components
2. Maintenance Organization
3. Preventive Maintenance
4. Corrective Maintenance
5. Maintenance Management by BMA
6. Coordination among Organizations
7. Maintenance Contract
8. Maintenance Check List

Maintenance Work Component 1

- Maintenance works consist of the following:
  - Preventive Maintenance
    - Regular and routine maintenance of equipment and system in order to keep the system running
  - Corrective Maintenance
    - Maintenance work performed to identify, isolate, and rectify a failure caused by wear and tear and other reasons not attributable to third party
  - Accident Repair
    - Work to restore the functionality of the equipment from the damage, and loss of functions caused by a third party

Maintenance Work Component 2

- The following works are also required for ATC system operation:
  - System Modification
  - ATC system often requires such works as timing parameter adjustment, modification of phase sequence, parameters used for signal timing selection
  - Spare Parts Inventory
  - Keeping spare parts inventory is essential for timely maintenance work.



Maintenance Organization

- Maintenance work will be carried out by a maintenance contractor

Maintenance management

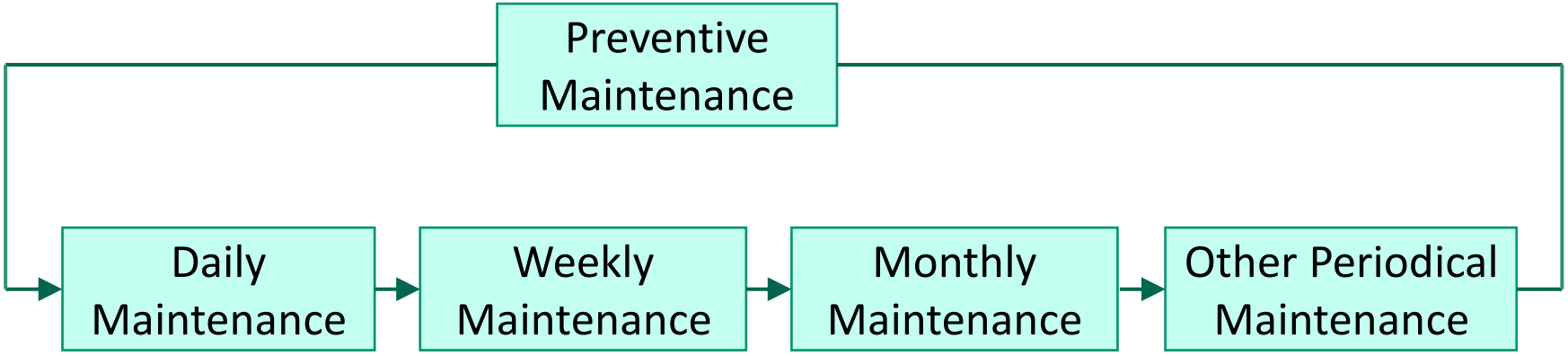
- Maintenance planning
- Budgeting and accounting
- Maintenance work supervision
- Minor modification initiative
- Quality and reliability analysis

Maintenance Execution

- Inspection and checking
- Defect/damage repair
- Minor modification implementation
- Spare parts inventory

Preventive Maintenance

- Preventive maintenance must be carried out by the maintenance contractor based on the inspection schedule specified in the maintenance contract.



Corrective Maintenance

- Corrective maintenance must be provided on a 24/7 basis.
- Maintenance work is divided into emergency repair and other repairs. Emergency repair requires immediate action by the maintenance contractor.
- Response time (Notice reception -> arrival at site) is specified

Response Time

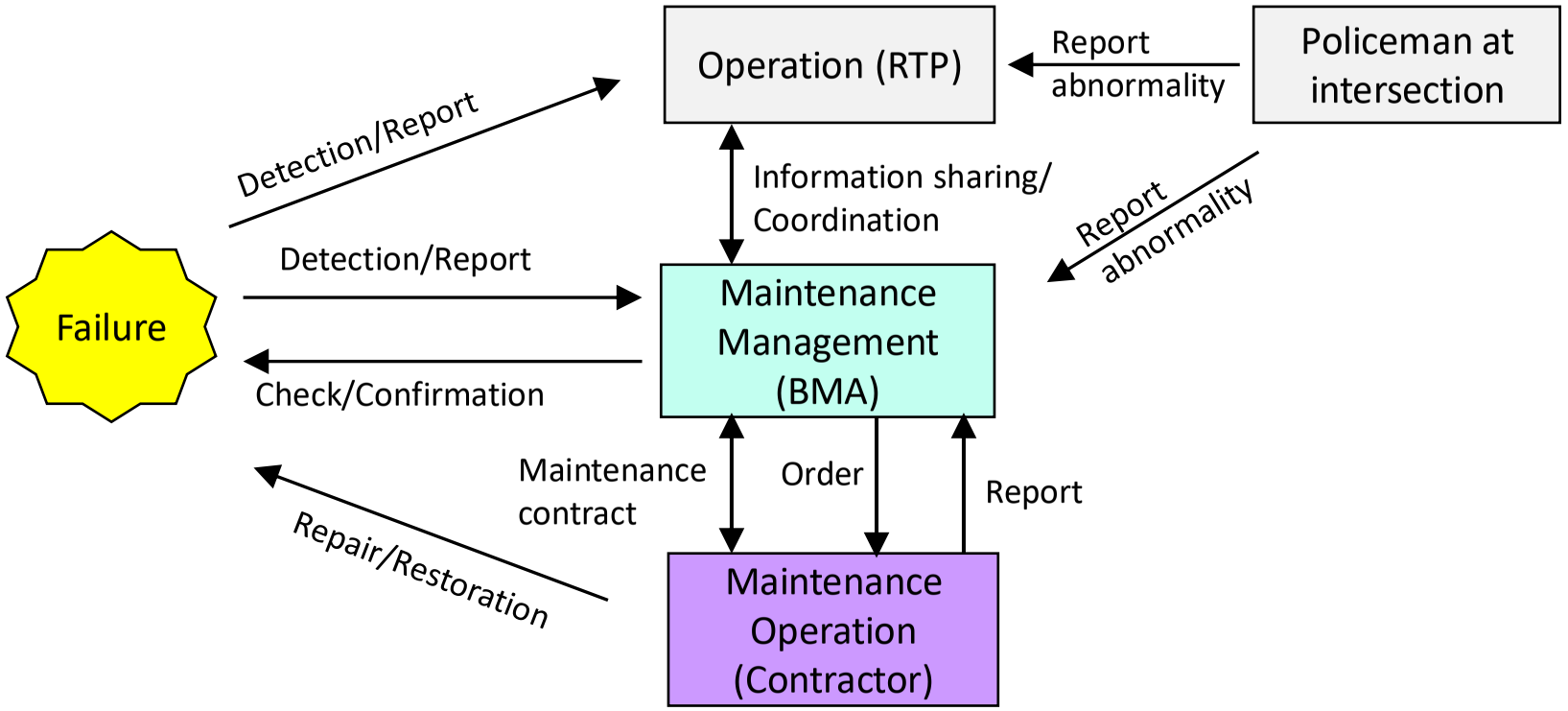
Work Type	Time Zone	Response Time
Emergency repair	Daytime (06:00 – 20:00)	Two (2) hours
	Night (20:00 – 06:00)	Four (4) hours
Other repairs	Whole day	24 hours

Maintenance Management by BMA

- Maintenance management by BMA
  - Supervision of maintenance contractor's work
    - Review and approval of the schedule and contents of preventive maintenance;
    - Notification of failure to maintenance contractor and debriefing;
    - Review and approval of accident repair work including cost; and
    - Inspection of maintenance work undertaken by maintenance contractor.
  - Planning, preparation and supervision of modification work
    - Modification / relocation work design;
    - Preparation of drawing, parts list and cost estimates; and
    - Supervision of modification work.
  - Reliability analysis
    - Data entry (type and cause of trouble, maintenance work undertaken, etc.) into maintenance database; and
    - Reliability analysis and countermeasure development.

Coordination among Organizations

- Good coordination among relevant organizations is indispensable for reliable operation of ATC System.



Maintenance Contract

- Maintenance Contract must be made between BMA and capable maintenance contractor.

Technical Specifications for ATC System Maintenance

1. General
2. Preventive maintenance of control center equipment
3. Preventive maintenance of field equipment
4. Schedule and check list
5. Corrective maintenance and accident repair
6. Spare parts and consumables
7. Work area safety and traffic safety

Special Conditions of Contract for ATC System Maintenance

1. General obligations
2. Measurement and payment
3. Contract renewal
4. Cost adjustment

Maintenance Check List

- Maintenance check list must be used to check and record preventive maintenance work.

BMA Preventive Maintenance Checklist
Intersection / Pedestrian Signal

Street Names:				Contractor:
ID No.:	Type: Standard		Pedestrian	Year:

MONTHLY INSPECTION

	1	2	3	4	5	6	7	8	9	10	11	12
Date												
By												

QUARTERLY / BI-ANNUAL INSPECTION

Task	Quarter-->	1	2	3	4
	Date Inspected-->				
	Inspected by -->				
Controller and Controller Interface Device					
o Check door hinges, seal, lock, mounting					
o Check breakers/voltage/switches/wiring					
o Check clock pulse					
o Check manual/standby operation					
o Check indicator lamps					
o Check corrosion or damage to cabinet					
o Check lock					
o Clean/touch-up cabinet					
Lanterns					
o Check mounting and direction					
o Check visibility not impaired by trees, advertisements, etc.					
o Check damage					
o Clean lens					
Pole					
o Check tilt, cracks, corrosion, anchor bolts					
o Touch-up scratches, remove rust					
o Clearn handhole					
Pedestrian pushbutton					
o Check normal operation					
o Check indicator lamp					
o Check mounting on pole					
Vehicle detector and network cabinet					
o Check door hinges, seal, lock, mounting					
o Check wiring/voltage					
o Check operation, adjust settings					
o Check and adjust direction					
o Clean/touch-up cabinet					

BMA REVIEW

	1	2	3	4	5	6	7	8	9	10	11	12
Date												
By												

Example of check list

Thank you
for your attention

Annex 12

Guidelines for Manual Operation of Traffic Signal

Guidelines for Manual Operation of Traffic Signal

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1. Objectives of manual operations 1
2. Effects of manual operation 2
   2.1 Advantage 2
   2.2 Disadvantage 2
3. Manual Operation Procedure 3
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4. Points to be considered 5
5. Manual control at specific intersections 9
   5.1 039: Tuk Chai Intersection 9
   5.2 038: Saphan Kwai Intersection 13

1. Objectives of manual operations

This “Guidelines for Manual Operation of Traffic Signals” is intended to make the manual operation of traffic signal safer and more efficient. It does not mean, however, to recommend use of manual operation all the time. Manual operation must be limited to a minimum and must be used when it is effective with maximum attention.

Manual operation of signal is mainly performed for two purposes:

(1) Preemption control in emergency situations (VIP convoy, traffic accidents, etc.)

Manual operation is implemented for the purpose of preemption control in emergency situations such as VIP convoy, ambulance, fire engine or traffic accidents. Priority must be given to these vehicles and roads must be cleared for smooth passage. In case of traffic accident, Capacity of accident site is limited and signal must cope with the unusual traffic pattern. The flexibility of the existing signal controller that allows switching to manual control at any phase regardless of current phase on display is very effective for these cases. Such flexibility of manual control will be retained under ATC to take advantage of this functionality.

(2) Easing traffic congestion occurred without specific cause

The manual operation of signal is intended for mitigating traffic congestion that has developed without any incident. Signal is controlled manually to mitigate congestion at downstream section blocking or disturbing the traffic flow at the intersection where manual control is applied. In this case, it is recommended to follow standard phase sequence but with different phase duration to avoid confusion by drivers.

Since automatic control of signal is efficient most of the time, manual operation of signals must be executed only when it is effective. At the same time, manual operation must be executed with the minimum adverse impact on the traffic flow. Automatic operation must be resumed as soon as the objective of the manual operation has been achieved.

2. Effects of manual operation

It is necessary to properly understand the advantage and disadvantage of manual operation of signal.

2.1 Advantage

(1) Immediate effect

By switching to manual operation, signals can be manually operated immediately with the phase and timing parameters suitable for the traffic situation. This is particularly effective in the event of an accident or other unusual incident.

(2) Reduction of traffic congestion

Reduction in traffic congestion is achieved in the following two cases:

- By extending the green time for a specific direction, traffic congestion in that direction can be eliminated (or eased).
- Efficient signal operation can be achieved by reducing green time wasted. Green time is wasted in case of no arriving traffic while signal is green, or vehicles cannot proceed due to congestion at downstream section. Green time saved can be allotted to other phases.

(3) Priority to be given to emergency vehicles

Priority can be given to the emergency vehicles by manual control to allow them to proceed with minimum delay.

2.2 Disadvantage

Manual control has the following disadvantages:

(1) Longer cycle time

Cycle length tends to become longer under manual operation. Longer green time allows more vehicles proceed into the downstream section causing congestion there. Once this happens, green signal is given to other movements. Such action often results in the unbalanced green time against demand and often creates a stack of vehicles. Manual control must be applied not only to deal with the stacking at the downstream section but also to prevent occurrence of stacking.

(2) Reduction of intersection capacity

Although manual operation is effective in responding to the changes in traffic flow in a timely manner and can easily provide priority control to the specific movement at intersection, total intersection capacity is reduced most of the case. If this is the case, traffic congestion cannot be avoided as traffic demand exceeds the intersection capacity reduced by manual operation.

(3) Congestion on other approaches

In case priority is given to a specific approach, congestion often occurs or becomes worse on other approaches resulting in reduced of performance of the intersection.

(4) Deployment of capable personnel required

Effective manual operation requires deployment of competent police officer, who is required to pay utmost attention to the traffic condition to achieve effective and safe manual operation of signal.

3. Manual Operation Procedure

3.1 Basic guideline

(1) Timing for starting manual operation

For a signal that operates in automatic mode, manual operation must be performed only when any of the following phenomena occurs.

- Priority measures for specific vehicles (VIP convoy, ambulance, fire engine, etc.)

  Manual operation of signal is initiated based on the instructions from the headquarters or police at the neighboring intersection in case of VIP convoy. In the case of other types of emergency vehicles, manual control is initiated when the approaching emergency vehicle is noticed.

- Measures in the event of an incident

  If a traffic accident or other unexpected incident occurs and traffic is disrupted, manual operations is initiated immediately to maintain the safety and to prevent the negative impact.

- Measures to prevent and/or alleviate traffic congestion

  When the degree of congestion, for example, queue length, on a specific approach exceeds the designated level (length) for three consecutive cycles.

- Measures to equalize the level of congestion at each approach

  When there is an imbalance of the congestion level among the approaches for three consecutive cycles.

- Reduction of green time wasted

  When green time is wasted for three consecutive cycles due to smaller number of arriving vehicles or congestion at downstream section for three consecutive cycles on any approach.

However, if there is a pedestrian crossing, the green time for non-priority approach must be truncated after the required pedestrian crossing time (converted at a speed of 1 m/second) has elapsed.

(2) Phase sequence

In principle, the phase sequence by manual operation must be same as the phase sequence of the automatic control as drivers expects the same sequence. The same phase sequence is also required to maintain coordination with the neighboring intersections.

However, different sequence may be selected depending on the purpose of manual control and traffic condition.

(3) Timing of the phase change

After the elapse of the minimum green time required for pedestrian crossing, the current phase is terminated when the following phenomena occur:

- When a green signal is wasted with no approaching vehicles
- When the specified maximum green signal time has been elapsed

There must be a minimum and maximum green time and also cycle time to prevent excessive green time or cycle length. Because excessively long cycle length is not only inefficient but

also unsafe. Congestion must be relieved in a gradual manner over several cycles.

(4) Restoration of automatic control

Manual operation must be terminated and automatic control must be resumed in the following cases:

- When the purpose of manual signal operation has been achieved (queue length has reduced to 300 m or less)
- When congestion in all directions has increased to 600 m or more.
- When the manual operation is not effective due to the occurrence of a congestion at the downstream section, etc.

Automatic control must be resumed after the last phase of phase sequence under manual control to prevent abrupt change of phase sequence.

(5) Feedback to automatic control

The duration of each phase under manual operations needs to be recorded, and the data is feedbacked to the automatic control parameters for operational improvement. The ATC system being installed as a pilot project has the capability of recording all signal timing implemented for both automatic and manual control. The data must be utilized and analyzed for review of manual control and effective signal operation.

In addition, if manual operation is not effective, it is required to investigate the cause and revise or update manual operation procedures.

The above procedure is presented in Figure 1.

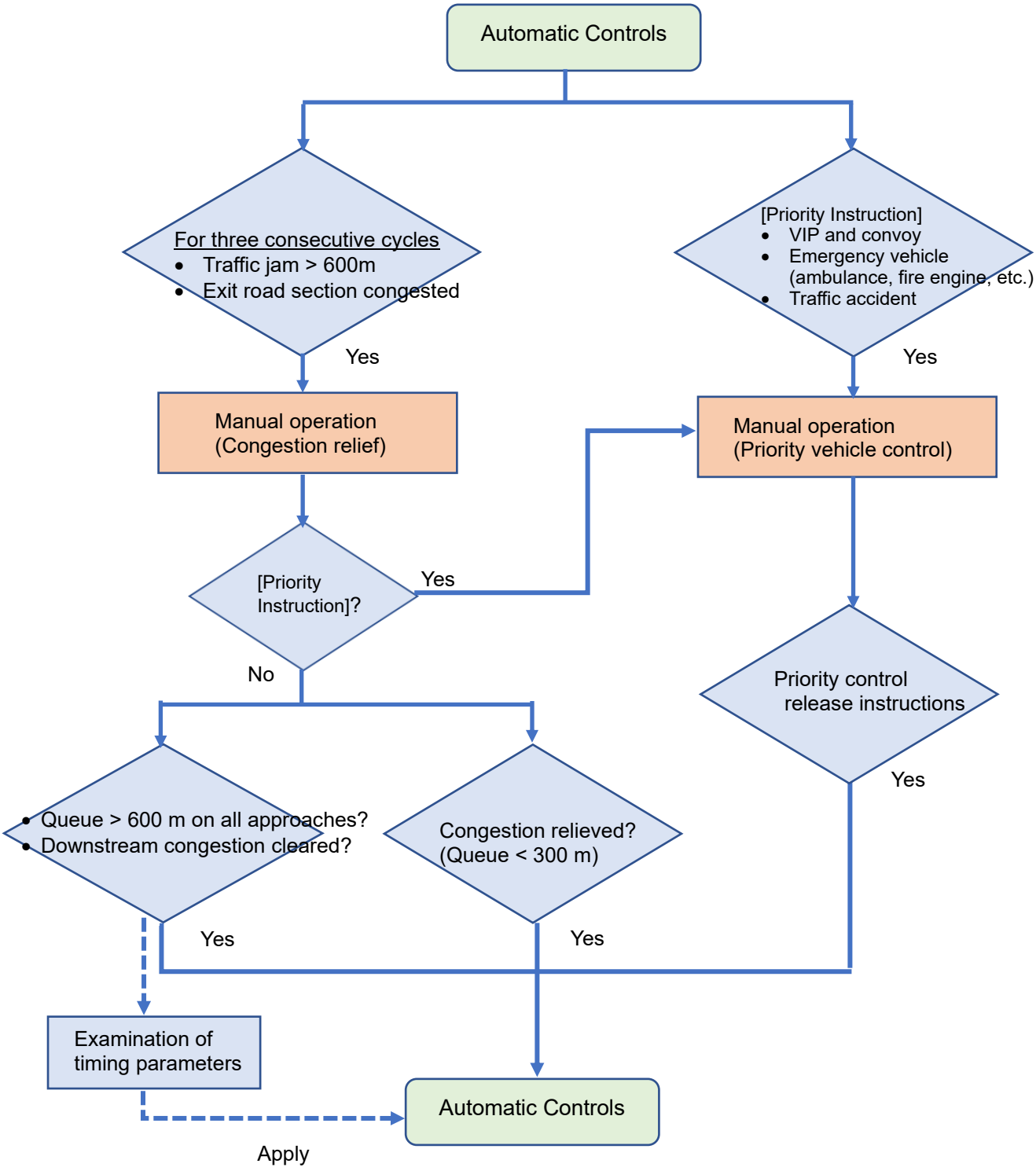


Figure 1 Initiation and Termination of Manual Operation

4. Points to be considered

Person in charge of manual operation must try to understand the traffic situation in order to ease the traffic congestion, and must also try to operate with due care of safety and convenience. The main points to be considered are as follows.

(1) Priority on safety

Highest priority must be given to the safety of both vehicles and pedestrians. For example, extremely short green time for vehicles may cause rear-end collisions.

In addition, the time that pedestrians can safely cross the street must be ensured. For this purpose, it is recommended to assume pedestrian walking speed of 1 meter per second to calculate the time required to complete a crossing. Also make sure that no pedestrians are left on the pedestrian crossing when terminating the current indication. This does not apply if no pedestrians are present.

(2) Consideration of pedestrian convenience

Pay attention to the pedestrians waiting for green. Making pedestrians wait for a long time is likely to encourage them to disregard traffic signals.

(3) Assess traffic conditions

In order to implement efficient operations, always be aware of traffic congestion at all approaches and exits, and of the cause of congestion, if there is a congestion.

The manual control of signals is executed based on the traffic condition observed at the intersection and on the information to be provided by the manual control assistance device introduced by the Project. The device is capable of showing the phase sequence being implemented under automatic condition and also traffic conditions on all approaches through CCTV camera. It also indicates the elapsed time of the current phase and issues a warning when the current phase is being shown longer than the preset duration.

It is also necessary to define priority route for each intersection to implement manual control more efficiently.

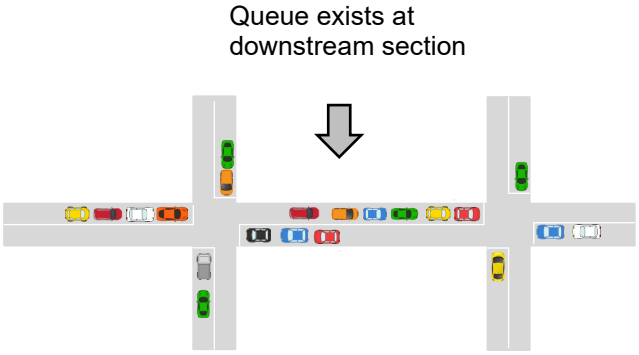
(4) Coordination with adjacent intersections

Depending on the scale of traffic congestion and distance to the neighboring signals, manual operation may affect adjacent signalized intersections. Manual operation should be performed in coordination with the neighboring intersections.

Typical case of inadequate manual operation is shown below. If an approach is congested by some reason, signal shows green for that approach manually until queue is cleared. The measure is generally effective when the downstream section is not congested. But longer green time for an approach may cause the congestion on exit side. It means congestion is just shifted to the downstream intersection.

In worst case, queue from the downstream signal extends to the intersection and blocks traffic on the crossing road. The case is shown in the figure below.

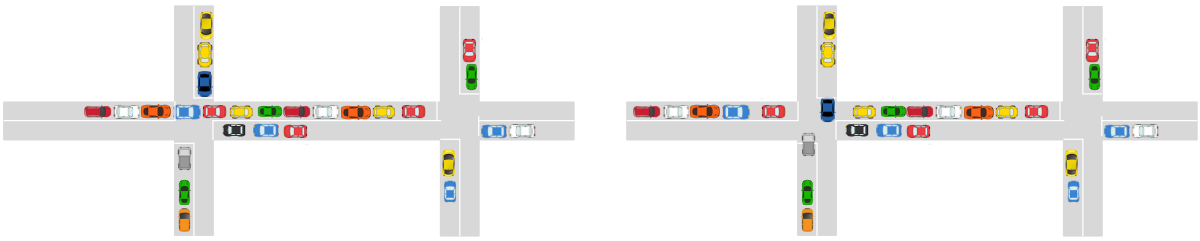
As stated earlier, relief of congestion must be made over several cycles to prevent propagation of congestion.



Traffic condition changes into two cases:

Case A) If eastbound traffic is not controlled by manual signal operation, queue occupies intersection and blocks vehicles on crossing road.

Case B) If eastbound traffic is controlled by manual signal operation, intersection is open and vehicles on crossing road can proceed.



Queue propagated

Queue propagation prevented

Figure 2 Propagation of Congestion due to blockage of Intersection

(5) Left turn on red

It is impossible to control left turn vehicles at an intersection where left turn is always allowed for that approach regardless of the signal indication. If congestion is created or becomes worse by left turn vehicles, left turn during red signal must be stopped by the traffic police at site. If the case occurs frequently, left turn on red must be reviewed.

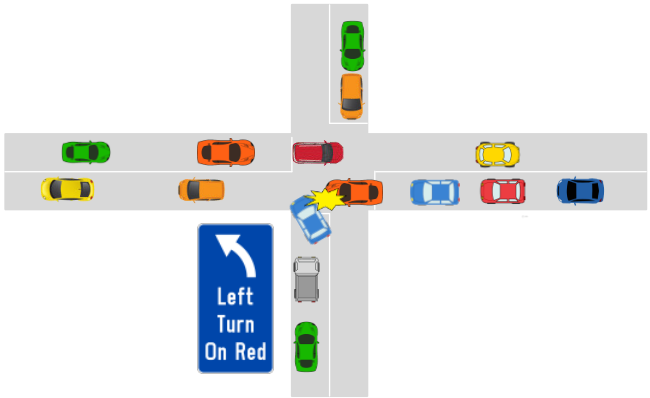


Figure 3 Congestion/Accident caused by "Left Turn On Red"

Other tips that may be helpful for managing traffic through manual operation is presented below.

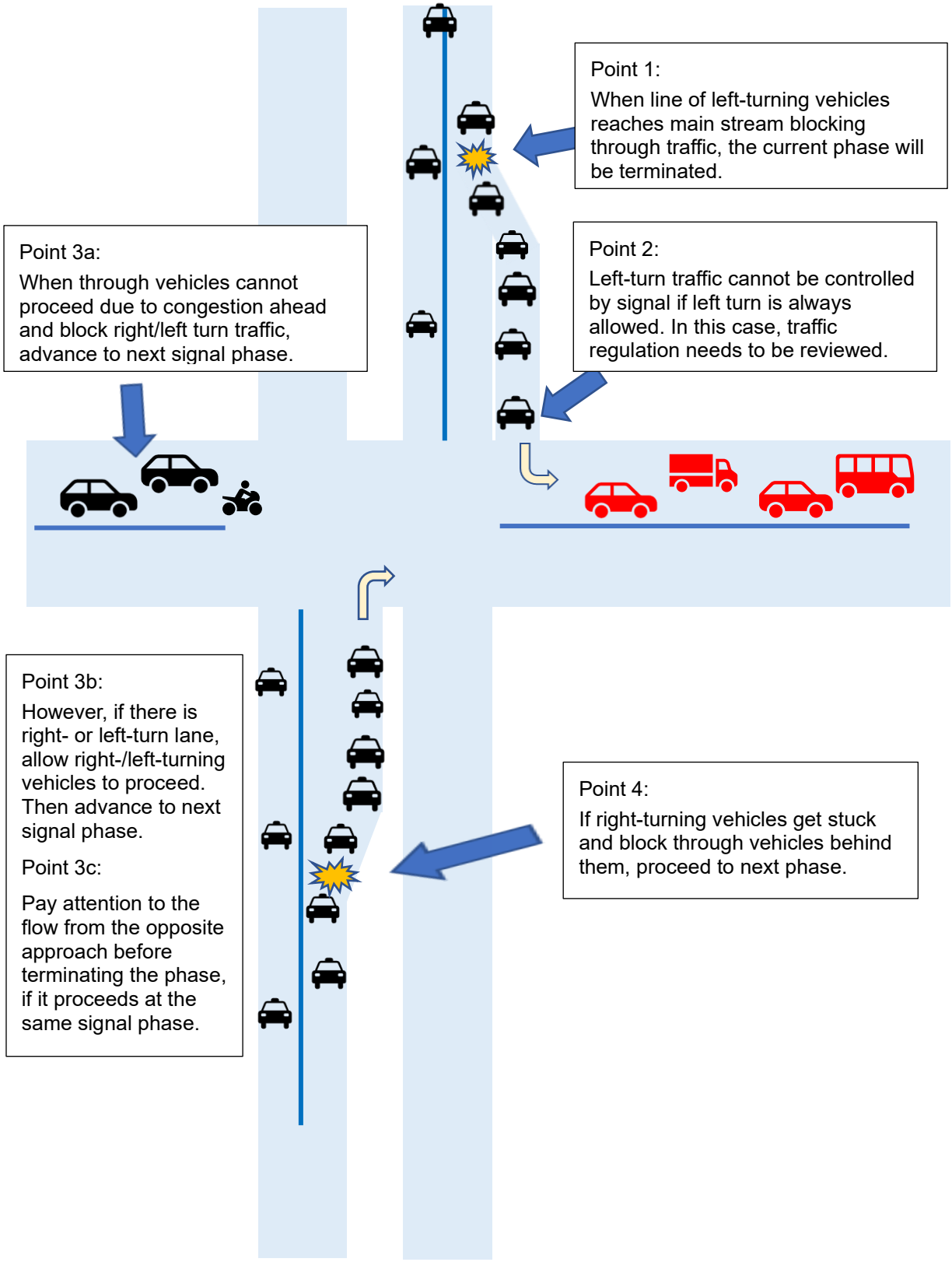


Figure 4 Tips for Manual operation in the event of Congestion at Downstream Section (proposed)

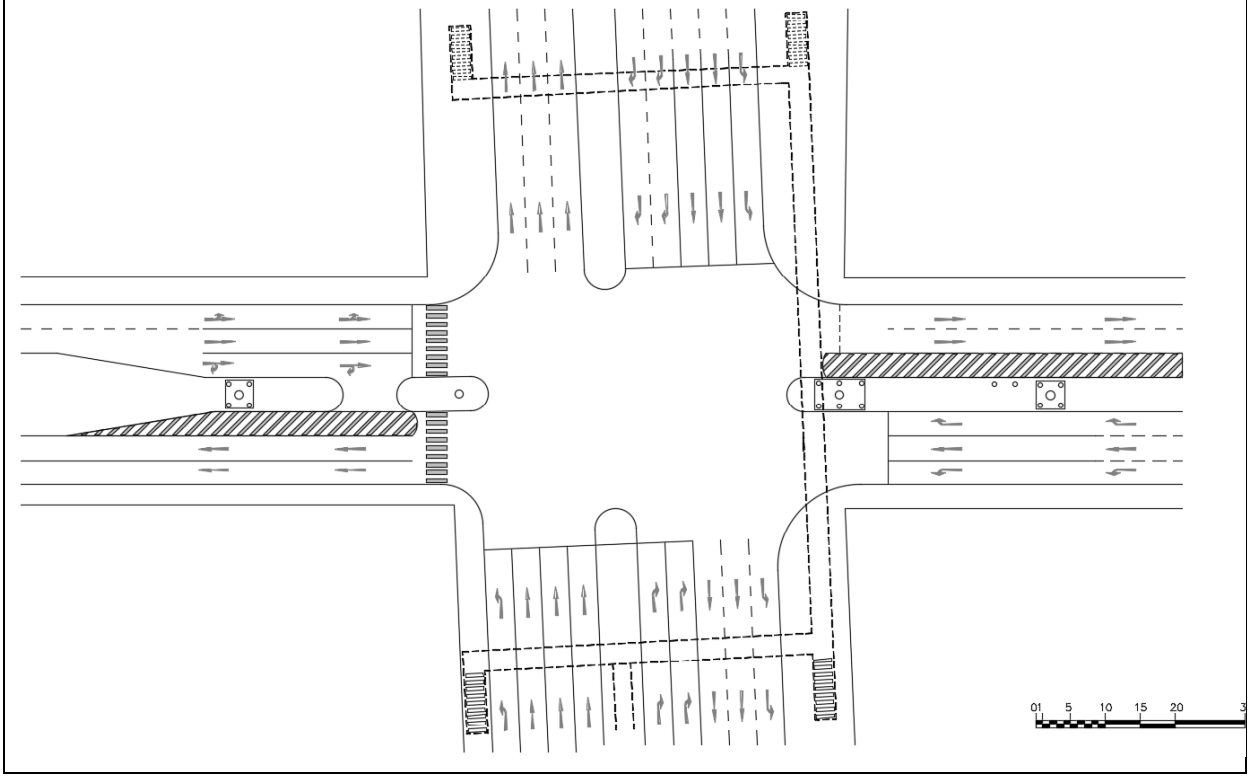
5. Manual control at specific intersections

5.1 039: Tuk Chai Intersection

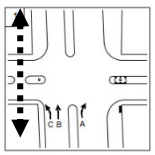
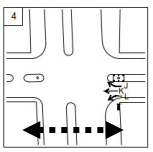
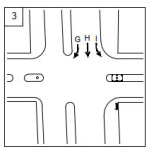
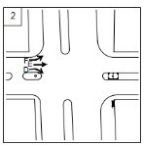
(a) Site Map

intersection number	039	Tuk Chai	

Intersection Diagram



(b) Manual operation procedures (excluding case of guarding and escorting)

Phase	1	4	3	2		
Flow diagram						
Timing to start manual operation	➢ The following incident is observed for three (3) consecutive cycles under automatic control: • When a traffic jam of 600 m or more is formulated. ← Visual observation or information on the manual control assistance device (MCAD) • When green signal is wasted due to long green time or downstream congestion. ← Visual observation ➢ When congestion extends to the intersection due to the closure of railway crossing ← Visual observation					

Timing to end manual operation	➢ When congestion decreases to 300 m or less. ← Visual observation or information on the manual control assistance device (MCAD) ➢ When cause of congestion is cleared. ← Visual observation ➢ When the queue from railway crossing is cleared. ← Visual or MCAD

Phase number is as per specified in the signal design drawing.

(c) Suggested phase duration[1]

The signal timing shown below is tentative and needs to be updated based on the latest intersection turning movement count data.

Item \ Phase		1	4	3	2	Cycle length	remarks
Shortest green time (sec)		25	25	25	25	100	
Maximum Green Time (sec)	Am peak	70	70	70	55	265	← priority
	Pm peak	70	70	70	45	270	↓ priority
	Other	70	70	70	45	255	
Automatic control time		60	65	65	40	230	(Current value)

Note: Maximum green time is set shorter to prevent extremely long cycle

(d) Specific operating instructions

(1) Common items

1. In case of green time is not effectively used, the current phase must be terminated immediately and signal must advance to the next phase. However, the minimum green time must be secured before terminating the current phase.
2. Make sure not to leave pedestrians on the pedestrian crossing, when a phase is terminated.
3. When a traffic congestion continuously exists from the downstream traffic signal, inform the situation to ATC control center.
4. When the maximum green time specified for current phase has elapsed, advance to the next phase.
5. If any of the following phenomena occurs after manual intervention, return to automatic control and investigate the cause. The results of investigation must be reported to the ATC control center to discuss and modify manual operation parameters, such as the maximum green time.[2]
   - When traffic queue along the priority direction does not decrease to 600 m or less.
   - When queue develops longer (600m or more) in all directions.
   - In case of traffic congestion caused by closure of railway crossing (when westbound traffic is blocked)

[1] If green is not terminated, cycle length becomes too long. Maximum green time is set short to resolve congestion over several cycles.

[2] If total demand equals or exceeds intersection capacity, congestion cannot be resolved. In this case, standard cycle length set under automatic control must be used or signal must be switched to automatic control.

6. If there is a traffic flow that can proceed without being affected by the blockage, the current indication shall be continued. When there are no vehicles of that flow, however, the current phase must be terminated and the signal indication must proceed to the next phase.
7. Be careful not to leave vehicles in the intersection. Do not allow too many vehicles proceed into intersection when there is no space on the exit.
8. When railway crossing opens, control must be given in the following order of priority.

   I. Priority direction
   II. Movement that is most affected by congestion downstream
   III. From the direction of the railway crossing (eastbound traffic)

   However, care must be taken not to cause another blockage by giving priority to only one direction. (Short cycle) is effective. (It is effective to control in short cycles.)

(2) During northbound traffic congestion

1. 1 Phase: In the northbound lane, when the through traffic lane is blocked by vehicles stuck in the right turn or vehicles entering or leaving the hospital, and green time is wasted, advance to the next phase. Pay attention to the crossing pedestrians.

(3) During southbound traffic congestion (priority during evening peak hour)

1. 1 Phase: In the southbound lane, when the through traffic lane is blocked by vehicles turning right, advance to the next phase.
2. 4 and 5 Phases: Pay attention to the vehicles turning left from the east approach when south exit section is congested. Left turn traffic from east approach must be controlled by police.

(4) At the time of eastbound or westbound traffic congestion

1. Phases 3 and 4: Be careful of traffic congestion at the downstream section.
2. Phase 4: Be careful of crossing pedestrians.

(e) Phase design (Reference)

The phase setting of the local controller is shown below.

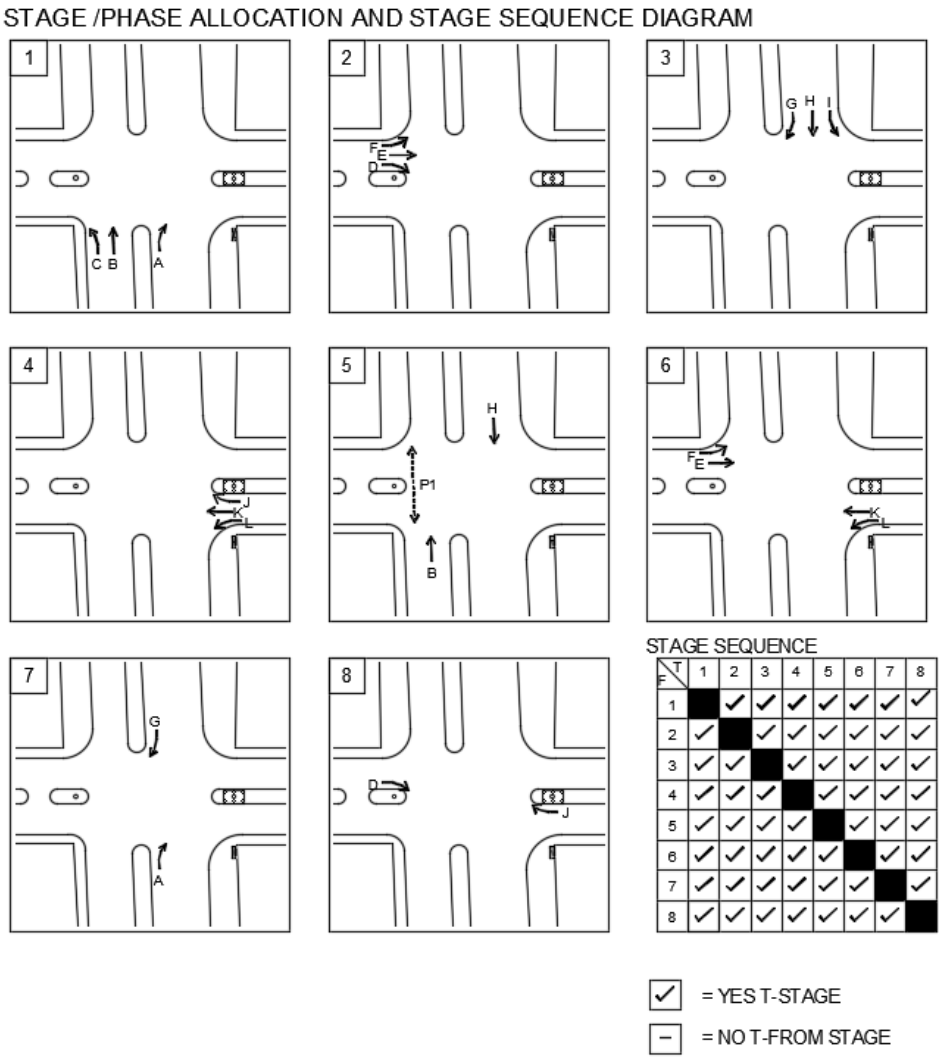
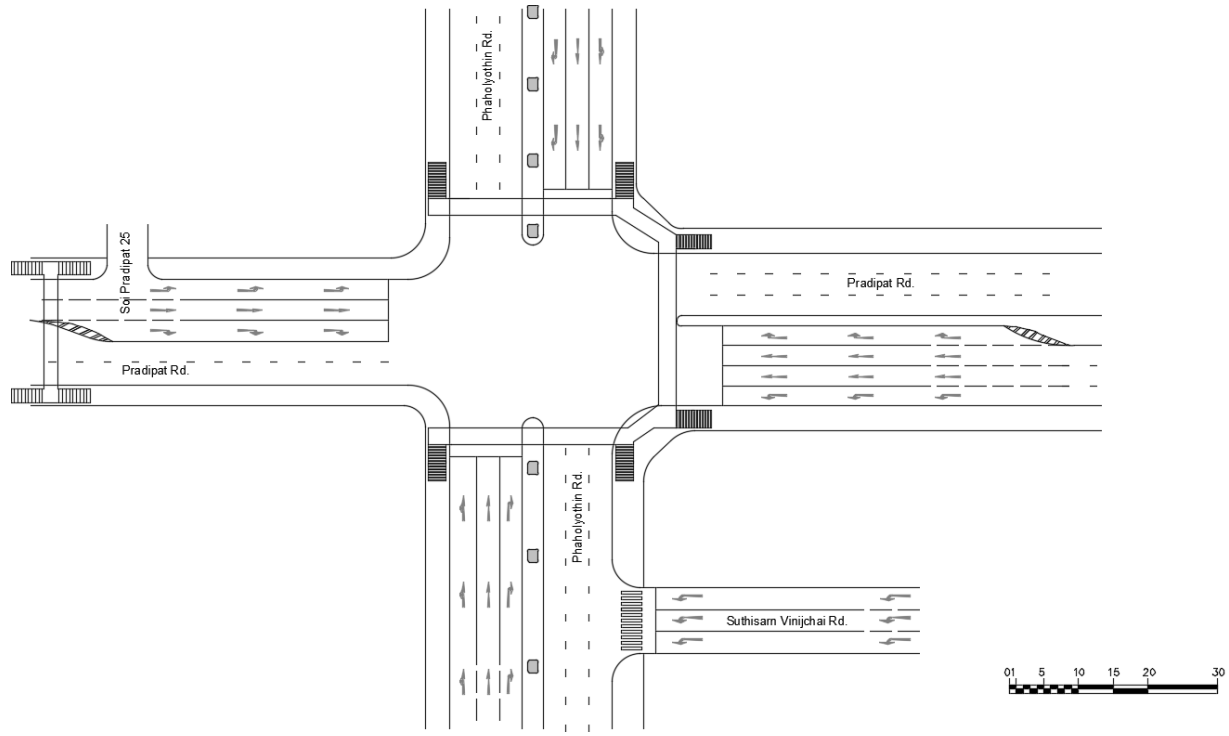


Figure 5 Signal Phase Setting for Tok Chai Intersection

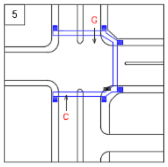
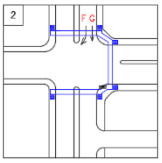
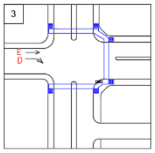
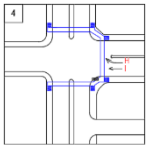
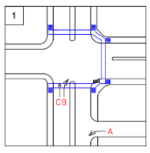
5.2 038: Saphan Kwai Intersection

(a) Site Map

Intersection number	038	Saphan Kwai	



(b) Manual operation procedures (excluding case of guarding and escorting)

Phase	5	2	3	4	1	
Flow diagram						
Goals of manual operation	➢ AM Peak Hour. Prevention/relief of northbound traffic congestion ➢ PM Peak Hour: Prevention/relief of northbound and southbound traffic congestion ➢ Other time zone: Ease traffic congestion in all directions					
Time to start manual operation	➢ The following incident is observed for three (3) consecutive cycles under automatic control: • When a traffic jam of 600 m or more is formulated. ← Visual observation or information on the manual control assistance device (MCAD)					

	• When green signal is wasted due to long green time or downstream congestion. ← Visual observation
Time to end manual operation	➢ To confirm congestion had decreased to 300 m or less. ← Visual observation or information on the manual control assistance device (MCAD) ➢ To confirm whether cause of congestion is cleared or not ← Visual observation

(c) Suggested phase duration[3]

The signal timing shown below is tentative and needs to be updated based on the latest intersection turning movement count data.

Item \ Phase		1	2	3	4	5	Cycle length	Remarks
Shortest green time (sec)		20	20	20	20	20	100	
Maximum Green Time (second)	Am peak	90	45	60	60	45	300	↑ priority
	Pm peak	90	60	60	60	30	300	↕ priority
	Other	70	45	60	60	45	280	
Automatic control time		50	30	50	50	30	210	reference

(d) Specific operating instructions

(1) Common items

1. In case of green time is not effectively used, the current phase must be terminated immediately and signal must advance to the next phase. However, the minimum green time must be secured before terminating current phase.
2. Make sure not to leave pedestrians on the pedestrian crossing, when a phase is terminated.
3. When a traffic congestion continuously exists from the downstream traffic signal, inform the situation to ATC control center.
4. When the maximum green time specified for current phase has elapsed, advance to the next phase.
5. If any of the following phenomena occurs after manual intervention, return to automatic control and investigate the cause. The results of investigation must be reported to the ATC control center to discuss and modify manual operation parameters, such as the maximum green time.[4]

➢ When traffic queue along the priority direction does not decrease to 600 m or less.

➢ When queue develops longer (600m or more) in all directions.

(2) Congestion along northbound traffic (priority direction during morning and evening peak

[3] If green is not terminated, cycle length becomes too long. Maximum green time is set short to resolve congestion over several cycles.

[4] If total demand equals or exceeds intersection capacity, congestion cannot be resolved. In this case, standard cycle length set under automatic control must be used or signal must be switched to automatic control.

hours)

1. Phase 1: In the northbound lane, when vehicles going north are blocked by vehicles stuck in the right-turn lane, advance to the next phase.
2. 5φ: Be careful not to block the through vehicle.
3. (Since the next indication also allows northward movement, yield with a margin of 1φ.)
4. Left turns from the west direction are always allowed, so special attention should be paid when a blockage occurs.

(3) During southbound traffic congestion (priority during evening peak hour)

1. 1φ: In the southbound lane, when the right-turning lane is blocked by vehicles stuck in the right-turning lane, walk forward.
2. 4 and 5φ: When a left-turning vehicle from the east direction moves southward, special attention should be paid when a blockage occurs ahead. (Proposed countermeasure: Traffic control by police officers)

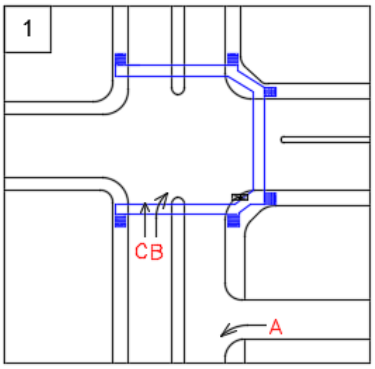
(4) Priority for eastbound and westbound traffic

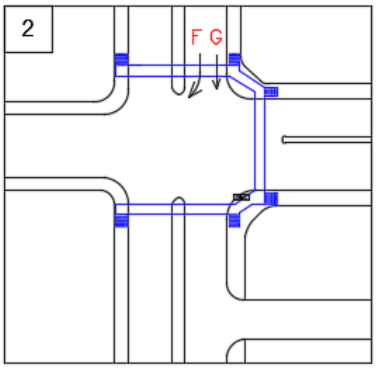
1. 3φ and 4φ: Pay attention to the congestion at the downstream section.

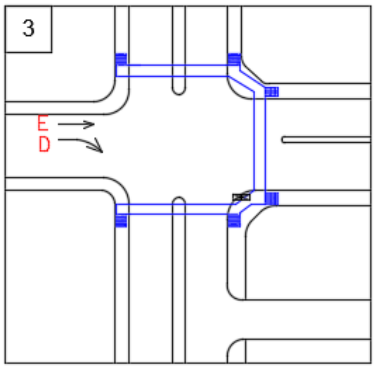
(e) Phase design (Reference)

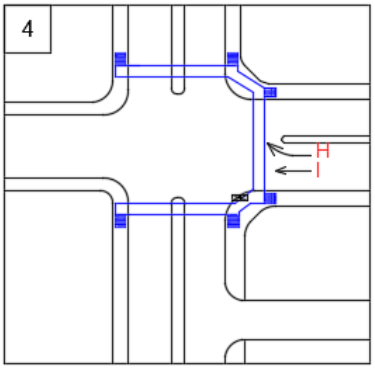
The phase setting of the local controller is shown below.

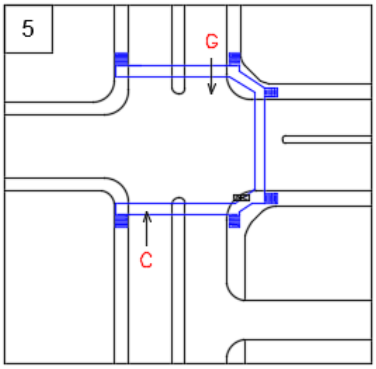
STAGE /PHASE ALLOCATION AND STAGE SEQUENCE DIAGRAM

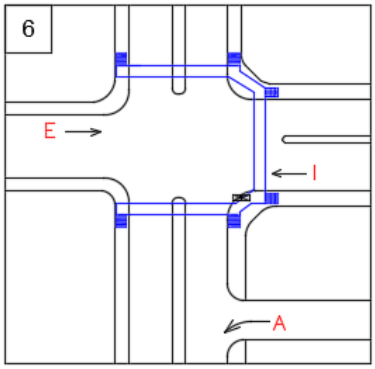


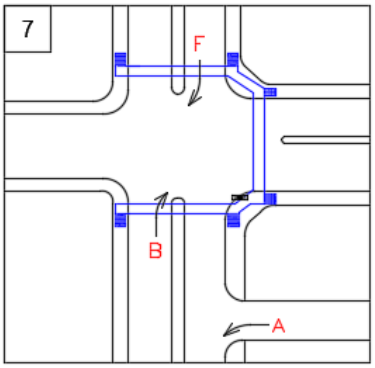


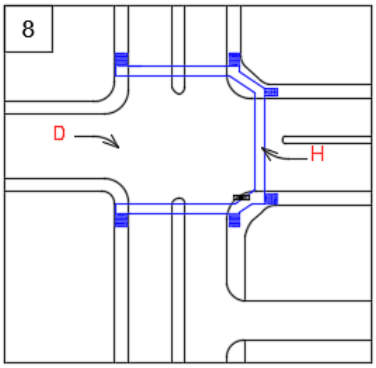












STAGE SEQUENCE

F \ T	1	2	3	4	5	6	7	8
1	■	✓	✓	✓	✓	✓	✓	✓
2	✓	■	✓	✓	✓	✓	✓	✓
3	✓	✓	■	✓	✓	✓	✓	✓
4	✓	✓	✓	■	✓	✓	✓	✓
5	✓	✓	✓	✓	■	✓	✓	✓
6	✓	✓	✓	✓	✓	■	✓	✓
7	✓	✓	✓	✓	✓	✓	■	✓
8	✓	✓	✓	✓	✓	✓	✓	■

✓ = YES T = STAGE

– = NO F = FROM STAGE

Appendix A.

Major Causes of Traffic Congestion and Countermeasures (draft)

Most of traffic congestion is not necessarily caused by a single incident listed below. Thus, it is necessary to understand fully the cause of congestion and develop countermeasures in a comprehensive manner.

Causes of traffic congestion		Countermeasures (Draft)	Issues, etc.
1. Restrictions on passage	Traffic signals	• Longer green time	• Congestion in other directions
	Railroad crossing	• Reduction of closed time of level railway crossing • Coordinated operation of signal with railway crossing	• Coordination with railway operators • Cost of improvement work
2. Lane reduction	Accident, car broken down	• Prompt processing • Traffic dispersal by providing traffic information	• Accident processing system
	Stopping or parking at prohibited location	• Traffic enforcement	• Traffic Enforcement System
	Road work	• Coordination of construction dates and times (avoidance of congestion) • Providing traffic information • Detour information	• Prior notification • Cooperation of construction companies
	U-turn road	• Efficient control of U-turn vehicles (actuated signal, formation of vehicle platoon) • Closure of U-turn lanes	• survey
	Reversible lane	• Confirmation of effectiveness and impact	• survey
	Decrease in width	• Road widening/improvement • Improvement of pavement markings	• Project cost
3. Decrease in speed	Access to off-street facilities	• Guidance by traffic aids • Improvement of entrance/exit layout	• Company OR commercial facilities have different hours • Cooperation of related agencies
	Jaywalking	• Traffic Instruction • Traffic safety education • Installation of pedestrian signal with push-button	• Guidance and education system
4. Concentration of traffic		• Road concentration • Traffic demand management (TDM) • Area Traffic Control System	• Future plan • Project Cost

Annex 13

Manual Control Analysis

Manual Control Analysis

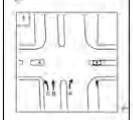
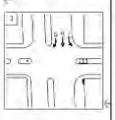
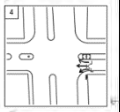
2022/10/19
Atsushi Suganuma（Traffic signal control）

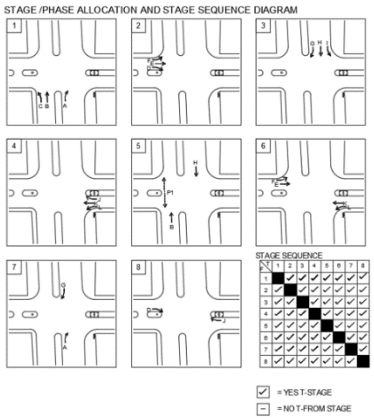
1. Introduction

With the introduction of ATC system and connection of local controllers with the center server system installed at BMA2, it became to record signal operation log. The log shows 1) whether signal operate in automatic mode or manual mode and 2) Phase No. implemented and its duration. Preliminary analysis was made on the operation record of two signals, Tuck Chai (039) and Victory Monument (255) Analysis. Findings of the analysis is presented below.

2. Int39 Tuk Chai

2.1 Phase Sequence (Current) Phase Diagram(Current)

Phase	1	3	4	6
Flow diagram				



2.2 Actual state of operation

- Manual control is applied during morning peak hours.
- The signal is operated most of the time under automatic control after the morning peak.
- Manual control is not implemented on Saturdays and Sundays
- During manual control, green time is shorter for north-south traffic and congestion occurs along north and south approaches.
- Green time tends to be longer during manual control, about twice longer than automatic control.
- There are operations that are suspected of not ensuring the necessary green time（8/3 pattern5, 8/4 pattern3）
- Analysis of phase pattern used, its frequency, and split, manual controls are intended to give more time to the eastbound traffic (pattern 2, which is not used by the automatic control).

2.3 Issues identified

(1) **Green time too long**

The long green time at an intersection for an approach sends more traffic to the downstream intersection, where green time must be made long to process the excessive traffic. Such operation causes long queue on other approaches causing long waiting time. Excessive priority given to one direction causes a chain of adverse effects on other approaches.

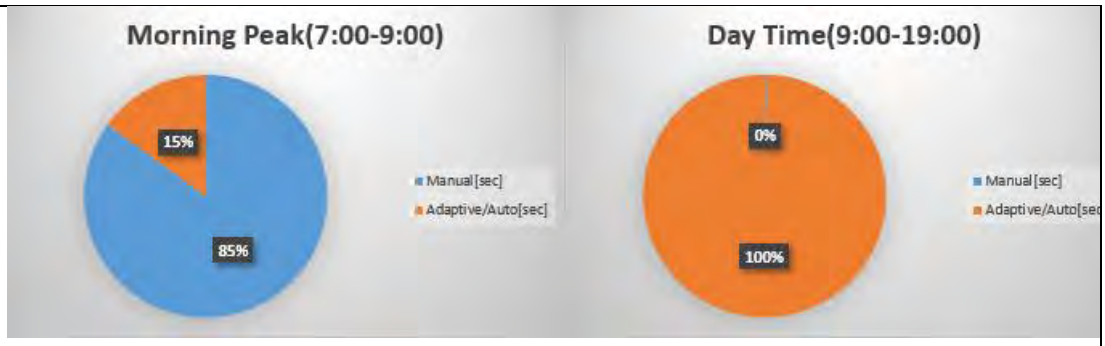
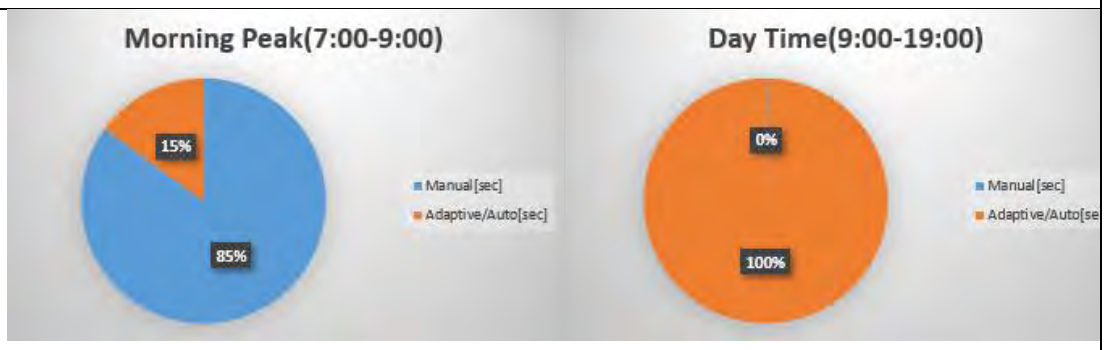
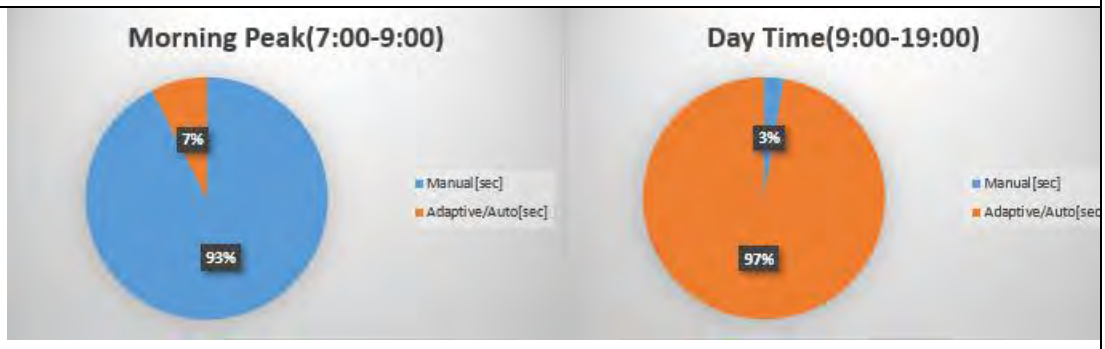
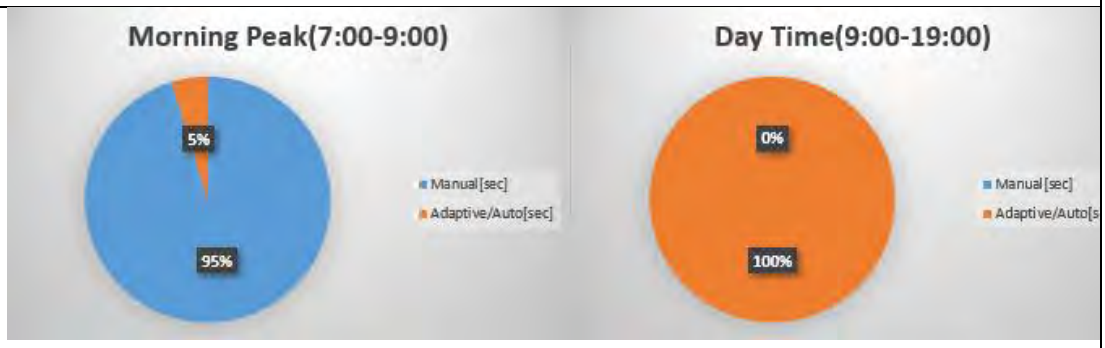
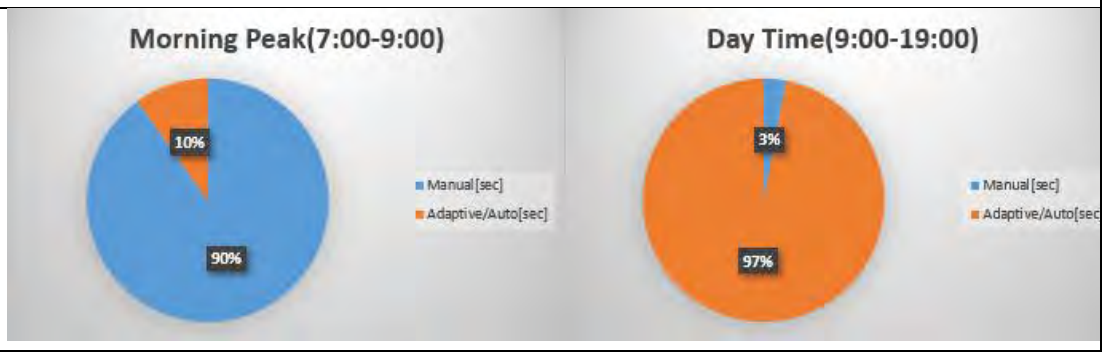
(2) **Manual control at specific times of the day**

Manual control is implemented at the same time every day for the morning peak. In addition, since the timing parameters (splits) are similar most of the time, there would be no need for manual control if the timing parameter of manual control are set in automatic control.

(3) **Fixed timing parameter under automatic control**

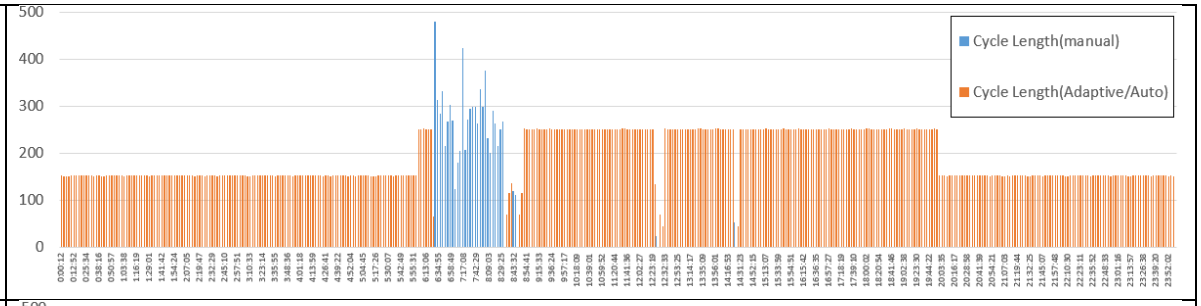
As traffic flow changes throughout the day, the system must operate automatically with the timing parameters suitable for changing traffic patterns. The existing system applies the same timing parameters throughout a day. Fixed automatic operation makes it necessary to resort to manual control.

2.4 Control mode（Morning peak 7:00-9:00/Day Time9:00-19:00）

8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	
8/5 Fri	

2.5 Cycle length

8/1 Mon



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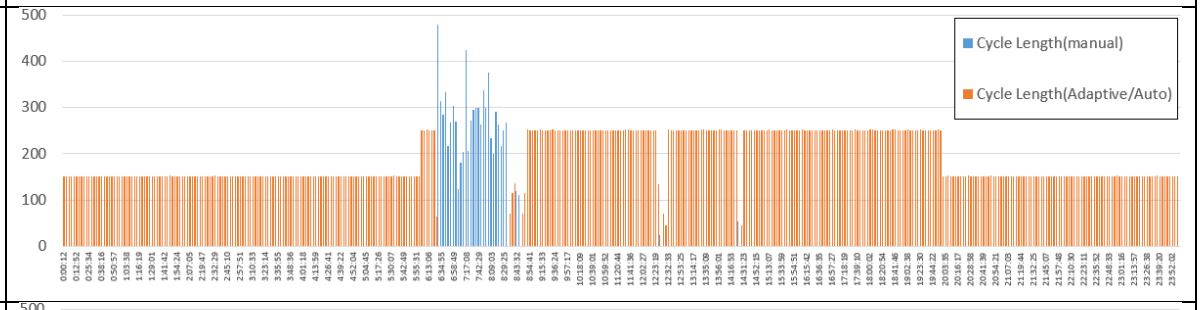

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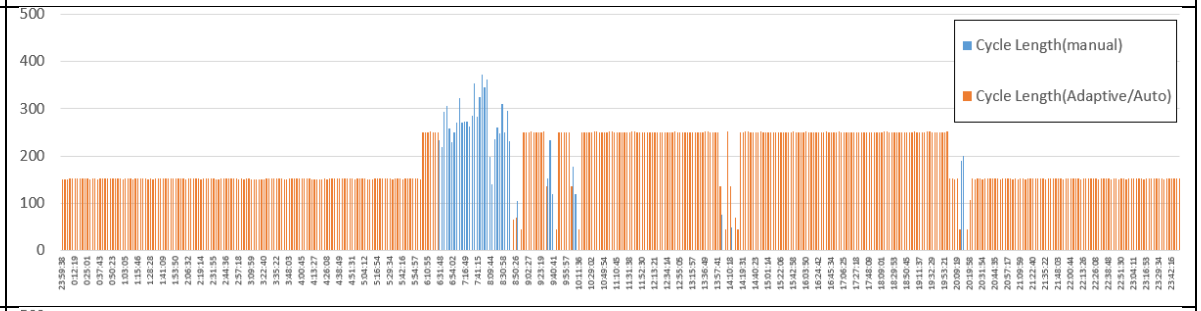

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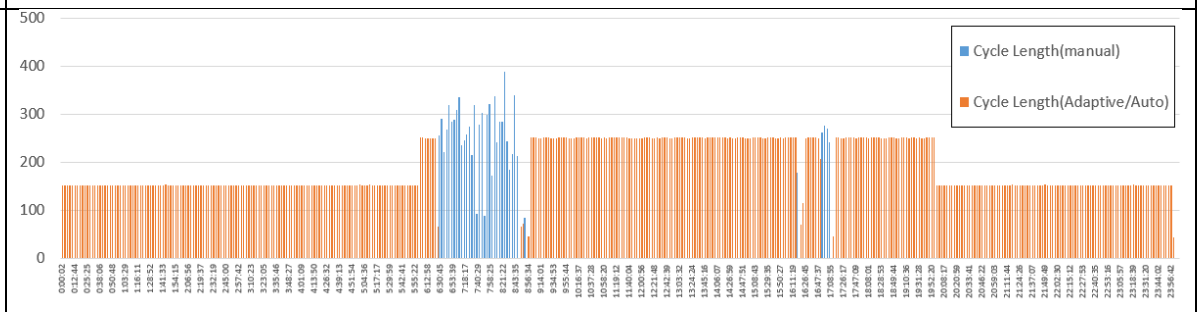

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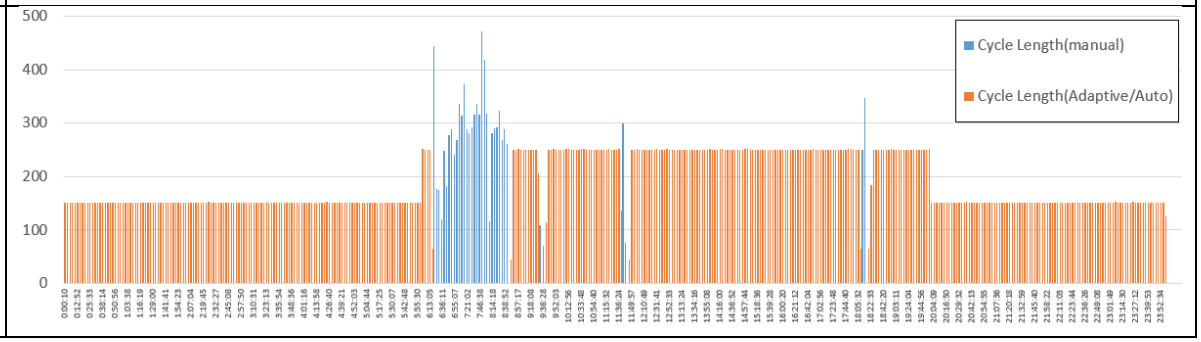
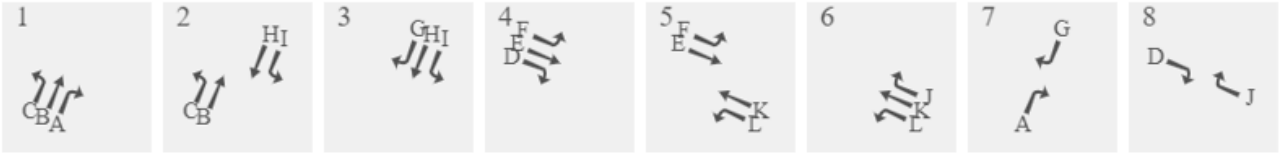
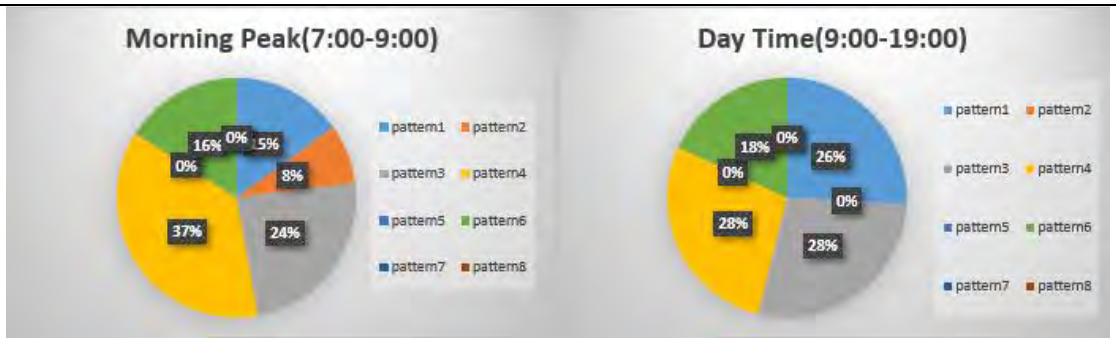
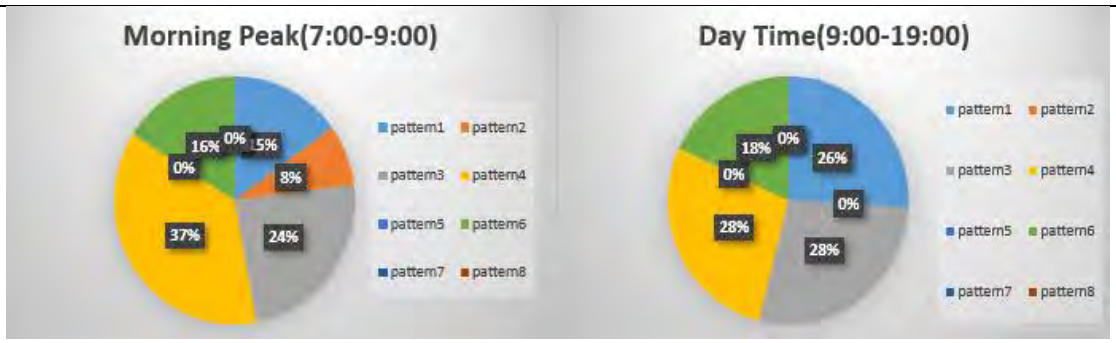
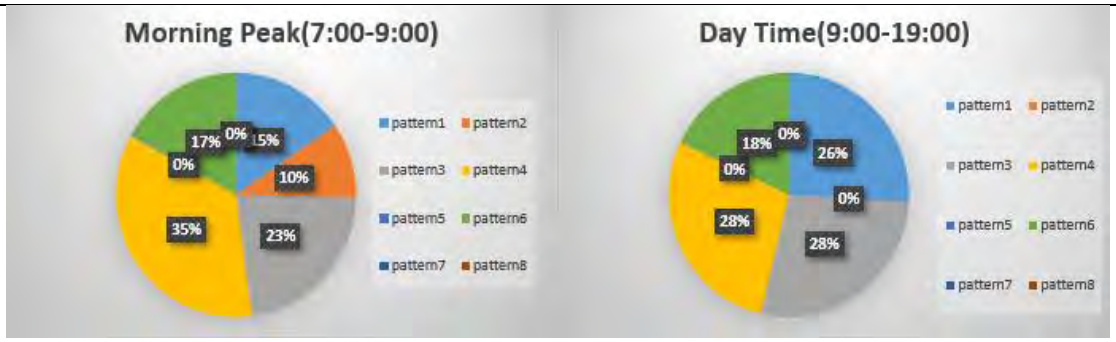
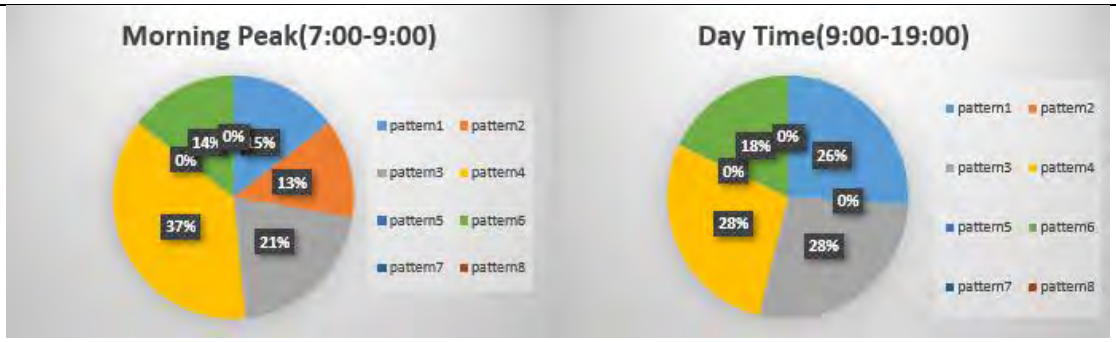
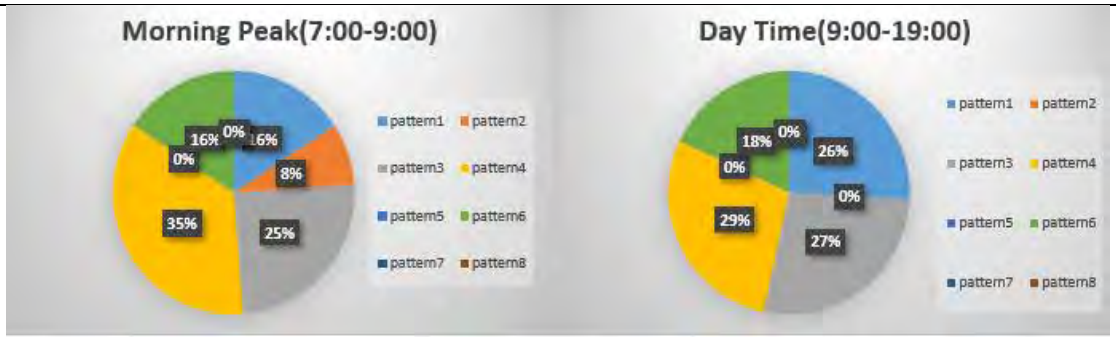


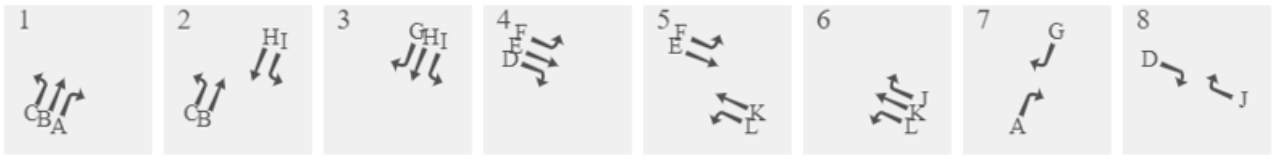
2.6 Split

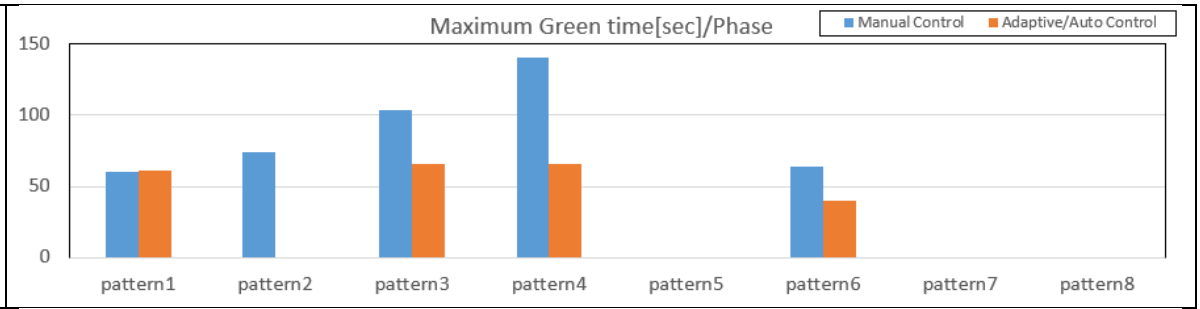
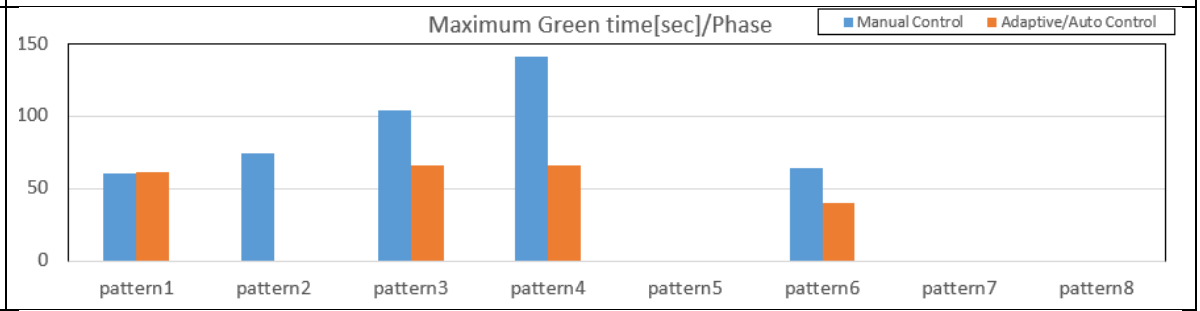
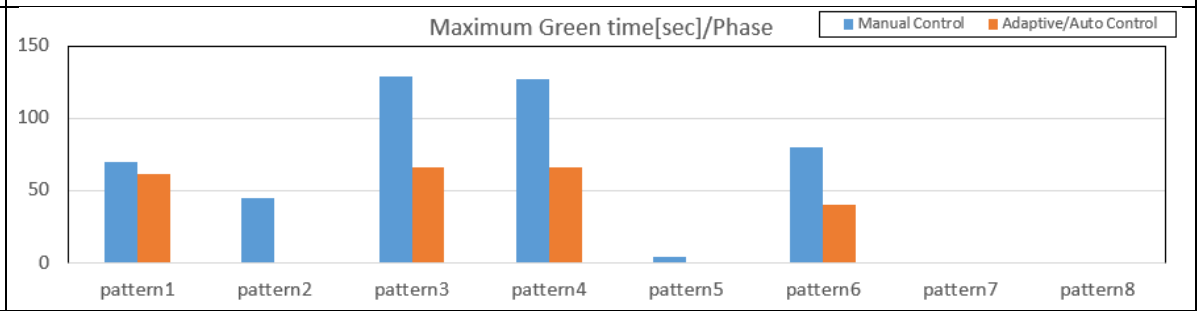
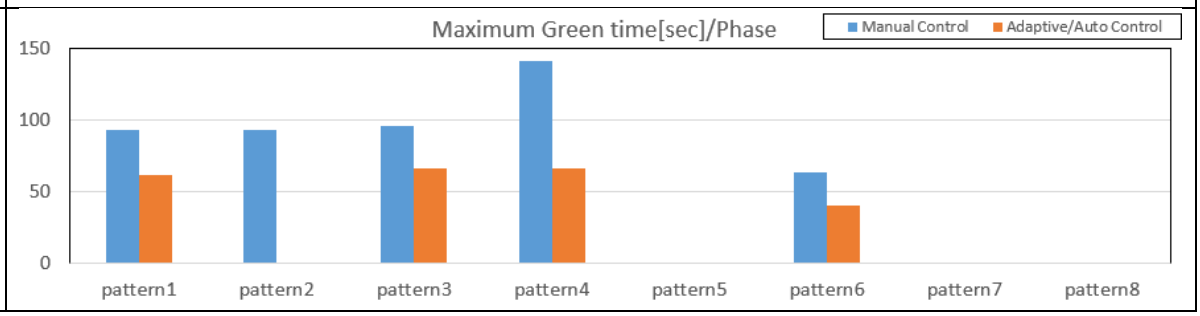


8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	

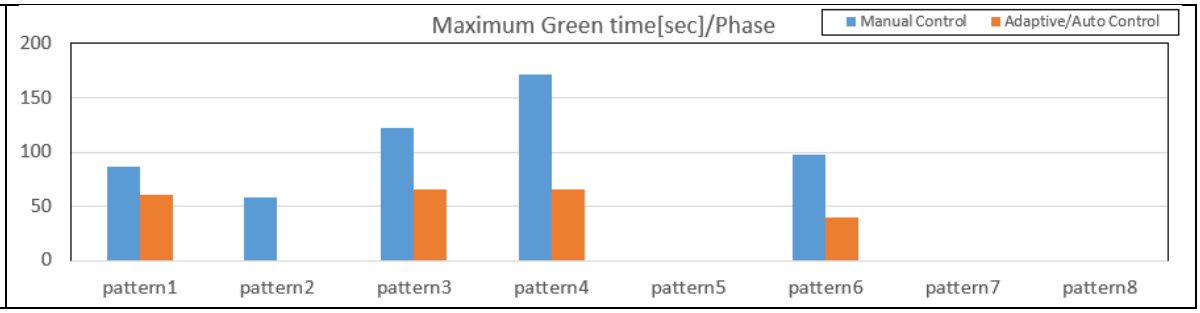
8/5 Fri	

2.7 Maximum green time

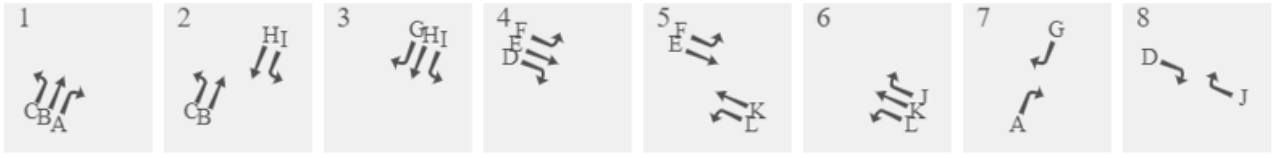


8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	

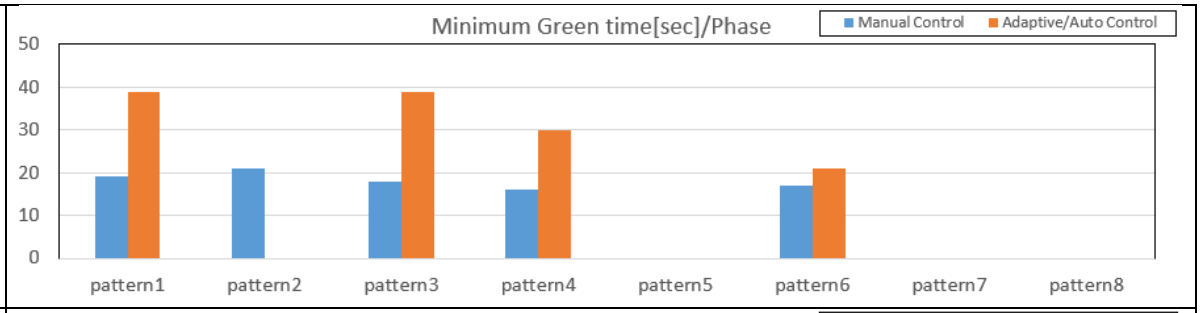
8/5 Fri



2.8 Minimum green time



8/1 Mon



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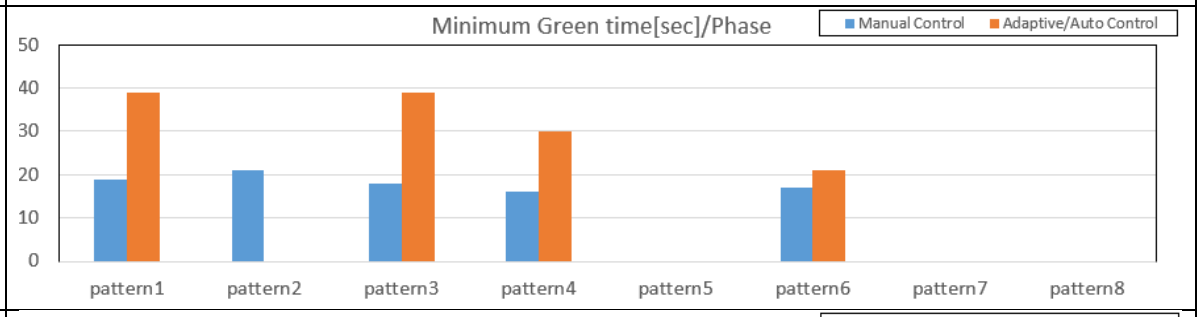

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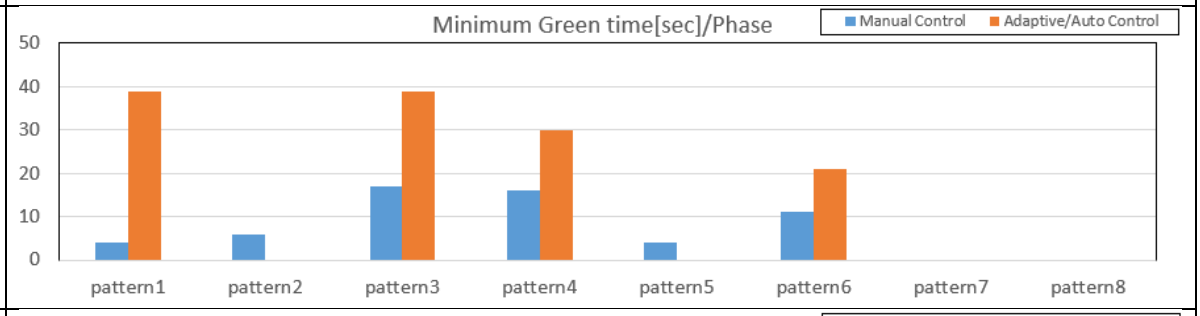
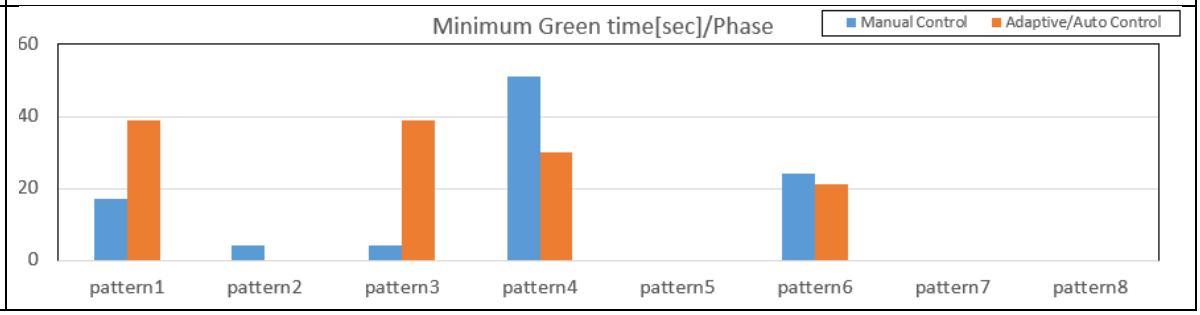


8/4 Thu



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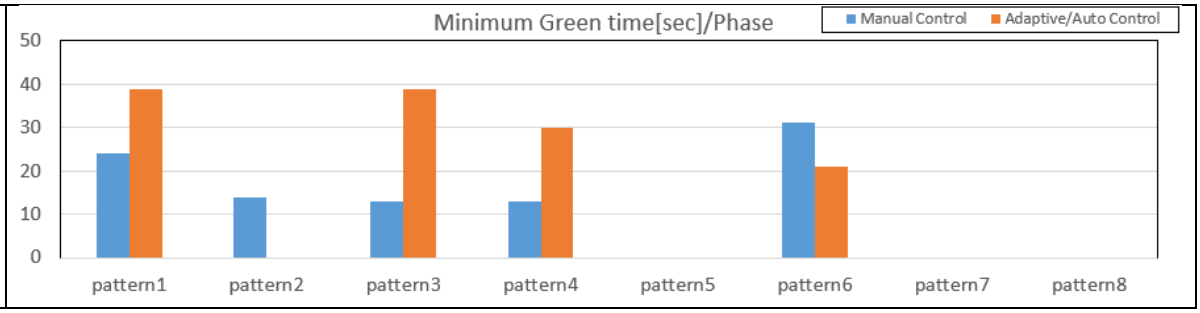
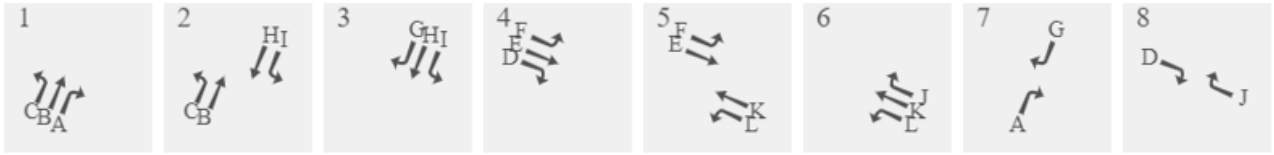
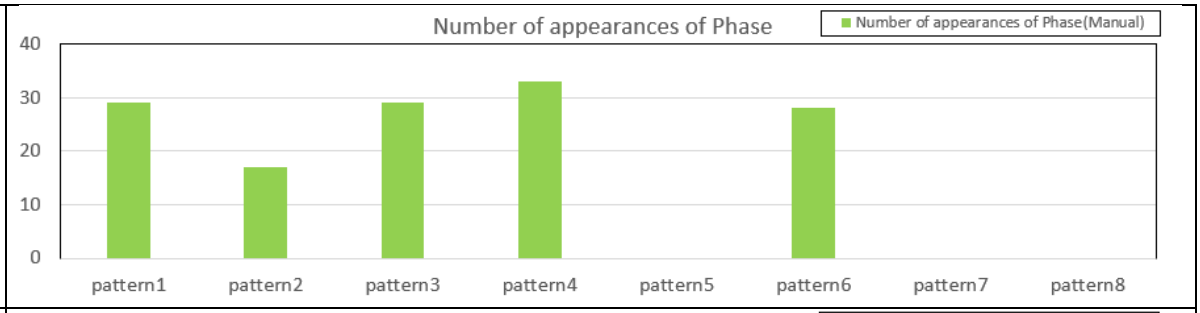


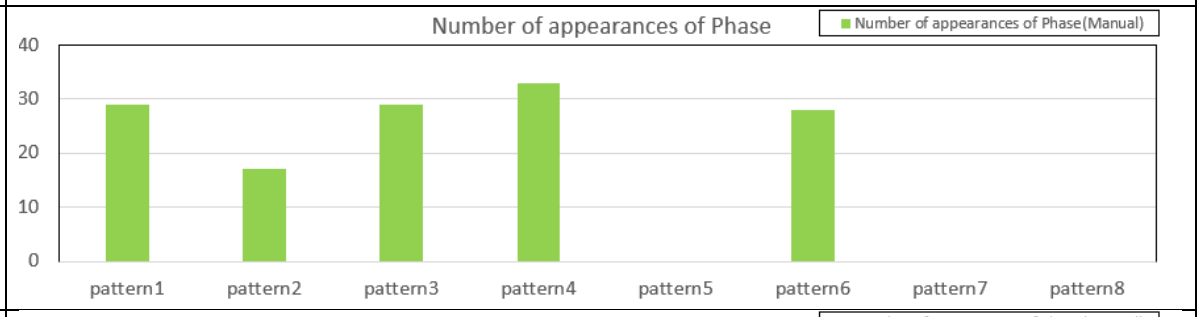
2.9 Number of occurrences of Phase Pattern (Manual Control)



8/1 Mon



8/2 Tue



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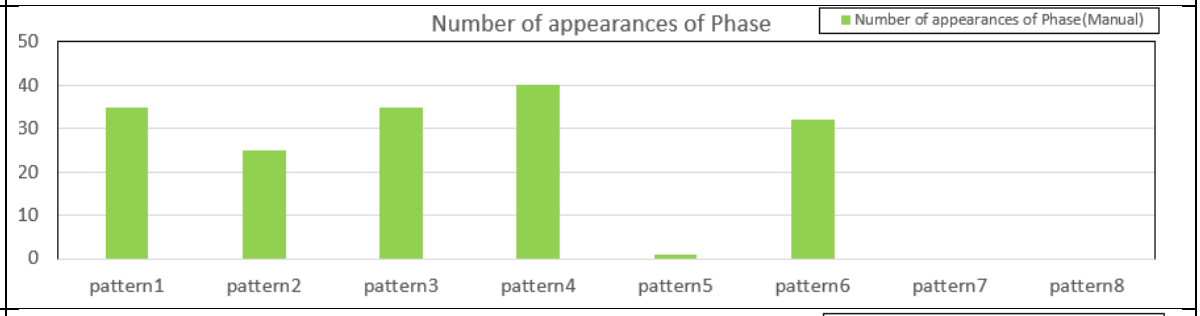
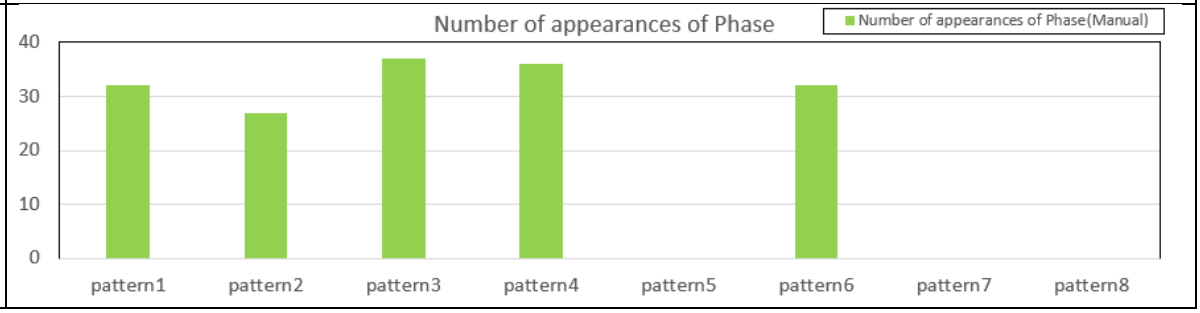
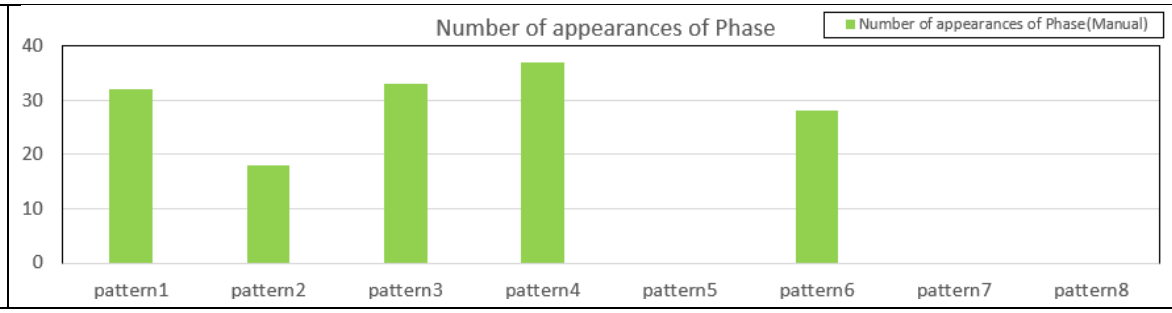
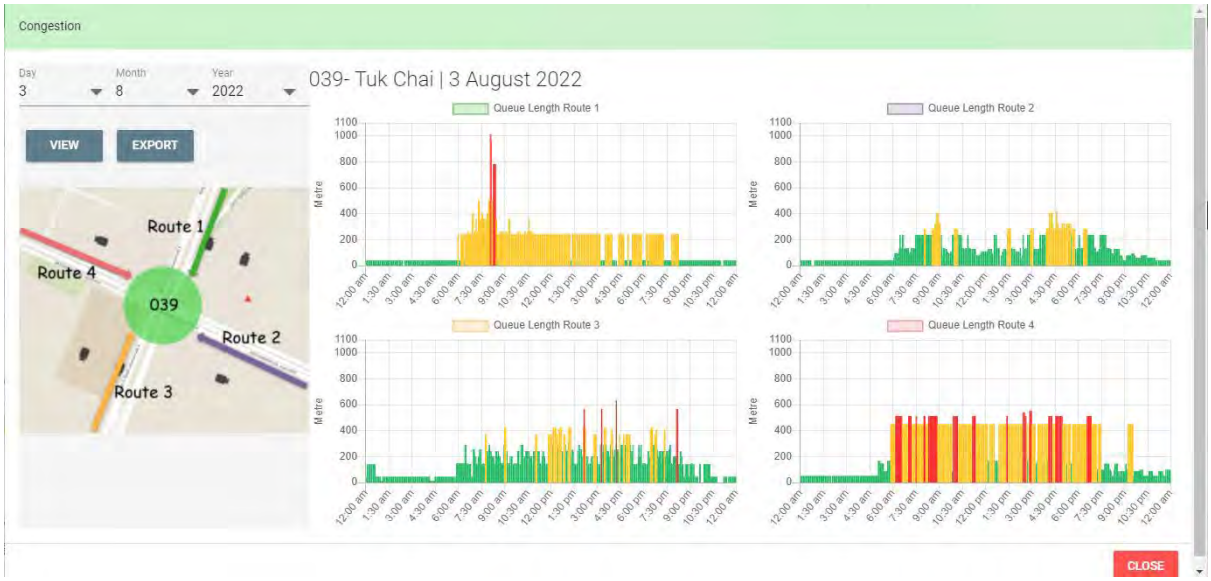


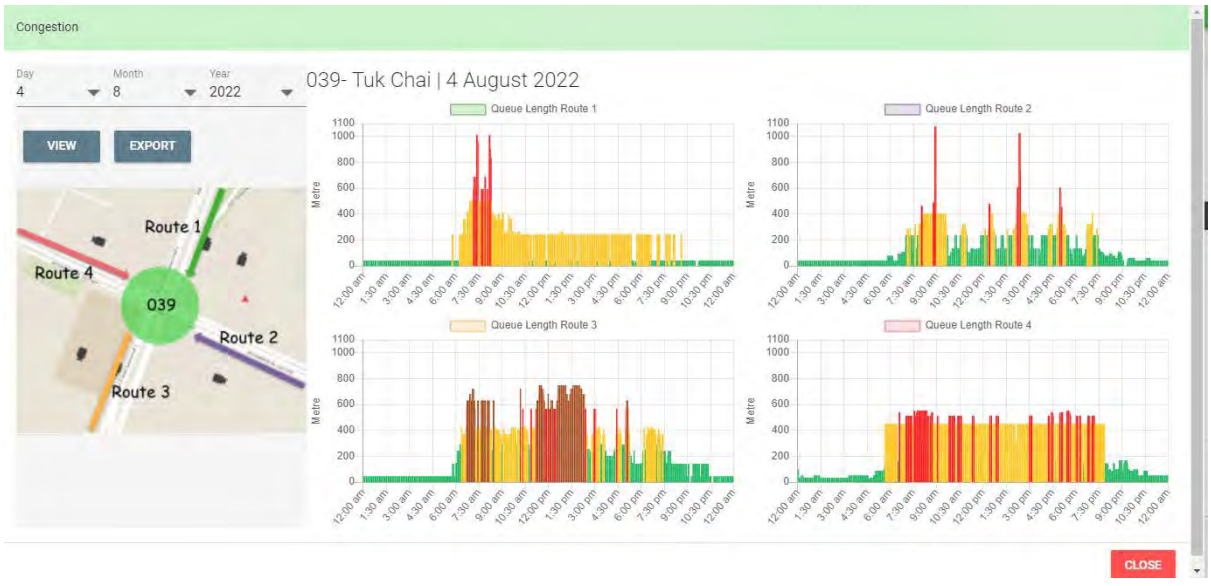
8/4 Thu

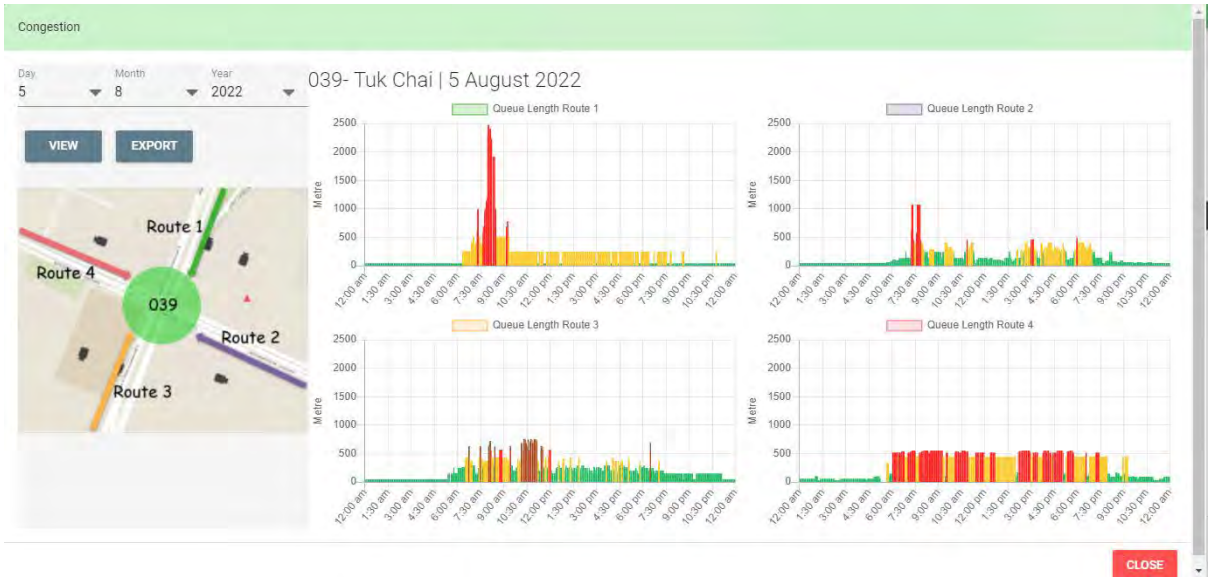


8/5 Fri	

2.10 Traffic congestion（Data not available for 8/1,8/2）

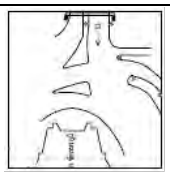
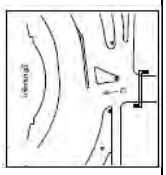
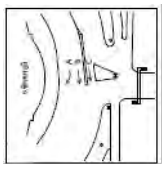
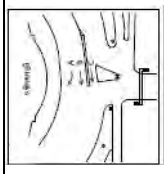
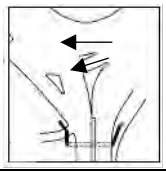
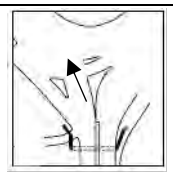
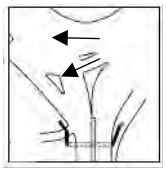
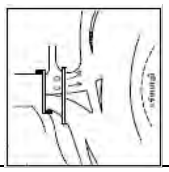
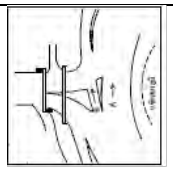
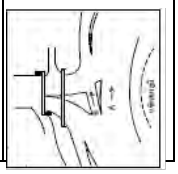


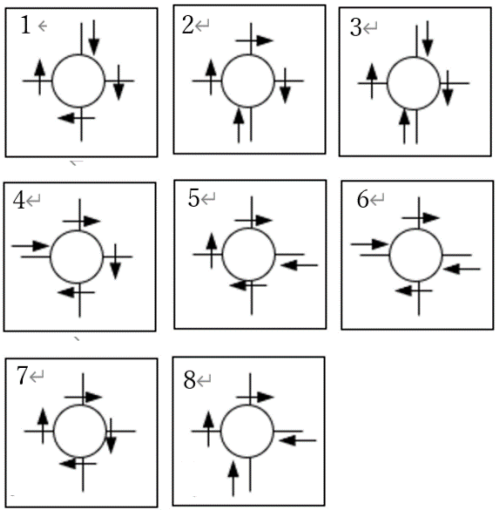



Congestion
Day
5
Month
8
Year
2022
VIEW
EXPORT
039- Tuk Chai | 5 August 2022
Route 1
Route 2
Route 3
Route 4
039
Queue Length Route 1
Queue Length Route 2
Queue Length Route 3
Queue Length Route 4
Metre
CLOSE

3. Int255 Victory Monument

3.1 Phase Sequence (Current) and Phase Diagram (Current)

Phase	6	3	7
Flow diagram 254			
Flow diagram 255			
Flow diagram 256			
Flow diagram 257			



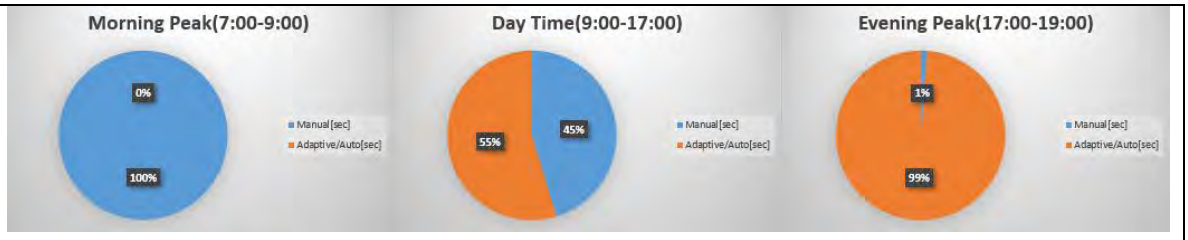
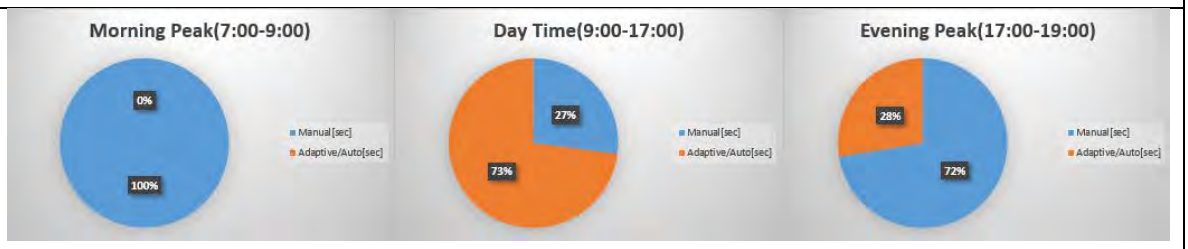
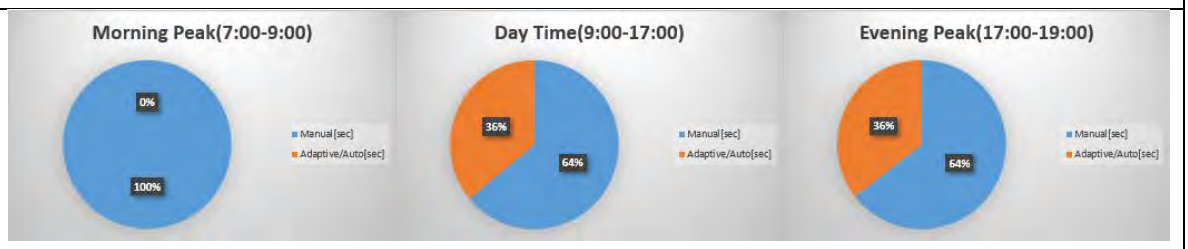
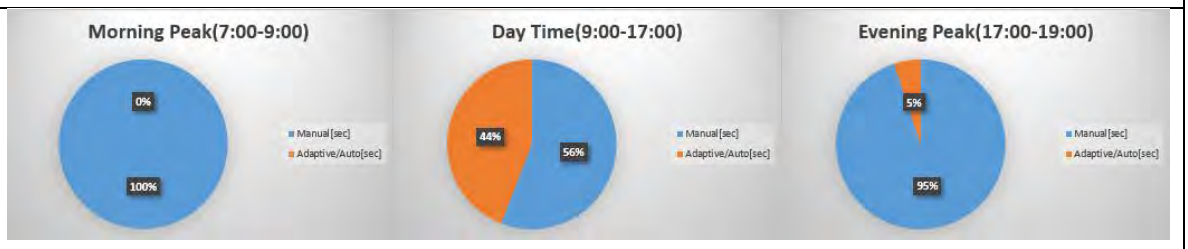
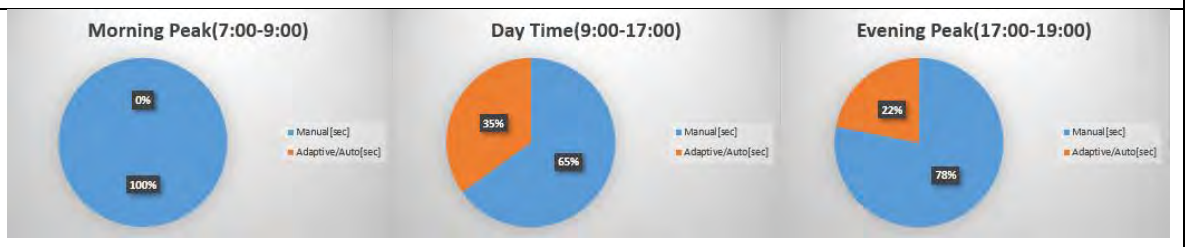
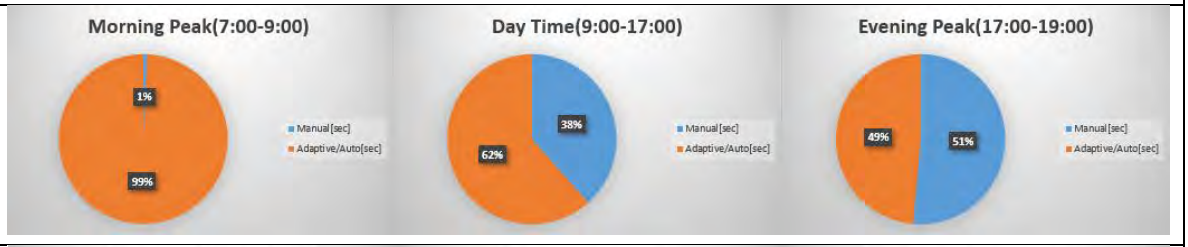
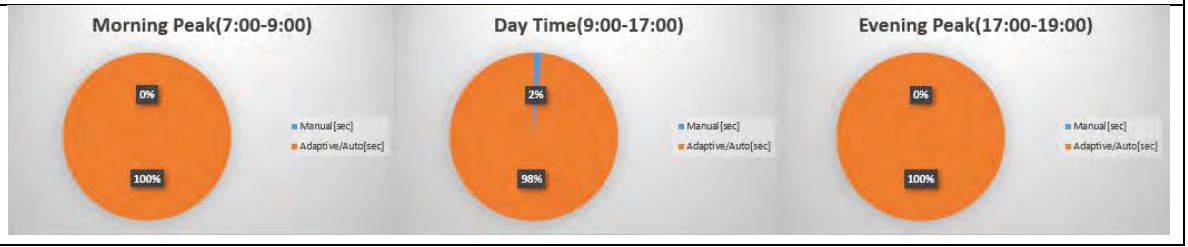
3.2 Actual state of operation

- Morning peak operation relies on manual control
- After the morning peak, the system is operated by manual and automatic control.
- Manual control is also used on Saturdays and Sundays depending on traffic congestion.
- The maximum green time tends to be longer under manual control than under automatic control (200 seconds per green display).
- The number of times the phase pattern appears during manual control indicates that all patterns are used.

3.3 Problems identified

- Because of the problem intersection, the operation time for manual control is also long. Because of the large size of the intersection and the complexity of the traffic flow, it is difficult to continue optimal operation by manual control itself.
- No regularity in manual control can be found. Extreme changes in green time and irregular signal indications are not recommended because they cause confusion for drivers.
- Westbound outflow areas are prone to blockages. In such areas, control should be done while taking care to control excessive feeds and to prevent the occurrence of pre-emergency jams.
- In automatic control, the same parameters are operated throughout the day, and control cannot respond to changes in traffic conditions. This is another reason for relying on manual operation.

3.4 Control mode（Morning peak 7:00-9:00/Day Time 9:00-17:00/Evening peak 17:00-19:00）

8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	
8/5 Fri	
8/6 Sat	
8/7 Sun	

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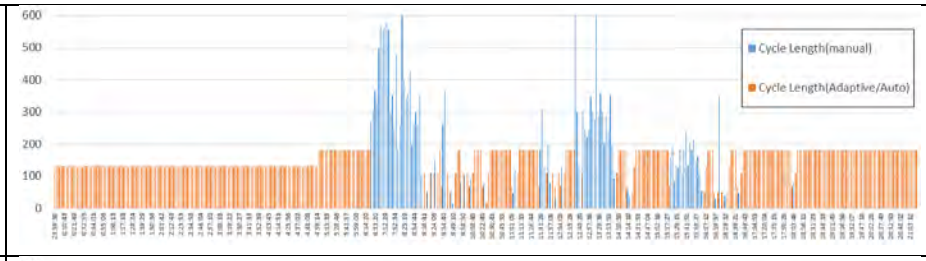
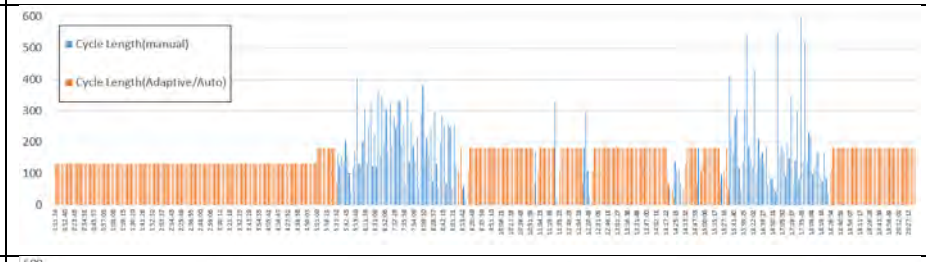
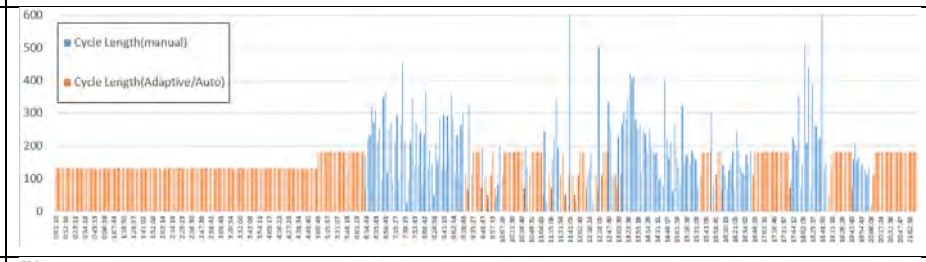
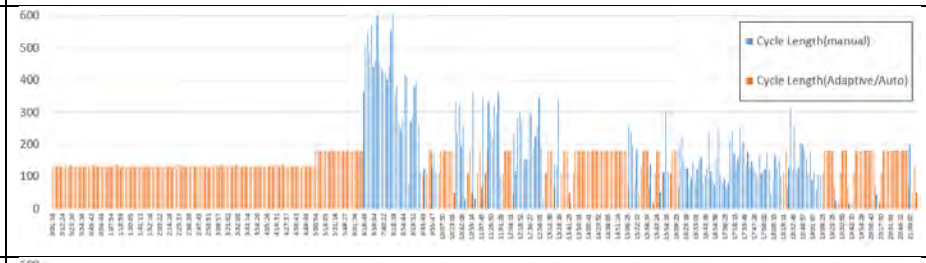
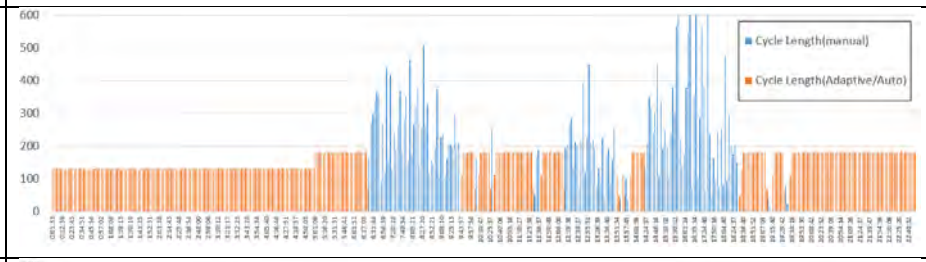
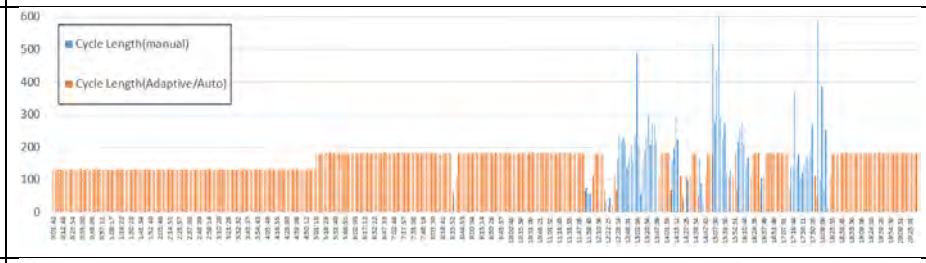
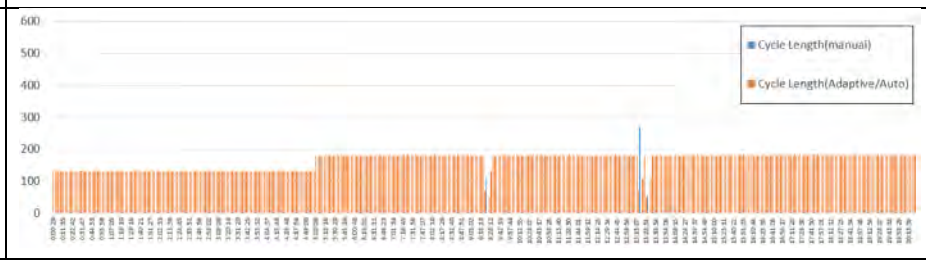
8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	
8/5 Fri	
8/6 Sat	
8/7 Sun	

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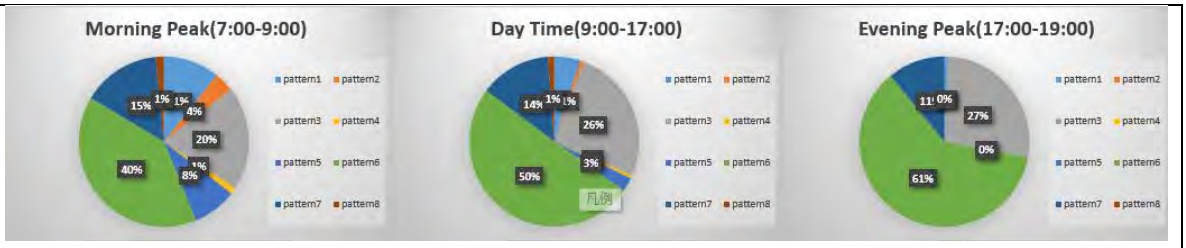
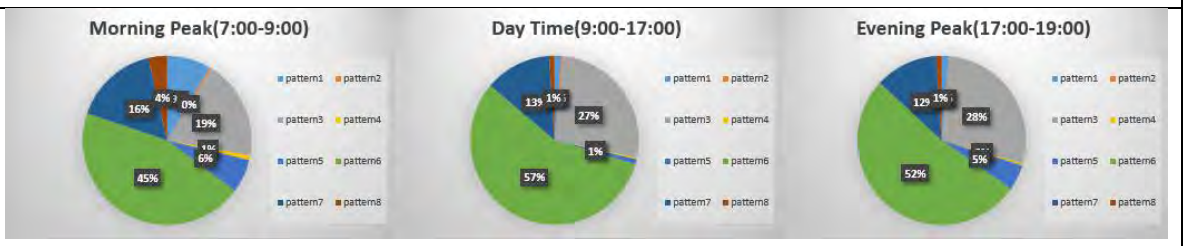
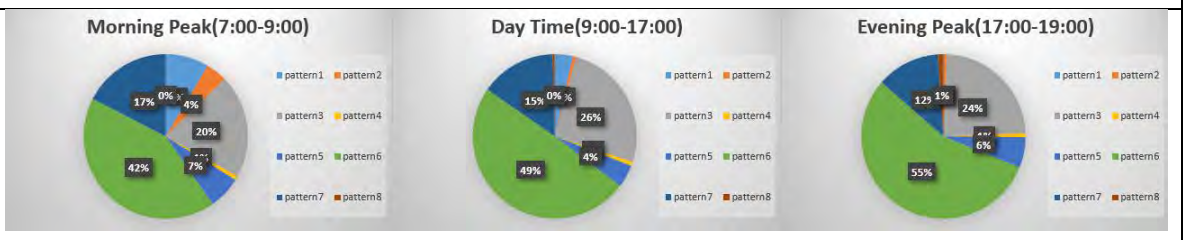
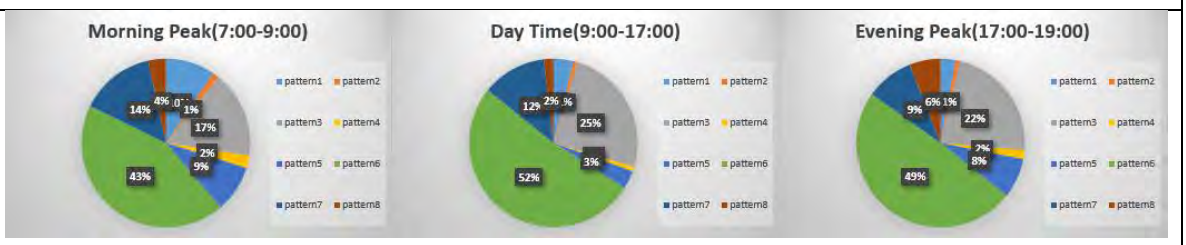
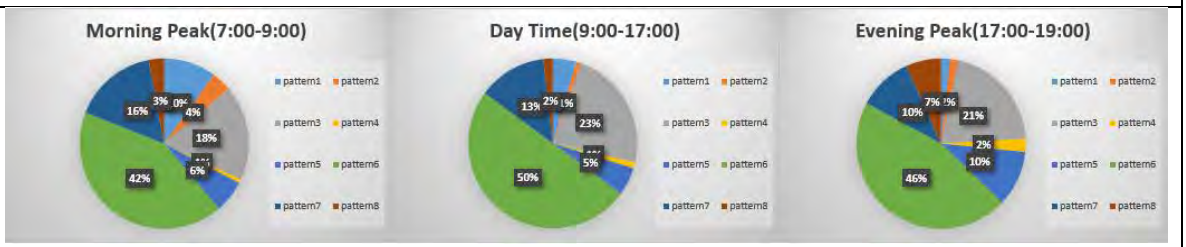
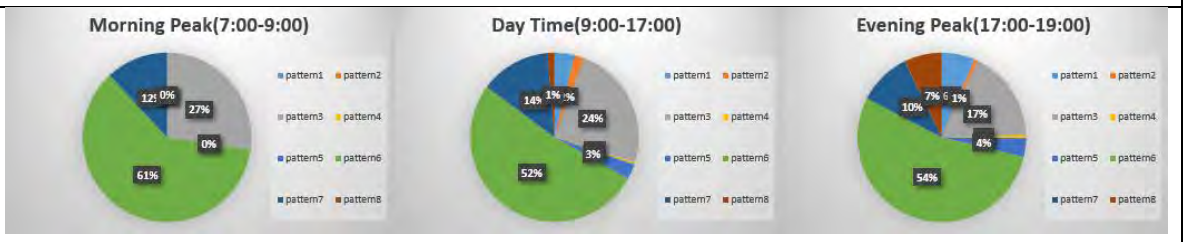
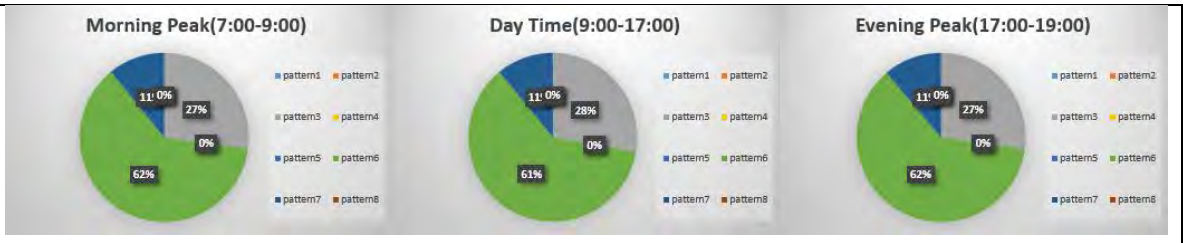
8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	
8/5 Fri	
8/6 Sat	

8/7 Sun	

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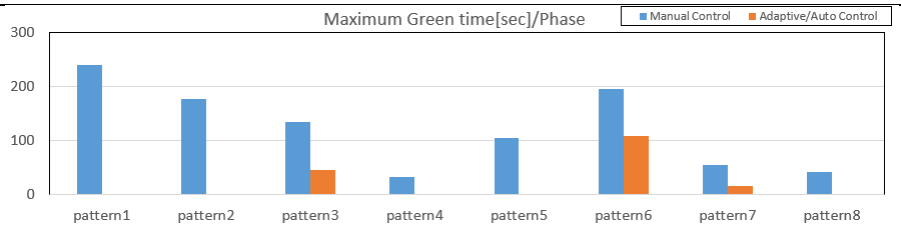
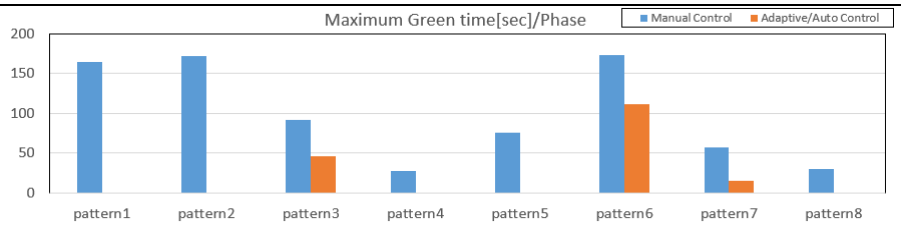
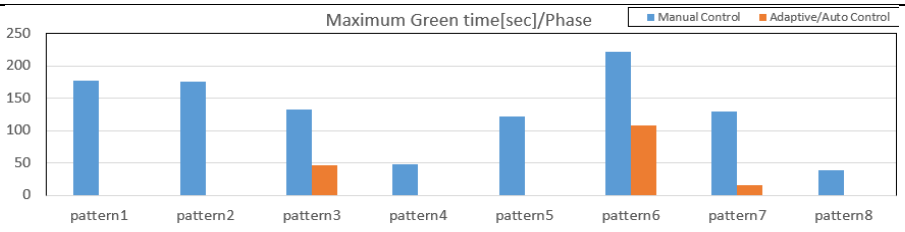
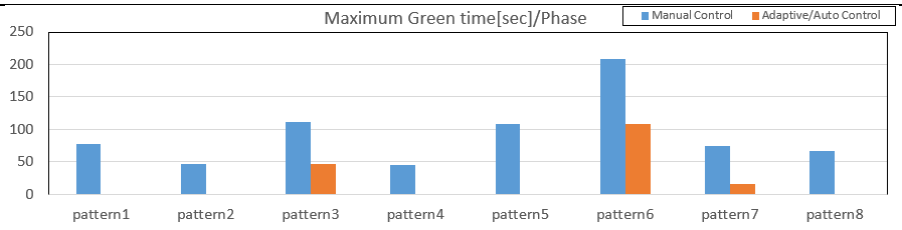
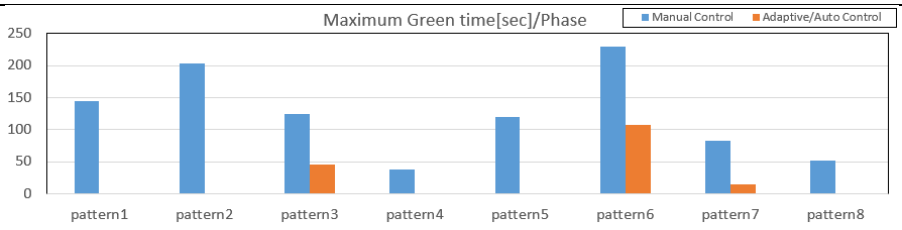
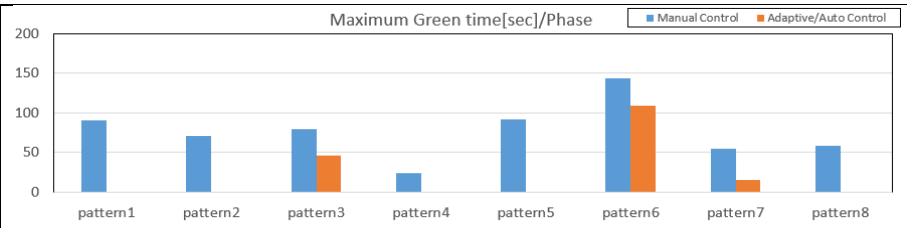
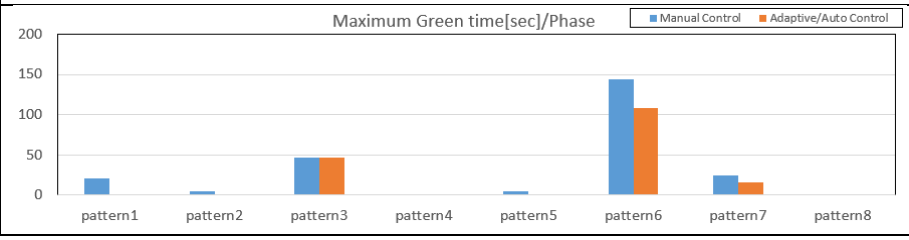
8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	
8/5 Fri	

8/6 Sat	
8/7 Sun	

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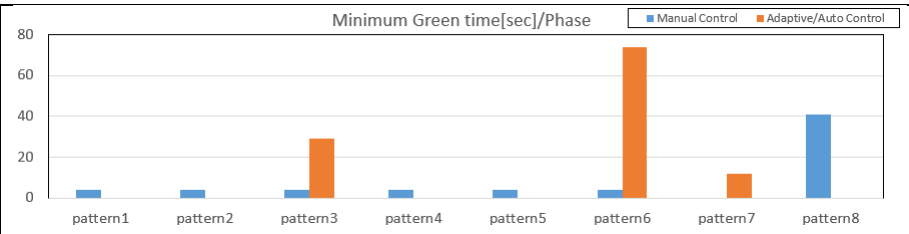
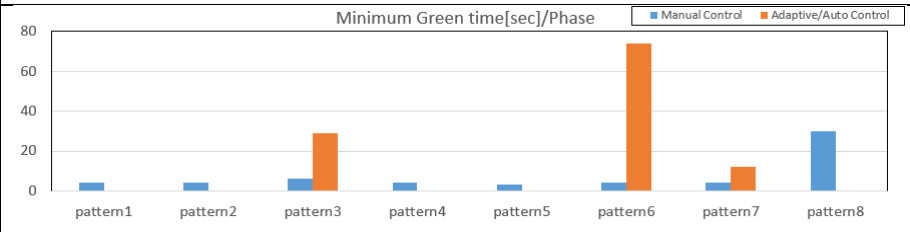
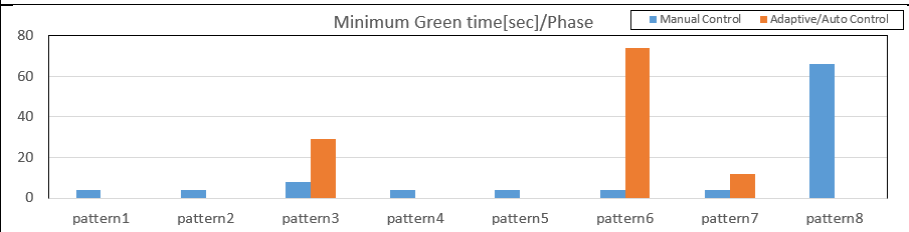
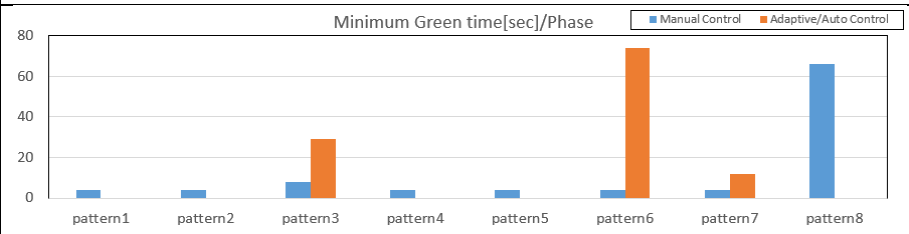
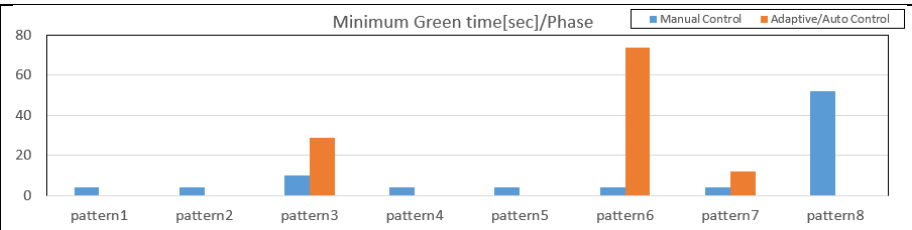
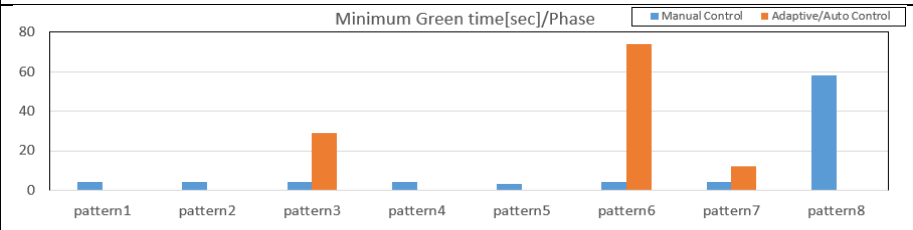
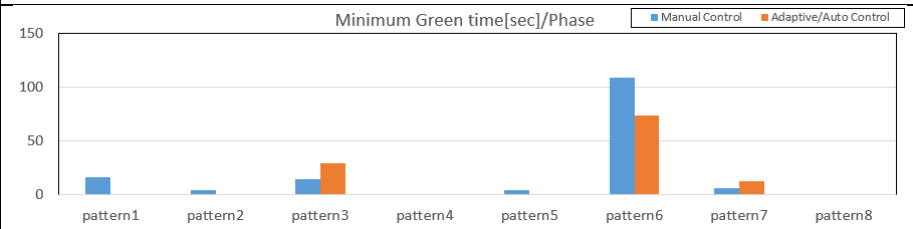
8/1 Mon	
8/2 Tue	
8/3 Wed	
8/4 Thu	

8/5 Fri	
8/6 Sat	
8/7 Sun	

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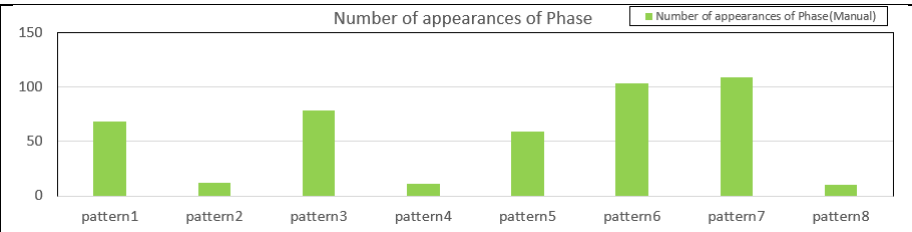
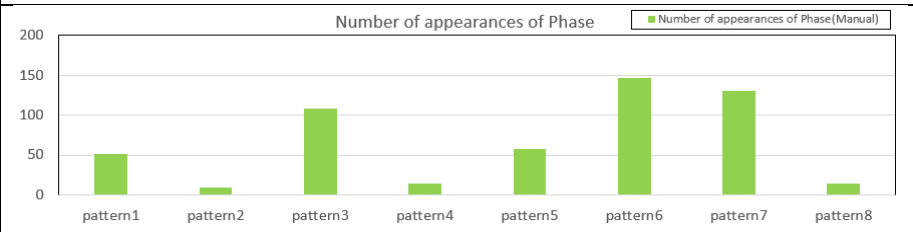
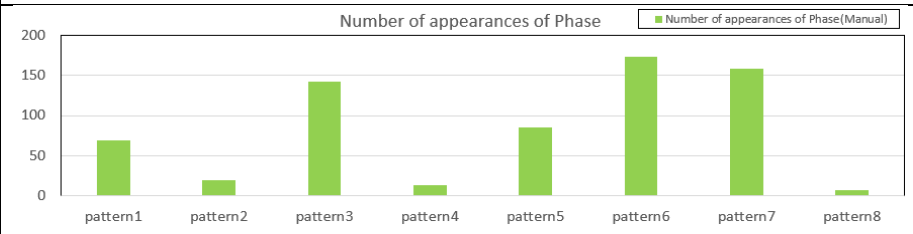
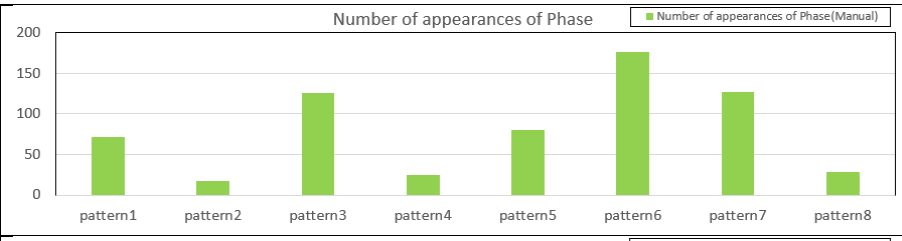
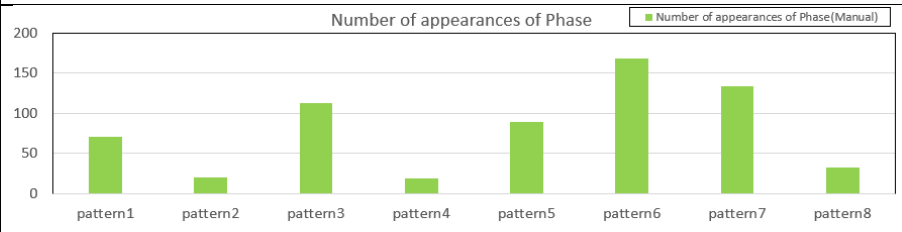
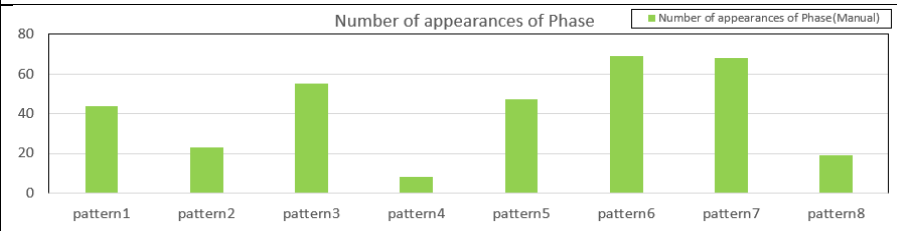
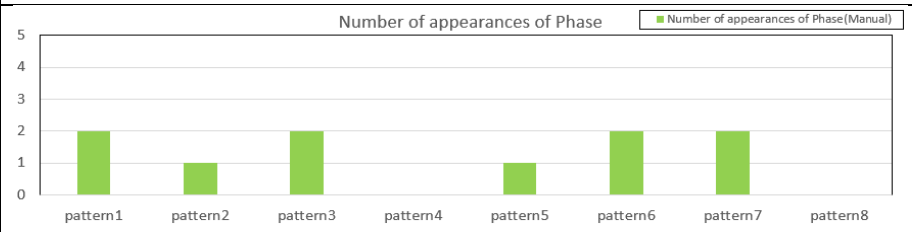
8/1 Mon	
8/2 Tue	
8/3 Wed	

8/4 Thu	
8/5 Fri	
8/6 Sat	
8/7 Sun	

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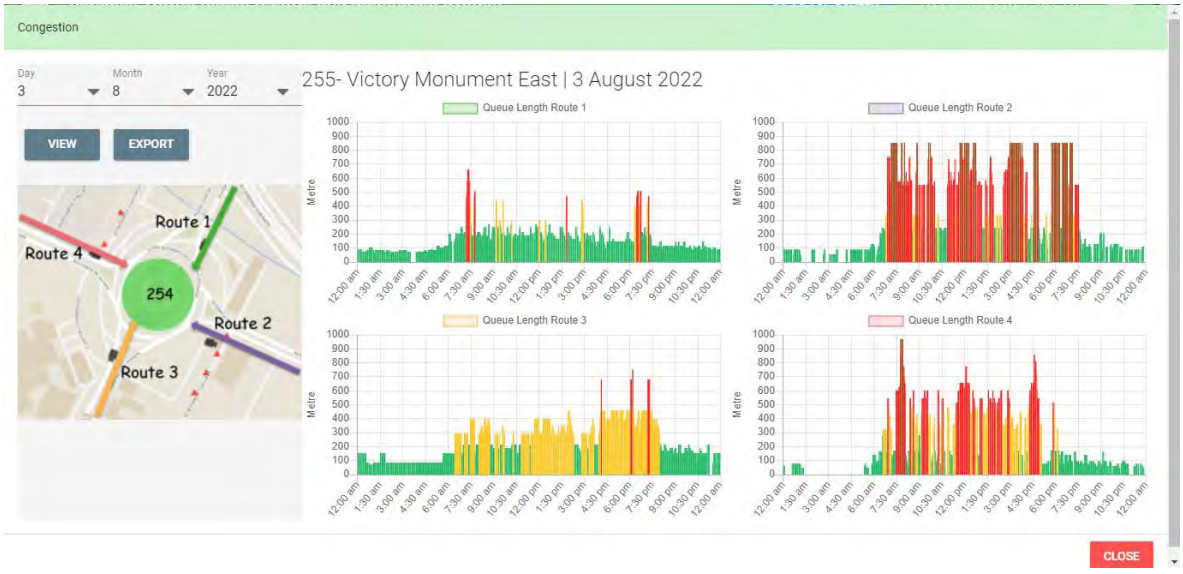
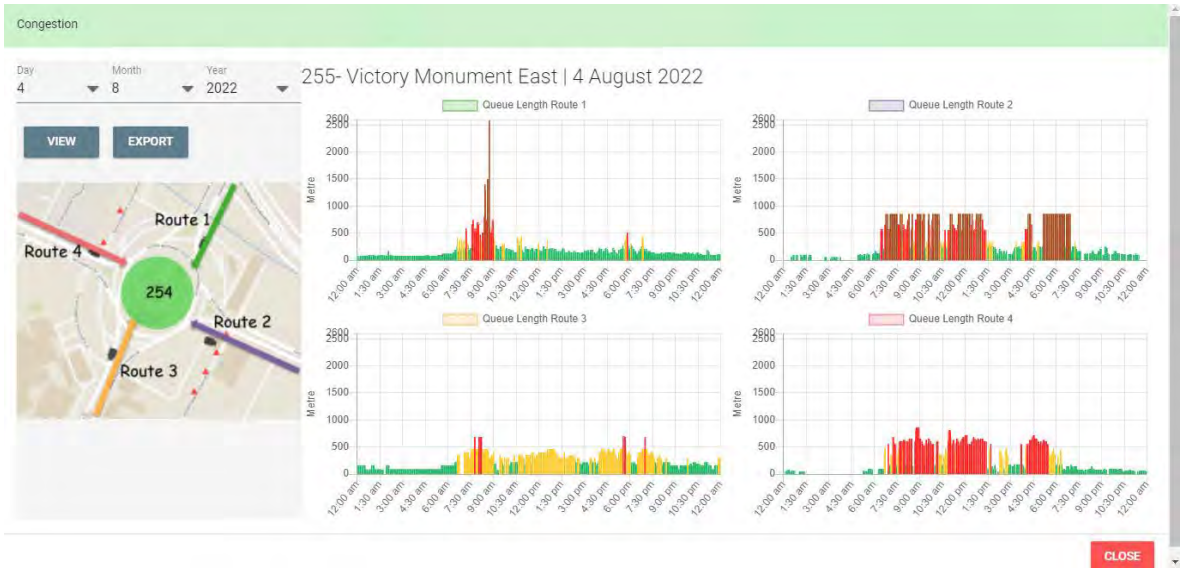
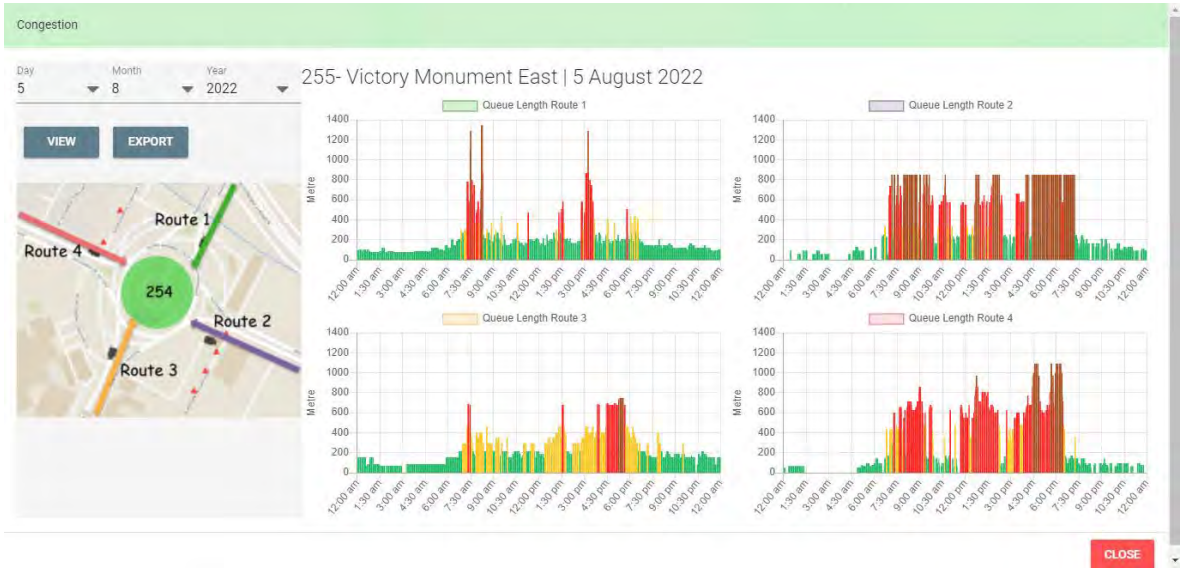
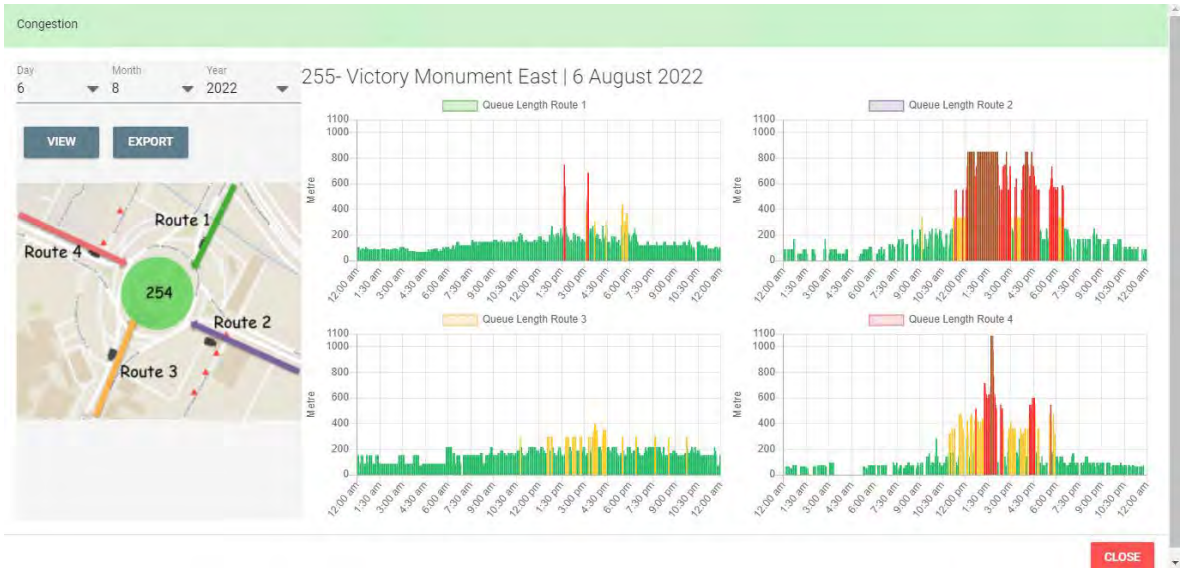
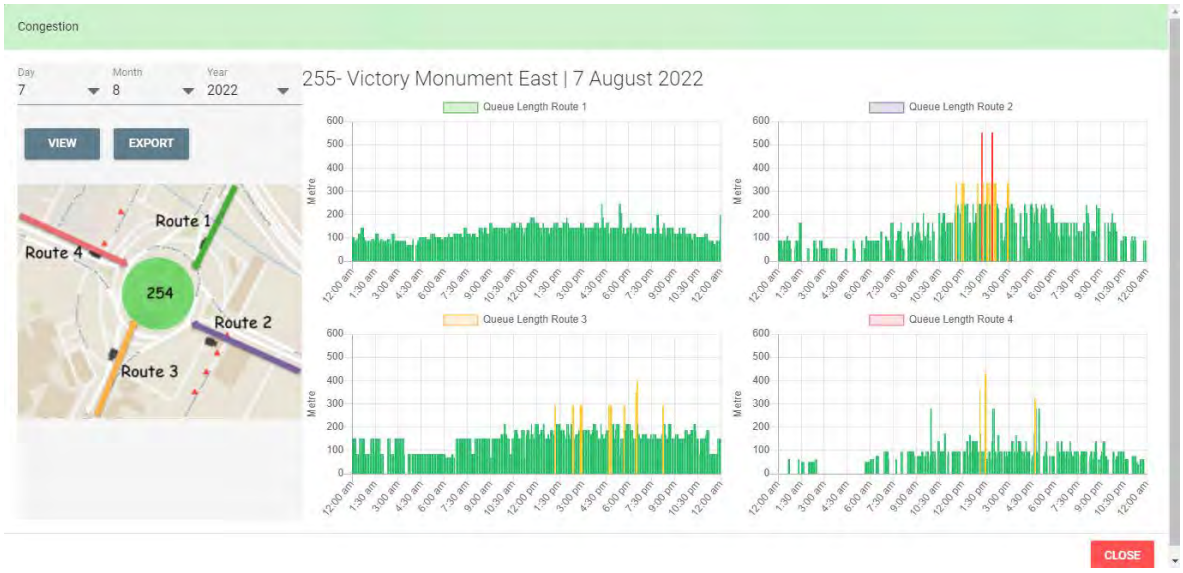



Congestion
Day
4
Month
8
Year
2022
VIEW
EXPORT
255- Victory Monument East | 4 August 2022
Queue Length Route 1
Queue Length Route 2
Queue Length Route 3
Queue Length Route 4
Metre
Route 1
Route 2
Route 3
Route 4
254
CLOSE


Congestion
Day
5
Month
8
Year
2022
VIEW
EXPORT
255- Victory Monument East | 5 August 2022
Queue Length Route 1
Queue Length Route 2
Queue Length Route 3
Queue Length Route 4
Metre
Route 1
Route 2
Route 3
Route 4
254
CLOSE


Congestion
Day
6
Month
8
Year
2022
VIEW
EXPORT
255- Victory Monument East | 6 August 2022
Queue Length Route 1
Queue Length Route 2
Queue Length Route 3
Queue Length Route 4
Metre
Route 1
Route 2
Route 3
Route 4
254
CLOSE


Congestion
Day
7
Month
8
Year
2022
VIEW
EXPORT
Route 1
Route 4
254
Route 2
Route 3
255- Victory Monument East | 7 August 2022
Queue Length Route 1
Queue Length Route 2
Queue Length Route 3
Queue Length Route 4
Metre
CLOSE

Annex 14

Draft of ATC System Development Plan

Draft of the ATC System Development Plan

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1. Introduction

1.1 Contents of the ATC System Development Plan

A development plan is formulated to introduce an area traffic control (ATC) system in Bangkok. The plan covers the following aspects:

1) Existing signals and ongoing signalization project
2) ATC system design
   - ATC system design policy
   - Coverage area
   - ATC system configuration
   - Intersection capacity analysis and signal warrant
   - ATC system functions and configuration
   - Traffic condition gathering
   - Signal control algorithm
   - Signal operation monitoring
   - Systems operation monitoring
   - Database
   - Control center
   - Local controllers
3) Communication network
4) Cost estimates
5) Implementation schedule
6) Project implementation
7) Maintenance of ATC system

The ATC System Development Plan includes the existing signals and the ongoing adaptive signal project which the Bangkok Metropolitan Administration (BMA) has been implementing since 2024 (2567[1]) BMA fiscal year. The description of adaptive signal is presented later in this chapter.

It is assumed that signal is warranted for the existing signals that will be connected to the ATC system, and no signal warrant is examined. No additional signal is considered for Phase 1 project in the plan as the area covers the central part of Bangkok and signals are already installed at the intersection where signal is warranted.

Currently, BMA is installing new signals and replacing existing ones with adaptive signals. Although details of the signal control mechanism for these signals are not clear, they are isolated signals with vehicle detector installed around intersections. The adaptive signal is expected to apply different signal timing based on the traffic data collected by the vehicle detector. CCTV cameras are mainly used as a vehicle detector in the adaptive signal system.

In the ATC system project, these signals will be connected to the ATC system with the addition of an interface device that makes it possible for local controllers to communicate with the traffic control center and apply the timing plan sent from the control center.

It is assumed that fiber optic cables (FOCs) must be installed to enable the ATC center to communicate with the local controllers and to receive traffic data detected by vehicle detectors.

[1] Figure in parhethesis is Thai calendar year.

According to BMA, the existing FOC network was designed for CCTV camera monitoring and is not suitable for the ATC system. For this reason, a new FOC network will be established for the ATC system.

1.2 Signal control modes

Generally speaking, there are several signal control modes as shown in Table 1.1. Each mode is suitable for different traffic and geographical conditions. If signal control needs to apply different signal timing parameters based on traffic conditions, a time-of-day control function is required. For varying traffic demand, vehicle detectors are used to collect traffic data and apply the timing plan suitable for the traffic condition. If two or more signals are required to operate in synchronization for efficiency, coordination through wired or wireless method must be provided.

The types of signal control are explained below.

Table 1.1: Signal Control Modes

Control type	Control method	Remark
Pre-timed	Same fixed signal timing is applied regardless of time of day and traffic conditions.	Mainly for traffic safety. Some of the existing signals in Bangkok are pre-timed, and they are being replaced with adaptive signals.
Time-of-day	Different signal timing is applied based on the time of day.	Effective for traffic that has similar hourly variation pattern every day. Correct time must be provided either by the internal clock or outside signal (GPS).
Actuated Control	Green period is extended or truncated depending on vehicle arrival during green.	Effective for vehicle arrivals that vary every signal cycle. One such case is right-turn traffic.
Adaptive Control	Signal timing is adjusted dynamically every cycle or at a specified time interval based on traffic conditions measured by vehicle detectors. Different types of vehicle detectors (loop, ultrasonic, CCTV camera, etc.) can be used for vehicle detection.	Definition of “adaptive” varies and mechanism is often not clearly explained when the term is used in literiture or brochures. Applicable to a series of signals along a corridor.
Coordinated Control	Multiple signals along a route operate with the same cycle time and the offset most suitable for the prevailing traffic demand is applied.	A master controller that determines cycle time and offset is required. All signals are connected to the master controller through communication lines or wireless networks for synchronization.
Area Traffic Control (ATC)	Signals in an area are controlled by a control center which collects traffic data through vehicle detectors and applies the signal timing most suitable for prevailing traffic conditions	Collects traffic data and determines the signal timing most suitable for prevailing traffic conditions is required at the control center. All signals are connected to the center through communication lines.

Traffic in Bangkok has reached the level at which heavy congestion is a daily occurrence. Traffic congestion at an intersection quickly spreads to neighboring intersections and traffic in this area often comes to a standstill. Under such circumstances, optimization of signals at a single intersection either automatically or manually (by traffic police) has limited effectiveness. A

coordinated operation of signals with the timing parameters that best suit prevailing traffic conditions is required.

2. Traffic Signals in Bangkok

2.1 Existing Signals

According to BMA, there are a total of 541 intersection signals and 323 pedestrian crossing signals in Bangkok as of November 2024. All of them are isolated signals except those covered by the model ATC system mentioned below. No coordination is made between signalse thSome of them are pre-timed signals, while others are time-of-day control signals. The latter operates based on the time of day plan every day, and this plan is not based on a particualr day of the week. The vehicle signals at key intersections are often controlled manually by the traffic police during peak hours.

Manual control of signals can be effective when traffic volume is low or moderate, or under abnormal traffic conditions. Green time is not fully utilized under pretimed control, as green time cannot be shortened just enough to process the demand like actuated signals. When traffic demand increases and approaches intersection capacity, however, manual control is not only ineffective but also causes adverse effect. Under near-saturated ocnditions, coordination among signals becomes more critical than optimizing the operation of a single signal.

Some of the existing signals called adaptive traffic signals are equipped with vehicle detectors, and signal timing is adjusted based on the traffic volume the detectors measure. Loop detectors were initially installed for this purpose, but CCTV cameras are now used as vehicle detectors.

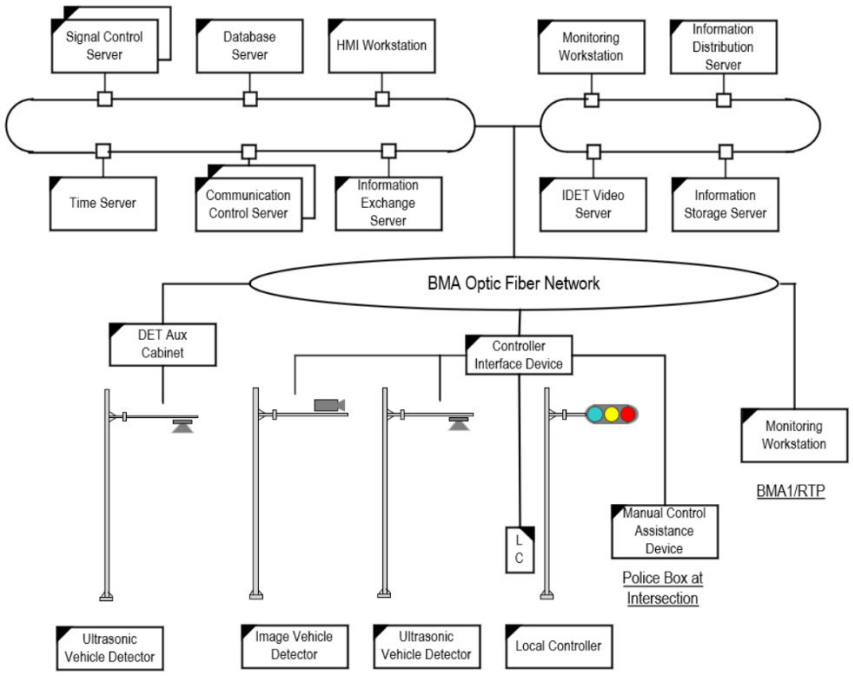
Actuated control is effective for isolated signals with no signals nearby as offset is not important for the efficiency of signal operation. On the other hand, if distance between two neighboring signals is short, offset must be suitably set.

2.2 Model ATC System Project

A model ATC system with the system configuration shown in Figure 2.1 was introduced to Bangkok under the Project. The system consists of a central server, 15 traffic signals at intersections[2] [3], four pedestrian crossing signals, video and ultrasonic vehicle detectors, and a data communication network which connects these devices to the control center. The system started operation in March 2023 and officially handed over to BMA in August 2023. “Before” and “after” surveys were conducted to evaluate the effectiveness of the system. Survey results show positive results, with queue lengths at key intersections reducing by about 30% from the figures before the operation of the ATC system. Encouraged by this, an ATC system development plan is being prepared.

[2] Four (4) local controllers are used for Victory Monument. But only one (1) local controller (master controller) is connected to the center and the rest acts as slave controllers.

[3] The local controller at Rama VI–Ali Phararam 6 intersection controls two intersections.

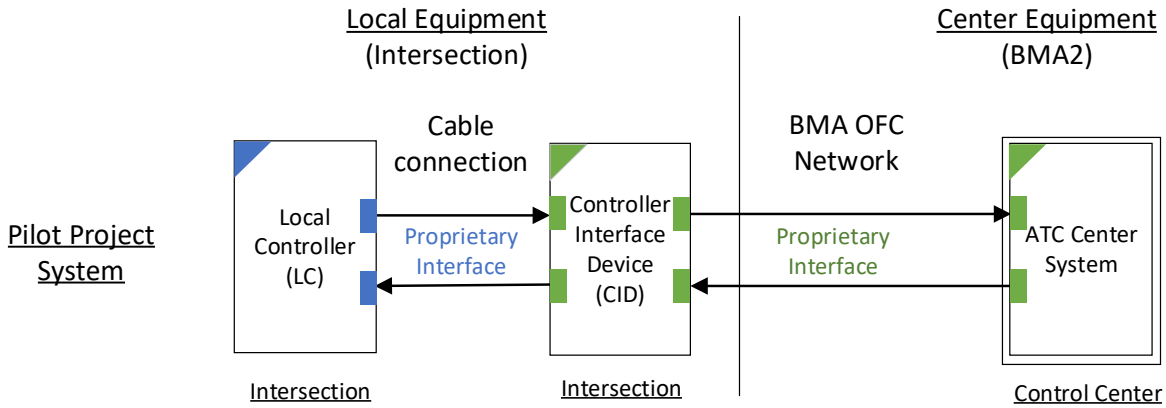


Source: JET

Figure 2.1: Configuration of the Model ATC System

The model ATC system (ATCS) adopted the data communication system shown in Figure 2.2, in which existing local controllers were connected to the ATCS control center through controller interface devices (CIDs). CIDs operate as an interface between local controllers and the ATCS control center and makes necessary data conversion without degrading the system function.

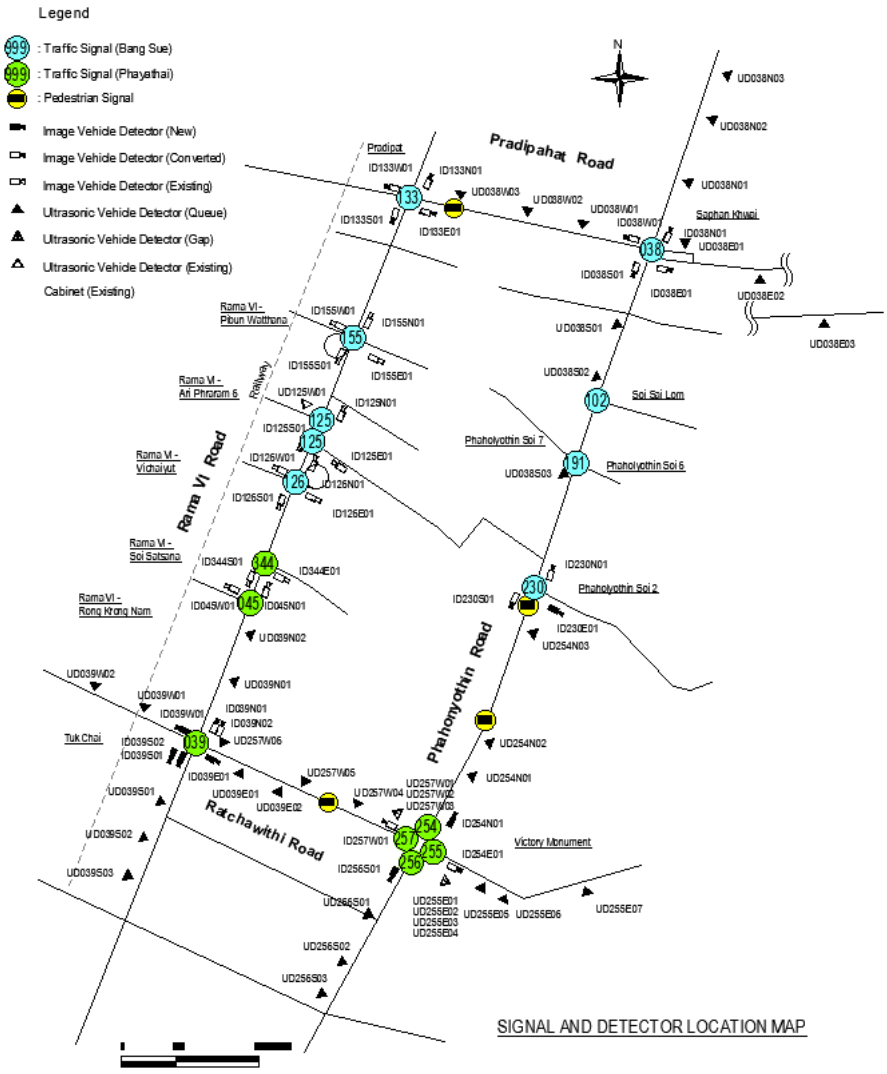
The control center established in the model project calculates and specifies the signal timing for green, yellow, and all-red indications, which can be separately and independently specified. On the other hand, local controllers made by local manufacturers adopt signal-phase-based timing in which phase durations, including yellow and all-red time, are specified. CIDs are used to resolve the difference between the two methods.



Source: JET

Figure 2.2: CIDs' Connection to the ATC Center System

Photo 2.1: Model ATC System Center Equipment



Source: JET

Figure 2.3: Location of Signals and Detectors in the Model ATC System

2.3 Adaptive Signalization Project

BMA initiated an adaptive signalization project in 2024 (2567 in Thai calendar). The adaptive signals use vehicle detectors, i.e., CCTV cameras, to collect traffic data, based on which signal timing is adjusted. The number of adaptive signals and their locations are shown in Table 2.1 and Figure 2.4, respectively.

The basic detector layout is shown in Figure 2.5. In addition to stop line detectors, other detectors are placed at about 150 meters upstream of the stop line. In addition, downstream detectors are placed at the exit side of the installation.

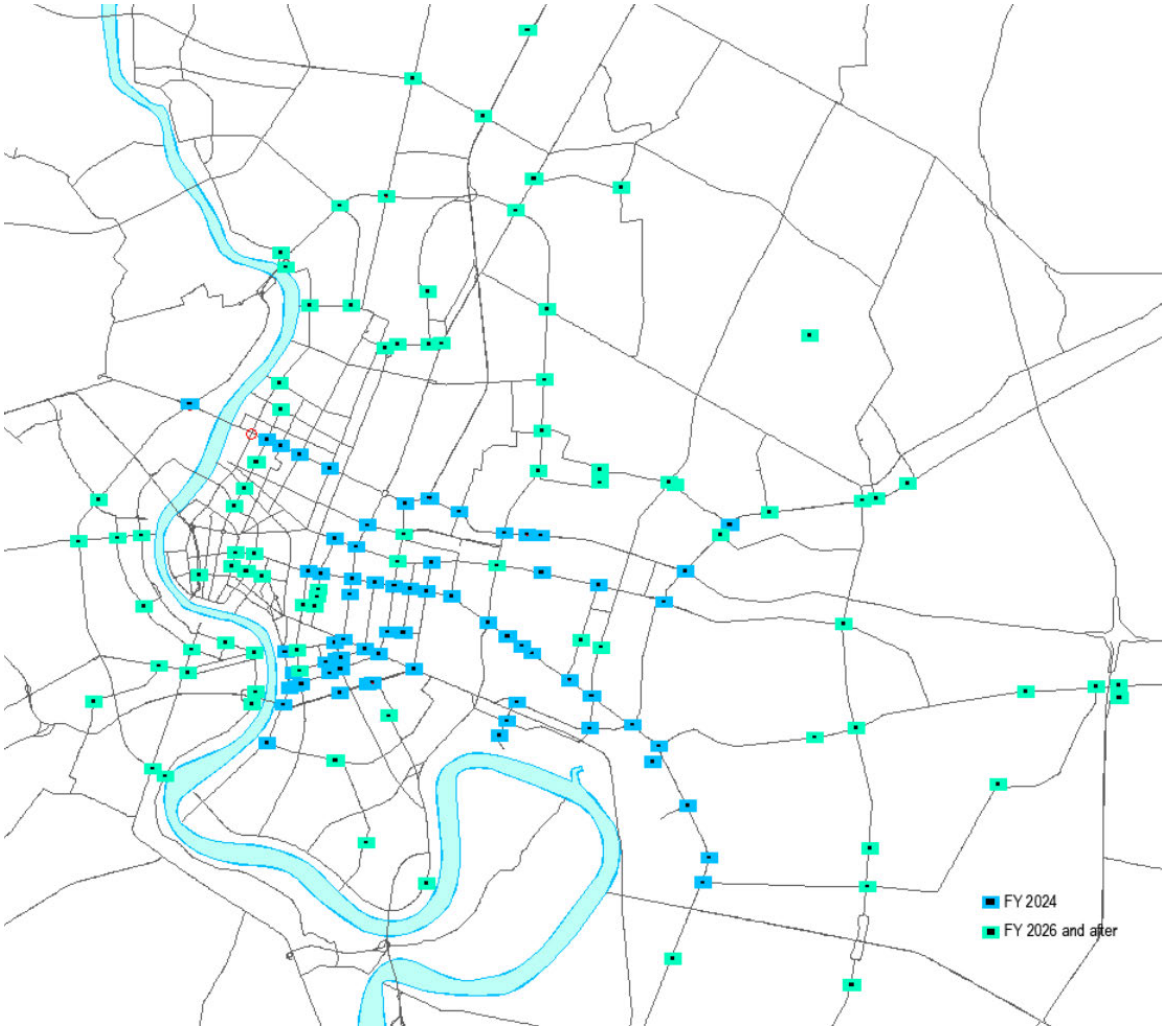
According to BMA and the supplier of the adaptive signals, the travel times of vehicles travelling between the upstream vehicle detector and the stop line detector are used for signal control. Number plates are read to obtain the travel time between these two points. The method is theoretically possible, but it would not be technically feasible in real world application for two reasons: 1) travel time between the upstream and the downstream detectors varies largely depending not only traffic conditions but also on the signal timing as travel time include waiting time in queue on the intersection approach, and 2) number plate recognition is technically feasible only when the number plates are visible. Under congested traffic situations and when the view of the number plates is obstructed by preceding vehicles (front number plate) or the following vehicles (rear number plate), the algorithm does not work properly. It is also not clear how data on travel time along each approach is used in adjusting signal timing.

The progress of BMA's adaptive signalization project as of November 2024 is shown in Table 2.1. The project's budget for fiscal year 2025 (2568) was not approved pending the proof of concept (POC) for the works undertaken in fiscal year 2024. BMA has a plan to install 100 adaptive signals in fiscal year 2026.

Table 2.1: Number of Adaptive Signals Planned by BMA

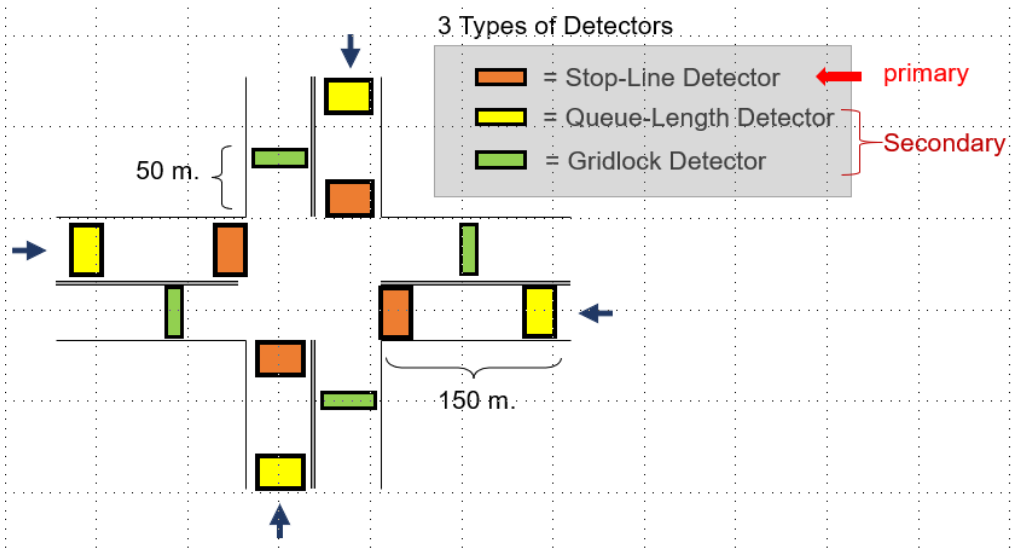
Fiscal Year (Thai)	No. of Signals	Remark
2024 (2567)	72	Ongoing (2 contracts) No. 1: 22 signals No. 2: 50 signals
2025 (2568)	0	No signal installation scheduled.
2026 (2569)	100	Planned

Source: BMA



Source: BMA

Figure 2.4: Location of Selected Adaptive Signals



Source: BMA

Figure 2.5: Detector Layout for Adaptive Signal Control

3. ATC System Design

3.1 System Design Policy

In formulatinng the ATC system development plan, the eventual system should meet the following conditions:

1) Should suit the road network and traffic conditions in Bangkok,
2) Should maximize the use of existing facilities and local resources,
3) Should ensure sustainable operation and maintenance, and
4) Should allow a phased expansion of the ATC system.

The factors considered in designing the ATC system includes the following:

1) Coverage area,
2) Intersection capacity analysis and signal warrant,
3) ATC system functions,
4) Capacity for traffic data gathering,
5) Signal control algorithm,
6) Local controller,
7) Type of vehicle detector,
8) Vehicle detector deployment rules and locations, and
9) Communication network,

In addition to the technical factors listed above, the following aspects are also considered:

1) Cost estimates,
2) Implementation schedule, and
3) Maintenance of the ATC system.

3.2 Coverage Area

According to BMA, there are a total of 539 intersection signals and 321 pedestrian crossing signals in Bangkok as of September 2023. These signals satisfied the signal warrant set by BMA, which determines the necessity of signals at particular locations based on traffic volume and intersection geometry. For this reason, the necessity of the existing signal is not examined in formulating the plan on ATC system expansion.

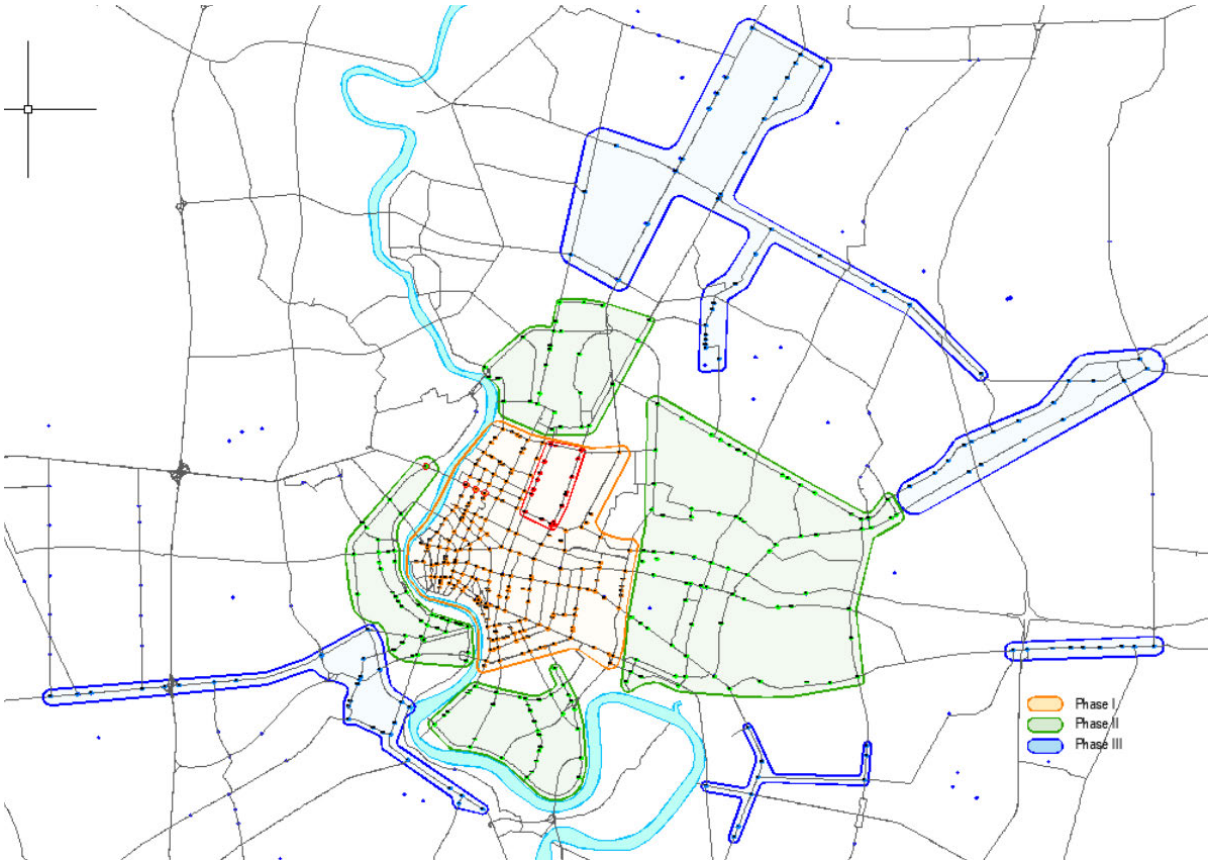
It is not practical to expand the ATC system to all candidate signals in one project from the viewpoint of project management, budgeting, and technology development. Thus, the expansion project is divided into three (3) phases. Each phase will cover 100–200 signals and each project period will take 1.5–2 years to complete. The first phase will cover the central districts of Bangkok, and succeeding phases will cover the areas toward the city's outskirts.

The tentative delineation of the project area is shown in Figure 3.1 for the entire Bangkok and Phase I project. The number of signals in each phase is shown in Table 3.1. There are a total of 159 intersection signals and 51 pedestrian crossing signals under Phase I. As shown in Figure 7.1, Phase I will take 2.5 years from the start of the detailed design by BMA until the completion of the system. It may be necessary to divide the phase into Phase Ia and Ib to make the project period shorter, or when there is a constraint in the budget.

Table 3.1 ATCS Development Plan by Phasing and Number of Signals

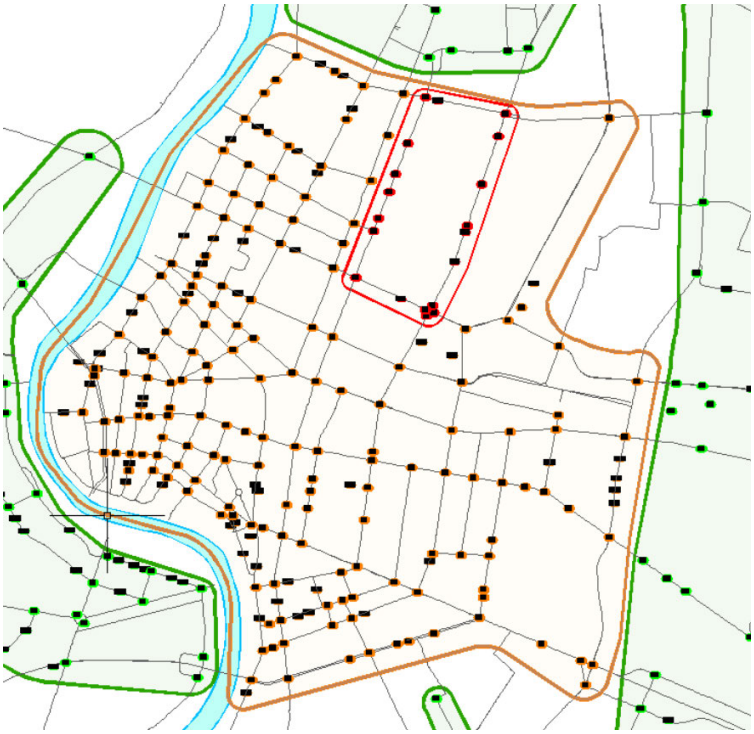
Item	BMA Signal[1]	No. of Signals				
		Phase P[2]	Phase 1	Phase 2	Phase 3	Total
Intersection signal	541	15	159	135	83	392
Pedestrian signal	323	4	51	44	18	117
Total	864	19	210	179	101	509

[1] Total number of signal that BMA operates.
[2] The number of signals that are connected with pilot ATC system.
Source: JET



Pilot Project Phase I Phase II Phase III

(a) Entire Bangkok



(b) Coverage Area of Phase I

Source: JET

Figure 3.1: ATC System Coverage Area

3.3 Intersection Capacity Analysis and Signal Warrant

A count of intersection turning movements and an intersection capacity analysis were conducted for major intersections to measure their saturation levels, design phase sequences, and develop timing plans. The number and locations of intersections for the count survey were decided based on available congestion data and site observation.

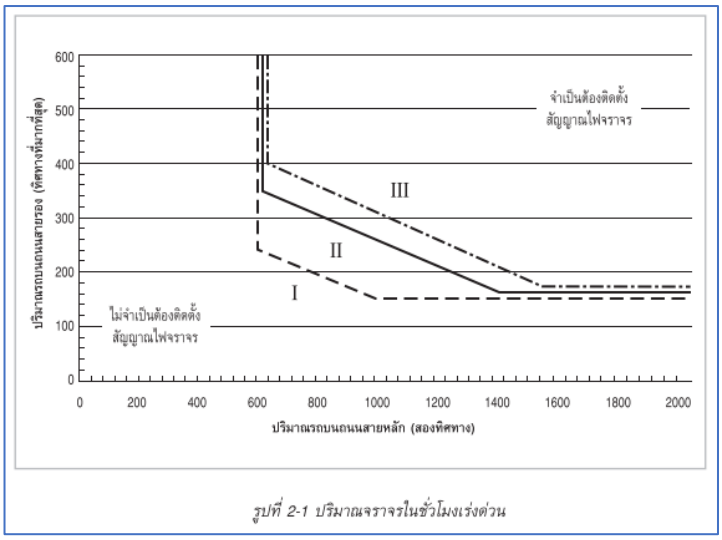
BMA has a signal design manual entitled "Traffic Signals Standard and Manual," and all signals are designed following this manual. All existing intersection signals are assumed to have satisfied the signal warrant indicated in this manual. Thus, JET deemed it not necessary to review the signal warrant for the existing signals to be covered by the ATC system. But, traffic count data is required at selected intersections to develop a signal phase and timing plan.

It is noted, however, that the manual only mentions traffic volume as basis for the signal warrant. Other factors, such as traffic accident record, number of crossing pedestrians, and facilities near the intersection, are not mentioned.

For critical intersections, where traffic demand is high and congestion is often observed, a traffic count survey must be conducted to design signal phasing and timing. Survey results are processed serve as input to the intersection capacity analysis. As the BMA's signal design manual does not show how signal phase and timing parameters must be designed, one of the several capacity analysis programs commercially available was used. Alternatively, BMA may develop their own analysis program as the nature of traffic in Bangkok differs from that in developed countries. A spreadsheet showing a sample capacity analysis is provided as Figure 3.4.

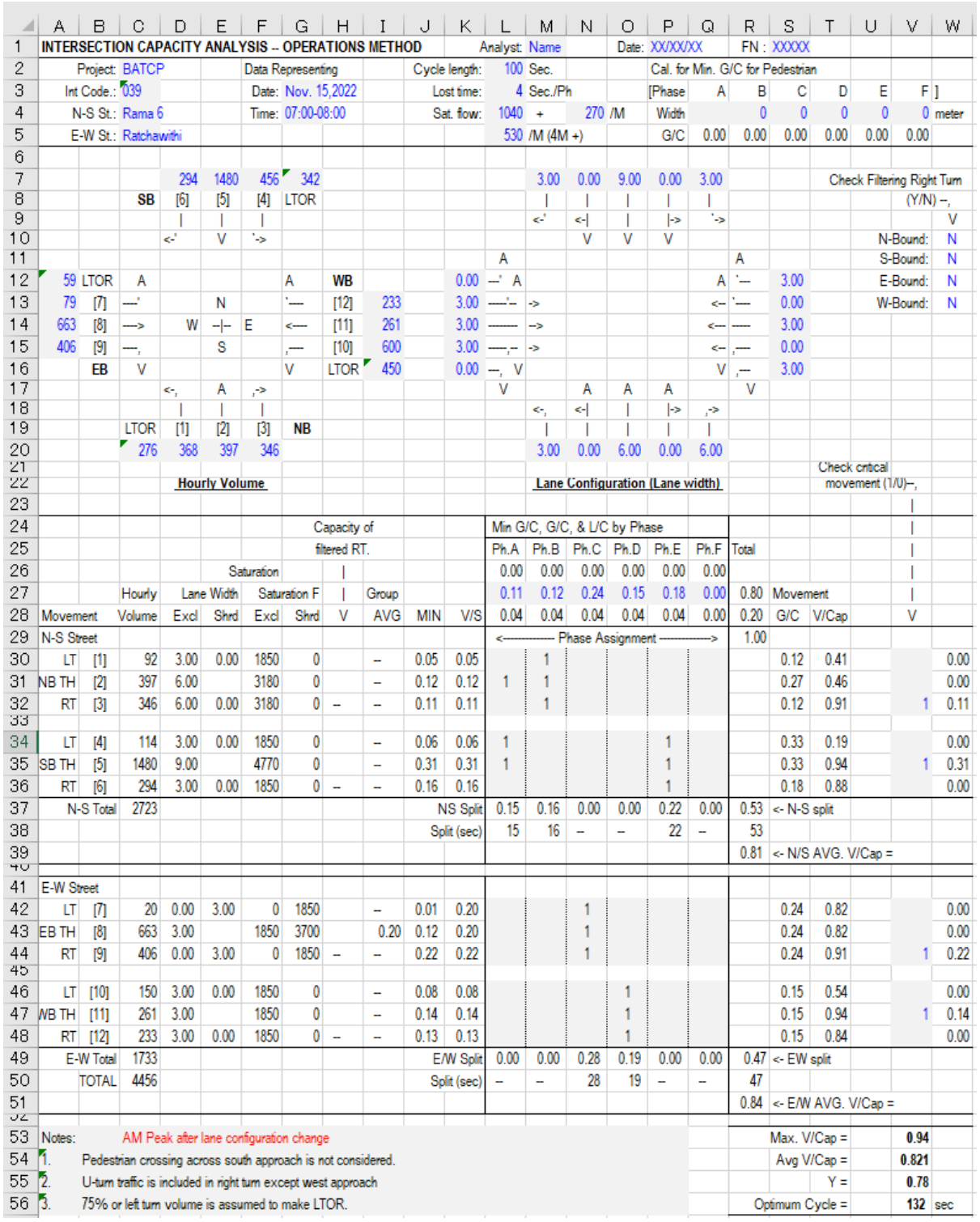
Source: BMA

Figure 3.2: BMA's Traffic Signals Standards and Manual



Source: BMA

Figure 3.3: Signal Warrant used by BMA



INTERSECTION CAPACITY ANALYSIS -- OPERATIONS METHOD												Analyst:	Name		Date:	XX/XX/XX		FN :	XXXXX				
Project:	BATCP				Data Representing				Cycle length:		100	Sec.			Cal. for Min. G/C for Pedestrian								
Int Code.:	039				Date:	Nov. 15,2022			Lost time:		4	Sec./Ph			[Phase	A	B	C	D	E	F	]	
N-S St.:	Rama 6				Time:	07:00-08:00			Sat. flow:		1040	+	270	/M	Width		0	0	0	0	0	meter	
E-W St.:	Ratchawithi										530	/M (4M +)			G/C	0.00	0.00	0.00	0.00	0.00	0.00		
			294	1480	456	342						3.00	0.00	9.00	0.00	3.00				Check Filtering Right Turn			
	SB	[6]	[5]	[4]	LTOR							|	|	|	|	|					(Y/N) –,	
		|	|	|							<-'	<-|	|	|->	`->						V
	<-'	V	`->										V	V	V						N-Bound:	N	
											A						A				S-Bound:	N	
59	LTOR	A			A	WB			0.00	—'	A					A	`—	3.00			E-Bound:	N	
79	[7]	—'		N		`—	[12]	233	3.00	----'–	->					<–	`—	0.00			W-Bound:	N	
663	[8]	—>	W	–|–	E	<—	[11]	261	3.00	------	–>					<–	——	3.00					
406	[9]	—,		S		,—	[10]	600	3.00	----,–	->					<–	,—	0.00					
	EB	V			V	LTOR		450	0.00	—,	V					V	,—	3.00					
		<-,	A	,->						V			A	A	A		V						
		|	|	|							<-,	<-|	|	|->	,->						
	LTOR	[1]	[2]	[3]	NB							|	|	|	|	|						
	276	368	397	346								3.00	0.00	6.00	0.00	6.00							
		Hourly Volume										Lane Configuration (Lane width)								Check critical movement (1/0)–,			
																				|			
						Capacity of						Min G/C, G/C, & L/C by Phase								|			
						filtered RT.						Ph.A	Ph.B	Ph.C	Ph.D	Ph.E	Ph.F	Total				|	
					Saturation		|				0.00	0.00	0.00	0.00	0.00	0.00					|	
	Hourly	Lane Width		Saturation F		|	Group				0.11	0.12	0.24	0.15	0.18	0.00	0.80	Movement			|	
Movement	Volume	Excl	Shrd	Excl	Shrd	V	AVG	MIN	V/S		0.04	0.04	0.04	0.04	0.04	0.00	0.20	G/C	V/Cap		V	
N-S Street											<———— Phase Assignment ————>						1.00					
LT [1]	92	3.00	0.00	1850	0		–	0.05	0.05			1						0.12	0.41			0.00	
NB TH [2]	397	6.00		3180	0		–	0.12	0.12		1	1						0.27	0.46			0.00	
RT [3]	346	6.00	0.00	3180	0	–	–	0.11	0.11			1						0.12	0.91		1	0.11	
LT [4]	114	3.00	0.00	1850	0		–	0.06	0.06		1				1			0.33	0.19			0.00	
SB TH [5]	1480	9.00		4770	0		–	0.31	0.31		1				1			0.33	0.94		1	0.31	
RT [6]	294	3.00	0.00	1850	0	–	–	0.16	0.16						1			0.18	0.88			0.00	
N-S Total	2723								NS Split		0.15	0.16	0.00	0.00	0.22	0.00	0.53	<- N-S split				
									Split (sec)		15	16	–	–	22	–	53					
																	0.81	<- N/S AVG. V/Cap =				
E-W Street																							
LT [7]	20	0.00	3.00	0	1850		–	0.01	0.20				1					0.24	0.82			0.00	
EB TH [8]	663	3.00		1850	3700		0.20	0.12	0.20				1					0.24	0.82			0.00	
RT [9]	406	0.00	3.00	0	1850	–	–	0.22	0.22				1					0.24	0.91		1	0.22	
LT [10]	150	3.00	0.00	1850	0		–	0.08	0.08					1				0.15	0.54			0.00	
WB TH [11]	261	3.00		1850	0		–	0.14	0.14					1				0.15	0.94		1	0.14	
RT [12]	233	3.00	0.00	1850	0	–	–	0.13	0.13					1				0.15	0.84			0.00	
E-W Total	1733								E/W Split		0.00	0.00	0.28	0.19	0.00	0.00	0.47	<- EW split				
TOTAL	4456								Split (sec)		–	–	28	19	–	–	47					
																	0.84	<- E/W AVG. V/Cap =				
Notes:	AM Peak after lane configuration change																	Max. V/Cap =			0.94	
1.	Pedestrian crossing across south approach is not considered.																	Avg V/Cap =			0.821	
2.	U-turn traffic is included in right turn except west approach																		Y =		0.78	
3.	75% or left turn volume is assumed to make LTOR.																	Optimum Cycle =			132	sec

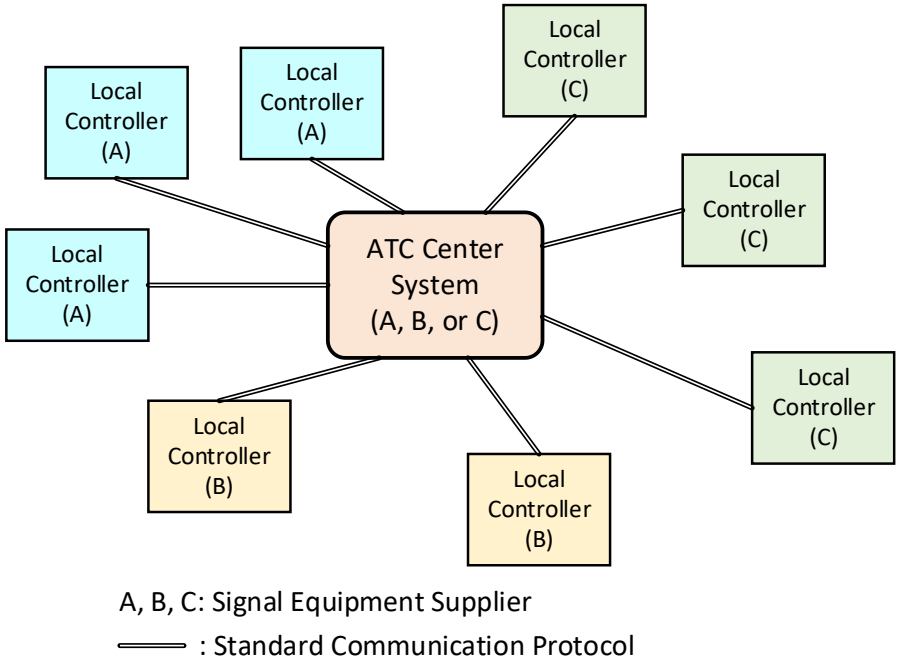
Source: JET

Figure 3.4: Sample Analysis of Intersection Capacity

3.4 ATC System Configuration

An ATC system consists of a control center, local controllers (signals at intersections and pedestrian crossings), vehicle detectors, and a data communication network connecting the control center to field equipment (local controllers and vehicle detectors). For the flexibility of supply source and timely maintenance operation, it is desirable to have multiple suppliers of local controllers that are connected to the control center using standard communication protocol as shown in Figure 3.5. A standard communication protocol must be established to allow multiple suppliers of local controllers to connect to the future ATC system in Bangkok.

Three (3) options are possible to realize the future ATC system, as shown in the next figures, namely, 1) open the communication protocol used in the pilot ATC system and expand the existing pilot ATC system (Figure 3.6); 2) introduce both a new control center system and local controllers (Figure 3.7); and 3) introduce a new control center system and use the existing local controllers by installing them with CIDs (Figure 3.8).

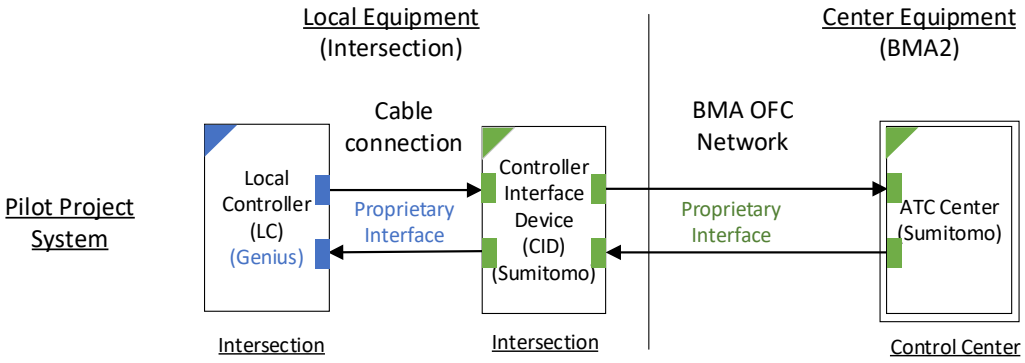


Source: JET

Figure 3.5: Configuration of the Future ATC System

■ Option A

Option A expands the existing pilot ATC system.



Source: JET

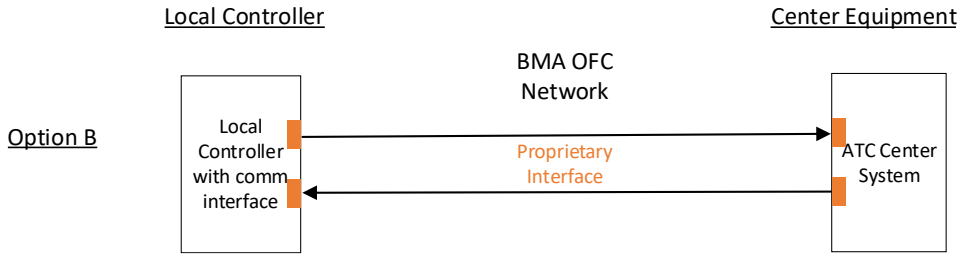
Figure 3.6: Option A (Expansion of Existing Pilot ATC System)

Interfaces between the ATC center and CIDs, as well as among local controllers, are not disclosed. The option is possible only when the supplier of the pilot ATC system discloses the specifications of the control center equipment, software, database, and the CID.

Merits · As the option utilizes the existing system, the development of hardware, communication protocol, software, and database is not necessary. · Communication protocol between the center and the local controller is already established. · Project period will be shorter as no development is required.
Issues · Only the supplier of the hardware and software of the existing ATC system can supply the system if details of the existing ATC system are not disclosed. · For the reason above, the competitiveness of the bidding for the system is not guranteed.

■ Option B

Option B replaces both local controllers and the ATC center system



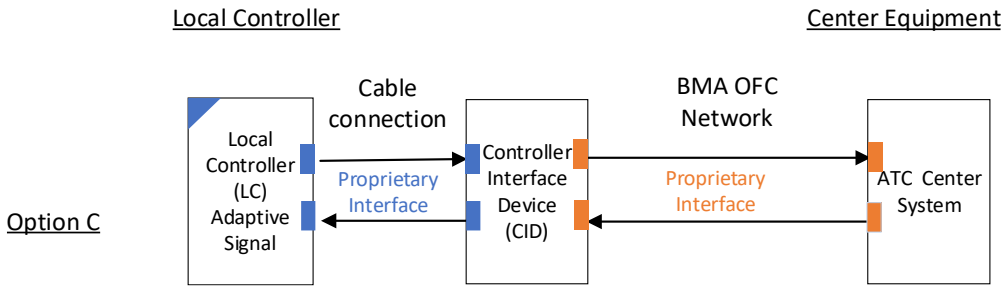
Source: JET

Figure 3.7: Option B (Introduction of a New ATC System)

Merits · No technical risk is expected and project period will be shorter based on the records of installation in other cities. · Any ATC system supplier can participate in the bidding for the ATC system. · Project period will be shorter beceause no development is required.
Issues · Existing facilities will not be utilized. · Cost will be higher because all devices and software will be new. · Maintenance and future system expansion can be an issue because the system is supplied by a foreign supplier.

■ Option C

CIDs are added to the existing local controllers and connection to the ATC center needs to be established.



Surce: JET

Figure 3.8: Option C (CIDs to Connect Local Controllers to ATC Center)

Merit

- The project cost will be lower because the existing local controllers will be utilized.

Issues

- With a new configuration, technical feasibility must be guranteed at the time of bidding.
- Development of a new type of CIDs is required. This will increase project cost and extend project period.
- The hardware that processes detector data in the adaptive signals will not be utilized.
- The progress of the project and target signal locations depend on the adaptive signal project that BMA is currently implementing.
- Realizing this option depends on the cooperation of the supplier of the adaptive signals.
- At the time of bidding, bidders must be informed about the specifications of the adaptive signals and whether they are required to develop CID that is compatible with the existing adaptive signal.

In selecting the contractor for the ATC system through competitive tendering, three options must be made acceptable to BMA and the selection must be made based on the technical adequacy of the proposed system and with the tender price.

3.5 ATC System Functions and Configuration

The proposed ATC system will be required to have the following five (5) basic functions:

- Traffic data gathering;
- Real-time signal control and monitoring;
- Systems operations monitoring;
- Database operation; and
- Data communication between the center and roadside equipment.

In order to perform the functions above, the control center will have several servers, workstations, monitors, local area network, and communication devices with the local controllers.

The configuration of the center's system will be left to the supplier of the system. Basically, multiple servers must be used each having specific tasks like traffic data collection, signal timing develoopment, signal control, etc. The signal control server may employ a dual or duplex system for higher reliability. Uninterruptible power supply and air conditioning systems specific to the needs of the control center must be provided for its continuous operation.

3.5.1 Traffic Data Gathering

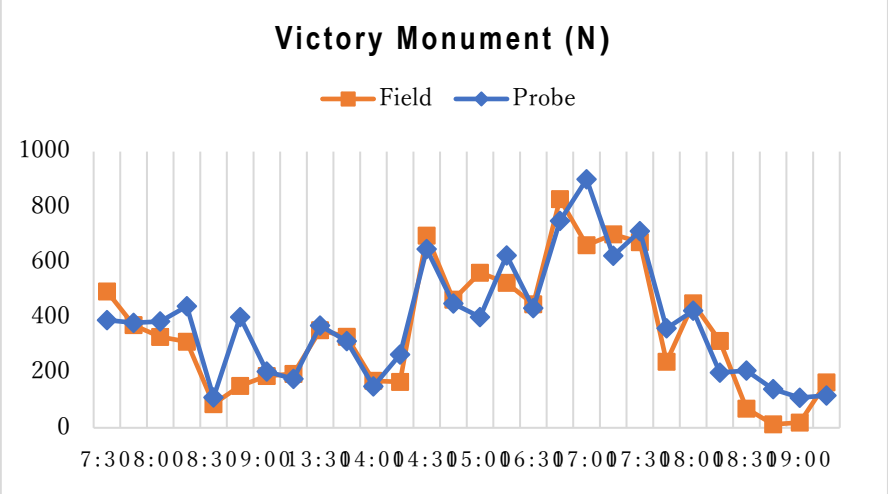
An ATC system applies a signal timing plan most suitable for prevailing traffic conditions. Data gathered by vehicle detectors are used for this purpose. Vehicle detectors, such as inductive loop detectors, ultrasonic detectors, and CCTV cameras, are used for gathering traffic data at particular spots along the roads. More detectors can provide more detailed traffic conditions. But the cost

of equipment and its maintenance becomes higher. It is necessary to install vehicle detectors at locations where representative data on traffic conditions can be obtained.

The recent development of GPS technology and the widespread use of car navigation systems (CNSs) have made the collection of vehicle positions in real time possible. Using vehicle position data, traffic conditions or average speeds on road sections along routes can be estimated. There are already service providers who offer real-time data on traffic in the urban road network.

The future ATC system will use both vehicle detector and probe data. The former will be used for specific purposes like actuation control of signal, while the latter will be used for gathering traffic data along road sections and within an area.

In the model ATC system project mentioned earlier, the applicability of vehicle probe data from TomTom NV in determining signal control was examined. Queue lengths calculated using probe data were compared with those observed at site. No substantial differences were identified, and the Project Team concluded that probe data could be used in lieu of vehicle detector data.

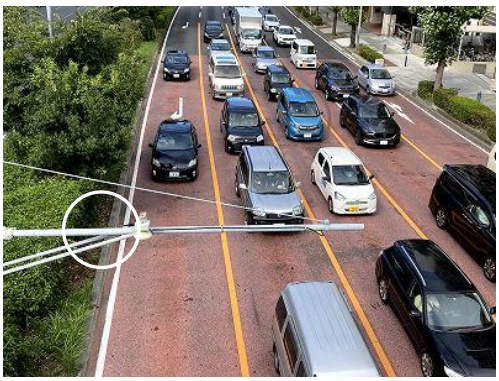


Source: JET

Figure 3.9: Comparison of Queue Lengths based on Field and Probe Data

However, probe data cannot completely substitute vehicle detector data. Probe data is processed data over a certain period, for example, one minute. On the other hand, actuated control truncates green time when there is no vehicle on the approach for which green signal is indicated. Thus, actuated control requires real-time data that indicates the existence or non-existence of vehicles at an intersection approach. Moreover, there is a risk of unavailability of data as service providers may stop operation anytime for any reason. For these reasons, probe data will not be used for the Phase 1 of the planned ATC system expansion.

CCTV Camera



Ultrasonic Vehicle Detector

Source: JET

Figure 3.10: Types of Vehicle Detectors

3.5.2 Real-time Signal Control

Signal timing parameters (cycle time, split, and offset) will be developed by the server at the ATC center based on the traffic data gathered by vehicle detectors. There are several signal timing development software commercially available such as SCATS, SCOOT, MODERATO, and UTOPIA.

The existing model ATC system uses MODERATO. Based on the results of a before-and-after survey conducted during the implementation of the model ATC system project, the algorithm proved effective. The use of MODERATO or at least the algorithm that considers queue in the calculation of timing parameters is recommended for the ATC system in Bangkok.

MODERATO takes into account not only traffic volume but also queue length along approaches to calculate optimum signal control parameters. The use of queue lengths allows the prevention of long queues from blocking upstream intersections and from generating congestion.

3.5.3 Signal Operation Monitoring

In an ATC system, signal operation is monitored continuously. This is done normally by local controllers sending signals about their operating status back to the control center by. At least there must be two types of monitoring signals, one for signal operation status and another that indicates the condition of the communication link. The control center detects any abnormality in the system by receiving and analyzing these two types of monitoring signals, which must be sent every second as a minimum.

In the control center, the status of local controller and communication link must be continuously checked. If any abnormality is found, an alarm will be issued, and details of the error must be recorded in the operation log.

Operation and monitoring data of local controllers, such as controller status and operating mode, must also be recorded in the database.

3.5.4 System Operation Monitoring

The ATC system must monitor the operating status of the control center's equipment, field equipment, and network equipment continuously, detect failure or abnormality, alarm the operator of equipment failure, and record the failure as operation log. The monitoring system must make use of the dynamic graphical monitor display and audible alarm through the speakers provided at the workstations.

3.5.5 Database Operation

The ATC system requires the database to set up, operate, monitor, and record traffic conditions and the operating condition of the system. The database should be capable of functioning in online, real-time mode. A reputable database system with good operating record will be used for the ATC system.

The database must be capable of managing the following data:

- System configuration data;
- List of local controllers, vehicle detectors, and other devices comprising the ATC system;
- List of sub-area and local controllers;
- Phase sequence and time-of-day plans;
- List of vehicle detectors and parameters associated with vehicle detectors;
- List of threshold values, weighing factors, and adjustment factors for detectors;
- Operation and error logs of control center equipment, local controllers, and vehicle detectors;
- Signal timing applied for each signal;
- Traffic parameter data collected by vehicle detectors; and,
- Manual operation and intervention records.

3.6 ATC Center

The ATC center is planned to be set up at BMA 2 building. The room is already reserved as shown in Figure 3.11. However, additional facility and interior works are still required. The current layout of the room is not suitable for a traffic control center as too many staff are not required for the operation of the control center. The staff who will be assigned to the center and their tasks must first be defined before finalizing the layout of the control center.

The outline of the proposed center is given below.

Location: Ground floor of BMA 2 North Annex

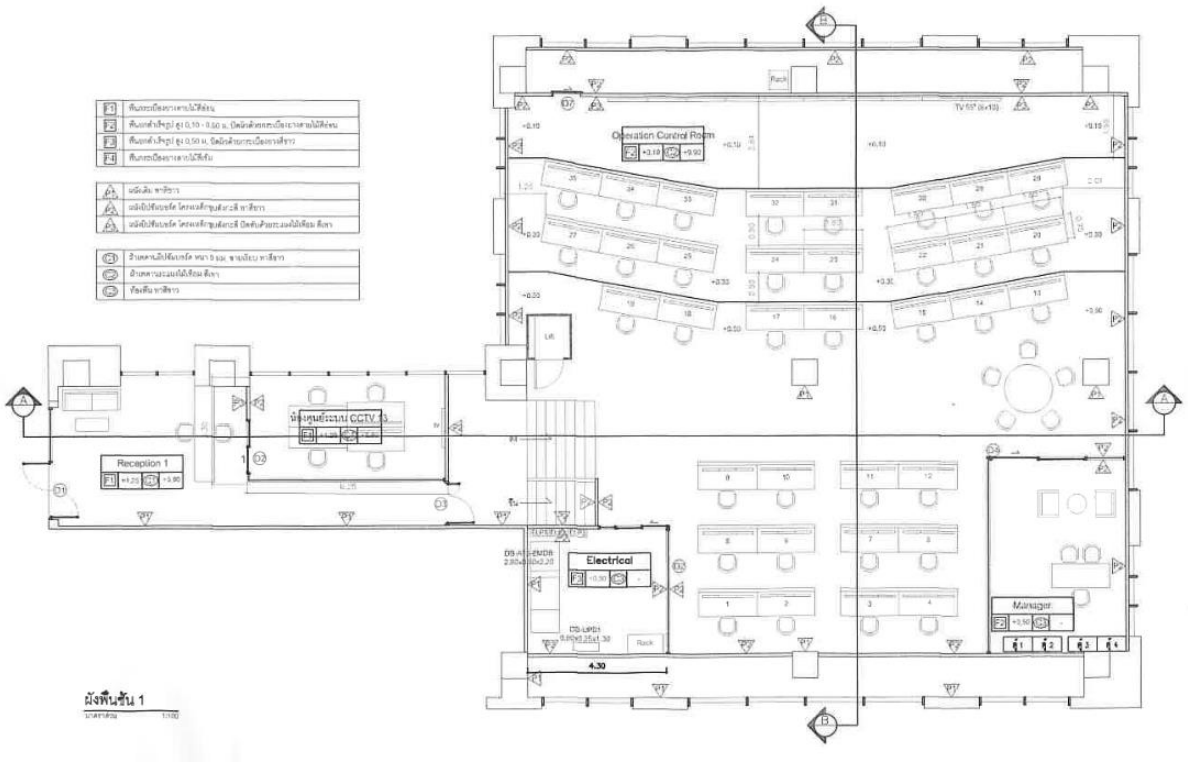
Area: 18 m x 18 m (324 m2)

Layout plan: See the drawings attached (operations room)

Machine room (not decided but must be next to the operations room, or operations room will be divided)

There are other facilities required for the room to function as a control center, as listed below. It is also suggested to have a visitor space from where the interior of the center can be viewed.

1) Uninterruptible power supply system preferably separated at the power reception from the power supply company;
2) Grounding (< 10 Ohm);
3) Air-conditioning system with sufficient capacity (heat dissipation from equipment);
4) Raised floor for machine room for cable laying;
5) Cable route between machine room and control room;
6) GPS antenna for system clock; and
7) Fire extinguishing system (preferable).



Source: BMA

Figure 3.11: Planned Traffic Control Center at BMA2

3.7 Local Controllers

The existing local controllers, including those for pedestrian crossings, are provided with the basic functions for signal control. However, they cannot be used for the future ATC system without upgrading. The changes or upgrading required are: 1) data communication function with the ATC center, and 2) pedestrian signal control function separate from vehicle signal control.

(a) Data Communication with Control Center

In an ATC system, all local controllers at intersections are connected to, and controlled directly from, the control center. The operating status of local controllers, including errors detected, are sent to the center. Vehicle detection signals by vehicle detectors are also sent to the center t compile traffic flow data, which is need in developing or selecting signal control parameters most suitable for the prevailing traffic conditions. For these purposes, local controllers must be capable of communicating with the control center.

The adaptive traffic signal system which BMA implemented in 2024 have local controllers designed for isolated control. It does not have the function to communicate data to the control center. Instead, it has a data processing function for vehicle detection data received from vehicle detectors. Additional hardware (communication device such as network adaptor) and data communication software must be added to the existing adaptive signals. The functions can be realized by installing CIDs between the local controllers and the control center like what was done in the model ATC system project.

For the ATC system expansion's Phase 1, adopting the same configuration used for the model ATC system project is recommended, in which CIDs were installed side by side with the local controllers to allow data exchange with the control center.

From Phase 2, it is desirable to use a new type of local controller with a data communication function and without a detector data processing function anymore. Detection signals from vehicle detectors will be sent to and processed at the control center itself, and traffic condition parameters will be calculated there as well. The configurations of existing isolated signals, adaptive signals being installed, and the proposed ATC system are shown in Figure 3.12. As the configuration and functions of adaptive signals have not been dislosed to BMA, the actual configuration may be differemt.

(b) Pedestrian Green Indication

Improvement is required for the pedestrian green indication. The local controllers currently used in Bangkok cannot set the pedestrian green time separately from vehicle green time. As a result, pedestrian green time terminates at the same time with vehicle green time, or a flashing green light is shown during vehicle yellow time as shown in the figure. These sequences are not safe as pedestrians are not given sufficient time to finish crossing. The pedestrian signal indication sequence must be changed to a phase design.

The existing pedestrian local controllers are not flexible enough to function under an ATC system, in which cycle, split, and offset are sent by the control center for local controllers to follow. The existing pedestrian signal is designed as a standalone, pushbutton type and is not fully capable of coordinating with other signals under coordinated operation. Under the model ATC system, only the operation of these signals could be monitored.

The local controllers for pedestrian crossing in Phase I must be capable of operating with the timing parameters sent from the control center. There are 51 pedestrian signals out of 211 signals planned for Phase I. Thus, the function is crucial for efficient signal operation along major roads where many pedestrian signals are located. Upgrading the controllers' function can be made by updating the software or upgrading the hardware.

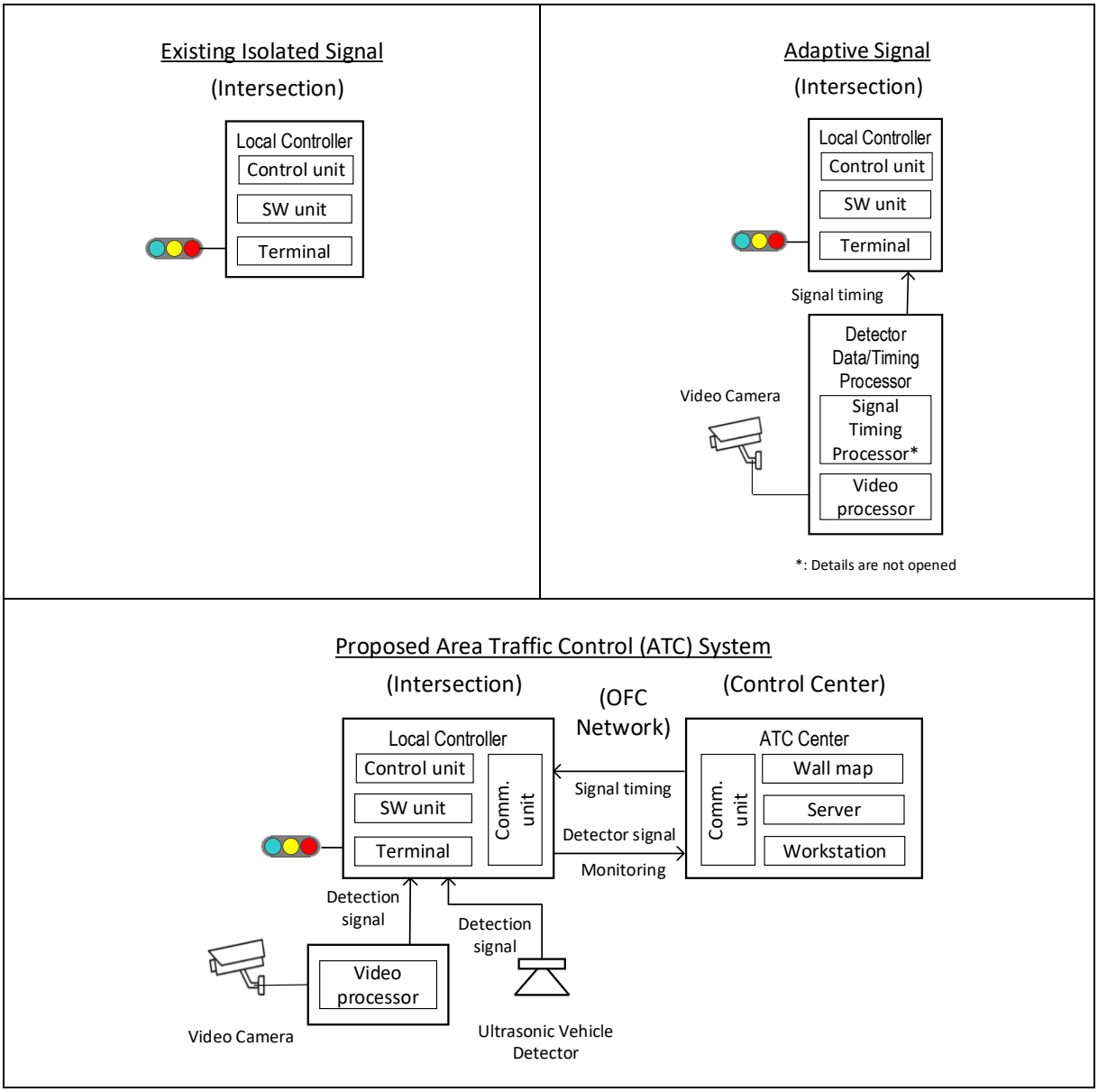
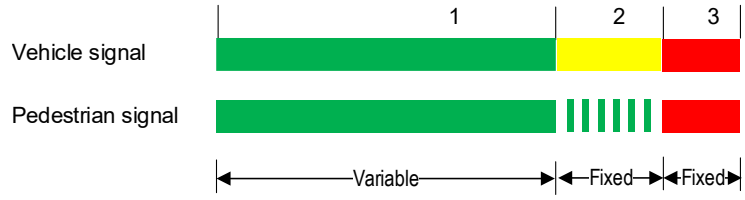


Figure 3.12: Configurations of Isolated Signals, Adaptive Signals, and an ATC System

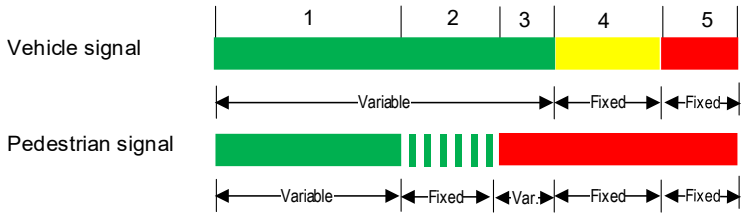
(a) Simultaneous ending of vehicle and pedestrian green time



(b) Pedestrian flashing green light during vehicle yellow light

Source: Project Team

Figure 3.13: Existing Pedestrian Green Sequences



Source: JET

Figure 3.14: Recommended Pedestrian Green Sequence

4. Fiber Optic Cable Network

The model ATC system uses BMA's FOC network for data communication between the control center and roadside equipment (local controllers and vehicle detectors). During the implementation of the model project, the project faced the difficulty of securing a reliable communication network. For one thing, BMA did not have the updated information about the FOC network (e.g., configuration, connection at splicing point, available core, condition of core, etc.). The drawings available were design drawings and do not reflect the current configuration and condition of the network and cable. Besides, proper maintenance was not carried out, and the cable was not usable at many sections. As a result, the FOC network was not available for the project at many sections, and BMA had to install new cables to connect the roadside equipment to the control center.

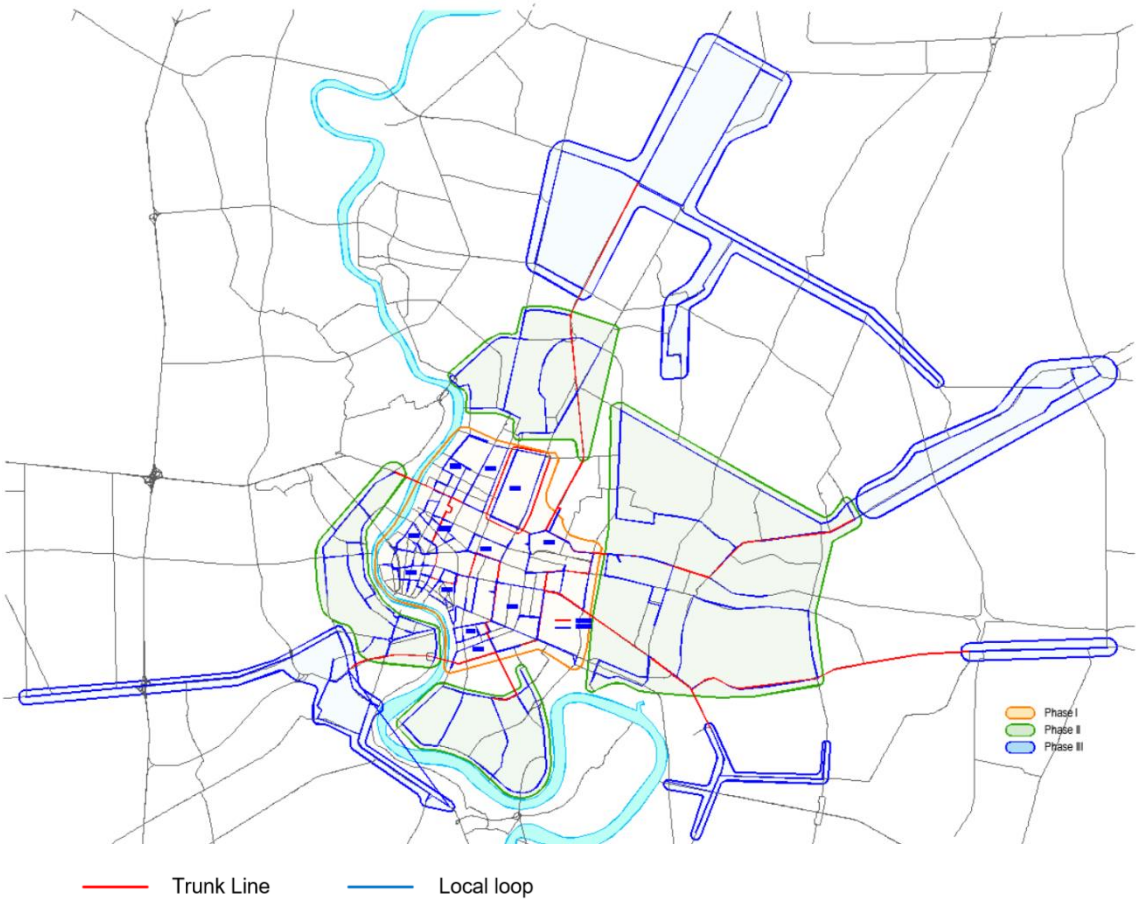
Based on the condition of the existing fiber optic network, it would be adequate to assume that the existing cable cannot be used for the proposed ATC system and new cables will have to be laid under the future ATC project. Only part of the existing conduits can be used for the new cable. In such a case, it is necessary to design an FOC network to connect all signals and vehicle detectors to the control center. Surveys will be made at the start of the consulting service for the ATC system expansion project to determine the condition of the FOC network in other areas and design the network to cover the entire project area.

A tentative FOC network (Figure 4.2), consisting of a trunk line and local loops, to connect all signals has been prepared to estimate the extent of the work. Based on this network, the length of the cables has been calculated as shown below.

Table 4.1: Length of Fiber Optic Cables

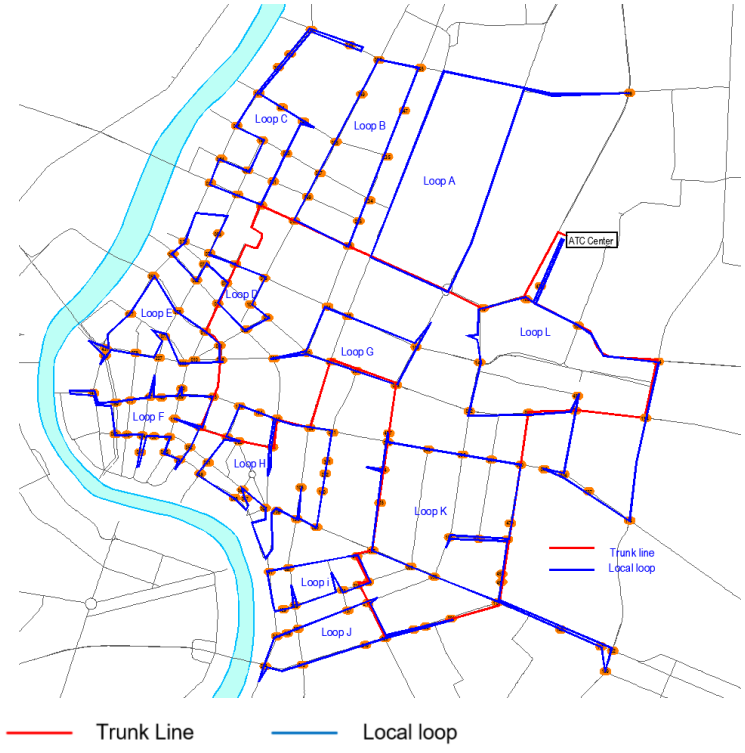
Type	No. of Cores	Phase 1 (km)	Phase 2 (km)	Phase 3 (km)	Total (km)
Trunk line	12C	27.9	26.9	29.2	86.6
Local loop	4C	95.6	154.2	134.3	384.1

Source: JET



Source: JET

Figure 4.1: Fiber Optic Cable Network for Bangkok



Source: JET

Figure 4.2: Fiber Optic Cable Network for Phase 1

5. Cost Estimates

The project cost is estimated for each phase of the expansion project. The cost estimate at this stage is rough at it was based on a conceptual design, i.e., the quantity of some equipment, such as vehicle detectors, and the length of communication cables cannot be estimated precisely at this stage. Moreover, the cost depends largely on the specifications and performance for the system and component equipment.

In preparation for cost estimation, the following assumptions were assumed:

- The ATC center system should have been adopted in other cities and has technical feasibility. Developing a new system for Bangkok is not recommended.
- The existing model ATC system may or may not be used for Phase I. The selection will left to the tenderer, and the contractor will be selected based on technical adequacy and cost.
- For Phase 1, the existing adaptive signals will be used but with the addition of CIDs to be installed between the control center and the adaptive signals to provide interface and compatibility between the center's system and the local controllers. Thus, the cost of adaptive signal local controllers was included in the estimates.
- For Phases 2 and 3, new controllers that are capable of communicating directly with the control center will be used. CIDs will no longer be used.
- Phases 2 and 3 will cover the expanded area with no addition of new functions nor upgrading of the system.
- Existing local controllers have a limit on the number of signal displays for each phase, and pedestrian green time cannot be separated from vehicle green time as mentioned earlier. The cost estimate does not cover the cost of modifying these existing local controllers to provide separate pedestrian and vehicle green time.
- Both vehicle detectors using images (CCTV camerass) and using loops (inductive or ultrasonic loops) will be used, the former near intersections covering multiple lanes, while the latter will be installed upstream of intersections to detector queues extending from the downstream intersection bottleneck.
- Upstream detectors will be used in the adaptive signal project, but the criteria in location selection and the number of vehicle detectors have not yet been determined by BMA. The number of detectors was assumed based on the number of intersections.
- A new FOC network, consisting of a trunk line and local loops, connecting all signals to the control center will be laid because the configuration and availability of the existing cable core cannot be confirmed.
- The cost of the FOC network was separately calculated as the network can be used for other communication needs of BMA. The ATC system requires communication link at the level of 10 kbit/sec, which is much smaller than the capacity of the FOC network.
- In Phase 1 all fiber optic cables will be laid underground inside the conduit. About 70% of the cables are run through conduits, and for the reamaining 30%, new conduits will be installed to accommodate the cables. If this is not the case, the cost of conduit installation must be adjusted.
- For Phases 2 and 3, the availability of conduits was assumed at 40% and 0%, respectively, as the project areas are away from the city center.
- O&M costs for the ATC system are not covered in the cost estimates.
- The costs were estimated at current prices and no price increase was assumed for Phases 2 and 3.

With the assumptions stated above, the costs of the ATC system at each phase are shown below.

Table 5.1: Estimated ATC System Project Cost (Excluding FOC Network)

Item No.	Description	Amount (THB)			Total (THB)
		Phase 1	Phase 2	Phase 3	
A	System Design	965,000			965,000
B	Documentation	850,000	160,000	160,000	1,170,000
C	Training	828,000	828,000	828,000	2,484,000
D	Traffic control center equipment	3,464,330	405,250	229,500	4,099,080
E	Remote monitoring system	243,770			243,770
F	Traffic control center software	8,997,000	3,774,000	1,818,000	14,589,000
G	Local controller	66,666,180	88,865,982	50,142,258	205,674,420
H	Vehicle detector	128,200,835	108,878,040	66,873,230	303,952,105
I	Communication equipment at Center	124,430	75,030		199,460
J	Optical fiber cable				
K	Spare parts and maintenance equipment	425,000	260,000	260,000	945,000
Total for Items A through K		210,764,545	203,246,302	120,310,988	534,321,835
	Overhead (10%)	21,076,455	20,324,630	12,031,099	53,432,184
	VAT (7%)	16,228,870	15,649,965	9,263,946	41,142,781
	Grand Total	248,069,869	239,220,897	141,606,033	628,896,800

Source: JET

Table 5.2: Cost of FOC Network

Item No.	**Description**	**Amount (THB)**			**Total** (THB)
		Phase 1	**Phase 2**	**Phase 3**	
J	Optical fiber cable	430,000,000	704,120,000	675,350,000	1,809,470,000
Total for Items A through K					
	Overhead (10%)	43,000,000	70,412,000	67,535,000	180,947,000
	VAT (7%)	33,110,000	54,217,240	52,001,950	139,329,190
	Grand total	**506,110,000**	**828,749,240**	**794,886,950**	**2,129,746,190**

Source: JET

6. Benefits of an ATC System

In general, an ATC system brings about various benefits not only to road users but also to the general public. For Bangkok, the main benefits of an ATC system are summarized below.

1) Economic Benefits

An ATC system makes traffic flow smoothly, and less congestion is realized by coordinating signals. The number of stops will be reduced and queue lengths at intersection bottlenecks will shorten. A smooth traffic flow also reduces fuel consumption. The operation of public transportation will be more efficient as their average speeds will increase. The same benefit can also be expected in cargo transportation. Although a precise calculation of these benefits is not possible as the basic traffic parameters, such as number of vehicles running on the network, capacity or efficiency of existing signals, particularly signals operated manually by traffic police, and amount or magnitude of delay incurred, are not known.

Nonetheless, a rough estimate of the economic benefit was made by applying the estimated benefits made in the model ATC system project. The steps are:

(a) Calculate the average benefit per intersection using the benefit estimate calculated in the model ATC sytem project.

(b) Apply the average benefit to all intersections covered by Phase 1.

Average benefit by Model ATC System Project

The benefits calculated in the model ATC system project is shown below. Two intersections were selected as the intersection for benefit calculation as other intersections were not congested and no substantial benefits were expected from the ATC system.

Table 6.1: Estimated Benefits at Two Intersections under the Model ATC System Project

Intersection	Benefit（THB/day）
Tuk Chai	107,355
Saphan Kwai	352,262
Average	229,808

Source: JET

The average benefit for all intersection signals in the model ATC project area was then calculated as follows:

Average benefit/signal: 229,808 / 15 = 15,320 (THB/day/signal)

= 5,515,200 (THB/year/signal)

Benefits for Phase 1 ATC system were calculated as shown below:

The above average benefit per intersection per day was applied to all intersections under Phase 1.

15,320 (Baht) x 159 (signal) = 2,435,880 (THB/day)

= 876,916,800 (THB/year)

The cost of Phase 1, excluding the fiber optic cable, was estimated at THB248,069,869. Thus, the cost of the ATC system is covered by the benefits within one (1) year.

2) Reduction in Traffic Accidents

In the past, Thailand held the worst record among ASEAN countries in traffic accidents. Over 20,000 deaths from traffic accident were recorded in 2023[4]. This implies that large number of deaths could have occurred in Bangkok. It is well known that smooth traffic can contribute to safer traffic because adequately timed and coordinated traffic signals under an ATC system contribute to the reduction of dangerious manuveurings such as red light running and sudden lane changes.

Many existing signals lack due consideration for crossing pedestrians, as pointed out earlier. By introducing traffic signals that are capable of showing pedestrian green time separately from vehicle green time, the safety of crossing pedestrians will be enhanced.

3) Reduction in Pollutant Emissions

It is well known that smooth traffic flow also contributes to the reduction in the emission of hazardous gases and contributes to cleaner air as the number of stops and the lengths of queues can be reduced by an ATC system.

[4] https://www.who.int/thailand/news/feature-stories/detail/turning-tragedy-into-action--advocacy-and-survival-on-thailand-s-roads

4) Useful Application of Police Manpower

According to the Metropolitan Traffic Police, about 4,000 police officers engage in traffic management. Most of them are assigned to intersections and often operate traffic signals manually, which is not only ineffective in easing congestion but also detrimental to the safety of road users. They intuitively try to manage traffic by showing green to one approach as long as there are approching vehicles even when traffic demand exceeds intersection capacity. This action often results in longer cycle times. It also runs counter to efficient signal operation because signal cycle times must be kept as short as possible; otherwise, it causes heavy congestion and longer waiting time.

There are many tasks that the traffic police must undertake other than manual signal operation like enforcing road traffic rules and promoting traffic safety.

7. Project Implementation

7.1 Phased Development

The ATC system in Bangkok is planned to be developed through the installation of adaptive signals in three phases, as outlined below.

7.1.1 Adaptive Signals

BMA has been implementing an adaptive traffic signal project, as explained in Section 2.3. The first batch of 72 signals was implemented in fiscal year 2024 (2567 in the Thai calendar). No adaptive signal is planned for installation in 2025 (2568) pending the validation of the effectiveness of the first batch. The second batch, comprising 100 signals, is scheduled for installation in fiscal year 2026 (2569).

7.1.2 Phase 1

The traffic control center will be established and connected to the existing adaptive signals and signals in the area covered by Phase 1, as shown in Figure 3.1. For these signals, CIDs will be used for data exchange.

The adaptive signals for the second batch mentioned above must already have some kind of hardware interface with the ATC system, which is scheduled to start in fiscal year 2027 (2570). The details of the data communication will be determined by the software once the supplier of the ATC system has been selected.

There are two options for the future ATC system development as shown below.

Option A	Expand the model (existing) system by adding more signals.
Option B	Install new local controllers and center system.
Option C	Use the existing adaptive signal by adding controller interface device (CID) to connect with the ATC control center.

(a) Option A

Option A expands the model ATC system with the same system configuration as shown in Figure 2.2 by adding more signals to the model ATC system. As the technology and data communication protocol are already established by the pilot ATC system, no technical issue is expected in adopting the configuration. The data communication protocol must however be disclosed so that other manufacturers of local controllers can offer their products.

The advantage of Option A is that the ATC system can expand with lower cost by utilizing the equipment and software already installed in the pilot ATC system. On the other hand, the data communication protocol and database in the control center must be disclosed to allow other suppliers to expand the ATC system.

(b) Option B

Option B introduces new ATC system consisting of new ATC center system and new local controllers. Any ATC system that has been proofed to be effective can be selected as there is no technical requirement to be compatible with the existing center and local controllers. On the other hand, total system cost will become higher as compared with other options due to introduction of new system and equipment.

(c) Option C

Under option C, a new ATC center system will be introduced and the existing adaptive traffic signals or new types of local controllers will be connected to the center either directly or through CIDs as shown in Figure 3.7 エラー! 参照元が見つかりません。. The communication protocol between the center and the local controller must be standarlized so that multiple suppliers can provide local controllers for the ATC system.

In selecting the contractor for the ATC system through bidding, three options must be made acceptable to BMA and the selection must be made initially based on technical adequacy of the proposed system and finally on the bid price.

7.1.3 Phase 2 and Phase 3

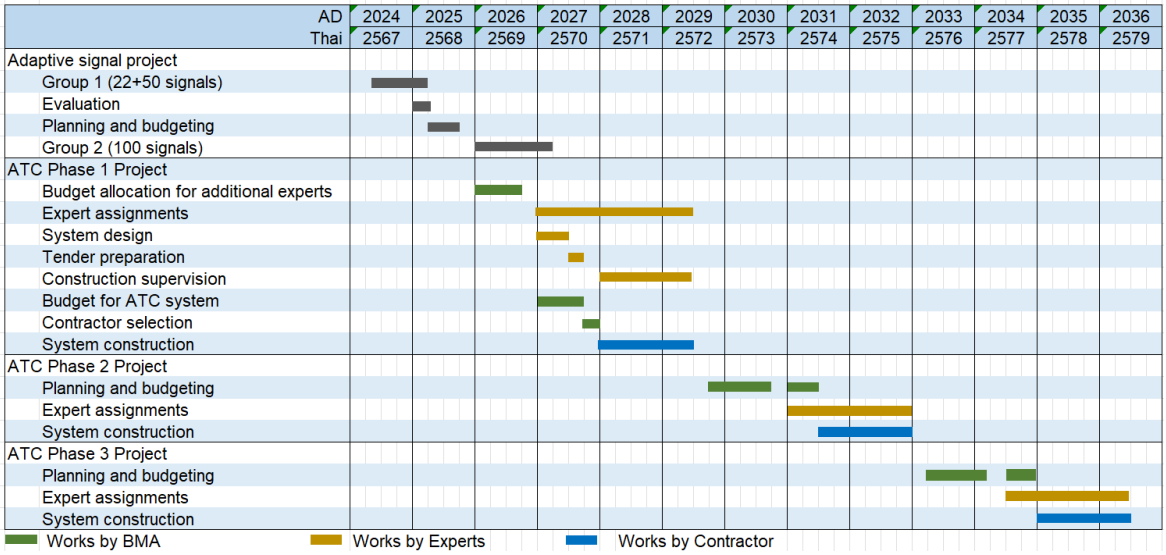
Traffic signals in the area covered by Phase 2 and Phase 3 will be connected to the control center based on the selected option in Phase 1.

The utilization of new data sources and new technologies shall be adopted for the expantion of the ATC system for effective and prompt establishment and operation of the ATC system, as shown in section 3.5.1.

7.2 Implementing Schedule

The ATC system will be constructed in three (3) phases. The implementation of Phase 1 will start from fiscal year 2027 (2570) after the budget for the services by experts has been secured. The design work, including technical specifications, cost estimates, and tender document preparation, will be carried out in nine months followed by the selection of the contractor for the ATC system by BMA. The local tendering will be based on BMA regulations. But it is strongly recommended that international standards for tendering be followed. For example, the conditions of contract should refer to those issued by FIDIC[5].

Phase 2 will be carried out in years 2031 (2574) through 2032 (2575), followed by Phase 3 in 2034 (2577) through 2036 (2579).



Source: JET

Figure 7.1: Implementation Schedule of the ATC System Expansion Project

5 https://fidic.org/bookshop

7.3 Implementation Procedure

The implementation of Phase 1 will have three stages of detailed design, i.e., tender document preparation and cost estimation, contractor selection, and system construction. The design and construction of an ATC system requires a wide range of knowledge in traffic engineering, server system, data communication, computer software and database, civil and telecommunication works, etc. BMA staff do not have the experience of designing and establishing an ATC system, and their capacity is not enough to undertake these tasks and manage the design and installation of a complex system like the ATC system, in which various technologies are used. Because of this, hiring a consultant team with members who are experienced and knowledgeable about ATC systems or similar projects is indispensable for the successful and timely implementation of the project.

8. Consultancy Services for the ATC System Project

The consultant for the ATC system must be experienced in the fields of ATC systems, signal design, traffic engineering, and project management. At the same time, it is recommended for BMA to form a task force that will exclusively be involved in the ATC project and work with the consultant team.

8.1 Scope of Consultant's Work

The scope of work to be undertaken by the consultant must be stipulated in the terms of reference (TOR) to be issued by BMA and is broadly composed as follows:

1) Project management;
2) Detailed design of the ATC system;
3) Cost estimation;
4) Preparation of tender documents;
5) Assistance in the selection of the contractor;
6) Construction supervision;
7) Acceptance testing and commissioning; and
8) Technology transfer.

The consultant will consist of members listed below at the minimum. They can be Thai nationals or foreigners with qualifications suitable for the positions.

1) Project manager;
2) Deputy project manager;
3) Systems engineer;
4) Traffic engineer;
5) Communication engineer;
6) Electrical engineer;
7) Cost estimator; and
8) Contract specialist.

8.2 System Design

System design covers such works as control center hardware, software and database, intersection signal design including phase design and timing parameters, detector or probe data processing, human-machine interface, system monitoring, and reporting.

Basically, no additional design is required for the equipment at the control center as the model ATC system is equipped with the functions required for an ATC. Only the addition of some equipment like communication control server is required to implement the system expansion.

Alternatively, it would be possible to introduce a new center system, if such option is beneficial for BMA in terms of system functions, system operation, and initial and operating costs.

Use of the existing local controllers is assumed but its function or specification needs to be upgraded. The local controllers will be fitted with CIDs to connect them to the control center through BMA's FOC network.

In addition to the design work above, general requirements about project management and technical requirements for installation work must be prepared by the consultant as part of design work.

8.3 Preparation of Tender Documents

The consultant will prepare the tender documents which consist of the following:

(a) Invitation for tender;

(b) Instructions to tenderers;

(c) Form of tender;

(d) Pricing documents;

(e) General conditions of contract;

(f) Conditions of particular application (if necessary);

(g) Employer's requirements; and

(h) Drawings.

It is recommended to adopt international standards and practices in the preparation of tender documents. For example, the general conditions of contract should follow the standards issued by FIDIC[6] supplemented by the conditions of particular application that stipulates conditions particular to the project.

8.4 Pre-qualification

Pre-qualification is recommended before tendering to exclude tenderers who are not qualified for the project. Prospective tenderers are required to prepare and submit the documents describing their qualification including general information, financial situation, average annual turnover, general experience, specific experience similar to the project, supporting subcontractor(s), curriculum vitae of key personnel, etc.

Only pre-qualified applicants will participate in the tender for the ATC system.

8.5 Assistance in Tendering

BMA will hold a tender for the ATC system and the consultant will assist them in selecting the qualified contractor. The consultant's work will include providing the response to clarification requests by prospective tenderers, reviewing the technical proposals, and preparing an evaluation report on the technical proposals.

8.6 Construction Supervision

The consultant will supervise the system's construction work based on the TOR for the consultant prepared and issued by BMA. The consultant will be the Engineer nominated by the Employer (BMA) and will supervise the construction including design review, work progress management, and acceptance testing.

8.7 Cost Estimate for Consulting Services

The cost for the consulting services for Phase 1 is estimated at THB141,660,250. It is noted that the scope and scale of the consulting services, in particular that for the communication network, cannot be estimated precisely at this moment due to the lack of information about the conditions

[6] https://fidic.org/

of the existing FOC network and the underground conduit system which accommodates the cables. The cost also depends on the progress of BMA's planned installation of adaptive signals. Thus the cost would vary during the detailed design.

Table 8.1: Estimated Cost of Consulting Services

	Item	Amount (THB)
1	Expatriate consultant	66,398,750
2	Local consultant	35,574,000
3	International Air Travel	4,840,000
4	Per diem	9,982,500
5	Supporting staff	16,940,000
6	Vehicle	3,630,000
7	Office	3,993,000
8	Report	242,000
Total		141,660,250

Source: JET

8.8 Selection of Consultant

The consultant for the project will be selected through a tender based on the quality of the proposal. The following documents must be prepared before inviting consultants to the tender:

(a) Letter of invitation

(b) Instruction to Consultants

(c) Data Sheet

(d) Technical Proposal Forms

(e) Financial Proposal Forms

(f) Terms of Reference

(g) General Conditions of Contract

(h) Special Conditions of Contract (If necessary)

A sample TOR is attached as reference.

9. Maintenance of the ATC System

Maintenance service must be procured for the maintenance of the ATC system after the defect liability period (one year after completion or any other period stipulated in the ATC system contract) and the system is finally accepted by BMA.

9.1 Objectives

The purpose of maintenance is to prevent failures from occurring, and if any problem is found, to restore functionality as soon as possible, in order for the ATC system to achieve the intended goal of a smooth and safe traffic.

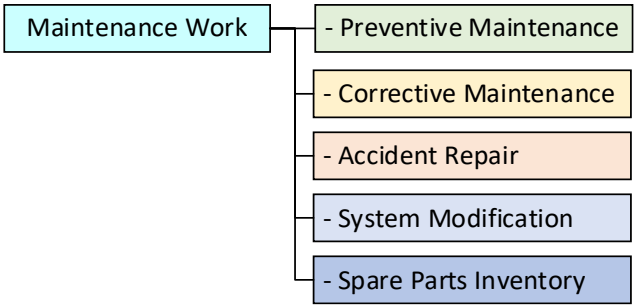
BMA's maintenance contract for adaptive signals focuses on the repair of euipment in case of breakdown. It must also cover other work to be carried out by the maintenance contractor as explained below and shown in Figure 9.1. While BMA's maintenance contract specifies the staff and equipment requirements, a maintenance contract must be a performance-based contract, in which the requirements, such as time to repair, must be specified.

9.2 Type of Maintenance

Effective O&M are indispensable for an ATC system to function efficiently for its lifetime. The existing maintenance contract between BMA and the maintenance contractor for the adaptive signals focuses on the repair of broken or damaged part of the signal equipment.

However, maintenance work is not only the repair of defective parts, it involves other works as illustrated in Figure 9.1. Preventive maintenance is carried out at regular intervals to confirm the normal operation of the equipment, while corrective maintenance and accident repair are done when any trouble or irregularity is found in the operation of the system. The difference between corrective maintenance and system modification is that the former is applied to the malfunction caused by wear and tear, abnormal environmental conditions, and acts of God, for which no one is responsible. Accident repair is the case when an equipment or part of it is damaged by a traffic accident or other acts by a third party. Repair work is required for these cases and, in the case of accident repair, the cost of repair is to be paid by the person or party who caused the damage.

The contractor or supplier of the equipment that becomes defective is not responsible for the defect after the defect liability period has expired, although the maintenance contractor is required to rectify or repair such defect.



Source: JET

Figure 9.1: Components of Maintenance Work

1) Preventive maintenance

Preventive maintenance is carried out by inspecting the devices and changing parts that need periodic replacement before the devices malfunction. The work includes:

- Inspection and testing of equipment (controller, vehicle detector, signal head, pole, mounting hardware, etc.)
- Cleaning of signal head
- Updating software at ATC center

2) Corrective maintenance

Corrective maintenance is to repair or replace defective parts and carried out on a priority basis based on the seriousness of the problems reported. The ATC system must be equipped with a monitoring and recording function of the equipment comprising the system. Alarms are issued for those problems that need immediate attention.

3) Accident repair

As the local controller, vehicle detector, and signal pole are placed on the street, they are often subjected to damage caused by traffic accidents or vandalism and stop normal operation. Such damage must also be repaired by the maintenance contractor. But the cost of such work must be paid to the maintenance contractor because repair work is not considered as part of corrective maintenance, and the maintenance contractor is not responsible for the damage.

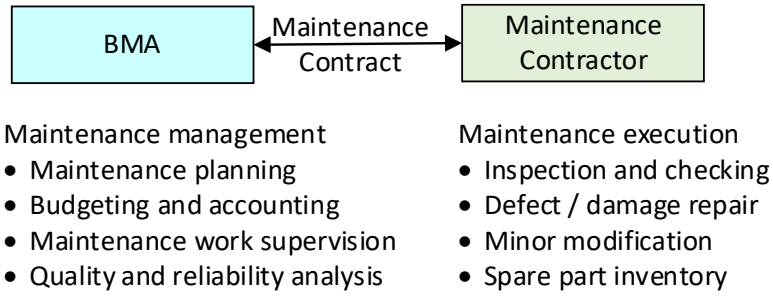
The contractor will be requested to prepare and submit quotation for the accident repair work. BMA will pay the contractor after scruitinizing the cost.

4) System modification

Traffic demand and flow change patterns over time. Changes in traffic regulations often cause such changes. The modification work required to cope with such changes must be covered and included in the maintenance contract.

9.3 Role Sharing between BMA and Maintenance Contractor

Although the Royal Thai Police is in charge of operating the ATC system, the Traffic Engineering Division (TED) of BMA is responsible for maintaining it. It is recommended to hire a maintenance contractor who carries out actual maintenance work, while maintenance work is managed and supervised by TED. The work to be carried out by these two parties are illustrated in Figure 9.2.

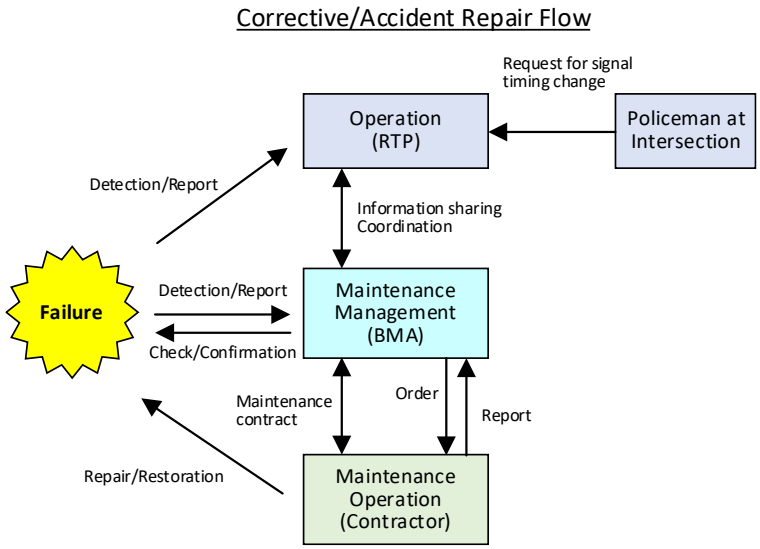


Source: JET

Figure 9.2: Role Sharing between BMA and Maintenance Contractor

9.4 Corrective Maintenance and Accident Repair

Maintenance and management of traffic signals, etc. will be carried out in cooperation with related organizations for the timely recovery of the system. Each organization will have the tasks assigned to them.



Source: JET

Figure 9.3: Flow of Corrective Maintenance and Accident Repair

Appendix

Terms of Reference for Consulting Service

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1. Background

1.1 Traffic in Bangkok

Thailand has shown a remarkable economic growth in recently years. The average growth rate during 2015-2019 was 3.42%[1]. Then, the economy contracted by 6.20% in 2020 due to Covid-19. The recovery is expected and the growth rate was 1.9% in 2023 and is expected to be 2.8% in 2024[2].

With the rapid economic growth, the number of registered vehicles in Bangkok also dramatically increased from 5.27 million in 2007 to 9.66 million vehicles in 2017 (increased around 1.7 times per 10 years). Car-dependent transportation of Bangkok caused the severe traffic congestion. Bangkok was ranked the second worst congestion in 2017 by TomTom[3].

1.2 Traffic signal in Bangkok

According to BMA, there are a total of 539 vehicle signals and 321 pedestrian crossing signals in Bangkok as of September 2023. All of them are isolated signal except the signals installed by pilot ATC system project mentioned below. No coordination is made between signals and each signal operates independently with neighboring signals. They operate based on the time of day plan every day and day of week is not considered. The traffic signals at key intersection are often controlled manually by the Traffic Police during peak hours.

Manual control of signal can be effective when traffic volume is low or moderate and green time is not fully utilized under pretimed control as green time can be shortened just enough to process the demand. It works like actuated signal. When traffic demand becomes higher and close to intersection capacity, however, manual control is not only ineffective but also becomes a cause of traffic congestion that propagate to neighboring areas.

BMA initiated a signal upgrading project and replace or installed signal that operates based on the traffic demand. The details of the control logic of “adaptive control” are not disclosed but it seems that it adopts some kind of actuated control.

Actuated control is effective for isolated signal with no neighboring signals nearby as offset is not important for efficiency of the signal operation. On the other hand, if distance between two neighboring signals is short, offset must be suitably set.

[1] https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=TH
[2] https://www.worldbank.org/en/country/thailand/overview
[3] https://corporate.tomtom.com/static-files/7b98ada1-ec2c-4da0-8579-f83ac0f31d88

Figure 1: Existing Signals in Bangkok

1.3 Pilot project of ATC system

BMA introduced a pilot area traffic control (ATC) system comprising vehicle signals and pedestrian signals in 2023 with the technical cooperation and fund from Japan International Cooperation Agency (JICA). The project covers signals along four arterial roads, namely Rama VI, Phaholyothin, Pradipat and Ratchawithi in Phaya Thai and Bang Sue Districts.

The Control Center of the ATC system pilot project is located at BMA2 compound from where all signals are controlled based on the traffic condition gathered by vehicle detectors installed at intersections and along routes. Both video and ultrasonic vehicle detector are used as detector.

Figure 2: Pilot Project Signal Locations

2. ATC System Project

2.1 Introduction

The traffic condition in Bangkok has reached the state in which traffic flow cannot be made efficient by controlling individual signals independently. Because of heavy traffic demand and existence of queue on all approaches, manual control currently often applied by traffic police is not effective as the police cannot grab the traffic condition on all approaches to the intersection and apply most suitable signal timing.

Area traffic control system is a system in which all traffic signals are connected and controlled by the signal control software installed at area traffic control (ATC) center, where a group of servers collect traffic condition of the road network gathered by vehicle detector, develop or select signal timing most suitable for prevailing traffic condition and control traffic signals directly from the center.

The benefits of ATC system are not limited to the reduction of congestion and reduced travel time, it also helps reduce the number of accidents and the severity of air pollution as movement of vehicles becomes more efficient and orderly even under congested condition.

2.2 Scope of Project

The Project is intended to introduce an area traffic (ATC) control system to Bangkok covering the most of the signals. The ATC system will be introduced in phases to limit the scale, cost and construction period to the manageable level.

Currently there are about 860 traffic signals operating in Bangkok. There signals will be connected with the ATC system in three (3) phases to make the number of signals in each group a manageable level based on the location, level of congestion and road network. New signals will also be added if the signal is warranted. The coverage area of the Phase I project is shown in orange in Figure 3. There are a total of 160 intersection signals and 51 pedestrian crossing signals in Phase I area.

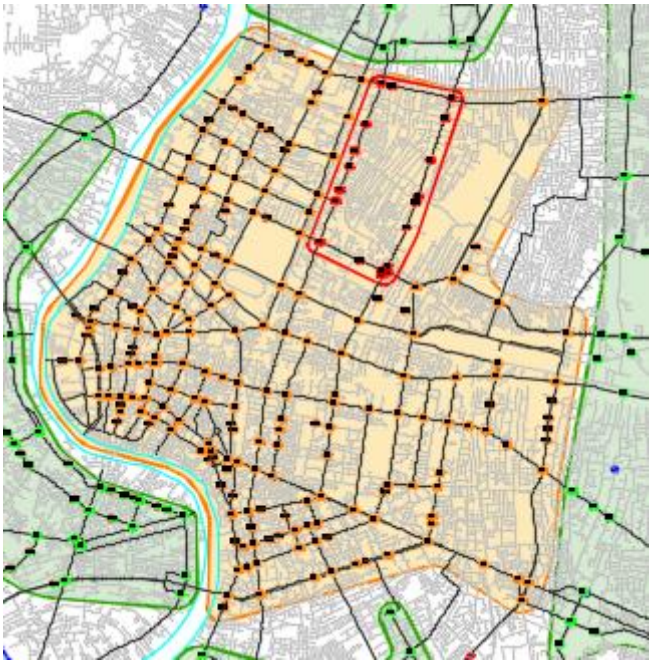


Figure 3: Phase I Area

An ATC Control Center will be established where servers and workstation are placed to monitor the operation of traffic signals, gather traffic condition data, prepare timing parameters, control directly traffic signals and disseminate traffic condition to the public. Traffic condition data and operation record of the equipment comprising the system will also be recorded. BMA has already secured a room for ATC system in BMA 2 compound.

The BMA's optical fiber network will be used for the data communication with local controller, vehicle detector and CCTV camera in the ATC system. The availability of the existing optical fiber cable is not certain at the moment and installation of new cable may be required for the ATC system. It is acceptable to use mobile communication network provided by mobile communication operator, if it is technically reliable and its initial and operation costs are acceptable to BMA.

The Project must be designed by competent and experience consultant who has an experience of ATC system project. The Consultant will also assist BMA in the selection of the contractor and supervise the construction work undertaken by the contractor.

2.3 Project structure

The Employer of the Project is the Bangkok Metropolitan Administration (BMA) and a consultant will be employed to undertake the design, construction supervision, acceptance testing and commissioning. The Contractor will be selected through an international competitive tendering based on the quality of technical proposal submitted by the tenderer (quality based selection, QBS).

3. Consultancy Services

3.1 Objectives

Consultancy services shall be provided by an experienced and capable consulting firm for the Metropolitan Bangkok Area Traffic Control System Project (hereinafter referred to as "the Project").

The Project is intended to establish an ATC system covering the central area of Bangkok. The system will utilize the existing local controller made by local manufacturer. Controller interface device (CID) will be added to local controller to fot the data communication between the center and local controller. Vehicle detectors will be installed at suitable locations to collect traffic condition data. The project is intended to ease the traffic congestion in the central area of Bangkok with the introduction of ATC system.

The Project is also intended to transfer the technologies related to traffic engineering and signal control to the local counterpart.

3.2 Scope of Works

The Scope of the Work to be undertaken by the Consultant are broadly composed of:

- Project management
- ATC system detailed design
- Cost estimates
- Preparation of tender documents
- Assistance in the selection of the Contractor
- Construction supervision
- Acceptance testing and commissioning
- Technology transfer

3.2.1 Project management

The Consultant shall engage in the project management and shall:

a) Assist BMA in the selection of the Contractor. If any inquiry is made by the prospective tenderer, the Consultant will assist BMA by preparing draft reply.

b) Monitor the progress of the work undertaken by the Contractor. If there is any delay or possibility of delay, the Consultant shall notify the Employer without delay.

c) Assist BMA in attending the issue that arise during the Project with other government agencies or private entity.

d) Prepare Consultant's monthly report that covers works undertaken during a month, assignment record of consultants, issues and problems encountered, if any, countermeasures to the issues and problems, and schedule for the next month.

e) Prepare and submit to the Employer a monthly billing for the works undertaken by the Consultant.

f) Review and comment on the monthly report prepared and submitted by the Contractor.

g) Review and recommend to approved to BMA the invoice prepared and submitted by the Contractor.

3.2.2 ATC system master plan

The Consultant shall prepare a ATC system masterplan for Bangkok and define the scope of work of phase I system.

The design work shall:

a) Locate the intersections and mid-block pedestrian crossing where traffic signal exists and prepare a map showing these locations.

b) Develop criteria to delineate the area to be covered by the phase I project based on the factors including but not limited to the road network, traffic volume, traffic bottleneck, traffic accident, existing and future BMA optical fiber network, and availability of the fund for the Project.

c) Identify the existing signal and the intersection where signal is warranted in the Phase I project.

d) Develop a phased expansion plan that covers the whole Metropolitan Bangkok

3.2.3 ATC system detailed design

1) Review of existing signal

The Consultant shall:

a) Review the existing design standards including signal design, pavement markings, traffic regulatory and guidance sign, and establish the design standards applicable to the Project.

b) Identify the locations and type of the existing signal in Bangkok to be covered by Phase I project.

c) Review the equipment malfunction records of the existing signals and other equipment comprising the system and identify the issues, if any.

d) Review the condition and availability of the existing optical fiber communication system and develop and design the communication network for the ATC system.

e) Based on the review works above, the Consultant shall prepare design policy and standards that include the followings:

- Signal warrants to determine necessity of traffic signal at a given location,
- Intersection signal design standards (hardware requirements and layout),
- Signal phasing and timing parameter development procedure,
- Optical fiber communication network design,
- Intersection signal design drawing standard, and;
- Pavement marking and traffic sign standards at intersection.

2) Design stage

The Consultant shall:

a) Conduct intersection turning movement count survey at thirty (30) high priority intersections in the Phase I area.

b) Conduct intersection capacity analysis for AM and PM peak hours at the turning movement count survey intersections and develop basic phase plan and basic timing parameters.

c) Prepare or update the intersection signal design drawing based on the design standards established during the previous works

d) Prepare functional requirements for the software of servers and workstations in the Control Center. The software shall cover:

- Vehicle detector data processing
- Timing parameter preparation
- Local controller control and monitoring
- Equipment status monitoring (center and local)

- Human-machine interface
- Traffic condition information dissemination
- Reports

e) Prepare the Employer's Requirements for the equipment comprising the ATC system including but not limited to:

Project management

Installation works

Control Center equipment

- Servers
- Workstation
- Communication equipment
- Wall map
- Control console
- Control center layout
- Control center wiring diagram
- Uninterruptible power supply (UPS)

Field equipment

- Local controller
- Local controller interface device (if used)
- Vehicle detector (various types to be used in the Project)

Communication system

- Optical fiber cable
- Media converter/switch
- data communication between the Control Center and local controller.

f) Prepare cost estimates for equipment, software, installation and other miscellaneous works to be included in the contract with the Contractor.

3.2.4 Assistance in the selection of the contractor

1) Pre-tender works

The Consultant shall:

Assist BMA in preparing tender documents in accordance with the standard tender documents of BMA and the international organization such as FIDIC. Tender documents include but are not limited to the following:

- Invitation for tender
- Instructions to tenderers
- Tender data sheet
- Evaluation and qualification criteria
- Tender forms
- Employer's requirements
- Drawings

- General conditions of contract
- Contract forms
- Conditions of particular document (if applicable)
- Prequalification document (if applicable)

2) Tender conference

The Consultant shall assist BMA in preparing the reply in writing to the questions raised by the prospective tenderers during tendering period and at the conference, if held.

3) Tender evaluation

The Consultant shall assist BMA in evaluating the technical proposals submitted by tenderers and prepare an evaluation report with the recommendations. The evaluation report shall indicate whether technical proposals submitted by the tenderers are in compliance with the Employer's Requirements issued by BMA.

3.2.5 Construction supervision

1) Construction stage

The Consultant shall:

a) Review, check and comment the system design manual prepared and submitted by the Contractor.

b) Carry out field inspections of the work undertaken by the Contractor and to see it that the works are being undertaken in compliance with Employer's Requirements, and the requirements of relevant regulation of the Government and industry.

c) Conduct periodic check of the work site safety and environment protection and instruct the Contractor to take necessary safety measures, if necessary.

d) Organize on a monthly basis and as needed project meeting with the Employer and the Contractor to review the progress of work, schedule for the next month, and discuss the issues encountered.

e) Report to the Employer any issue that may affect the progress, quality or scope of the work.

f) Review and verify the amount of works accomplished and certify the amount of progress payment on a monthly basis.

g) Review the documents including system design, specification of equipment, software and database, and operation and maintenance manuals prepared and submitted by the Contractor and comment on them.

h) Explain and/or adjust ambiguities and/or discrepancies in the Contract Documents and issue necessary clarifications or instructions to the Contractor in consultation with the Employer.

i) Assist and advise BMA in coordinating with the other government agencies and private entities as to the issue that has arisen in connection with or with regard to the Project.

2) Acceptance and commissioning

The Consultant shall:

a) Review and comment the acceptance test items and procedure prepared and submitted by the Contractor.

b) Attend the acceptance tests and review and confirm that the test results meet the requirements.

c) Review the documentations and as-built drawings prepared and submitted by the Contractor and confirm the correctness and adequacy of the documents and the correctness of the drawings.

3.2.6 Technology transfer

The Consultant shall carry out the technology transfer to the BMA counterpart as an important aspect in the design and supervision of the Works. BMA will nominate the suitable number of staff as counterpart of the Project who will work with the Consultant team.

The technology transfer will include but not limited to the following:

a) The Consultant shall provide the opportunity to the BMA counterpart to be involved in the working team of the Consultant during all stages of the Project.

b) The Consultant shall explain the technical details and provide background knowledge related to the Project to the BMA staff, if requested.

c) The Consultant shall provide the BMA counterpart with a copy of all documents and drawings submitted by the Contractor and arrange a meeting with the Contractor

3.3 Reports

The Consultant shall prepare and submit to the Employer the following reports with the number of copies indicated and in electronic form. All reports shall be made in English.

Report	Number of copies
• Tender evaluation report	3
• Monthly reports	5
• Supervision reports	5
• Draft final report	3
• Final report	5

3.4 Expected Schedule

The total duration of the Project and the consultancy services will be 36 months. The expected implementation schedule is as shown below.

Table 1: Expected Project Schedule

Activities	Period		Duration
Project management	1 January, 2026 -	31 December, 2027	24 months
ATC system masterplan	1 January, 2026 -	31 March, 2024	3 months
ATC system design	1 April, 2026 -	31 December, 2026	9 months
Assistance in contractor selection	1 January, 2027 -	31 March, 2027	3 months
Construction supervision	1 April 2027 -	31 March, 2028	12 months
Technology transfer	1 January, 2026 -	31 December, 2027	24 months

3.5 Consultant Team

3.5.1 Team composition and expected duration of assignment

The Consultant Team for the design, tender assistance, construction supervision and other miscellaneous consulting services consists of the following key personnel together with supporting staff. The minimum allocation of person-month for the respective phases of the consulting services is as shown in the table below. This person-month schedule is, however, indicative and the Consultant may deploy additional professional experts and/or support staff necessary for timely execution of the Project.

Depending on the pace of the progress of the project, the Employer may require the Consultant to adjust the deployment of their personnel.

Table 2: Input in person-month (reference)

		Design	Tender assistance	Construction supervision	Total
	Expatriate consultant				
1.	Project manager	6	1	9	16
2.	Systems engineer	4		6	10
3.	Traffic engineer	4		4	8
4.	Communication engineer	6		4	10
5.	Electrical engineer	2		4	6
6.	Cost estimator	2			2
7.	Contract specialist	1	1		2
		25	2	28	54
	Local consultant				
8.	Deputy project manager	9	1	18	28
9.	Traffic engineer	3		3	6
10.	Communication engineer	3		3	6
		12	1	24	40
		37	3	52	94

3.5.2 Scope of work of respective personnel

Expected tasks and duties that each consultant shall perform is provided below.

Table 3: Tasks and duties of the respective consultants

	Position	Tasks and duties
1.	Team Leader and Deputy Team Leader	1. Lead consultant team and ensure all deliverables are prepared in accordance with quality and time constraints. 2. Administrate and supervise site investigation, design, and documentation activities for the Project. 3. Identify appropriate design codes and standards to be applied in coordination with BMA. 4. Assist other consultant team members in the preparation of the functional specifications for the ATC system, software, database, and equipment comprising the System and see to it that specifications are adequate and applicable to the traffic in Bangkok. 5. Assist BMA in the evaluation of technical proposals submitted by the tenderers. 6. Hold project meeting with the Employer and Contractor to discuss and decide any matters related to the quality and progress of the Project. 7. Issue a Contract Change Order, if necessary, after consultation and agreement with BMA.

		8. Assist the Employer in coordinating with other government agencies or private entities as to the Project. 9. Review the monthly billing submitted by the Contractor and advice BMA about adequacy and correctness of the billing. 10. Review the acceptance test results and approve them if the results are satisfactory. 11. Prepare monthly progress reports in the form agreed with BMA. 12. Prepare a final report that compile the activities.
2.	Systems engineer	1. Review the composition and functions of the existing ATC systems including but not limited to the data acquisition, data processing, signal control parameter preparation, system and equipment monitoring, and human-machine interface. 2. Based on the review above, develop the requirements for ATC system in terms of system composition and functions and prepare the requirements and specifications for the system. 3. Compile the Employer's Requirements regarding the works above. 4. Review the technical proposals submitted by the tenderer in terms of system design and system function. 5. Review the system design manual submitted by the Contractor and comment on them for revision or modification. 6. Monitor and supervise the Contractor's work and see to it that all works are in compliance with the Employer's Requirements. 7. Conduct acceptance test and review and approve / disapprove the test results.
3.	Traffic engineer	1. Select the intersection where turning movement count survey is conducted. 2. Prepare TOR and contract documents for the intersection traffic count survey. 3. Administer the selection of the local consultant for the survey. 4. Review the survey results and request the consultant to conduct the survey again, if necessary. 5. Decide the location, type and coverage area of vehicle detector in collaboration with Senior Traffic Engineer. 6. Prepare / update intersection drawings that show signal equipment layout, signal cable route, pavement markings and traffic sign using AutoCAD with the proper scale. 7. Assist Cost Estimator to estimate the quantities of equipment, device, and works at intersection for cost estimates. 8. Develop timing parameter sets together with Senior Traffic Engineer. 9. Observe the signal operation at site and update the timing parameters for efficient operation.

4.	Communication engineer	1. Study the route and condition of the existing FOC network and conduit system and determine the availability of the existing network for ATC system and decide the amount of work of FOC and conduit system for ATC system. 2. Design additional FOC network for ATC system if the existing network does not meet the requirements for ATC system. 3. Prepare the technical specifications of the device for data communication between the control center and roadside equipment. 4. Prepare cost estimate of communication system in cooperation with Cost Estimator.
5.	Electrical / installation engineer	1. Prepare installation work drawings in cooperation with traffic engineer. 2. Estimate the quantity of various materials and works required at the intersection. 3. Review the work schedule prepared and submitted by the Contractor. 4. Inspect the work undertaken by the Contractor and see to it that all works are undertaken in compliance with the Contract, relevant regulations and work site safety. 5. Conduct the acceptance test of the installation work. 6. Review the amount of works undertaken by the Contractor and report to the Team Leader. 7. Advise Team Leader as to the design modification required due to site conditions.
6.	Cost estimator	1. Collect the data of cost prevailing in Bangkok for various equipment, software, materials and works required for the Project. 2. For the imported equipment and software, collect reference and sample data. 3. Confirm tax, duty and other indirect costs to be imposed on the materials and works of the Project. 4. Compile and prepare cost estimates in Thai Baht including the overhead of the Contractor and indirect costs. 5. Explain the procedure and details of cost estimate in reply to the inquiry by BMA, if any.
7.	Document / procurement / contract specialist	1. Assist BMA to administrate and monitor all project activities to ensure compliance with the relevant laws and regulations. 2. Prepare pre-qualification (PQ) documents in compliance with the BMA's procurement guidelines, if PQ is to be held. 3. Assis BMA in pre-qualification in accordance with PQ documents and prepare PQ report for approval by BMA. 4. Prepare documents required for ATC system in compliance with the relevant regulations and rules of BMA. 5. Review the tenders submitted by the tenderer and see to it all documents are in compliance with the requirements in terms of composition, format, and signatory.

		6. Evaluate the claims submitted by the Contractor with the support from other consultants and prepare a draft answer to Team Leader. 7. Support to the Team Leader to issue Contract Change Order, if any, and various certificates to the Contractor

The local consultant will assist their expatriate counterpart consultant.

Annex 15

Probe Data Experiment of the ATC System

Probe Data Experiment

1. Introduction

This report summarizes the results of comparative analysis between the queue length derived from probe car data and that measured by ultrasonic detector. This experiment aims to achieve the following two objectives:

1) Determine whether the queue length derived from probe car shows the same length and trend as that measured by vehicle detector, and
2) Analyze the differences in the traffic signal operation based on the probe car and the vehicle detector.

2. Methodology

2.1 Procedure

The Probe Data Experiment for the ATC system follows the steps outlined below:

1) **Recording of queue length by two methods**: In the model ATC system, the queue length derived from probe car, which is provided by a navigation service provider, and that measured by vehicle detector installed by the project are automatically recorded every minute in the ATC system's database.
2) **Comparison of queue length by two methods**: Queue length data was retrieved and averaged over the days selected for comparison. A correlation test was performed to determine if probe car-derived queue length data follows the same trend as detector-measured data. If correlation it high, it indicates that the two datasets exhibit similar trends. Additionally, the system's ability to detect area-wide queue lengths was assessed by directly observing the detection range and interval of queue lengths processed through probe data.
3) **Observation of change in traffic signal operation**: Operation record of traffic signal timing at each intersection recorded in the system was retrieved and analyzed. The average split for each phase was compared between scenarios where queue length data from probe car and detector data were used over a 24-hour period.

2.2 Data Used for analysis

1) Study location

   Data was collected and analysis was made along approaches of three locations below.

   - Tuk Chai Intersection,
   - Victory Monument Roundabout (VMR)
   - Saphan Kai Intersection

2) Queue Length

   One-minute average queue length is calculated by the ATC system using the procedure below.

   Probe car: Probe system provides 1-minute average speed at each road section. The sections are defined by the navigation service provider and the length of section ranges

from less than 10 meters to more than 200 meters depending on the geometric condition of road and road network. Sections that show slower than threshold average speed are considered congested. Queue length is calculated by adding length of congested road section starting from the intersection along the approach.

Vehicle detector: Vehicle detectors are placed along approach at 300 m, 600 m, and 900 m from the intersection stop line in principle. Occupancy rate[1] measured by vehicle detector is used to calculate the average speed at the detector point and then queue length along approach is estimated based on the occupancy rate at vehicle detector locations.

3) Signal timing

Split is a ratio of green time against signal cycle length and the total of splits for all signal phases equals one. The signal timing algorithm implemented in the system takes into account not only traffic demand but also queue length into the split calculation. In the pilot ATC system, signal timing implemented is automatically recorded and can be retrieved from the database by specifying the date and time.

4) Data set used

Refer to Table 1 for the dates when data was collected for the analysis.

Table 1: Data sets used in the analysis

Location	Queue Length Comparison		Phase Split Comparison	
	Detector	Probe	Detector	Probe
Tuk Chai	5/29~6/2	5/29~6/2	6/13~6/16	8/23~8/24, 8/28~9/1, 9/7~9/8
Victory Monument	5/29~6/2	5/29~6/2	6/13, 6/16	8/22, 8/28
Saphan Khwai	5/29~6/2	5/29~6/2	6/13, 6/15	8/11, 8/23, 8/28

Source: Study Team

3. Analysis

3.1 Comparison of queue length

The queue length estimated by two methods is presented in Figures 2 through 4. Both methods show similar trend for all approaches and locations. But difference is notable between them. The followings are observation and analysis of the queue length by two methods

1) **Difference in queue length**: Queue length by probe car generally shows longer queue than that by vehicle detector. There are two reasons for the difference. Firstly, vehicle detector cannot recognize slow moving vehicles until queue extends longer and reach the location of vehicle detector. Secondly, if queue extends beyond the vehicle detector located at the most upstream point, there is no way to locate the end of queue.

2) On the other hand, probe car data provides average speed of each section along approach and there is no limit on the distance from the intersection. For this reason, probe car data is considered more representative of the actual queue condition.

[1] Occupancy rate is the percentage of time that sensing area, which is a circle of about 1.2 meter in diameter under ultrasonic sensor head, is occupied by vehicle.

3) For signal control, whether queue is cleared in one green interval or not is an important factor to consider. For this reason, first queue detector is placed at about 300 m from stop line as queue is cleared if its length is less than 300 m. For this reason, discrete queue length data is considered applicable to signal control.

4) It is noted that signal operates cyclically and queue extends or shortens following the signal indication. On the other hand, both probe car and vehicle detector methods average speed data at one minute interval. As signal cycle and data measurement cycle do not coincide or not synchronized, speed and queue length estimated by both methods fluctuate and queue length estimation error cannot be avoided.

5) A clear distinction is evident when comparing the plotted average queue lengths of probe car and detector data for each approach at every intersection. Probe car exhibits the remarkable capability to detect more continuous queue lengths compared to vehicle detectors. This is attributed to the relatively larger interval between detectors. Furthermore, the probe car system has the ability to detect queue lengths at greater distances, overcoming the limitations of detector reach. It's important to emphasize that the Root Mean Square Error (RMSE) value alone does not accurately represent the precision of Probe car data.

6) The majority of approaches at all intersections exhibit notably high correlation values, surpassing approximately 0.7. This strong correlation demonstrates that Probe car data closely aligns with the trend of queue lengths detected by the respective detectors. This strong correlation indicates the potential of substituting detector-derived queue length data with queue length data obtained from Probe car.

7) As pointed above, whether magnitude of queue length is longer than the limit that a green time can process is a key factor in signal operation. In this sense, it is not required to measure queue length proportionally all the time.

8) The findings from this analysis affirm the robustness of the probe car system in capturing queue length trends that align well with detector-detected queue lengths. This suggests the possibility of utilizing probe car data as an alternative to detector data for queue length estimations, enhancing the accuracy and reliability of the ATC system's traffic management strategies.

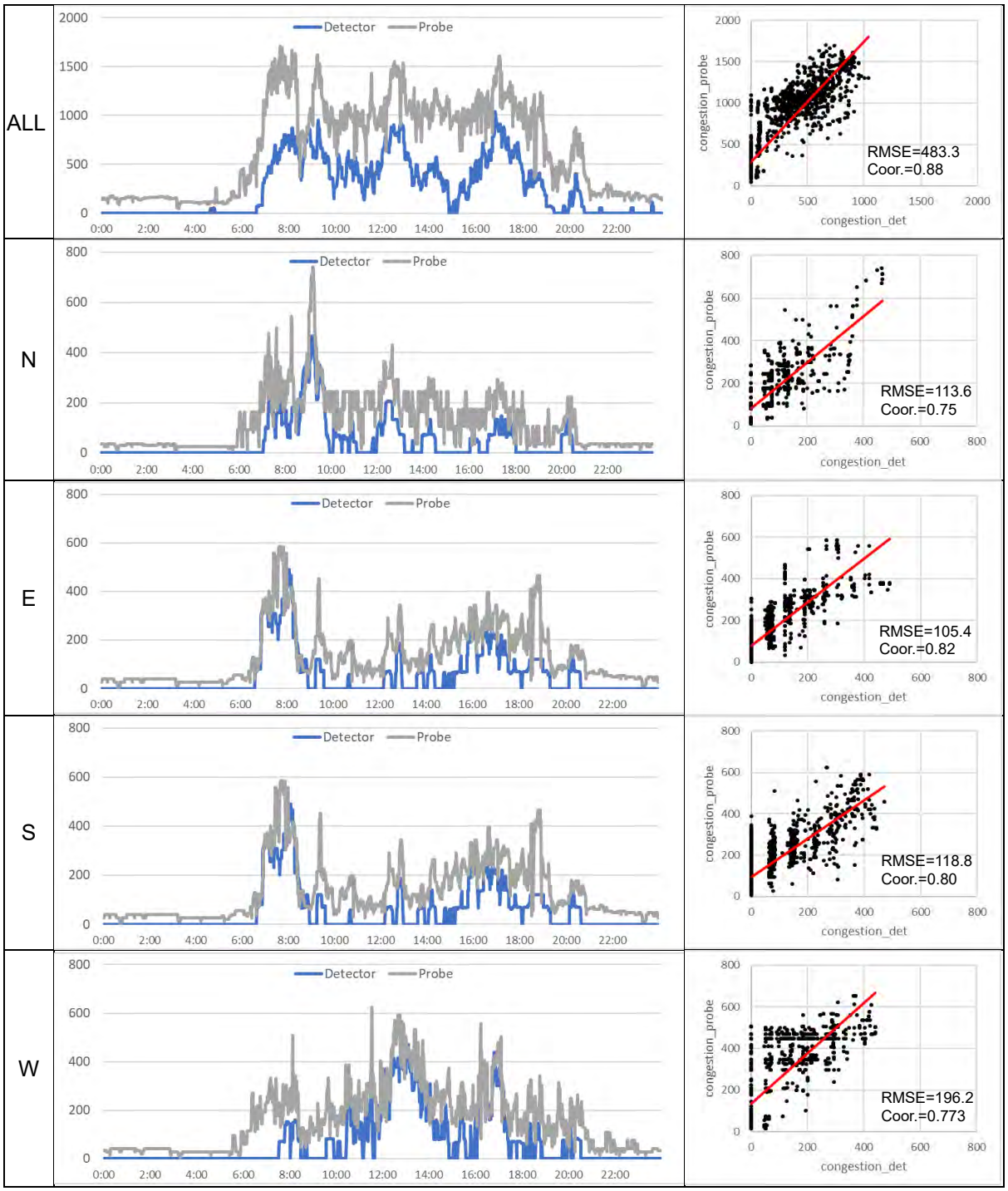
4. Conclusion and recommendation

The followings are conclusion of the experiment:

- Both probe car and vehicle detector produce the queue length with the accuracy sufficient enough to apply to signal control.
- Both methods have their own tendency about queue length due to their measurement / detector mechanism. But the difference is insignificant for signal control.
- Queue length by vehicle detector has a limitation on the maximum queue length that can be detected.
- Probe car method provides queue length with the sufficient precision for signal control under this experiment. But applicability may be affected by how sections are defined, which is beyond control of the signal system.

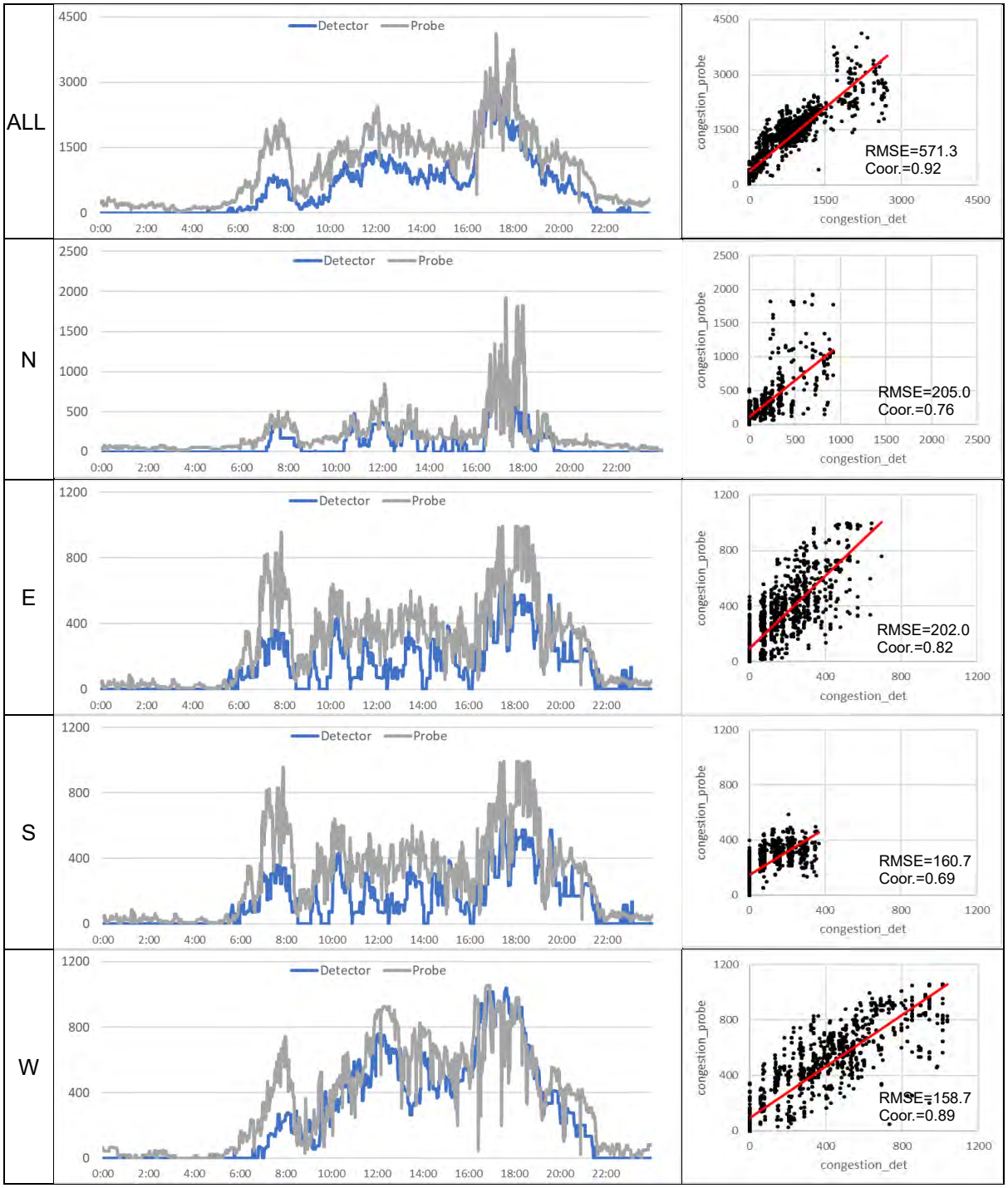
- Continues availability of probe car data is a key factor that would affect the usefulness of probe car data. Multiple sources of probe car data is desiable.
- Although no analysis is made in this study, probe car method has large advantage over vehicle detector method in terms of initial, operation and maintenance costs.

Based on the conclusions stated above, use of probe car method is recommended for the future ATC system in Bangkok.



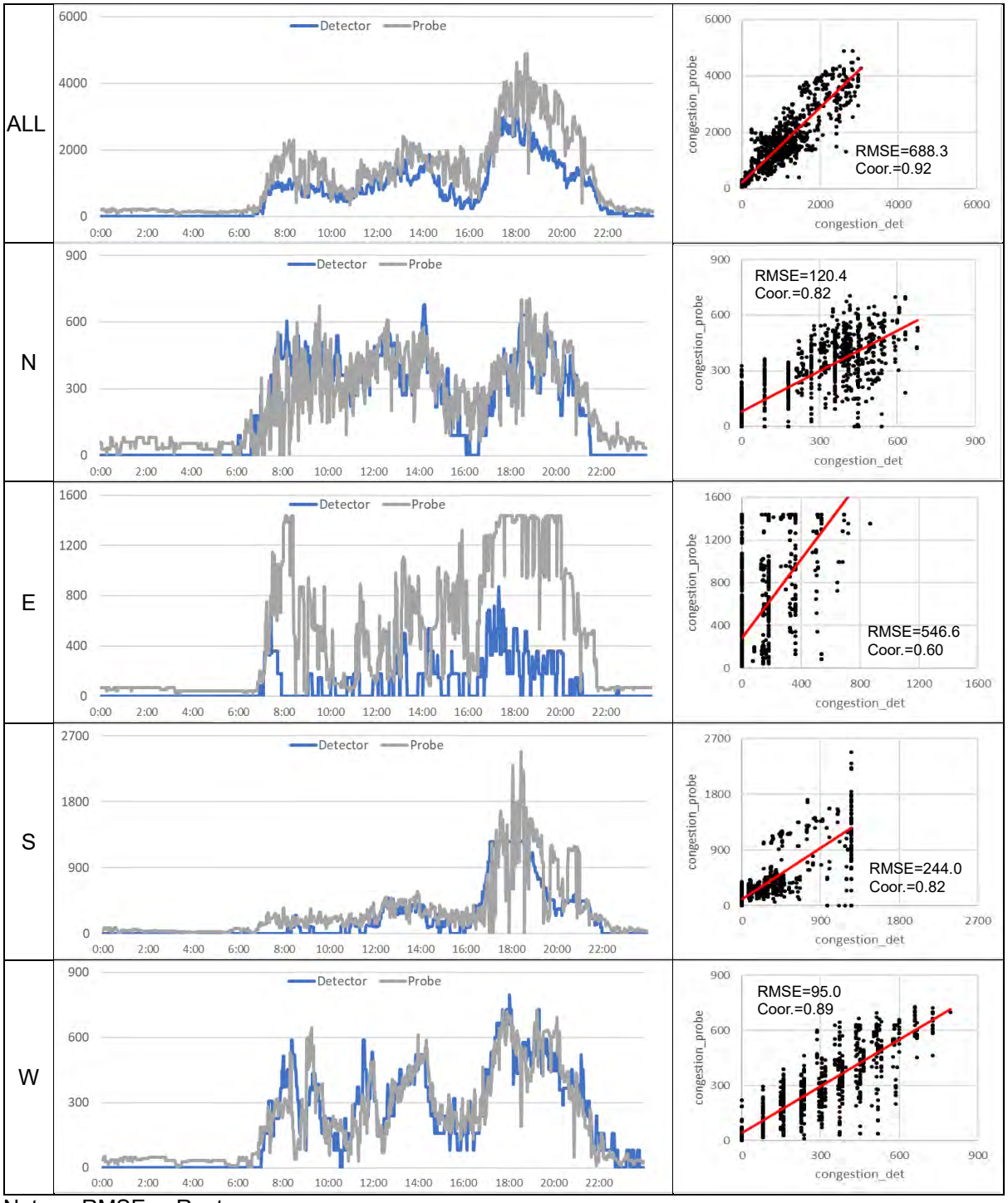
Notes: RMSE: Root mean square error
Coor: Correlation value

Figure 1: The comparison of queue lengths observed by Probe car and detector data at Tuk Chai Intersection



Notes: RMSE: Root mean square error
Coor: Correlation value

Figure 3: The comparison of queue lengths observed by Probe car and detector data at VMR



Notes: RMSE: Root mean square error
Coor: Correlation value

Figure 4: The comparison of queue lengths observed by Probe car and detector data at Sapahan Kwai Intersection

4.1 Traffic signal operation changes

9) Through a comparative analysis of signal data obtained from both detector-based and probe-based traffic signal control during periods of reduced manual intervention by police officers, and with no loss of probe data (as presented in Table 2 below), we identified slight modifications in the split timings of each signal phase. These adjustments were made to align the signal operations more closely with the actual traffic conditions. Notably, the probe data exhibited a superior capacity for detecting queue lengths, particularly in continuous stretches of road segments. Consequently, the alterations in split timings were specifically tailored to better reflect the real-time traffic dynamics.

Table 2: Dataset Utilized in Split Timing Comparison

		Control by Detctor	Control by Probe
Saphan Khwai	Off Peak	2023/06/13 12:00	2023/08/11 12:00
		2023/06/13 13:00	2023/08/23 12:00
		2023/06/15 12:00	2023/08/23 13:00
		2023/06/15 13:00	2023/08/28 12:00
		4.0[h]	**4.0[h]**
Victory Monument	Off Peak	2023/06/13 12:00	2023/08/22 13:00
		2023/06/13 13:00	2023/08/28 12:00
		2023/06/16 12:00	
		2023/06/16 13:00	
		4.0[h]	**2.0[h]**
Tuk Chai	Morning Peak	2023/06/14 07:00	2023/08/24 07:00
		2023/06/14 08:00	2023/08/24 08:00
		2023/06/15 07:00	2023/08/30 08:00
		2023/06/15 08:00	2023/08/31 08:00
		2023/06/16 07:00	2023/09/01 07:00
		2023/06/16 08:00	2023/09/08 07:00
		6.0[h]	**6.0[h]**
	Off Peak	2023/06/13 12:00	2023/08/23 12:00
		2023/06/13 13:00	2023/08/23 13:00
		2023/06/15 12:00	2023/08/28 12:00
		2023/06/16 12:00	2023/08/28 13:00
		2023/06/16 13:00	2023/08/31 12:00
			2023/08/31 13:00
		5.0[h]	**6.0[h]**
	Evening Peak	2023/06/13 17:00	2023/08/29 17:00
		2023/06/13 18:00	2023/08/29 18:00
		2023/06/14 17:00	2023/08/31 17:00
		2023/06/14 18:00	2023/08/31 18:00
		2023/06/15 17:00	2023/09/07 17:00
		2023/06/15 18:00	2023/09/07 18:00
		6.0[h]	**6.0[h]**

Note: periods of increased manual intervention by police officers were excluded

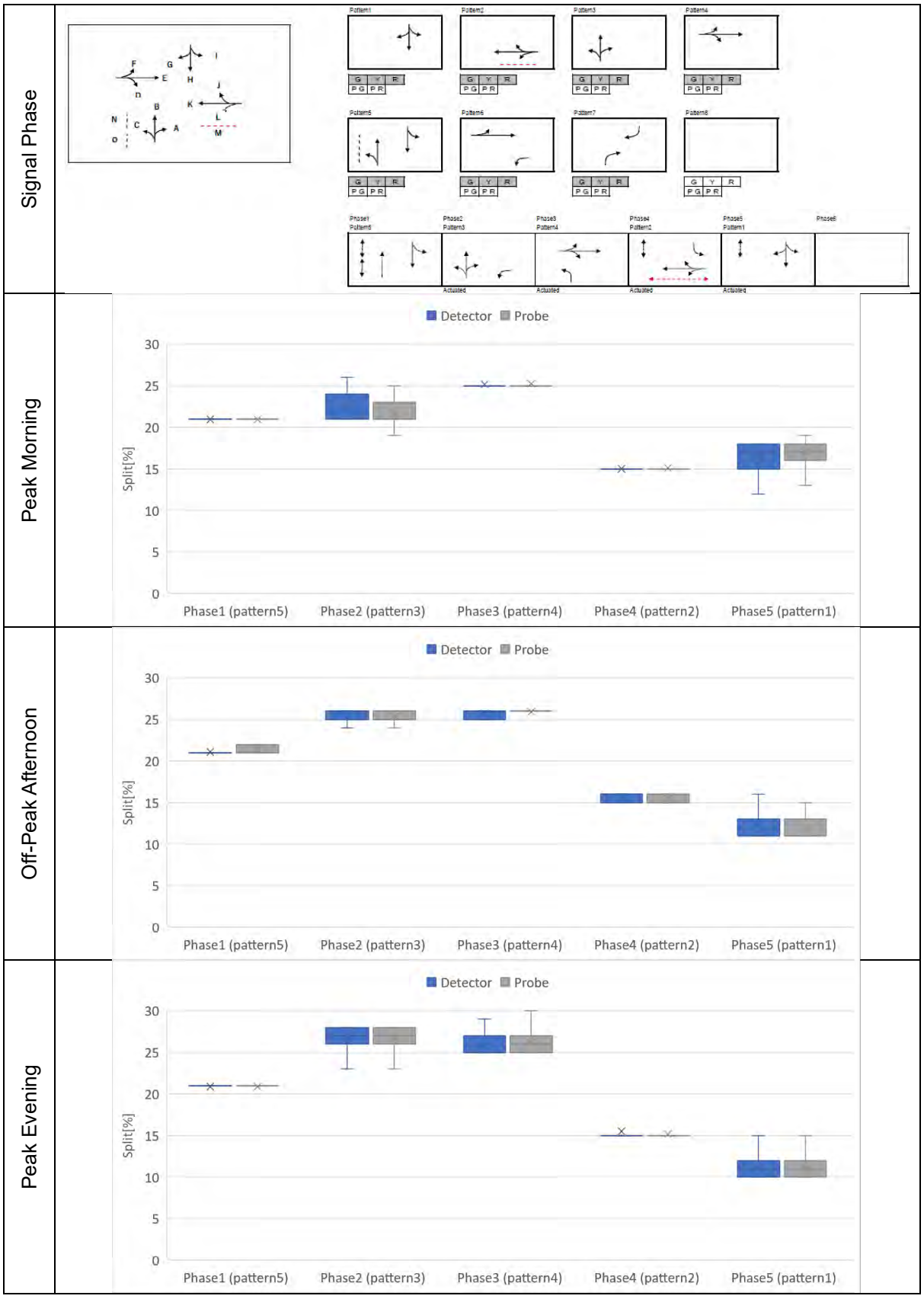


Figure 5: The comparison of split timing by using Probe car and detector data at Tuk Chai Intersection

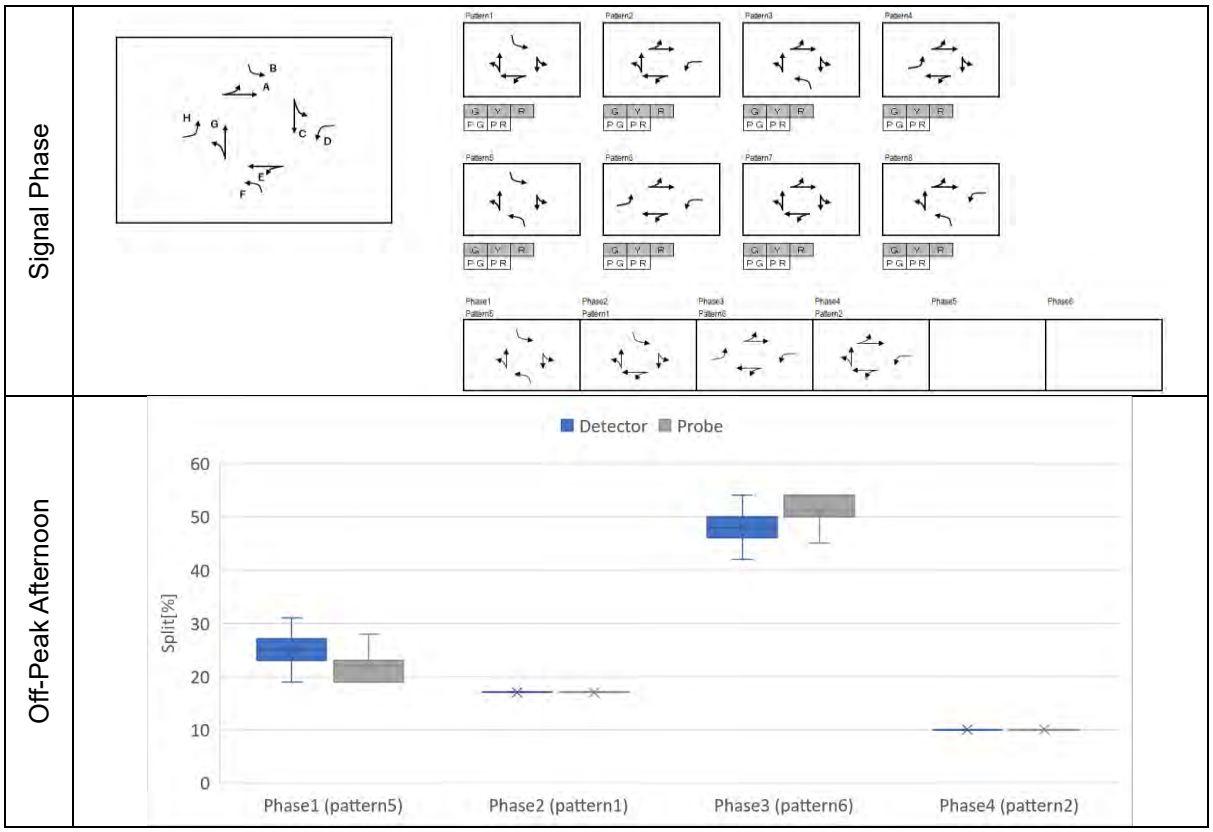


Figure 6: The comparison of split timing by using Probe car and detector data at VMR

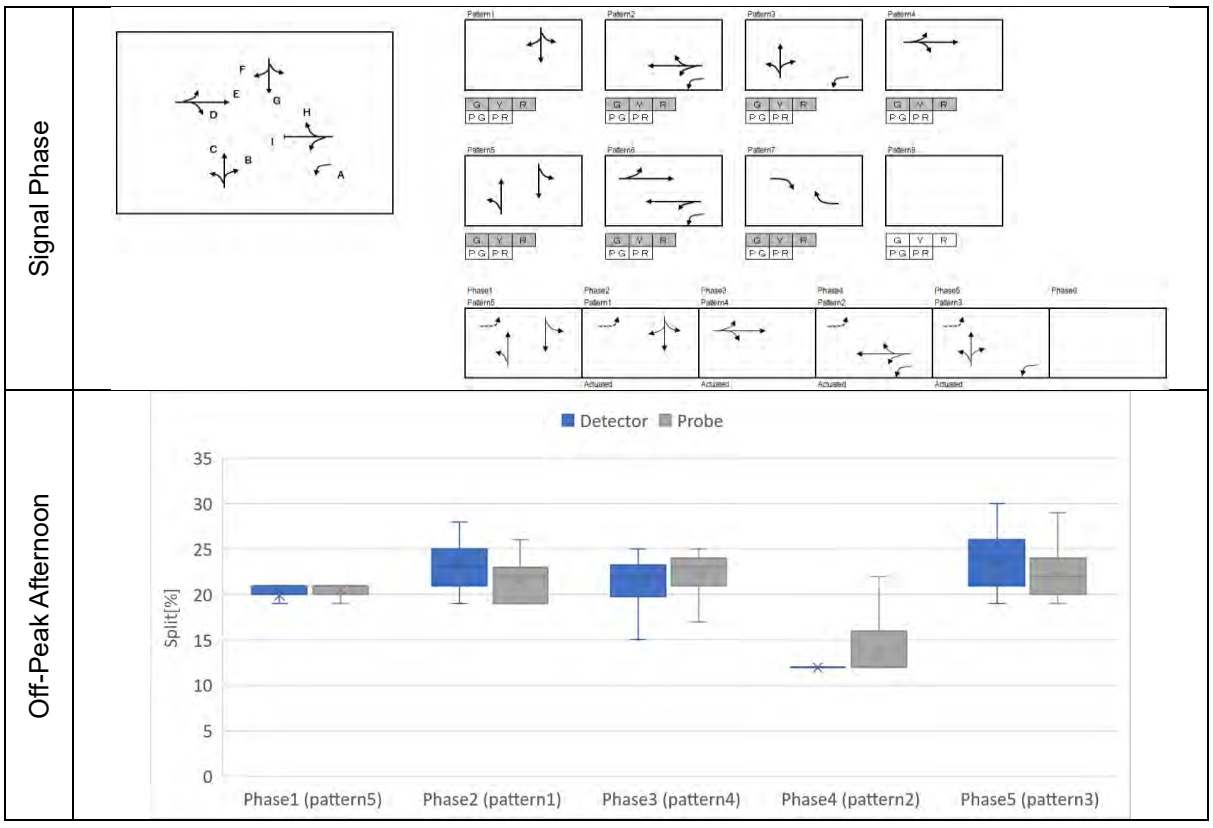


Figure 7: The comparison of split timing by using Probe car and detector data at Saphan Kwai