DEPARTMENT OF PUBLIC
WORKS AND TRANSPORT

MAINTENANCE MANAGEMENT MANUAL

Project for Capacity Development on Comprehensive Traffic Management Planning and Traffic Control Center Operation and Maintenance in Phnom Penh Capital City (PPTMTC)

METS RESEARCH & PLANNING, INC.
INTERNATIONAL DEVELOPMENT CENTER OF JAPAN
ORIENTAL CONSUTANTS GLOBAL

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MAINTENANCE MANAGEMENT MANUAL PHNOM PENH TRAFFIC SIGNAL SYSTEM (PPTSS)

CHAPTER 1 Introduction

Section 1 – Background

The Phnom Penh Traffic Signal System (PPTSS) is a grant aid project of the Japanese government to Phnom Penh Capital City. “The Project for Development of Traffic Management System in Phnom Penh” as its project title is a comprehensive traffic management project for the capital city consisting of an area traffic control system and other traffic management works. The basic design was completed in 2014, followed by the detailed design in 2015, and the project was started in March 2016 and completed in December 2018. From the original 109 intersections the system presently consists of the following features shown in Table 1 and the system basic structure in Fig 1:

Table 1: System Overview

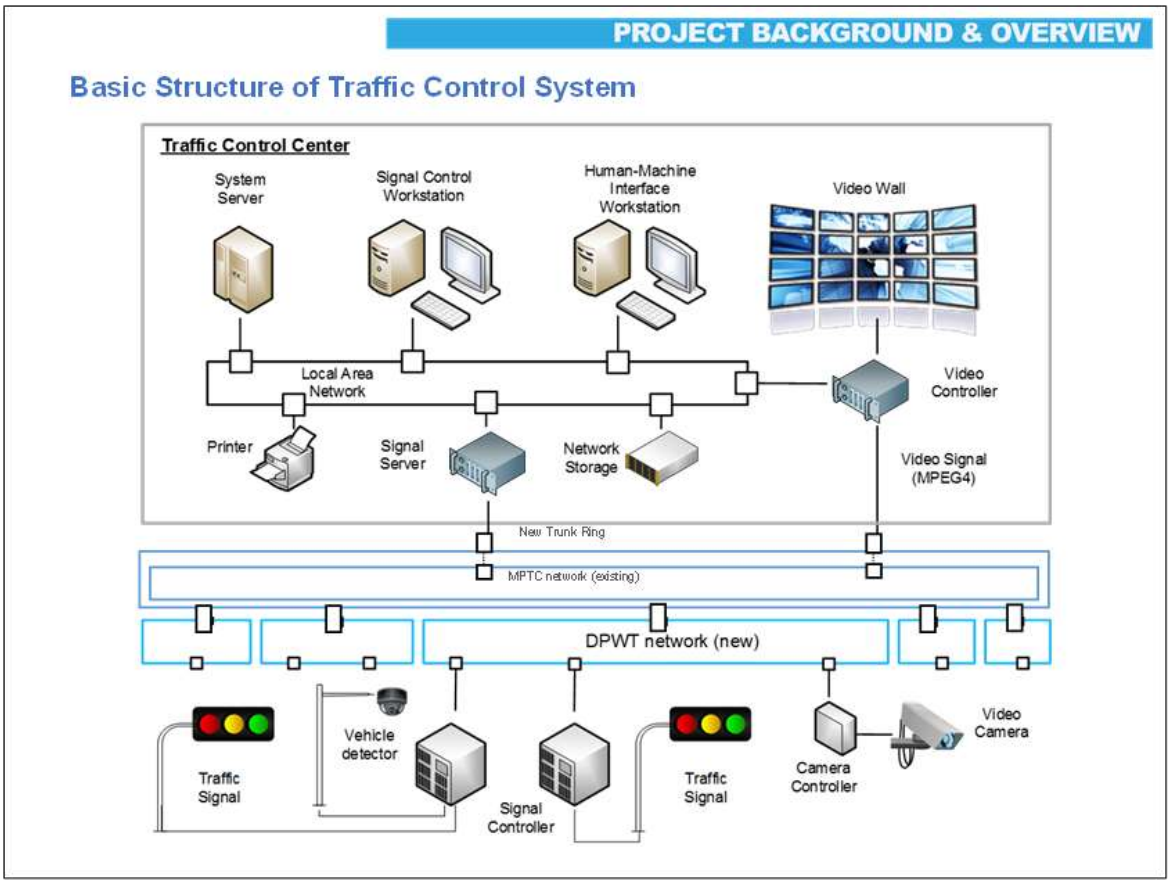
Items	Qty
TCC Equipment	1
Local Controller	115
Vehicle Detector	194
CCTV Camera	26

As per design, the operation of traffic control system includes the following works:

A. Monitoring of signal operation
B. Monitoring of traffic condition in the area
C. Checking of daily, monthly, and annual reports
D. Reception of incident information from road user or other organizations
E. Preparation and implementation of countermeasure against incident
F. Periodic communication with other organizations
G. Review of signal timing plan and development of new phase and timing plans
H. Calculation of timing parameter and input into database
I. Reception of report on defective equipment and abnormal operation of signal

J. Supervision of maintenance work by maintenance contractor
K. Review and keeping of system operation log
L. Spare parts inventory management

Figure 1: Basic Structure of the Traffic Control System



Section 2 – Importance of Preparing this manual

It is of utmost importance that the maintenance of PPTSS is well planned, organized, and well managed. Therefore, the JICA included the development of maintenance management in the implementation of this project. Even it will be for the best interest of the Phnom Penh based organization that they prepare most part of the manual so that they can adopt the policies to fit their needs, the project will be priming up the TCC and prepare the Maintenance Management Manual to serve as starting point for this very important responsibility that will benefit not only its stakeholders and the public but the image of the government as well. Traffic professionals and politicians know that there are consequences in inefficient or faulty management practices in maintaining the traffic signal system as enumerated and explained hereunder.

Consequences of system failure and malfunctions caused by design, installation, accident, faulty maintenance, and operational deficiencies can be categorized into five major areas:

- Increased motorist costs,
- Increased maintenance,
- Increased accidents and liability,
- Poor air quality, and
- Poor public image.

Increased Motorist Costs

Frequent malfunctions of signal control system resulted to unnecessary delays that waste motorists' time and fuel and increase pollutant emissions. Travel time, fuel and maintenance cost can exceed and compensate the cost of good signal maintenance program.

Traffic signal phasing and timing to provide smooth progression through adjacent signalized intersections is a technique that can mitigate this consequence.

Increased Maintenance

Faulty control system equipment requires maintenance expenditures to repair or replace parts, and often shortens the useful life of the equipment. Inadequate design attention to future maintenance requirements, inadequate inspection during installation, and improper maintenance practices may lead to unnecessary failures or malfunctions, increasing staff time, replacement part costs, and inventory requirements.

Increased Accidents and Liability

Faulty installations and improper or negligent maintenance can increase accident rates and may subject responsible agencies and their personnel to liability claims.

Poor Air Quality

Faulty control system equipment and improper or insufficient maintenance can affect traffic flow and possibly degrade air quality, increase fuel costs, and air pollutant emissions. Unnecessary vehicle stops contribute significantly to these consequences. Emphasis must be placed on establishing systems to improve air quality either locally or regionally.

Poor Public Image

The public usually has no perception of traffic control devices unless the devices malfunction because of non-operability or degradation, or if motorists are consistently delayed at a traffic signal with no traffic on the cross street.

Poor maintenance may evoke negative public image. The consequences of faulty maintenance increases motorist costs, maintenance, accidents, and liability, poor air quality, and tarnished public image—combine to reinforce the importance of traffic control system maintenance.

Budgeting Funding is crucial to the proper maintenance of any system. It determines the types of equipment procured and the number of staff hired. Budgeting available funding is important to providing adequate service to an agency's jurisdiction. It is not always an easy task since it involves a balance and distribution of available funds, which are not always in cash. It also deals with systems, which by their nature, should be transparent to the decision makers.

Service Life of system components.

In general, even if a device is well inspected and repaired, there is a limit to the usability period, which is called the life. The life of the equipment includes the absolute life due to aging, wear and tear, and the occurrence of irreparable failures, and the practical life due to technological innovation and obsolescence of functions in response to social demands. The absolute life depends on the installation environment of the equipment. As the absolute life of the equipment approaches, the frequency of failures suddenly increases, so it is necessary to manage the failure history and strive to update the equipment that has reached the end of its life as soon as possible.

Section 3 – Scope and Purposes of this Manual

a. This manual intends:

- to ensure that PP Traffic Signal System (PPTSS) is operated sustainably by the TCC team,
- to provide TCC with necessary full-time staff with adequate basic knowledge to a level needed to operate and maintain the PPTSS to its full efficiency.
- To consolidate vital information, policies, and procedures into one reference document, and
- To serve as an initial educational material for new staff to be assigned or employed at TCC in the future.

b. Purposes

Full operation of the traffic control system is possible only when the equipment is kept in perfect condition. Maintenance management is an important issue because traffic signal equipment is often installed outdoors and have many relationships between them. The increase in the number of signal installation and variations in the resulting deterioration, the sophistication and diversification by the technological developments, etc. make maintenance work complicated and difficult, which is why proper maintenance management is strongly required.

The purposes of maintenance are as follows:

- to make the equipment free from failure,
- to prevent equipment failure that is more expensive to correct, and
- to recover the function immediately after failure occurs.

To make the equipment trouble-free, it is important to consider the reliability of the equipment at

the design, manufacture, and construction stages.

At the same time, it is necessary to perform feedback statistical analysis of failures and attempt to improve equipment, construction methods, and materials. To prevent breakdowns, preventive maintenance is necessary, and inspection cycles, inspection items, and inspection methods must be defined and carried out systematically. In the event of a breakdown, the situation at the site must first be grasped, and in parallel with that, immediate repair must be carried out.

The Maintenance Management Manual of the Traffic Control Center summarizes the implementation of the traffic control system operation and maintenance that responds quickly to the traffic conditions in the central business district (CBD) of Phnom Penh Capital City for the safety and smoothness of traffic in Phnom Penh.

Section 4 – Organization of the Manual

This manual is organized into two parts, namely: PART I - Mission, Organization and Responsibility of TCC Staff, and PART II: Maintenance Management Policy and Procedures which describes in detail first (1st) – the basic functions of the Traffic Control System and second (2nd) – how to maintain it properly using the principles of Maintenance Management.

Part I is laid out under Chapter 2 which explain all the items from the TCC mission up to the responsibilities of each unit of the traffic signal system management.

Part II begins with the basic function of the system and is intended for new employees and future training for the new recruits, discussed in Chapter 3. Maintenance Management processes and procedures are discussed under Chapter 4 up to Chapter 7 covering explanation of all items needed for the maintenance of the system.

Chapter 8 concerns with the coordination and information dissemination which is also one of the inherent responsibilities of an organization doing public service to the community of people.

Chapter 9 is one of the most important aspects of operation and maintenance of the Traffic Signal System which is about the safety of the motorists, the public and the maintenance crew themselves.

Section 5 – Acronyms and Abbreviations

PPTSS – Phnom Penh Traffic Signal System
TCC – Traffic Control Center
HMI – Human-Machine-Intervention
RSE – Roadside Equipment
PPCA – Phnom Penh Capital Administration
PPCC – Phnom Penh Capital City

DPWT – Department of Public Works and Transport
TSSAC – Traffic Signal System Advisory Committee
EWP – Elevated Work Platform
IMSA – International Municipal Signal Association
ITE – Institute of Transportation Engineers
WSCC – Workers' Safety and Compensation Commission
MAD – Minimum Approach Distances
CBD – Central Business District
NRSC – National Road Safety Committee
OSHA – Occupational Safety and Health Administration
TBM – Toolbox Meeting

CHAPTER 2 Mission, Organization, Responsibility

Section 1 – Mission Statement

With the goal of 'Creating a sustainable urban transport environment through proper traffic control system operation" for all stakeholders and urban transport-related organizations, it is the mission of TCC to:

(1) Manage vehicular and pedestrian road surface traffic flow in Phnom Penh CBD,

(2) Operate and maintain facilities of the traffic signal system, and

(3) Collect and analyze traffic data and road information, and support publication and sharing of traffic information to all public entities or government instrumentalities and the public that may need them.

Section 2 – Organization and Responsibility

A preliminary organizational set-up, staff composition and management system are shown on the succeeding pages. They are drawn up based not only on the present status and issues of TCC in Phnom Penh but also with reference to TCC in Japan and the Philippines.

(1) The Traffic Signal System Advisory Committee, which is the upper management of Phnom Pehn Traffic Signal System (PPTSS) managed under Traffic Control Center (TCC) team, appoints the Chief and Deputy Chief of TCC. The Chief and Deputy Chief of TCC manage and operate the entire Traffic Signal System with the help of the TCC team.

Management policies of the Goal toward its achievement will be done by the TCC Advisory Committee and related organizations, but the TCC mission will be managed by the TCC management; and it is necessary to develop the countermeasures in case it cannot be achieved.

(2) TCC Management (TCC Chief and Deputy Chief)

The necessary abilities for a TCC Chief and Deputy Chief are management, communication, information gathering, and risk management. In addition, listening, fair judgement, organizational management, self-management, and the knowledge of traffic management/traffic control system are also required.

(3) The Four (4) Sections in TCC Operations

- ❖ Finance/Personnel Section
- ❖ Analysis/Planning Section

- ❖ Operation Section
- ❖ Maintenance Section

Four sections shall comprise the technical and administrative functions of the day-to-day operations and maintenance of the whole traffic signal system under the TCC organization. Detailed functions of each unit are enumerated in the succeeding tables.

(4) The Existing Manpower of the TCC

The following existing staff that is currently maintaining the Phnom Penh Traffic Control Center are the initial manpower that is recommended to fill up the necessary positions as per their qualification, training, and experience. Aside from their experience in the actual performance of their duty for about 4 years, they have undergone the seminars on “Capacity Development on Comprehensive Traffic Management Planning and Traffic Control Operation and Maintenance” under the current project.

Table 2: Existing Staff at TCC

July 22, 2022				
No.	Name	Sex	From	Position
1	Ms. Pheng Pharinet	F	DPWT	Chief at TCC
2	Mr. Ouch Sansothy	M	DPWT	Deputy Chief
3	Mr. Lim Kimseang	M	DPWT	Technical Staff
4	Mr. Eang Sophalla	M	DPWT	Technical Staff
5	Mr Man Kimchhuon	M	PPCH	Technical Staff
6	Mr. Sam Phalla	M	PPCH	Technical Staff
7	Mr. Chea Vandeth	M	Private	Technical Staff
8	Ms. Kun Sokhim	F	Private	Technical Staff
9	Mr. Heng Venglim	M	Private	Technical Staff
10	Mr. Phok Uy	M	Private	Technical Staff
11	Mr. Kem Ravy	M	Private	Technical Staff
12	Mr. Im Setha	M	Private	Technical Staff
13	Mr. Uy Lysin	M	Private	Technical Staff

(5) Function

Each layer of management group has been tasked with their specific responsibilities for the complete management of the signal system as enumerated below.

Table 3: Functional Chart

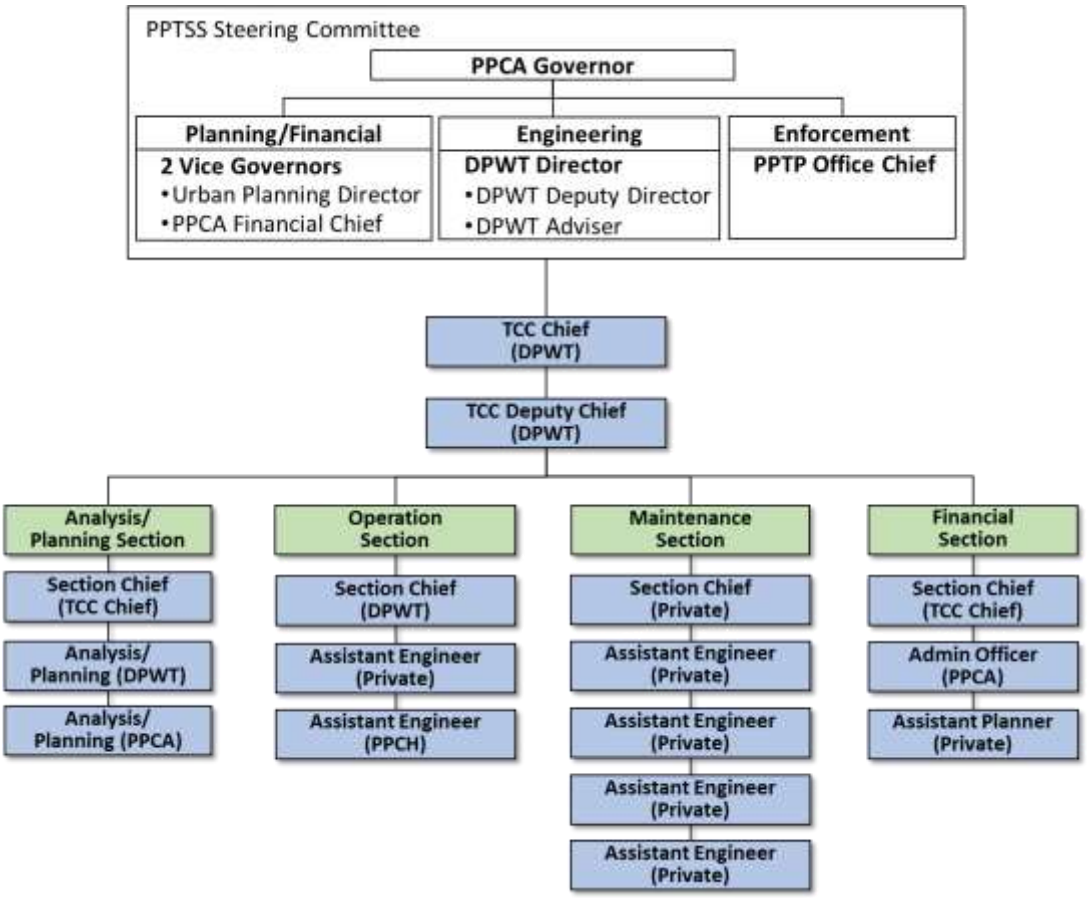
Functional Chart	
Group	**Function**
PPTSS Steering Committee	• **Overall steering function for the administration of Phnom Penh Traffic Signal System and Traffic Management component.** • **Receive and review the annual report submitted by the TCC, understand the issues of the past year, make recommendations, etc.** • **Conduct annual regular Joint Committee Coordination meeting.** • **Review, consider and approve the TCC budget plan for the coming year.**
TCC Management **(Chief & Deputy Chief)**	• **Overall management of the TCC Operation and Maintenance Team.** • **Prepare annual report, budget requirement, and annual plans and submit them to the Steering Committee for review and approval.** • **Disseminate information and coordinate with other related organizations, media entity, traffic enforcers, service and safety organizations.**
Analysis & Planning Section	• **Conduct periodic traffic-related surveys (time, day, week and specific day, month, quarterly and yearly) such as traffic volume count survey, travel speed survey and congestion queue length survey by subcontracting.** • **Investigate the revision of road-related regulations and road conditions by collaboration with DPWT, and** • **Analyze the traffic accident data by collaboration with traffic police.**
Financial & Personnel Section	• **Preparation of annual financial plan for the necessary yearly total expenses for traffic signal system** • **Calculation and management of annual buffer fund for emergency repairs** • **Manage the disposition of funds and necessary expenses for day-to-day operation and maintenance of the system at the required time.** • **Preparation of TCC annual financial report**

	• **Recruitment, training, and evaluation of human resources** • **Plan and implement better working environment for TCC staff and field personnel.**
Signal Operation Section	**Operate traffic signal system continuously and efficiently 24/7/365:** • **Promote orderly movement of traffic,** • **Increase the traffic-carrying capacity of the intersection,** • **Reduction of the frequency and severity of certain types of crashes (e.g., right-angle crashes),** • **Continuous traffic flow when traveling in a coordinated signal system, and** • **Interruption of heavy traffic flow to provide safe opportunities for minor movements to cross.**
Signal Maintenance Section	**Maintain traffic signal system making sure of its continuous operation:** • **Manage and conduct routine maintenance under the principles of maintenance management practices for preventive, responsive, and design modification of the signal system.** • **Conduct inventory of all existing component, their history, present status, and location, maintain recording system and develop data base of the system assets,** • **Maintain appropriate inventory of spare parts in appropriate type and quantities needed for the continuous operation of the system,** • **Maintain storage room which can include work area (or desks) for simple repair of system component.**

(6) Organization

Complete organizational set-up for the management of PPTSS is shown in the following chart (Table 4). The PPCA Governor on top, the advisory committee sets the policy and approves the recommended budget by the TCC, and the engineering aspect of operations through the DPWT. The committee shall convene annually for the discussion of budget and policies. Special meetings can be called upon by the governor when there are important issues to be discussed.

Table 4: TCC Organizational Chart



(7) Responsibilities

Table 5 shows the individual duties and responsibilities of each staff of the control center. During the start of operation, the TCC Chief also cover the responsibilities of Analysis/Planning Section and Finance and Personnel Section.

Table 5: Roles and Responsibilities

TCC Personnel	Roles and Responsibilities
TCC Chief	❖ Manage the activities of the entire TCC, and to be sure of the efficient operation and maintenance of the Phnom Penh Traffic Signal System. ❖ Formulate plans and programs for the yearly operations and maintenance for the purpose of budget proposals and justifications. ❖ Attend the TCC Advisory Committee annual & special meetings, and ❖ Participate in discussions with related organizations such as traffic police, media entities/organizations, public safety organizations, and other stakeholders. ❖ Establish relationships with businesses or organizations that may cause traffic issues, such as schools or construction companies ❖ Check, approve, and submit TCC Annual Reports.

TCC Deputy Chief	❖ Assist the TCC Chief and manage the entire TCC activities when the TCC Chief is absent, ❖ Except for delicate issues such as budget, he/she has the capability to work on behalf of the TCC Chief, and ❖ Participate in 6 months of training of traffic control system in Japan in the first year of being installed as deputy chief. ❖ Coordinate with other city departments, such as police or fire departments, to ensure effective responses in day-to-day operations, emergencies, or special events ❖ Determine whether proposed construction projects will have an impact on traffic flow and whether alternative routes are available.
Section Chief of Analysis/Planning (Acted by the TCC Chief)	❖ Collect and analyze traffic-related data provided by the TCC and/or related organizations and develop a database, ❖ Provide numerical data for issues and proposals related to PPCA and DPWT traffic management measures, ❖ Develop a close working relationship with the Operation Section and Maintenance Section, and provide advice as well as data on traffic signal phasing and split revision, ❖ Advise DPWT on revision of the geometric design of intersections and traffic signs, ❖ Plan the driver education such as traffic safety campaigns with traffic police and related organizations, and ❖ Outsource necessary traffic surveys, etc.
Section Chief of Operation	❖ Manage TCC traffic control system operation in general, ❖ Analyze and monitor traffic data while paying attention to any change in traffic patterns, ❖ establish an appropriate operation system and actively carry out regular and systematic coordination and analysis ❖ Monitor and intervene in traffic signal parameters such as phasing pattern for effective operation, and smooth flow of vehicles, and ❖ Work closely with the traffic police to deal with special traffic such as VIP traffic pre-emption function of the affected intersection.
Section Chief of Maintenance	❖ In charge of maintenance department, coordinate work schedules of maintenance personnel, ❖ Supervise crews, schedule work activities, oversee maintenance and construction, issue work orders, ❖ Supervise shop including inventory work orders, daily activities ❖ Manage maintenance of TCC traffic control system in general, ❖ Manage the daily monitoring work at intersections from TCC and from the site, ❖ Manage preventive inspection and corrective maintenance work, ❖ Troubleshooting, perform repairs, cabinet tests, ❖ Perform training in signal maintenance work, ❖ Request trimming of the roadside tree branches from DPWT to ensure traffic signal visibility, and ❖ Coordinate with Operation Section.
Section Chief of Finance and Personnel (Acted by the TCC Chief)	❖ Develop a TCC budget plan (TCC staff salary, operation, and maintenance costs), so that the costs required for emergency repairs such as accidents and other faults with safety issues can be done on designated response time, ❖ Manage the balance of money in TCC, and ❖ Hiring of new TCC staff.
Staff 1 of Analysis/Planning Section	❖ Assist the Section Chief of Analysis/Planning, ❖ Manage traffic surveys and road inventory conducted by subcontractors, and ❖ Discuss and develop a plan of intersection improvement in cooperation with DPWT.

Staff 2 of Analysis/Planning Section (CAD Operator/Data Entry Operator)	❖ Develop drawings such as the geometric design of intersections based on the traffic survey/road inventory survey and instruction of signal operation and maintenance management staff, and ❖ Data entry of road traffic, etc.
Staff of Operation Section	❖ Monitor the status of all equipment and ensure full operation of the traffic signal system 24/7/365 ❖ Monitor system fault report and inform the maintenance team for their action, and ❖ Monitor and intervene in the phasing and timing of traffic signals.
Staff of Maintenance Section	❖ Responsive and preventive maintenance, equipment repair and installation ❖ Monitor the traffic signal equipment such as detectors and CCTV cameras, ❖ Monitor the preventive and emergency/response maintenance conditions of the entire PP traffic signal system and related equipment, ❖ Compile records related to traffic control system trouble shooting and repairs such as OFC disconnection, accidents, fires, etc. and ❖ Replace the local controller, boards inside controller, damaged traffic lights and other equipment. ❖ , ❖ Perform field repairs, assist technicians
Staff of Finance/Personnel	❖ Assist Section Chief of Finance/Personnel and perform finance-related calculations according to the Section Chief's instructions, and ❖ Perform administration related work.

Organization and responsibilities discussed in this chapter are starting documents to spearhead and assure the continued operation and maintenance of the PPTSS as originally designed. The content on this part and in other chapters can be revised by the TCC Organization under the consent and approval of the steering committee as they see fit and to the best interest of the proponent and stakeholders of the PPTSS.

CHAPTER 3 Basic Functions of the PPTSS

Section 1 – Function, System Configuration, TCC, and RSE

Fig. 2 & 3 shows diagram of the function of 3 major component of the PPTSS, the Control Center, Roadside Equipment, and the communication cable network comprising the operational setup of the system.

Figure 2: Basic Function Diagram

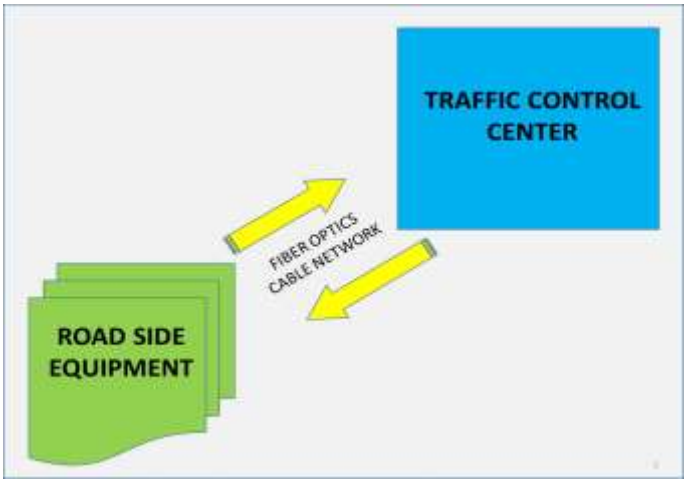


Figure 3: Configuration Diagram

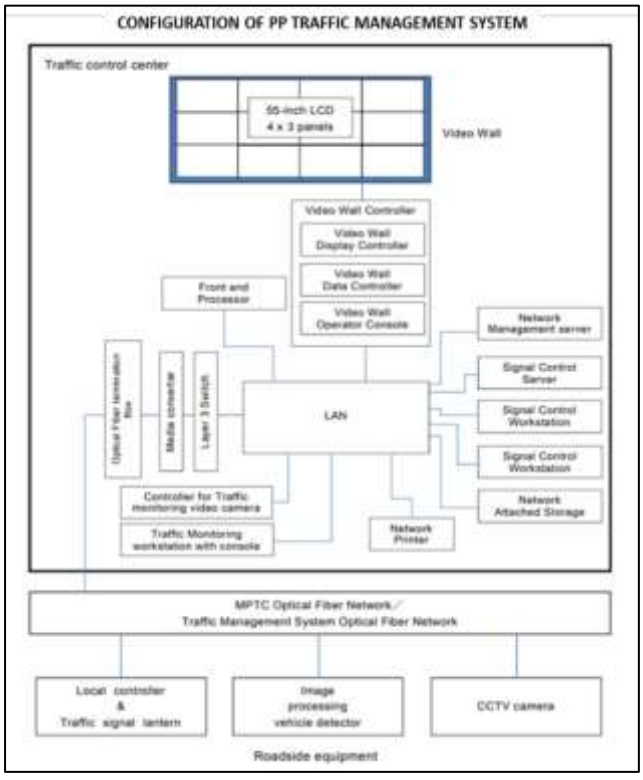


Fig. 4 shows the location of the signalized intersections within the central business district. Each

intersection carries all signal system component as per the design based on the behavior of traffic.

Figure 4: Location Map of RSE at Intersection

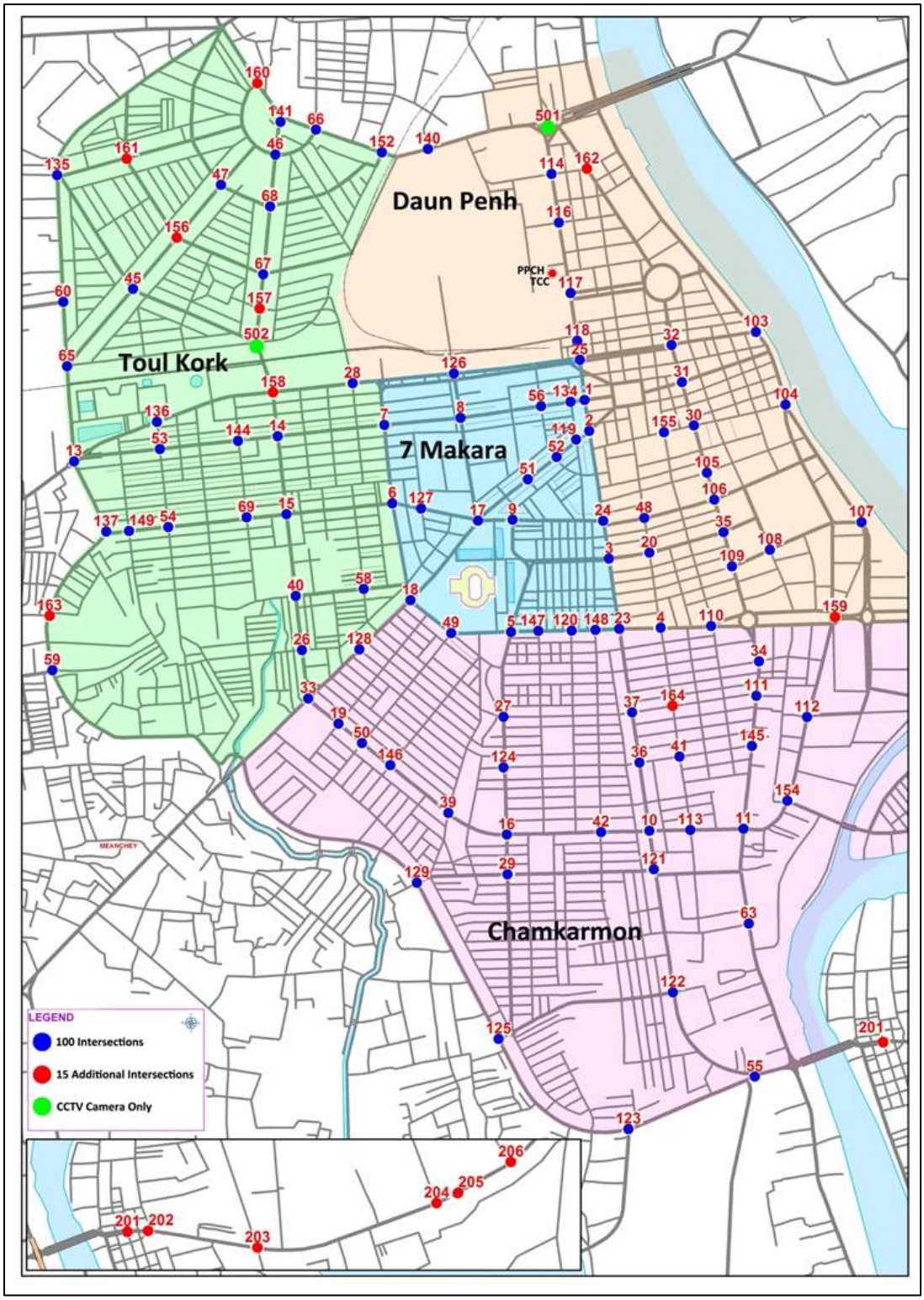
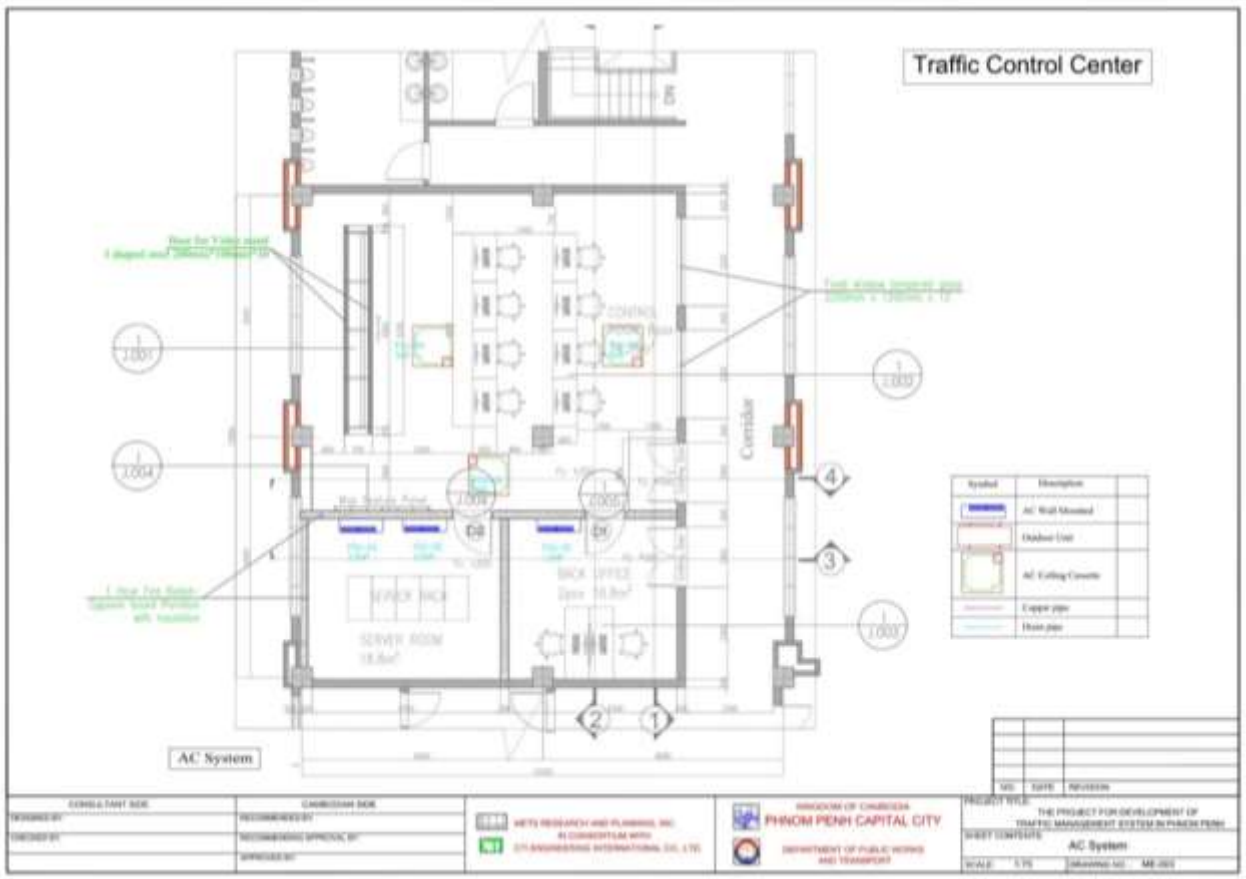


Fig. 5 is an image of floor plan of existing Traffic Control Center (TCC) at the 9th floor of City Hall New Building showing the area for control room, server room, and the back office – a total floor

area of 144 sq. m and effective usable area of 109.86 sq. m.

Figure 5: TCC Floor Plan



Section 2 – How the System Operates

The control center has the capability of managing the system operation in many ways. The control center and the roadside equipment are connected by Optical Fiber Cable making it possible to control most operation remotely from the control center. **Appendix 2** shows illustrative TCC-RSE functional diagrams for each major component of the system. The appendix also included in figures and diagrams the reasons for introducing traffic control system and the benefits of coordinated signal system with regards to smooth traffic flow.

The Traffic Control Center (TCC) and Roadside Equipment (RSE) managed by competent technical staff play a major role in the management of Phnom Penh Traffic Signal System, and maintenance management must be developed after installation of the system to achieve the quality of traffic-related administration within the stated mission of the TCC team.

Section 3 – Operations Management

Operations management involves managing a wide range of tasks – devising strategies is of utmost importance to execute the tasks efficiently. Strategies of operations management could

include the utilization of data, handling data, inventory analysis, identifying departments or specific processes within departments that need overhauling, social accountability, departmental collaboration, human resource management, and many more.

PPTSS is a computer-based system composed of sophisticated electronic equipment running the signal operation. The feature for human-machine-intervention (HMI) is a significant component of operation and maintenance and is really needed to completely manage the system by technically qualified staff. Road traffic conditions change over time, so it is necessary to constantly check and coordinate the traffic signal parameters with the traffic at the time. For this, the TCC Chief and the Section Chief of Operation Section needs to establish an appropriate operation system and actively carry out regular and systematic coordination and analysis.

The contents of operation management are:

- phasing,
- monitoring,
- coordination of signal parameters,
- monitoring of traffic signal lantern,
- traffic signs,
- geometric design of intersection, etc.

It should be noted that the Analysis/Planning Section conducts the countermeasures on improving the traffic environment and survey on the traffic conditions. Therefore, it is necessary to coordinate with the Analysis/Planning Section as much as possible for the appropriate design and with the Maintenance Section for the implementation of the design through the Design Modification type of maintenance.

Analysis and Planning Section as stated in the functional chart is tasked with traffic data gathering and analysis and TCC management should provide all the necessary support in terms of technical capability, equipment and materials for in-house operation or give them the responsibility of supervising and monitoring the works of a contractor in the event of sourced out or contracted data gathering. This section should maintain a traffic data base and analysis road, signage and road marking inventory for the appropriate and acceptable references when needed.

Operations management encompasses all activities that is being utilized by the TCC organization in day-to-day operation of the whole traffic system.

CHAPTER 4 Signal System Maintenance

In order to administer the maintenance of the

Section 1 – Modes of Signal System Maintenance

There are two distinct modes of maintaining a traffic signal system, *by contract* or *by administration*. It shall be the first thing to discuss and decided upon specially with regards to the funding requirement.

A. Maintenance by Administration (In-house)

1. The organization develop the capability to repair and maintain all the equipment. Training is essential.
2. Acquire equipment and spare parts and manage the storage area.
3. Motor pool or parking area for maintenance and service vehicles is needed.

B. Maintenance by Contract (Source Out)

1. Contracted with the supplier of the system.
2. Contracted with a private maintenance company.
3. TCC staff supervises/check the accomplishment of the contractor and certify the billing documents by the contractor.

Maintenance can be done as a combination of the two modes, with common preventive activities and minor repairs that is within the equipment capability to be executed by administration, and the selected maintenance works that need major equipment not available in-house to be done by contract. However, because decision making will go through a delicate approval process, **this document** shall be initially directed on the **in-house maintenance mode** and therefore will be discussing maintenance by administration with minimum equipment needed for the complete maintenance activities.

Section 2 – Maintenance Management

Maintenance management of traffic signal control system is the skillful and efficient use of resources to keep the systems operating as intended. Maintenance management is the process of maintaining your assets efficiently. This is to ensure that operation proceeds efficiently and that resources are used effectively. The purpose is to extend the life of your assets, reduce the risk of asset failures and downtime, schedule maintenance and allocating your resources more efficiently, control your costs, ensuring the safety of your workers and the public, and implement better policies

and procedures. In Phnom Penh Traffic Signal System, maintenance is divided into three types: Preventive, Corrective, and Design Modification.

A. Preventive Maintenance

Preventive maintenance is performed on a regularly scheduled basis using a set of procedures to preserve the intended working condition of the traffic signal system. Periodic maintenance can prolong the life of the system and usually includes inspection, cleaning, replacement, and record keeping. These activities occur based on each component's function and rated service life. The objective of preventive maintenance is to ensure that the system operates properly. Defective equipment can be replaced or repaired before failure occurs reducing the need for responsive maintenance resulting in reduced road user costs, and liability exposure. Education and research have led to the acknowledgment that preventive measures and changes in design and operations are just as important as response or emergency measures.

To maintain the performance of the equipment and prevent breakdowns, the following inspections are performed:

1. **Normal or Routine inspection**.

   Normally, the inspection work is performed without stopping the operation of the equipment, and if it is performed regularity, the period is about once every three months up to once a year depending on the location and status of the intersection.

2. **Detailed inspection**.

   Performed once a year and is subcontracted to SUMIDEN. This is the type of preventive maintenance work that is performed by stopping the operation of the equipment, and inspect the component where failures occur more frequently than in the normal operation. This usually involve sensitive parts or program that is better handled by the supplier.

B. Corrective Maintenance

Corrective maintenance, sometimes termed as response or emergency maintenance, is performed on an as-needed basis. It is required when equipment breaks down or malfunctions. On notification, the responsible agency or unit is expected to dispatch a repair service team to secure the site, diagnose the problem, perform the repairs, and record their activities as quickly as possible.

In the event of a failure, inspection and repair must be carried out immediately. For that purpose, it is necessary to improve the failure repair system and failure repair technique. When repairing a failure, be sure to use the failure repair forms, check the history of the failed device based on statistical record shown in the inventory data base.

Although Phnom Penh signal system has the capability of fault reporting through its communication cable and can make it possible for systems to monitor many functions and notify the maintenance team automatically, the TCC team still rely on traditional notification practices. These practices include notification through internal sources (the operations team), external sources (the media, police, etc.), and the public.

After the agency has been notified of an equipment break down, a repair team is dispatched. The team secures the site so repairs can be made safely. The first step is to diagnose the problem. After the problem has been identified, the faulty equipment is replaced and then repaired in the shop or by the manufacturer to ensure that traffic conditions are returned to normal as quickly as possible. Performing repairs in the shop rather than in the field improves the quality of the repair and enhances proper maintenance documentation. In some instances, a temporary repair must be made because replacement parts are unavailable, or the damage cannot be repaired immediately. The temporary repair may use temporary control devices and or timing changes. All activities performed should be clearly and concisely documented for future reference. Computerized records can reduce the time required for record keeping and can be retrieved quickly and easily, even from remote locations.

C. Design Modification

Design Modification is an important maintenance strategy which addresses the need in correcting recurring problems, to accommodate changes in prevailing traffic or physical condition of the traffic control system, when additional intersections are needed to expand the coverage of the system, or update installation to cope with the new technology. This type of maintenance is included to avoid complexity in the implementation of preventive and corrective maintenance activities which geared on the existing system. All additional features not included in the original design shall be under this maintenance type.

This type of maintenance is a change in the approved design and operations of an existing traffic signal system.

Aside from the items stated above the common examples of design modifications include:

- Timing Changes
- Signal upgrades
- Phasing Changes
- Changes in signal displays, configurations, or locations,
- Detector upgrades
- Controller upgrades
- Mast arm improvements
- Intersection upgrades

- New Installations
- Fiber optic cable installation
- Emergency upgrades and repairs
- Revisions to related signs and pavement markings,
- Equipment revisions or upgrading (hardware and software), and
- Design changes

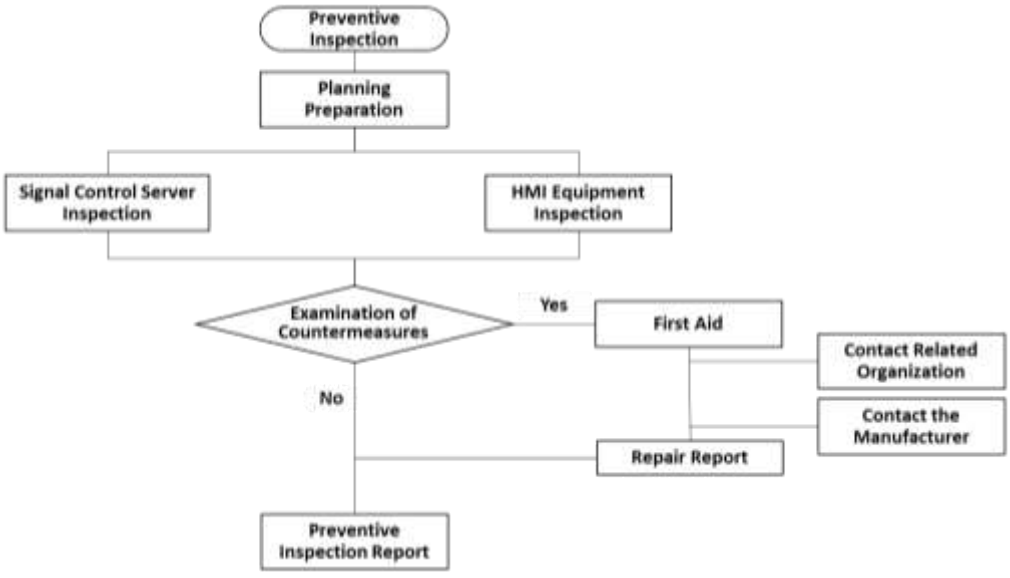
Available personnel time must allow resources for design modification, for a signal system can be efficient only if it is responsive to traffic demands

Section 3 – Preventive Maintenance Procedures

a. TCC Equipment

Preventive maintenance for each TCC equipment can be done easily than Roadside Equipment (RSE). This can be done with simple schedule as the maintenance staff is working more frequently on the control center and no service vehicle or manlift truck is needed. As part of preventive maintenance, the preventive inspection procedures and schedule have to be planned so that the activity would not intervene with the day-to-day operation of the system. There are two main components of the TCC equipment, the signal control servers, and the HMI equipment. Countermeasures shall carefully be made upon discovering flaws or defects found during examination. Fig. 6 shows the flow chart of the inspection for preventive maintenance at TCC.

Figure 6: Flow Chart of Preventive Maintenance at TCC



Implementation Plan

Preventive maintenance of the TCC equipment which includes checking of performance and appearance, among other things, is carried out once a year.

b. Roadside Equipment

Preventive maintenance for the Roadside Equipment (RSE) necessitates major equipment mainly manlift and service vehicles. And because preventive inspection is normally scheduled, the maintenance crew can prepare all the necessary tools and testing equipment beforehand following the planned procedures previously prepared by the team. Fig. 7 show the flow of activity for the preventive maintenance of RSE.

Figure 7: Flow Chart of Preventive Maintenance - RSE

c. Determination of time allocated for year-round preventive maintenance on RSE

Sample computation for scheduling of yearly inspection:

No. of intersection = 115
Frequency of inspection = 2x per year per intersection
No. of days to inspect all intersections = 115 x 2 = 230 days
No. of intersections inspected per day = 2
Resulting no. of days = 230/2 = 115 days

The number of days shall be distributed by the maintenance team depending on the appropriate schedule and availability of personnel.

The check list given in Appendix 3 and the computation for the schedule are starting list

and shall be improved by the TCC to jive with the need of the system.

In all the maintenance activities, it is very important to keep complete and clear records that are inputted to the maintenance data base. This will easily be the basis of daily, monthly, and annual report.

Section 4 – Corrective Maintenance Procedure

Corrective maintenance, sometimes termed as response or emergency maintenance, is performed on an as-needed basis. It is required when equipment breaks down or malfunctions. On notification, the responsible agency or unit is expected to dispatch a repair service team to secure the site, diagnose the problem, perform the repairs, and record their activities as quickly as possible.

In the event of a failure, inspection and repair must be carried out immediately. For that purpose, it is necessary to improve the failure repair system and failure repair technique. When repairing a failure, be sure to use the failure repair forms, check the history of the failed device based on statistical record shown in the inventory data base.

Although Phnom Penh signal system has the capability of fault reporting through its communication cable and can make it possible for the system to monitor many functions and notify the maintenance team automatically, the TCC team still rely on traditional notification practices. These practices include notification through internal sources (the operations team), external sources (the media, police, etc.), and the public.

After the agency has been notified of an equipment break down, a repair team is dispatched. The team secures the site so repairs can be made safely. The first step is to diagnose the problem. After the problem has been identified, the faulty equipment is replaced and then repaired in the shop or by the manufacturer to ensure that traffic conditions are returned to normal as quickly as possible. Performing repairs in the shop rather than in the field improves the quality of the repair and enhances proper maintenance documentation. In some instances, a temporary repair must be made because replacement parts are unavailable, or the damage cannot be repaired immediately. The temporary repair may use temporary control devices and or timing changes. All activities performed should be clearly and concisely documented for future reference. Computerized records can reduce the time required for record keeping and can be retrieved quickly and easily, even from remote locations.

Corrective maintenance procedures vary per equipment, allocated resources, and company requirements, among other factors. For example, machines using modern technology can reduce the time it takes to diagnose a problem and lower the cost of repair while maintaining uptimes.

Steps of corrective maintenance per equipment:

- □ Reach the equipment with caution

- □ Diagnose
- □ Elimination of the part causing the failure
- □ Ordering the replacement
- □ Replacement of the part
- □ Test of function, and finally
- □ The continuation of use.

Here is a general process of corrective maintenance steps to help TCC managers and technicians get started:

Step 1: Be aware of a detected malfunction in the system

Once detected, machine failure must be confirmed by onsite technicians. If proven that there was no fault found, then the system is generally returned to service. However, if a malfunction is confirmed to have occurred, then corrective maintenance actions must be taken. Normally, a failure report must also be completed prior to carrying out corrective maintenance tasks.

Step 2: Localize the defect to a specific equipment within the system

Fault localization or fault isolation is the process of determining the location of a fault to the extent necessary in order to effect repair.

In the context of corrective maintenance, it is the act of pinpointing the defect to a specific equipment within the system. Technicians need to identify in which equipment in the entire system the fault took place.

Step 3: Diagnose the issue of a particular component within the equipment

Upon identifying exactly where the fault is, diagnosis of the defective part in the equipment happens next. Certain hardware, software, or other documented means are typically utilized to determine the cause of the malfunction. In most machines, a built-in-test capability with existing hardware and/or software components can help diagnose the problem of a faulty part.

Step 4: Repair or replace the faulty part or item in the equipment

In the corrective maintenance process, this is when technicians implement corrections such as repairing or replacing machine parts, among other corrective maintenance actions. This step can also be called “fault correction”, where maintenance tasks are carried out to rectify the malfunction. Basic measures of maintainability like the mean-time-to-repair, or corrective maintenance time, often encompasses this step.

Step 5: Align and calibrate the repaired or new part in relation to the system

After correcting the faulty item, alignment and calibration usually follows which marks the

beginning of checkout, or the series of tests on the item to determine its condition or status. It is crucial to perform the necessary adjustments when restoring any item to a specified operation. Moreover, a comparison of a measuring device with a set standard and a subsequent alignment must be applied to remove deviations.

Step 6: Clean and lubricate the equipment accordingly

Following calibration, contamination control and lubrication commonly takes place to help keep the item in good operating condition. It is essential to use a clean lubricant in the right amount. Thorough cleaning of the equipment and its components not only can make it easier to discover potential issues and yield longer life, but it can also help achieve better reliability and lower costs.

Step 7: Validate performance before returning the system to service

Finally, tests must be made so that the performance of the item can be verified to have reached its specified condition. This step completes the checkout and the general sample of a corrective maintenance process. If the results reveal that the item in relation to the equipment works satisfactorily, then the system can be returned to service and business operations can resume.

Section 5 – Design Modification Procedure

Design modification as previously discussed depend mainly on the need for changing the system component itself, its function, the need for replacement or upgrading, and to implement a new design or additional intersection – items listed in Chapter 4, Section 2C.

Signal timing should be revisited when any of the following occur:

- Increased demand or changing turning movements (5 to 10 percent; lower percentage change critical when intersections operate at or near capacity)
- Reduced traffic flow (typically 10 to 15 percent reduction)
- Changed vehicle mix (increased truck percentages)
- Construction activities on the study route or on a parallel route
- Changed land uses associated with development or travel patterns due to shifts in employment centers
- Observed queue spillback caused by oversaturation of adjacent traffic signal; or
- Other factors (such as the addition of a new traffic signal to a corridor associated with new development or changes in the roadway network).

These changes can be produced by several physical alterations to the roadway network, including new roadways, geometric changes to existing roadways, or added or relocated bus stops. Changes may also result from modifications to surrounding land uses, such as new or expanded residential,

business, retail, or educational facilities. Most communities experience many of these transformations over a period of three to five years. Changes in traffic flow and roadway network characteristics often lead to the need for new signal timing. Equally important, they may also require changes in the times of day during which the timing is implemented. In the case of reduced demand, they may also lead to situations in which signal removal or flash operation during certain periods of the day is appropriate.

Section 6 – Scheduling

Some types of maintenance, such as preventive maintenance, should be performed on a regularly scheduled basis to keep the system operating properly and provide for the most effective use of resources. Developing, tracking, and adjusting a maintenance schedule requires management of activities. The schedules should be developed based on system needs, agency personnel, and funding and be adjusted according to changes in these criteria.

Other types of maintenance, such as response maintenance, cannot be scheduled in the same manner. However, based on experience and trends, the amount of time, staff, and budget required can be estimated and it is necessary to allow for emergencies. It should be noted that a schedule should reflect factors such as climate. For example, an area that is prone to flooding may experience more knockdowns, therefore requiring more maintenance, than an area that rarely has hurricane activity. Available personnel time must allow resources for design modification, for a signal system can be efficient only if it is responsive to traffic demands.

In determining the proportion of the yearly maintenance budget for each type of maintenance many factors, such as the type and age of equipment, and the experience and expertise of the maintenance personnel should be considered. The proportions are system-dependent and are reactive to each other. If insufficient time was allocated to preventive maintenance, it might end in an ever-increasing demand for response maintenance. The result was too little time for preventive maintenance and the overall maintenance effort was larger than would have been required with an adequate level of preventive maintenance. This situation should be remedied.

Section 7 – Personnel and Staffing

An adequate number of well-trained staff is important for the proper maintenance of a system. Personnel should be properly trained to match their responsibilities so they can fill an assigned role within an organizational structure. The number of personnel employed should be adequate to fulfill the maintenance needs of a system and is usually dependent on the size of the system and the scope and skill level of each employee classification in the organization.

TCC management should continue to enhance the technical capability of its staff by updating the knowledge in terms of the new developments in traffic management technology.

Section 8 – Record Keeping

Record keeping to track schedules, budgets, equipment, and staff performance is important to the management of maintenance activities. Records provide a reference for future problems and can be important to liability issues. There are several philosophies on record keeping. At one end of the spectrum are those who want to keep only the data that are used to manage the performance of the system. At the other end are those who want to keep all data gathered for an indefinite period. A variety of forms, ledgers, and logs are presently used.

The following records are recommended by ITE in the Traffic Systems Installation, Maintenance and Operations Manual:

Master Record

A master log of all service calls listing the date, type of maintenance performed, and signature(s) of the maintenance personnel performing the work. It should also include design-modification maintenance.

Preventive Maintenance Record

A log for each preventive maintenance service call of the date, tasks performed, and signature(s) of the maintenance personnel performing the work.

Preventive Maintenance Problem Record

A record of problems or potential problems identified (if any), corrective action taken, and follow-up inspection, including date(s) and signature(s) of the maintenance personnel performing the work.

Response Repair Log-on Record

A log recording the location. date, time, caller, receiver, and nature of complaint received; maintenance personnel and time dispatched; trouble found, and time cleared. The log shall be basically in electronic and could be in hard copies as needed.

Response Maintenance Repair Record

A complete record for each call of the problem, notification details, prevailing conditions, work performed, parts replaced or repaired, time and condition on departure, and signature of the responsible repair person and supervisor. Each of these logs or records can be maintained on paper or in computer files or data bases on a variety of software available from various computer vendors and software manufacturers. Signature requirements can be accomplished by using

personnel codes. With the increase in office microcomputers, there has been an increase in the use of computerized record keeping. In some cases, paper records have been eliminated and field personnel use laptop computers and transfer their files to the office computer system daily. Computer systems provide the capability to sort, select, tabulate, and display data in a format to enhance maintenance decisions, reduce wasted resources, and ease the record-keeping burden.

Section 9 – Signal Timing Charts

Signal timing charts are another form of maintenance management. Signal timing charts, prepared by the traffic engineer, are best kept in both the signal controller cabinet and in the operations office. The charts are used by signal mechanics and other maintenance personnel to verify, and sometimes, adjust the signal timings at an intersection. Any changes to the timing plans are noted and a copy is sent to the operations office. A computerized data base is considered essential by many agencies with large systems.

Section 10 – Manuals and As-Built Plans

Equipment manuals can be an invaluable tool for maintenance personnel. Copies of manuals should be available in the field, and in the operations (in the case of operations manual provided by the SUMIDEN), or maintenance office for quick reference. As-built plans should always be available in the controller cabinets and in the operations or maintenance office. Any design modifications should be noted on the as-built plans. Unfortunately, in many cases, the as-built plans are kept but are not updated. This could adversely affect the efficiency of future maintenance or the design of reconstruction or modification. Some governmental agencies may require additional records. Computer systems now provide the opportunity to develop, store, revise, and retrieve plans as part of a computer-aided drafting (CAD) system.

Section 11 – Emergency Response

Emergency response is one kind of corrective maintenance wherein urgency is needed due to the possible safety considerations putting the public and the motorists in danger. Table 6 shows a calibrated emergency response for any kind of faults reported and encountered in the field. Similarly, Table 7 shows a list of the required response also indicating the ideal response time for each kind of fault and damages.

Table 6: FLOW CHART OF EMERGENCY RESPONSE

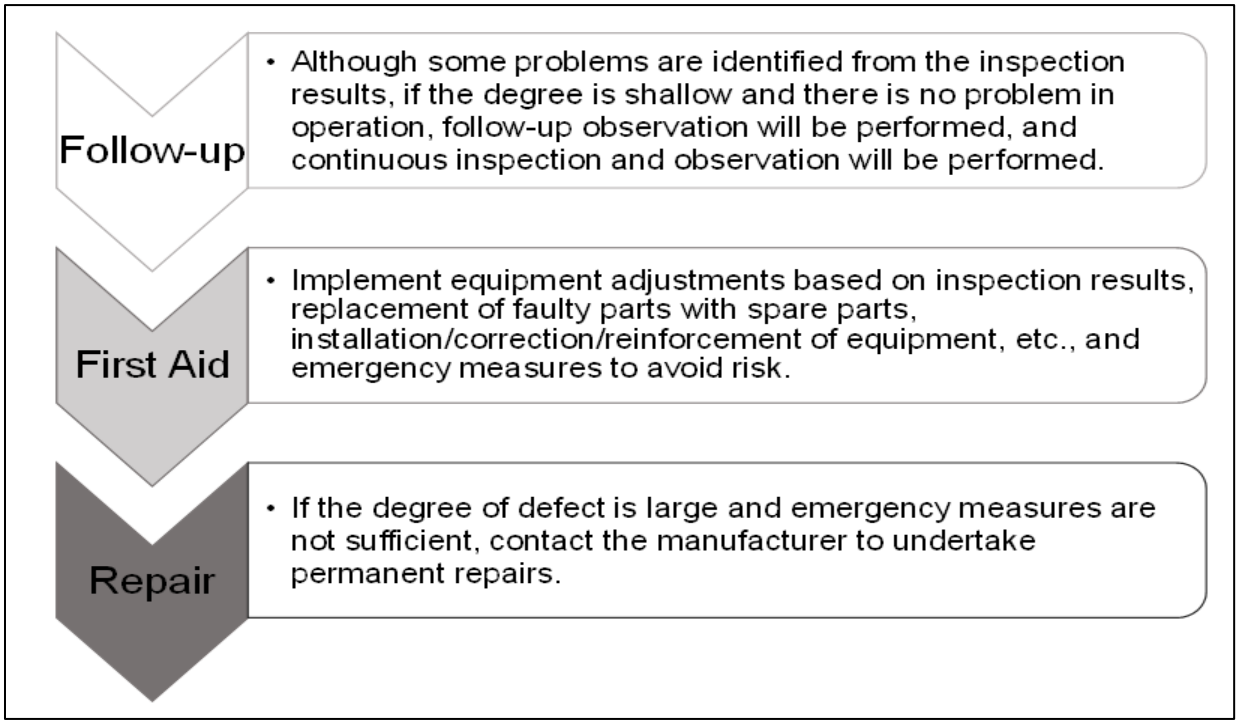


Table 7: Required Response to faults/damages

Type of fault/damage	Required response
Inefficiency – Operationally Inefficient ➢ The failure does not stop the signal operating safely, but the performance is inefficient, e.g., Detector failures causing phases to be called and /or extended unnecessarily.	Address operational inefficiency within 24 hours
Degraded – Operationally Degraded ➢ Signaling or appearance is degraded, e.g., Lamp outages, poor lantern aiming, loss of displays failed inductive loops.	Rectify within three weeks
Aesthetics and Presentation Issues ➢ Finish, controller obviously out of plumb, pole obviously out of plumb, Tidiness, Cleanliness, etc. ➢ Offensive graffiti	Rectify within three weeks Remove within two working days

CHAPTER 5 Equipment Data Base, Inventory Control, and Data Management

Controlling the amount of spare equipment that is stocked while maintaining a supply of necessary items is important. Some methods of inventory control include paper documentation, regular inventory checks, computerized databases, and bar code systems

It is important for PPTSS to maintain a history of maintenance activities. This is usually in the form of paper or computerized logs or reports. In addition, timing plans and original drawings are to be maintained in central computers and servers. These records can be useful in case of liability charges to provide written proof of proper maintenance activities and for reference during design modification or reconstruction activities.

Section 1 – Inventory of System Component

In developing maintenance strategies, the *first step* is to conduct inventory of all the existing system component inside the TTC and in the field, recording in an organized manner their history (repair and/or replacement), present status, and exact location (coordinates). Recording should be consistently performed to keep track on the updated status of all components. The bottom line is for the TCC to develop a data base of the system assets, activities, and accomplishments. Previous records shall also be reviewed and included to the data base.

A list of all components of the Traffic Signal System that need to be maintained is provided hereunder constituting the items within the Traffic Control Center and the Roadside equipment during the initial setting up of the PPTSS under the “Project for Development of Traffic Management System in Phnom Penh”.

The following list is an excerpt from the original document provided by the supplier. Present status of these equipment must be checked at site one by one and record their location, condition, and history for the initial signal system data base as part of the development of this manual.

The following figures illustrate the component of Traffic Control Center (TCC) and Roadside Equipment (RSE):

Figure 8: Traffic Control Center Equipment

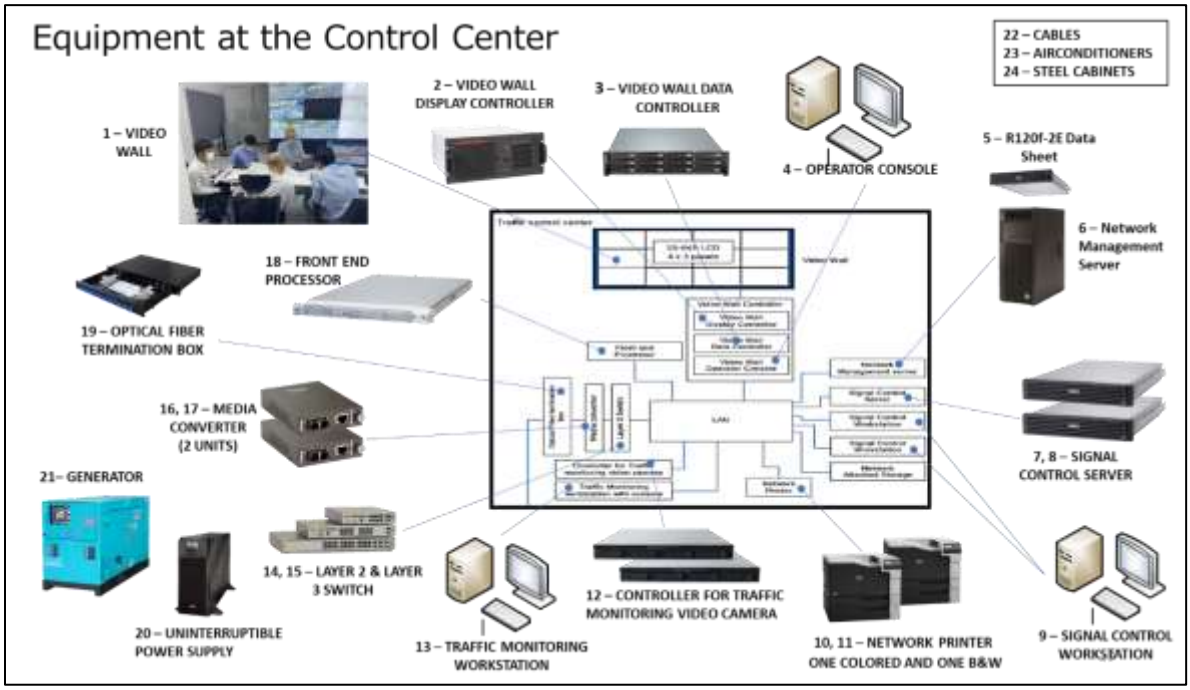


Figure 9: Roadside Equipment

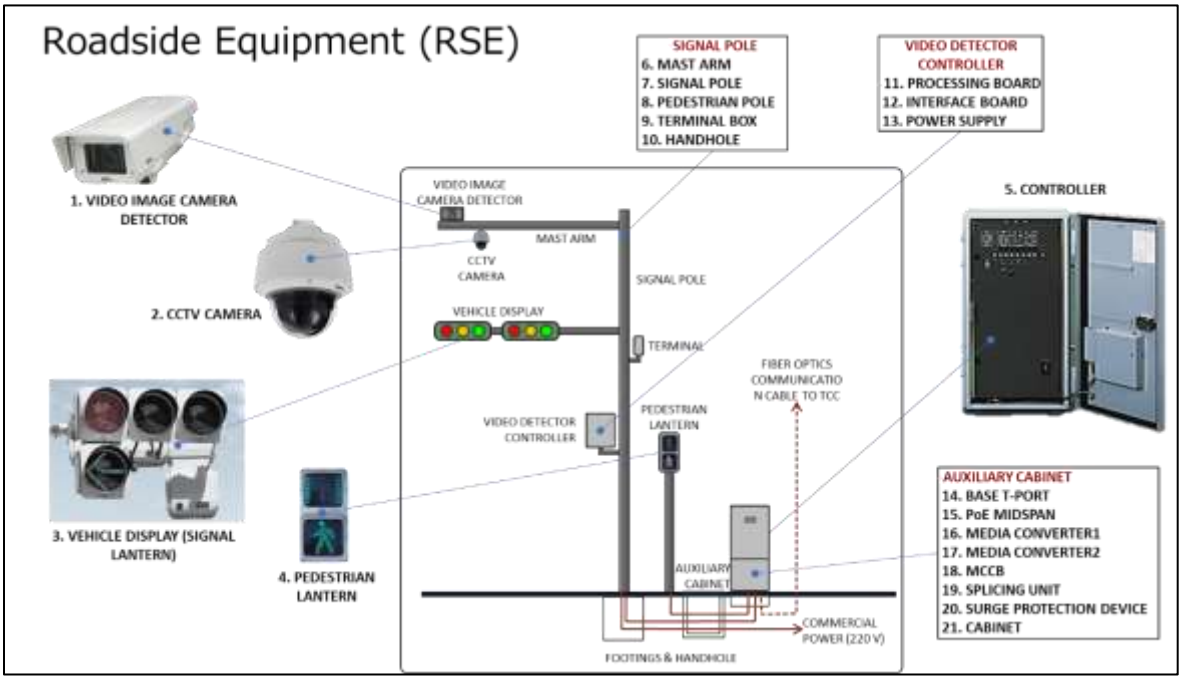


Table 3 & 4 are the original list of equipment and spare parts from the system supplier. From this original list, TCC shall incorporate the new quantities upon completion of the new equipment and

parts inventory. The complete list of information can be gathered during the preventive maintenance inspection.

Table 8: Initial List of System Component Under Original Contract

LIST OF EQUIPMENT				
Equipment/Material Number	Name of Equipment	Specification (Items)	Quantity	Unit
1	Control Center	1. Traffic control server	1	set
		2. Signal control WS	2	set
		3. Front-end processor	1	set
		4. Network Printer	1	set
		5. Video wall	1	set
		6. Video wall controller	1	set
		7. Vehicle detector data processing software	1	set
		8. Signal control software	1	set
		9. Equipment operation monitoring software	1	set
		10. Human-machine interface	1	set
		11. Statistics software	1	set
		12. Database software	1	set
		13. Parameter setting for vehicle detector	180	set
		14. Signal control parameter setting	100	set
		15. Controller for traffic monitoring video camera	1	set
		16. Layer 3 switch	1	set
		17. Layer 2 switch	1	set
		18. Media Converter	128	set
		19. Network management system	1	set
		20. Uninterruptible power supply	1	set
2	Intersection	1. Local controller (Standard) (Central control with actuation control)	1	set
		2. Local controller (Large) (central control with actuation control)	1	set
		3. Layer 2 switch	1	set
		4. Media converter	1	set
		5. Chassis	1	set
		6. Vehicle lantern 300 mm 3 lights (Round)	1	set
		7. Vehicle lantern 300mm 3 lights (arrow)	1	set
		8. Vehicle lantern 300mm 1 light (arrow)	1	set
		9. Pedestrian lighting device	1	set
		10. Vehicle detector	1	set
		11. Traffic monitoring video camera	1	set

Section 2 – Present Issues on Spare Parts and Budget Management

- Some of the maintenance related problems at present are the following:
  (1) It is necessary to secure a storage place for spare parts,
  (2) Reduction of spare parts shortages,
  (3) Preparation of next year's budget for spare parts, and
  (4) Decision is needed whether repair or new purchase of the spare parts.
- It is also important to improve the tables prepared by the TCC staff and develop a more effective spare parts management table.
- For example, Table 4 summarizes purchased spare parts (In) and used spare parts (Out) based on Tables 1 and 2 by year so that trends can be checked. This can be used to predict the necessary items and quantities of future spare parts.
- On the other hand, Table 9 summarizes the items and quantities of spare parts required in 2023 by TCC staff.
- However, regarding TCC's budget request for next year, not only spare parts but also TCC staff's salaries and Sumiden engineer's business trip expenses for failures of the traffic signal system that have not been disclosed to the Cambodian side must be included.

Table 9: Proposed Spare Parts Cost for the Year 2023

Prepared by TCC Staff

N0	Part	Type/Part Number/Model	Quantity	Unit Price	Amount
1	[SP-6] LCC Power Supply Unit	SP-TS3E Power	20	150	3,000
2	[SP-20] Layer 2 Switch	AT-x230-10GP	20	1,600	32,000
3	Switch + Power supply	AT-IE300-12GT-80, AT-IE048-480-20	2	4,357	8,714
4	Level 5 board	LEVEL5	5	530	2,650
5	LCC Board	S3-LCC-A	5	980	4,900
6	Media Converter	AT-SPLX10	10	1,500	15,000
7	RJ45-1POE	Surge Protector	20	200	4,000
8	Axis RJ45 PushPull Connector IP67	5700-371	20	100	2,000
Total					72,264

The above issues particularly the budget problem must be addressed within the steering committee. TEC management to prepare the necessary justification for the needed expenses for the operation and maintenance of the signal system. Estimating the yearly budget start with the inventory of existing system component and a very good judgement and analysis on what spare parts to purchase and added to the present inventory of materials. These topics are discussed in Chapters 5 and 7.

Section 3 – Inventory of Spare Parts

Management and control of the spare parts are one of the most important responsibilities of the maintenance manager or the TCC Chief when a proper maintenance of the traffic system is concerned. All maintenance activities on all system component depends on the availability of replacement parts. In most traffic signal organizations or agencies, the availability of a well-

organized ***storage area*** and ***in-house repair shop*** helps to reduce most problems because some reusable parts can be saved and utilized not only during emergency situations but on the normal maintenance activities.

Table 10: Initial List of Spare Parts

LIST OF SPARE PARTS				
Equipment/Material Number	Name of Equipment	Specification (Items)	Quantity	Unit
1	Control Center	Server and Workstation		
		Signal system server power supply unit	1	Set
		Workstation power supply unit	1	Set
		Video Wall		
		Video wall controller power supply unit	1	Set
		Network		
		Layer 3 switch	1	Set
		Media Converter	6	Set
		Layer 2 switch	6	set
2	Intersection	*Local Controller*		
		Local controller main board (standard)	5	Set
		Local controller main board (large)	1	Set
		SSR Unit	30	Set
		Power supply unit	5	Set
		Surge arrester	28	pc
		PROM writer	1	unit
		Local controller for testing	1	unit
		Signal lantern simulator	1	set
		Notebook computer	1	Set
		Diagnosis and set-up software	1	Set
		Signal Lantern		
		Power supply unit for vehicle lantern	50	Set
		Power supply unit for pedestrian lantern	40	Set
		Vehicle detector		
		Power supply unit for camera unit	9	Set
		Control board of camera unit	9	Set
		Controller unit power supply unit	9	Set
		Controller main board	9	Set
		Video Camera		
		Control board	2	Set
		Power supply unit	2	Set
3	Communication			

During more than four years of operation, the TCC staff recorded parts that have been removed. Reused parts from the removed items were also included in the following table to be incorporated with the maintenance database.

Table 11: Removed and Reused Parts List

N0	**Part**	Type/Part Number/Model	Date	From	Status	Storage	Quantity	Remark
1	[SP-5] SSR Unit	S3-SSU-GL		Int.027	Fried		1	2016-04, Y622B0156
2	[SP-6] LCC Power Supply Unit	SP-TS3E Power	7/24/2019	Int.045	Broken		1	
3	Mast-arm		1/22/2020	Int.202	Broken	DPWT	1	
4	Level 5 board		1/30/2020	Int.027	Port fried	Contractor bring to Japan for investigation	1	
5	Pedestrian lantern + bracket		1/24/2020	Int.011	Green doesn't light up	TCC	1	
6	[SP-5] SSR Unit	S3-SSU-GL	3/11/2020	Int.203	Fried		1	2017-03, Y622B0154
7	[SP-20] Layer 2 Switch	Allied Telesis	3/12/2020	Int.160	No power to OFC module	TCC	1	000154G174500011 KY
8	Pedestrian lantern + bracket		6/5/2020	Int.014	Usable	Generator house	4	
9	Pedestrian lantern + bracket		6/6/2020	Int.014	Usable	Generator house	4	
10	Hand hole 1m		6/6/2020	Int.014	Usable	DPWT	2	H1 & H4, 1 has reused at Int.126
24	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.136	New (unused)	TCC	2	
25	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.045	New (unused)	TCC	2	
26	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.046	New (unused)	TCC	2	
27	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.067	New (unused)	TCC	2	
28	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.068	New (unused)	TCC	2	
29	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.066	New (unused)	TCC	2	
30	[SP-5] SSR Unit	S3-SSU-GL	12/4/2020	Int.152	New (unused)	TCC	2	
31	[SP3/4] Local Controller Main Board	LEVEL5	12/5/2020	Int.036	Broken	TCC	1	
32	[SP-6] LCC Power Supply Unit	SP-TS3E H110-I/F Power 50W	5/27/2020	Int.149	Broken	TCC	1	
~~33~~	~~[SP3/4] Local Controller Main Board~~	~~S3-LCC-A~~	~~7/7/2021~~	~~Int.149~~	~~Error no power~~	~~TCC~~	~~1~~	Put back into package no 4
34	Media Converter	AT-SPLX10	7/20/2021	Int.127	No connection	TCC	1	A03236R161300116 C
35	[SP3/4] Local Controller Main Board	S3-LCC-A	1/10/2022	Int.152	Error TIMER	TCC	1	0008F614B81B Error TIMER malfunction, confirmed by Contractor
36	[SP-6] LCC Power Supply Unit	SP-TS3E Power	1/30/2022	Int.016	Broken	TCC	1	625KS30033P355EHFP
37	[SP-6] LCC Power Supply Unit	SP-TS3E Power	2/4/2022	Int.152	Broken	TCC	1	Error LCC TIMER, malfunction confirmed by Contractor
38	[SP-6] LCC Power Supply Unit	SP-TS3E Power	3/26/2022	Int.206	Usable	To replace broken Power supply unit at Int.037	1	
39	[SP-6] LCC Power Supply Unit	SP-TS3E Power	3/26/2022	Int.037	Broken	TCC	1	
40	[SP-20] Layer 2 Switch	Allied Telesis	5/27/2022	Int.059	Broken	TCC	1	We use Layer 2 Switch from Int.155 to replace temporary

The succeeding table show the recorded data on the movement of spare parts within the four years of operation and maintenance of the PPTSS developed by TCC staff with the initial list coming from SUMIDEN as a starting reference.

Table 12: Movement of Equipment and Parts

N0	Part	Type/Part Number/Model	Serial	Quantity		Remaining Qty	Package N0	Date	Taken/brought by	Remark
				In	Out					
1	[SP-15] For pedestrian lantern	Pedestrian / Red	-		1	7	8	7/16/2019	Masazumi Horie	To replace damage LED at Int.016
2	[SP-6] LCC Power Supply Unit	SP-TS3E Power	-		1	1	4	7/24/2019	Phok Uy	To replace at Int.045
3	RJ45-1POE	Surge Protector	18043440		1	9	Novaris	11/14/2019	Kem Ravy	To replace at Int.045
4	[SP-20] Layer 2 Switch	Allied Telesis	00154G161600047 E		1	1	Novaris	11/14/2019	Phok Uy	To replace at Int.160
5	Vehicle lantern (3 aspect full ball)			1		1		3/16/2020	Masazumi Horie	New with with bracket
6	Vehicle lantern (3 arrow aspect)			2		2		3/16/2020	Masazumi Horie	New with with bracket
7	Pedestrian lantern			1		1		3/16/2020	Masazumi Horie	New with with bracket
8	Vehicle lantern (3 aspect full ball)			1				3/16/2020	Masazumi Horie	Old, damaged
28	[SP-5] SSR Unit	S3-SSU-GL	-	2		19		12/4/2020	Im Setha	New from Int.136
29	[SP-5] SSR Unit	S3-SSU-GL	-	2		21		12/4/2020	Kem Ravy	New from Int.045
30	[SP-5] SSR Unit	S3-SSU-GL	-	2		23		12/4/2020	Kem Ravy	New from Int.046
31	[SP-5] SSR Unit	S3-SSU-GL	-	2		25		12/4/2020	Kem Ravy	New from Int.067
32	[SP-5] SSR Unit	S3-SSU-GL	-	2		27		12/4/2020	Kem Ravy	New from Int.068
33	[SP-5] SSR Unit	S3-SSU-GL	-	2		29		12/4/2020	Kem Ravy	New from Int.066
34	[SP-5] SSR Unit	S3-SSU-GL	-	2		31		12/4/2020	Kem Ravy	New from Int.152
35	[SP-5] SSR Unit	S3-SSU-GL	-		6	25		1/5/2021	Kem Ravy	To to installed at Int.017
36	Mother Board for SSU (Bottom part, 4 SSU)	-			1	0	From training LCC	1/5/2021	Kem Ravy	To to installed at Int.017
37	[SP-5] SSR Unit	S3-SSU-GL	-		4	21		1/19/2021	Uy Lysin	To to installed at Int.206
38	RJ45-1POE	Surge Protector			1	6	Novaris	2/15/2021	Kem Ravy	To replace at Int.002
39	[SP3/4] Local Controller Main Board	LEVEL5			1	1	2	5/12/2021	Kem Ravy	To replace at Int.036
40	Circuit breaker 30A	NIKKO Electronic MFG Co., Ltd, KM51			1	0	From training LCC	5/27/2021	Phok Uy	To replace at Int.149
41	[SP-6] LCC Power Supply Unit	SP-TS3E H110-I/F Power 50W			1	0	4	5/27/2021	Phok Uy	To replace at Int.149
42	[SP3/4] Local Controller Main Board	S3-LCC-A	0008F614E0B6		1	1	From training LCC	7/7/2021	Phok Uy	To replace at Int.149, Not utilized, brought back to TCC
43	Media Converter	AT-SPLX10	A03236R161300275 C		1	1	4	7/20/2021	Kem Ravy	To replace at Int.127
44	[SP3/4] Local Controller Main Board	S3-LCC-A	0008F614E0B6		1	1	From training LCC	1/10/2022	Vandeth CHEA	To replace at Int.152, Not utilized, brought back to TCC
45	[SP-6] LCC Power Supply Unit	SP-TS3E Power	912KW10003P218EHFP	2		1	16-6-20	1/29/2022	Koto san	
46	[SP-6] LCC Power Supply Unit	SP-TS3E H80-I/F Power 50W		2		3	16-6-20	1/29/2022	Koto san	
47	[SP-6] LCC Power Supply Unit	SP-TS3E H110-I/F Power 50W	912KW10112P218EHFP	2		2	16-6-20	1/29/2022	Koto san	
48	[SP3/4] Local Controller Main Board	S3-TB-IFC	-	1		3	16-6-20	1/29/2022	Koto san	

49	[SP3/4] Local Controller Main Board	LEVEL5	0008F6151FA1	1		2	16-6-20	1/29/2022	Koto san	
50	Mother Board for SSU (Bottom part, 4 SSU)	-	Y831C9186	1		1	16-6-20	1/29/2022	Koto san	
51	Mother Board for SSU (Top part, 2 SSU)	-	Y7YXB7233	1		1	16-6-20	1/29/2022	Koto san	
52	[SP-6] LCC Power Supply Unit	SP-TS3E Power	-		1	1	16-6-20	1/30/2022	Im Setha	To replace at Int.016
53	[SP-6] LCC Power Supply Unit	SP-TS3E Power	-		1	0	16-6-20	2/4/2022	Kem Ravy	To replace at Int.152
54	[SP-6] LCC Power Supply Unit	SP-TS3E H110-I/F Power 50W	912KW10112P218EHFP		1	1	16-6-20	4/1/2022	Chea Vandeth	To install at Int.206
55	RJ45-1POE	Surge Protector			1	5	Novaris	6/8/2022	Im Setha	To install at Int.008
56	RJ45-1POE	Surge Protector			1	4	Novaris	6/8/2022	Kem Ravy	To install at Int.014

Table 13: Current Inventory of Spare Parts (as of August 2022)

	No	Name	Part number	Manufacturer	Qty	2019			2020			2021			2022			Remarks
						In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	
1. Tool & Equipment	1	Capture cable		-	2			2			2			2			2	
	2	RCA Cable		-	2			2			2			2			2	
	3	BNC Conversion plug		-	2			2			2			2			2	
	4	HDMI Cable		-	1			1			1			1			1	
	5	USB to D-sub 9 Cable		I Buffalo	1			1			1			1			1	
	6	D-sub 9 to LAN Cable		-	1			1			1			1			1	
	7	[SP-12] Diagnosis & Setup Software			1			1			1			1			1	
	8	Traffic monitoring workstation with console Accessories CD		AXIS Camera Station	1			1			1			1			1	
	9	Laptop (S/N: JPH638F717)		HP, [SP-8] PROM WRITTER	1			1			1			1			1	
	10	Display port cable 1.5m		SANWA Supply	7			7			7			7			7	Seiko Time Server
	11	Display port cable (No box)			5			5			5			5			5	Seiko Time Server
	12	DVIP-DVIP 3m			2			2			2			2			2	Seiko Time Server
	13	Monitor cable blue			9			9			9			9			9	Seiko Time Server
	14	USB to LC port			9			9			9			9			9	Seiko Time Server
	15	Audio adapter cable 1.5m		SANWA Supply	1			1			1			1			1	Seiko Time Server
	16	USB to USB (extender 12m)		SANWA Supply	1			1			1			1			1	Seiko Time Server
	17	ADSL to CATV 3m		SANWA Supply	1			1			1			1			1	Seiko Time Server
	18	Network cable (not LAN, unknown)			2			2			2			2			2	Seiko Time Server
	19	LAN Green cable			1			1			1			1			1	Seiko Time Server
	20	KVM Switch 1600x1200 75Hz			1			1			1			1			1	Seiko Time Server
	21	NEC Cusom Calibrater (NEC Display)		NEC	1			1			1			1			1	Seiko Time Server
	22	Accessory pack for NEC Display			31			31			31			31			31	Seiko Time Server

	23	Genlock cable for NEC Display			4			4			4			4			4	Seiko Time Server
	24	Mura accessory pack			4			4			4			4			4	Seiko Time Server
2. Consumable Items	**1**	**Surge Protector**	**RJ45-1POE**	**Novaris**	10		1	9		1	8		1	7		2	5	
	2	Circular / Red	[SP-13] For vehicle lantern		8			8			8			8			8	
	3	**Circular / Yellow**	**[SP-13] For vehicle lantern**		8			8			8			8			8	
	4	Circular / Green	[SP-13] For vehicle lantern		9			9		1	8			8			8	
	5	Arrow / Red	[SP-14] For vehicle lantern		3			3			3			3			3	
	6	Arrow / Yellow	[SP-14] For vehicle lantern		3			3			3			3			3	
	7	Arrow / Green	[SP-14] For vehicle lantern		1			1			1			1			1	
	8	Pedestrian / Red	[SP-15] For pedestrian lantern		8		1	7	1		8			8			8	
	9	Pedestrian / Green	[SP-15] For pedestrian lantern		8			8			8			8			8	
	10	[SP-7] Surge arrester	ERZV14D511		10			10			10			10			10	
	11	[SP-7] Surge arrester	SPR-TB-CAT5E		10			10			10			10			10	
	12	Automatic trasfer switch FUSE	FCF2-3	Fuji electric Co., Ltd	1			1			1			1			1	
	13	Automatic trasfer switch FUSE	FCF2-5	Fuji electric Co., Ltd	1			1			1			1			1	
	14	Automatic trasfer switch FUSE	FCF2-10	Fuji electric Co., Ltd	1			1			1			1			1	
	15	Indicator lamp Orange	APS111DNA	IDEC Corp	1			1			1			1			1	
	16	Indicator lamp Red	APS111DNR	IDEC Corp	1			1			1			1			1	
	17	Indicator lamp Orange	APS1260DNA	IDEC Corp	2			2			2			2			2	
	18	Indicator lamp Yellow	ALS22611DNY	IDEC Corp	2			2			2			2			2	
3. Spare Parts	1	[SP3/4] Local Controller Main Board	S3-LCC-A		2			2		1	1			1			1	2
	2	[SP3/4] Local Controller Main Board	LEVEL5		2			2		1	1		1	0	1		1	2
	3	[SP3/4] Local Controller Main Board	S3-TB-IFC		2			2			2			2	1		3	2
	4	[SP-5] SSR Unit	S3-SSU-GL		7			7	24		31		10	21			21	2
	5	[SP-6] LCC Power Supply Unit	SP-TS3E Power		2		1	1			1			1	2	2	1	4
	6	[SP-6] LCC Power Supply Unit	SP-TS3E H80-I/F Power 50W		1			1			1			1	2		3	4
	7	[SP-6] LCC Power Supply Unit	SP-TS3E H110-I/F Power 50W		1			1			1		1	0	1	1	0	4
	8	[SP-16] Vehicle detector	ZWS30B-5/CO2		2			2			2			2			2	4
	9	[SP-17] Vehicle detector	IDET-TROY-FLAT-SC		2			2			2			2			2	4
	10	[SP-17] Vehicle detector	IDET-TROY-P1		2			2			2			2			2	4
	11	[SP-17] Vehicle detector	IDET-TROY-CAM-IF-WW		2			2			2			2			2	4
	12	[SP-17] Vehicle detector	IDET-TROY-S4569-IF		2			2			2			2			2	4
	13	[SP-18] Layer 3 Switch	AT-x930-28GTX	Allied Telesis	1			1			1			1			1	
	14	[SP-19] Layer 2 Switch (Type A)	AT-x930-52GTX	Allied Telesis	1			1			1			1			1	
	15	[SP-20] Layer 2 Switch	AT-x230-10GP	Allied Telesis	2		1	1			1			1			1	13
	16	Keyboard Unit	856-129693-610-00	NEC Corp	2			2			2			2			2	
	17	Media Converter	AT-SPLX40	Allied Telesis	1			1			1			1			1	4

	18	Media Converter	AT-SPLX10	Allied Telesis	2			2			2		1	1			1	4
	19	Video wall controller spare board	MURA-MPX44HF	Matrox	1			1			1			1			1	Seiko Time Server
	20	Video wall controller spare board	MURA-MPX40HF	Matrox	1			1			1			1			1	Seiko Time Server
	21	Detector Controller & Detector all set			2			2			2			2			2	
	22	E1- Network Management Server (cable plug)	RD81-2012C-2		1			1			1			1			1	
	23	E2- Signal control server	RD86-1E2-S2-N224		1			1			1			1			1	

Table forms shall be developed and perfected by the TCC staff based on the above tables and use them for the day-to-day operation of the system and the maintenance activities. Forms are indispensable tool for the signal system and shall be the basis of most decisions to be made.

Section 4 – As-built Drawings

As-built drawings shall be kept updated and available for all the maintenance staff and design section at any given time. Updated drawings shall include all modifications made and instituted since the turnover of the project up to the present and shall consider not only the intersection plan but all the system components including signage and lane markings. For this reason, CAD file of all the plans and drawings should be kept and stored in the official computers.

A hard copy of the updated drawing of each signalized intersection shall also be kept in the controller cabinet for ready reference of the maintenance technicians, engineers, and staff.

Section 5 – Maintenance Waste Disposal

Disposal of waste and unserviceable equipment after it is removed from service must be undertaken in accordance with government regulations and in a safe and environmentally friendly manner.

Because PPTSS is a state-of-the-art system, most of the component are computers and electronic solid state in nature and it is understandable that the excess unusable parts are considered *"e-wastes"*.

E-wastes Are Still Hazardous Wastes

Although they can be handled under more relaxed standards, e-wastes still contain hazardous materials and must be taken to a designated handler or recycler—e-wastes may not be disposed of with other solid wastes.

CHAPTER 6 Ancillary Equipment and Repair Facilities

After deciding on the mode of maintenance and budgetary considerations, planning for policies and procedures shall be made starting with the assessment of technical capabilities of the existing staff, training, and acquisition of the needed testing equipment and maintenance vehicles.

Section 1 – Equipment and Tools

Listed hereunder are recommended basic necessary equipment for the signal system maintenance. The TCC shall include other accessories as needed including appropriate testing equipment :

Figure 10: Heavy Equipment and Cleaning Accessories

Figure 11: Tools and Testing Equipment

Tools and Training

Agencies performing traffic signal maintenance should have the means of inspecting and testing traffic signal equipment routinely. The following list of equipment, though not exhaustive, is an example of items recommended for those performing routine inspections and maintenance:

- A computer with agency-specified software installed
- A certified CMU or MMU tester (printouts of system timing tests, voltage tests, power conflict, red fail conflict, short yellow indicator, AC power failure transfer, restore, power fluctuation, etc.)
- Loop detector analyzer and tester for testing loops and detector amplifiers (signal strength, inductance and change of inductance, resistance)
- Video monitor to observe detection operation
- Suitcase tester or test box for controller
- Load switch tester (verify current outputs)
- BIU tester
- Earth ground clamp
- Power quality meter
- Digital multimeter
- Test kits for communication

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The name and use of equipment for inspection as provided by the supplier are shown in Table 14.

Table 14: List of Inspection Equipment

Inspection Equipment	Use
Tester	AC and DC voltage and current measurement
Protocol Analyzer	Confirmation of transmission procedure, control signal and monitoring signal between the traffic control center and the termination (controller)
Multi-function level meter	Transmission / reception level measurement, unnecessary transmission level measurement, etc. between the center and the terminal
Encounter tester	Noise confirmation between transmission lines

Section 2 – Fiber Optics Signal System Communication

The original design of the traffic signal communication system partly utilized the existing OFC network of the Ministry of Posts and Telecommunications (MPTC) with the addition of 2 core OFC under the Project. However, a defect was found in the MPTC's OFC network system, so the project built a new unicursal OFC network for the communication system between roadside traffic signals and TCC. In starting the traffic signal operation, there was also another problem found, i.e., many OFC cutting cases. The Project Team addressed this problem by rebuilding the combination of one main line and 4 branch lines of the OFC network using the L2 switch from 2022. OFC cuts, however, can still happen because of fires and/or strong winds; but the risks on the OFC network can be minimized.

Table 145: MPTC Fiber Optic Cable

Fiber Optic Cable	Purpose	Note
36-core fiber optic cable	Trunk network connecting the seven major governmental offices in a ring shape	The 2 cores to be provided by MPTC
24-core fiber optic cable	Communication between the Phnom Penh central area and DPWT(Department of Public Works and Transport) where the traffic control center located.	The 2 cores to be provided by MPTC
12-core fiber optic cable	Feeder network which connect the major governmental office to other governmental offices	

The communication network has 103 nodes as shown in Table 8 which are connected through the 2 optic fiber cores in a rin shape.

Table 15: Network Node and Network Topology

Node	Qty	Equipment
Traffic Control Center	1	
Intersection (Type A)	76	Traffic signal
Intersection (Type B)	24	Traffic signal and traffic monitoring video camera
Intersection (Type C)	2	Traffic monitoring video camera
Total	103	

Maintenance of the communication network, the link between the TCC and RSE is also the responsibility of the TCC maintenance team. Therefore, testing equipment to troubleshoot the problem particularly the continuity and integrity of the fiber optic cables has to be acquired together with the splicer and other equipment and tools needed.

The major equipment for the maintenance of the communication lines is listed below.

- Visual Fault Locator (VFL) - Illuminates a fiber with a visible laser, which will “leak” at points where connections are bad, or the fiber is bent or broken. These work well if you can visually inspect the entire fiber run – not so great if the run is kilometers long.

- Optical Fault Finders – quickly and efficiently measure length and identify high loss events and breaks on multimode fiber, up to 1,500 meters.

- Optical Time Domain Reflectometer (OTDR) – calculates signal loss based on the amount of reflected light, or backscatter, that it detects. Using this technology, an OTDR can be used for locating fiber breaks, bends, splices, and connectors and for measuring the loss of these specific event. An OTDR gives you the complete picture of the fiber optic link.

- Fiber Optic Splicer/Fiber Splicing Machine – A Fiber Optical Splicer utilizes modern telecom technology to splice together fiber optical cable.

Fig.12 & 13 show the most important equipment for the maintenance of the fiber optic cable being utilized by the PPTSS.

Figure 12: Fiber Optic Cable Testing Equipment

Figure 13: Fiber Optic Cable Splicing Equipment

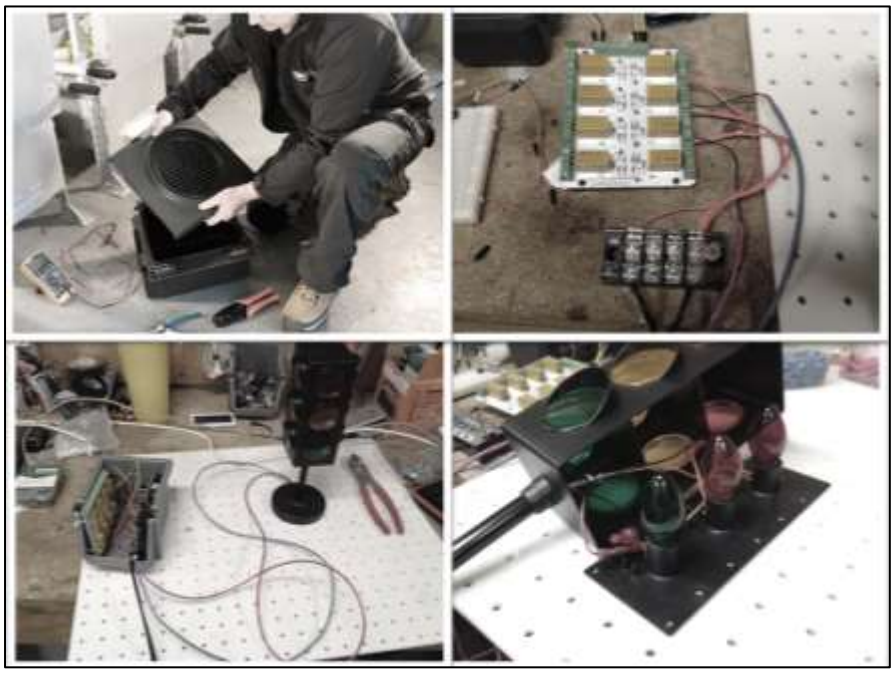
Section 3 – Repair Shop, Material Storage, and Equipment Yard

It is a normal practice by Traffic System agencies that maintenance vehicles, test equipment and tools, and replacement parts and supplies, are usually housed in a centrally located repair shop. This is to ensure that close coordination of repair technician, storage staff, and maintenance vehicle operator is maintained and fast response to the need of maintenance services and emergencies are ensured.

The number and types of equipment will vary depending on the size of the system. PPTSS can start with minimum requirement of two rooms (repair area and storage area) and a parking lot for 2 or 3 vehicles. If there is no available area beside the Control Center, the shop and yard can be on another government owned land or a leased property not far from the location of TCC and must be provided with reliable communication line.

Specific maintenance procedures are more applicable for certain components. For example, computer and communication system components, may be much more practical to have "contract maintenance" for two reasons: 1) it reduces the agency's need for inhouse highly skilled technicians and contracts for their services on an as-needed basis, and 2) it eliminates the agency's need for an inventory of costly spare components.

Figure 14: Repair Shop for Signal Maintenance



CHAPTER 7 Maintenance Cost and Funding

In-house maintenance of traffic signal system necessitates the need for equipment to reach most equipment like signal lantern, camera detector, CCTV camera, branches of trees covering signal lights, and other components above ground. This major maintenance equipment is needed mainly for all types of maintenance activity. For PPTSS the ideal set up is to own at least one bucket truck and a service truck or pick up for efficient and reliable response to emergency situations. This is a capital investment on the part of the government but is worth to acquire when service to the public giving them safe travel along the city roads is considered' This is also good for building positive public image for the government.

List of recommended equipment for operation and maintenance activities is shown in Chapter 6. The TCC Officers and staff shall evaluate what equipment is really needed, prepare the estimates, and submit to the Advisory Committee for discussion and approval.

Section 1 – Preventive Maintenance Budget Cost

Budget cost for preventive maintenance shall comprise the cost of equipment and tools for the routine inspections, including consumable items and replacement parts. Because a year-long preventive maintenance for PPTSS has not been done in the past, detailed estimates is necessary to get the total amount as there is no previous record that can be used as reference. Estimators should consider the frequency of preventive inspection as finalized by the team for one whole year to justify the yearly budget that will be requested for approval.

Section 2 – Corrective Maintenance Budget

Costing for corrective maintenance cannot be estimated as fault call, a trouble or an emergency call cannot be predicted and is being done as needed. However, TCC staff have a great deal of experience for four(4) years doing corrective, response or emergency maintenance that can be considered as reference. Previous records and experiences can be considered for the prediction estimates of the maintenance activities per year.

Section 3 – Design Modification Estimates

Budgeting design modification is like the corrective maintenance. Some considerations however can give a different basis which is the planned improvement of the system, additional intersections, or signal upgrading. Day-to-day design modification can also be estimated by the previous experiences where changing traffic behavior for example is observed.

CHAPTER 8 Coordination with Other Agencies, Private Organizations and Public Awareness.

Traffic management is about the movement of people and goods, and the primary concern of everyone using the roads and its amenities is to have smooth and safe travel (concerns that is also the aim and responsibility of the traffic signal system's management office, the TCC). In any urban cities, people are in a daily clash with different entities mostly motor vehicles, pedestrians, motorcycles, tricycles, bicycles, and bystanders. On the part of the organizations managing the traffic (TCC and the Traffic Police), the task is not only their own duties and responsibilities of making the road safe and ensure smooth movement of traffic. They are bound to coordinate each other in many instances. They are also bound to coordinate with other concerned agencies both the government and the private organizations.

Section 1 – Concerned Agencies

Government and private organizations that should be coordinated as far as traffic management and safety are concerned are listed, but not limited to the following:

- Traffic Police Unit
- National Road Safety Committee (NRSC) – Funded in the national budget, and has a road safety strategy which is partially funded. The functions of the agency include coordination, legislation and monitoring and evaluation of road safety strategies.
- OSHA – Occupational Safety and Health Administration of Cambodia
- Ministry of Health

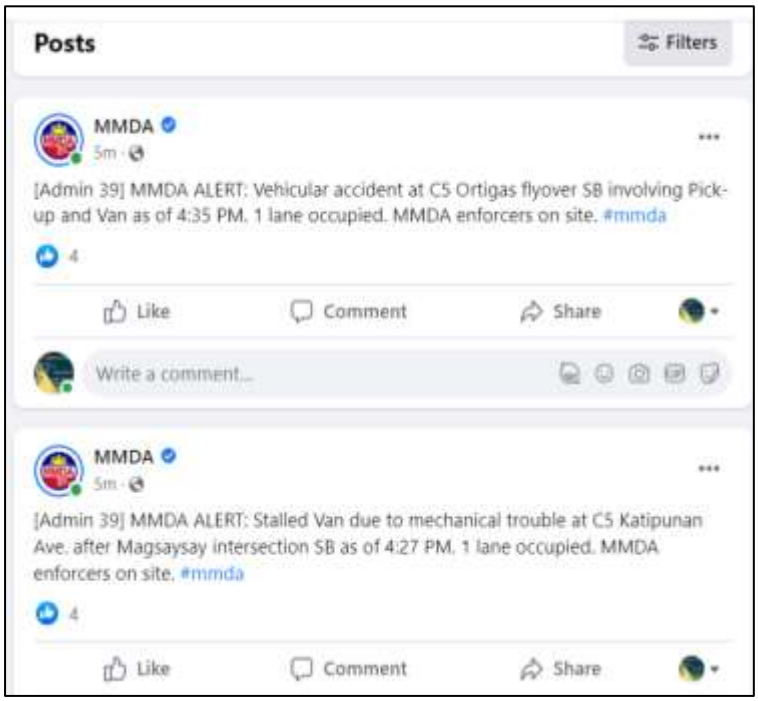
Section 2 – Public Awareness, Education, Information Dissemination

The PPTSS through the TCC organization under the PPCA and DPWT has the implied responsibility to the PP citizens to deliver smooth and safe travel. And in doing so they are delivering a public service to the people of Phnom Penh. Given this responsibility, the office is also responsible to inform the motorists and the public of what is happening on their signal system specially if there are faults, accidents, and dangerous situation along the road so that they can plan their trip.

It is for the above reasons that a system of information dissemination must be developed by the TCC in whatever platform - print, radio or TV broadcast, social media, variable message signs and other ways just to have an updated report to the public from time to time about the traffic situation and road condition. For this task the TCC must coordinate with the appropriate government agencies to get the necessary permits.

Fig.15 shows the MMDA (Philippines) monitoring room called the Metro Base. Shown here as an example, the command center inside the Metro Base disseminates the traffic situation in all major roads and intersections daily on radio programs of several radio and TV stations. Motorists can also call the center through its hot line 136 to ask the traffic situation in any road covered by the 203 CCTV cameras around the metropolis. Hot line 136 is also used to report accidents and other situation within the metropolis so that the MMDA emergency units can respond, and the Metro Base can inform the motorists to avoid such areas.

Figure 15: MMDA Metro Base Monitoring Metro Manila Traffic



MMDA can also be reached through its FB page that contains information about roads within the metropolis.

MMDA also has Instagram account being used to disseminate information through pictures. Social media is being used as they certainly are verry effective in providing information to the public and this experience can be adopted by the PPTSS.

Section 3 – Relationship with Police Traffic Enforcers

Aside from the traffic signal system which manage the flow of traffic for the whole area of Phnom Penh central district, the role of the traffic police is equally important for obvious reasons. As a partner agency managing the roads, it is very important that the TCC develop harmonious relationship and create a good coordination with them.

This is the reason for the inclusion of the PPTP Office Chief to the advisory committee, and the TCC management must explore a systematic coordination with the police enforcers on the ground. Meetings between the technical team of the TCC and the police traffic enforcers preferably the head of unit shall be made aside from the meeting with the advisory committee specially when there is problem in the field.

The PPTSS have no pre-emption methodology set up within the operation manual and the task of VIPs and Emergency vehicle safe and smooth passage along the needed route is currently left to the police on the ground. This system capability should be explored, developed, and incorporated in the standard operation of the system.

Section 4 – Communication System with other Agencies

Communication system with other agencies and organizations shall be established aside from the normal landline telephone and mobile phone. There is almost unlimited way of communication during this generation using mobile application and internet platform. The concerned parties and the TCC should agree with the procedure particularly during emergencies. Chatrooms like Telegram, Skype, Teams, WhatsApp, and other internet-based applications are commonly used today in business teleconferences.

CHAPTER 9 Occupational Safety and Health

Occupational Safety and Health (OSH) deals with all aspects of health and safety in the workplace and has a strong focus on primary prevention of hazards. Its goal is to prevent accidents and harm to people from work-related activities. Traffic signal maintainers provide a vital service to keep the travelling public safe, but in doing so they may face dangers from moving vehicles, falls and electrocution.

Section 1 – International Labor Law on Safety and Health

The International Labour Organization is the source of international labour law, It is the only tripartite U.N. agency, since 1919. The ILO brings together governments, employers, and workers of 187 Member States , to set labour standards, develop policies and devise programs promoting decent work for all women and men. The main aims of the ILO are to promote rights at work, encourage decent employment opportunities, enhance social protection, and strengthen dialogue on work-related issues.

Convention No. 155 on Occupational Safety and Health provides for the adoption of a coherent national occupational safety and health policy, as well as action to be taken by governments and within enterprises to promote occupational safety and health to improve working conditions.

The Royal Government of Cambodia, since its first establishment in 1993 after the 1st General Election, has paid highest attention on the protection of Cambodian people from diseases and injuries as well as the provision of the health care services.

For this reason, Constitution, Laws, National Strategy, and some other regulations have been issued. In earlier 1980's the Ministry of Planning established the Department of Wage and Labour and the Labour Protection Office from which there were quite several technical officers performing the OSH in factories and enterprises. The Department also initiated the 1992 Labour Code. National Tripartite Seminars on the OSH in small enterprises, construction sites and farms, have been conducted from 2000 to 2008 under the Technical Assistance of the International Labour Organization and the Governments of the Republic of Korea and Japan.

A short summary is discussed in this document, but this is not to mean that the TCC personnel can go with the maintenance activities without the proper and comprehensive actual training on Occupational Health and Safey. The information given here is just to give the reader some insight on the importance of Occupational Safety and Health through this information and knowledge. Many private OSH training providers accredited by the government can fulfil the required hours of training.

Section 2 – Personal Protection from Vehicular Accident

Temporary traffic controls should be set up prior to performing any signal-related maintenance activities. In an organization that usually work outside particularly along roadways a “traffic control person” should be assigned for the safety of motorists, pedestrians, and fellow workers. Maintenance staff should receive training in:

- **temporary traffic control,**
- **electrical line safety, and**
- **fall protection.**

The traffic control person must undergo training on road safety and work zone traffic management. PPTCC may set at least one week training for all traffic signals staff. But there should be assigned one in charge during any operation and maintenance activities on roadway.

Training modules available on site can be used as a preliminary guide and to set the responsible persons on the importance of the actual training intended to the place of work where different needs and culture may take place. The international standards and industry practice if not exactly appropriate in local setting can be a starting point and guide to devise a standard adopted to the local situation.

The US based Manual on Uniform Traffic Control Devices (MUTCD) sets a very good standard practice based on engineering principles. Many countries in the world somehow adopts and modify such principles and standards and adopt them for their local use.

a. Traffic Control Devises

Traffic control devices are markers, signs and signal devices used to inform, guide and control traffic, including pedestrians, motor vehicle drivers and bicyclists.

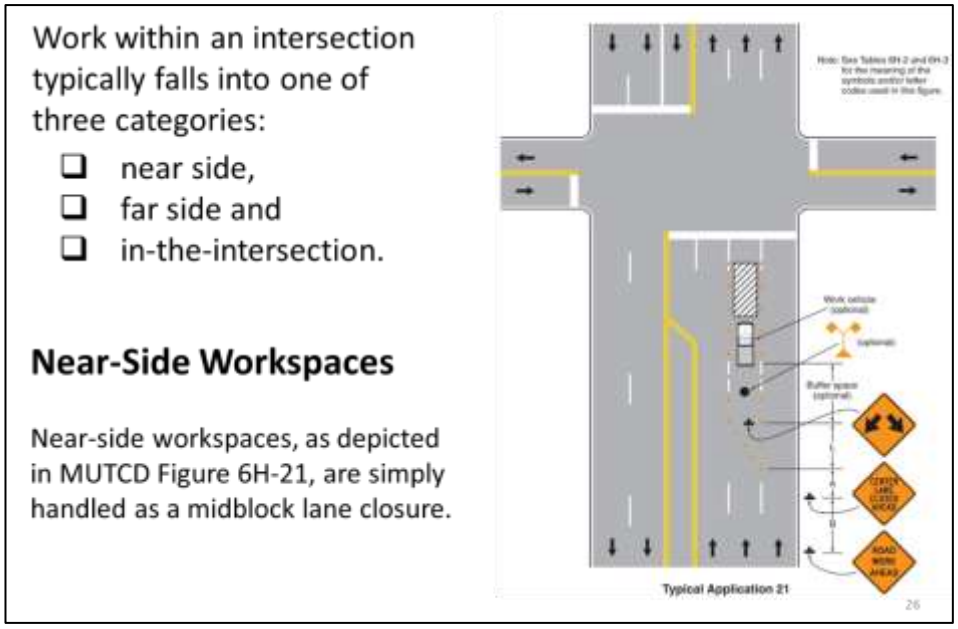
These devices are usually placed adjacent to, over, or along the highways, roads, traffic facilities and other public areas that require traffic control due to work activities on roadway or intersection.

b. Guide for the Installation of Traffic Control Devices

Work within an intersection typically falls into one of three categories:

- near side,
- far side and
- in-the-intersection.

Figure 16: Near Side Workspaces



Reduction in capacity – could result in congestion and backups. When near-side workspaces are used, an exclusive turn lane may be used for through vehicular traffic.

Two warning signs may be used in the advance warning area, and a third action-type warning or a regulatory sign (such as Keep Left) may be placed within the transition area.

Figure 17: Far Side Workspaces

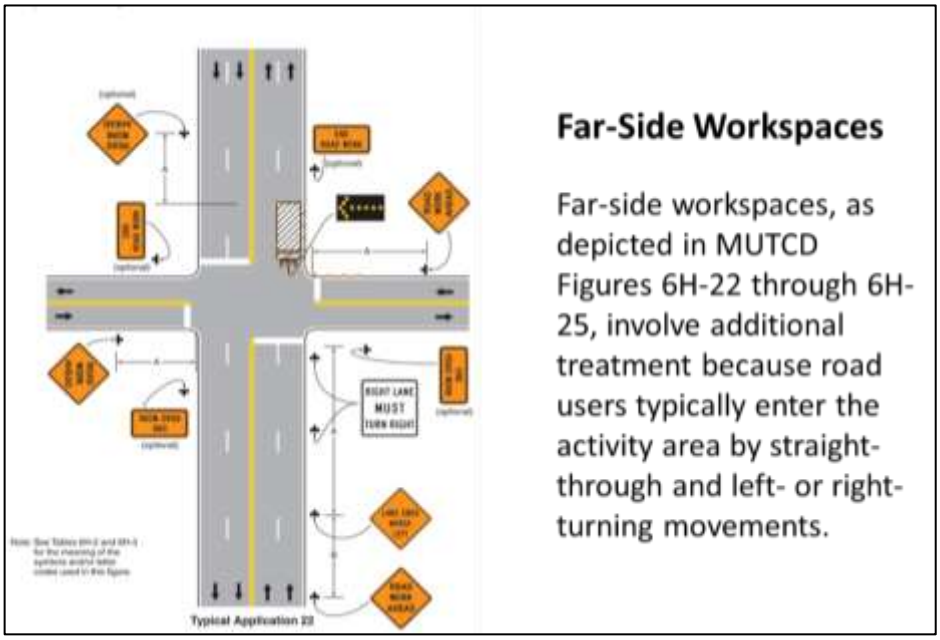
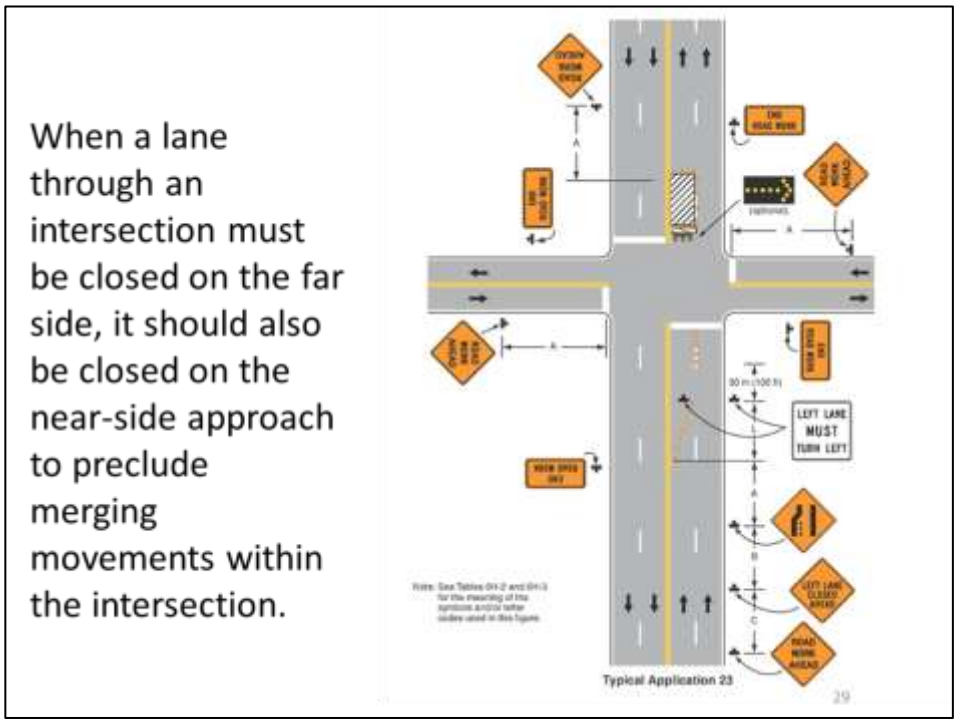


Figure 18: Far Side Inner Lane



Far-side workspaces, as depicted in MUTCD Figures 6H-22 through 6H-25, involve additional treatment because road users typically enter the activity area by straight-through and left- or right-turning movements.

When a lane through an intersection must be closed on the far side, it should also be closed on the near-side approach to preclude merging movements within the intersection.

Figure 19: Center of the Intersection

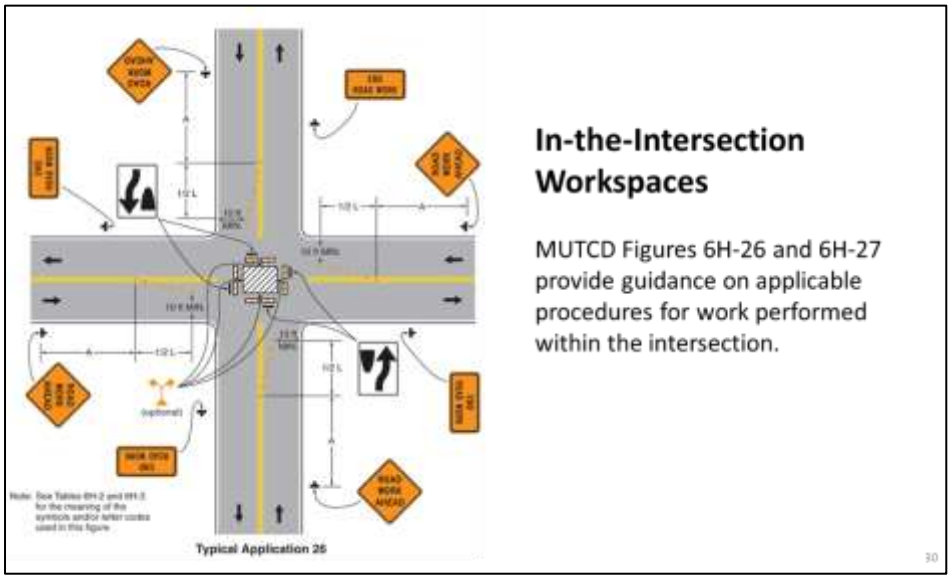
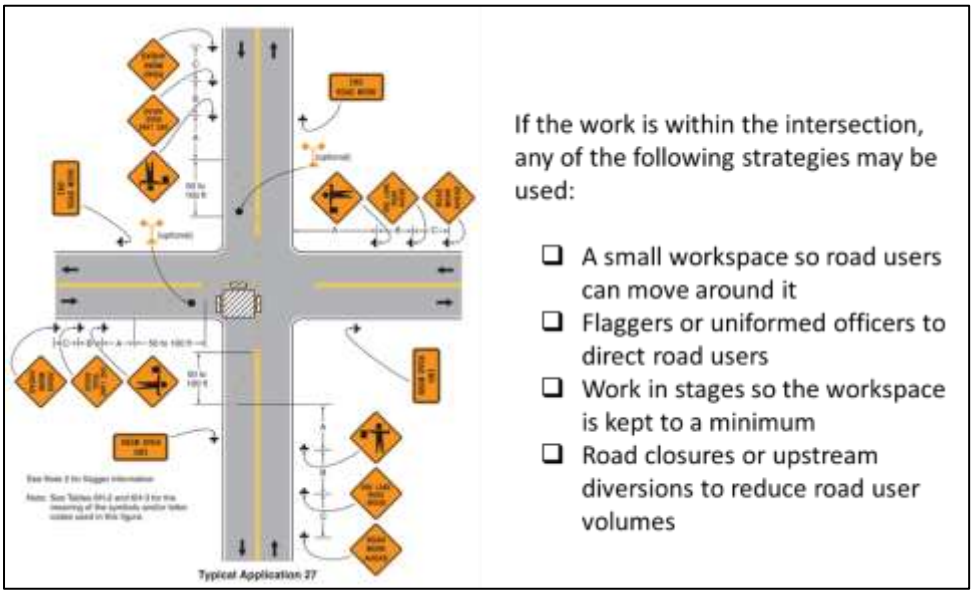


Figure 20: Intersection Corner Closure



c. Traffic Management PPEs and Traffic Control Devices

Section 3 – Personal Protection from Electrical Accident

According to National Safety Services,10% of all fatal work injuries in the US every year are the result of falls, and 53% of fall accidents are a result of electrocution. Electrical safety procedures for Traffic Signal employees, ensures compliance with Occupational Safety and Health Administration (OSHA) and National Electrical Code (NEC) standards. Only qualified Traffic Signal employees are permitted to work on energized electrical equipment.

Figure 21: The Danger Zone in Electrical Power Lines

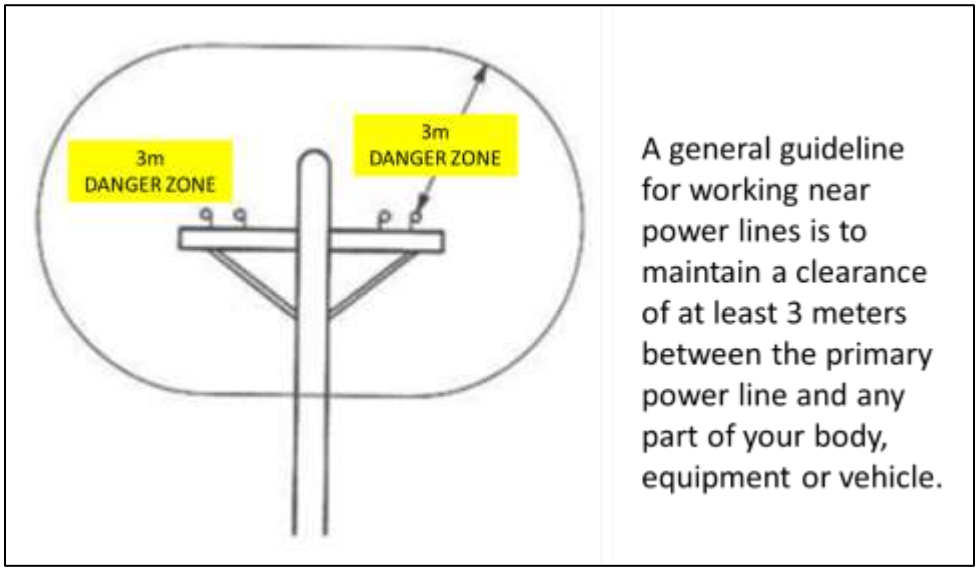
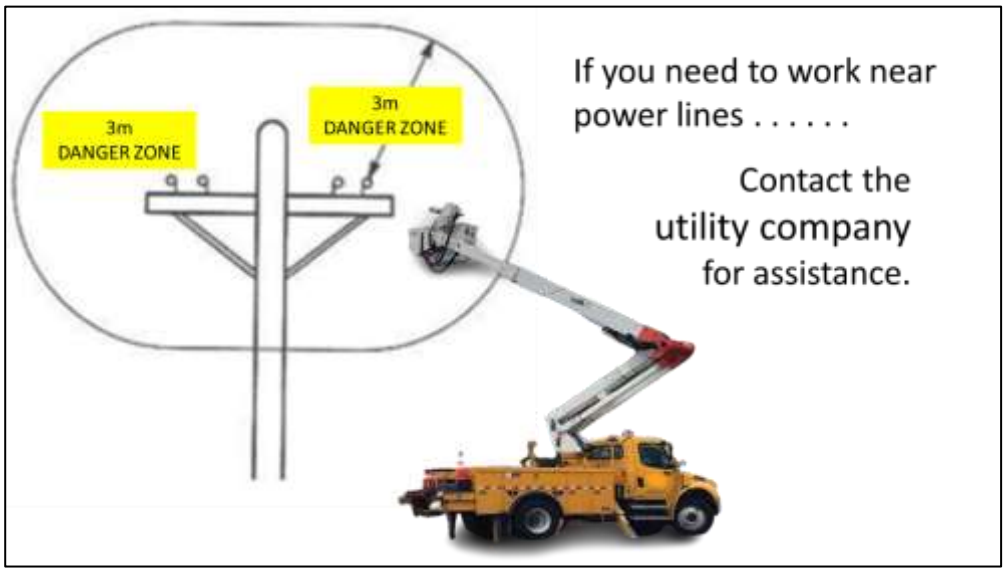


Figure 22: Working Near Power Lines - Contact the Utility Company



General Requirements

Only qualified Traffic Signal employees shall work on energized electrical equipment consistent with their training and within the limitations of their tools and personal protective

equipment (PPEs).

Traffic signal employees shall not perform work on electrical utility lines or perform emergency repairs or any other work that is clearly responsibility of the utility. Employees shall consult with their supervisor with any questions.

Unqualified persons, including non-department employees and members of the general public, shall not be permitted closer than 4 feet of an open “Energized” traffic signal box (limited approach boundary). Employees shall verify that cabinets are not energized by using a non-contact voltage detector prior to making physical contact with the enclosure. Traffic Signal employees shall wear all appropriate PPE, including but not limited to, eye protection, gloves, and safety footwear prior to work on exposed or live conductors.

Personnel working from non-insulated platform trucks or other vehicles that are not insulated shall not be closer than 10 feet to energized equipment of 600 volts or greater. The distance will be measured from the closest body part of the employee or any part of the non-insulated vehicle to the closest energized conductor.

Non-insulated platform trucks or other un-insulated vehicles shall not be used within the Minimum Approach Distances (MAD). When an energized conductor will be less than 10 feet from the Traffic Signal employee and the voltage is unknown, the Supervisor shall be consulted and contact the Utility company as necessary. If the Utility company cannot provide the voltage the conductor shall be 600V or greater. Only ANSI/ASI approved aerial lifts shall be used when working closer than 10 feet to energized equipment of 600V or greater.

Any work performed near energized equipment of 600 volts or greater shall be done under adequate lighting conditions, either natural or artificial. A spotter shall observe all overhead operations while personnel is in proximity to energized conductors of 600V or greater. Spotters shall be trained in the operation of the insulated lift device.

Traffic Signal employees shall report any electrical shocks to their immediate supervisor. Supervisors shall determine the likely cause and recommend corrective actions prior to work beginning again. All Traffic Signal Employees shall be trained with certification. A first aid kit shall be provided in all traffic signal crew response vehicles.

PPE requirements for electrical safety is given here as a reference and must be checked with the policies of Cambodia Department of Wage and Labour and the Labour Protection Office

Minimum PPE for Work on Fused Energized Equipment

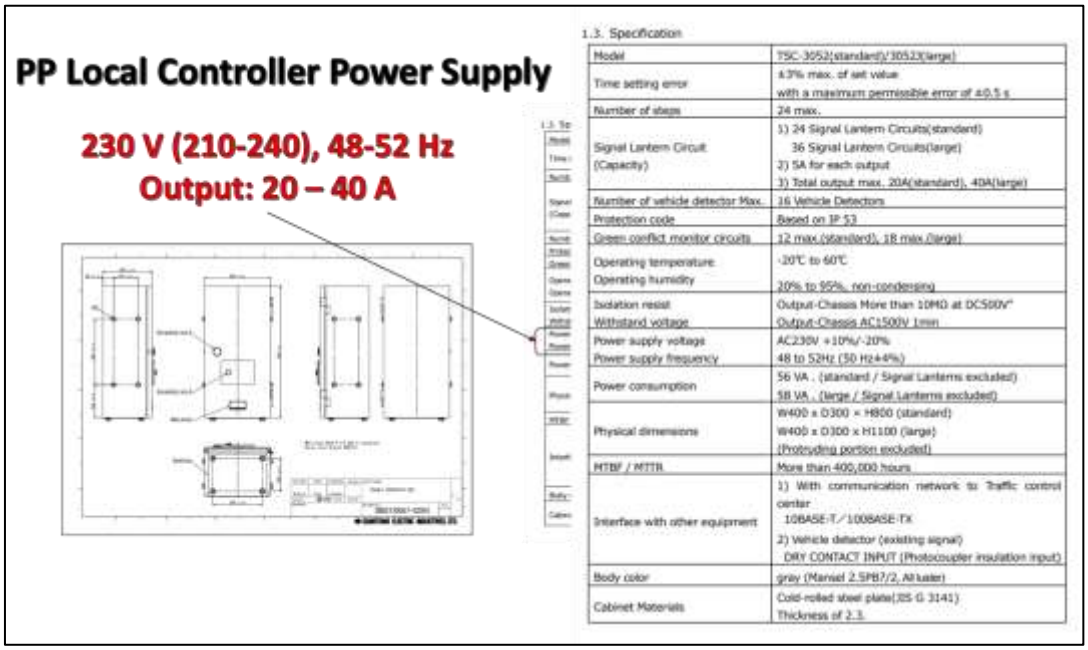
Head	Department issued, high-visibility orange, non-conductive, high impact, ANSI EG rated hard hat.
Eye	ANSI Z87.1 Safety Glasses
Hand	ASTM voltage rated gloves with leather over gloves*
Torso	Garments that meet current Department requirements for high visibility apparel. ASTM Arc Rated Clothing may be required when working on un-fused PDAs.
Foot	ASTM F/I/75/C/75 or M/I/75/C/75 with EH (nonconductive notation).
Tools	Voltage rated tools

Minimum PPE for Work on Un-fused Energized Equipment

Head and Face	Department issued, high-visibility orange, non-conductive, high impact, ANSI EG rated hard hat and arc rated balaclava and face shield.
Eye	ANSI Z87.1 Safety Glasses
Hand	ASTM voltage rated gloves*, heavy duty leather gloves (as needed)
Torso	ASTM arc rated coveralls or arc rated rain jacket and pants.
Foot	ASTM F/I/75/C/75 or M/I/75/C/75 with EH (nonconductive notation) and insulated over boot.
Tools	Voltage rated tools
Hearing protection	Ear canal insert

d. Personal Protective Equipment for Electrical Safety

Figure 23: Phnom Penh Controller Power Supply



PPEs for Electrical Works

1. Helmet
2. Globes
3. Face Sheild & Safety Glasses – Face PPE
4. Insulation Equipment
5. Gas Detection Devices
6. Non-Conduction Rods
7. Earthing Clamps and Fittings
8. Safety Signs
9. Safety Shoes – PPE for Shoe
10. Hearing Protection earmuffs
11. Safety Vest

Section 4 – Personal Protection from Fall

Aerial Lift Safety and Fall Protection

Aerial lift trucks should only be used by properly trained personnel. When working from an elevated bucket, always keep your feet firmly on the floor of the bucket and always remember to wear a harness secured to the bucket with a lanyard.

Maintain equipment on a regular basis and inspect the vehicle and all personal fall protection devices before each use.

PFAS

A personal fall arrest system (PFAS) is comprised of three vital components:

- ❑ an anchorage,
- ❑ body wear (full-body harnesses), and
- ❑ a connecting device (a shock-absorbing lanyard or self-retracting lifeline).

a. Bad Practices for Fall Protection PPE

What not to do

1. Do not let untrained employees work at height.
2. Do not provide untested or expired PPE to your employees.
3. Prevent employees from starting the work if they do not wear the appropriate PPE for the job.
4. Do not store PPE outside or in direct sunlight.
5. Do not use fall protection PPE if it is damaged.
6. Do not adjust fall protection PPE. Even writing on a harness with marker can damage the webbing.
7. Do not allow employees to use PPE that doesn't fit them properly.
8. Do not use equipment that has been involved in a fall without it being inspected by a competent person.

b. Good Practices for Fall Protection PPE

What to do

1. Provide all who work at height with proper equipment and training.
2. Urge employees to take safety very seriously and provide a culture where workers can address each other on possible wrongful use of PPE.
3. Make sure all equipment you provide is suitably tested and conform (local) regulations.
4. If possible, provide employees with their own PPE, that is perfectly suited to them. Pay attention to the fact that most harnesses are tested for a weight of max 130 kg (286 lbs.).
5. Ensure employees know their fall clearance and the corresponding maximum length of their lanyard.
6. Store PPE in a clean, well-ventilated, dust free and dry place. Preferably offer a

place on the jobsite so you can keep track of the proper storage of PPE.

7. Ensure PPE are kept clean. Dirt and other substances can be rinsed of with water and mild soap. Also read our blog on how to maintain a safety harness, for instructions on cleaning a harness. If PPE is stored on site this can be checked easily.
8. Have employees perform pre-work inspections of PPE before each use. Let them check for any damages or deformations. We have written a blog series with downloadable posters on inspecting a lanyard, examining a fall arrest device and checking a harness. Your employees can do this visual inspection themselves if you've trained them and the aforementioned posters can help them remember.
9. When in doubt about the safety of PPE do not use it. Have a competent person check the equipment. If it is still suitable for use you'll get confirmation in writing. If it isn't, throw it out.
10. Have all PPE inspected annually by the manufacturer, or a certified party.

Section 5 – Toolbox Meeting (TBM)

TBM is a meeting held on site with the participation of all workers.

The purpose of this program is to check physical condition, work content, and to raise safety awareness.

If there is a problem with the confirmation result, we will implement countermeasures as necessary.

TBM Checklist:

1. Physical condition
2. Explanation of work content
3. Possible hazards
4. Confirmation of Equipment
5. Check PPEs
6. List of emergency contact numbers

Appendices

Appendix 1 References

A. Publication, Research Papers:

1. Preventive Maintenance and Inspection for Traffic Signals, Roadway Lighting and Overhead Sign Structures Prepared by CTC & Associates LLC - TRS 2004, November 2020
2. Traffic Signal Control Systems Maintenance Management - Practices WALTER H. KRAFT, D. Eng. Sc., P.E. Parsons Brinckerhoff/Farradyne Systems, Inc., TRB-1997
3. Traffic Signal Operations and Maintenance Staffing Guidelines by: Dunn Engineering Associates, P.C. in cooperation with Kittelson and Associates, Inc., March 2009
4. Traffic Signal Operations Handbook-James Bonneson, Srinivasa Sunkari, and Michael Pratt, March 2009
5. Traffic Control Signal Design Manual Connecticut DOT, Bureau of Engineering and Construction, Division of Traffic Engineering,2009
6. Traffic Signal Design Manual-City of Columbus - 5-01-14
7. Maintenance Management Manual: Texas Department of Transportation, Oct. 2020
8. Traffic management project in Phnom Penh, Seiya Matsuoka Matsuoka & Associates, Inc., 4-10-3 W1705, Minatomirai, Nishi-ku, Yokohama City 220-0012, Japan
9. Traffic Signal Maintenance, April 2015-State of Queensland (Department of Transport and Main Roads), 2015
10. The importance of a procedure's manuals in maintenance management, Alexandre Veríssimo Carvalho1, April 2020

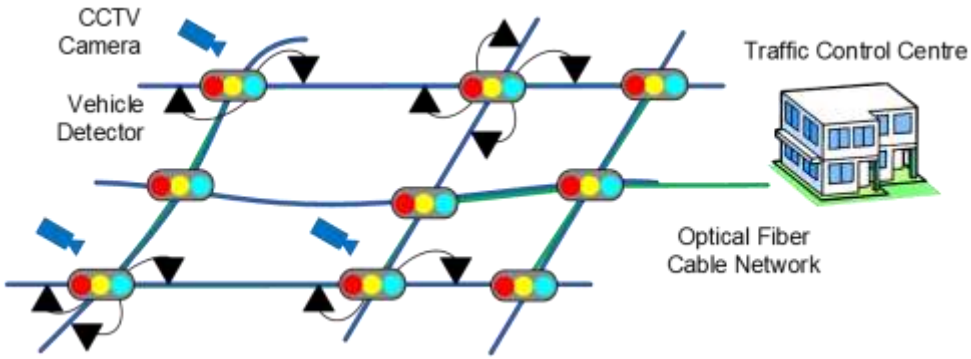
B. Definition of Terms:

Traffic Control System	consist of intersection traffic signals, a communications network to connect them together, and a central computer or network of computers to manage the system.
Area Traffic Control System	This is used to control the traffic signals of a certain area as a group and operate the system to minimize traffic congestion in the entire area. It is often implemented in urban areas where roads are dense. The traffic control system in Phnom Penh does not introduce this system, but it adopts a sub-area system that links the surrounding signalized intersections that are directly related to the main intersections.
Actuated Traffic Control	Actuated control consists of intervals that are called and extended in response to vehicle detectors. The controllers are capable of not only varying the cycle length and green times in response to detector actuation, but of altering the order and sequence of phases.
Adaptive Traffic Control System	This is a combination of technology that is used in traffic signals to resolve traffic congestion adaptively. It provides the real-time variation of signal timing that implies improved decision-making capabilities at intersections. It is a management of the traffic system as actual traffic demand. It counts vehicles via measuring devices such as vehicles video image detector and analyzes the incoming data; gives the real-time response at intersection geometrics and changes the traffic lights according to traffic demand.
Preventive Inspection	The work to be done consists of the monthly inspection/cleaning and quarterly and annual checking, cleaning, and servicing of various system components and related equipment. Any problems which require further attention or use of spare parts shall be recorded.
Corrective Inspection	The work to be done consists of correcting malfunctions resulting from the equipment deterioration and failure under normal operating conditions.
System Availability Rate (SAR)	This is the probability rate that a system will not fail or have to undergo repairs when it needs to be used.
Mean Time Between Failures (MTBF)	This is the expected time between two failures for a repairable system.
Mean Time to Recovery (MTTR)	This is the average time it takes to repair an equipment failure; it indicates the reliability of the equipment.
Fixed-time signals	Produce routine gaps in traffic that may be used to turn into or cross the street. Help make pedestrians an equal part of the traffic signal system by providing them with regular and consistent intervals.
Traffic Signal Controller	This is used to control the traffic flow in multiple ways at an intersection; it is used for individual intersection control.
Traffic Signal Lanterns	These are facilities that provide a signal - green (go), yellow (caution) and red (stop) - to vehicles and pedestrians. Lanterns are basically classified as primary, secondary or tertiary. Depending on location, the basic classification can be qualified such as; dual primary or overhead primary, secondary or tertiary.
Traffic Signal Phasing	This provides output display for Vehicles and Pedestrian movement sequences with allotted green time.
Video Image Vehicle Detectors	These are sensors installed above the roadway to detect the presence or absence of vehicles on the spot. The traffic data collected are transferred to the front-end-processor and the computer, which processes them into such traffic-related data as traffic volume, occupancy rate, travel speed and congestion level. The Japanese model vehicle detectors introduced in Phnom Penh do not detect 2- or 3-wheeled vehicles. Therefore, the data processed is only congestion level.
Qualified Employee	An Employee who has successfully undergone on the-job training for the purpose of obtaining skills and knowledge necessary to be considered a qualified employee, and who has attended department provided training on electrical safety, and who has demonstrated ability to work safely on energized equipment at his or her level of training.

Appendix 2 How the System Operates

Why Traffic Control System is introduced?

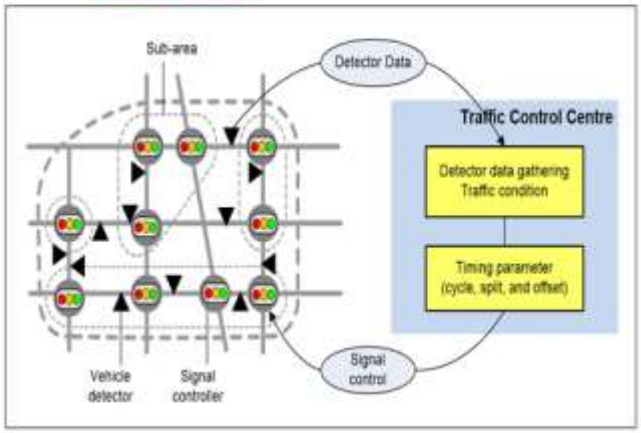
- Benefits of area traffic control system
  - Signals will operate with timings most suitable for prevailing traffic demand measured by vehicle detector.
  - Signal operation is flexible and efficient contributing to the reduction in congestion, fuel consumption and CO2 gas.



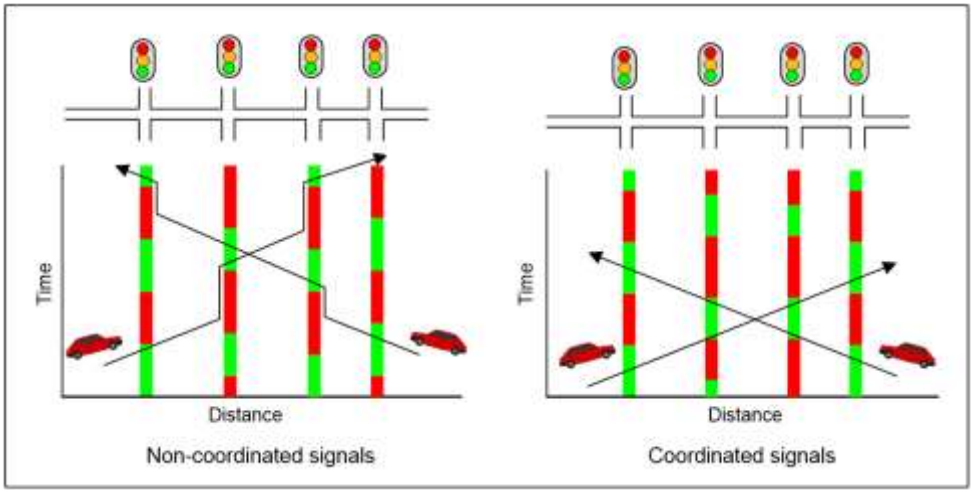
Role of Traffic Control Center

- Observation of traffic through CCTV Camera.
- Signal timing optimization (manual intervention) in case of congestion.
- Preparation and implementation of special control during event.
- Monitoring of system operation.
- Maintenance of signals, detectors and CCTV cameras.
- Development of system upgrading plan.
- All signals are directly controlled from Traffic Control Center based on the traffic condition data gathered by vehicle detector.
- Signal operation is optimized at intersection level as well as along arterial street and sub-area.

Image of Signal System



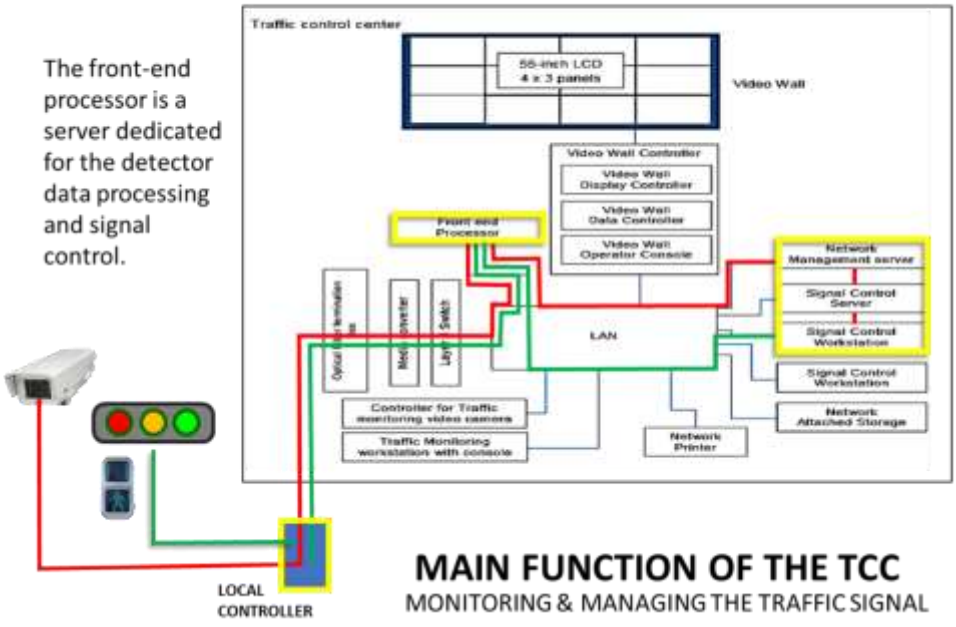
Benefits of Coordinated Signals



- Green wave is formulated and vehicles can pass several intersections without stopping.

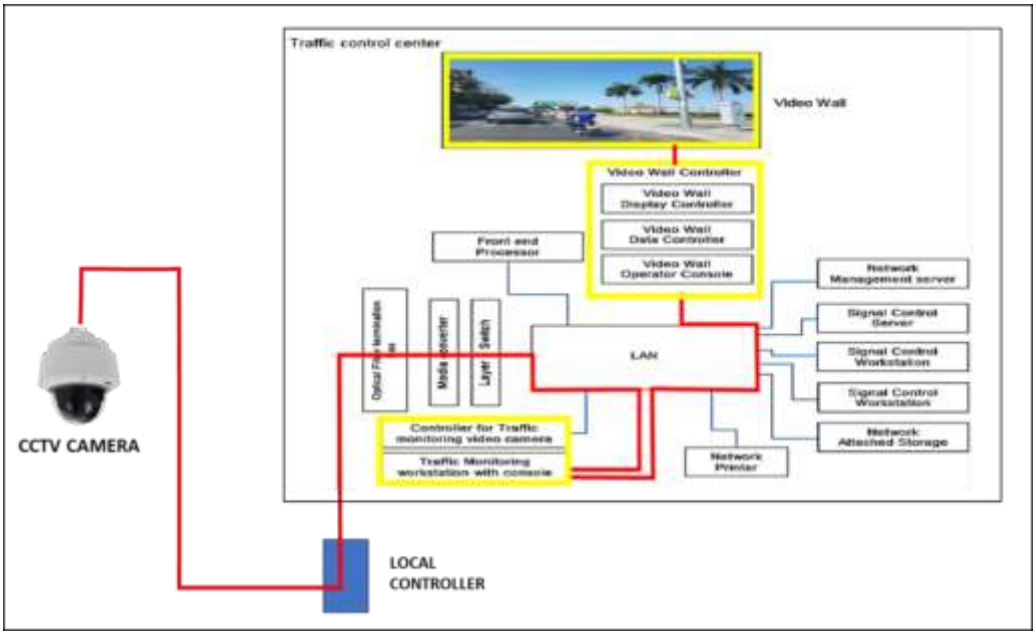
HOW DO THE TCC WORK?

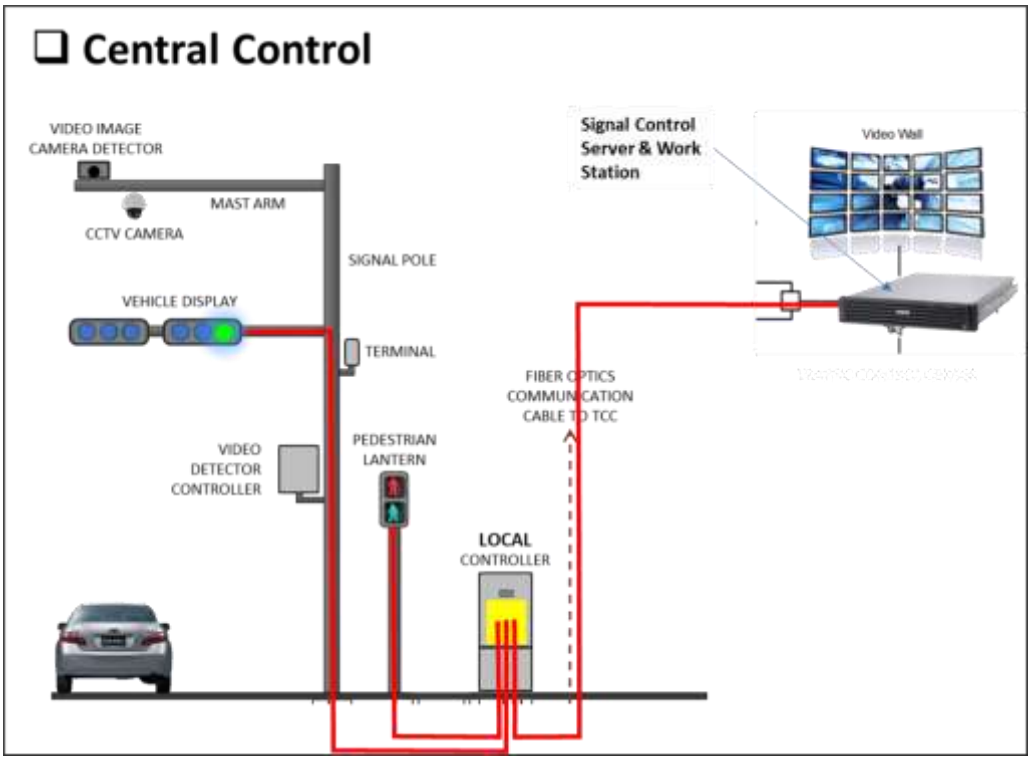
The front-end processor is a server dedicated for the detector data processing and signal control.



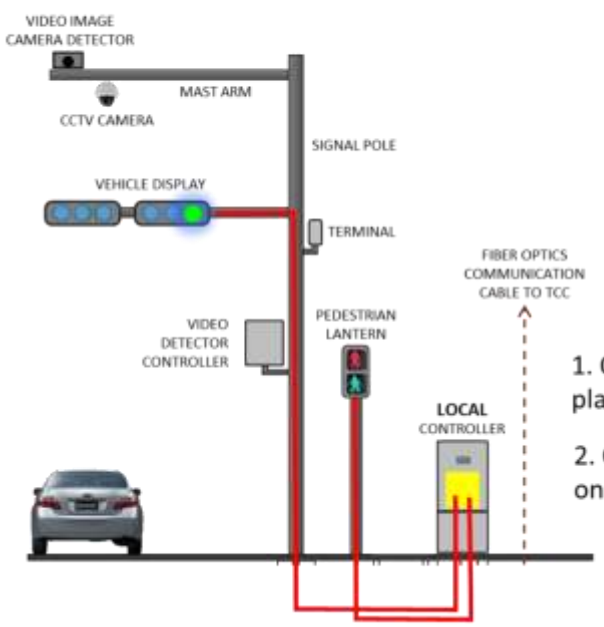
MAIN FUNCTION OF THE TCC

MONITORING & MANAGING THE TRAFFIC SIGNAL


Traffic control center
Video Wall
Video Wall Controller
Video Wall Display Controller
Video Wall Data Controller
Video Wall Operator Console
Front end Processor
Network Management server
Signal Control Server
Signal Control Workstation
Signal Control Workstation
Network Attached Storage
Network Printer
LAN
Controller for Traffic monitoring video camera
Traffic Monitoring workstation with console
CCTV CAMERA
LOCAL CONTROLLER


Central Control
VIDEO IMAGE CAMERA DETECTOR
MAST ARM
CCTV CAMERA
SIGNAL POLE
VEHICLE DISPLAY
TERMINAL
FIBER OPTICS COMMUNICATION CABLE TO TCC
VIDEO DETECTOR CONTROLLER
PEDESTRIAN LANTERN
LOCAL CONTROLLER
Signal Control Server & Work Station
Video Wall

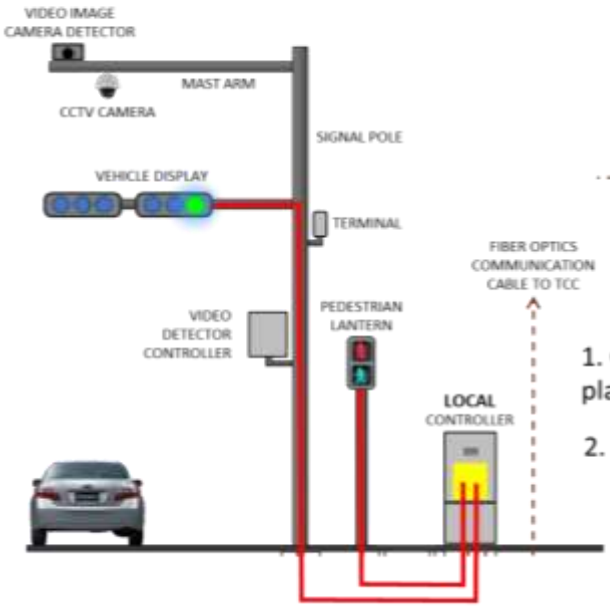
❑ Local Coordinated Control



1. Operates using one of the timing plans stored in the controller

2. Offset is applied if specified based on the internal clock.

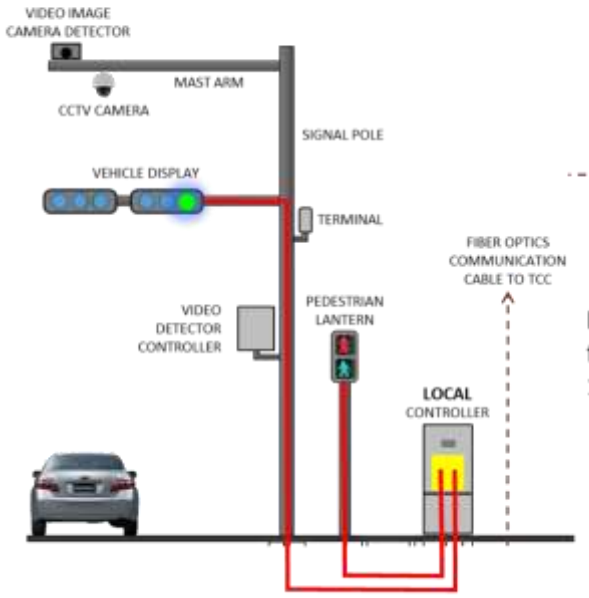
❑ Local isolated control

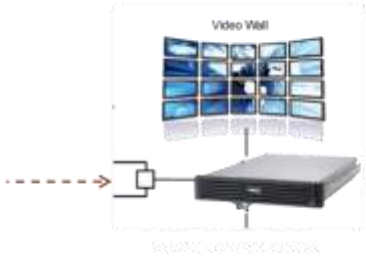


1. Operates using one of the timing plans stored in the controller

2. Offset is not applied.

❑ Fail-safe fixed time control

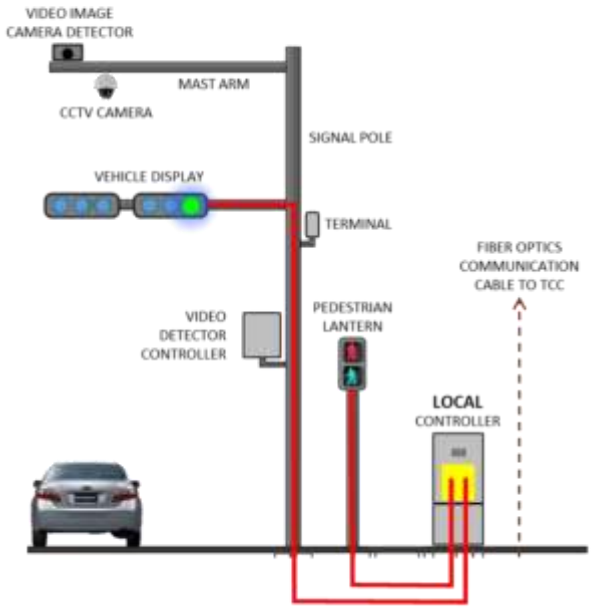


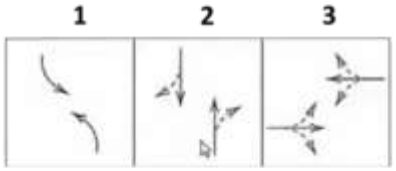


In the event of microprocessor failure, internal clock failure:

1. Controller is provided with the capability to control the signal using a fixed-time timing plan stored in a ROM or other non-volatile memory and can be executed directly by a special LSI circuit

❑ Manual control





Appendix 3 Forms

1. Forms for Inventory of System Component

Initial inventory of all system component (TCC & RSE) shall be done and recorded accordingly under the system data base to be developed for Maintenance Management.

Table 5 is the inventory form for the Control Center equipment showing historical information and present status. Table 6 is the inventory form for RSE equipment which shall be done per intersection and recorded as such.

Table 5 – Equipment Inventory at Control Center

CONTROL CENTER				
Name of Equipment	Historical Information			Present Status / Remarks
	Procurement Date	Replacement Date	Repair Date	
1. Traffic control server				
2. Signal control WS				
3. Front-end processor				
4. Network Printer				
5. Video wall				
6. Video wall controller				
7. Vehicle detector data processing software*				
8. Signal control software*				
9. Equipment operation monitoring software*				
10. Human-machine interface				
11. Statistics software*				
12. Database software*				
13. Parameter setting for vehicle detector				
14. Signal control parameter setting				
15. Controller for traffic monitoring video camera				
16. Layer 3 switch				
17. Layer 2 switch				
18. Media Converter				
19. Network management system				
20. Uninterruptible power supply				
21 Generator				
Note: As-built drawing of the Control Center shall be attached to this form. The drawing shall be reviewed and updated.				

Table 6 – Equipment Inventory of RSE per Intersection

INTERSECTION NO. _____ **Date:** _____
Street Name & Number _____
Location Coordinate _____ , _____

Name of Equipment	Historical Information			Present Status / Remarks
	Procurement Date	Replacement Date	Repair Date	
Local Controller				
Local controller main board (standard)				
Local controller main board (large)				
SSR Unit				
Power supply unit				
Surge arrester				
PROM writer				
Local controller for testing				
Signal lantern simulator				
Notebook computer				
Diagnosis and set-up software				
Signal Lantern				
Power supply unit for vehicle lantern				
Power supply unit for pedestrian lantern				
Vehicle detector				
Power supply unit for camera unit				
Control board of camera unit				
Controller unit power supply unit				
Controller main board				
Vi**deo Camera**				
Control board				
Power supply unit				

Note: As-built drawing for this intersection shall be attached to this form. The drawing shall be reviewed and updated at site.

2. General Inspection Form

Table 16: General Inspection Form 1

	Inspection Items	Check	Remarks
1	Basic part 1 ・CPU operation, calendar, interrupt function, logging information Check with system management software		
2	Basic part 2 ・ Memory function, hard disk operation check Check with system management software		
3	External recording device ・ Check the operation and capacity of the external recording device ・Check system backup operation Check with system management software		
4	Input power supply voltage ・ AC1-AC2 and AC1-E are AC100V ± 10%, record measured values ・ AC2-E is 0V, records measured value		
5	Uninterrupted power system ・Power is supplied from the battery when the commercial power input is turned off. ・ AC1-AC2 and AC1-E are AC100V ± 10%, record measured values. ・ AC2-E is 0V, records measured value		
6	Inside view (printed circuit board and connector) ・ Presence or absence of deformation of the printed circuit board and looseness of the connector		
7	Inside view (terminal board and cable) ・ Presence or absence of loose terminal board and terminals ・ Presence or absence of cable damage		
8	Appearance (installed state) ・ Presence or absence of rattling ・ Presence or absence of heat generation, abnormal noise, vibration and offensive odor of the main body of the device		
9	Cleaning ・ Filter cleaning ・ Removes dust and dirt		

Table 17: General Inspection Form 2

	Inspection Items	Check	Remarks
1	Printed circuit board and connectors ・ Check if the printed circuit board is deformed or the connector is loose		
2	Terminal board and cable ・ Check if the terminal board and terminals are loose and if the cable is damaged		
3	Lightning arrester ・ Presence or absence of burning, cracking and discoloration		
4	Spare parts quantity ・ Check the type and quantity of spare parts		
5	Casing, mounting brackets, piping, etc. ・ Check for stains, deformation and rust		
6	Matching the housing and door ・ Presence or absence of damage to the waterproof packing ・ Check if the door is completely locked		
7	Pole ・ Check the appearance (cracks, corrosion, deformation) ・ Confirmation of illegal attachments		
8	Aerial cable ・ Check for damage and looseness		

Table 18: Controller/Lantern Inspection Form

	Inspection Items	Check	Remarks
1	Monitor lamp ・ Check the lighting of remote operation ・ Check that the abnormal lamp is not lit		
2	Date and time ・ Matches the time After confirming the time signal and deviation, execute time adjustment		
3	Multi-stage seconds ・ Check the setting status of multi-stage seconds		
4	Signal lamp lighting status ・ Check the lighting status of the LED		
5	Impaired visibility of signal lanterns ・ Appearance (dirt, deformation, rust) confirmation, illegal attachment confirmation ・ Inside view (terminal board and cable, socket and unit)		

Table 19: Video Image Vehicle Detector

	Inspection Items	Check	Remarks
1	Sensing display and sensing output voltage confirmation ・ If there is sensing, the sensing indicator lights up and the voltage between terminals D0 and D1 is up to 15V. ・ If there is no detection, the detection indicator will be turned off and the voltage between terminals D0 and D1 will be 2.5V or less at maximum.		
2	Abnormal operation check ・ If the camera cable is not connected, the error indicator lights up and pruduces a signal output response. ・ When the main power switch is turned off, the output is with a sensing signal.		
3	Check the camera installation status ・ The direction of the camera corresponds to the vehicle measurement area of the target lane. The measurement area is within the range described in the instruction manual.		

Table 20: CCTV Camera

	Inspection Items	Check	Remarks
1	Picture ・ Is the image displayed normally?		
2	Camera operation ・Pan, Tilt, Zoom, Focus, Preset		

Table 21: Common Equipment

	Inspection Items	Check	Remarks
1	Measure input power supply voltage and check polarity on the ground side ・ AC1-AC2 and AC1-E record AC100V ± 10% measured values. ・ AC2-E records 0V measured value		
2	Control power supply voltage measurement ・ Measure the voltage of the control power supply described in the instruction manual. (Example: + 5V, + 12V, -12V, + 48V, -48V)		
3	Measurement of ground resistance ・ Record the measured value of 100Ω or less. In principle, the 3-electrode method is used for measurement, and if it is difficult due to the installation situation, the 2-electrode method is used.		

3. Forms for Preventive Maintenance

Table 22: Preventive Maintenance Inspection Checklist (RSE)

PREVENTIVE MAINTENANCE INSPECTION CHECKLIST (RSE)

Form PM - 001

Intersection: _____

Date / Time: _____

Technician: _____

Legend: √ = no problem found, ● = problem found, // = not applicable

A. Cabinet Equipment

1. ____ Visually inspect the cabinet for damage and cleanliness.
2. ____ Visually inspect lightning surge protection for damage.
3. ____ Check and record the safety ground rod for conductivity (ground must be dry when testing ground, reading should be less than 25 ohms).
4. ____ Check that cabinet drawings are legible and in good condition. (5 copies and cd)
5. ____ Check layout of cabinet and UPS agree with signal drawings
6. ____ Check Cabinet dimensions: W400 x D300 × H800 (std.) W400 x D300 x H1100 (large)
7. ____ Empty conduits must be capped or blocked with duct seal

B. Cabinet Service

1. ____ Check all breaker connections.
2. ____ Check all ground connections.
3. ____ Check and record service voltage.
4. ____ Check and record service amperage.

C. Cabinet General Inspection

1. ____ Check thermostat and fan operation
2. ____ Check for GFCI (ground fault circuit interrupter) convenience receptacle.
3. ____ Check relays.
4. ____ Check cabinet light.
5. ____ Check for proper load switch seating.
6. ____ Check all terminal screws and connections for tightness and discoloration.
7. ____ A 1” conduit shall be installed from the controller cabinet to nearest junction box for future use.
8. ____ Check pole foundations for arrows indicating conduit runs.

D. Cabinet Switch Inspection

1. ____ Check for Police Switches.
2. ____ Check for Cabinet switches.
3. ____ Check stops time toggle for proper position

E. Cabinet Mechanics.

1. ____ Inspect lock mechanism and hinges.
2. ____ Check anchor bolts.
3. ____ Check cabinet documentation. (Operating manuals for equipment)
4. ____ Check cabinet weatherproofing.
5. ____ Check for cabinet filter.
6. ____ Check to make sure door(s) on cabinet opens completely without obstruction

F. Conflict Monitor.

1. ____ New Conflict Monitor? If new, SN#_____.
2. ____ Ensure Load Switch and traffic signal indications are the same.
3. ____ Check for correct time and date.

G. Pedestrian Detection.

1. ____ Inspect pedestrian push buttons.
2. ____ Operate each push button and check for proper operation.
3. ____ Inspect pedestrian's signs and markings.
4. ____ Check height of pedestrian pushbuttons (1.07m) ADA requirement
5. ____ Check for proper height of pedestrian signals per MUTCD
6. ____ Check ped. button for open weep hole and mounting base sealed with silicone.

H. Mast Arm Intersections.

1. ____ Check all exposed signal cable for jacket and insulation damage.
2. ____ Check all nuts and bolts on signal pole, mast arm and signal heads for proper tightness.
3. ____ Check hand hole covers for proper installation.
4. ____ Measure and record height of lowest point of signal to roadbed beneath (m).
5. ____ Check pole foundations for arrows indicating conduit runs
6. ____ Check signal pole for proper ground min. of _25_ ohms

I. Signal Indications.

1. ____ Check alignment of signal heads
2. ____ Make sure signal head has drip loop.
3. ____ Check condition and mounting of back plates.
4. ____ All signal wire must be 14 AWG
5. ____ A continuous wire shall be run from cabinet to signal head (No Splices)

J. Signal Heads.

1. ____ Check signal door gasket.
2. ____ Check mounting of LEDs.
3. ____ Check signal door hinges and wing nut attachments.
4. ____ Check signal head hardware for damage.
5. ____ Check all electrical connections.

6. ____ Check head visibility, alignment and that it is level and plumb
7. ____ Check to make sure signal placement and alignment agree with signal drawings
8. ____ LEDs must meet 2007 Signal Modules (10 inch (300mm) and 12 inches (300mm)

K. Traffic Control Signs and Markings.

1. ____ Check signals, signs, and markings for agreement.
2. ____ Check signals for agreement with signal drawings
3. ____ Check intersection signage.

L. Video Detection.

1. ____ Check for proper zone alignment
2. ____ Check zones to ensure proper vehicle detection and controller receiving calls.
3. ____ Check video wiring/coax connections for all cameras.
4. ____ Using #10 welding shield to simulate night operation. Check for proper operation.
5. ____ Verify video does not show horizon within view.
6. ____ Check for proper alignment of all cameras.
7. ____ Check camera brackets and hardware for tightness and proper mounting.
8. ____ Check BNC connectors for proper crimp and that they have a solid connection
9. ____ Wire connections must be crimp style bullet connections (No wire nuts)
10. ____ Check camera unit for any physical defects.
11. ____ Check mounting brackets, video ports for rust, dirt, etc.
12. ____ Check surge protection for AC input.
13. ____ Check circuit breaker.

M. Opticom.

1. ____ Check channels for proper phasing using portable emitter.
2. ____ Test for communication with all detectors (push selector till F is displayed and push toggle switch to high). Verify all detectors in use should flash.
3. ____ Check detectors for proper alignment (all detectors).
4. ____ Check detector brackets and hardware for tightness and proper mounting.
5. ____ Check wiring for proper connection within detector.
6. ____ Verify weep holes have been opened.
7. ____ Opticom must be 3M (Global Technologies) 721 detectors must be on each mast arm pole
8. ____ Check for proper installation of wireless system/fiber optic system
9. ____ Verify proper communication system has been installed according to signal drawings

N. Power pedestal

1. ____ Check mounting (loose hardware, connections)
2. ____ Check for proper breaker size for UPS (20-amp square D QO)
3. ____ Check for proper breaker size for traffic cabinet (20-amp TSC 3052, 40-amp TSC 3052J)
4. ____ Make sure power pedestal ground is cad welded.

O. Junction Boxes.

1. ____ Inspect junction boxes and covers.
2. ____ Check junction boxes for water. Verify weep hole is opened in concrete boxes.
3. ____ Check wire connections within junction box for proper weatherproof splice.
4. ____ Check insulation for cracks and missing sections of insulation.
5. ____ Check and record grounding rod reading. Ohms.
6. ____ Ensure boxes are flush and level with ground. (Trip hazard)
7. ____ Ensure that signal cables are not in contact with the junction box cover to avoid damage to the cable.
8. ____ Verify lid has lifting hook or ring.

P. Drawings

1. ____ Contractor must supply as built drawings.

Comments:

Date & time of completion of inspection: _____.

4. Forms for Corrective Maintenance

Table 23: Handling Form for Failure of Signal Components

Handling Form for Failure of Traffic Signal Components			
			Form CM-001
Received (Date and Time):		Weather:	No.
Name of Intersection:		Intersection No.:	Suburb:
Reporter:		Receiver:	
Status of Failure	01 – Blackout	11 – Abnormality of TCS	21 – Signal lantern damage
	02 – Partially blackout	12 – Detector defective	22 – Veh sig lantern damage
	03 – Malfunctioned bulb	13 – CCTV defective	23 – Ped signal lantern damage
	04 – Signal flashing	14 - Others	24 – Signal pole damage
	05 – Signal phasing problem		25 – OFC damage
	06 – Abnormal display status		26 – Others
	07 – Offset failure		
	08 – Others		
Dispatcher:			
Departure Time:		Arrival Time (1):	
Completion Time (2):		Repair time duration (2) – (1)	
Cause and repair details: Failure Code:			
Replacement Parts (Name, Type, Qty.):			
Local Controller Details (Type Manufacturer, date installed):			
Repair Completion Report:	Month:		Input Person (Affiliation/Name):
	Day:		
	Time:		
Signal management system input:	Month:		Input Person (Affiliation/Name):
	Day:		
	Time:		
Note: Suburb – Toul Kork, Daun Penh, Makara, Chamkarmon			

Appendix 3 – Inspection Form, Operation

Table 24: Inspection Standard Form - Operation

Inspection Standard Form - Operation				
				Form SO-001
Classification		Inspection Points	Check	Countermeasures
Accident Prevention	Causes an accident at the encounter	・Is the visibility of the signal lantern sufficient? (Is it necessary to add a signal lantern on the exit side at the intersection?)		
		・Are there any M/C or pedestrians who can't wait and ignore the signal because the signal in red is too long?		
		・Are there any vehicles that mistakenly identify the traffic signal and enter the intersection?		
		・Is it turn to green light at the crossing side of the intersection before cars and pedestrians who enter the intersection at "end of green" or "yellow" pass the intersection?		
	Causes of right-turn /straight-ahead accidents	・Making an unreasonable right turn due to traffic jams such as many right turning vehicles?		
		・Is there any risk of a collision between a M/C traveling straight on the side of a congested queue and an oncoming left-turning vehicle?		
	Causes a right turn entanglement accident	・Is the sufficient the visibility of crossing pedestrians from a right-turning vehicle?		
		・Since right-turning vehicle congested due to many crossing pedestrians and motorcycles, making an unreasonable right turn?		
		・Is there a left-turning vehicle that does not approach the leftmost end?		
		・(Intersections with traffic flow restrictions by vehicle type, etc.)		
	Causes a rear-end collision	・Is there a situation where the discovery of signal lights and stopped vehicles is delayed due to curves, slopes, etc.?		
		・Is there an unreasonable stop such as sudden braking due to the short yellow time of the traffic light?		
Congestion Prevention	Traffic jam in a specific direction or time	・Is there a situation where traffic in a specific direction is congested depending on the morning, evening, day of the week, or season?		
		・Is a right- or left-turning vehicle blocking a straight-ahead vehicle?		
	Others:	・Is the flow obstructed because the distance between adjacent intersections is short and not coordinated?		
		・Has the traffic flow changed due to development around the intersection?		

1. Forms for Design Modification

Signal modification particularly when proposing an additional signal or modifying an existing intersection due to the to the danger of conflicts with existing signal facilities and road signs, and the plan and design must be thoroughly studied and checked. The following tables will serve as guidance so that all important features of the design shall be taken into consideration.

Signal Design / Modification Request Form

Phnom Penh Traffic Signal System

This form, as well as the attached Signal Design Checklist, should be completed for all new signals and for all existing signals requiring design modifications.

Location: _____ **Int No.:** _____

If **new**, signal warrants met: *(Signal warrant evaluation forms should be attached)*	☐ Warrant #1 ☐ Warrant #2 ☐ Warrant #3	☐ Warrant #4 ☐ Warrant #5 ☐ Warrant #6	☐ Warrant #7 ☐ Warrant #8 ☐ Warrant #9
If **existing**, proposed changes:	☐ Pedestrian upgrades ☐ Maintenance upgrades ☐ Developer	☐ Phase / Operational Upgrades ☐ Intersection Improvements ☐ Paving & Rehabilitation	
	☐Other_____		

Requested By: _____ **Date:**

Recommended By: _____ **Date:**
Consultant

Approved By: _____ **Date:**
Chief Traffic Engineer or Designer

TRAFFIC SIGNAL PLAN REVIEW CHECKLIST				
	Yes	No	N/A	Comments
The following items are included and shown correctly on the Plan Sheets:				
• Existing and proposed conditions (Only pertinent information should be shown on plans. All other levels should be turned off.)	☐	☐	☐	
• Limits of work	☐	☐	☐	
• Base mapping	☐	☐	☐	
• North arrow	☐	☐	☐	
• Correct scale	☐	☐	☐	
• Consultant logo	☐	☐	☐	
• Legend	☐	☐	☐	
• Right-of-way lines and labels (existing and proposed)	☐	☐	☐	
• Equipment within Right-of-Way	☐	☐	☐	
• Overhead utilities (heights indicated)	☐	☐	☐	
• General Notes	☐	☐	☐	
• Street names	☐	☐	☐	
• Route numbers with cardinal direction (e.g. I-70 (WBL)) and road names	☐	☐	☐	
• Current borders / signature / revision block	☐	☐	☐	
• Construction details (if required)	☐	☐	☐	
Existing Signal Information				
• Existing signal plans have been verified	☐	☐	☐	
• Site characteristics have been inventoried and examined	☐	☐	☐	
• Existing signals to be removed are noted	☐	☐	☐	
Proposed Signal Information				
• Appropriate signal structures	☐	☐	☐	
• Appropriate signal structure configuration / placement	☐	☐	☐	
○ Lateral clearance requirements are met	☐	☐	☐	
○ Alternative pole configurations are used where applicable	☐	☐	☐	
• Signal controller cabinet location and type	☐	☐	☐	
○ Cabinet location permits safe access by maintenance	☐	☐	☐	
○ Cabinet is located near a power source (if possible)	☐	☐	☐	
○ Cabinet is protected (if needed)	☐	☐	☐	
○ Cabinet does not restrict driver visibility	☐	☐	☐	
• Signal heads are numbered and placement is correct	☐	☐	☐	
○ Distances from stop line are acceptable (40’ to 120’; up to 180’ with near side)	☐	☐	☐	
○ Minimum of two signal heads are provided for each movement	☐	☐	☐	
○ Vertical signal head clearance requirements are met	☐	☐	☐	
○ Adequate signal visibility is provided	☐	☐	☐	
○ Appropriate signal head sections	☐	☐	☐	

TRAFFIC SIGNAL PLAN REVIEW CHECKLIST				
	Yes	No	N/A	Comments
• Countdown pedestrian signals and pushbuttons follow Design and Installation Guidelines	☐	☐	☐	
○ Countdown signal located near and visible within crosswalk	☐	☐	☐	
○ Pushbuttons located correctly and readily accessible from 60”x60” level landing area on the sidewalk (maximum 10 feet from curb)	☐	☐	☐	
• Availability of electrical power determined	☐	☐	☐	
○ Power location and feed coordination with utility company complete	☐	☐	☐	
○ Power service with pole number and transformer number	☐	☐	☐	
○ Confirm cabinet / service pedestal / electrical service equipment locations are constructible as shown	☐	☐	☐	
• Metered service pedestal	☐	☐	☐	
• Utility pole or transformer number labeled	☐	☐	☐	
○ Confirm service load is available	☐	☐	☐	
• Signal equipment meets clear zone requirements	☐	☐	☐	
• Junction wells are appropriately located	☐	☐	☐	
• Junction wells, conduit and wire are correct size and type	☐	☐	☐	
• Conduit sizes accommodate fill requirements (26% maximum fill for new construction, 35% for modifications)	☐	☐	☐	
• Signal preemption provided	☐	☐	☐	
• Numbering (including signs) is correct	☐	☐	☐	
• Signal legend matches plan	☐	☐	☐	
Signs				
• Street name signs	☐	☐	☐	
• Route marker / shield assemblies	☐	☐	☐	
• Signal warning signs	☐	☐	☐	
• Turn prohibitions	☐	☐	☐	
○ LTOR / RTOR	☐	☐	☐	
• Lane use control signs	☐	☐	☐	
• Remove Stop / Stop Ahead signs	☐	☐	☐	
• Pedestrian pushbutton and sign (oriented correctly)	☐	☐	☐	
• Special sign layouts	☐	☐	☐	
• Sign legend matches plan	☐	☐	☐	
• New signal warning signs with NEW plaque and flags	☐	☐	☐	
• Signs on signal plans match signing plans	☐	☐	☐	

TRAFFIC SIGNAL PLAN REVIEW CHECKLIST				
	Yes	No	N/A	Comments
Pavement Markings				
• Arrow / Only for lane drops	☐	☐	☐	
• Stop lines (perpendicular to curb)	☐	☐	☐	
• Edgelines, centerlines, lane lines	☐	☐	☐	
• Turn bays	☐	☐	☐	
• Crosswalks	☐	☐	☐	
• Other markings per DE MUTCD	☐	☐	☐	
NEMA Phasing				
• Correct orientation	☐	☐	☐	
• Solid / Dashed lines shown correctly	☐	☐	☐	
• Notes	☐	☐	☐	
• Pedestrian phases	☐	☐	☐	
• Split phasing	☐	☐	☐	
Dimensions / Stationing				
• Pavement Markings	☐	☐	☐	
• Signals and Signs	☐	☐	☐	
• Detectors (presence and advanced)	☐	☐	☐	
• Poles	☐	☐	☐	
• Controller cabinet	☐	☐	☐	
• Breaklines	☐	☐	☐	
Detectors (Loop)				
• Detection included and applied properly	☐	☐	☐	
• Location of presence detection (2' behind stop line) is correct	☐	☐	☐	
• Location of system detection is correct	☐	☐	☐	
• Sizes and locations are correct	☐	☐	☐	
• Detector sleeves conduit for loops	☐	☐	☐	
• Video detection equipment locations are correct	☐	☐	☐	
• Dilemma zone at correct distance	☐	☐	☐	
Geometrics				
• Stop line set back adequate distance for turning vehicles	☐	☐	☐	
• Crosswalk curb ramps are correctly located	☐	☐	☐	
• Pad or sidewalk provides access to pedestrian push button	☐	☐	☐	
• Detectable Warning Surfaces (DWS) are applied correctly	☐	☐	☐	
Maintenance of Traffic				
• Standards specified as needed	☐	☐	☐	

TRAFFIC SIGNAL PLAN REVIEW CHECKLIST				
	Yes	No	N/A	Comments
OTHER DESIGN CONSIDERATIONS				
• ADA requirements are met	☐	☐	☐	
• Median disturbance is minimized	☐	☐	☐	
• Design addresses environmental concerns (if present)	☐	☐	☐	
• Design addressed unique construction problems (if present)	☐	☐	☐	
• Design adheres to driver expectancy for the corridor	☐	☐	☐	
• Equipment locations do not hinder maintenance activities	☐	☐	☐	
• Coordination has occurred with the Telecommunication Group	☐	☐	☐	
• Other facilities within the project limits that require traffic signal devices (i.e. schools) are noted	☐	☐	☐	
• Railroad signal interconnect is provided (if required)	☐	☐	☐	
• Signal is not in conflict with any utilities	☐	☐	☐	
• Special design considerations such as HIBs, pedestrians, preemption or interconnection are addressed	☐	☐	☐	
• Signal will work as a system with the roadway, signing and marking design	☐	☐	☐	
• Design is in accordance with standards	☐	☐	☐	
UTILITIES				
• Overhead utility conflicts avoided	☐	☐	☐	
• Underground utility conflicts avoided	☐	☐	☐	
• Special signal poles detailed (if needed)	☐	☐	☐	
• Special pole foundations detailed (if needed)	☐	☐	☐	
• Utility relocations coordinated	☐	☐	☐	
○ Utility relocation details provided (if required)	☐	☐	☐	
• Overhead clearance callouts at cable crossing with signal structure are provided	☐	☐	☐	
RIGHT-OF-WAY				
• Adequate right-of-way is available for proposed pole locations	☐	☐	☐	
• Required right-of-way acquisitions are noted (if needed)	☐	☐	☐	
• Easement for special purpose is noted (if needed)	☐	☐	☐	

Project for Capacity Development on Comprehensive Traffic Management Planning and Traffic Control Center Operation and Maintenance in Phnom Penh Capital City (PPTMTC)

PILOT PROJECT HANDBOOK

FEBRUARY 2025

Japan International Cooperation Agency
(JICA)

Mets Research & Planning, Inc.
International Development Center of Japan
Oriental Consultants Global Co., Ltd.

Acknowledgement from Cambodian Side

Thank you for developing the following deliverables to strengthen the capability of TCC staff in managing the traffic control system and enhancing the urban transport environment in Phnom Penh.

(1) Maintenance Management Manual

Mr. Ramon J. Ona, a traffic signal maintenance management expert of the JICA-PPTMTC Project, developed this manual based on his over 20 years of experience as head of the Traffic Control Center in Metro Manila, Philippines, incorporating insights from discussions with TCC staff, and on-site inspections in Cambodia. The manual spans over 100 pages and comprehensively covers the entire traffic signal maintenance management system, consisting of 10 chapters and appendices. We believe that it will greatly contribute to improving the maintenance management work of TCC staff.

(2) Pilot Project Handbook

This handbook is a compilation of the results and lessons learned from the Pilot Project, the largest activity of the JICA-PPTMTC Project, and which primarily covered three newly signalized intersections. The handbook details the Pilot Project activities from planning to construction led by TCC staff with JICA-PPTMTC team members providing their specific areas of expertise. The handbook as a whole is designed to assist TCC staff and engineers in other cities, such as Siem Reap and Sihanouk Ville when installing signals in the future.

(3) Traffic Control System Expansion Plan

This expansion plan was developed with a priority on the sustainability of the traffic control system. It outlines short-term issues (The improvement of current problematic signal intersections) and medium- to long-term issues (The traffic control system for the next 10 years), proposing the development procedures as a work plan. It will serve as a guideline for the future development of the Phnom Penh traffic control system.

We plan to make effective use of our experience and these deliverables to continue improving the urban transport environment in Phnom Penh.

Thank you very much.

Mr. Sam Piseth

Director of Department of Public Works and Transport, Phnom Penh

Table of Contents

1. INTRODUCTION

1.1 Background of the PPTMTC Project

One of the projects among the group of highest priority projects for the Short-Term Plan (2016) in PPUTMP is the introduction of a traffic control system in an effort to mitigate the worsening traffic congestion problems in Phnom Penh.

The reason for proposing the Traffic Control System as the highest priority project was chiefly due to the present condition of the existing traffic signals in the city. Although Phnom Penh City has a total of 69 signalized intersections (64 of which are within the city center), most of them are isolated signal control, and each of them individually operates using an independent timing plan. They are not functioning as a coordinated and consistent group of signals and thus are not able to effectively respond to the changing traffic pattern especially during the morning and evening peak hours.

With the above background and situations, the Government of Cambodia requested a Grant Aid Project from the Japanese Government in July 2013, for the implementation of the high priority project in the Short-Term Plan, namely the introduction of a traffic control and surveillance system covering a total of 100 intersections (inclusive of the existing 64 signals in the city center) and its traffic control center facilities.

This Grant Aid Project is aimed at installing 115 new traffic signals at selected intersections and a centralized traffic control center which together form a computerized signal control and surveillance system capable of on-line and real time systematic control functions, thus contributing to the mitigation of the existing traffic congestion and aiding in the improvement of traffic operation and urban living environment in Phnom Penh.
Then, the PPCC, the Department of Public Works and Transport (DPWT) and the Traffic Control Center (TCC) have been striving to make effective use of these facilities and equipment. Considering the sustainable and effective utilization of the traffic control system, it is necessary to cooperate with the Phnom Penh Traffic Police (PPTP) to properly fulfill the traffic management function of PPCC. Based on above, the technical cooperation project, aimed at improving the operation and maintenance capability of TCC staff and related agencies of the traffic control system and comprehensive traffic management measures in Phnom Penh, started in January 2022.

1.2 Project Purpose, Output and Activities of the PPTMTC Project

Based on the Project Design Matrix (PDM) of the PPTMTC project, the project purpose, outputs, and activities are given below. And the Pilot Project is Output 3.

Table 1.1 Project Purpose, Output and Activities of the PPTMTC Project

Project Name	Project for Capacity Development on Comprehensive Traffic Management Planning and Traffic Control Center Operation and Maintenance in Phnom Penh Capital City (PPTMTC)	
Project Area	The Whole Area of Phnom Penh	
Counterpart Institution	Implementing Agency: Phnom Penh Capital Administration (PPCA), Department of Public Works and Transport (DPWT), Traffic Control Center (TCC) and Phnom Penh Traffic Police (PPTP)	
Overall Goal	Sustainable Urban Transport Environment is Formed.	
Project Purpose	Traffic Management Measures Including Traffic Safety Measures in Phnom Penh is Improved.	
Expected Output	Output 1	Maintenance Management System of Traffic Control System is Established.
	Output 2	Capacity of TCC Staff on the Operation of Traffic Control System is Strengthened.
	Output 3	Capacity to Design Traffic Signals is Strengthened through the Implementation of Pilot Projects for Traffic Signal Improvement.
	Output 4	Capacity of the Relevant Staff to Traffic Control System in PPCA, DPWT and TCC Staff to Develop the Expansion Plan of Traffic Control System is Strengthened.
	Output 5	Capacity of Urban Transport Related Organizations on Traffic Management Measures is Strengthened towards Enhancement of the Project Sustainability.

1.3 Aims of the Pilot Project

The aims of the pilot project are as follows:

- Mainly to improve traffic signal system and implement traffic management measures including 3Es;
- To keep costs down as much as possible and maximize and effectively utilize existing facilities; and
- To enable counterparts to apply on field lessons learned during the training on traffic management plans, traffic signal system and communication system, so that they can practice handling issues that may arise themselves or with some coaching.

1.4 How to Use the Pilot Project Handbook

This handbook is a compilation of the process of the pilot project implementation with main focus on the improvement of the signalized intersection. Since this handbook discusses the process of the implementation, the approach is more practical.

TCC staff should find this handbook helpful as a reference when they try to improve the other intersections as a signalized intersection not only in Phnom Penh but also in other urban areas in Cambodia.

2. LOCATION OF THE PILOT PROJECT INTERSECTIONS

2.1 Aims and Target Intersections of the Pilot Project at the Beginning of the PPTMTC Project

Based on the aim of the pilot project, the activities in Table 2.1-1 and Figures 2.1-1 to 3 below were selected as the Pilot Project in consideration of the following factors (determined after consultation and coordination with JICA and C/P during the implementation of TCP):

- Development and resumption of unused land are progressing due to the active economic activity, and implementation of intersections where the current situation is not suitable for urban activities and traffic conditions at many intersections;
- Connection of standalone signalized intersections with TCC from the viewpoint of securing the maintenance;
- Support a bus priority lane with the Bus Operation Improvement TCP;
- Conduct of pilot activity of traffic management measures proposed by PPUTMP that improve the pedestrian environment along local street;
- Propose traffic safety measures by 3Es; and
- Collaboration with urban transport related organizations.

In preliminary study of the project, proposed contents of the pilot project were made in a wide range of fields from traffic control systems to communication systems and traffic management plans from MPWT, PPCA, DPWT, JICA, TCC and others.

Table 2.1 Implementation of Pilot Projects and Support for Formulating Traffic Management Plans from the Perspective of 3Es

Type	Criteria	Purpose of Pilot Project	Related Measures	Candidate Intersections
(1)	Improvement of intersections where the road geometric design and traffic conditions have changed since the handover of the traffic control system	Consideration of changes including traffic lights corresponding to signalized intersections where the road structure, traffic volume, and conditions have changed significantly since the start of operation of the traffic control system	・Traffic safety measures by 3Es (Engineering: installation of road marking and traffic sign, Education: traffic safety campaign, Enforcement: traffic enforcement by traffic police officers)	#55 , #126 and #502
(2)	Coordination of intersections in sub-areas along trunk roads	To change the traffic signal control parameters to cope with the change of traffic conditions in the sub-area	・Improvement of sidewalk surrounded area of 2 intersections, directly connected to the Central Station (collaboration with DPWT) ・Traffic safety measures by 3Es	#25 and #118
(3)	Intersection improvement in collaboration with the Project for the Improvement of City Bus Operation	To collaborate with City Bus Improvement TCP through the introduction of bus priority traffic signal system	・Bus priority traffic signal ・redundancy of OFC ・Improvement of sidewalk (collaboration with DPWT) ・Traffic safety measures by 3Es	Newly TS installation
(4)	Installation of new traffic signal at intersection at fringe of private development area	To introduce new traffic signal at intersections located at fringe of large-scale of private development where can anticipate the increase of traffic volume near future	・Traffic safety measures by 3Es	Newly TS installation
(5)	Connection between TCC and stand alone intersections along NR No.1	To connect the TCC and stand alone signalized intersections along NR No.1 by using private internet connection	・Driver education and traffic enforcement from 3Es (Traffic safety campaign and traffic enforcement by traffic police officers)	#201～#206
(6)	Improvement of St. 240 after traffic signal installation mainly pedestrian circumstances	Improvement of safe and comfort pedestrian network by traffic signal installation	・Traffic safety measures by 3Es ・Installation of safe and comfort pedestrian environment (Installation of street furniture such as bench and flower box)	St.240 (Norodom - St.19)

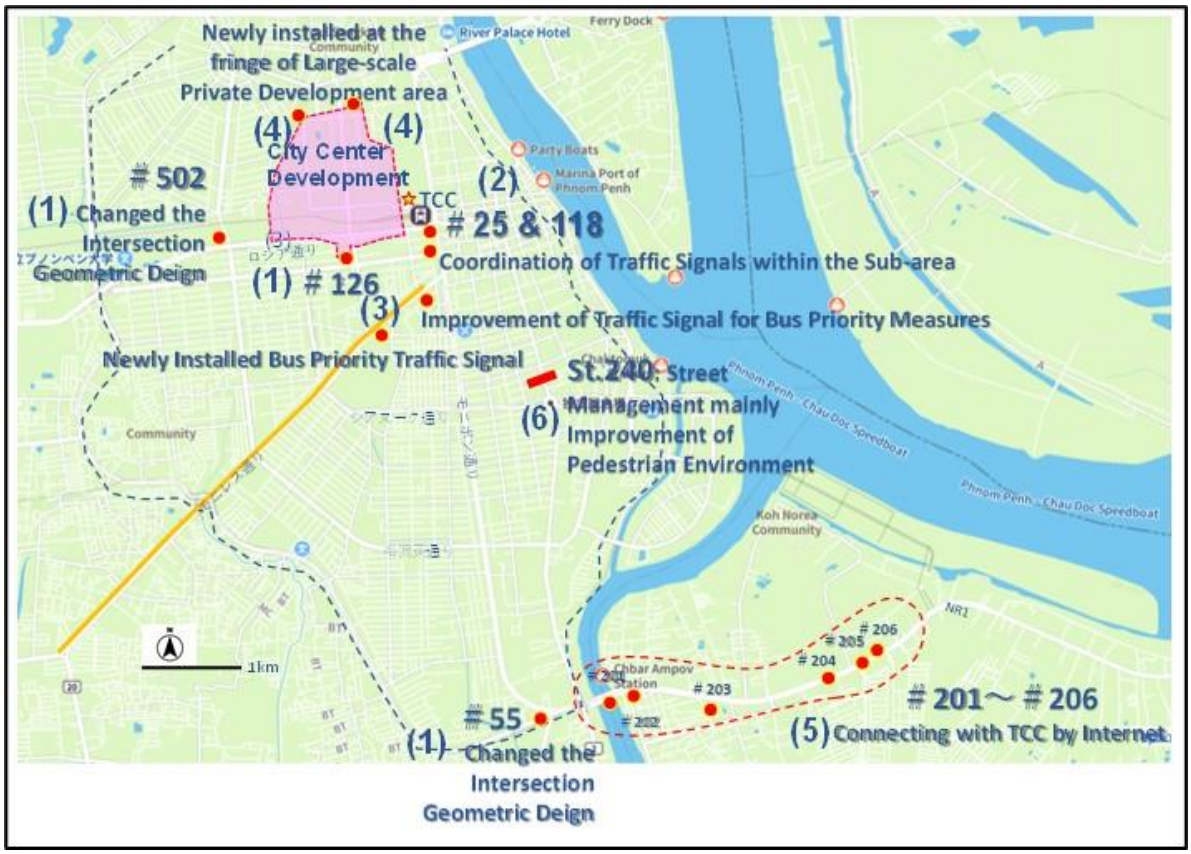
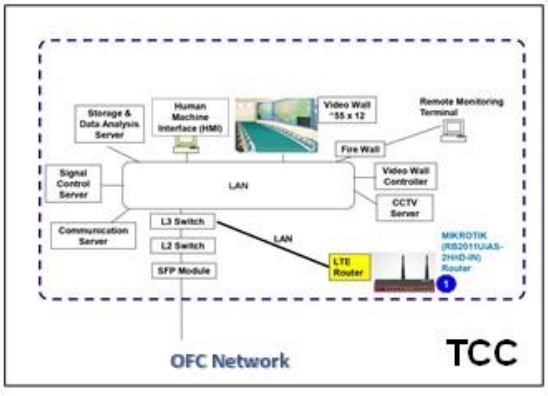


Figure 2.1 Implementation of Pilot Projects and Support for Formulating Traffic Management Plans from the Perspective of 3Es

The 6 intersections along NR No.1 will be connected to the TCC by wireless use, and will be used to cope with problems/issues at these intersections. As a result, all 115 signalized intersections developed by the Japan Grant Aid project will be connected to the TCC. Also, if the pilot project of this new communication system is successful, it can be one of the alternatives to the communication system when the traffic control system is expanded to the suburban area. There is also the advantage that all the wireless routers (yellow devices in the image below) required for this trial can be procured in Cambodia.



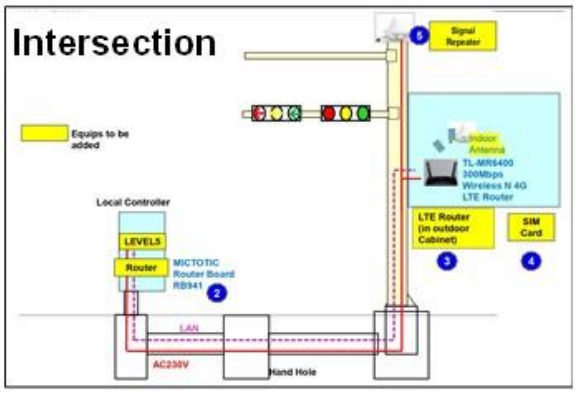


Figure 2.2 TCC Connection with 6 Intersections of NR No. 1 by Internet Wireless Use

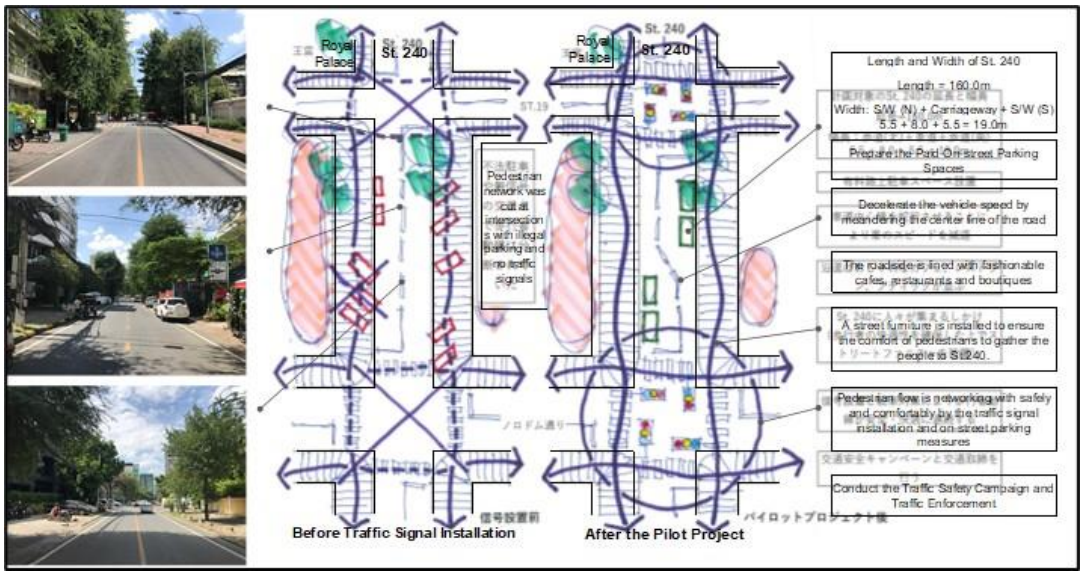


Figure 2.3 Street Management mainly Improvement of Pedestrian Environment and On-street Parking Measures

2.2 Subsequent Narrowing Down of the Pilot Project Candidate Intersections

Of these, Type (1) #55, Type (3) and Type (6) were excluded from the pilot project due to changes in Phnom Penh's urban environment and surrounding conditions. To be precise, #55 is in the process of being construct into three levels grade separation, as it will be the access point of the new international airport access road in the city. Type (3) was implemented under the bus operation improvement project that enables redundancy of the communication system. Type (6) requires more serious parking measures and will be implemented in Output 5 Training in collaboration with related organizations including MPWT, which is currently drafting a parking lot ordinance.
As a result, before the second JCC meeting in 2022, the target locations for the pilot project were narrowed down from the original 10 to 7 locations

2.3 Target Intersections for Pilot Project Approved by the 2nd JCC

After analyzing the latest traffic situation in Phnom Penh and discussing with a wider range of stakeholders (MPWT, PPTP and University, etc.), the following seven (7) intersections were approved by the 2nd JCC as the Pilot Project.

(1) #165: After the Grant Aid Traffic Signal Project, a large urban complex (Phnom Penh City Center (PPCC)) is established. Roads were also added and new intersections constructed around PPCC. The #165 intersection is one of these, and it connects to the newly constructed 4-lane road using the old railway track that connects to the National Road No. 5.

(2) #166: This was the largest roundabout in the Phnom Penh Central Area, and DPWT developed it as a 5-leg signalized intersection. Although it is a signal-controlled intersection, several traffic flows in the intersection are overlapped. The intersection area is large, and this makes a dangerous situation to not only drivers but also pedestrians to cross this intersection. Therefore, it is urgently needed to improve the intersection. This pilot project is a good training to convert a roundabout to a signalized intersection, because there are several roundabouts in Phnom Penh central area which cannot meet the current traffic situation.

(3) #28: Toul Kork district, located northeast of PP Central Area, is an area where high-rise residential development has been active in recent years, and the population and traffic volume are increasing significantly. Despite this, there are only two main access roads from the PP Central Area. During peak hours in the morning and evening, much traffic concentrates on these

two roads, especially Kim Il Sung Blvd. which is close to the PP Central Area. From East to Northbound traffic along Russian Blvd. is prohibited because the local road (northern side of St. 221) was narrow. Road widening (2 to 4-lane) on the north side of St. 221 was recently completed, and by using it as a new access road to the Toul Kork district, it will be possible to distribute the incoming traffic to the Toul Kork district and reduce the traffic load on Kim Il Sung Blvd.

(4) #126: Initially, this was a T-intersection where the main arterial roads are crossing points of Russian Blvd. and Czechoslovakia Blvd. However, it was improved to a 4-leg intersection because of the new road connection from the above-mentioned Phnom Penh City Center development. Another characteristic of this intersection is the two deer statue located inside the intersection. This makes it more complicated to drive in this intersection. Therefore, this intersection requires several efforts to improve above-mentioned issues, mainly soft component such as driver education and traffic enforcement.

(5) #25 & #118: Located at the largest mode interchange area in Phnom Penh (at the intersection of Monivong Blvd./Russian Blvd. and also close to the Cambodian Railways Central Terminal Station), the road density is high and there are many signal intersections within a short distance. For this reason, it is important to coordinate between intersections in the sub-area, as well as to strengthen driver education and traffic enforcement.

(6) #59 & #167: These intersections are located on the western fringe of the Phnom Penh central area where urbanization is actively progressing. The two intersections are close to each other (L=200m): #59 is networked to the TCC system, but #167 is a standalone intersection installed by the DPWT. In addition, traffic safety education in suburban areas is insufficient and road markings are not installed in some areas, so these intersections need to be strengthened by 3Es (Engineering, Education and Enforcement).

(7) #201 - #206: Out of the 115 intersections installed under the Grant Aid Traffic Signal Project, 6 intersections along National Route 1 are not connected to the TCC. To enable TCC to monitor all of the currently installed 115 signalized intersections, a wireless connection will be implemented using private internet lines.

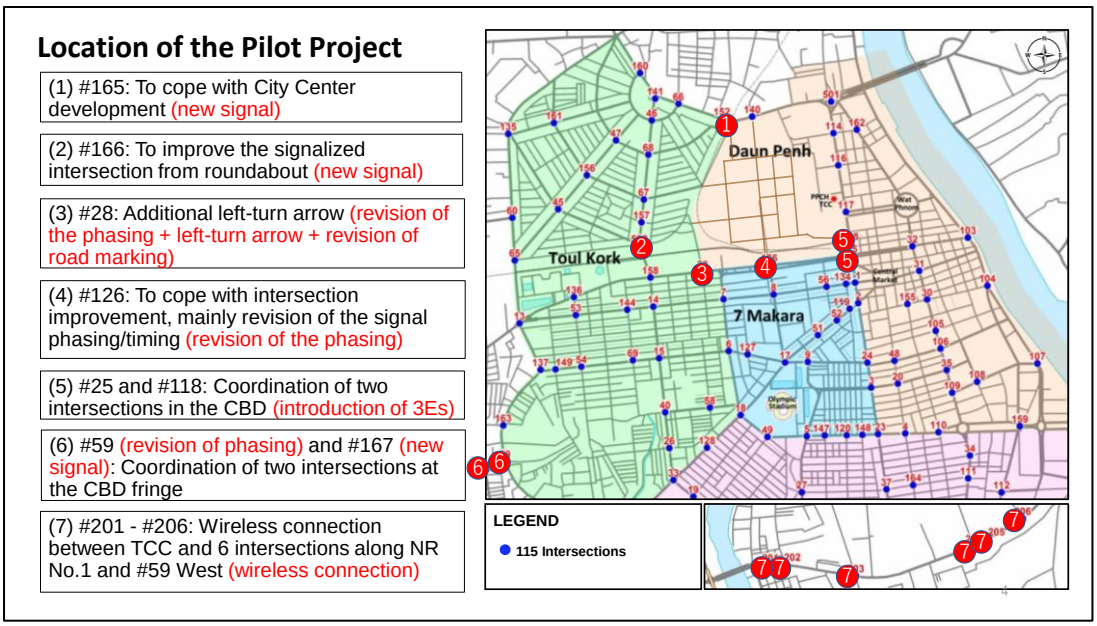


Figure 2.4 Location Map of Pilot Project Intersections

3. TRAFFIC SURVEY

3.1 Outline of Traffic Surveys

3.1.1 Objective of Traffic Surveys

A series of traffic studies were conducted as part of the pilot project with the following objectives:

1) To understand the current situation using objective data.
2) To provide input data for the improvements of traffic signals or intersection structures.
3) To perform before-and-after evaluations of the pilot project.

3.1.2 List of Traffic Surveys

Table 3.1 summarizes the series of traffic surveys conducted for the pilot project. These surveys were conducted by a local consultant company based on the terms of reference prepared by the JICA study team.

Directional traffic counting surveys are essential for any type of signal or intersection improvement. Surveys on queue length, travel speed, and driver violations are also important but not always necessary. A topography and layout survey is required when the improvement plan involves structural improvements to an intersection or the installation of signal poles.

Table 3.1 List of Traffic Surveys

	Survey name	Outline
1	**Directional Traffic Counting**	Counting traffic volume at target intersections by inflow-outflow direction by vehicle type
2	**Queue Length**	Measuring the queue length at each inflow direction to evaluate the congestion level of target intersections
3	**Travel Speed**	Measuring the travel time along major road sections which include target intersections
4	**Driver Violation**	Counting the number of traffic rule violation at the intersections by violation type by vehicle type
5	**Topography and Intersection Layout**	Making the as build drawing around target intersections for the planning of intersection improvement or installation of equipment

3.2 Directional Traffic Counting Survey

3.2.1 Methodology of Directional Traffic Counting Survey

Location	- 8 target intersections of the pilot projects
Survey term	- Base line (March/April, 2023); - End line (April, 2024)
Survey duration	- Morning Peak (7:00-8:00); - Off-Peak (14:00-15:00); - Evening Peak (17:00-18:00) on a weekday from Tuesday to Thursday (excluding public holidays)
Methodology	- Surveyors install CCTV cameras at least 5 meters from ground level to capture the turning movement of vehicles from each inflow direction of intersections (refer to Figure 3.2). - Surveyors record the video image of the road traffic during the survey period by using the CCTV cameras. - Surveyors count the number of vehicles by inflow and outflow direction and by vehicle type (refer to Figure 3.3) and record in the survey form (refer to Figure 3.4) every fifteen minutes based on the video image. - Supervisors review the survey results.
Input form	- 240213_ISS form.xlsx

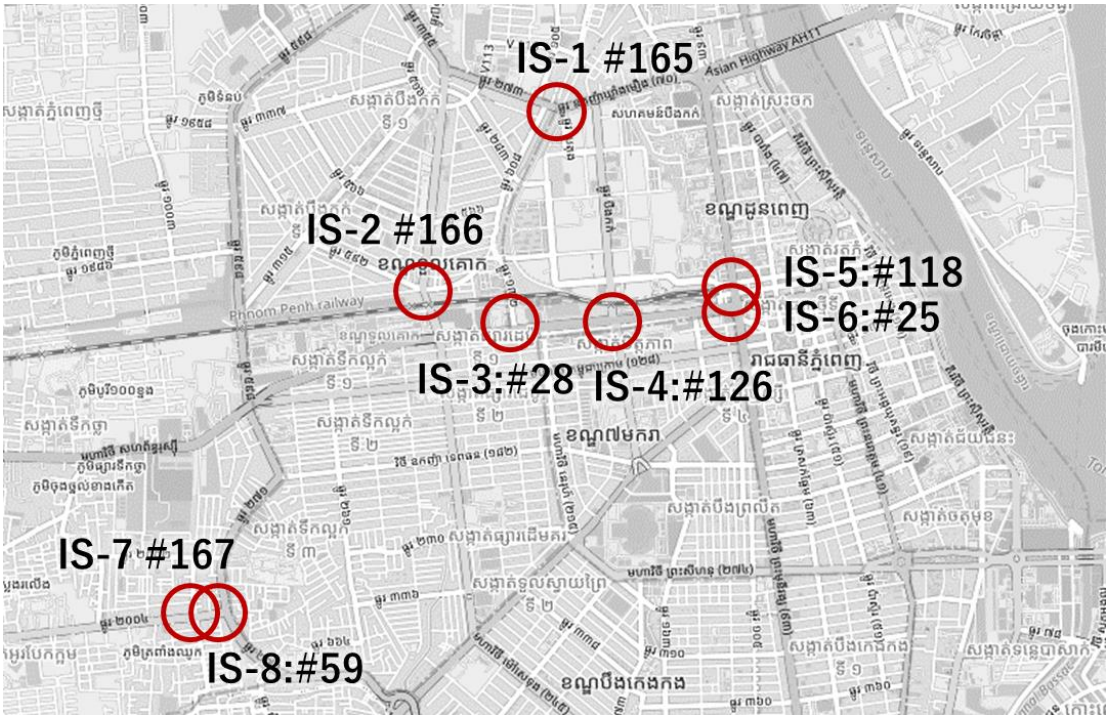


Figure 3.1 Traffic Survey Location

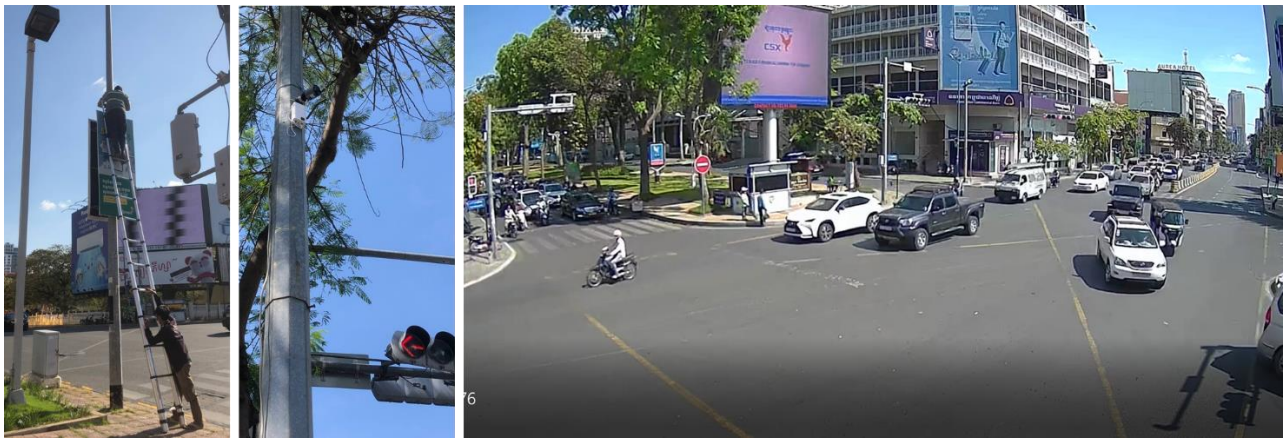
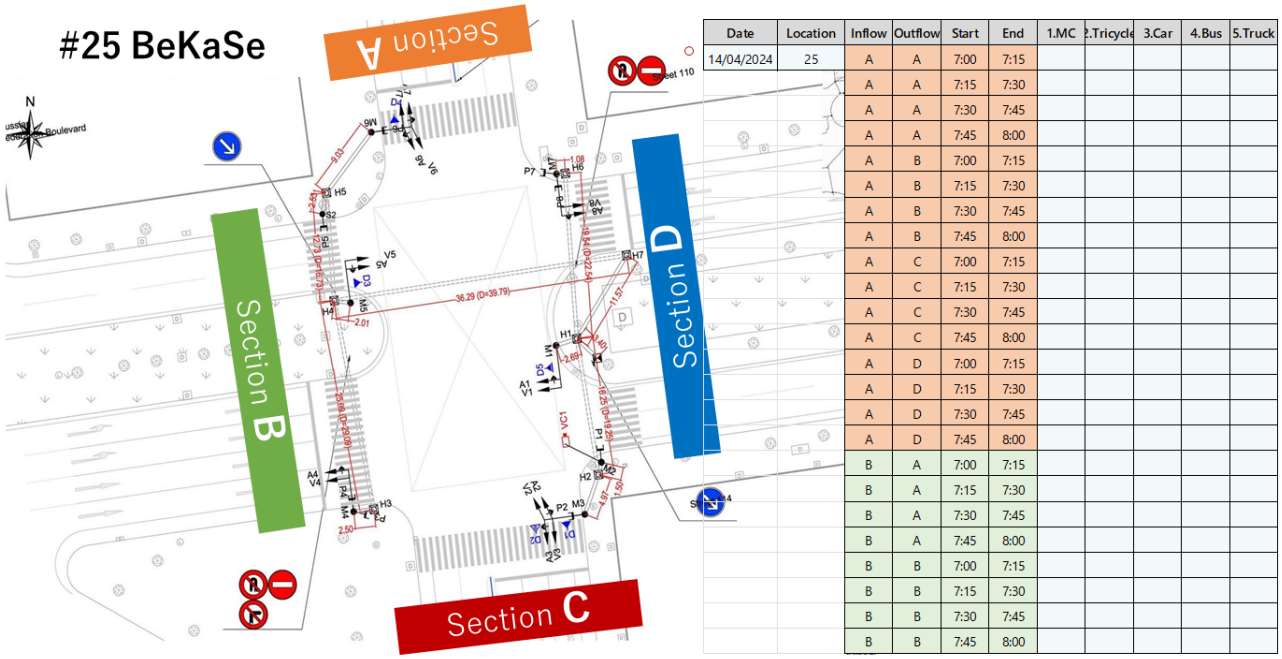


Figure 3.2 Camera Installation and Captured Image

Figure 3.3 Vehicle Classification



Date	Location	Inflow	Outflow	Start	End	1.MC	2.Tricycle	3.Car	4.Bus	5.Truck
14/04/2024	25	A	A	7:00	7:15					
		A	A	7:15	7:30					
		A	A	7:30	7:45					
		A	A	7:45	8:00					
		A	B	7:00	7:15					
		A	B	7:15	7:30					
		A	B	7:30	7:45					
		A	B	7:45	8:00					
		A	C	7:00	7:15					
		A	C	7:15	7:30					
		A	C	7:30	7:45					
		A	C	7:45	8:00					
		A	D	7:00	7:15					
		A	D	7:15	7:30					
		A	D	7:30	7:45					
		A	D	7:45	8:00					
		B	A	7:00	7:15					
		B	A	7:15	7:30					
		B	A	7:30	7:45					
		B	A	7:45	8:00					
		B	B	7:00	7:15					
		B	B	7:15	7:30					
		B	B	7:30	7:45					
		B	B	7:45	8:00					

Figure 3.4 Example of Input Form and Section Definition

3.2.2 Results of the Directional Traffic Counting Surveys

Table 3.2 summarizes the results of the Directional Traffic Surveys at each survey location in the peak hour and off-peak hour in 2023 and 2024. In general, the total traffic volume of all locations in the morning and evening peak hour increased 6.8% between 2023 and 2024. The increase is significant in the traffic volume at IS-4 where a new signal was installed and IS-7 and 8 where the coordinated control at two intersections was implemented. The possible reasons for this increase are:

- Increase of intersection capacity by the pilot projects;
- Traffic influx from surrounding roads due to congestion mitigation; and
- Natural increase of traffic volume by urbanization and motorization.

The detailed survey results by location is summarized in "Appendix-1 Traffic Survey Results in 2023 and 2024.pdf".

Table 3.2 Summary of the Directional Traffic Counting Survey

	2023				**2024**				**2024/2023**			
Hour Location	7:00	14:00	17:00	7:00+ 17:00	7:00	14:00	17:00	7:00+ 17:00	7:00	14:00	17:00	7:00+ 17:00
IS-1	4,288	3,356	3,508	7,796	4,720	3,501	4,523	9,243	10.1%	4.3%	28.9%	18.6%
IS-2	7,510	5,814	8,257	15,767	6,212	5,524	7,927	14,139	-17.3%	-5.0%	-4.0%	-10.3%
IS-3	6,480	4,380	6,779	13,259	6,728	4,977	6,646	13,374	3.8%	13.6%	-2.0%	0.9%
IS-4	6,800	4,886	7,158	13,958	6,647	5,004	7,582	14,229	-2.3%	2.4%	5.9%	1.9%
IS-5	7,516	5,846	7,822	15,338	7,798	5,848	7,943	15,741	3.8%	0.0%	1.5%	2.6%
IS-6	6,293	5,168	6,064	12,357	6,456	5,191	6,297	12,753	2.6%	0.4%	3.8%	3.2%
IS-7	4,974	4,458	5,209	10,183	5,804	4,267	6,128	11,932	16.7%	-4.3%	17.6%	17.2%
IS-8	4,886	4,551	5,216	10,102	5,705	4,310	5,688	11,393	16.8%	-5.3%	9.0%	12.8%
Total Excl. 2	**41,237**	**32,645**	**41,756**	**82,993**	**43,858**	**33,098**	**44,807**	**88,665**	**6.4%**	**1.4%**	**7.3%**	**6.8%**

Unit: PCU/hour/intersection
Note: IS-2 is not included to total because of the road closures for VIP along Russian Blvd. in 2024 survey data.

Table 3.3 Vehicle type composition in the Directional Traffic Counting Survey

	2023					2024				
Location	MC	Tricycle	Car	Bus	Truck	MC	Tricycle	Car	Bus	Truck
IS-1	70%	10%	19%	0%	1%	71%	10%	18%	0%	1%
IS-2	72%	10%	17%	0%	1%	74%	9%	16%	0%	1%
IS-3	74%	10%	16%	0%	1%	74%	9%	16%	0%	0%
IS-4	73%	9%	17%	0%	0%	72%	9%	18%	0%	0%
IS-5	67%	12%	20%	0%	1%	70%	11%	19%	0%	0%
IS-6	69%	12%	19%	0%	1%	70%	10%	19%	0%	0%
IS-7	75%	10%	14%	0%	1%	74%	10%	15%	0%	1%
IS-8	71%	11%	16%	0%	1%	74%	10%	15%	0%	1%
All	71%	10%	17%	0%	1%	72%	10%	17%	0%	1%

3.3 Queue Length Survey

3.3.1 Methodology of the Queue Length Survey

Location	- 8 target intersections of the pilot projects
Survey term	- **The same day** as the intersection directional traffic counting
Survey duration	- The same duration as the intersection directional traffic counting
Methodology	- Surveyors install the **markings at least every 20 m** for each inflow section of the target intersection. - Surveyors record the distance between the stop line and the tail of the last vehicle in the queue **few seconds after traffic light changed to red (queue length)** and fill out the survey form. - Supervisor examines the survey results.
Input form	- 240213_QLS form.xlsx

- The last vehicle in the queue is defined as the last vehicle moving at a speed slower than walking speed, approximately 4 km/h.
- In cases of multiple lanes, the length of the longest queue is recorded.
- If the queue length exceeds the distance between the target intersection A and the upstream intersection B, the distance from the stop line of intersection B to the end of the last vehicle in the queue should be included.

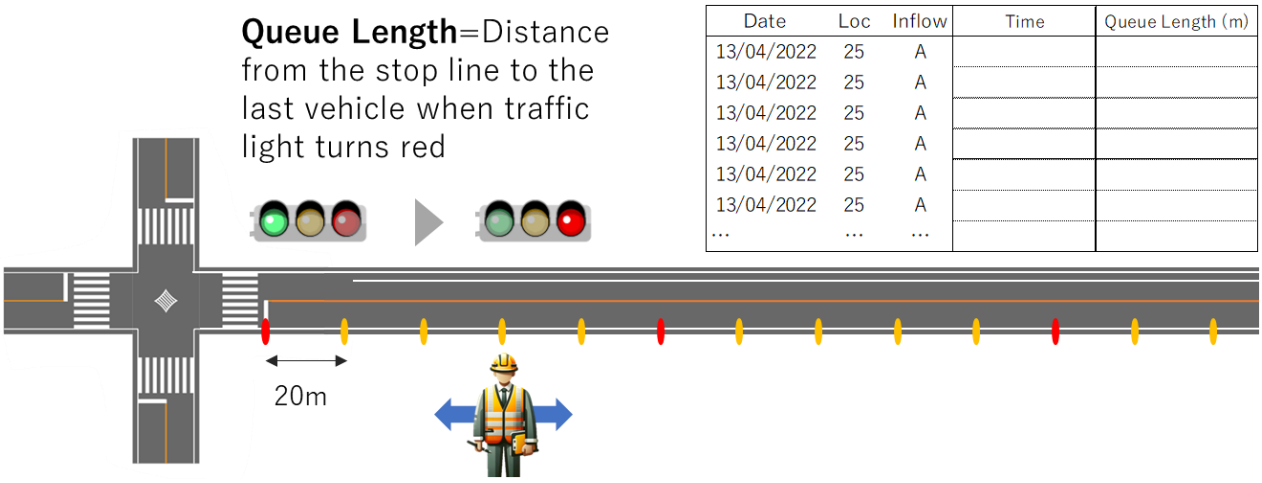


Figure 3.5 Example of Output Drawing at #167 (1:250)

3.3.2 Results of the Queue Length Survey

Table 3.4 summarizes the results of the Queue Length Survey. The number in each cell indicates the average queue length in all inflows of the survey location in 1 hour from 7:00, 14:00 and 17:00. In general, the weighted average queue length of all intersections decreased by 15.4% from 40m to 34m between 2023 and 2024. The change from a year ago varies significantly depending on the location and time of day. Significant decrease in queue length was observed at IS-1 where a new signal was installed and IS-7 where the coordinated control at two intersections was implemented. Contrary, substantial increase in queue length was observed at IS-3 where left turn restriction from west inflow was removed for the enhancement of convenience of road users in this area.

Table 3.4 Summary of the Queue Length Survey

	2023				**2024**				**2024/2023**			
Location	7:00	14:00	17:00	Avg.	7:00	14:00	17:00	Avg.	7:00	14:00	17:00	Avg.
IS-1	15	8	159	61	9	10	21	14	-39.1%	29.7%	-86.6%	-77.5%
IS-2	18	15	36	23	19	16	123	53	4.9%	7.9%	237.8%	128.1%
IS-3	13	15	31	20	25	35	122	60	92.2%	133.3%	293.3%	208.5%
IS-4	73	47	66	62	27	39	76	47	-62.8%	-15.3%	15.5%	-23.2%
IS-5	16	23	41	26	35	16	82	44	121.2%	-27.7%	101.5%	68.3%
IS-6	29	24	47	33	55	24	58	46	90.5%	-2.3%	22.8%	36.4%
IS-7	41	11	47	33	15	7	13	12	-62.4%	-39.6%	-71.7%	-64.2%
IS-8	32	20	26	26	31	24	27	27	-4.6%	21.3%	4.6%	5.0%
Avg. Excl. 2,5	**36**	**22**	**61**	**40**	**27**	**23**	**51**	**34**	**-24.6%**	**4.1%**	**-17.0%**	**-15.4%**

Unit: meter per each inflow
Note: IS-2 is not included for the average because of the road closures for VIP along Russian Blvd. in 2024 survey data and IS-5 is not included because request for remeasurement is ongoing to the survey company.

3.4 Travel Speed Survey

Survey routes	- The 3 routes shown in surveyed. - **2 vehicles** were prepared for a route for frequent observation. - 4 round trips were made for each survey duration for each route. - The starting point of the round trip was “Suburban Side” in the morning peak hour and “City Center Side” in the evening peak hour.
Survey term	- The same term as the intersection directional traffic counting
Survey duration	- The survey was conducted in the **morning peak hours (07:00-09:00)**, **evening peak hours (17:00-19:00)**, and **off-peak hours (12:00-14:00)** of weekday from Tuesday to Thursday.
Methodology	- The survey employs the "floating car method," which necessitates the surveyed vehicle to maintain a consistent position within the traffic flow. This means if the surveyed vehicle is overtaken by others, it must then overtake the same number of vehicles to regain its position. - The survey is carried out in both directions using GPS equipment capable of recording data at least every 5 seconds. - A minimum of two surveyors are needed: one to serve as the "driver" and the other as the "recorder." - The "recorder" is responsible for documenting the time and reasons for congestion after passing through checkpoint intersections and for filling out the survey form.
Input form	- 240213_TSS form.xlsx

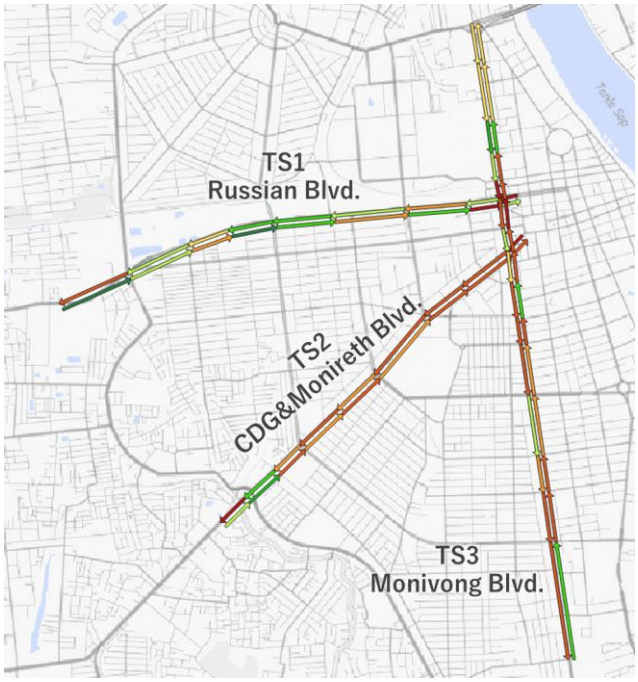


Figure 3.6 Target 3 Routes of Travel Speed Survey

3.4.1 Results of the Travel Speed Survey

Table 3.5 shows the results of the Travel Speed Survey by time of day, by direction, by corridor, by survey year. The weighted average speed of the three corridors was almost the same in 2023 and 2024, decreased by 0.8% from 13.3km/h to 13.2km/h.
The change from 2023 varies significantly depending on the corridor and time of day. Analyzed by time of day, the weighted average travel speed decreased in morning & evening peak and increased in afternoon off-peak hour. Combined with the results of the Directional Traffic Counting Survey, the increase of traffic volume may cause the slowdown of the traffic along the corridor.
Analyzed by corridor, CDG&Monireth shows some improvements in travel speed in general. Contrary, Russian and Monivong shows slowdown in inbound direction in morning peak hour and outbound direction in evening peak hour.

Table 3.5 Summary of the Travel Speed Survey

Year	Route	Corridor	Dir	7:00	8:00	12:00	13:00	17:00	18:00	Avg.
2023	TS1	Russian	In	16.4	15.6	16.2	15.5	11.8	16.3	**15.3**
	TS2	CDG&Monireth	In	8.6	8.2	10.5	12.0	6.9	11.8	**9.7**
	TS3	Monivong	In	12.5	13.4	14.3	14.7	10.8	10.6	**12.7**
	TS1	Russian	Out	19.1	20.7	22.3	19.5	10.1	13.7	**17.6**
	TS2	CDG&Monireth	Out	13.6	16.5	13.4	14.8	7.2	8.4	**12.3**
	TS3	Monivong	Out	13.6	11.9	13.5	13.5	10.1	10.3	**12.2**
	Weighted Avg.			**14.0**	**14.3**	**15.0**	**15.0**	**9.7**	**11.8**	**13.3**
2024	Route		Dir	7:00	8:00	12:00	13:00	17:00	18:00	**Avg.**
	TS1	Russian	In	12.5	12.6	20.2	18.9	15.3	15.4	**15.8**
	TS2	CDG&Monireth	In	9.5	9.7	12.9	10.9	11.3	10.7	**10.8**
	TS3	Monivong	In	11.3	11.6	14.1	16.3	9.9	11.5	**12.5**
	TS1	Russian	Out	18.4	19.2	21.6	22.0	7.6	9.1	**16.3**
	TS2	CDG&Monireth	Out	14.2	14.2	14.2	14.0	6.8	10.8	**12.4**
	TS3	Monivong	Out	12.0	11.7	13.8	15.0	7.0	10.6	**11.7**
	Weighted Avg.			**12.9**	**13.1**	**16.0**	**16.3**	**9.5**	**11.3**	**13.2**
2024/2023	Route		Dir	7:00	8:00	12:00	13:00	17:00	18:00	**Avg.**
	TS1	Russian	In	-24.1%	-19.6%	25.0%	22.1%	29.2%	-5.4%	**3.3%**
	TS2	CDG&Monireth	In	9.7%	19.1%	22.9%	-9.2%	62.7%	-9.9%	**11.8%**
	TS3	Monivong	In	-9.9%	-12.9%	-1.2%	10.6%	-8.5%	8.7%	**-2.1%**
	TS1	Russian	Out	-4.1%	-7.3%	-3.0%	12.8%	-25.0%	-33.8%	**-7.2%**
	TS2	CDG&Monireth	Out	4.4%	-14.2%	5.9%	-5.2%	-6.3%	28.6%	**0.3%**
	TS3	Monivong	Out	-11.9%	-1.6%	2.4%	11.0%	-30.1%	2.7%	**-3.8%**
	Weighted Avg.			**-8.1%**	**-8.5%**	**6.6%**	**8.7%**	**-1.6%**	**-3.7%**	**-0.8%**

Unit: km/h

3.4.2 Driver Violation Survey

Location	- The same locations as the intersection directional traffic counting
Survey term	- The same day as the intersection directional traffic counting
Survey duration	- The same duration as the intersection directional traffic counting
Methodology	- The surveyors trained for the survey check the CCTV camera image captured for the intersection directional traffic counting survey. - The surveyors detect the driver violation and record the type of driver violation, vehicle type, time, inflow direction and location ID in the input form.
Input form	- 240213_DVS form.xlsx

Counting 10 types of driver violations[1] was tried at the beginning, however the traffic situation was much more chaotic than expected and the number of violations depended on the subjective judgement of each surveyor. Therefore, the types of driver violations were limited to the following 3 types which can be counted based on objective criteria.

- Red-light running (going straight);
- Red-light running (turning left);
- Driving in opposite direction;

3.4.3 Results of the Driver Violation Survey

Table 3.6 summarizes the number of red-light violations in 3 hours (7:00, 14:00 and 17:00). In total, it decreased by 21.1% from 1,592 to 1,256 in average between 2023 and 2024.

Table 3.6 Red Light Violations (straight-ahead and left-turn)

Phase	2023	2024	2024/2023
IS-1	0	1,141	
IS-2	3,057	2,333	-24%
IS-3	2,664	997	-63%
IS-4	910	815	-10%
IS-5	190	835	339%
IS-6	373	929	149%
IS-7	2,410	1,079	-55%
IS-8	1,537	1,803	17%
Total Excl.1	11,141	8,791	-21%
Avg. Excl. 1	1,592	1,256	-21.1%

Unit: number of violating drivers in 3 hours (7:00, 14:00, 17:00)

3.5 Topography and Intersection Layout Survey

Location	- #165, #166, #167
Area	- 100m for each direction from the target intersection.
Survey term	- Base line (March, 2023)
Items in drawing	1/1000 scale drawing • Structures of intersections including lane and shoulder; • Access road; • Road markings; • Traffic signs (no entry, no U-turns, no right or left turns, keep right, etc.); • Bus stops; 1/250 scale drawing • Items in 1/1000 scale • Traffic signal pole, light and controllers; • CCTV camera; • Information boards; • Lighting, advertising and communication poles; • Trees; • Median strips; and • Handholes (electricity, water supply, drainage, communications). See Figure 3.7 as example of the output drawing.
Methodology	A plane survey is conducted using GNSS land survey instruments, and the plane drawing is created using AutoCAD.

Figure 3.7 Example of Output Drawing at #167 (1:250)

3.6 Traffic Monitoring with Image Processing AI

3.6.1 Objectives

There are following two objectives for traffic monitoring with image processing AI.

1) To identify changes in traffic volumes on major arterial road **SECTIONS** over time for the effective traffic management and planning
2) To update signal parameters based on the traffic volume at major **INTERSECTIONS**
*Need to install cameras with "better conditions" such as Cameras Installed higher than 8 m from ground and close to the center of intersection, and Multiple cameras to cover all turning movement at intersection.

3.6.2 Work Flow of Traffic Volume Monitoring by using AI

There are following 7 steps for the traffic volume monitoring by using AI.

1) Select camera & angle based on the criteria
2) Export the target footage (Clear, High resolution, 27~30 fps)
3) Upload the footage to Data From Sky
4) Receive the output file (.tlgx) through email
5) Determine the "gates" for traffic count
6) Check how the "gates" work and modify
7) Export to csv and analyze

The first and the most important step is the 1) "Select camera & angle". The camera and angle should be satisfy the following criteria.

Quality of camera footage

No noise: Use cameras without noise or delay.

Resolution: high-resolution cameras to capture clear vehicle details.

Frame Rate: Use cameras with a high frame rate (27~30 fps) to ensure smooth footage.

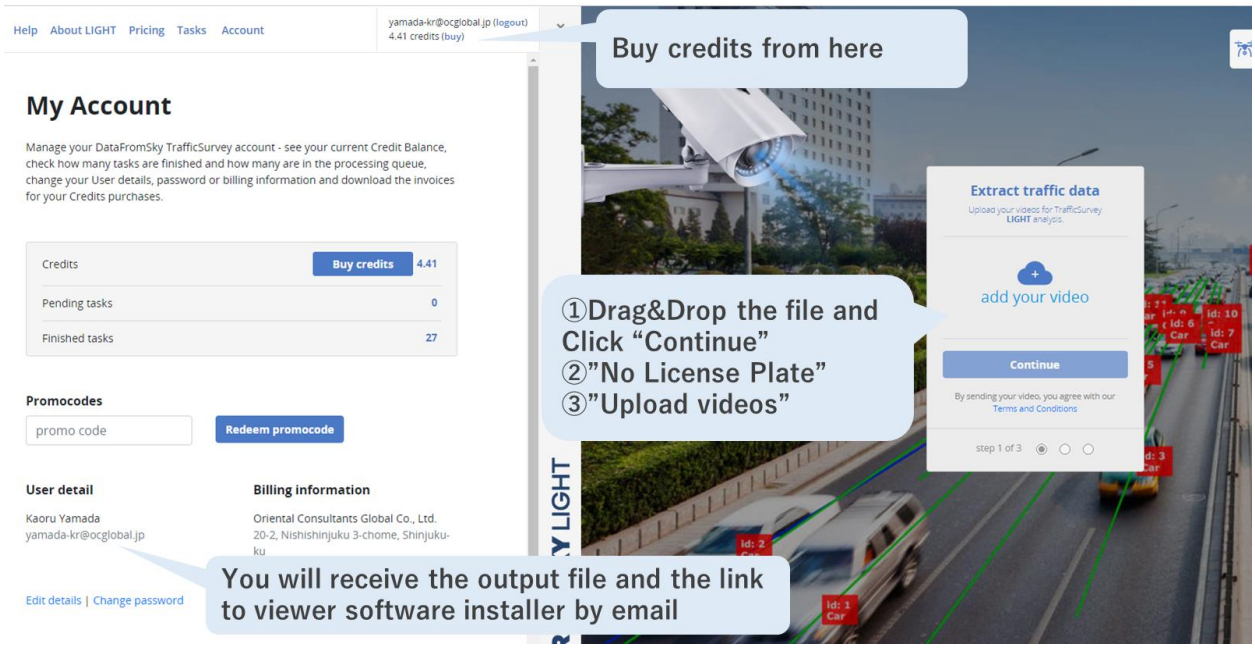
Lens Cleanliness: Regular cleaning and maintenance to prevent dust and dirt from blurring images.

Stability Features: Stable mounting to prevent shaky footage.

Location and Angle of cameras

- **High Elevation:** Cameras installed high place to cover wide areas and reduce occlusion (8 m+).
- **Close to Road Center:** Near the road's center to monitor both directions with less occlusions.
- **Fewer Lanes in Background:** Choose section with fewer lanes in background to reduce occlusions.
- **Avoid High Density Section :** Avoid sections before stop lines as high density increase occlusions.
- **Unobstructed Views:** Install where there are no blockages like power cables or trees.
- **Lighting Condition:** Ensure good visibility in the target time of day.
- **Privacy & Laws Compliance:** Respect privacy and adhere to local regulations.

Step 3) is uploading the input video footage to the web application of Data From Sky. Sign in and purchasing credit are required before uploading the input video footage.



https://ai.datafromsky.com/light

Figure 3.8 Example of the traffic survey results (IS-6, #25)

From step 5) to 7), video tutorial is provided. Watch “240411_Traffic Volume Monitoring by TCC staff_0.mp4” for the detail process to get the traffic counting results.

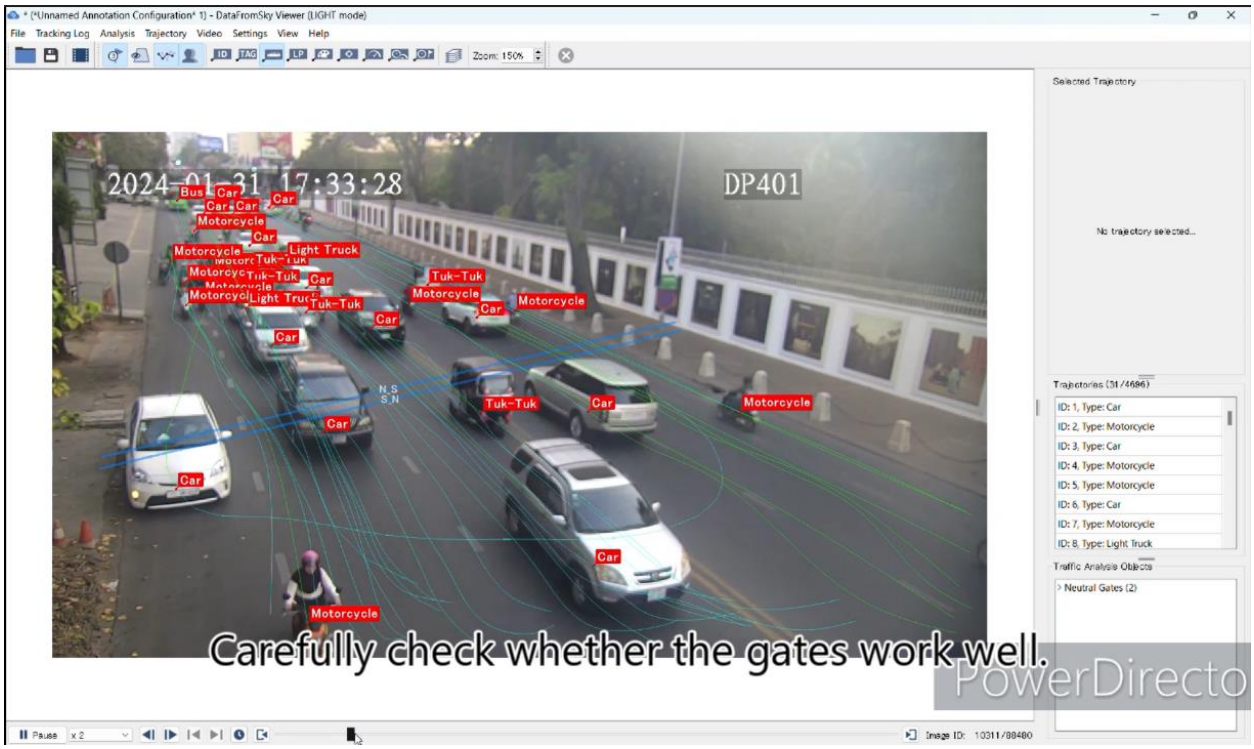


Figure 3.9 Image Capture of the Video Tutorial

4. TRAFFIC SIGNAL PARAMETER DESIGN

4.1 Traffic Improvement Works on Traffic Control System

In order to maintain an appropriate traffic environment, signal parameters, signal phases, and intersection structures need to be periodically reviewed and continuous monitored in response to changing traffic conditions. This is necessary because the traffic environment changes and evolves over time. The tasks for improving traffic control systems include the following:

Table 4.1 Traffic Improvement Works

work	Contents
Signal Parameter change	One of the basic measures is optimizing green time allocation. This measure is easy to implement because it requires no additional equipment.
Signal Phase change	Changing the signal phase is a measure to improve traffic flow. If changing signal parameters does not resolve the issue, changing the phase might.
New Signal Instalation	When traffic issues occur at intersections without signals, installing signals can resolve the issue.
Connection to TCC (Existing signal)	Even with traffic signals, issues caused by changes in traffic demand or signal coordination can be improved by connecting to the Traffic Control Center (TCC).

The pilot project was carried out with the aim of enhancing the skills required for traffic improvement work. The skills required for traffic improvement work include the following:

Table 4.2 Required Skill for Traffic Improvement Works

work	Required skill
Signal Parameter Change	・Traffic survey and complilation of survey result ・Signal Parameter design
Signal Phase Change	・Traffic survey and complilation of survey result ・Signal phase design ・Signal Parameter design
New Signal Instalation	・Traffic survey and complilation of survey result ・Intersection geometry and signal phase design ・Signal Parameter design
TCC Connection	・kowledge of the differences between wired and wireless

Table 4.3 Matching Pilot Project and Traffic Improvement Work

No.	Intersection	Signal Parameter Change	Signal Phase Change	New Signal Instalation	TCC Connection	Enforcement	Civil Work
1	#165			✔			✔
2	#166			✔			✔
3	#28		✔				✔
4	#126		✔				✔
5	#25,#118					✔	
6	#59,#167	✔	✔	✔			✔
7	#201～206				✔		

4.2 Procedures for Signal Improvement Work

The person in charge will give approval at key points.

Figure 4.1 Flowchart of Signal Improvement Work

4.3 Understand Current Situation

Understand the current situation in terms of road conditions, traffic conditions, and safety.

Table 4.4 Understand Current Situation

	Contents
Road condition	・Road geometry ・Intersection geometry and road marking ・Position of signal equipment(controller, pole, lantern) ・Road facility
Traffic situation	・Traffic volume ・Traffic congestion ・Signal phase and signal parameter
Safety	・Accident occurrence situation ・Dangerous event

4.3.1 Understand Traffic Situation by On-Site Survey

Check the traffic situation at site.
The important points to check are as follows:

・Traffic congestion (time of occurrence, direction, cause)
・Intersection configuration (lane markings, road markings, road width)
・Signal control (signal phase, signal parameter)

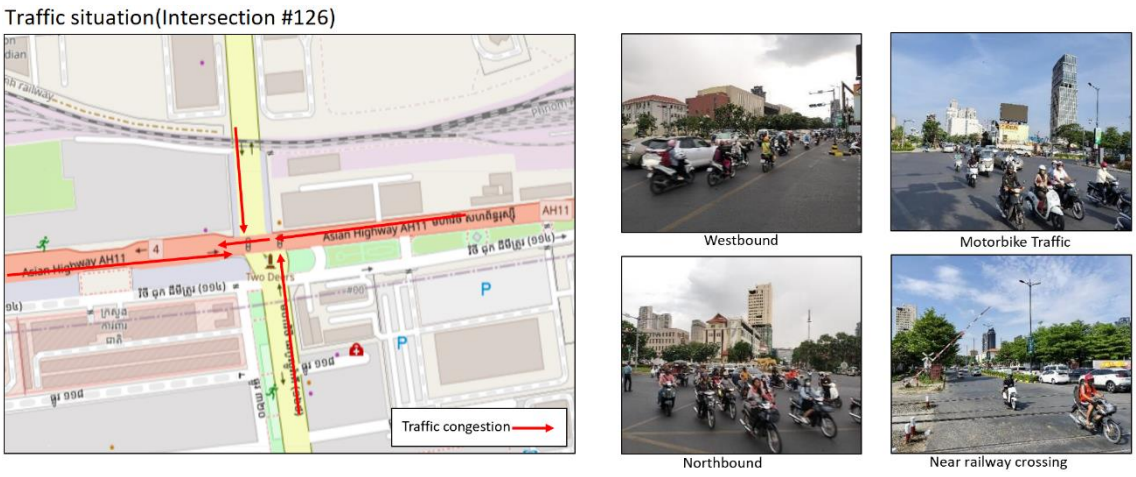


Figure 4.2 Example of Summary (Traffic Congestion)

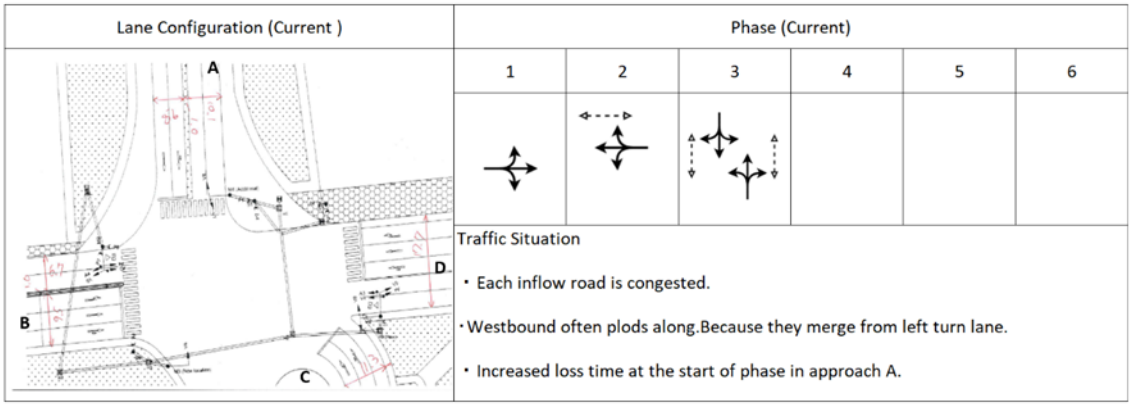


Figure 4.3 Example of Summary (Signal Control)

4.3.2 Understand Traffic Situation by Traffic Data

Generally, the traffic volume used for signal design is the hourly traffic volume. Traffic volume is summarized by vehicle type and direction on an hourly basis.

(1) **PCU Conversion of Traffic Volume**

PCU (Passenger Car Unit) conversion is a method of expressing traffic volume by converting various types of vehicles traveling on roads into passenger car equivalents. This method defines the number of vehicles that have an impact equal to that of one passenger car under specific conditions as 1. Traffic volumes containing a mixture of different vehicle types can be expressed using a unified index.

Table 4.5 PCE (Passenger Car Equivalent)

	Name	PCU
1	Motorcycle	0.30
2	Tuk Tuk (3 Wheelers)	0.75
3	Motorumok	1.25
4	Passenger Car	1.00
5	Taxi	1.00
6	Minibus (8-15 seats)	2.00
7	City Bus	3.00
8	Medium & Large Bus (16+ seats)	3.00
9	Light Truck (<4 Tons) & Pick Up (For Goods Only)	2.00
10	Medium Truck (>4 tons)	2.50
11	Heavy Truck and Trailer (Rigid 3 axles or more)	3.00

(2) **Traffic Volume Converted into Hourly Rate**

Traffic surveys are measured in 5- or 15-minutes increments. Therefore, it is necessary to convert the traffic volume into an hourly basis.

Table 4.6 Original Traffic Volume Data

Inflow	Direction	Start	End	1.MC	2.Tricycle	3.Car	4.Bus	5.Truck	PCU
A	1	14:00	14:15	23	11	8	0	4	29
A	1	14:15	14:30	20	16	18	0	2	38
A	1	14:30	14:45	21	7	15	0	1	26
A	1	14:45	15:00	39	17	16	0	3	43

Table 4.7 1hour Traffic Volume Data

IS-3 (#28) 2023.4.5

Inflow	A	A	A	A	B	B	B	B	C	C	C	C
Direction	1	1U	2	3	4	4U	5	6	7	7U	8	9
Turn	Left	U-Turn	Straight	Right	Left	U-Turn	Straight	Right	Left	U-Turn	Straight	Right
7:00	208	0	316	614	319	11	2,359	31	0	27	1,288	231
14:00	136	0	229	395	26	20	1,619	31	0	30	1,215	218
17:00	154	0	295	671	490	16	1,637	34	0	41	1,950	298

(3) **Traffic Demand Conversion of Traffic Congestion**

It is possible to estimate traffic demand from the queue length.

Table 4.8 Queue Length Data

Location	Inflow	Queue (m)	Time_rv	Hour	15 min	Police	Minutes
IS-3	A	0	17:00:10	17	1		17:00
IS-3	A	0	17:15:18	17	1		17:15
IS-3	A	8	17:30:12	17	1		17:30
IS-3	A	50	17:46:35	17	1	1	17:45
IS-3	B	40	17:01:27	17	1		17:00
IS-3	B	19	17:16:28	17	1		17:15
IS-3	B	11	17:31:30	17	1		17:30
IS-3	B	19	17:46:15	17	1	1	17:45
IS-3	C	9	17:01:23	17	1		17:00

(4) **Data Visualization**

Data visualization makes it easier to understand traffic trends.

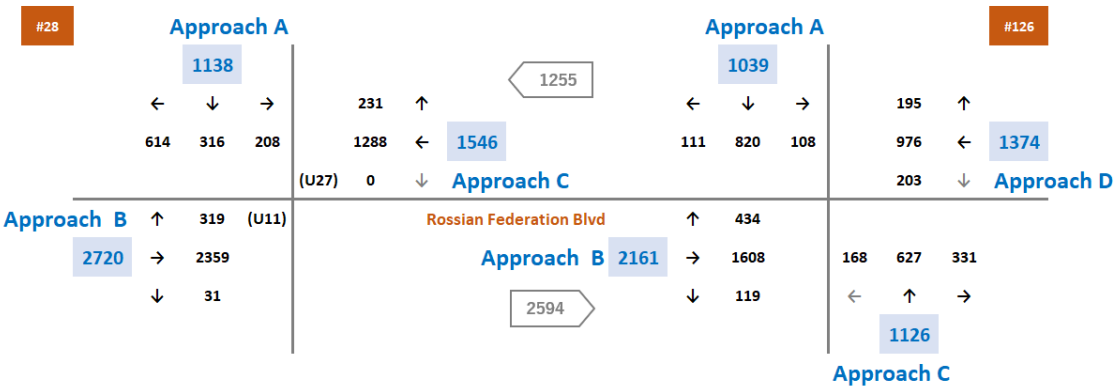


Figure 4.4 Example of Data Visualization

4.4 Signal Phase Design

Understand the surrounding road traffic conditions and establish the lane layout and lane width at the target intersection.
Based on the traffic conditions, determine the combination and sequence of traffic flows that can pass simultaneously.

Step1: Create Traffic Movements for Each Approach

Draw the flow directions from each approach and create combinations of traffic movements that do not intersect or merge with each other.

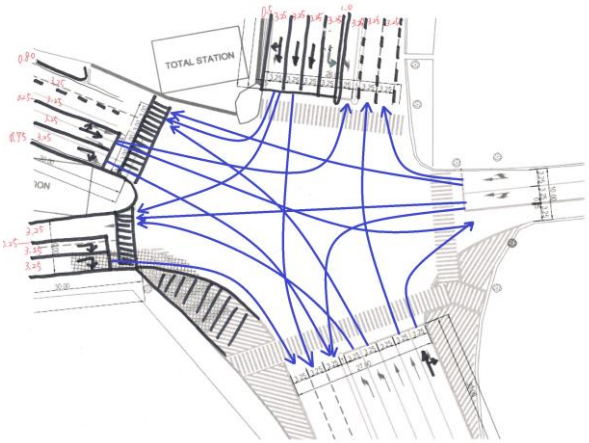


Figure 4.5 Drawing Traffic Flow

Step2: Phase Assignment

When crossing or merging is permissible for safety and smooth traffic flow, one phase is assigned.
Conflicting traffic movements cannot share the same phase.

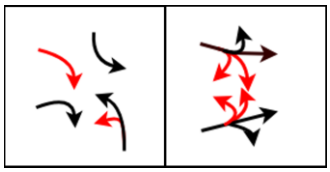


Figure 4.6 Conflicting Traffic Movement

Step3: Continuous Traffic Movement

If two or more phases are assigned to one traffic movement, they are made consecutive.

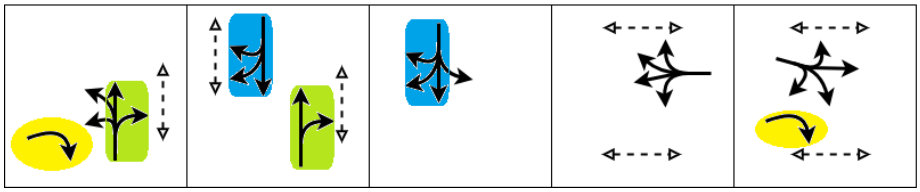
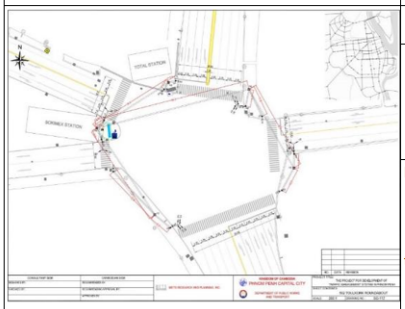


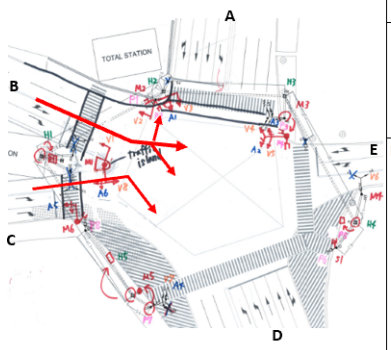
Figure 4.7 Continuous Traffic Movement

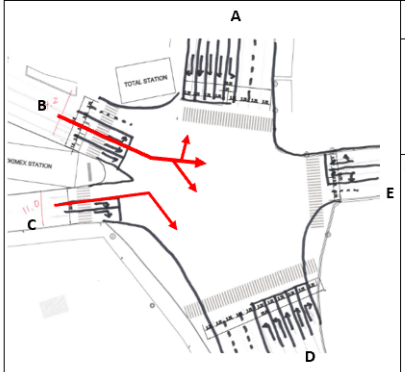
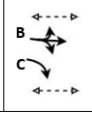
Step4: Phase Performance Evaluation

Considering a multiple-phase plan is advisable. Performance is evaluated using flow ratio of intersection. For each plan, the flow ratio of intersection is used to determine phase plan with highest traffic capacity.

However, Signal phases will consider not only traffic capacity but also safety aspects.

Lane Configuration (Current)	Phase (Current)						Flow ratio of intersection	
	1	2	3	4	5	6	By time zone	
							Morning	0.945
							Afternoon	0.729
							Evening	1.099
	Main traffic conditions ・In Phases 2 and 3, Vehicles confliction and it is dangerous. ・The demand for south-bound traffic is concentrated, and traffic congestion occurs, starting near the railroad tracks. ・Northbound traffic is congested, starting at the intersection.							

Lane Configuration (Proposal#1)	Phase (Proposal)						Flow ratio of intersection		
	1	2	3	4	5	6	By time zone		Comparison with priors
							Morning	0.861	-0.084
							Afternoon	0.748	-0.197
							Evening	1.070	-0.029
	Proposal ・Add right-turn-only restriction on Inflow Road C. ・Main road has very different left turn volume so apply read & rag phasing.								

Lane Configuration (Proposal #2)	Phase (Proposal #3)						Flow ratio of intersection		
	1	2	3	4	5	6	By time zone		Comparison with priors
							Morning	0.880	-0.065
							Afternoon	0.714	-0.015
							Evening	1.086	-0.013
	Proposal ・Add new traffic regulations ・From approach B, only left turns and straight ahead are allowed; from approach C, only right turns are allowed. ・Reduce vehicle confliction and Lower flow ratio of intersection.								

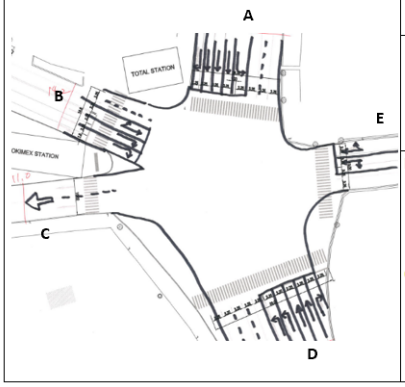
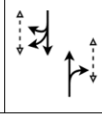
Lane Configuration (Proposal #3)	Phase (Proposal #1)						Flow ratio of intersection		
	1	2	3	4	5	6	By time zone		Comparison with priors
							Morning	0.995	0.050
							Afternoon	0.833	0.104
							Evening	1.141	0.042
	Proposal ・Make the approach C one-way road and make the intersection more compact. ・Proposed phases to reduce vehicle confliction and improve safety. ・approach B is expected to be overloaded and congestion is expected to worsen due to the addition of approach C demand. ・The flow ratio of intersection will be higher than at present.								

Figure 4.8 Multiple Phase Plan

4.5 Signal Parameter Design

Signal parameters include cycle, split, and offset.
The procedure for setting signal parameters is as follows.

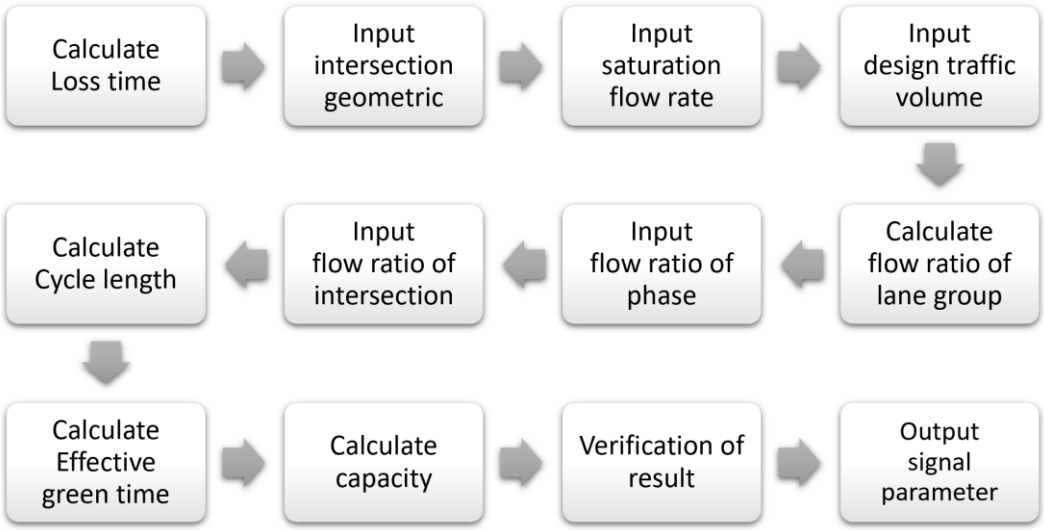
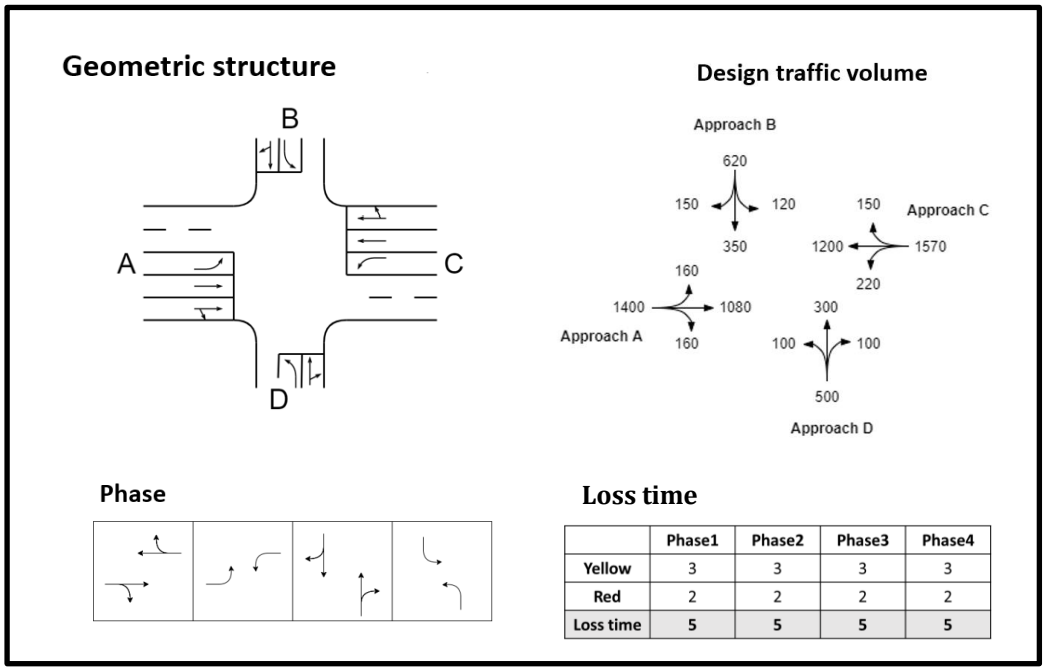


Figure 4.9 Flowchart of Signal Parameter design

Calculate signal parameter from signal phase and intersection structure.
The calculation requires the following data:

- Approach
- Direction
- Number of lanes
- Saturation flow rate
- Design traffic volume
- Signal Phase
- Loss time



	Phase1	Phase2	Phase3	Phase4
Yellow	3	3	3	3
Red	2	2	2	2
Loss time	5	5	5	5

Figure 4.10 Example of Sample Data

Approach		A			B			C			D				
Direction		LT	Th	RT/Th	LT	Th	RT/Th	LT	Th	RT/Th	LT	Th	RT/Th		
Number of lanes		1	1	1	1	1	1	1	1	1	1	1	1		
Saturation Flow Rate (S)		1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800		
Design Traffic Volume (q)		160	1200 (1020+180)		180	900 (740+160)		150	1220 (1100+120)		190	840 (720+120)		Flow ratio of phase	Flow ratio of intersection
Flow ratio of lane group		0.089	0.333		0.100	0.250		0.083	0.339		0.106	0.233			
Flow ratio of phase	Phase1		0.333						0.339					0.339	0.784
	Phase2	0.089						0.083						0.089	
	Phase3					0.250						0.233		0.250	
	Phase4				0.100						0.106			0.106	
Effective green time(sec)	Phase1		60						60					Cycle length (sec)	
	Phase2	16						16						160	
	Phase3					45						45			
	Phase4				19						19				
Capacity (C_i)		180	1350		214	1013		180	1350		214	1013			
q / C_i		0.889	0.874		0.841	0.888		0.833	0.889		0.888	0.829			
Results		OK	OK		OK	OK		OK	OK		OK	OK			

Figure 4.11 Calculation Form

		Phase1	Phase2	Phase3	Phase4
					
A	LT	R	G16 Y3R2	R	R
	Th	G60 Y3R2	R		
	RT				
B	LT	R	R	R	G19 Y3R2
	Th			G45 Y3R2	R
	RT				
C	LT	R	G16 Y3R2	R	R
	Th	G60 Y3R2	R		
	RT				
D	LT	R	R	R	G19 Y3R2
	Th			G45 Y3R2	R
	RT				
C = 160		65sec	21sec	50sec	24sec
		41%	13%	31%	15%

Figure 4.12 Calculation Split

4.6 Signal Parameter Adjustment

Check for new signal control issues.
The issue here is whether there are any significant deviations from the traffic conditions anticipated by the designer. The points to check are as follows:

- Is the allocation of green time appropriate?
- Is the balance of traffic congestion appropriate?
- Are dangerous situations occurring frequently?
- Is congestion occurring at specific times?

5. INTERSECTION GEOMETRY

5.1 Basic Policy of Intersection Geometry Planning/Design

The most important factor to consider in the planning and design of traffic signal control and roadway / intersection geometry is traffic safety. Traffic safety should be prioritized over traffic congestion mitigation. Most traffic accidents occur at intersections, and in Japan, more than 50% of traffic accidents occur at or near intersections. Based on the above, the first policy in the planning and design of intersection geometry should be to ensure the traffic safety.

On the other hand, intersections are the main bottlenecks in urban areas. Traffic signal control is an intersection traffic control method that eliminates or alleviates traffic congestion by efficiently controlling various directional traffic flows, while at the same time improving safety by appropriately separating directional traffic flows and crossing pedestrians. However, intersection geometries that are not in harmony with traffic signal control may conversely cause traffic congestion and even lead to traffic accidents. Therefore, the second policy is to ensure the intersection geometry that is in harmony with traffic signal control.

When installing new signalized intersections or reviewing the traffic signal control of existing signalized intersections, the planning and design of intersection geometry should be conducted in accordance with the above basic policies, based on the relevant laws and design standards in Cambodia, while flexibly introducing overseas design standards and guidelines depending on the situation through coordination with relevant agencies and authorities.

5.2 Intersection Geometry Ensuring Traffic Safety

5.2.1 Area of Intersection

It is obvious that larger intersection area results in more traffic accident risk due to higher possibility of conflicts between vehicles in the intersection. Therefore, the intersection geometry including the location of pedestrian crossings and stop lines should be designed to have the trajectories of vehicle in the intersection as short as possible. It also greatly contributes to increasing traffic capacity of the signalized intersection by reducing red time. Examples of the measure are shown in Figure 5.1 and Figure 5.2

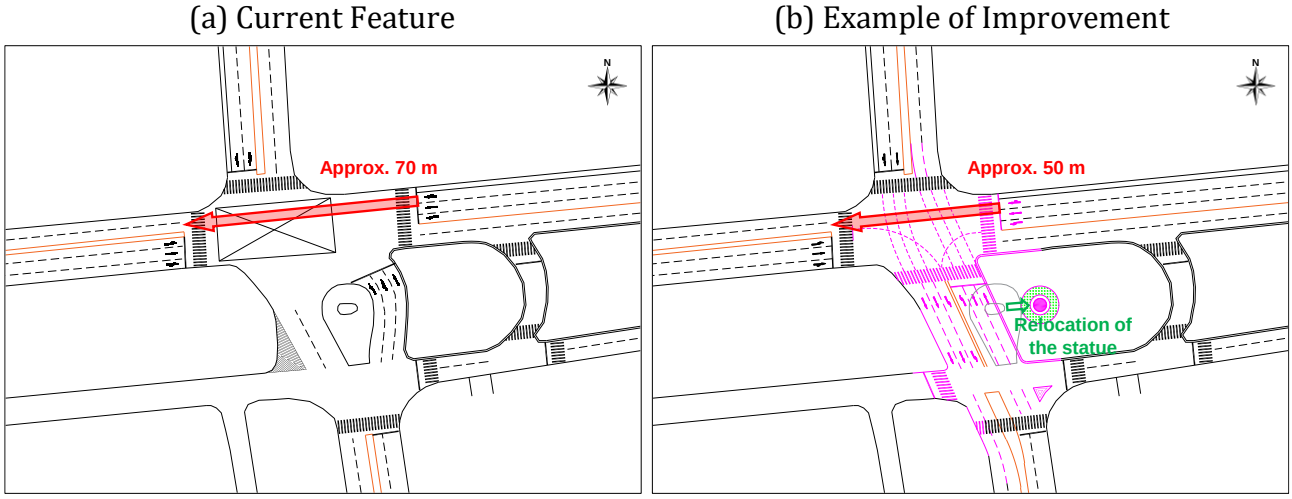


Figure 5.1 Example 1 of Reducing Intersection Area (Intersection #126)

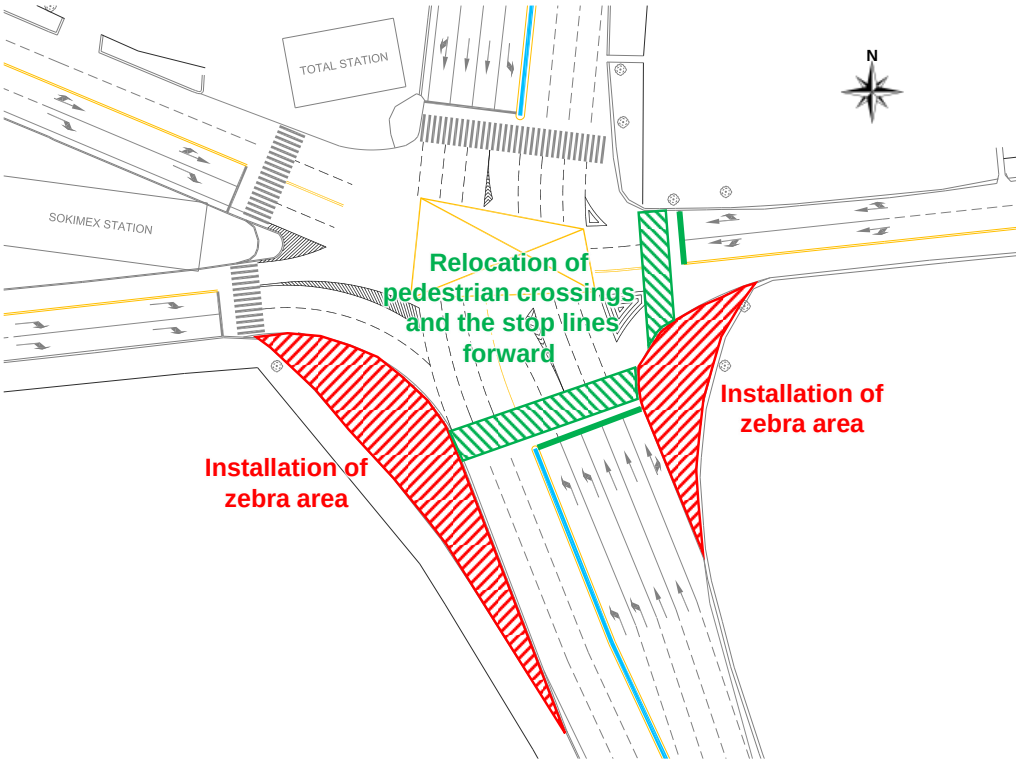


Figure 5.2 Example 2 of Reducing Intersection Area (Intersection #166)

5.2.2 Installation of Dedicated Turning Lanes

Separating traffic movements in and near the intersection can not only improve the traffic capacity but also reduce the risk of traffic accidents. When planning and designing an intersection, installation of dedicated turning lanes such as left-, right-, and U-turn lanes should be positively examined and implemented.
In many cases, particularly the cases of existing roads and intersections in urban area, it is difficult to increase traffic lanes due to limited width of road or roadway. Lane width in Cambodia is considered generally as wide as that of expressways in Japan (3.5 m for expressways and 3.25 m for national highways and other arterial roads), and there are no design standards about reducing lane width in Cambodia. It is preferable to adopt Cambodian standards and keep the lane width as wide as possible, but, in those cases, it is recommended to adopt Japanese standards of minimum lane widths at intersections: 3.0 m for thru lanes and 2.75 m for dedicated turning lanes.

5.2.3 Intersection Approach Section Design

Basically, Cambodian design standards should be applied to the design of intersection approach. If there is no relevant design standard, it is recommended to apply Japanese design standards. Even in case that there are relevant Cambodian design standards, it is recommended to examine the application of the Japanese design standards if those are considered more suitable for the site condition than the Cambodian standards. In this sub-section, the Japanese standards are introduced, which is described in “Commentary on the Road Structure Ordinance of Japan and Its Application” (Japan Road Association, June 2015).
The design of intersection approach is examined from three aspects. One is the transition section where the traffic lanes are laterally shifted to accommodate additional lanes including turning lanes in the given roadway at the intersection. Another is the section required for deceleration so that vehicles can stop safely and avoid rear-end collision with preceding vehicles stopped at the intersection for the traffic signal. The other is the road section where the additional lanes excluding the tapers are installed.
Figure 5.3 shows an example of intersection approach. Here, Section 1 is the transition section required to laterally shift all vehicle movements. Design of horizontal curve is not necessary since the transition section should be designed so that the vehicular maneuver can be done safely within the lane width. Section 2 is the taper section for the left-turn lane. There must be cases that all vehicles including left-turning vehicles do not decelerate in Section 1, especially when the traffic signal is green. Therefore, Section 2 should be a part of or

equal to the section where the left-turning vehicles can safely reduce speed and stop. Section 3 is the section required to accommodate stopped left-turning vehicles and separate those from the thru traffic, so that the traffic capacity of the intersection is maximized.

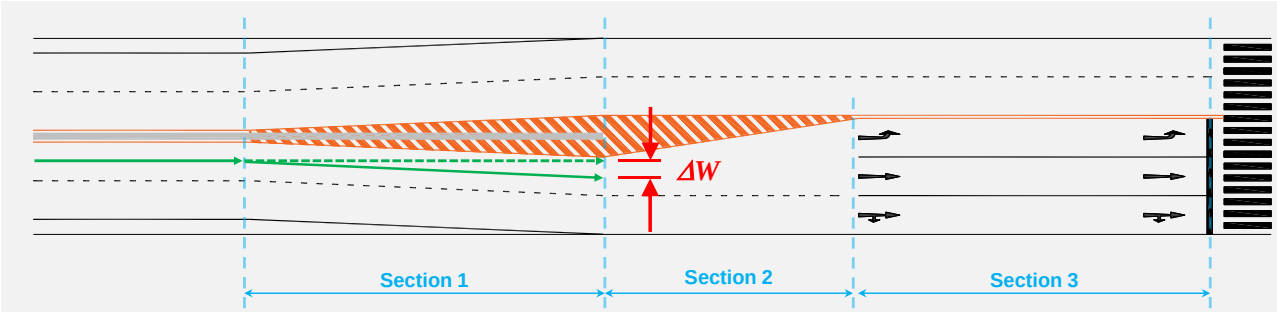


Figure 5.3 Example of Intersection Approach

(1) Length of Road Section for Lane Shift

Length of the transition section for laterally shifting traffic lanes is determined using either equation shown in Table 5.1. If the calculated value is smaller than the minimum value that is also shown in the same table, the minimum value should be adopted and applied to the design. In the equations, V is design speed (km/h), and ΔW is the lateral distance of maneuver (m) (see Figure 5.3). For traffic safety, operating speed observed on the road section is preferable as the design speed. However, the value of posted speed or speed limit is generally used in practice.

Table 5.1 Transition Section Length for Lateral Lane Shift by Japanese Design Standards

Design speed, V (km/h)	Rural Area		Urban Area	
	Calculation (m)	Minimum (m)	Calculation (m)	Minimum (m)
80	$\frac{V \cdot \Delta W}{2}$	85	-	-
60		60	$\frac{V \cdot \Delta W}{3}$	40
50	$\frac{V \cdot \Delta W}{3}$	40		35
40		35		30
30		30		25
20		25		20

- ΔW (m): the lateral distance of maneuver (see Figure 5.3)
- The transition section length should be determined from the calculation but should not smaller than the minimum value.

(2) Length of Road Section for Deceleration

Minimum length for deceleration (l_{d1}) is determined from the values in Table 5.2.

Table 5.2 Minimum Length for Deceleration (l_{d1}) for Intersection Geometry Design

Design speed, V (km/h)	Main roads in rural area (m)	Intersecting roads in rural area and roads in urban area (m)
80	60	45
60	40	30
50	30	20
40	20	15
30	10	10
20	10	10

The taper section length (l_{d2}) is calculated using the following equation.

$$l_{d2} = \frac{V \cdot \Delta W}{6}$$

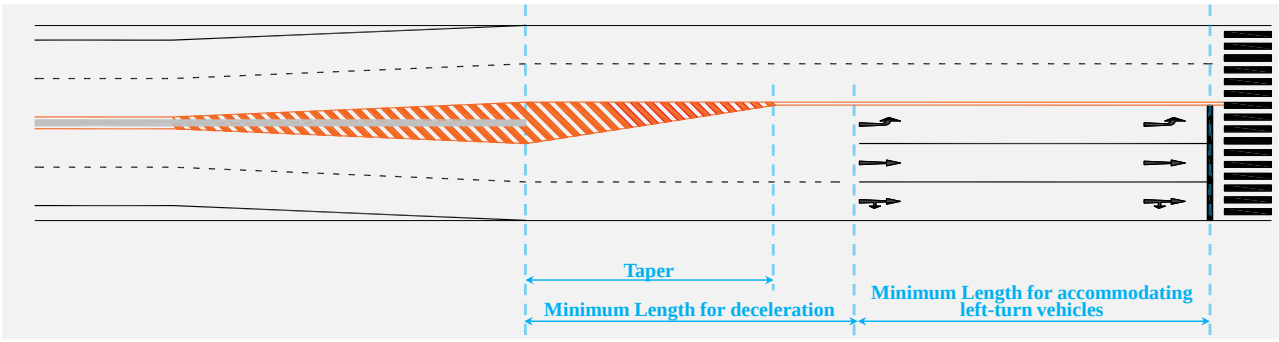
where, l_{d2}: Taper section length (m)
V: Design speed (km/h)
ΔW: Lateral distance of maneuver to the left-turn lane (m)

The length of the road section for deceleration should be the larger of l_{d1} and l_{d2}. The cases are depicted in Figure 5.4.

$$l_d = \max(l_{d1}, l_{d2})$$

where, l_d: Length of the road section for deceleration (m)

(a) $l_{d1} > l_{d2}$



(b) $l_{d1} < l_{d2}$

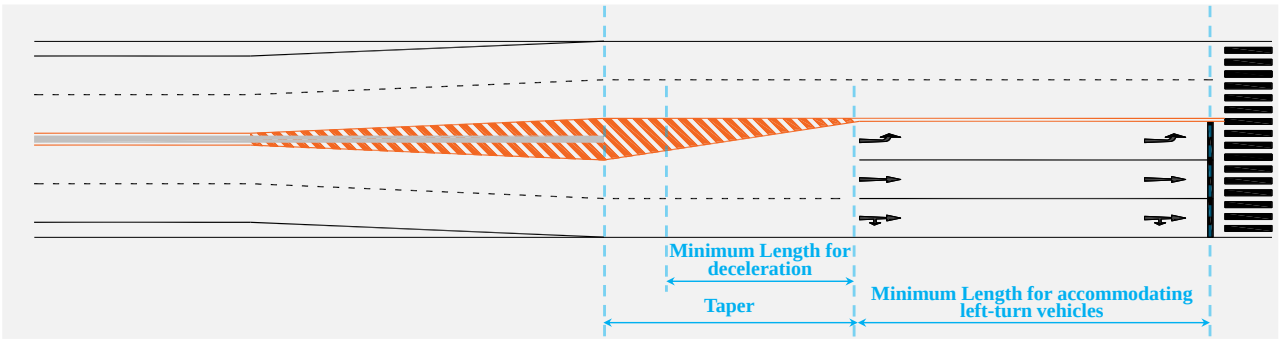


Figure 5.4 Cases of Road Section for Deceleration at Intersections

(3) Length of Road Section for Accommodating Left-Turning Vehicles

The length of road section for accommodating left-turning vehicles (l_s) is calculated from the following equation.

$$l_s = \lambda_l \times N \times S$$

where, l_s: Length of road section for accommodating left-turning vehicles (m)
λ_l: Coefficient for accommodating left-turning vehicles
N: Average number of left-turning vehicles per 1 cycle (veh)
S: Average spacing while stopped at the intersection (m)

The coefficient (λ_l) used in the above equation is to adjust the required length for accommodating left-turning vehicles considering the fluctuation of the number of arrival vehicles for left-turn, which should be determined from a value indicated in Table 5.3. In unavoidable cases due to site conditions and others, λ_l can be reduced to 1.5, which is the minimum value that should be applied to calculating l_s.

Table 5.3 Values of Coefficient (λ_l) for Accommodating Left-Turning Vehicles

N	2 or less	3	4	5	6	7	8	9	10 or greater
λ_l	2.2	2.0	1.9*	1.8	1.73*	1.66*	1.6	1.55*	1.5

* Values calculated by interpolation and proposed by the JICA Study Team based on the guideline written in "Commentary on the Road Structure Ordinance of Japan and Its Application" (Japan Road Association, June 2015)

When calculating the average spacing (S), 6 m is used for passenger cars, and 12 m for heavy vehicles. If the composition of arrival vehicles by vehicle type is not known or given, 7 m may be applied as S. In practice, it may be accepted to use pcu (passenger car unit) for the unit of *N* and, in this case, 6 m for *S*.
When the calculated value is less than 30 m, it is recommended to apply 30 m as the minimum value of l_s. There are cases in practice that the traffic demand is not known or given and that it is difficult to calculate l_s. In those cases, it is also recommended to apply 30 m for l_s.

(4) Overlapping Road Sections for Lane Shift and Deceleration

Sections for the lane shift and the taper are designed based on the instruction explained above. On the other hand, it is also accepted in Japan to overlap those sections as depicted in Figure 5.5.

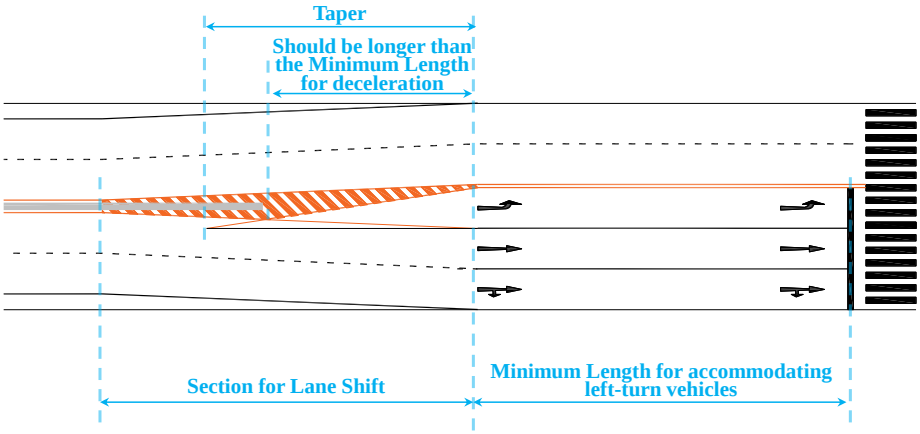


Figure 5.5 Overlapping Sections for Lane Shift and Taper

Figure 5.6 shows the proposed intersection geometry improvement plan for Intersection #165. This intersection was originally three-leg intersection (T-shape) without the northern leg, which was designed and installed to connect a new road to this intersection during the pilot project.

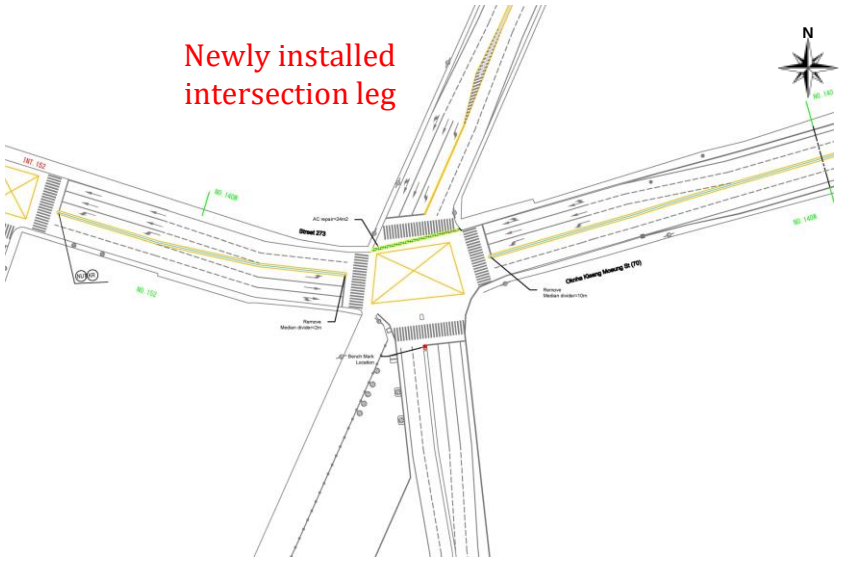
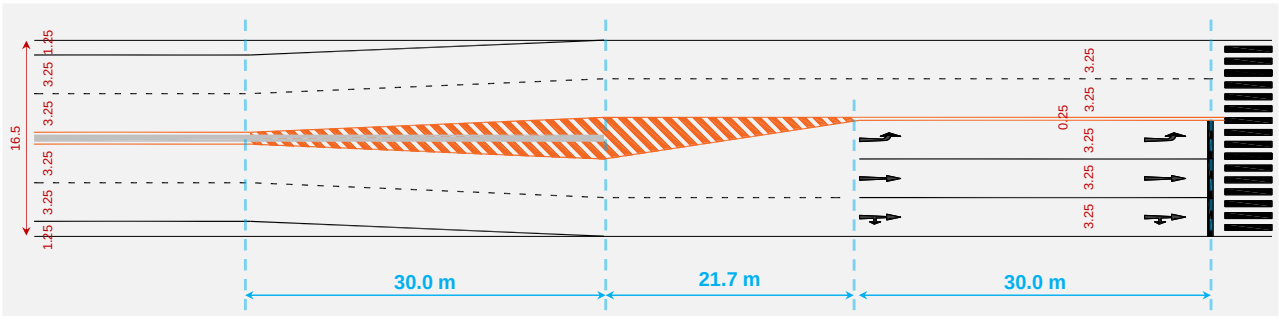


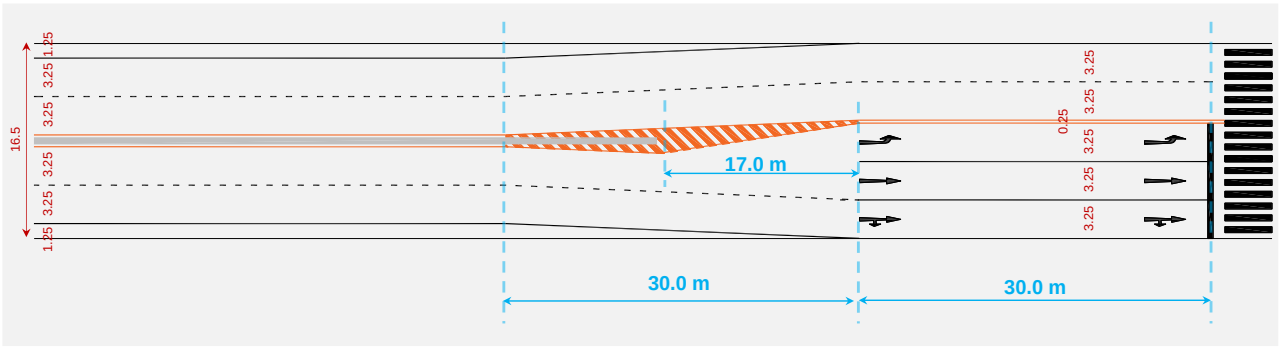
Figure 5.6 Proposed Intersection Geometry Improvement Plan for Intersection #165

Figure 5.7 shows options examined for the design of the northern leg. Option 1 is the case that the sections for the lane shift and the taper are separated, and Option 2 is the case that those sections are overlapped. Under the given condition, the minimum length for the deceleration is 15 m. Therefore, Option 2 is considered acceptable.

(a) Option 1



(b) Option 2



* Design speed: 40 km/h, traffic demand: unknown

Figure 5.7 Options of Intersection Approach for the Northern Leg of Intersection #165

5.2.4 Adoption of Curves with Small Radius for Intersection Corners

Larger radius of curve at intersection corners ensures smoother right-turning movement and may increase the traffic capacity. On the other hand, the higher speed of right-turning is considered risky since it often causes traffic accidents between right-turning vehicles and road-crossing pedestrians. For the countermeasure, it is strongly recommended to apply smaller radius of curve if the site situation and traffic condition allow. It is best practice in Japan to use curves with as small radius as possible to reduce the speed of right-turning vehicles.

5.2.5 Installation of Pedestrian Crossings

Intersection is for not only the vehicle traffic but pedestrians, so, in principle, pedestrian crossings should be installed at all intersection legs. Otherwise, it makes the pedestrians commit the illegal road crossing, which threatens the safety of road-crossing pedestrians. The example of Intersection #126 is shown in Figure 5.1.

5.2.6 Horizontal Alignment of Traffic Movement

Basically, the alignment of traffic movement in and near the intersections should be straight or close to a straight line. Actually, there are many cases that the trajectory is curved, but it should be reminded that the complicated maneuver increases the risk of traffic accident. One example is Intersection #126, where the trajectory from the south to the north becomes continuous S-curves due to the Statue of Two Dears (see Figure 5.8). One proposed solution is shown in Figure 5.1.

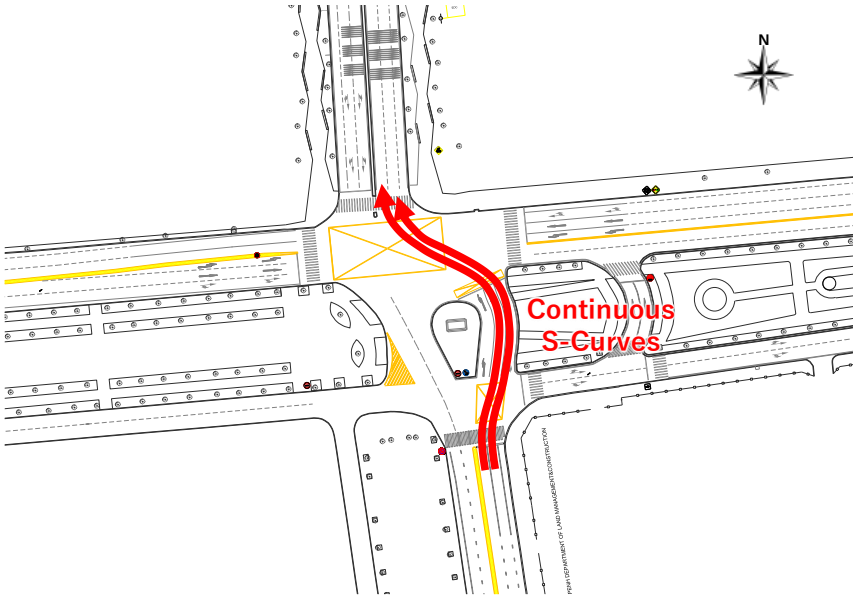


Figure 5.8 Unpreferable Trajectory of Traffic Movement at Intersection #126

5.3 Other Measures for Traffic Capacity and Traffic Safety

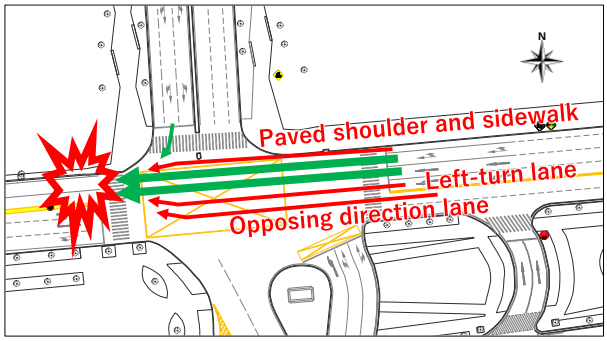
5.3.1 Physical Directional Separation

On single-carriageway roads, opposing direction traffic lanes are divided by centerline pavement marking. Vehicles are supposed not to cross the centerline and should not run on the opposing direction traffic lanes. However, the illegal driving is often observed in Phnom Penh. When necessary, it is recommended to physically separate opposing direction lanes by installing objects such as fence, barrier, etc. to improve the traffic safety.

Figure 5.9 Concrete Barrier for Directional Separation of Traffic in Phnom Penh

On the other hand, the situation observed at Intersection #126 shows another issue (see Figure 5.10). It not only has the high risk of traffic accident but also makes a bottleneck inside the intersection. The approach from the east has two lanes for the thru traffic. However, there are many thru traffic also using the left-turn lane, and, furthermore, there are vehicles using the opposing direction lane to go thru. In addition, there are many motorcycles running between vehicles. They are all concentrated at the discharge section with two lanes, of which width is narrower than that of thru lanes at the east side approach due to the existing concrete barrier installed at the west side discharge. As a result, the discharge of the west side leg becomes a bottleneck, and the vehicles that cannot be discharged during the green time block other traffic movement. To solve the problem, tighter enforcement is essential, and physical directional separation of traffic, e.g., installation of concrete barriers at the east leg, can be a good solution for preventing vehicles from running on the opposing direction traffic lanes.

(a) Situation



(b) Thru Traffic from the Left-Turn Lane

Figure 5.10 Illegal Driving at Intersection #126

5.3.2 Lane Marking Inside the Intersection

As already mentioned, the intersection should be planned and designed so that the complicated traffic maneuver is avoided. If there are two or more lanes for the same direction at the intersection, and if their trajectories are curved inside the large intersection, it is safer to clearly indicate the route of each movement inside the intersection by using pavement marking. However, the pavement marking inside the intersection should not confuse the drivers and should be as simple as possible.
Intersection #166 is a good example. It was originally a big rotary and has been upgraded to a signalized intersection, and it has wide intersection area. The trajectories of traffic movement inside the intersection are curved, and, especially, there are three lanes per direction for the north-south direction of traffic. One example of pavement marking inside the intersection is shown in Figure 5.11.

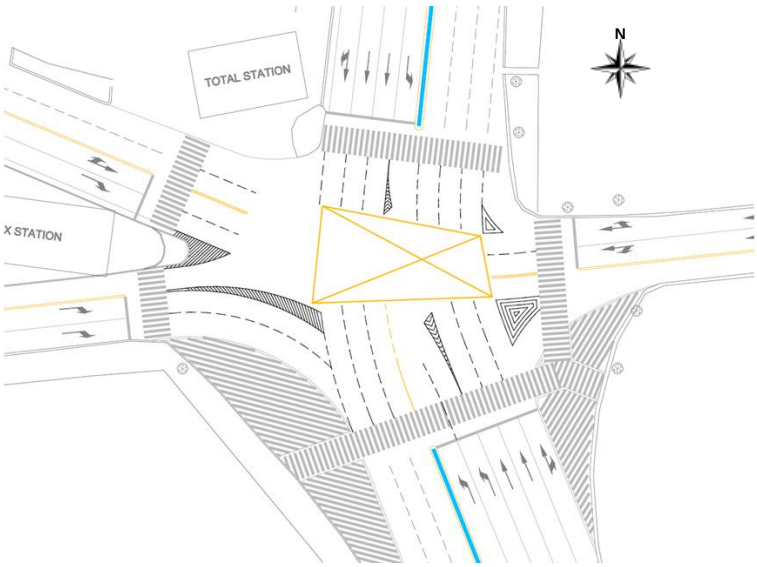


Figure 5.11 Example of Pavement Marking Inside Intersection #166

5.3.3 No Parking/Stopping in and near the Intersections

In principle, no parking and no stopping are allowed in and near the intersection. It should be strictly enforced to improve the traffic capacity and safety. One example is shown in Figure 5.12. The vehicle parked at the discharge of the west side leg caused a traffic congestion at Intersection #126 during the evening peak hours.

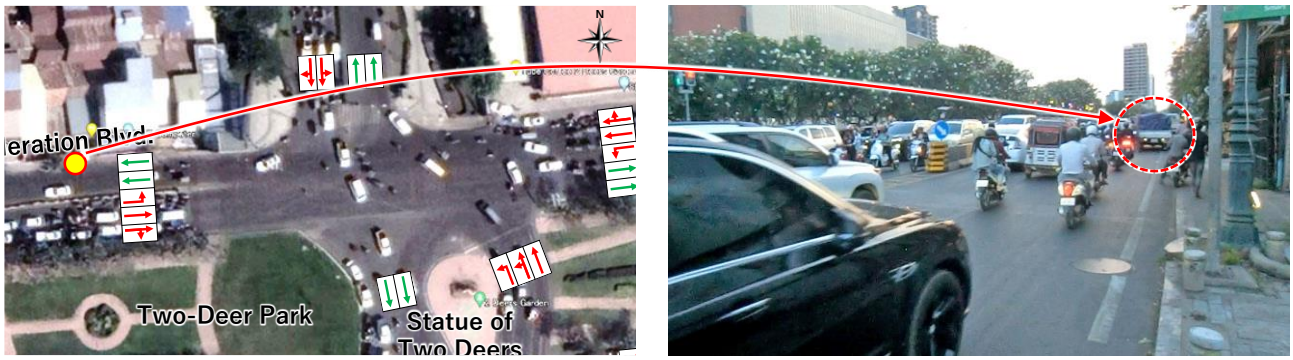


Figure 5.12 Example of Parking near the Intersection (Intersection #126)

5.3.4 No Vehicle Entrance/Exit in and near the Intersections

Vehicles merging into and diverging from the traffic in or near the intersection significantly affect the traffic flow and decreases the traffic capacity of intersection. Therefore, those should be prohibited, and, basically, there should be road structures that do not allow the entrance and exit in and near the intersection.
Figure 5.13 shows one example of intersection in which traffic generation facilities are located. For better traffic condition in Phnom Penh, those facilities should be prohibited to park cars inside the intersection or to influence on the traffic flow. Facilities that need to have vehicles parked in front of those facilities or get in/out those facilities should be relocated.

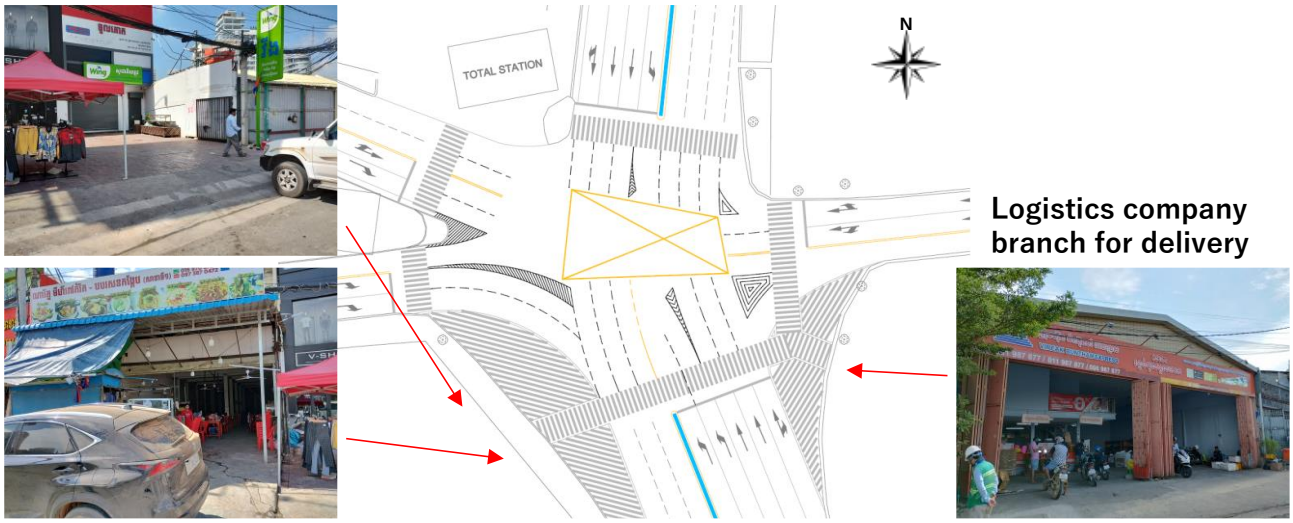


Figure 5.13 Traffic Generation Facilities inside Intersection #166

Another example is shown in Figure 5.14. There is a street connected to the approach of the west side leg of Intersection #59. During the morning peak hours, the street is used by many vehicles to merge into the approach of the intersection, and they obviously increase the traffic congestion and significantly decrease the traffic capacity. It is not easy to reduce the traffic from the street or close it, but it might be a solution to close it or operate it as one-way road from north to south.

Figure 5.14 Street Connected to Intersection #59

The example shown in Figure 5.15 is similar to the case of Figure 5.14. This street in the figure is directly connected to the intersection. It is unpaved, and few vehicles merge from or diverge into the street. This street is not currently considered to affect the traffic operation of Intersection #165, but, when it becomes paved and attracts more traffic, it should be noted that the street will seriously affect the traffic flow and the traffic safety of the intersection and need countermeasures.

Figure 5.15 Street Connected to Intersection #165

5.3.5 Installation of Devices for Traffic Safety

To guide the traffic safely, it is recommended to use traffic devices such as road studs (so-called cat's eyes) and plastic poles. Upon the necessity, pavement marking for route guidance would be also effective. When strengthening the traffic enforcement, it should be followed to install traffic signs to clearly inform the drivers of the traffic rules of the road section and the intersection.

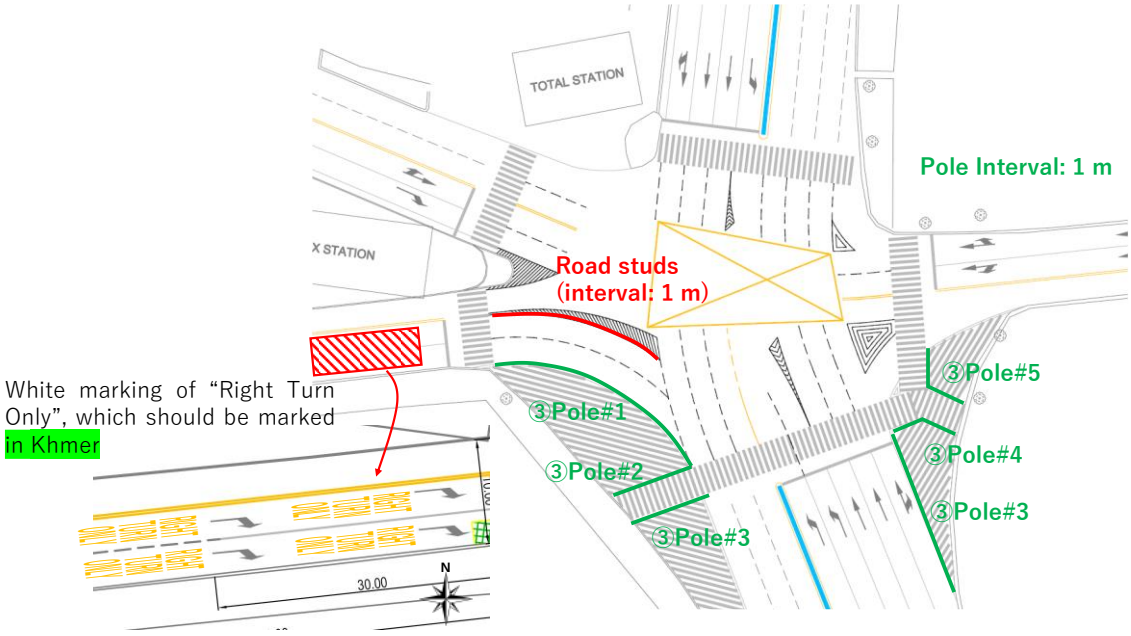


Figure 5.16 Examples of the Installation of Safety Devices and Route Guidance Marking at Intersection #166

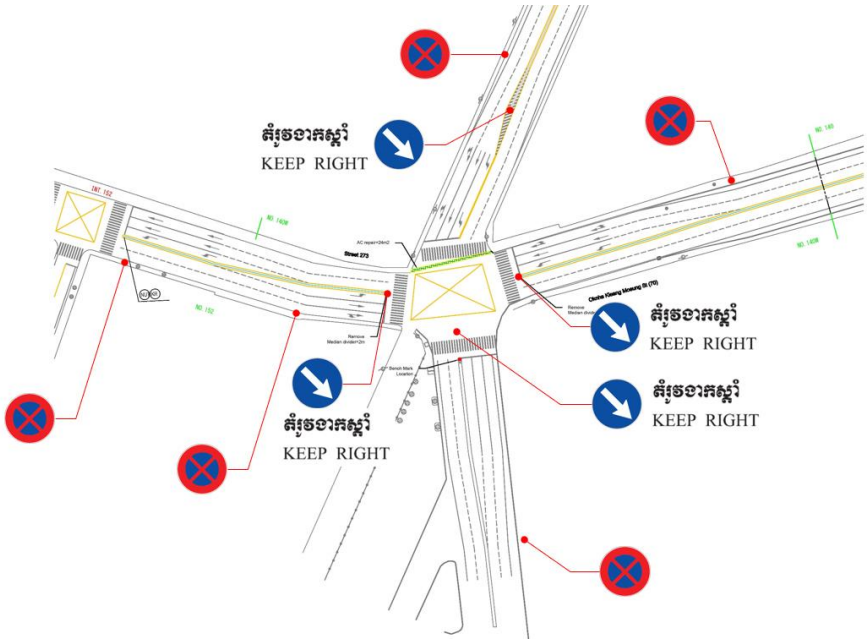


Figure 5.17 Examples of the Installation of Traffic Signs at Intersection #165

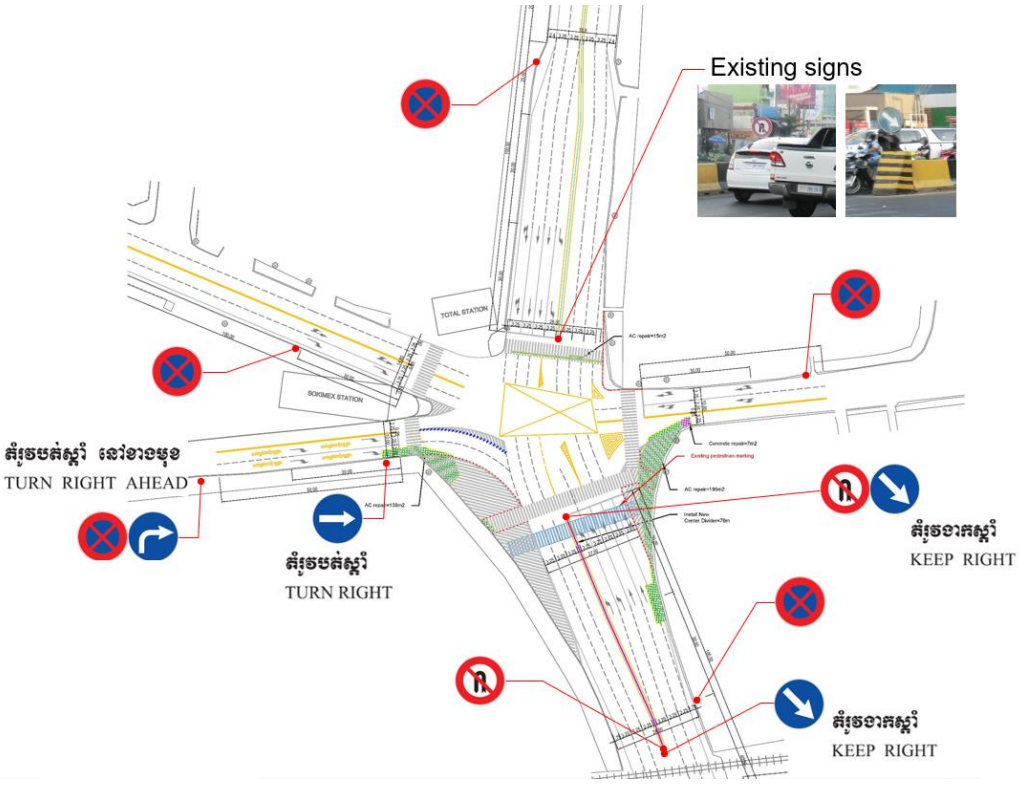


Figure 5.18 Examples of the Installation of Traffic Signs at Intersection #166

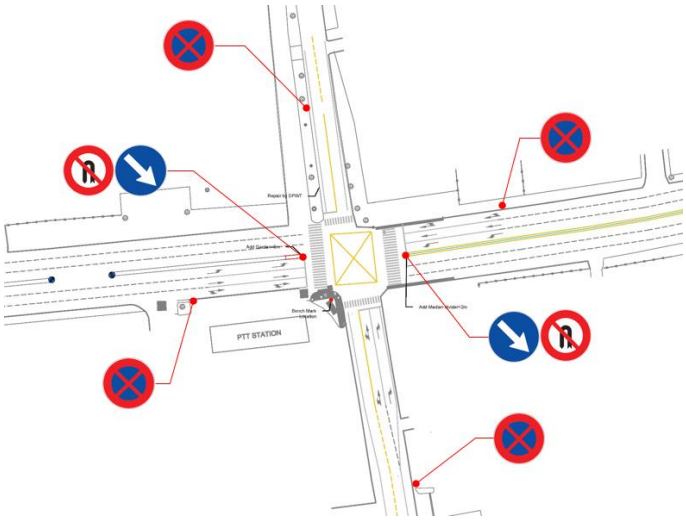


Figure 5.19 Examples of the Installation of Traffic Signs at Intersection #167

6. COMMUNICATION SYSTEM

6.1 Objective of the Pilot Project for Communication System

The objective of the pilot project is to connect TCC and traffic signals at each intersection using wireless communication. The network contents of TCC and approximately 100 intersection traffic signals are currently connected by fibre optical cables.
By implementing a pilot project using wireless communications and verifying its effectiveness, it is expected that it will have the effect of adding flexibility to the TCC network, which is expected to expand further in the future, and improve its resilience.

6.2 The Background of Pilot Project for Communication System

Though the TCC operation since TCC network was established, some issues were identified. They are two categories of existing issue and future potential issue. Issue related to the pilot project are below. The trial pilot project is to solve such each issue

Existing Issue and Solution
[Issue] Network Disconnection
The existing network is constructed with Optical fiber cables, which are installed overhead in most of the area. Therefore, they are often accidentally disconnected, causing the network to go down.

[Solution] Eliminating the risk of mechanical disconnection of the cables by using WIRELESS COMMUNICATION

FUTURE POTENTIAL ISSUE
[Issue] Sparse traffic signal in the suburban area
Laying optical fiber cables often involves civil engineering work such as erecting poles and embedding pipes between relevant intersections, making installation difficult. In addition, in the suburban area where the traffic signals are not concentrated, the cable installation cost is relatively high.

[Solution] Minimization of construction work between intersections by using WIRELESS COMMUNICATION

6.3 The Implement a Pilot Project of communication

The sites for pilot project were selected at the following intersections that are not currently connected to TCC.

i) Each intersection of #201 to #206 along Route 1 and TCC
ii) Connection between existing intersection #59 and existing intersection #167 installed by DPWT and indirectly connection with TCC

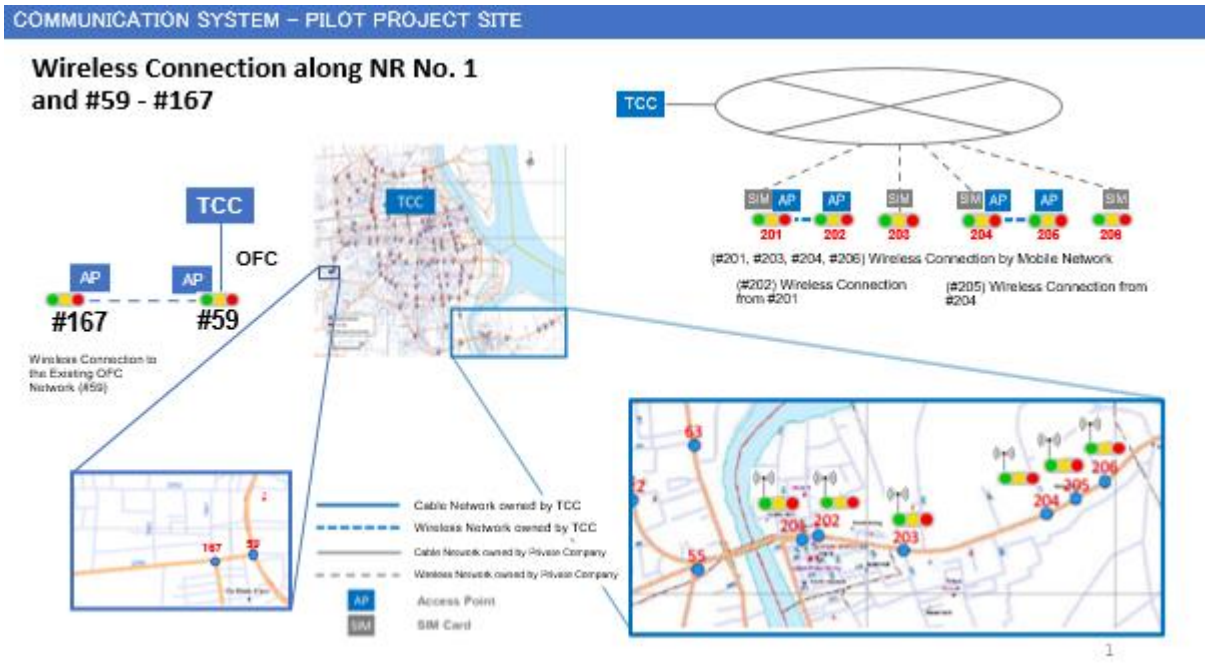


Figure 6.1 Pilot Project Site

The connection method proposed are one of the following types.

Type A
To extend the existing OFC network to additional traffic signal using wireless communication.
This type is applied to the connection between #59 and #167.

Type B
To utilize wireless communication infrastructure using SIM cards of private carriers.
This type is applied to the connection between TCC & #201, #203, #204 and #206 separately.

Combination of Type A and B
As a mixed type of 1 and 2, the network to TCC using SIM of private carriers and wireless is further extended using Wifi.
This type is applied to the connection between #201 & #201 and #204 & #205 respectively.

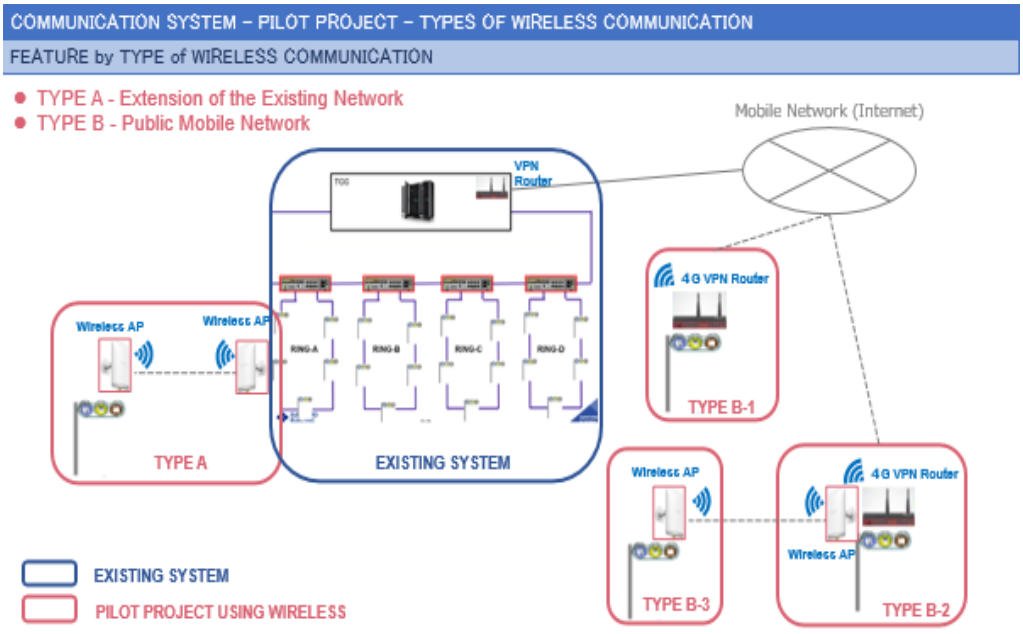


Figure 6.2 Types of Wireless Communication

The advantages and disadvantages of each method are described below.

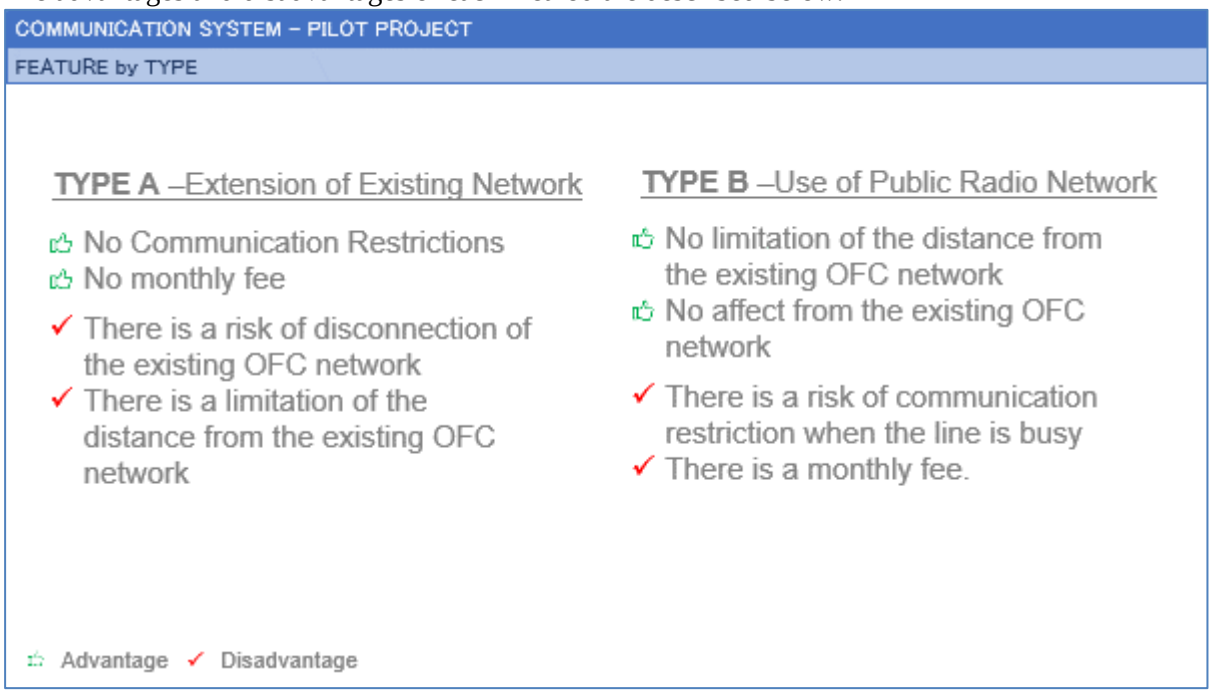


Figure 6.3 The Feature of each Method

6.4 The Diagram of each site of Pilot Project

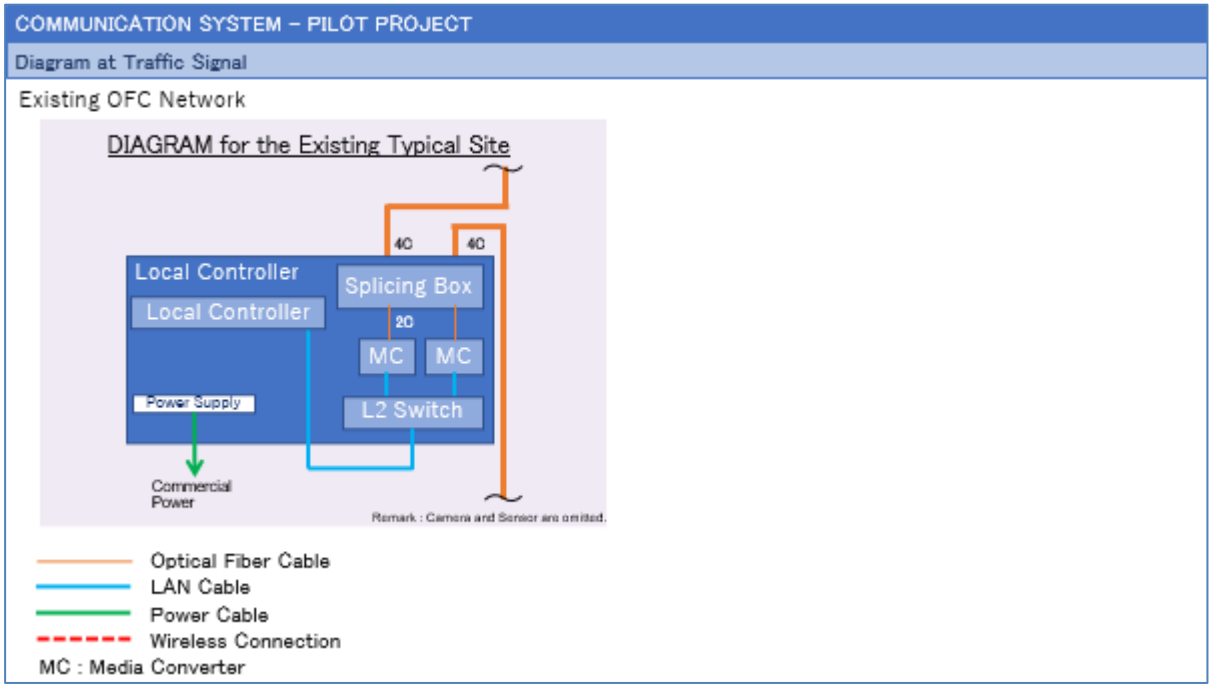


Figure 6.4 The Diagram of Existing Typical Site

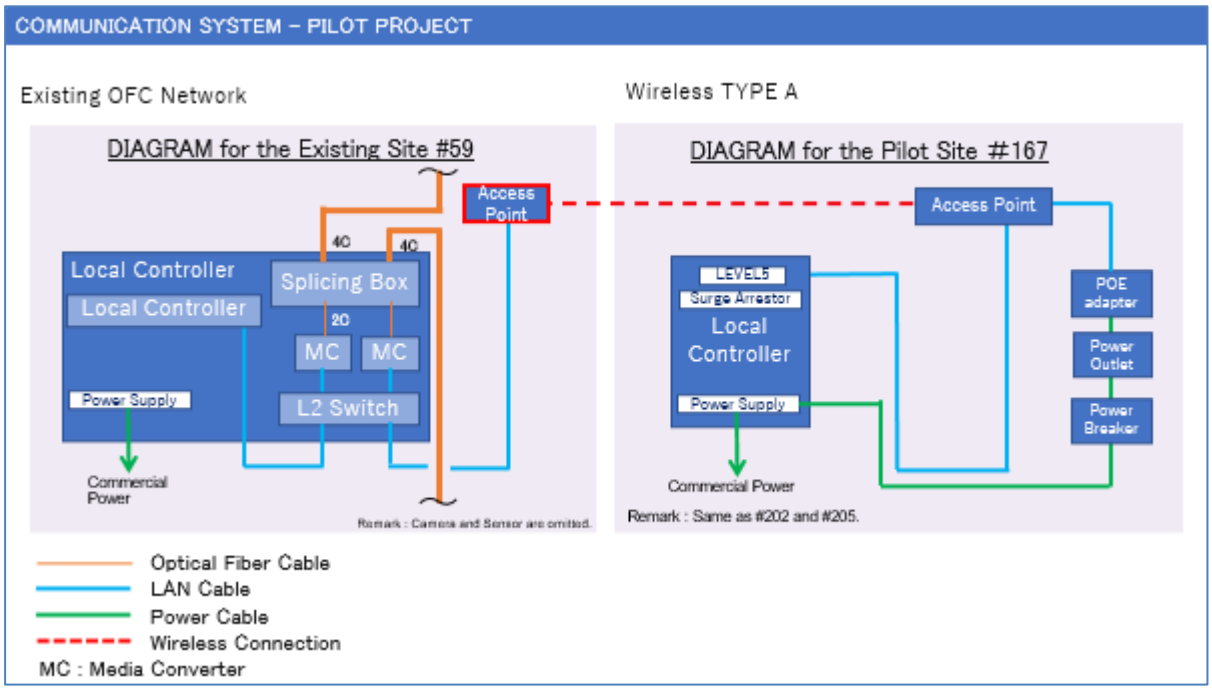


Figure 6.5 The diagram of Type A of Pilot Project

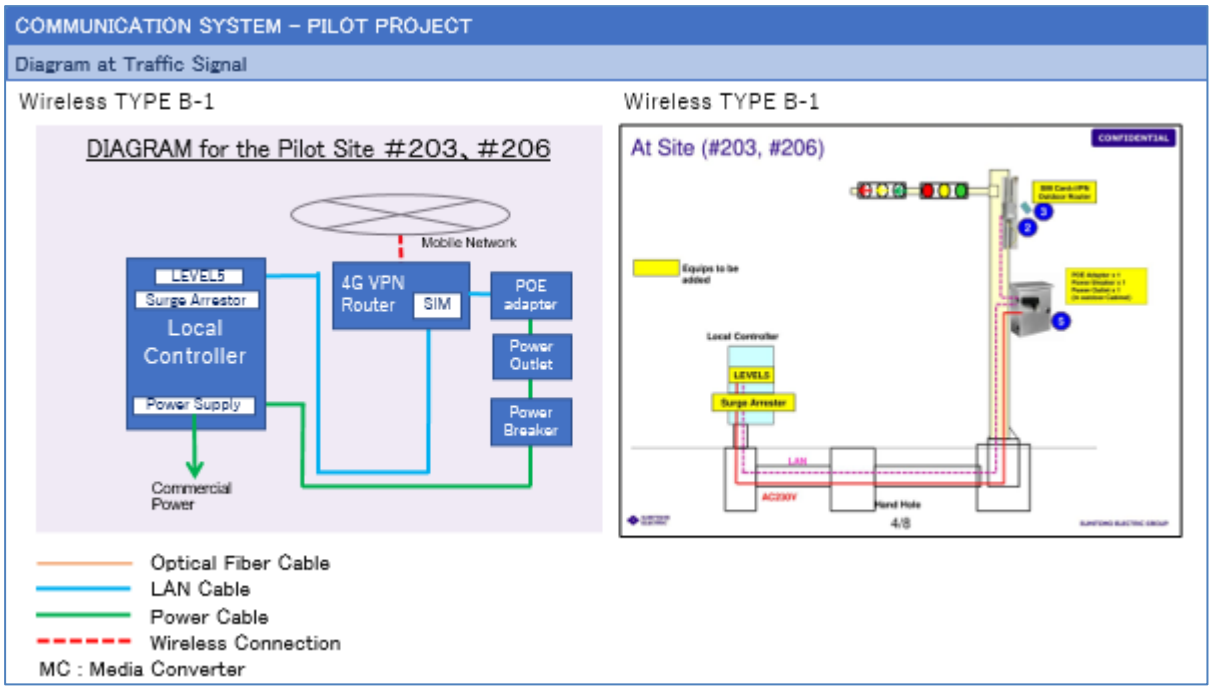


Figure 6.6 The Diagram and Elevation of Type B-1 of Pilot Project

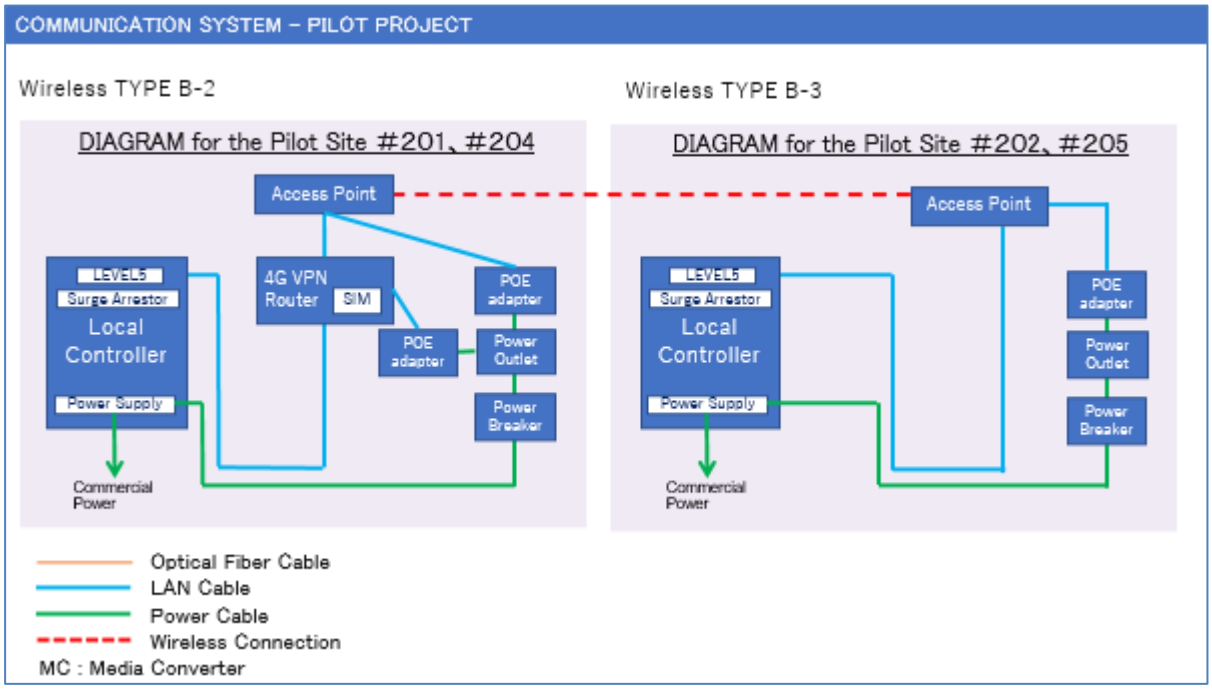


Figure 6.7 The diagram of Type B-2 and B-3 of Pilot project

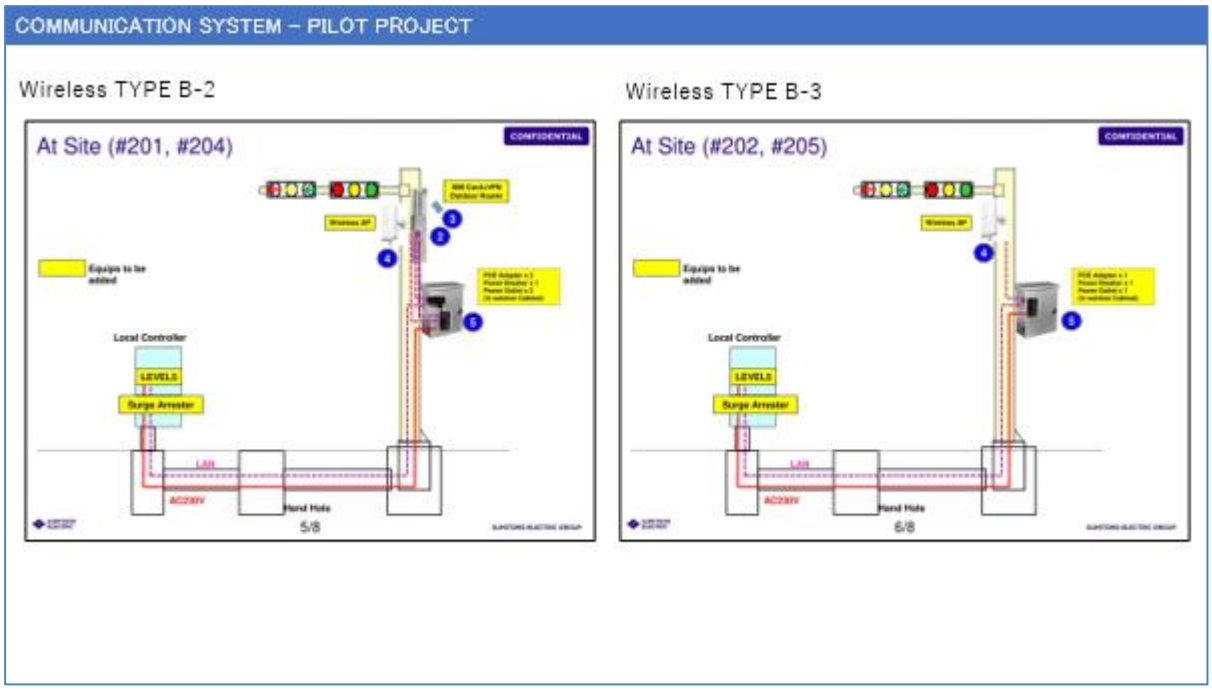


Figure 6.8 The elevation of Type B-2 and B-3 of Pilot project

The devices installed in the pilot project are listed below.

Table 6.1 The Equipment List of the Pilot Project

No	Item	#201	#202	#203	#204	#205	#206	#59	#167	TCC
1	Ruijie/Reyee 5GHz Outdoor wireless_RG-EST350	1	1		1	1		1	1	
2	MIKROTIK (RB2011UiAS-2HnD-IN) Router									1
3	4G Industrial Outdoor Router	1		1	1		1			
4	Outdoor Cabinet (Local)	1	1	1	1	1	1	1	1	
5	Schneider RCBO 2P-16A. 30mA	1	1	1	1	1	1	1	1	
6	Schneider MCB 2P-16A	1	1	1	1	1	1	1	1	
7	Schneider Surge arrester	1	1	1	1	1	1	1	1	
8	Schneider Double power socket 13A, 2P+E	2	2	1	2	1	1	1	1	
9	Novaris Network Surge Protector	1	1	1	1	1	1	1	1	

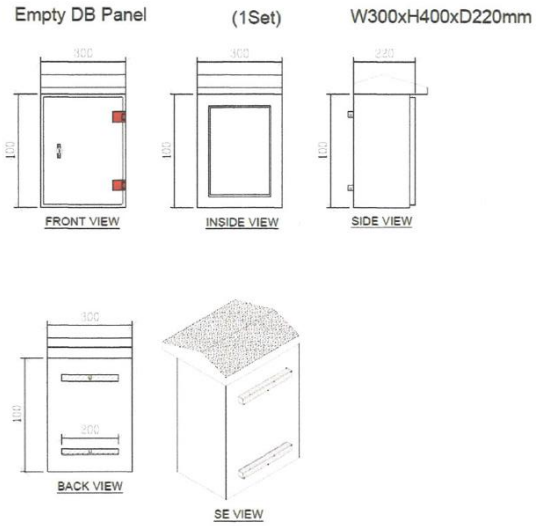


Figure 6.9 The Outdoor Cabinet Installed Traffic Signal Pole

Prior to the determination of the selection of wireless method and installation of the equipment for the pilot project, the field test was carried out to make sure the radio signal will reach to the target traffic signal site. The results were listed below.

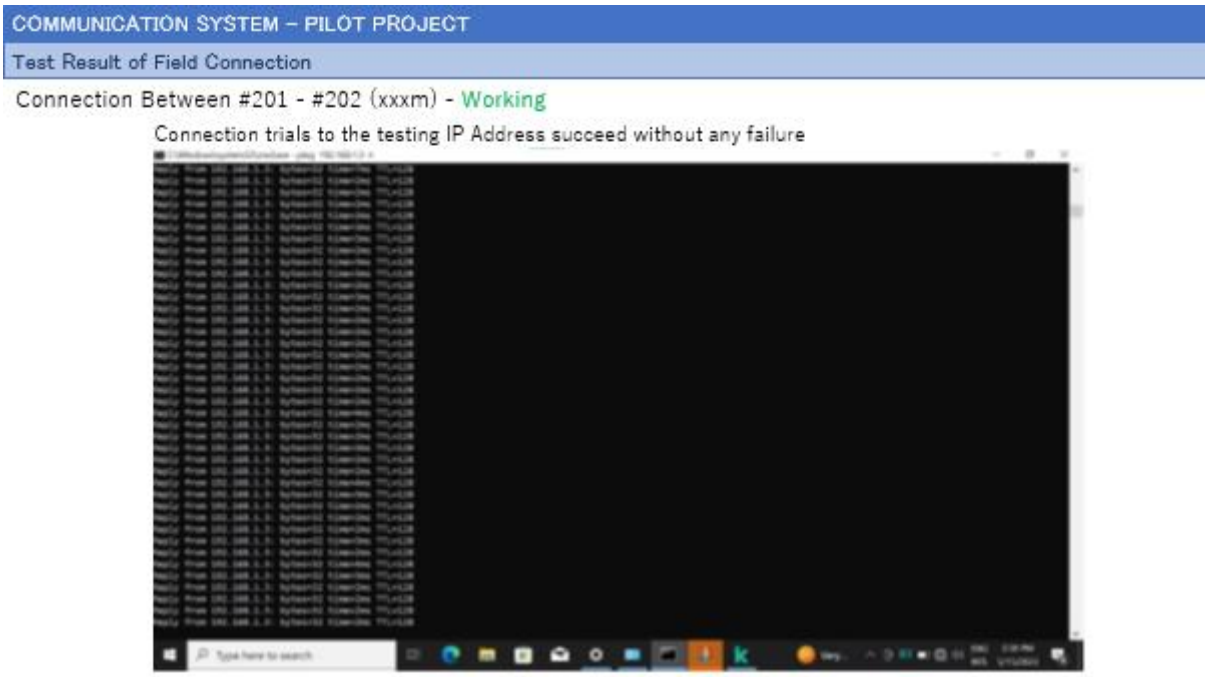


Figure 6.10 Test Result of Between #201 and #202 - Pass

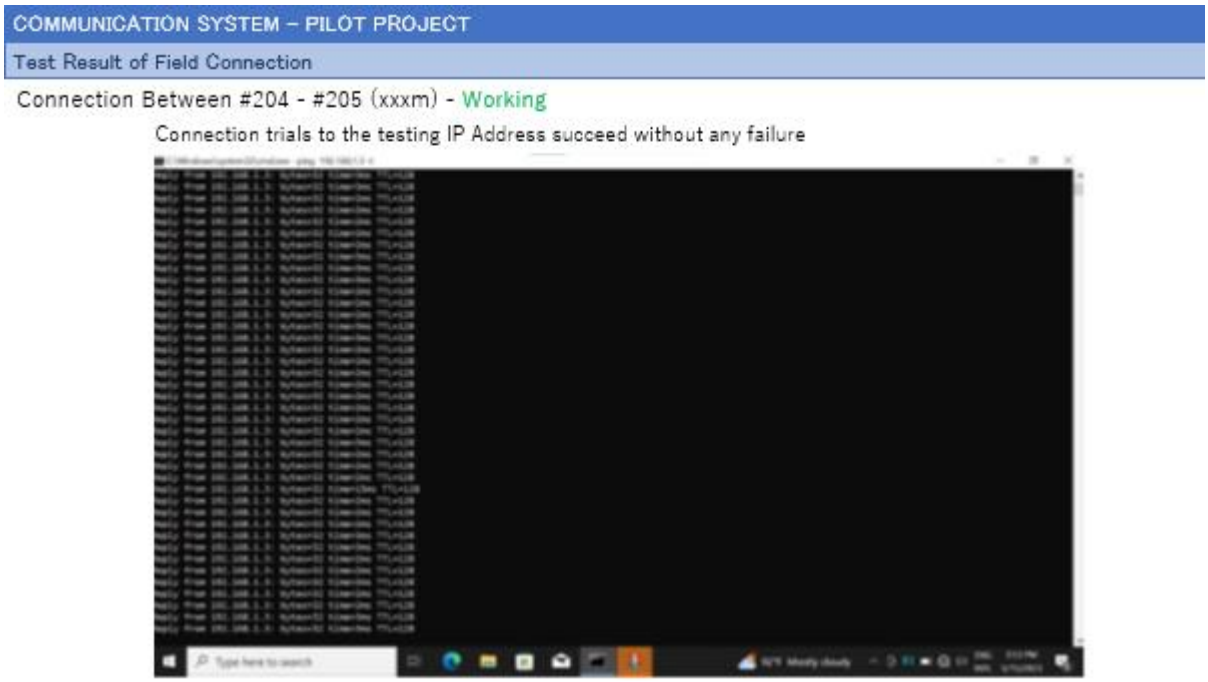


Figure 6.11 Test Result of Between #204 and #205 - Pass

The test result was not ideal between #203 and #204.

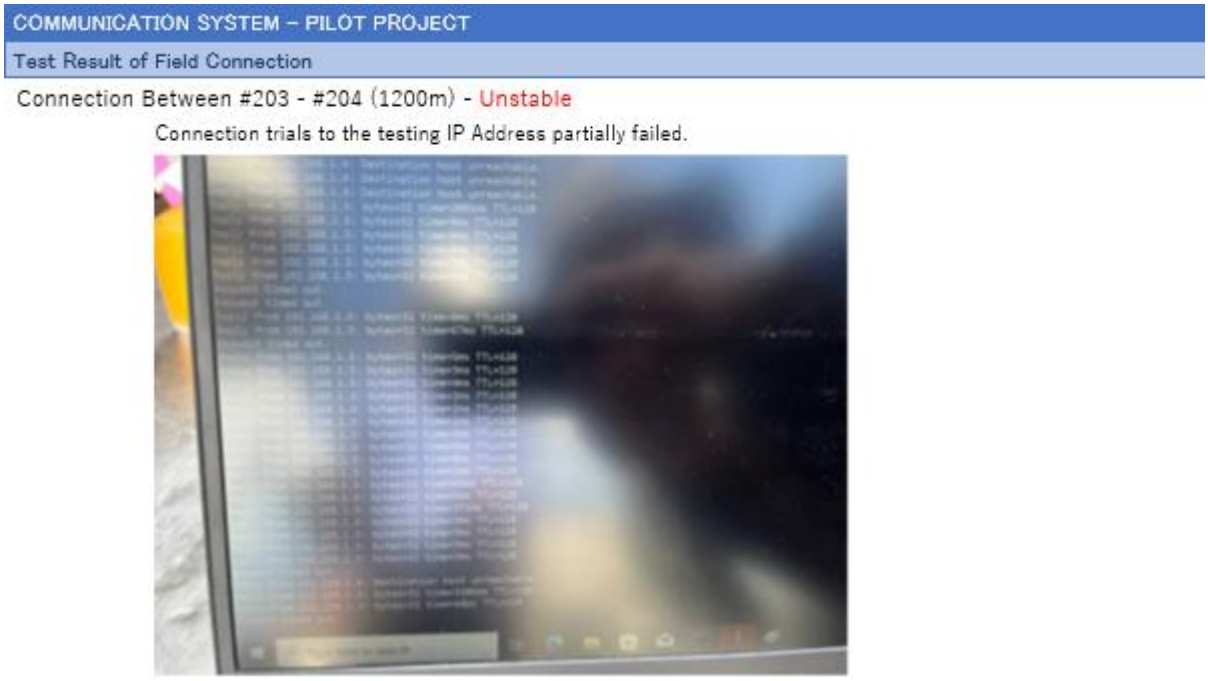


Figure 6.12 Test Result of Between #203 and #204 - Fail

6.5 The Construction of the Wireless Communication

The wireless equipment was properly installed at each site.

Figure 6.13 Route 1 Intersection #201

6.6 The Conclusion of Communication System

The additional intersection connected by wireless communication were properly included in the TCC system as displayed at TCC network monitor.

Figure 6.14 The Display of the Network Monitoring System at TCC

It was confirmed that it was able to monitor the network status for those added in pilot project and operate traffic signal configurations at TCC.

Findings

It was confirmed that the communication quality between #201 & #202 and #204 & 205 were unstable and causing traffic signal system disconnected frequently.
To avoid confusion of traffic, it was decided to turn off the #202 and #205 wireless connection. For better quality of the communication for those sites, the use of SIM with better grade can solve the issue.

Potential future applications

At the target intersections of this pilot project, there are only traffic signals, and no CCTV cameras are installed. Therefore, the volume of data transmission is relatively small. When 5G infrastructure is widely available, it is expected to become easier to send and receive large amounts of data such as images from CCTV cameras.

7. PILOT PROJECT WITH 3Es (ENGINEERING, EDUCATION AND ENFORCEMENT)

7.1 Introduction

To enhance the effectiveness of the pilot project, a road safety campaign was planned and implemented that took into account the 3Es (Engineering, Education and Enforcement).
The 3Es in this project are as follows:

E1: Road markings and road signs will be installed according to the designed signal parameters. In addition, damaged pavement will be repaired to ensure the safety of vehicle traffic at the intersection. →Completed as a pilot project by March 7, 2024.

E2: Traffic safety education for intersection users by distributing banners, pamphlets and flyers at the pilot project intersection.

E3: Enforcement of traffic violations by drivers at the pilot project intersection by Phnom Penh Traffic Police.

7.2 Implementing Organization

The campaign was implemented by the DPWT Road Safety Division, Phnom Penh Police, TCC staff and JICA experts. Phnom Penh Capital Administration (PPCA) and the JICA Cambodia Office supported various coordination with relevant agencies. In addition, National Road Safety Committee (NRSC, MPWT) confirmed Cambodia's traffic rules and provided accident data. The Cambodian Red Cross supported youth volunteers' participation. Furthermore, CAMSAFE produced the campaign materials such as printed banners, flyers, and road safety video clips.

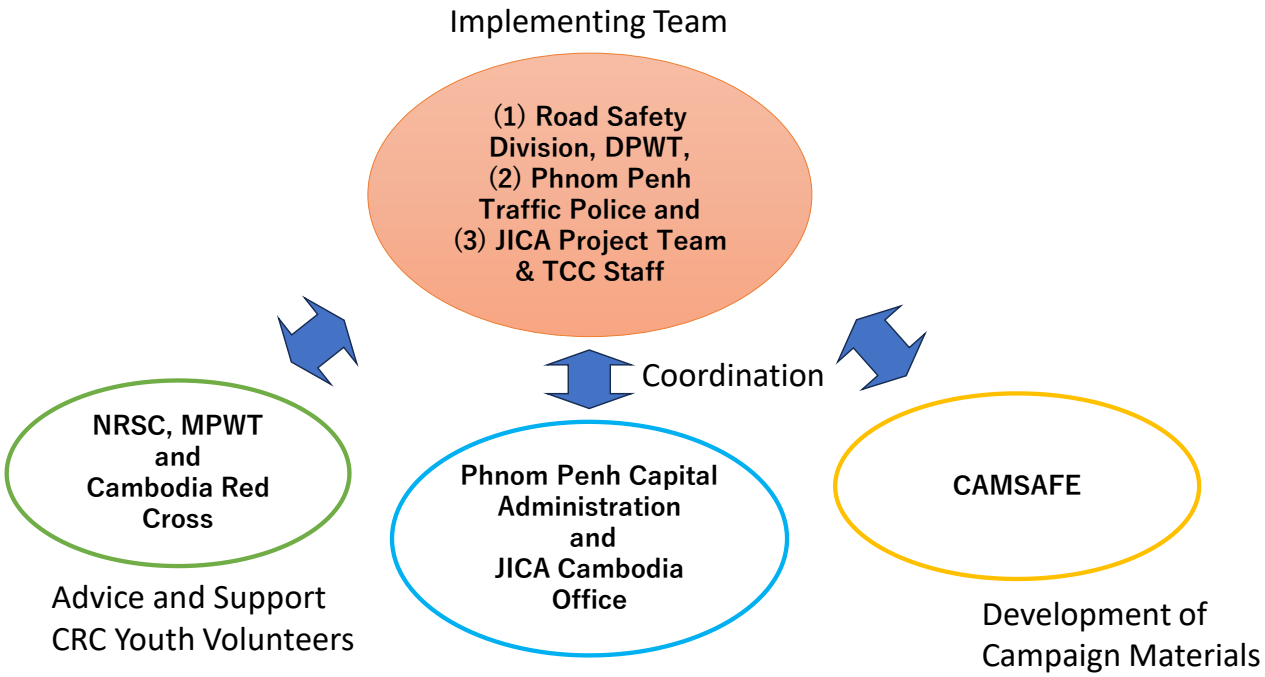


Figure 7.1 Campaign Implementing Organization

7.3 Location and Schedule of the Road Safety Campaign

The campaign conducted at six out of the seven locations where the pilot project was implemented, excluding the six intersections along NR No. 1, because, pilot project at six intersections along NR No. 1 was wireless connection and did not include intersection improvements. So, it was excluded from the direct traffic safety campaign. Refer to Figure 7.2.
The campaign schedule was set to be in late March (March 26-28, 2024) after E1: Engineering activities (signal installation and intersection improvement) were completed. This period also coincides with the Khmer New Year in April, when traffic accidents increase nationwide. Since road safety campaigns are more effective when this is conducted regularly and continuously, the campaign is planned to be conducted by the Road Traffic Safety Division of the DPWT in March and September every year (before Khmer New Year and before Pchum Ben) from 2025 onwards.

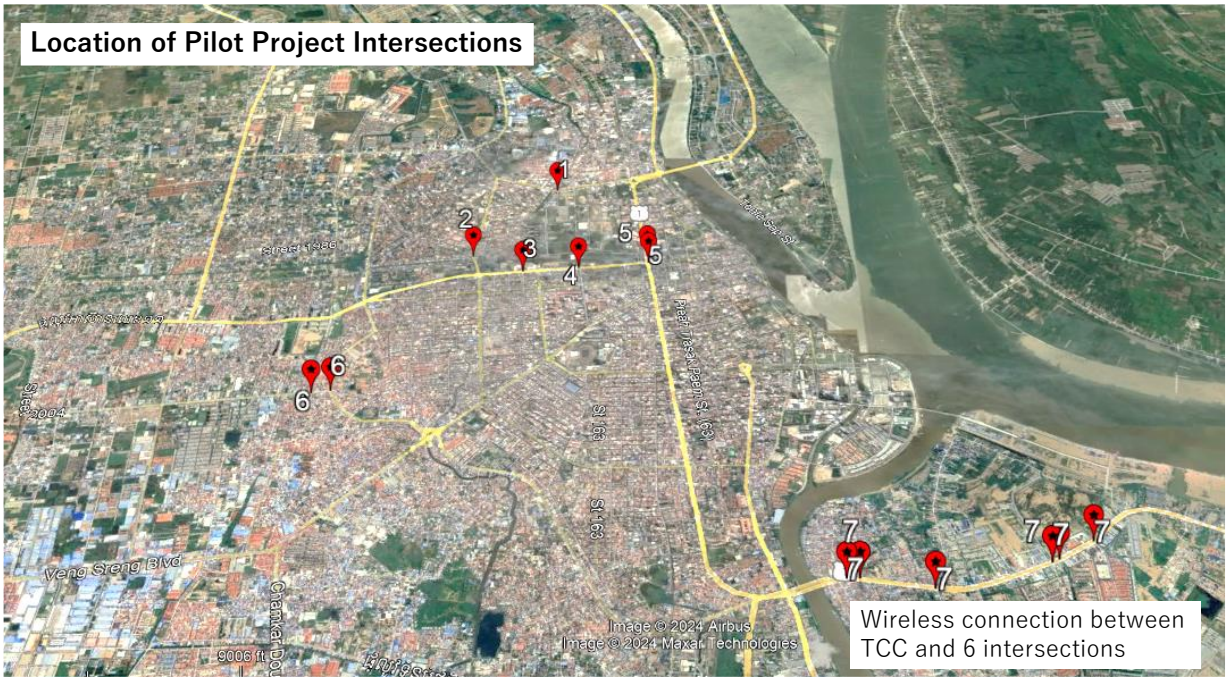


Figure 7.2 Location of Pilot Project Intersections

Table 7.1 Schedule of the Road Safety Campaign

Date	Time	Location # and Name		
March 26	7:00 - 10:30	1	#165	St. 70 corner Old Railway
	13:00 - 16:30	6	#167 & #59	Nokia & Solar
March 27	7:00 - 10:30	3	#28	Neakvorn
	13:00 - 16:30	2	#166	Toul Kouk Roundabout
March 28	7:00 - 10:30	5	#25 & #118	Bekase
	13:00 - 16:30	4	#126	Kdan Pir

7.4 Target Age Group and Vehicles

Age Group: Mainly 15 – 39 Years Old (Car and Motorcycle Users)
Primarily target of age group is young people (aged 15 to 39), who are high percentage of death in traffic accidents.

Vehicles, etc.: Motorcycles, Cars and Tuk-tuk including Pedestrian
The target vehicle types will mainly be motorcycles, which account for approximately 80% of traffic accidents, and private cars, which account for 5%; however, consideration will also be given to pedestrians (which account for around 8% of accidents).

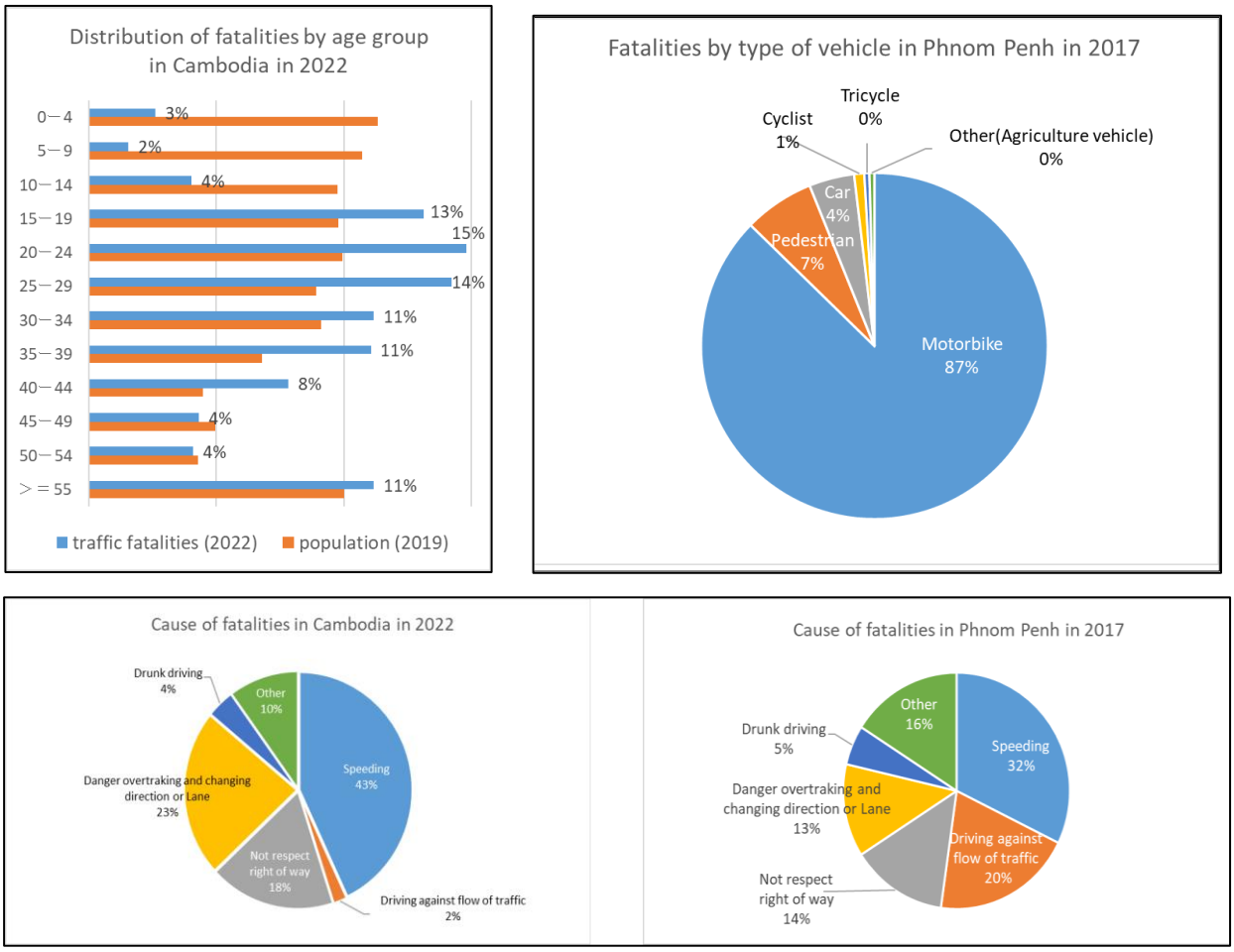


Figure 7.3 Characteristics of Traffic Accidents in Cambodia and in Phnom Penh

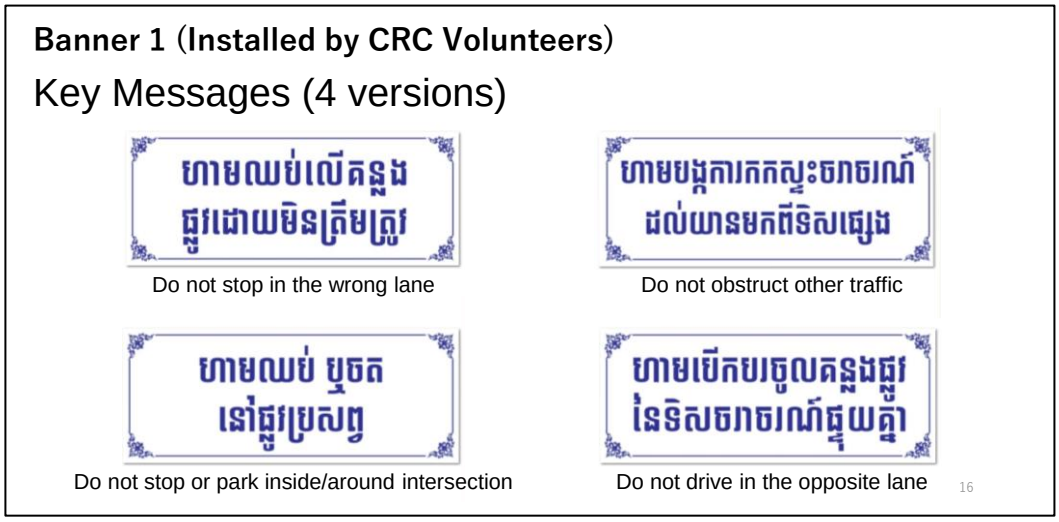
7.5 Campaign Catchphrase and Key Messages

Taking into account the traffic environment and characteristics of traffic accidents surrounding Phnom Penh, the catchphrase for the PPTMTC road safety campaign is "Follow Road Traffic Rules at Signalized Intersections for Your Safe and Smooth Drive".
Based on the campaign catchphrase, project team developed four key messages, as follows:

(1) Do not stop in the wrong lane, for example, waiting in the left turn lane for cars going straight,
(2) Do not interrupt with other vehicles,
(3) Do not park or stop in or around intersection, and
(4) Do not drive in the opposite lane.

7.6 Campaign Tools

Tool 1: Banner, Flyer and Education Materials
Banner 1



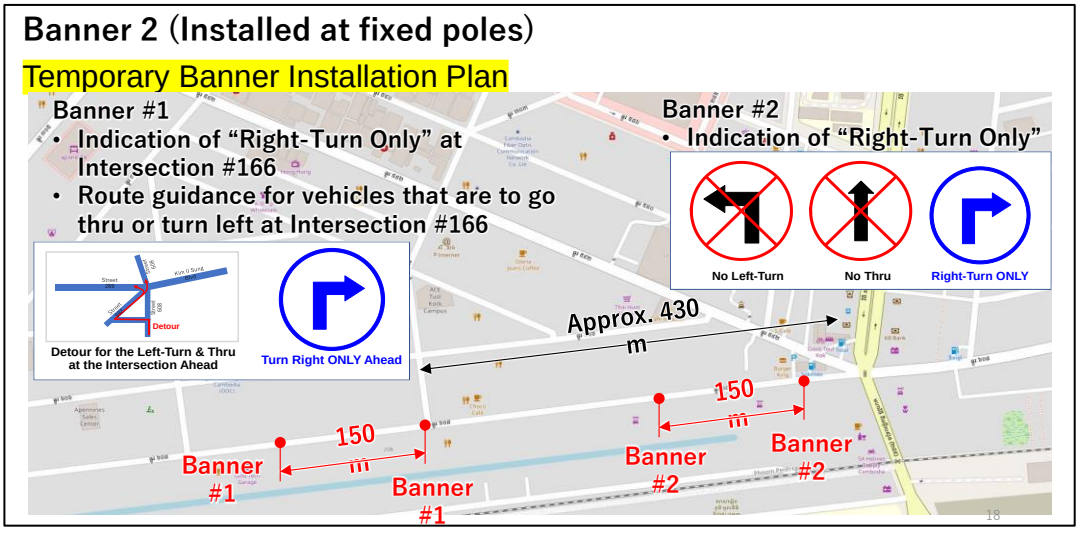


Figure 7.4 Banners

Flyer

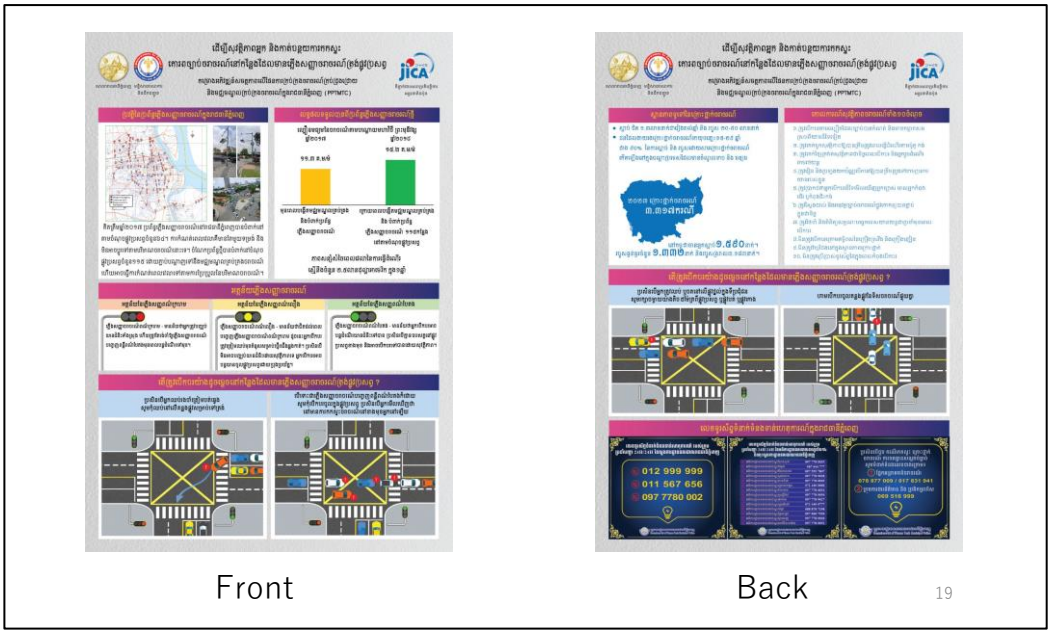


Figure 7.5 Flyer

Tool 2: Design of Video Clips for SNS (Website, X and YouTube)

(1) Phnom Penh Capital Hall
(2) JICA Cambodia Office

7.7 Campaign Activities

Activity 1: Installation of traffic signals and intersection improvement

Activity 2: Cambodia Red Cross Youth Volunteers

CRC student volunteers used loudspeakers to inform drivers on how to use the intersections properly and handed out flyers promoting traffic safety at the pilot intersections.

Activity 3: Traffic Enforcement by Phnom Penh Traffic Police Officers at Pilot Project intersections

7.8 Evaluation and Assessment of Traffic Safety Campaign

(1) Type of Vehicles with Driving license

Among all motorbike drivers, about 20% hold driving license, while 100% of car drivers have a driving license. And about 30% Tuk-tuk or Remork drivers have a driving license.

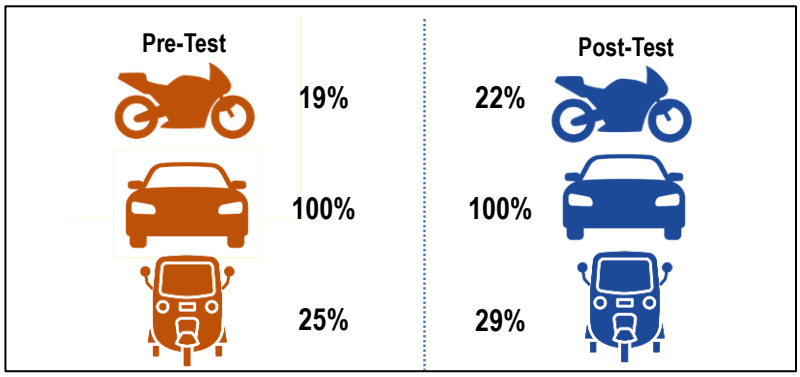


Figure 7.6 Type of Vehicles with Driving license

(2) Source of Information of Traffic Safety Campaign

(3) Comments and Opinion of Survey's Respondents

- It is help to reduce traffic jam and traffic accident
- Good message for reminding road users to drive safe and respect traffic law
- It will be better to do the campaign once a month
- Increase knowledge of public people on traffic law

8. EVALUATION OF THE PILOT PROJECT

8.1 Evaluation and Assessment of Traffic Safety Campaign

8.1.1 Evaluation 1: Traffic survey results

The evaluation was conducted by checking the changes in "travel speed," "congestion queue length," and "number of traffic law violators" through traffic surveys before and after the pilot project (before: April 2023 and after: April 2024). Please refer to Chapter 3 for details of the traffic survey results which are the basis for the evaluation.

(1) Travel speed

A travel speed survey was conducted on three major roads in the city center: Monivong, Charles de Gaulle, and Russia Blvd. The results showed almost no change, from 13.3 km/h in 2023 to 13.2 km/h in 2024. On the other hand, the total traffic volume during the morning and evening peak hours for the seven Pilot Project intersections (a total of eight intersections, but the #166 Toul Kork Roundabout was not included because it was blocked by VIP traffic) is as shown in the table below.

Table 8.1 Two-hour Traffic Volume in Morning and Evening Hour at 7 Pilot Project Intersections

Intersection	Year 2023	Year 2024	Increase rate of 24/23
Fringe of Central Area (#165＋#167＋#59)	28,081	32,568	15.98%
Central Area (#28＋#126＋#25＋#118)	54,912	56,097	2.16%
Total	82,993	88,665	6.83%

(Note) #165 has a new access road from the north, so most of the traffic is diverted from Route 5. Between #167 and #59, the traffic lights were not coordinated until 2023, so this intersection was congested and much of the traffic was dispersed to the surrounding narrow streets.

Based on the above, it is assumed that traffic volume in the Central Area in Phnom Penh increases by approximately 2%, which is the figure for "Central Area" in Table 8.1

(2) **Congestion Queue Length**

The average congestion queue length at the pilot project intersections was 40m (per entrance section of the intersection) in 2023, decreasing by 15.4% to 34m in 2024. This is assumed to be a direct effect of the 3Es activities (signal parameter revision, intersection improvement, and traffic safety campaign) at the pilot project intersections.

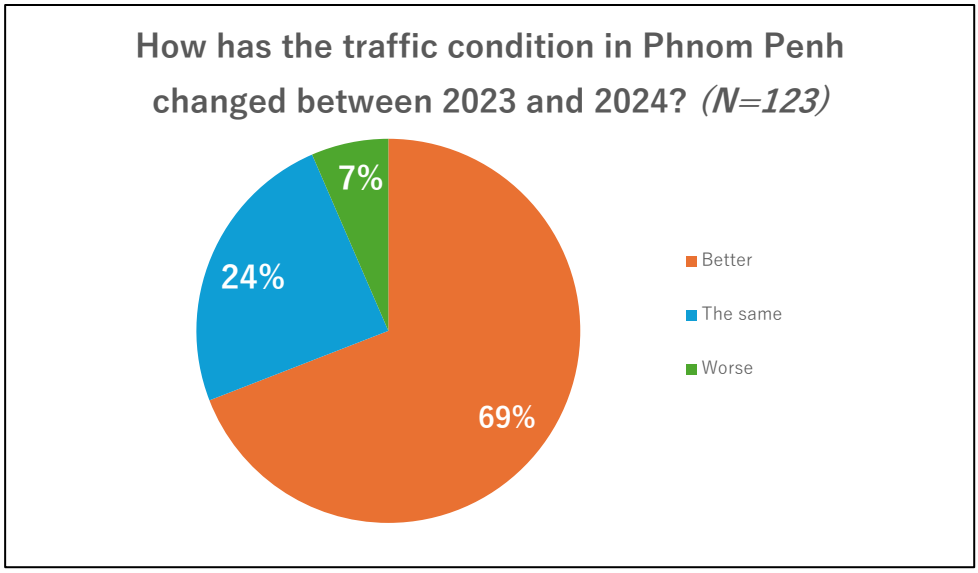
(3) **Number of Violators of Traffic Laws**

At the Pilot Project intersections, the number of drivers who "fail to follow traffic signals" or "fail to follow road markings and signs" decreased by 21.1%, from 1,592 per intersection in 2023 to 1,256 in 2024. This is partially due to the road safety campaigns of the pilot project intersections, but it is also assumed that the daily efforts of the DPWT Road Safety Division, NRSC, and MPWT, as well as the support of donors such as ADB and WHO, are also major factors to reduce Traffic Law violators.

8.1.2 Evaluation 2: Results of a questionnaire survey of participants of the PPTMTC Pilot Project Seminar

A questionnaire survey of participants of the PPTMTC Pilot Project Seminar held on 08 August 2024 asked about changes in traffic conditions in 2023 and 2024. Approximately 170 people participated in the seminar, including government officials from PPCH, DPWT and MPWT, police, students, Phnom Penh residents, and donors. The survey covered a wide range of topics, including the seminar contents; as the final question, the participants were asked about "changes in traffic conditions in 2023 and 2024" (123 people responded to this question). The results are shown in the figure below, with 69% of participants answering that "traffic conditions improved in 2024 compared to 2023," 24% answering that "there are no significant changes in traffic between 2023 and 2024," and 7% answering that "it becomes worse."

When participants who answered "improved" or "no change" were asked the reasons they answered that way, many of them answered, "Traffic volume increased in 2024 compared to 2023, but traffic has improved overall due to progress in both hard and soft traffic measures (development of traffic infrastructure and traffic safety education, etc.)."



Source: PPTMTC Pilot Project Seminar Questionnaire Survey Results

Figure 8.1 How traffic conditions in Phnom Penh have changed between 2023 and 2024

8.2 Conclusion

From the above, the traffic survey results and stakeholder comments on the traffic conditions can be said to be as follows:

- There was a slight increase (2%) in traffic volume in central Phnom Penh in 2023 and 2024.
- There was almost no change in travel speed in central Phnom Penh (around 13 km/h).
- Congestion queue length and the number of traffic rule violators at the pilot project intersections decreased by 15% to 20%. Looking at the changes in traffic conditions throughout the city, traffic volume increased slightly, but there was no significant change in travel speed; congestion length and number of traffic rule violators also decreased. This suggests that the pilot project by the PPTMTC's 3Es has contributed to this effectiveness, but the daily efforts of the DPWT Road Safety Division, NRSC, and MPWT, as well as the support of donors, such as ADB and WHO, are also major factors in the results. However, under Cambodia's current Road Traffic Law, motorcycle users under 125cc do not need a license, so 80% of motorcycle users, who account for 70% of road traffic, are unlicensed. To create a safer and more comfortable traffic environment, a major challenge is how to provide traffic safety education to as many motorbike users as possible.

ANNEX4: Traffic Control System Expansion Plan

Project for Capacity Development on Comprehensive Traffic Management Planning and Traffic Control Center Operation and Maintenance in Phnom Penh Capital City (PPTMTC)

Traffic Control System Expansion Plan

February 2025

Japan International Cooperation Agency
(JICA)

Mets Research & Planning, Inc.
International Development Center of Japan
Oriental Consultants Global Co., Ltd.

Table of Contents

1. INTRODUCTION

1.1 Background of the PPTMTC Project

By covering not only central Phnom Penh but also the rapid urbanized suburbs with the traffic control system, safer and smoother traffic flow will be ensured. And this contribute to the revitalization of Phnom Penh and the improvement of the urban environment. Preconditions for considering the expansion area of the traffic control system.

(1) Urbanization has spread to 216.6ha in the suburban areas, and if a traffic control system were to be established in these urbanized suburban areas, it would need to cover an area 7.6 times larger than the 28.4ha in the central Phnom Penh (PP) where the current traffic control system is in place.

(2) On the other hand, the road network in suburban areas is less dense but more varied than in the central PP.

1.2 Traffic control system in Phnom Penh: Current Status and Future Considerations

The city center of Phnom Penh utilizes an advanced, comprehensive traffic control system. This system features real-time signal adjustments based on current traffic conditions and coordination between multiple traffic signals, significantly contributing to efficient urban traffic management.
Traffic Control Center (TCC) is staffed by specially trained professionals who are responsible for continuous monitoring of traffic congestion, swift detection of faulty equipment, and immediate response to emerging traffic issues. During this project, TCC staff were instrumental in optimizing and improving signal operations. The valuable insights and experience gained through this process will benefit future traffic management solutions.
In contrast to the city center, suburban traffic signals are independently managed by the Department of Public Works and Transport (DPWT). These signals are not connected to the central traffic control system, resulting in functional limitations and efficiency challenges compared to city-center signals. As suburban areas continue to urbanize, it is anticipated that traffic management challenges in these areas will become more pronounced, and the disparity between city center and suburban traffic management may increase.

To address these challenges and improve overall traffic management in Phnom Penh, it is recommended to conduct a comprehensive review of the entire traffic control system. This review should consider both technical integration of systems and management structures, as well as reassess role distribution among various entities involved in traffic management. Implementation of these recommendations is expected to optimize traffic flow across the entire city, enhance overall road safety, and improve the efficiency of urban mobility in Phnom Penh.

2. CURRENT SITUATION

2.1 Characteristics of the Suburban Area

In Phnom Penh, population growth and urbanization have been significant, with approximately 40% of the city urbanized as of 2020. Three distinct suburban areas have developed surrounding the urban core. Each of these areas has access to national roads that connect to the city center and is linked by a ring road. Given these circumstances, an increasing number of traffic signals will be required in suburban areas in the future.

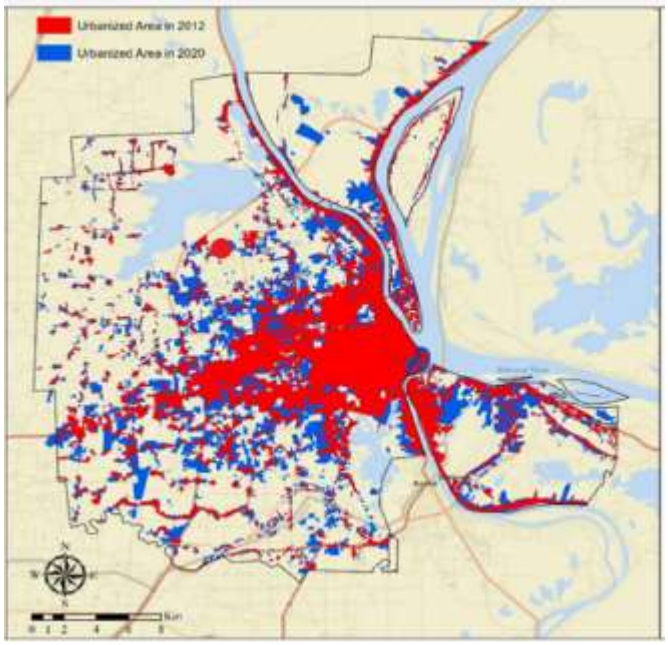


Figure 2.1 Built-up area(2012 and 2020)

2.2 Characteristics of the each Area

The suburban areas can be classified into three regions: northern, western, and southern. The characteristics of each region are as follows:

(1) Northern Area (Major Roads: National Road 5 and 6)
- The density of intersections is low.
- Residential development is prominent.

(2) Western Area (Major Roads: Veng Sreng Boulevard, National Road 3 and 4)
- This area provides access routes from the city center to the current airport.
- This area is characterized by the intersection of significant east-west and north-south roads.

(3) Southern Area (Major Road: National Road 2)
- Construction of roadways connecting to the new airport is underway.
- The density of intersections is low.

(4) Common Characteristics of Suburban Areas
- Each traffic signal operates independently.
- The distance between traffic signals is considerable.
- There is no integrated road network.
- Urban development is progressing everywhere.
- Major roads serve as routes for public transportation.

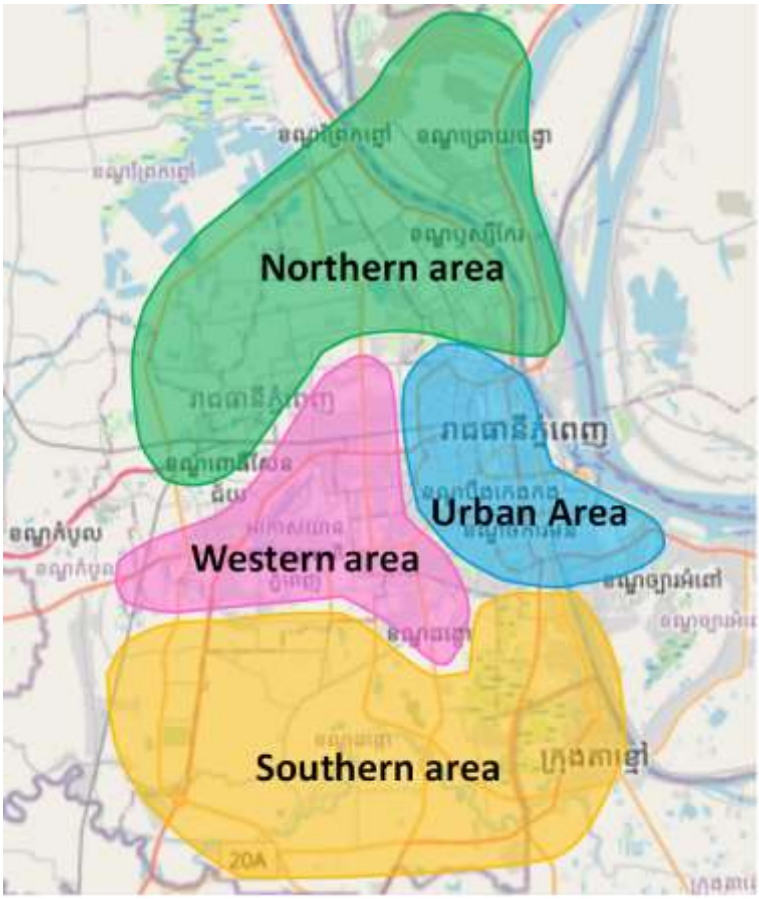


Figure 2.2 Zoning map of suburban area

2.3 Issues in the Suburban Area

The suburban areas have different issues compared to the well-developed city center.

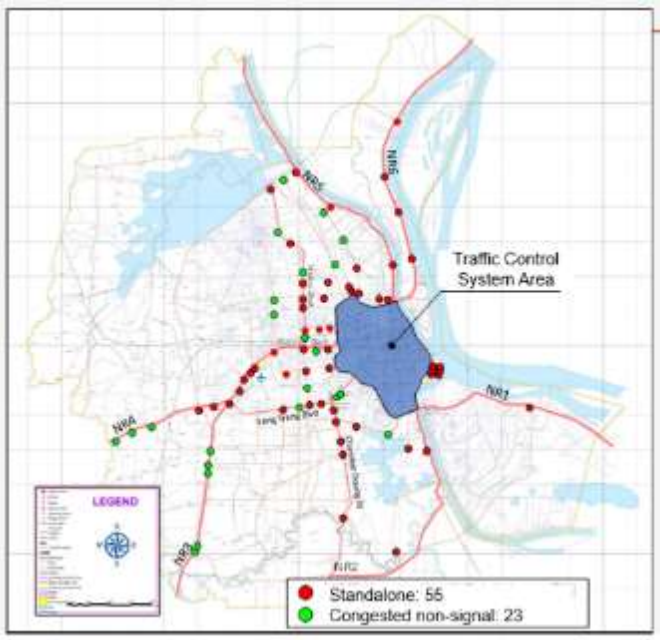


Figure 2.3 Urbanozation area in Phnom Penh

(1) Traffic Signal Display

Various types of traffic signal displays exist. Non-uniform signal displays can lead to confusion among drivers.

Figure 2.4 Traffic signal display

(2) Unclear Road Marking

There are many intersections with unclear lane markings, crosswalks, and yellow boxes.Road markings at most signalized intersections are unclear.

Figure 2.5 Unclear road markings

(3) Problematic Traffic Management

There are stop signs remaining at signalized intersections and traffic signs facing the wrong direction.

Figure 2.6 Problematic traffic management

(4) Equipment Malfunction
There are pedestrian signals that are off, countdown timers, and traffic lights with poor visibility.

Figure 2.7 Malfunctioning traffic signal

(5) Poor Road Conditions
There are intersections with poor drainage and intersections with very poor road conditions.

Figure 2.8 Poor road condition

(6) Traffic obstraction
There are many locations where the central divider is open to provide access to narrow streets. While convenience is high, there are cases where conflicts with main traffic and queues of U-turning vehicles cause obstructions to traffic.

Figure 2.9 Traffic obastraction

(7) Stagnation of Public Bus Users
The main routes in the suburban areas have become bus routes. However, the number of bus users has stagnated.

Figure 2.10 Public bus in suburban area

2.4 Desired Functions in Suburban Areas

(1) Standardization of Traffic Signal Displays
It is desirable for traffic signal displays to be standardized with the same specifications throughout the city. In suburban areas, the display standards of nearby traffic signals differ, and they are also different from the signals in the city center that are connected to the traffic control system. The traffic signals in the city center should be used as the standard specification, and consistent traffic signals should be installed.

(2) Coordinated Signal Control
Each traffic signal operates independently, making it impossible to coordinate control across multiple intersections. By introducing coordinated signal control for traffic signals along the same route, traffic flow can be improved, and this system can effectively help alleviate congestion.

(3) Intersection Improvement
Most intersections lack clear road markings and have incomplete traffic signal installations. A comprehensive approach to intersection improvement is recommended, encompassing signal phasing optimization and the implementation of proper road markings.

(4) Prioritization of Route Buses
To increase the number of public transport users, it's important to ensure punctuality and improve convenience. By expanding the system, it becomes possible to implement traffic measures for buses, such as priority lanes and signal priority during peak hours.

(5) Maintenance Management
There are cases where equipment that has broken down due to aging is left unattended. Just as in urban areas, the scope of maintenance will be expanded by implementing monitoring and regular inspections using the traffic management system.

3. SIGNALIZED INTERSECTION PLAN

3.1 Signalized Intersection Plan

As of January 2024, there are 186 signalized intersections in Phnom Penh, of which 118 are in the central PP and 68 are in suburban areas. DPWT plans to build 25 new signalized intersections in suburban areas where urbanization is progressing. The PPTMTC project, a JICA-TCP project that began in 2022, proposed 38 new signalized intersections. The above plans and proposals were consulted at a coordination meeting (held on January 25, 2024) inviting representatives from Khans, mainly from suburban areas, and 19 additional signalized intersections were requested. In light of the above, the PPTMTC project decided to focus on 268 signalized intersections as part of the suburban expansion of the traffic control system.

Table 3.1 Number of signalized intersections plan(As of January 31, 2024)

Control System		Management Body	No. of Intersections	Remarks
Existing	Centrally Control	TCC/DPWT	118	109 (Central Area) 6 (Along NR No. 1) 3 (Pilot Project)
	Pre-time Setting	Public Lighting/DPWT Standalone	68	70 (Existing) 2 Relpaced by PPTMTC PP
	Sub Total		186	
Plan	DPWT		25	2021 - 2023
	JICA-PPTMTC		38	Proposed
	Requested by Khan		19	By Coordination Meeting held in 25 Jan. 2024
	Sub Total		82	
Grand Total			**268**	

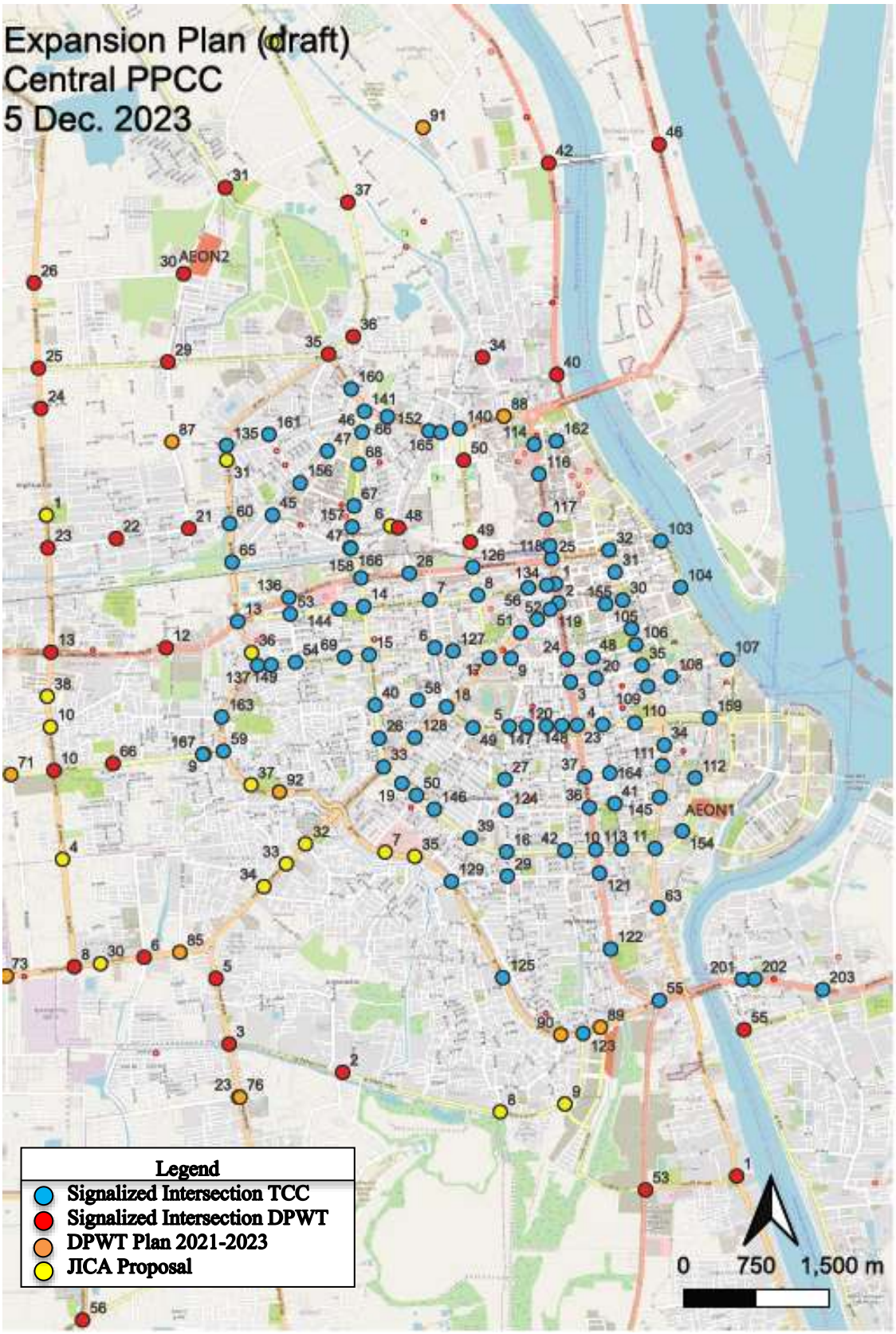


Figure 3.1 Location of signalized intersections plan (Central Phnom Penh)

Figure 3.2 Location of signalized intersections plan (Suburban Area)

4. SIGNAL CONTROL SYSTEM

4.1 System Update Cycle

All products have a lifespan, and traffic control systems are no exception. The bathtub curve (Figure 4.1) represents the life cycle of a product: a high initial failure rate, followed by a stable operational phase, and then an increase in failures due to wear and tear. The Traffic Control Center (TCC) has been in operation for five years since its launch in 2019 and is currently stable. However, in the future, it may face performance degradation and security risks.
IT systems typically require planned updates, including hardware renewals, software upgrades, and the application of security patches. However, since Phnom Penh's traffic control system lacks a clear update plan, it should consider system updates alongside plans for expansion to suburban areas.
Japan's update cycle of every five years can be a benchmark, but ideally, updates within 15 years are recommended.

Figure 4.1 Bathtub Curve

4.2 Lesson Learnt from Other Country (In the case of Metro Manila, Philippines)

The lifespan of a Japan-made traffic control system is about 15 years, and the Japan-made Panasonic traffic control system in Manila, Philippines operated for 14 years from 1980 to 1994. Manila's Panasonic traffic control system mainly stopped operation due to the discontinuation of production of spare parts and other products.

Table 4.1 History of the Metro Manila Traffic Signal System (1981 – 2024)

PHASE	Implementation		Agency	Funding		No of	Traffic Control		Controller	Manufacturer /
	From	To	Responsible	Source	Amount	Int.	System	Country		Supplier
Planning & Design	1977	1980	TEAM PH-1							
Phase I	1980	1982	MPWH TCC	IBRD/WB	US$5.8M	134	ATC	Japan	NEMA TSI National	Matsushita Elec
Phase II	1984	1987	DPWH-TCC	OECF-Japan	3.86B Yen	170	ATC	Japan	NEMA TSI-National	Matsushita Elec
Phase III	1989	1994	DPWH-TEC	OECF-Japan	4.61B Yen	131	ATC	Japan	NEMA TSI-National	Matsushita Elec
Renewal of System										
Phase IV (P&D)	1993	1994	DPWH TEC							
Phase IV (Imp.)	1998	2002	MMDA TEC*	EFIC AUS	US$22.8M	419	SCATS	Australia	Delta 5	AWA Plessey
Upgrading/System Replacement										
Phase 1	2012	2017	MMDA-TEC**	Local	P295.26 M	98	Hermes	Spain	RSIM	Indra
Phase 2	2014	2018	MMDA TEC	Local	P395.78 M	161	Cosmos	Korea	Korean LC	Keon A Info Tech
Phase 3	2015	Terminated	MMDA TEC	Local	P390.39 M	155	Cosmos	Korea	Korean LC	KYUNG BONG CO. LTD.
Phase 4	2017	2021	MMDA-TEC	Local	P229.00 M	48	Cosmos	Korea	Korean LC	Easy Traffic
Phase 5	2018	2024	MMDA-TEC	Local	P292.33 M	49	Cosmos	Korea	Korean LC	Easy Traffic
						506				

* Transfer of TEC Operation & Maintenance to the MMDA Aug. 15, 1998 (Verify)
** Transfer of TEC whole office Feb. 2003

For these reasons, it is important for TCC staff to use the current system effectively for the next ten years (2035) and completion of renewal of Phnom Penh's traffic control system is also 10 years later, at least in 2035.

4.3 History and Roadmap to the Next Stage

Overview of the history of Phnom Penh's traffic control system summarized in Figure 4.2 and 4 stages as below.

Stage 1 (Master Plan: 2012 – 2014)
Traffic Control System was proposed one of the Short-term Action Plan.

Stage 2 (Japan Grant Aid: 2015 – 2018)
Traffic Control System with 109 signalized Intersections approved Implementation by Japan Grant Aid

Stage 3 (TCC Management 1: 2019 – 2021)
Technical Cooperation Project (TCP) may be started from 2019; however, because of COVID-19, TCP was postponed and TCC staff were tasked with operation and maintenance of the traffic control system by themselves.

Stage 4 (Technical Cooperation Project: 2022 - 2024)
The experience gained from Stage 3 and Stage 4 has enabled TCC staff to operate and maintain the Phnom Penh traffic control system themselves, as well as installed new signalized intersections.
Based on the system update cycle, lesson learnt from other country and history of the Phnom Penh traffic control system, next stage is divided into 3 aera as below.

Stage 5 (TCC Management 2 and Preparation for new system: 2025 – 2030)
Improvement of 10 problematic intersections will mainly be covered by TCC themselves based on the experience of stage 3 and 4.
At the same time, it is necessary to discuss the basic concept of the new traffic control system and start installation work of new traffic control system in 2030.

Stage 6 (Transition from current to new: 2030 – 2035)
This is a construction period for the new traffic control system. There will be a period of coexistence of the existing and new traffic control systems, but this should be minimized.

Stage 7 (New system mainly managed by TCC: 2035 –)
Completion of new traffic control system and will start operation at least in 2035.

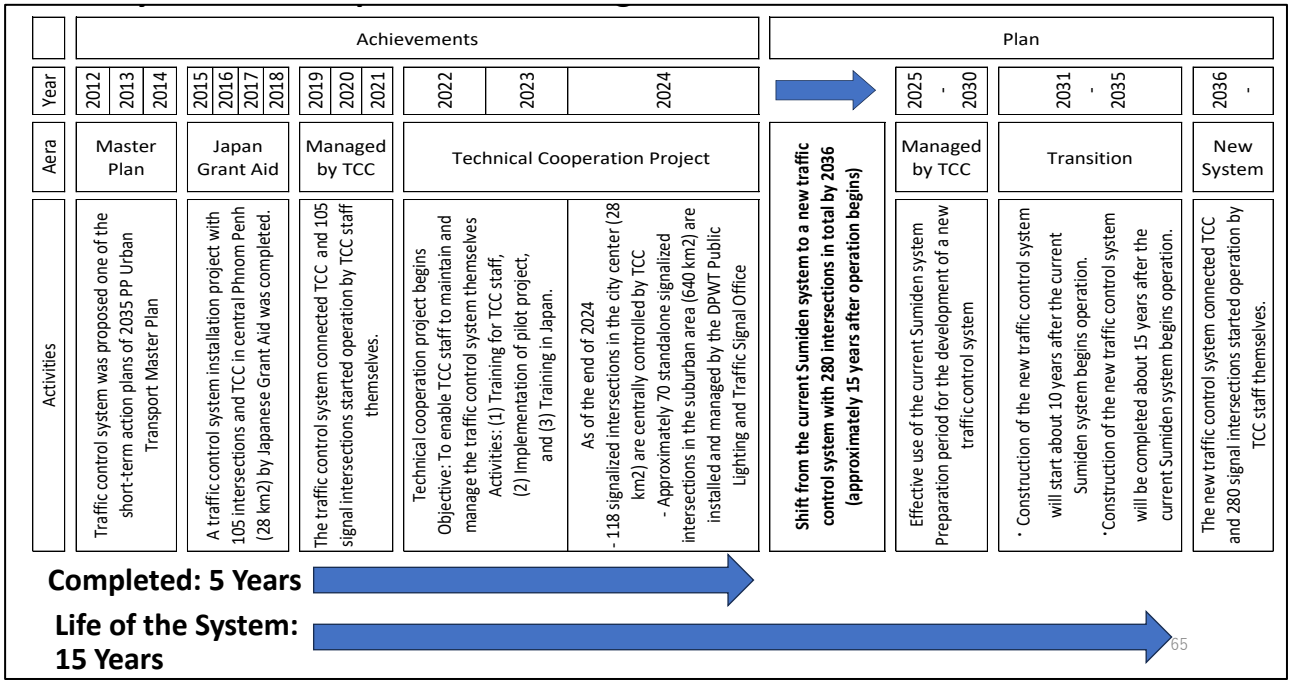


Figure 4.2 History and Roadmap to the Next Stage

4.4 Tasks to Complete before the System Update

Updating the traffic control system before the current system reaches the end of its lifespan is recommended. A 15-year update cycle is suggested, with the existing system maintained until then. After 15 years, integrating both urban and suburban areas into a single, new traffic control system is ideal. In the meantime, signalized intersections in suburban areas will remain independent from the main traffic control system. Issues can be addressed by standardizing signal displays, improving intersections, and replacing local controllers with those that have coordination capabilities. Choosing local controllers that are compatible with the existing system is advised to enable future integration with the traffic control system.

4.5 Scenarios to the Next Step to the System Update

4.5.1 Alternative Study

Considering the lifespan of Japan's traffic control system, examples from other countries, and the history of Phnom Penh's traffic control system, the following three Alternatives are made for the replacement of current traffic control system.

Alternative 1: The traffic control system in Phnom Penh has a capacity of 512 local controllers and can accommodate existing and planned expansion (186 + 82 = 268), so Alternative 1 is technically possible with provision of communication system (optical fiber cable, etc.). However, with the current spare parts problem of the present system, this may not be possible without utilization of a different controller or system to maintain or change any controller that ran out of major spare parts. Each controller that is replaced with a different brand of controller will become stand alone.

Alternative 2: Is more viable than Alternative 1 in the sense that the new manufacturer can change or repair any controller that may be down and cannot be repaired due to spare parts problems. However, as stated in the figure, Alternative 2 has the disadvantage of having 2 systems in the same city with only 268 signalized intersections including the proposed expansion during the transition period to the new system.

Alternative 3 is the simplest scheme in increasing the number of signalized intersections with the disadvantage that it cannot be collectively controlled by the TCC. Another setback is that the problem of spare parts of the existing system remains and every intersection that may be down and replaced will have to be a standalone controller like Alternative 1.

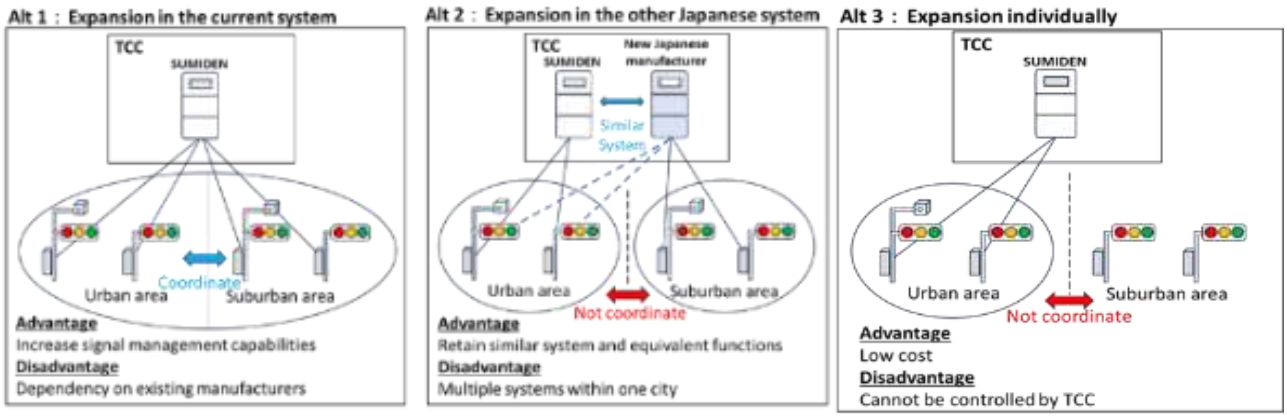


Figure 4.3 Outline of the 3 Alternatives for the Replacement of Current Traffic Control System

Recommended Alternative

TCC has become an essential system for managing traffic in Phnom Penh, and expansion to the rapidly developing suburban areas is necessary. While expanding the system, it is also important to make it sustainable and cost-effective. Since TCC is a continuously operating system that cannot be interrupted, it requires annual running costs and regular updates. A system should be built that is financially feasible in the long term. Under these conditions, Alternative 2 is considered the best fit for Phnom Penh's city size and traffic environment. In the suburbs, where most intersections do not require advanced functions except for a few congested ones, limited functions are suitable for future Phnom Penh.

4.5.2 Activities by Stage

The activities for each stage of Alternative 2 are shown in Table 4.4, and the replacement of the existing system will be completed by 2035.

Table 4.4 Activities by Stage (From Current System to Other Japanese Traffic Signal Manufacturer)

Stage *Refer to Fig. 4.2	STAGE 3 & 4 (Until 2024)	STAGE 5 (2025 – 2030) Managed by TCC Period	STAG 6 (2031 – 2035) Transition Period	SAGE 7 (After 2035) Completion of Replacement
Descrip-tions	・Under Current system	・If current system will stop their service to Phnom Penh, another Japanese signal maker will be used to respond to the existing traffic control system. ・For tis stage (next 5 years), the SUMIDEN central server still will be used in the urban area. ・In the case of malfunction of spare parts in controller, it is necessary to replace whole controller of another signal maker's in the central Phnom Penh. Quality control is performed under the Japanese MODERATO system for compatibility with other companies in Japan. ・Problematic intersections in suburban areas will be replaced by the other signal maker's stand-alone traffic signals. At the same time, intersection improvement and other issues will be considered in collaboration with relevant offices under DPWT. ・At the same time, it is necessary to consider the replacement of current system and hopefully year 2030 will start the construction of the replacement system	・Replacement to other signal maker's system from current traffic control system within 3 to 5 years at least before 2035. ・During this period, the central systems of current and another signal maker will coexist. ・Basically, almost all signalized intersections in Phnom Penh will be under another signal maker's system at least before 2035.	・Under new another signal maker's system

4.5.3 How to Proceed to the Next Stage of the Phnom Penh Traffic Control System

Stage 3&4 (Until 2024)
Five years have passed since the TCC started operating, and it has been functioning without major issues. Traffic signals in urban areas are controlled by TCC. Traffic signals in suburban areas are standalone signals installed by DPWT.

Stage 5 (2025 – 2030)
Critical intersections in suburban areas will be upgraded to the same standard of traffic signals as those in the urban areas. When a failure occurs in the existing system, it is restored using spare parts or replaced with new controllers.

Stage 6 (2031 – 2035)
Construct a new system and connect standalone traffic signals in the suburban areas. At the same time, replace the traffic signals urban area and switch their connections to the new system. This period will serve as the transition from the existing system to the new system

Stage7 (After 2035)
Traffic signals in suburban areas will be upgraded, and the majority of traffic signals in Phnom Penh Capital will be controlled by the new TCC system.

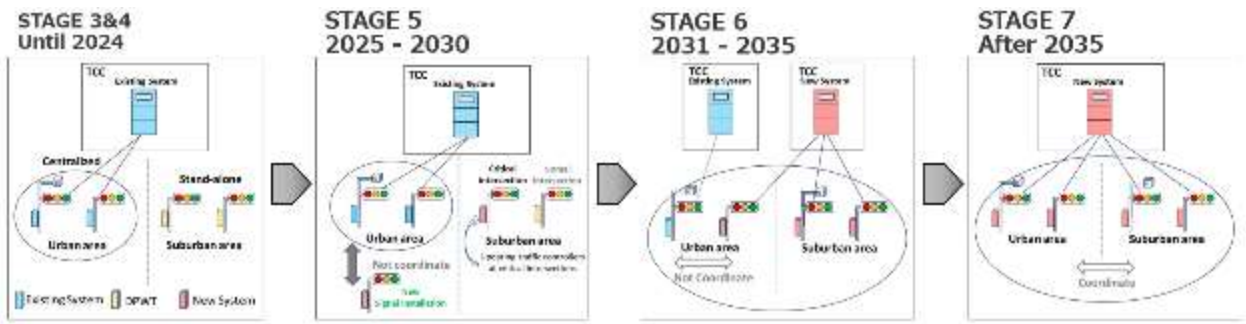


Figure 4.4 How to Proceed the Next Stage of the Phnom Penh Traffic Control System

4.5.4 Number of Signalized Intersections in the Traffic Control System Expansion Plan (2019 – 2035)

Indicating the intersections that will be down due to spare parts problem and gradually replaced with the controller of the new manufacturer.

- The year 2025 is for the review, assessment, and approval of the PPTMTC'S project completion or end report.
- Improvement of problematic standalone intersections located in the western suburban area with rapid urbanization is going-on just after the completion of the PPTMTC project (refer to Section 4.6).
- Discussion, negotiation, planning, design & procurement can be targeted up to 2030.
- Upgrading of all PLTSO controllers, signal installation of new intersections on the expansion plan and replacement of all current controllers, to complete in 5 yrs., or up to 2035.
- Upgrading of 68 standalone signals of PLTO – 1 to 1.5 years in two stages with the first stage – upgrading of standalone controllers, and second, the installation of new signals.
- Replacement of current controllers gradually until the end of practical life in 2035 (16 yrs. from start of full operation in 2019).
- The 82 planned suburban signals expansion by DPWT, JICA, and requested by Khans will be installed by the new manufacturer until completed in 2035 during which the existing system have all been replaced. Hence by 2035 there will be one system for the central and suburban areas.
- There are some intersections (approx. 8 remote intersections) that are isolated and far from other groups but are included in the planned expansion. Because these intersections will not affect the synchronization of signals, they can remain as "standalone".

The figures used in the above analysis are as of January 2024. Currently, a new Technical Cooperation Project including revision of 2014 PPUTMP launched in Phnom Penh starting from 2024. Additionally, the Urban Planning Division in Phnom Penh Capital Administration is currently reviewing its PPCA Land Use Plan for 2030 with assistance from France, which was provided in 2009 as "White Paper". After the revision of above plans, number of proposed signalized intersections will be revised accordingly.

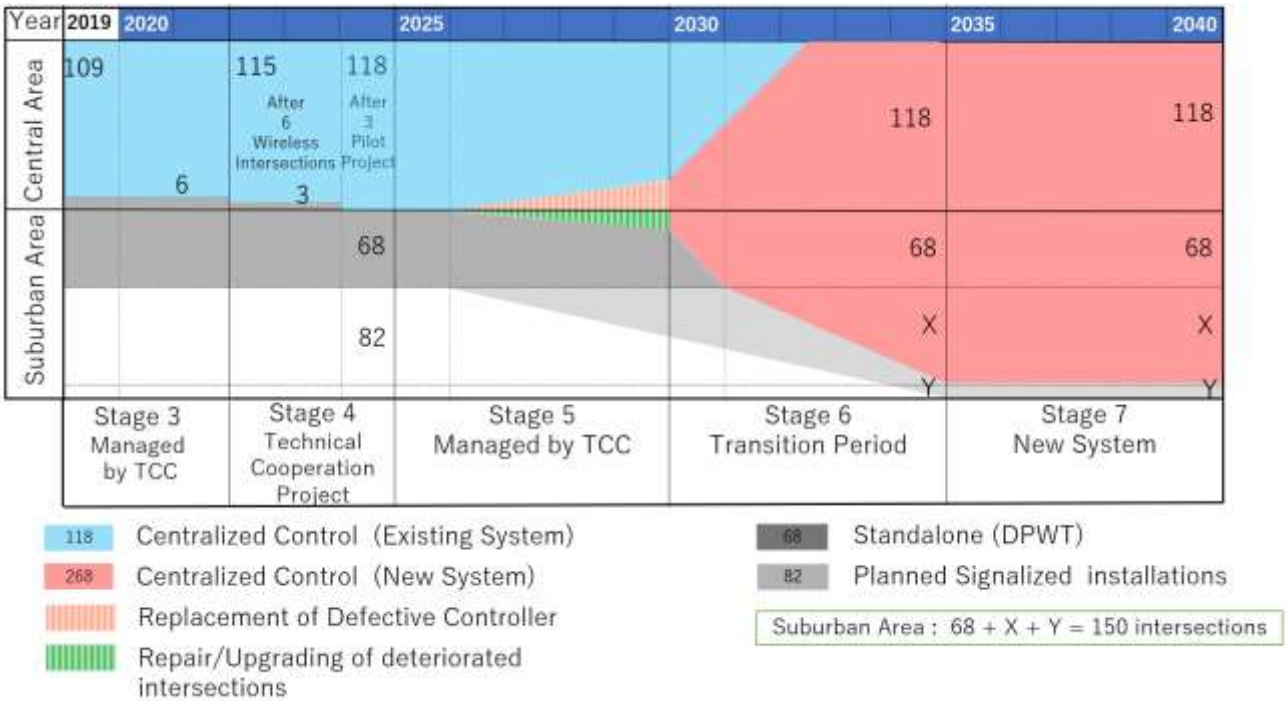


Figure 4.6 Proposed Staging of Traffic Signal Development in Phnom Penh

4.6 Priority Tasks

Stage 5(2025-2030)

Expand into the rapidly urbanizing western area, focusing on major arterial roads such as Russian and Veng Sreng Blvds. Considering the current traffic situation and future growth, it is desirable to control these areas with the traffic control system as soon as possible. It is recommended to prioritize critical intersections where congestion occurs first. Congested intersections in this area are shown in Figure 4.7.

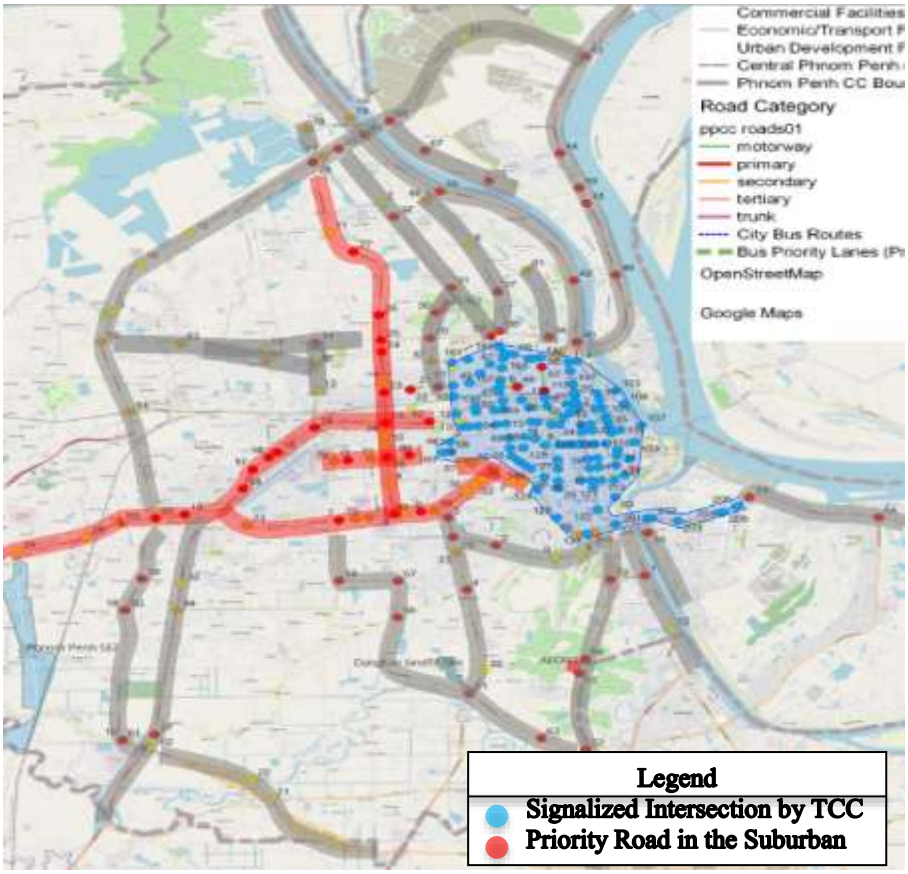


Figure 4.6 Priority Area Map

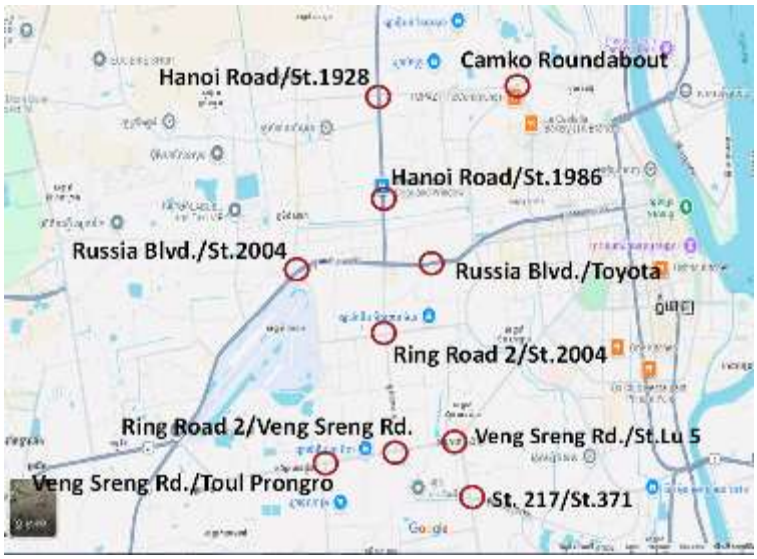


Figure 4.7 Congested Intersections in the Western Area

Stage 7(After 2035)

Ultimately, the system will be extended to National Roads 1, 2, 5, 6, and the ring road. This will enable control of Phnom Penh's main arterial roads from the TCC, expected to improve traffic flow between the urban and suburban areas.

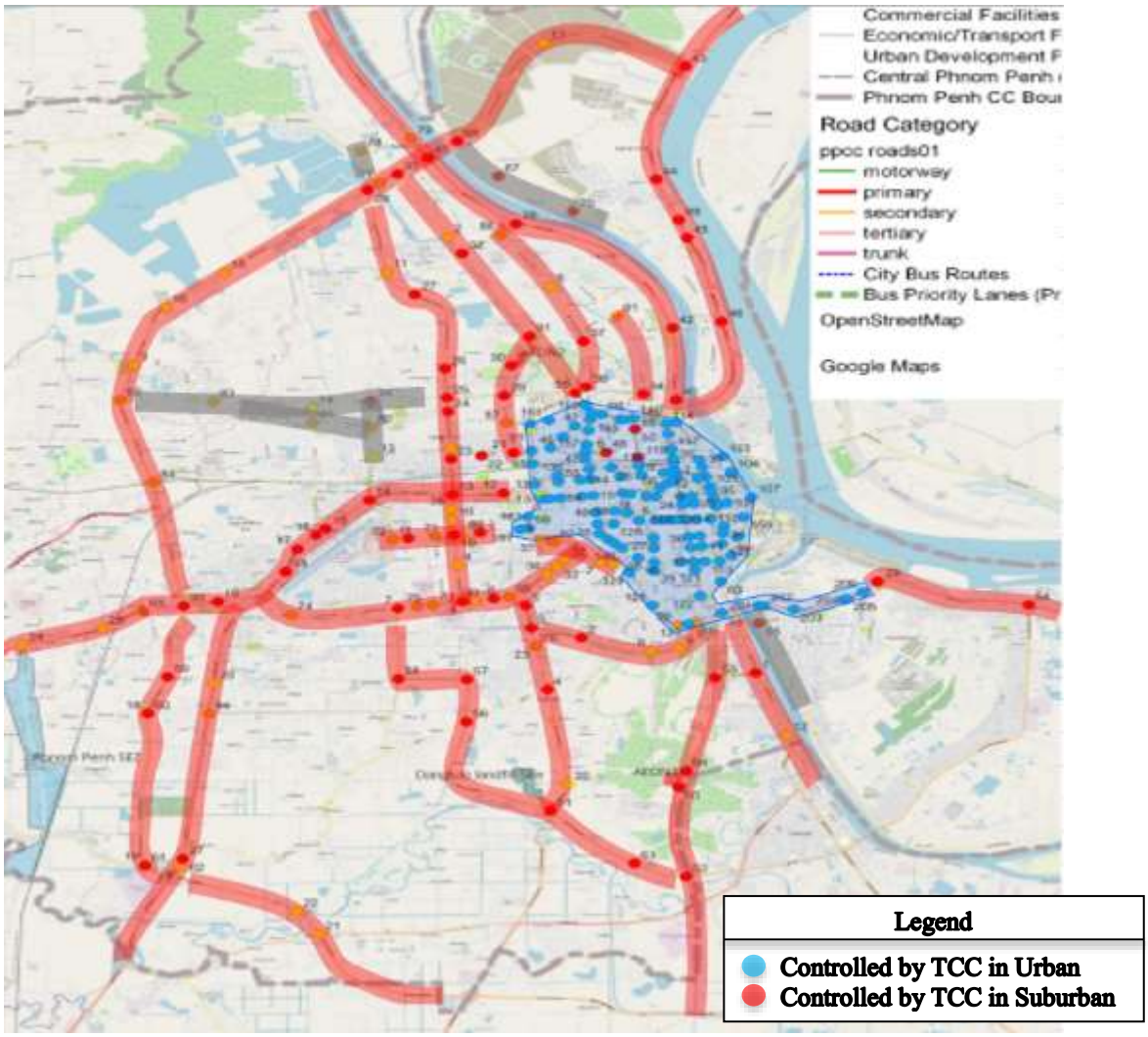


Figure 4.8 After Expansion Map

4.7 Signal Control Methods

Traffic signal control systems can be categorized into three types: Standalone, Coordinated Control, and Area Traffic Control. Urban areas typically employ area traffic control systems to integrate and manage traffic across extensive regions. In contrast, suburban areas, characterized by their linear road layouts, benefit from coordinated control. Moreover, isolated signals, operating independently without coordination with neighboring signals, do not pose significant issues in such settings. Given that suburban main roads frequently serve as public transportation routes, appropriate signal control can facilitate the smooth operation of public transit and encourage a shift from private to public transportation.
Since suburban areas typically have linear road networks, traffic flow can be effectively managed using coordinated control or standalone.

Figure 4.9 Signal control image (Standalone)

Figure 4.10 Signal control image (Coordinated control)

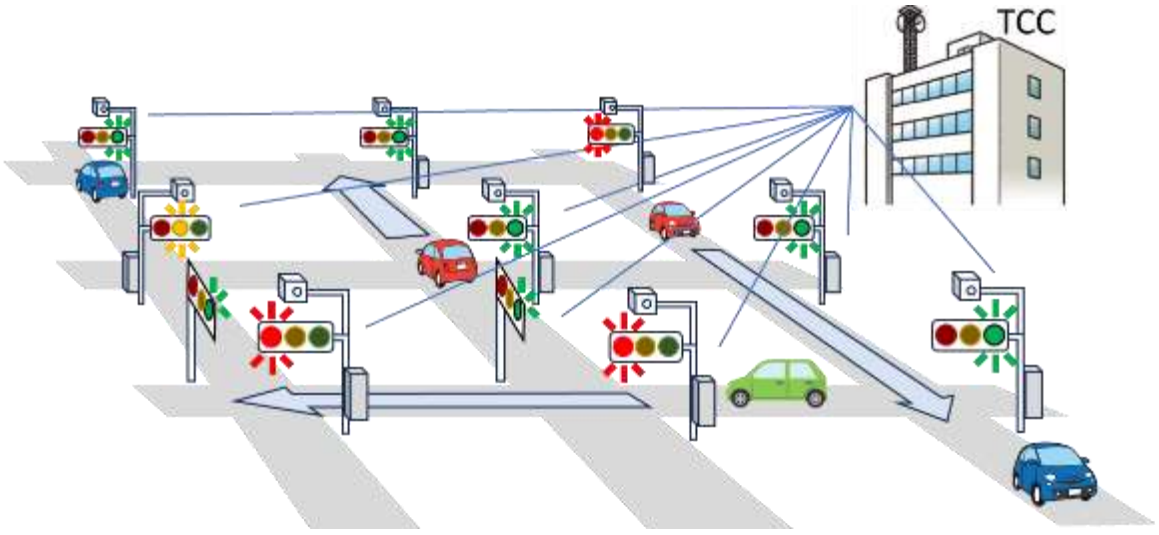


Figure 4.11 Signal control image (Area Traffic Control)

Table 4.1 Characteristics of each traffic signal control methods

	Standalone Non-centralized	Coordinated Control Corridor Control	Area Traffic Control Centralized
Purpose	Isolated intersection optimization	Corridor intersection optimization	Wide-area intersection optimization
Control Summary	Signal controlled independently	Multiple signals under coordinated control	Area coordinated control
Requirement	Standard local controller	Controller with coordinated system functionality or centralized control	Centralized control by TCC
Advantage	Low-cost for stable traffic	Effective for high-volume main roads	Effective for complex and dense road networks
Disadvantage	Weakness in adapting to traffic changes and uncoordinated signals	Not suitable for complex and road networks	High performance but expensive

4.8 Adaptive Control

(1) Signal Control in Phnom Penh

Intersections where congestion occurs are defined as 'critical intersections,' and it is considered desirable to apply Adaptive control. Adaptive control involves changing signal parameters according to changes in traffic conditions. At major intersections in the city center, 'Actual Control' has been effective in alleviating congestion. However, it has drawbacks such as being unable to control based on overall congestion and decreased effectiveness when all directions are congested.

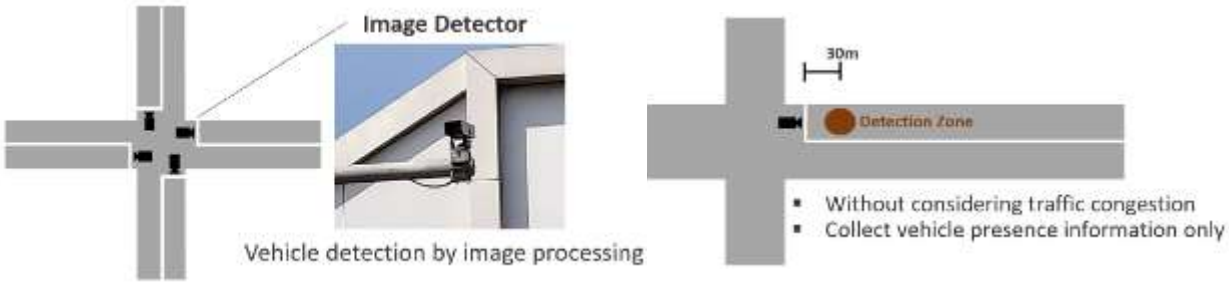


Figure 4.12 Example of detector installation for actual control

(2) Signal Control in Japan

MODERATO is known as Japan's adaptive control. Adaptive control is desired for effective signal control at intersections where traffic changes are significant and congestion occurs due to traffic concentration. MODERATO can calculate optimal signal parameters by considering not only traffic volume but also queue length. To implement this control system, sensors are required to detect both traffic volume and congestion levels.

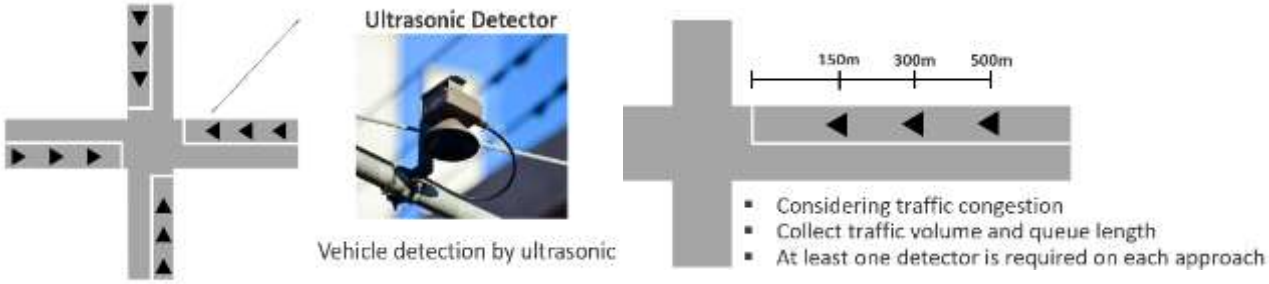


Figure 4.13 Example of detector installation for MODERATO

5. COMMUNICATION SYSTEM

5.1 Consideration of Network Topology

When expanding the range of target intersections, it is necessary to understand the current network topology and the characteristics of each Network Topology The type of basic Topology are demonstrated in the following figure.

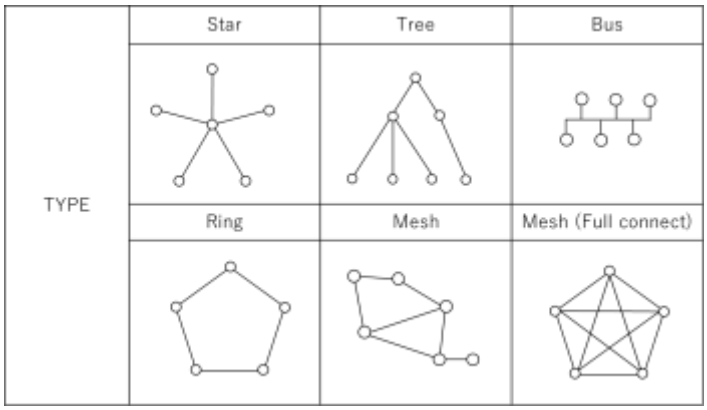
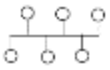
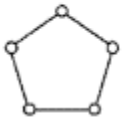


Figure 5.1 The type of Network Topology

The characteristics of each Network Topology are as the table below. In general, as communication reliability improves, network becomes more complex and expensive.

Table 5.1 The characteristics of each Network Topology

	Advantage	Disadvantage
Star 	✓ Easy to manage from one point – the switch ✓ Easy to add and remove nodes ✓ Durable ✓ Low cable usage ✓ Good for small businesses	✓ Requires specialist network hardware (the switch) ✓ Makes the network reliant on the switch's performance ✓ A finite number of switch ports limits the network's size
Tree 	✓ Blends bus and star topologies ✓ Easy to manage / expand ✓ Suitable for middle-sized businesses	✓ Requires networking expertise ✓ Involves a lot of cable ✓ Larger implementations require monitoring software ✓ Can get expensive
Bus 	✓ Easy to install/mange ✓ Fewer cables required ✓ Low cost	✓ Backbone performance is critical ✓ Easily congested on busy periods
Ring 	✓ Low incidence of collision ✓ Low cost ✓ Suitable for small businesses ✓ Dual Ring option provides redundancy	✓ One faulty node will bring the entire network down. *1 ✓ Requires extensive preventative maintenance and monitoring ✓ Performance declines rapidly with each additional node ✓ Reorganizing the network requires a full system shutdown

Mesh  Mesh (Full connect) 	✓ High speeds data transfers ✓ Durable network that isn't dependent on any one node ✓ Very secure ✓ Suitable for high-value networks for small to middle-sized networks ✓ Easy to identify faulty equipment	✓ Requires a very large amount of cable ✓ Can be difficult to provide all the cable ✓ Takes a long time to set up ✓ Requires detail advanced planning ✓ There is a limit to the number of cables each computer can accommodate

The current TCC network topology is shown in the diagram below. It is based on the Ring network topology configuration.

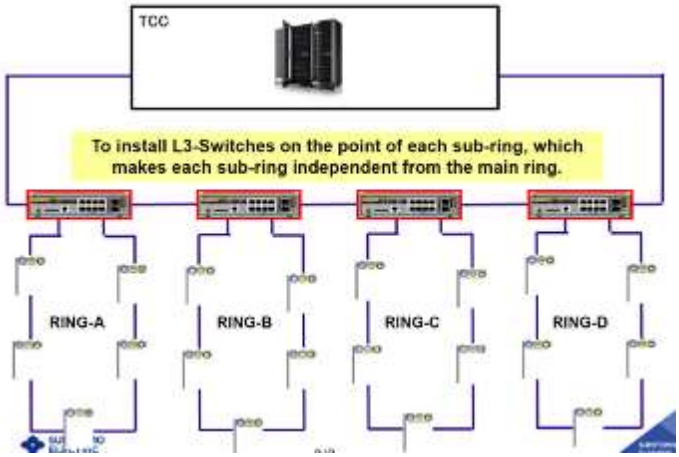


Figure 5.2 Current TCC Network Topology

When planning an expansion, it is necessary to effectively select and combine network topologies by considering the geographical conditions of the area to be expanded, (linear/ reticular/ distributed). It is also considered that whether it is a trunk line of communication, and the importance of intersections.

5.2 Optical Fiber Cable Network

The communication network consists of optical fibre cables, and communication equipment. Fiber optic cables connect the TCC with communication equipment at intersections and relay points splitted throughout the city. When expanding the current network and extending the OFC, it is necessary to consider the construction method.
There are two types of construction methods:

- Overhead Cabling Method

The Overhead Cabling method is a widely used construction method. Although it is generally advantageous in terms of price, there is a high risk of cable breakage due to accidents, and in Phnom Penh city, cables are often cut due to the city's aesthetic policy.

- Embedded Cabling Method

Embedded Cabling methods include direct embedded cabling, cabling with conduits and embedded common utility space. There is little risk of cable breakage. Depending on the type, it is more expensive than the overhead wire method.

EXISTING ISSUE

・Network Disconnection

The existing network is constructed with Optical fiber cables, which are installed overhead in most of the area. Therefore, they are often accidentally disconnected, causing the network to go down.

Taking the above into account, it is recommended that new cables for network extension be constructed using a embedded method whenever possible.

5.3 Ownership of the OFC network

The existing communication network consists of dedicated lines operated by TCC. In the extension plan, the use of other companies' infrastructure will also be considered.
The characteristics of each communication infrastructure based on ownership are as follows.

(1) Entirely Own network

TCC's current communications are entirely networked through own lines. High degree of freedom in route planning. The cost is high because it is a proprietary system that is constructed in-house, but in general there is almost no OFC network maintenance cost. There is no internet access except for one for remote control, it is its own communication network and is isolated from public or other companies, so security reliability is high.

(2) Use of other companies' dark fiber and networks

Utilize communication networks installed by other public or private organizations or unused dark fiber optical cables. When using a dedicated line for TCC by such entities, the security reliability is high as in (1) dedicated line. Existing connection points limit routes and complicate coordination. In addition, it is necessary to confirm the contract details such as terms of use and quality of the service. The maintenance cost needs to be considered as usage fees are required over the period of use, while the initial investment can be reduced.

5.4 Consideration of Wireless Communication System

When considering expansion plans to the suburbs, the density of intersections is lower than in the central of the city. As a result, construction costs per intersection are expected to be higher than those in the central area of the city.
Therefore, wireless communication methods may be considered for communication between TCC and each traffic signal at each intersection.
The following wireless methods could be one of the options, and they were demonstrated through a pilot project.

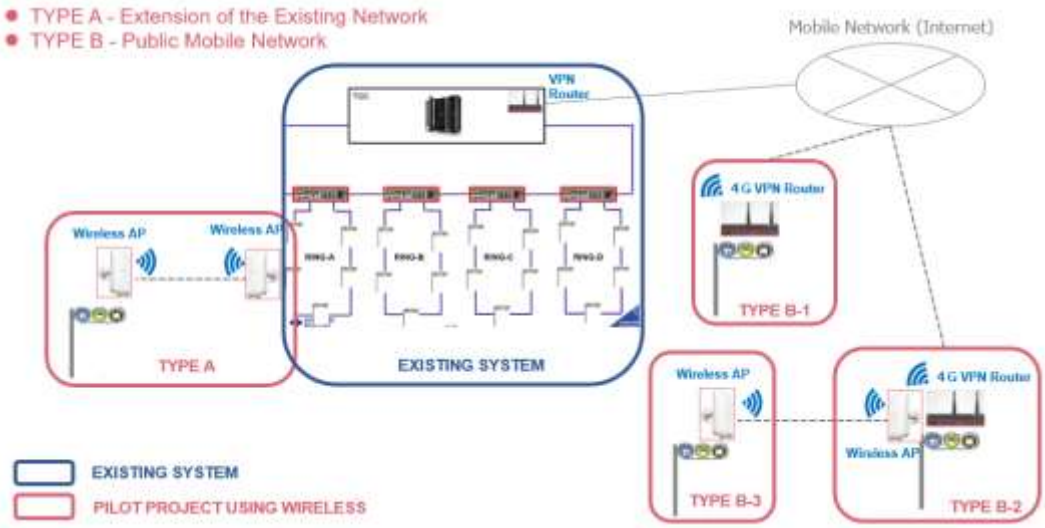


Figure 5.3 The type of Network Topology

	Advantage	Disadvantage
Type A	✓ The connection is rely on existing OFC network, the quality of communication is relatively high ✓ No monthly fee	✓ There is a risk of disconnection of the existing OFC network ✓ There is a limitation of the distance from the existing OFC network
Type B	✓ No limitation of the distance from the existing OFC network ✓ No affect from the existing OFC network	✓ There is a risk of communication restriction when the line is busy ✓ There is a monthly fee.

The result observed as through the pilot project is as follows:
The quality of the communication by Type A was Excellent and it is almost same as existing wired communication. On the contrary, the quality of the communication by Type B were Poor or Good depending on the type B-1, B-2and B-3.

The results of the pilot project have confirmed that communication with TCC using a commercial 4G SIM has issues with communication stability, and errors such as Failure and Down occur in the TCC system. On the other hand, the wireless communication from the network connected to the dedicated OFC line with TCC is stable.

6. MAINTENANCR MANUAL FOR EXPANSION PLAN

6.1 Introduction

PPTMTC Project in central Phnom Penh, Cambodia was envisioned to "form a sustainable urban transport" and to enhance capacity development for the operation and maintenance of the traffic control system installed in 2019. Of 69 standalone intersections in 2018 managed by DPWT's Public Lighting and Traffic Safety Office (PLTSO) within the central Phnom Penh, the system has now 118 coordinated and centralized intersections being managed by 8 technical staff of the TCC.

Aside from the availment of the Technical Cooperation Project (PPTMTC Project) from the Japanese government for the traffic control system, the most important task for the management team is the operation and maintenance to sustain the functionality of the system equipment. This includes the technical capacity of the maintenance team and the availability of spare parts. The PPTMTC Project therefore included the capacity development of the internal personnel and educating the traffic policemen manning the traffic in the field. Series of training lectures were done indoor and outdoor, administered by different traffic, transportation, and signal system experts of JICA, including additional group trainings in Japan.
In addition to the hands-on training, a maintenance manual has been written to guide system management and the engineers and technicians on the standard procedures and policies of the day-to-day operations and maintenance requirement of the traffic control system.

6.2 Current Situation

Phnom Penh traffic control system facility is currently composed of two types of operation. One is the centralized system of Area Traffic Control (ATC) installed in the central Phnom Penh, and the other is the scattered standalone intersections mostly located in the suburban in Phnom Penh.
The ATC system is currently managed by the TCC personnel trained in the operation and maintenance of the system while the Standalone intersections are managed by the PLTSO of the DPWT. Matrix of the current situation is shown in the following table:

Table 6.1 Current Situation

Operation & Management:	TCC Team	PLTSO, DPWT
System/Type of Controller:	ATC-SUMIDEN	Standalone
No. of Intersections:	118	68
Area / Vicinity:	Central Phnom Penh	Suburbs in Phnom Penh
Mother Unit:	PPCA/DPWT	DPWT
Organization Status:	Temporary	Regular/Permanent
Major Maintenance Equipment (Manlift, etc.):	Borrowed from PLTSO	Assigned to Unit

Table 6.2 Capacity of Current Traffic Control System

	Particular	Capacity
1.	Local controller	512
2.	Vehicle detector	2048
3.	Signal control subarea	256
4.	CCTV camera	64

Table 6.3 Milestones of the Traffic Signal in Phnom Penh

Year	Central PP	Suburban Area		Managed by		Remarks
		Planned	Existing	TCC (Central)	PLU (Suburban)	
2016	69 (Standalone)	-	6	-	○	
2018	75 (Standalone)	-		-	○	
2022	115 (Centralized SUMIDEN)	67 (Standalone)	1	●	○	Int. 21 new
2024	118 (Centralized SUMIDEN)	68 (Standalone)	68	●	○	
2030	118 (Centralized SUMIDEN)	82 (Standalone)		●	○	
2035	268 (Centralized New System)	-	-	●	-	

Because the ATC traffic system is a coordinated system and being managed by area or group of areas, the tasks and responsibility of the TCC team is more than managing individual isolated intersections, there is a greater need of the appropriate specialty equipment and tools most particularly manlift or elevated platform to work in elevated system component like signal lantern and CCTV cameras, from cleaning and repair activities. And this is currently one of the shortcomings of the operation and maintenance set-up.

6.3 Lesson Learned from Japan and Philippines

(1) Japan

In the 1970s, Japan experienced rapid economic growth, which led to the advancement of motorization, resulting in severe traffic congestion and accidents. To address these traffic issues, traffic control centers were introduced, and efforts were made to optimize traffic signal control and provide traffic information. This system expanded its coverage area over the years, not only to major highways but also to local roads used in daily life.
Japan's traffic control system has evolved with advancements in information processing technology, significantly contributing to the alleviation of traffic congestion and the realization of a safe traffic environment.
On the other hand, the operation and maintenance of the traffic control system by each prefectural police force have become a significant financial burden. In response to this, to ensure operation within limited budgets, cost-reduction measures such as reconfiguring traffic signals and extending the replacement cycle of equipment are being implemented.
In comparison to Japan, Phnom Penh's traffic environment is significantly underdeveloped, and system expansion is essential for improving traffic conditions. However, excessive functionality or over-expansion of the system could lead to significant maintenance cost issues in the future. Therefore, it is crucial to consider not only the initial costs but also the running costs and to expand the system gradually, starting from areas of high necessity.

(2) Philippine

Being neighboring countries and both in the southeast Asian continent, Cambodia and the Philippines share many similarities as tropical countries. The prime cities of Phnom Penh and Metro Manila have almost the same area. Manila, however, started the traffic management using traffic control system under Area Traffic Control System (ATC) way ahead in 1977 and has a great deal of experience in managing the system, including all the complexities and problems related to it. Starting in the city of Manila the signal system expanded to 17 cities comprising the National Capital Region or better known as Metro Manila. The system expansion started in 1984 and from then the system improvement extended to the whole region of Metro Manila. The standard life of a signal system ranges from 10 to 15 years at that time, and so the installation in Metro Manila passed several changes - 4 Phases on the first three (3) decades (1977–2012), and 5 Phases in the last two (2) decades (2012-2024).

The history of Metro Manila signaling system is depicted in the following table showing the milestones throughout the five decades.

Table 6.4 History of ATC in Manila

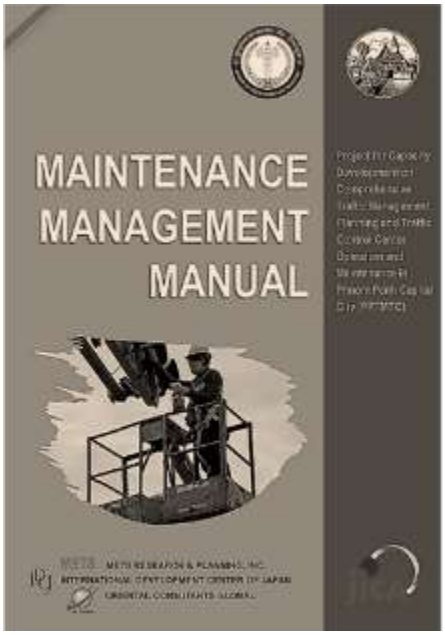
History of the Mero Manila Traffic Control System (1981 - 2024)

PHASE	Implementation		Agency	Funding		No of	Traffic Control		Controller	Manufacturer / Supplier	Consultant	Maintenance		Role of
	From	To	Responsible	Source	Amount	Int.	System	Country				Company	No of Staff	Government Side
Planning & Design	1977	1980	TEAM PH-1											Planning & Design
Phase I	1980	1982	MPAW-TCC	BRD/WB	US$5.8M	134	ATC	Japan	NEMA TSI-National	Matsushita Elec	PGPak Poy Aus	Sidcophil		Operation
Phase II	1984	1987	DPWH-TCC	OECF-Japan	3.868 Yen	170	ATC	Japan	NEMA TSI-National	Matsushita Elec	FCI (Fukuyama)	Sidcophil		Operation
Phase III	1989	1994	DPWH-TEC	OECF-Japan	4.61B Yen	131	ATC	Japan	NEMA TSI-National	Matsushita Elec	with Matsuoka	Sidcophil		Operation
Renewal of System														
Phase IV (P&D)	1993	1994	DPWH-TEC											Planning & Design
Phase IV (Imp.)	1998	2002	MMDA-TEC*	EFIC-AUS	US$22.8M	419	SCATS	Australia	Delta S	AWA - Plessey	-	TYCO		Operation & Maint
Upgrading/System Replacement														
Phase 1	2012	2017	MMDA-TEC**	Local	P795.26 M	93	Hermes	Spain	RSIM	Indra	-	MELCOR/Armspeal	15 crew and 4 staff	Operation
Phase 2	2014	2018	MMDA-TEC	Local	P395.78 M	161	Cosmos	Korea	Korean LC	Keon-A Info Tech	-	Armspeal		Operation
Phase 3	2015	Terminated	MMDA-TEC	Local	P190.39 M	155	Cosmos	Korea	Korean LC	KYUNG BONG CO. LTD.	-	Armspeal		Operation
Phase 4	2017	2021	MMDA-TEC	Local	P229.00 M	88	Cosmos	Korea	Korean LC	Easy Traffic	-	Armspeal		Operation
Phase 5	2018	2024	MMDA-TEC	Local	P292.33 M	80	Cosmos	Korea	Korean LC	Easy Traffic	-	Armspeal		Operation
						506								

* Transfer of TEC Operation & Maintenance to the MMDA - Aug. 15, 1998 (Verify)
** Transfer of TEC whole office - Feb. 2003

History itself tells its own story of how the system operates and has been changed from system to system in 47 years. And with this experience comes the exposure of every personnel connected with the management of each system. The experience ranges from technical, organizational, and institutional in nature. From the training of personnel, creation of management unit, funding requirement and even the relationship between agencies of government that has jurisdiction over traffic matters for there are some overlapping of functions like the Department of Transportation, Department of Public Works and Highways, the Philippine national police, and the Local Government which also have mandate in traffic management under the Local Government Code.
Summing up, by mere looking on the above table, the Phnom Penh team can learn from the Metro Manila, Philippine experience in the conduct of its own signal system and traffic management.

6.4 Creation of Traffic Signal Maintenance Management Manual



Preparation for the manual started in November 2022 with the purpose of formalizing and documenting the policies, plans, procedures, and other support activities that are performed to achieve the TCC'S mission, goals and objectives. The 2022 draft was revised in June to July 2024 incorporating the two years additional experience in operation. The final version was prepared in November 2024.

The manual comprises 10 chapters with a detailed discussion on occupational safety and health for the maintenance personnel, motorists, pedestrians, and the public in general. The manual also concentrates on the function of the different components of the system and how they work together as a whole, for the reference and familiarity of the current technicians and information of those new staff that are recruited to join the maintenance team.

One of the most important topics also included is the inventory management of system components for the building up of accurate data base, which is the lifeblood of the system operation (Chapter 5). When the status of each component is clearly known, more accurate maintenance and procurement activities can be done more efficiently.

Chapters 6 to 9 deal with the equipment for testing and repair, maintenance cost, relationship with other agencies, and reporting while Chapters 2 to 3 discuss the team's mission and organization. Chapter 4 highlighted the topic on signal system maintenance that includes procedures on maintenance management, staffing, record keeping and emergency response to fault call.

As have been mentioned in the manual the TCC would continue to improve the manual adopting to the development on the system performance inputs from the public, local policies and tradition, the technology development, including the status of each of the system components.

Chapter 1 is about the system background, importance of preparing the manual, scope and purposes, organization of the manual, acronyms and abbreviations. A copy of the manual is attached to this report as one of the PPTMTC deliverables.

6.5 TCC Organization Analysis and Proposals

The Traffic Control Center is presently manned by 8 technical staff, one coming from DPWT and 7 recruited from private source. Since the beginning of the project there have been a proposal to organize the Traffic Control System management team into a more complete organization with the intention to execute an efficient operation and maintenance of the system's equipment and component. The proposal is to integrate selected personnel from DPWT and PPCA to complete the initial set up of the operation and maintenance team, under the executive supervision of a steering committee as shown in the diagram below.

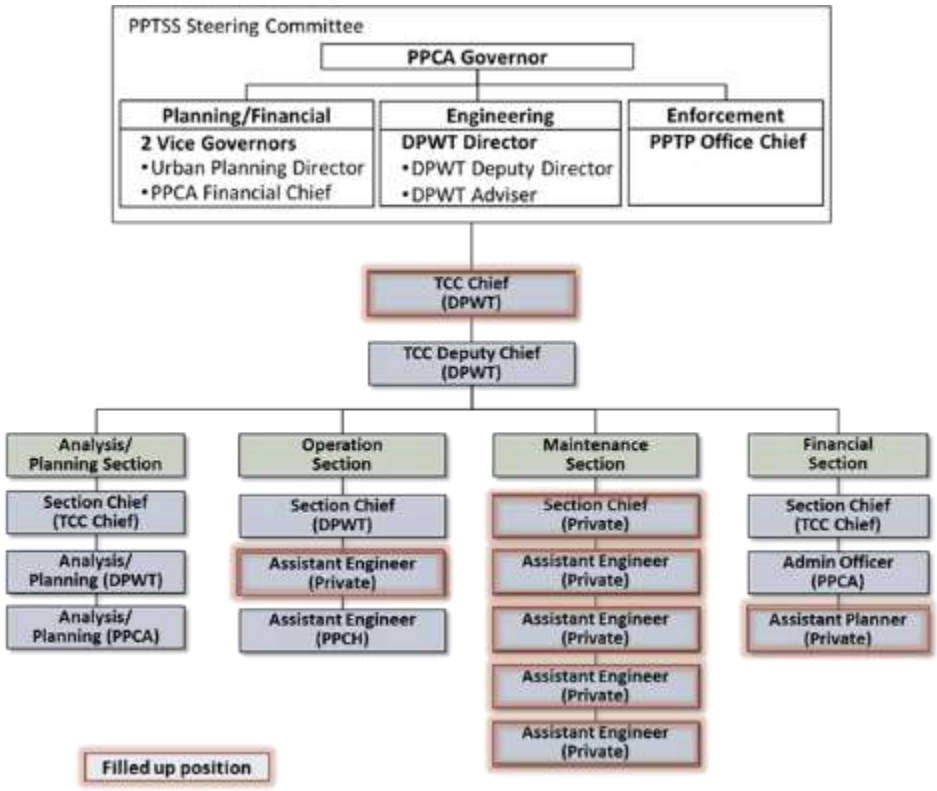


Figure 6.1 Proposal of TCC Organization

The additional personnel proposed in the preceding diagram have also undergone training together with the group presently managing the operation of the TCC. However, the additional staff have not yet been formally assigned to the proposed position up to the present.

One of the reasons is assumed to be due to the budget for the TCC which is not yet fully established and allocated. The budgeting, however, of an organization may also emanate from the assessment of the organization itself of the needed amount for its maintenance and operating expenses. Depending on the DPWT and PPCA, those proposed personnel can be assigned in detail and get their salary from their mother office. In this way the organization of TCC can be enhanced and do their job efficiently, including the assessment and advanced planning for the one-year operation, the budget needed and logistical requirement. The operation can be justified to the steering committee upon submission of the annual report to the Governor through the DPWT.

6.6 The Maintenance Equipment Problem

On the maintenance problem the technical team encounter difficulty in checking and cleaning the signal lantern, the CCTV cameras, the vehicle detectors and other elevated components due to the absence of a manlift truck or a mobile elevated working platform (MEWP) dedicated to the team. The former truck is available only in DPWT SLTSO which they can borrow from time to time when not being used. A service pick-up truck is acquired through the PPTMTC project of JICA. Also, the team have Optic Fiber Cable (OFC) splicer which is a very vital piece of equipment for the maintenance of the communication cable.

With regards to the technical capabilities of the TCC maintenance team, they have a fair training and actual exposure to the system's component being assigned to maintain it for more than 5 years already, plus the training and lectures being received from the start of this project.

Office on the 9th floor, PPCH New Building along Monivong Blvd. in Phnom Penh, the TCC room has enough space to accommodate the equipment of the signal system's control center. However, there is not enough space for the storage of retrieved components and repair room for the maintenance activities. Also, there is no area for a motor pool if appropriate maintenance vehicles like manlift and pickup trucks will eventually be provided for the maintenance team. Because the area is in the office complex of the Governor, it is unlikely that even parking for the special maintenance equipment will be allowed around the relatively small parking area at ground level which are intended only for visitors and official cars and vehicles. They can however be provided with an area for the motor pool in another place separate from the TCC office and assign dedicated personnel to supervise them. The repair shop and storage area can also be integrated with the motor pool. But this set up will surely need additional personnel aside from the proposed organization of the signal system management.

In modern times, traffic signal systems are a very important and vital way of controlling traffic congestion on at-grade level intersections, ensuring the safety of all road users particularly in a fast-growing city like Phnom Penh. No one can ignore the positive impact of a traffic signal system in managing traffic as compared to stand alone or manually controlled intersections, much more if it is traffic actuated or responsive. For this very reason, the management of the organization in maintaining the operation of the equipment is vital for the city, its inhabitants particularly the motorists and pedestrians, and the governing body of the city of Phnom Penh as well for their sensitivity on the welfare of the citizens. The traffic management team of the TCC therefore should be accorded the necessary attention by the government.

6.7 The Spare Parts Problem

The full utilization of a signal system lies not only in the management, skills and know-how of the team that maintains them. It is equally dependent on the availability of spare parts. Having parts readily available only means that the team can readily and immediately repair any defective component of the system, reducing the down time and restoring the safety features on any of the intersections within the system.
The topic for inventory management as discussed in the maintenance manual gives advanced information and guidance. "Spare parts management plays a very important, if not crucial role in the operation and maintenance of any signal system. When the right part is not available when needed, it can cause the TCC operation to struggle with operational inefficiencies and safety issues among the motorists, pedestrians and the public".
The Phnom Penh Traffic Signal System (PPTSS) was installed under the PPTMTS and being maintained by the TCC team using the spare parts supplied by current manufacturer being the main contractor and manufacturer of the system's component. The initial needed spare parts were supplied by current manufacturer under the contract comprising 139 sets of fast moving and critical spares for the initial operation and maintenance of the Traffic Control Center (TCC) and Roadside Equipment (RSE). Most of the critical components were produced or manufactured by the system owner.

The TCC team was continuously maintaining the system until, in year 2022 a major problem occurred that current manufacturer will no longer supply spare parts anymore. These spare parts are composed of 13 sets of items, (some of them are critical component of the system specifically of the controller) without giving any reason at all. Upon checking with the TCC staff, the system is still running, and all intersections are normally operating presently. But the problem must be addressed immediately before the remaining spare parts, 4 sets of which are exhausted. And with most of the parts specially the critical mainboard components of the controller have been designed and programmed by current manufacturer, the replacement is very hard to find much more almost impossible to produce. Although several of the problem components especially the power supply components can be found in the local electronic stores, the problem remains if the controller unit module is defective.
Sourcing out for assessment and repair possibilities from the more experienced signal system maintenance technicians in Manila were also tried but the problem may not be solved due to the multiple testing process that need the Phnom Penh controller to do. The technicians in the Metro Manila Traffic Engineering Center (TEC) have a great deal of experience in the maintenance area because they already experienced the same problems in a span of 24 years with 4 different system manufacturers. Before changing from one system to another they must maintain the controllers for several years repairing defective controller component one after the other.
Due to this problem, alternative recommendations, integrated to a whole system approach strategy for the continuation of the operation in future years is offered and included in the next chapters.

6.8 Integration of TCC with DPWT Public Lighting and Traffic Signal Rooms

It is important for the management of signal systems of a city to have one umbrella organization. First, is because the management should have a uniform policy and directions, rules and regulations. Second, the consolidation of maintenance assets like vehicles, specialized equipment, repair tools, and office spaces minimizes duplication and additional expenses ensuring full utilization of resources.

At present there are two groups managing the signal system with the Public Lighting Unit (PLU) of DPWT maintaining the stand-alone controllers and the TCC team, also technically under DPWT, assigned in the operation and maintenance of the central coordinated signals. With the proposed expansion of signal installations to the outskirts of Phnom Penh by JICA, DPWT and Khans of the districts totalling 268 intersections, the area of operations will increase with the farthest intersection reaching 18 km from TCC office at Phnom Penh City Hall.

The proposed future upgrading of DPWT's 68 standalone controllers together with the gradual replacement of Current manufacturer's 118 controllers, and integration of 82 future other controllers to be installed under a single system will leave only one option for the management, that is, consolidation of the two management groups into one. When the proposed expansion plan follows the strategy discussed above in section III, the Phnom Penh Traffic Signals will be under one system and one supplier by the year 2035.

Consolidation can be done in two options:

1. Transfer the current TCC management as a special division under the Public Lighting Unit of DPWT
2. Because Public Lighting Unit is a very important unit of public works particularly in the safety aspect along roadways and thoroughfares, the second option is that the technicians and engineers under them that are well versed and currently assigned in the maintenance of the current traffic signals will be integrated into the present TCC organization and put them entirely directly under DPWT as one division, special unit or Project Management Office. The Public Lighting Unit can concentrate on their responsibility. In this way the operation and maintenance of the traffic signal system will be well organized and can be included in the yearly budget of the DPWT and have regular funding for the operation and prompt response to maintenance emergencies.

6.9 Maintenance Management Plan Proposal for Traffic Control System Expansion Plan

As discussed above, consolidation of the management team into one for the whole signal system is a priority and highly recommended. In this premise, there should be one maintenance manual to be used. The said manual as prepared for the TCC team is a general guide and the details can be included following the actual situation and experience during the actual activities as the operation of the system progresses. Because the recommendation is for the controllers to be of only one system type and preferably by one manufacturer, there should be only one maintenance manual. If the manufacturer of the expansion plan is different from the current supplier, the specific Chapter 3 and Appendix 2 which are about "system configuration" and "how the system operates" respectively should be replaced. Other chapters are general in nature and should be retained.

With the maintenance management manual in place, the additional decisions can be concentrated on the mobility of the maintenance personnel for the fast response to the system fault alerts and emergencies. One recommendation is the establishment of at least one (1) sub-station located strategically at the center of the expanded area of the signal system, ideally in the airport area or 9 km from the present location of the control center. The sub-station should be located where all the main roads can be reached easily to facilitate faster response during emergencies.

6.10 Wireless Communication to Central Control

The implementation of 3 Pilot Projects exposed the team to the process of defining the warrant, the process of planning, design, and implementation of additional traffic signal on one or more intersections. This was done as part of the training for the actual management of traffic signal organization. In the same manner, the decision, and activities for the wireless connection of 6 intersections is a good opportunity for the team to gain additional knowledge and experience on the application of emerging technology of Intelligent Transportation System – the wireless communication technology (WCT). For this reason, the engineers and technicians of the team should make the most of this experience and accept the problems as a challenge to discover the flaws, deficiencies and imperfections as this technology is used in the traffic signal network. This is also an opportunity to explore the additional knowledge of emerging technologies of WCT as used in traffic signal systems that the operation and maintenance team could utilize in the performance of their maintenance activities for the purpose of sustaining the continuous operation of the system.

7. INTERSECTION GEOMETRY AND OTHER CONSIDERATIONS

7.1 WARRANTY OF INTERSECTION SIGNALIZATION

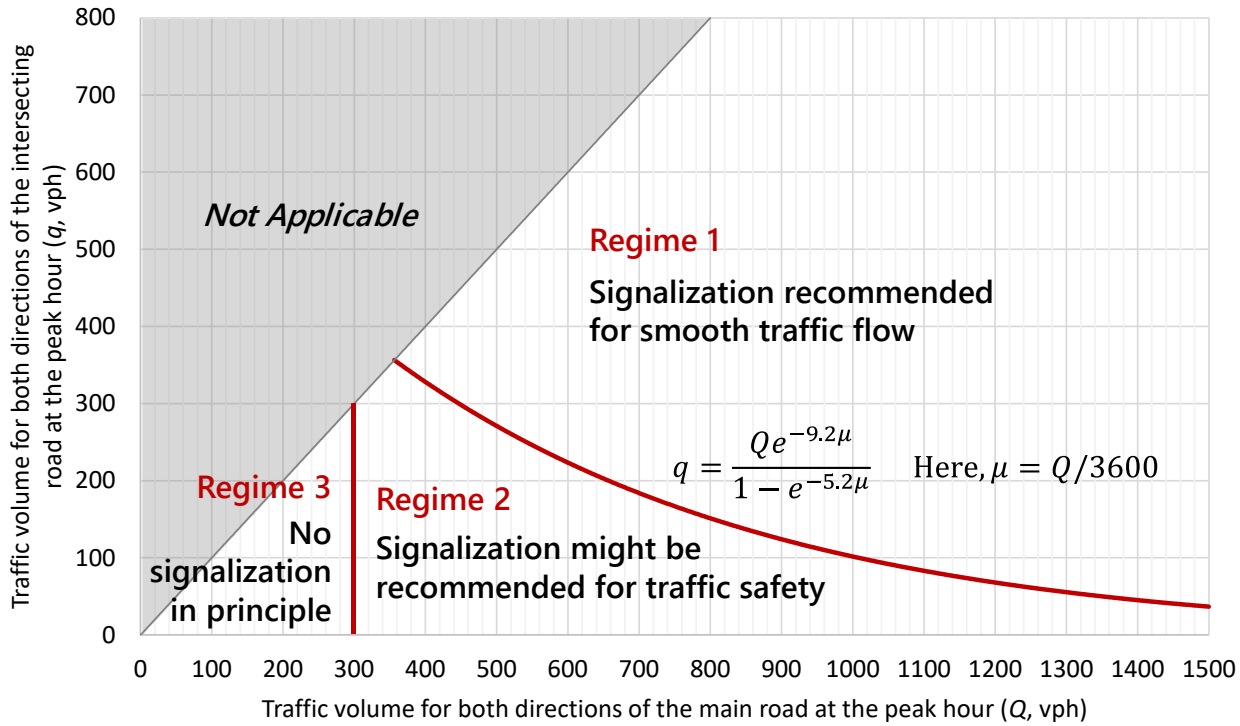
Since traffic signal control is a method of traffic control at intersections by interrupting traffic flow by direction in sequence, signalization of intersection under a certain level of traffic demand causes the increase of total delay at intersections. In addition, it incurs high costs not only for the installation of traffic lights, but also for their maintenance. For these reasons, intersection signalization should be considered when it is difficult to resolve traffic congestion with unsignalized control, including roundabouts, or when other measures to ensure traffic safety other than traffic signal control are difficult. Currently, not only the JICA Study Team but also DPWT and districts are proposing or planning new signalized intersections. There might be other intersections where the signalization is required. When examining signalization at those intersections, it is advisable to check the traffic demand as well as the occurrence of traffic accidents as described above and reconfirm before the implementation whether the signalization is necessary. In this section, "Guidelines for the Installation of Traffic Signals" of Japan is introduced as an overseas guideline that can be used as a reference for intersection signalization.

In Japan, National Police Agency has established guidelines for traffic signal installation, and all intersections in Japan should be reviewed to determine whether they need to be signalized or have their traffic signals removed in accordance with these guidelines. The guidelines present five mandatory conditions and four optional conditions. To signalize an intersection, all of the mandatory conditions must be met, as well as one or more of the optional conditions. If an existing signalized intersection does not satisfy the above guidelines, removal of the signal may be considered. The five mandatory conditions and four optional conditions are listed below.

Table 7.1 Warranty of Intersection Signalization in Japan

Five mandatory conditions (All must be met for signalization)
1. Except the case of one-way road, the roadway width is sufficient for discharging vehicles to safely pass vehicles stopped at the intersection approach during the red signal. 2. There is a safe space for pedestrians waiting for crossing the road. However, this condition is not applied to intersections where there is no crosswalk. 3. Traffic volume for both directions of the main road at the peak hour is 300 vph or more. 4. The distance from any adjacent traffic light is 150 meters or longer. However, this condition is not applied if it is considered that there is no risk of misunderstanding the signal lights and that it will not impede the smooth flow of traffic. 5. Signal poles can be installed in such a way that they do not interfere with traffic safety and smooth traffic flow, and so that traffic lights can be clearly seen by drivers and pedestrians. However, this condition is not applied if the signal lights are clearly visible to drivers and pedestrians without the installation of signal poles.
Four optional conditions (One or more must be met for signalization)
1. There have been two or more accidents resulting in casualties during the one year before the examination of the installation of traffic lights, which could have been prevented by traffic lights. At the same time, it is accepted that there are no other alternatives than the traffic signal to prevent those accidents, based on the investigation and analysis of causes of accident including intersection shape, visibility, vehicle speed, and number of accidents without casualties at the location. 2. There are schools, kindergartens, parks for children, hospitals, facilities for the elderly, or others, so that there is a special need to ensure traffic safety for students, children, the disabled, or the elderly. 3. The traffic volumes for both directions of the main road and the intersecting road fall into Regime 1 of the requirement of traffic volume for the signalization (see Figure) 4. There is a high demand of pedestrian crossing, but the crossing is difficult due to high traffic volume. At the same time, there is no pedestrian bridge nearby.

Source: Website of Metropolitan Police Department of Japan
(https://www.keishicho.metro.tokyo.lg.jp/kotsu/doro/singoukisetchi/index.html)



Source: Document of National Police Agency of Japan
(https://www.npa.go.jp/laws/notification/koutuu/kisei/kisei20210324.pdf)

Figure 7.1 Traffic Volume Requirement for Traffic Signal Installation & Removal in Japan

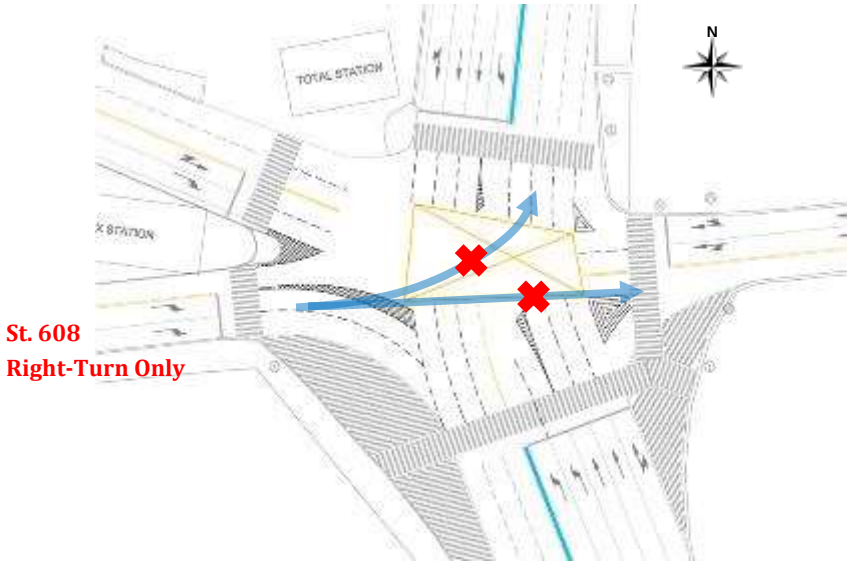
7.2 SIGNALIZED INTERSECTION GEOMETRY

Signalized intersections can improve the traffic capacity of at-grade intersections by controlling traffic flow using traffic signals. However, inappropriate intersection geometry not only reduces traffic capacity but also causes a reduction in safety. In other words, it is extremely important to ensure the appropriate intersection geometry provided to the signalized intersection in addition to the installation and operation of traffic signals. This section describes the intersection geometry that should be considered and ensured when signalizing at-grade intersections.

7.2.1 Number of Intersection Legs

In principle, intersections should have three or four legs, because it is much easier to have excessive traffic demand concentrated on one intersection from five or more approaches, and even traffic signal control cannot handle the oversaturated traffic condition. For those intersections, it is recommended to consider the change in the traffic operation, e.g., making some of the legs one-way or other measures, so that there are no more than four inflows to the intersection. Grade separation providing some directions with an overpass or underpass may also be recommended to consider. If none of these measures are feasible, another road may be built or improved to divert the traffic demand. The case includes roundabouts with five or more approaches that is examined to be signalized.

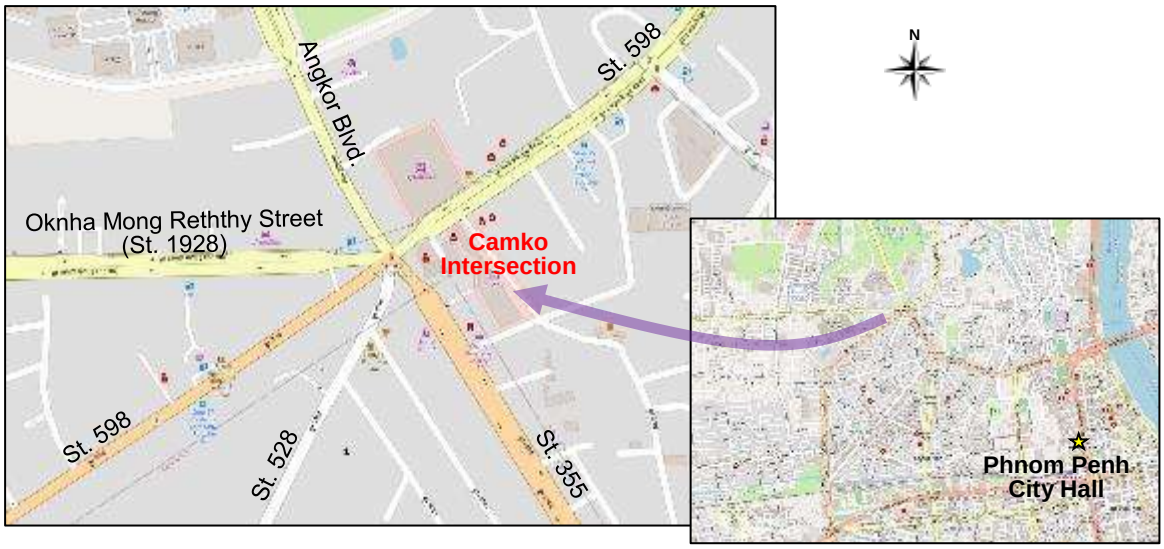
One example is shown in Figure 7.2. The #166 intersection is a five-leg signalized intersection that was upgraded by DPWT from a roundabout and upgraded again by JICA through a pilot project for the intersection improvement and connection to the Phnom Penh Traffic Control Center. In the pilot project by JICA, thru and left turn became prohibited from Street 608, which contributes the mitigation of traffic congestion of all approaches.



Source: JICA Study Team

Figure 7.2 Change in Traffic Operation at Intersection #166

Camko Intersection (DPWT ID: #35) is also a signalized intersection upgraded by DPWT from a roundabout (See Figure7.3). It is a 6-leg intersection, which has one more leg than Intersection #166, so that it is recommended to reduce intersection approaches, such as St. 528, by changing traffic operation of one or more connected roads to one-way, or to implement other traffic corridors and strengthen the road network to disperse the traffic demand concentrated on the intersection.

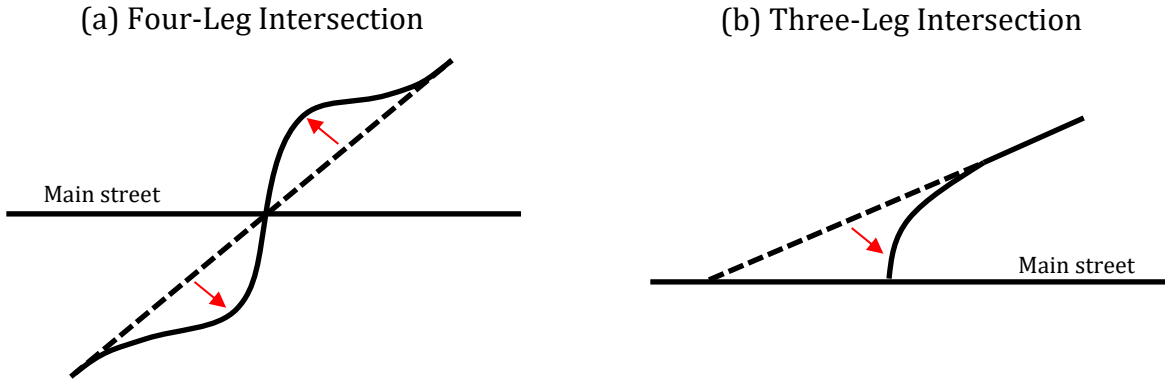


Source: JICA Study Team *Map data: OpenStreetMap (https://www.openstreetmap.org/)

Figure7.3 Camko Intersection (DPWT ID: #35)

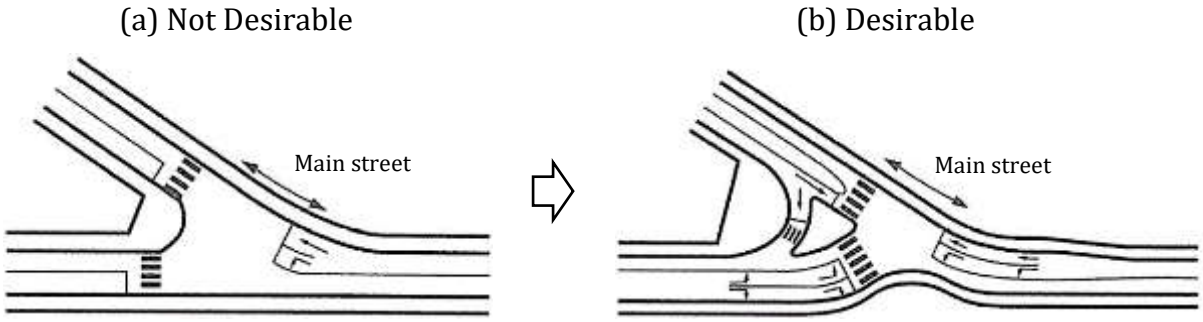
7.2.2 Intersection Angle

Road intersection angles at at-grade intersections should be close to right angles from the perspective of ensuring traffic safety and improving traffic capacity, including safe driving behavior inside the intersection, ensuring visibility, and minimizing intersection crossing distance and intersection area. In planning and design of at-grade intersections, the intersection angle is recommended to be 75 to 105 degrees. Even in unavoidable cases, it should be 60 to 120 degrees. When signalizing or upgrading existing intersections, it is recommended that the intersection angle be as above as possible.



Source: JICA Study Team

Figure 7.4 Adjustment of Horizontal Alignment for the Installation of Intersection



Source: "Commentary on and Application of Road Structure Ordinance", Japan Road Association, Revised in March 2021.

Figure 7.5 Example of the Improvement of Intersection Angle

There are mismatched intersections in Phnom Penh where the center lines of each intersecting road do not meet at one point within the intersection, as shown in Figure 7.6. Such intersections not only pose traffic safety problems due to poor visibility, complicated driving behavior inside the intersection, and increased crossing distances, but also reduce intersection traffic capacity due to reduced crossing speed and increased crossing distance. Therefore, such a feature of intersection should be avoided as much as possible and is recommended to be improved when the signalization or the improvement of intersection is carried out.

Source: JICA Study Team *Map data: OpenStreetMap (https://www.openstreetmap.org/)

Figure 7.6 Examples of Mismatched Intersection in Phnom Penh

7.2.3 Horizontal & Vertical Alignment of Roads at the Intersection

It is rare to find intersections on major roads in Phnom Penh with unpreferable horizontal alignment of roads near the intersections. However, it should be noted that the curvature of horizontal alignment of roads near intersections is recommended to be as small as possible, which means a straight line, and the radius of horizontal curve near intersections should be greater than that indicated in Table.

Table 7.2 Minimum Radius of Horizontal Curve of Main Roads near Signalized Intersections

Design speed (km/h)	Minimum radius of horizontal curve (m)	
	Standard value	Value for unavoidable cases
80	280	230
60	150	120
50	100	80
40	60	50

30	30	-
20	15	-

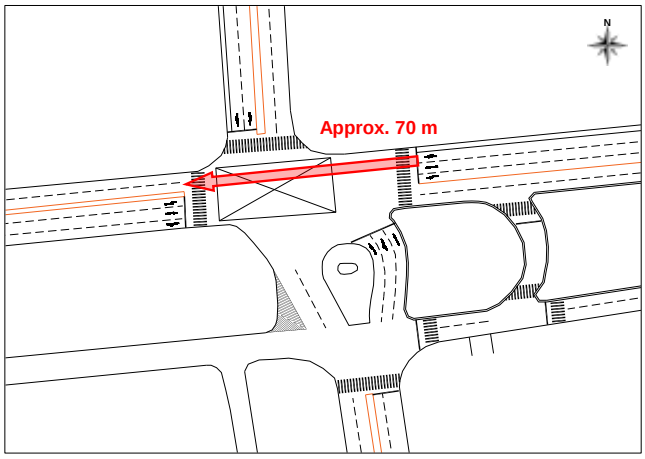
Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

7.2.4 Intersection Size

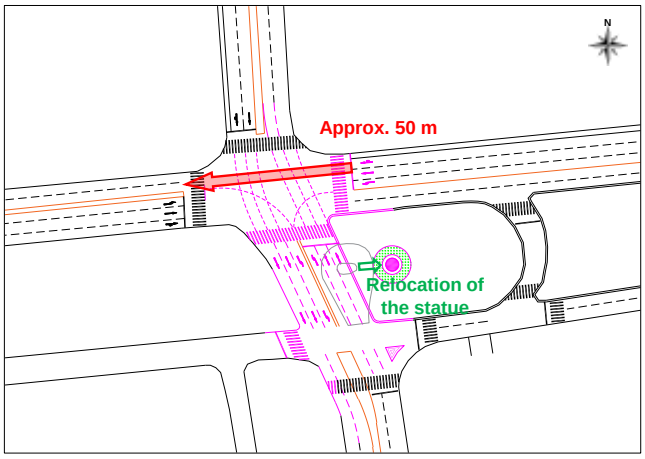
It is obvious that larger intersection area results in more traffic accident risk due to higher possibility of conflicts between vehicles in the intersection. Therefore, the intersection geometry including the location of pedestrian crossings and stop lines should be designed to have the trajectories of vehicle in the intersection as short as possible. It also greatly contributes to increasing traffic capacity of the signalized intersection by reducing red time.

Figure 7.7 and Figure 7.8 show examples of intersection area reduction. Figure 7.7 is a typical example of an incorrect intersection geometry that needs to be improved, not only because it is a mismatched intersection and the monument left in the intersection makes the crossing distance long, but also because vehicles traveling straight from south to north pass through the intersection in the path of two consecutive S curves. The #166 intersection shown in Figure 7.8 is an example of how the intersection area was reduced as much as possible through the pilot project.

(a) Current Feature

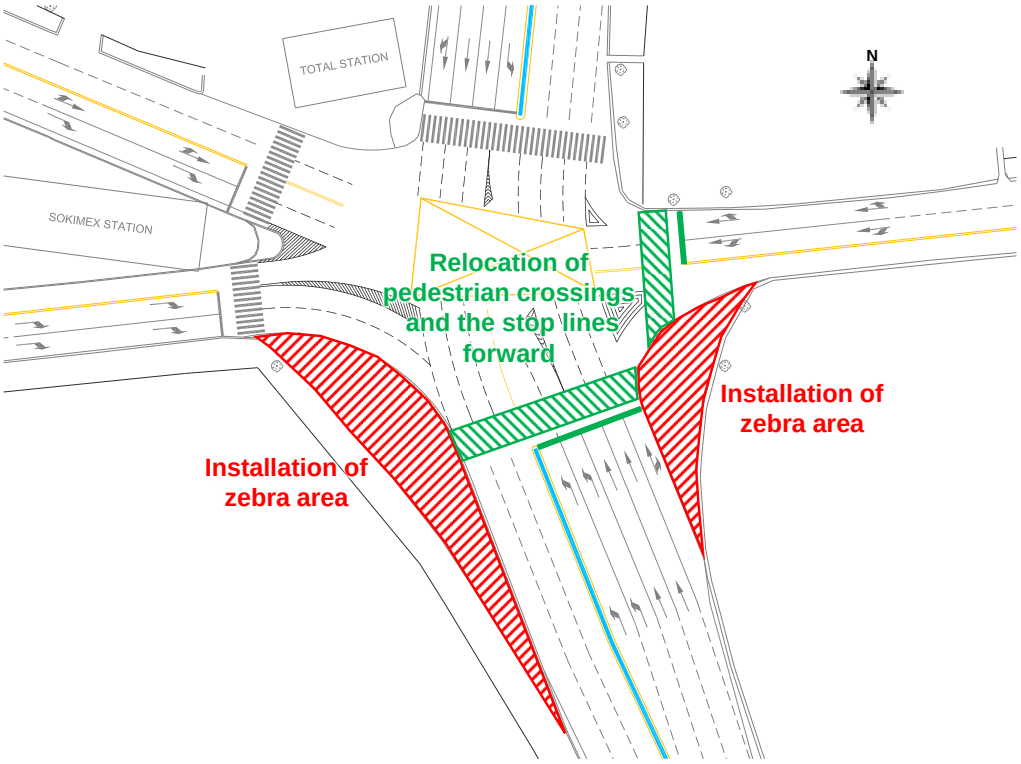


(b) Example of Improvement



Source: JICA Study Team

Figure 7.7 Example 1 of Reducing Intersection Size (Intersection #126)

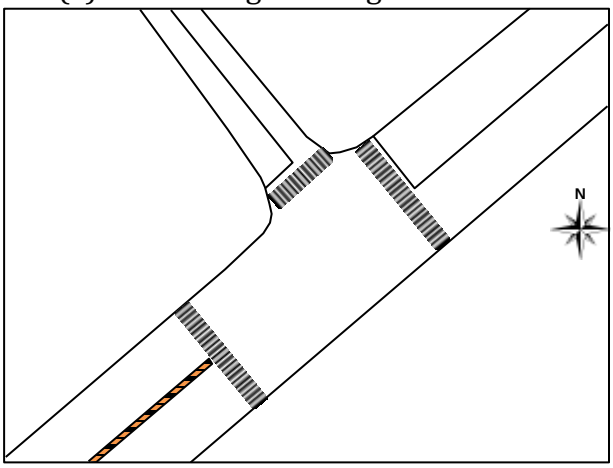


Source: JICA Study Team

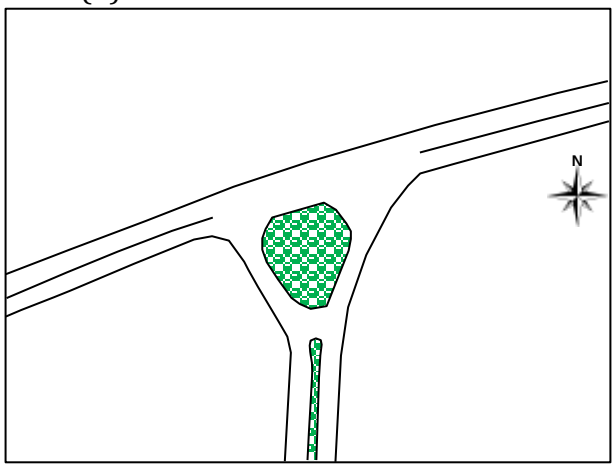
Figure 7.8 Example 2 of Reducing Intersection Size (Intersection #166)

Figure 7.9 shows examples of intersections where the intersection area should be reduced, which are intersections where the signalization is proposed or planned, or intersections that are existing signalized intersections but need upgrade for being connected to the Traffic Control Center. The intersection shown in Figure 7.10 is a DPWT signalized intersection and might be classified as a small-size intersection. However, there is unnecessary space inside the intersection, complicating the flow of vehicles. It would be worthwhile to consider making the west side of Street 221 one-way or widening the road.

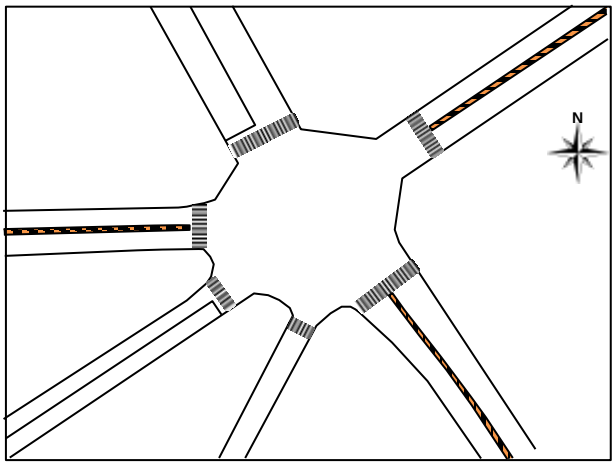
(a) Wat Taking Korsang Intersection



(b) Phnom Penh EPZ Intersection

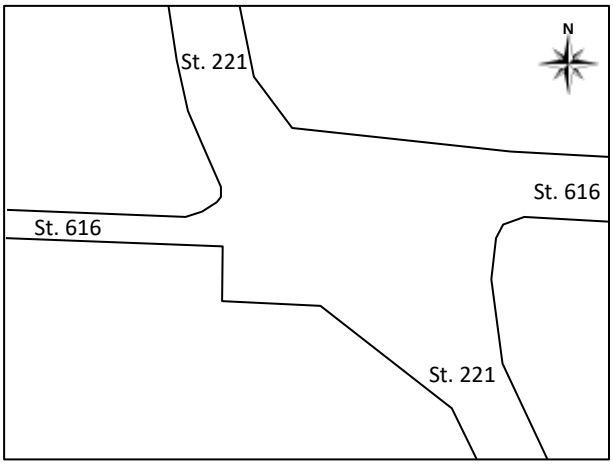


(c) Camko Intersection



Source: JICA Study Team

Figure 7.9 Intersections Recommended for the Size Reduction



Source: JICA Study Team

Figure 7.10 Srae Leab Intersection Recommended for the Improvement

7.2.5 Visibility at the Intersection

To improve safety, it is important that drivers be able to see the presence of intersections in advance; traffic signals should be visible from a certain distance upstream depending on the design speed for signalized intersections, and traffic signs for unsignalized intersections. In the intersection approaches, the queue of stopped vehicles expands and contracts, lane changes and weaving occur more frequently, and there is more information for the driver to pay attention to than in the single-road section, so the visibility distance of the intersection must be longer than the braking stop sight distance.

In Japan, the minimum visibility distance is calculated from the following equation, and the values are summarized in Table 7.2 by design speed and other factors. In other words, at signalized and unsignalized intersections, traffic signals and roadway signs must be installed so that traffic signals and intersection signs are visible from at least the values shown in the table, respectively, and any trees or other obstructions to visibility of the intersection must be removed through periodic inspections after the intersection is completed. Trees and other obstructions to the visibility of the intersection must be removed through periodic inspections even after the intersection is completed. Standard values for urban areas would be good to be used for most areas of Phnom Penh. However, for roads in the suburban areas of Phnom Penh, consideration should be given to applying the standards for rural roads, depending on the situation. On roads with a speed limit of 80 km/h, visibility of at least 350 m should be confirmed even in urban areas.

$$S = \frac{V \cdot t}{3.6} + \frac{1}{2\alpha}\left(\frac{V}{3.6}\right)^2$$

Here, S : Minimum distance for intersection recognition (m)
V : Design speed (km/h)
a : Deceleration rate (m/s^2) = 0.2g = 1.96 m/s^2
t : Response time (s) from the perception of intersection until the beginning of braking

- Signalized intersection in rural area: 10 s
- Signalized intersection in urban area: 6 s
- Unsignalized intersection: 2 s

Table 7.2 Minimum Distance for Intersection Recognition

Design speed (km/h)	Signalized intersection		Unsignalized intersection (m)
	Rural area (m)	Urban area (m)	
80	350	-	-
60	240	170	105
50	190	130	80
40	140	100	55
30	100	70	35
20	60	40	20

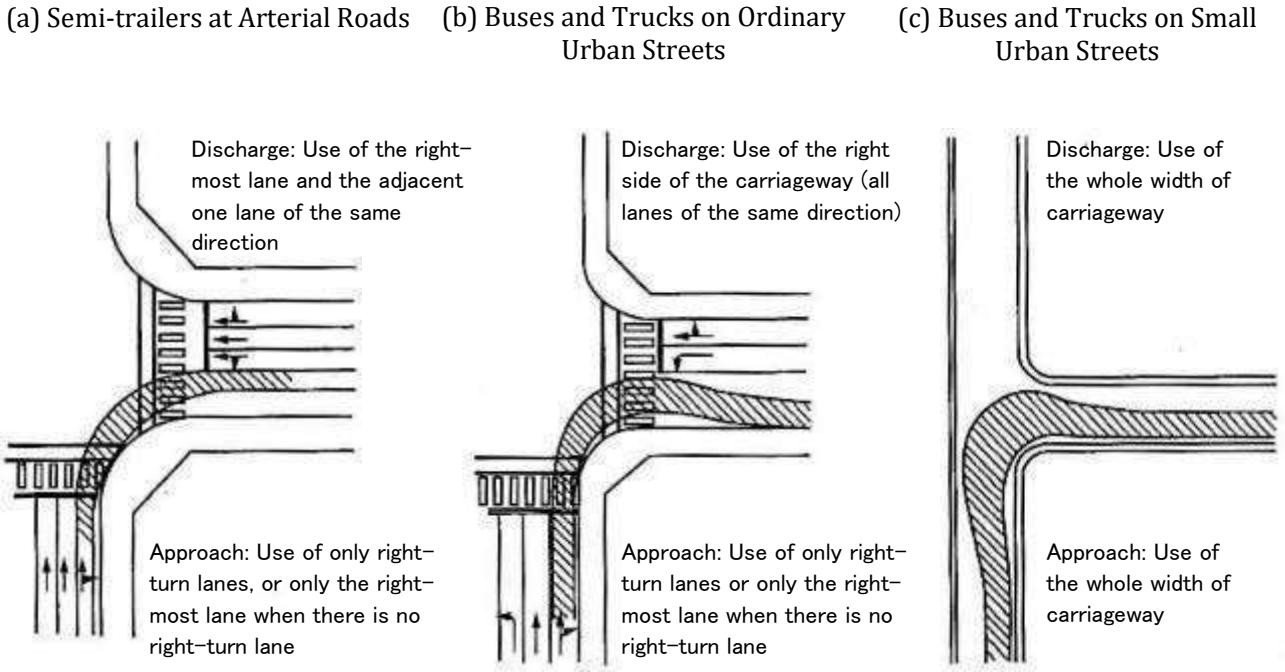
Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

7.2.6 Intersection Corner Design

Larger radius of curve at intersection corners enables higher right-turning speed and smoother movement that may increase the traffic capacity. On the other hand, the higher speed of right-turning often increases the risk of traffic accident between the right-turning vehicles and pedestrians for road crossing. For this reason, it is the best practice in Japan to apply as small radius of curve as possible to those risky intersection corners, which is also recommended to intersections in Phnom Penh.

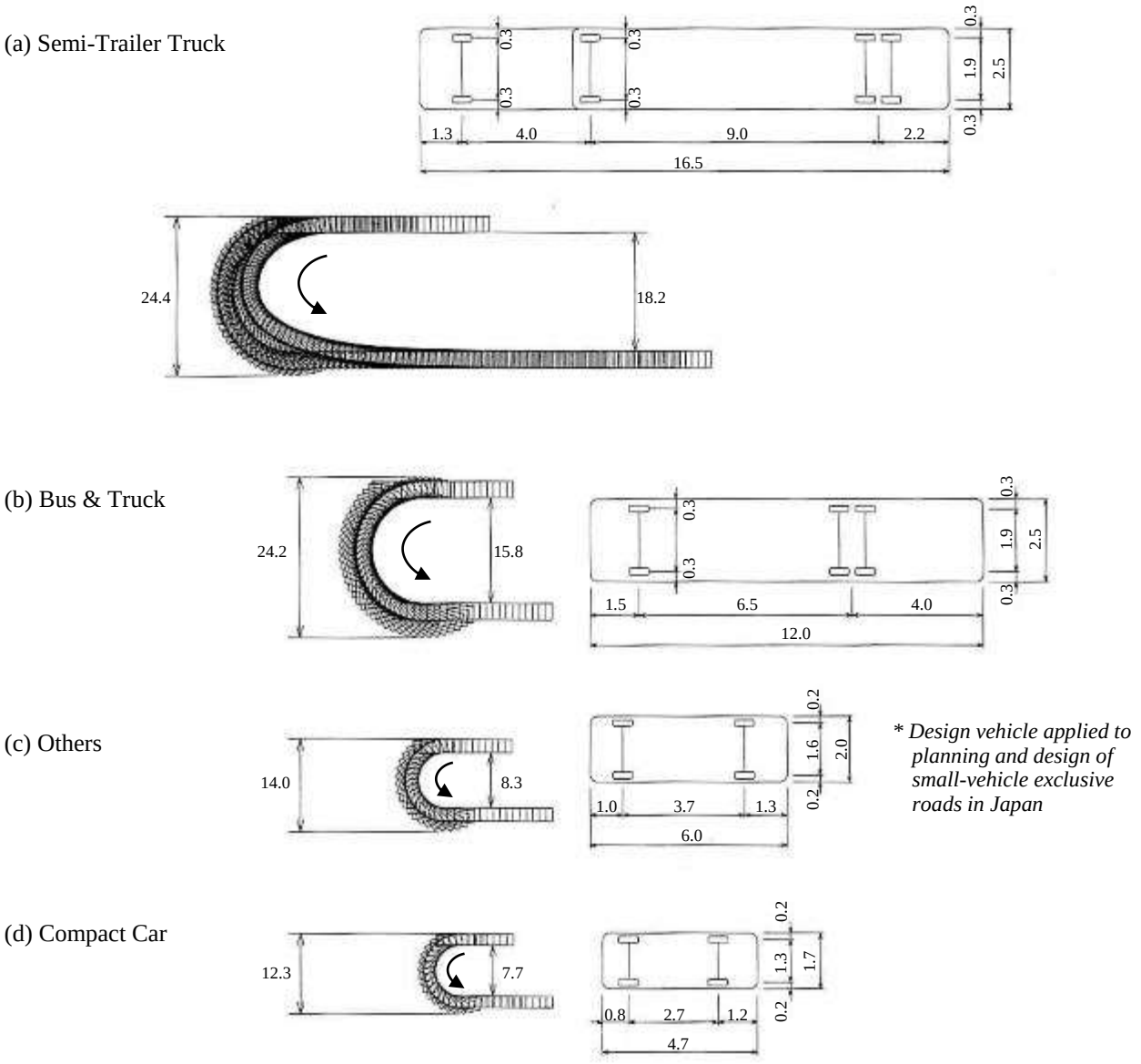
At intersections on roads with insufficient roadway widths, it is possible to minimize the curve radius and intersection area by devising a right-turn method. Figure 7.11 shows the right-turn methods assumed in the planning and design of urban signalized intersections in Japan. For reference, Figure 7.12 shows the dimensions of the design vehicle used for road planning and design in Japan and the vehicle trajectories when

turning at the minimum turning radius. In Phnom Penh, the design vehicle should be the semi-trailer truck for roads where semi-trailer trucks are expected to pass, such as arterial roads, and the ordinary vehicles like a bus or truck for other roads.



Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

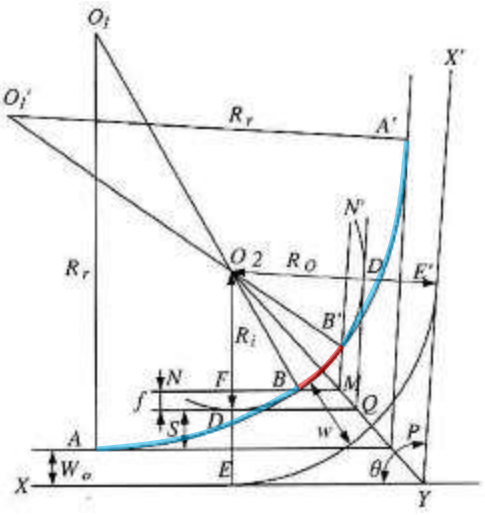
Figure 7.11 Right-Turn Methods Assumed in the Design of Urban Signalized Intersections in Japan



Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

Figure 7.12 Trajectories of Design Vehicles in Japan

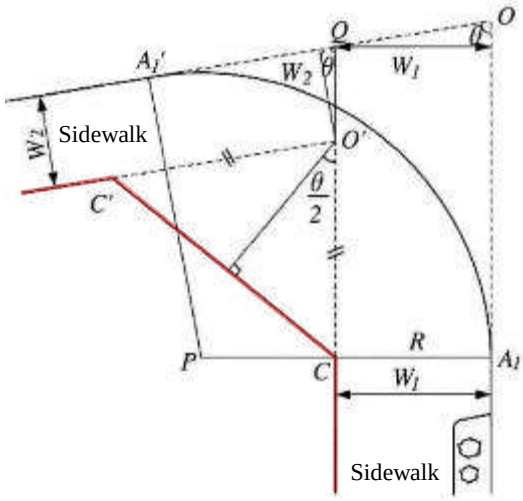
Due to the difference in radii of trajectories of front and rear tires of vehicles at curves, it is the design standard in Japan to use combination of three circular curves with different radii for one corner as shown in Figure. However, the combination curve takes more intersection area, so that the design method applying as small radius as possible introduced above is recommended for improving the traffic safety. It is also recommended to apply the actual vehicular trajectory for the curb lines at the intersection corners, which ensures larger pedestrian space and safe vehicular path for right-turning.



Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

Figure 7.13 Design of Combination Curves for Intersection Corner

For the visibility and the safety reasons, corner cut should be designed and provided at all kinds of at-grade intersections, including signalized intersections. At the same, it is important to keep the space created by corner cut empty without any kind of obstacles including trees, buildings, structures, and other obstacles to the visibility. Figure 7.14 shows how to generally determine the corner cut in Japan.



Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

Figure 7.14 Determination of Intersection Corner Cut Generally Applied in Japan

7.2.7 Auxiliary Lanes at Intersections

It is desired that, in principle, right- and left-turn lanes are installed at horizontal intersections. The number and length of such lanes depend on traffic demand and the intersection operation method. When signalizing existing intersections or upgrading existing signalized intersections, it is important to conduct a new traffic study and demand analysis and consider intersection geometry along with traffic signal control methods. In some situations, roadway or road widening may be necessary. If traffic signal control and other traffic management measures are not sufficient to handle the traffic demand, roadway widening or road widening through land acquisition should be implemented.

Separating directional traffic movements in and near the intersection can improve the traffic capacity and, at the same time, reduce the risk of traffic accidents. When planning and designing an intersection, installation of dedicated turning lanes such as left-, right-, and U-turn lanes should be positively examined and implemented.

In many cases, particularly the cases of existing roads and intersections in urban area, it is difficult to increase traffic lanes due to limited width of road or roadway. Lane width in Cambodia is considered generally as wide as that of expressways in Japan (3.5 m for expressways and 3.25 m for national highways and other arterial roads), and there are no design standards about reducing lane width in Cambodia. It is preferable to adopt Cambodian standards and keep the lane width as wide as possible, but, when the lane width reduction is required, it is recommended to adopt Japanese standards of minimum lane widths at intersections: 3.0 m for thru lanes and 2.75 m for dedicated turning lanes.

(1) **Auxiliary Lane Width**

Cambodian design standards should be primarily applied in intersection planning and design. However, Cambodian standards for lane width do not distinguish between urban and rural areas, making it difficult to install additional lanes in urban areas where it is difficult to secure road widths. In addition, it is a situation in Phnom Penh that the traffic safety is not ensured with such wide traffic lanes, since those lanes enable motorbikes to travel in even plural lanes between vehicles. As Japanese design standards have already been applied in the development of signalized intersections in urban areas by JICA, it is recommended that Japanese standards be used in the development of signalized intersections in the future as much as applicable.
The minimum lane widths recommended for urban roads in Phnom Penh are shown in Table 7.3. It is recommended to use them for roads in Phnom Penh where additional lanes are difficult to install by using Cambodian standards. For reference, Table 7.4 shows the design standards for lane widths on ordinary roads in Japan.

Table 7.3 Minimum Values of Lane Width in Urban Area of Phnom Penh (unit: m)

Road classification	All lanes on the basic section	Thru lanes where auxiliary lanes installed	Auxiliary lanes
All arterial roads	3.25	3.00	2.75
Other streets	3.00	3.00	2.75

Source: JICA Study Team

Table 7.4 Standard Lane Width in Japan (unit: m)

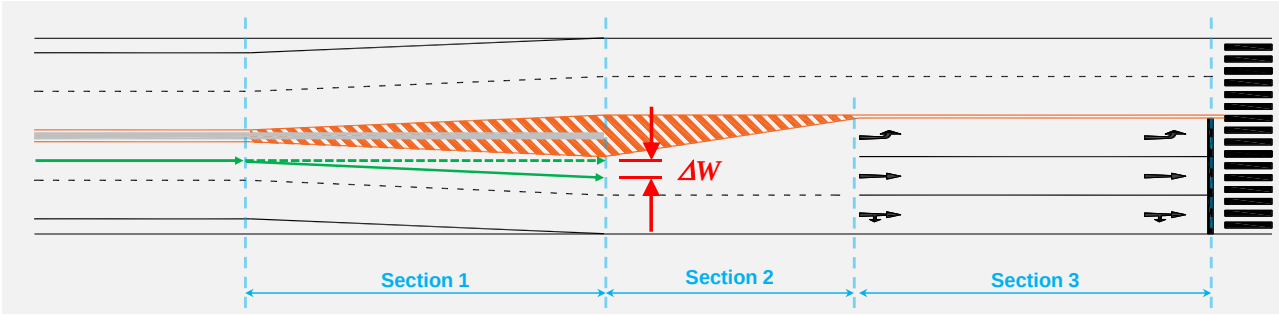
Road classification	All lanes on the basic section	Thru lanes where auxiliary lanes installed	Auxiliary lanes
● Rural Area			3.25, 3.00, or 2.75 *If unavoidable, 2.50
National Highways with AADT 20,000 veh. or more	3.50	3.50	
Local streets with AADT less than 1,500 veh.	2.75	2.75	
Others with AADT of 4,000 veh. or more	3.25 *If required, 3.50	3.25 *If required, 3.50	
Others with AADT less than 4,000 veh.	3.00	3.00	
● Urban Area			
National highways with AADT of 4,000 veh. or more	3.25 *If required, 3.50	3.25 or 3.00	
Others with AADT of 10,000 veh. or more	3.25 *If required, 3.50	3.25 or 3.00	

Others	3.00	3.00 or 2.75	

Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

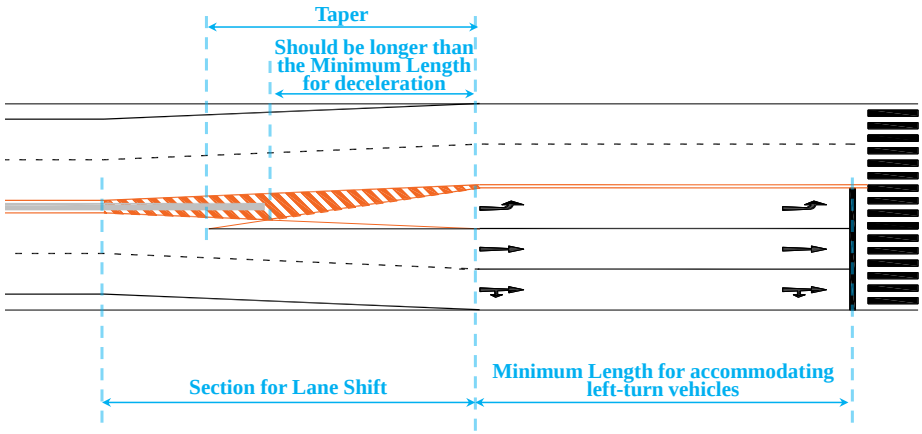
(2) Intersection Approach and Length of Auxiliary Lane

The design of intersection approach is examined from three aspects. One is the transition section where the traffic lanes are laterally shifted to accommodate additional lanes including turning lanes in the given roadway at the intersection. Another is the section required for deceleration so that vehicles can stop safely and avoid rear-end collision with preceding vehicles stopped at the intersection for the traffic signal. The other is the road section where the additional lanes excluding the tapers are installed for stopped vehicles that can wait for the traffic signals safely. Figure 7.1 shows an example of intersection approach. Here, Section 1 is the transition section required to laterally shift all vehicle movements. Design of horizontal curve is not necessary since the transition section should be designed so that the vehicular maneuver can be done safely within the lane width. Section 2 is the taper section for the left-turn lane. There must be cases that all vehicles including left-turning vehicles do not decelerate in Section 1, especially when the traffic signal is green. Therefore, Section 2 should be a part of or equal to the section where the left-turning vehicles can safely reduce speed and stop. Section 3 is the section required to accommodate stopped left-turning vehicles and separate those from the thru traffic, so that the traffic capacity of the intersection in improved. It is possible to shorten the installation section of the additional lane by overlapping sections 1 and 2 as shown in Figure 7.16.



Source: JICA Study Team

Figure 7.15 Typical Feature of Intersection Approach



Source: JICA Study Team

Figure 7.16 Overlapping Sections for Lane Shift and Taper

1) Section for Transition

The minimum length of section for the transition (lateral lane shift) indicated in Figure 7.1 and Figure 7.16 should be determined with the value indicated in Table 7.5 or greater.

Table 7.5 Transition Section Length for Lateral Lane Shift by Japanese Design Standards

Design speed, V (km/h)	Rural Area		Urban Area	
	Calculation (m)	Minimum (m)	Calculation (m)	Minimum (m)
80	$\frac{V \cdot \Delta W}{2}$	85	-	-
60		60	$\frac{V \cdot \Delta W}{3}$	40
50	$\frac{V \cdot \Delta W}{3}$	40		35
40		35		30
30		30		25
20		25		20

ΔW (m): the lateral distance of maneuver (see Figure 7.1)

- The transition section length should be determined from the calculation but should not smaller than the minimum value.

Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

2) Section for Deceleration

The minimum length of section for the deceleration indicated in Figure 7.1 and Figure 7.16 should be determined with the value indicated in Table 7.6 or greater.

Table 7.6 Minimum Length of Section for the Deceleration by Japanese Design Standards

Design speed (km/h)	Minimum length for deceleration (m)	
	Main roads in rural area	Intersecting roads in rural area and roads in urban area
80	60	45
60	40	30
50	30	20
40	20	15
30	10	10
20	10	10

Source: "Planning and Design of At-Grade Intersections (Basics) - Guidelines for Intersection Planning, Design, and Traffic signal Control", Japan Society of Traffic Engineers, November 2018.

3) Section for Stopping for Traffic Signal

The length of auxiliary lane for accommodating left-turn, U-turn, or right-turn vehicles should be determined considering traffic demand, fluctuation characteristics of the traffic demand, and parameters of traffic signal control. It should be 30 m or longer if the traffic demand and the fluctuation characteristics are unknown, e.g., in such cases that intersections are planned on a new road not existing currently.

7.2.8 Pedestrian Crossing

Intersection is for not only the vehicle traffic but also pedestrians. In principle, pedestrian crossings should be installed at all intersection legs, unless it is obvious that there are no pedestrians crossing the road. Otherwise, it makes the pedestrians commit the illegal road crossing, which threatens the safety of road-crossing pedestrians. Examples of those intersection are shown in Figure 7.17.

(a) Intersection #126

(b) Dang Nangkol Intersection

Source: JICA Study Team

Figure 7.17 Examples of Intersections without Pedestrian Crossings

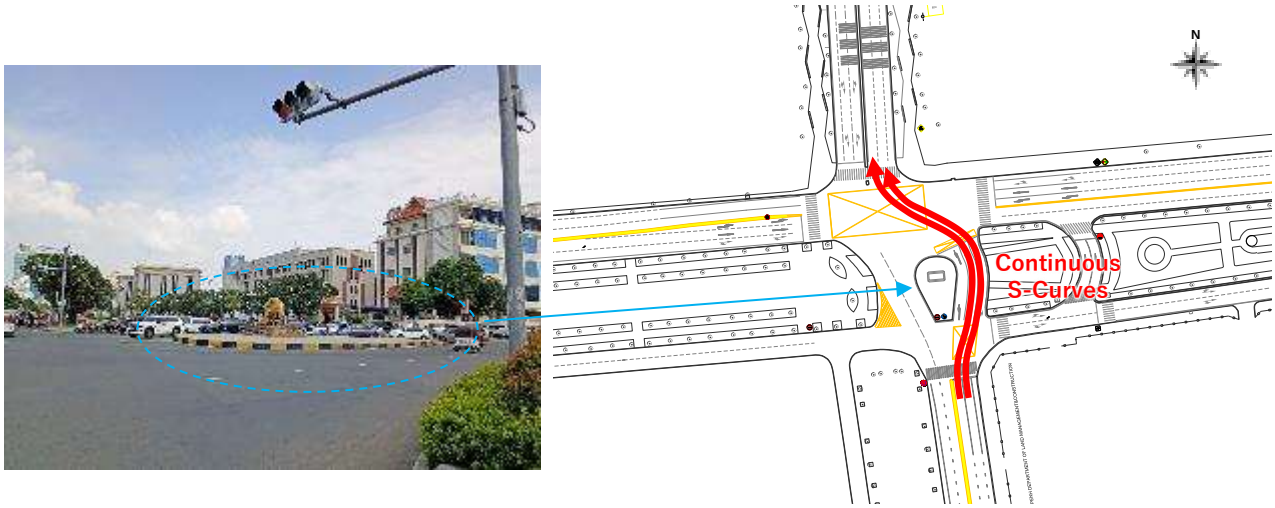
There are many pedestrian crossings that were initially installed but have disappeared, as have other road markings. It is desirable to repair them immediately.

Source: JICA Study Team

Figure 7.18 Example of Disappeared Pedestrian Crossings

7.2.9 Horizontal Alignment of Traffic Movement

Basically, the alignment of traffic movement in and near the intersections should be straight or close to a straight line. In fact, there are many cases that the trajectory is curved, but it should be reminded that the complicated maneuver increases the risk of traffic accident. One example is Intersection #126, where the trajectory from the south to the north becomes continuous S-curves due to the Statue of Two Dears (see Figure7.19). One proposed solution is shown in Figure 7.7.



Source: JICA Study Team

Figure7.19 Unpreferable Trajectory of Traffic Movement at Intersection #126

Another example is shown in Figure7.20. This intersection is always severely congested and is a mismatched intersection, resulting in long crossing distances and reduced intersection traffic capacity. Furthermore, as at intersection #126 (Figure7.19), the raised median strip within the intersection, left in place for a lighting pole, impedes the flow of traffic in the north-south direction, especially for semi-trailer trucks.

Source: JICA Study Team

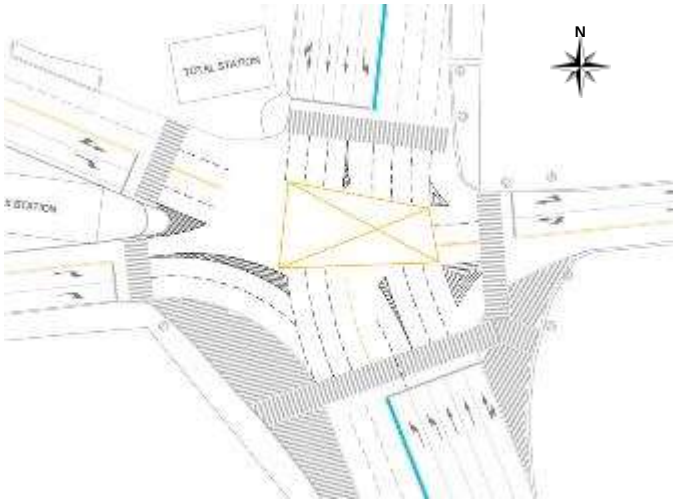
Figure7.20 Toul Pongror Intersection Recommended for the Improvement

7.2.10 Others

(1) Lane Marking Inside the Intersection

As already mentioned, the intersection should be planned and designed so that the complicated traffic maneuver is avoided. If there are two or more lanes for the same direction at the intersection, and if their trajectories are curved inside the large intersection, it is safer to clearly indicate the route of each movement inside the intersection by using pavement marking. However, the pavement marking inside the intersection should not confuse the drivers and should be as simple as possible.
Intersection #166 is a good example. It was originally a big rotary and has been upgraded to a signalized intersection, and it has wide intersection area. The trajectories of traffic movement inside the intersection are

curved, and, especially, there are three lanes per direction for the north-south direction of traffic. One example of pavement marking inside the intersection is shown in Figure7.21.



Source: JICA Study Team

Figure7.21 Example of Pavement Marking Inside Intersection #166

(2) Removal of Existing Traffic Signs after Intersection Signalization

There are traffic signs remained in place even after the signalization of intersection. Most of them are “stop” signs that were required to be installed when the intersections were unsignalized. They are obviously unnecessary at signalized intersections. They not only confuse drivers but may also cause traffic accidents depending on the situation. Therefore, when signalizing an intersection, not only should new traffic signs be considered, but the removal of existing signs should also be examined and carried out. It should be noted that the use of inappropriate traffic signs and road markings is also a factor that reduces the driver's awareness of traffic rules.

Source: JICA Study Team

Figure 7.22 Examples of Inappropriate Traffic Signs (Stop Signs at Signalized Intersections)

(3) Correction of Inappropriate Road Surface Markings

As shown in Figure 7.23, inappropriate road markings are found at existing intersections. This photo was taken at Intersection #65 installed by DPWT near AEON 3, and the next intersection, Intersection #65 has the same problem. As inappropriate road markings cause traffic accidents and reduce traffic capacity as traffic signs do, they should be corrected immediately.

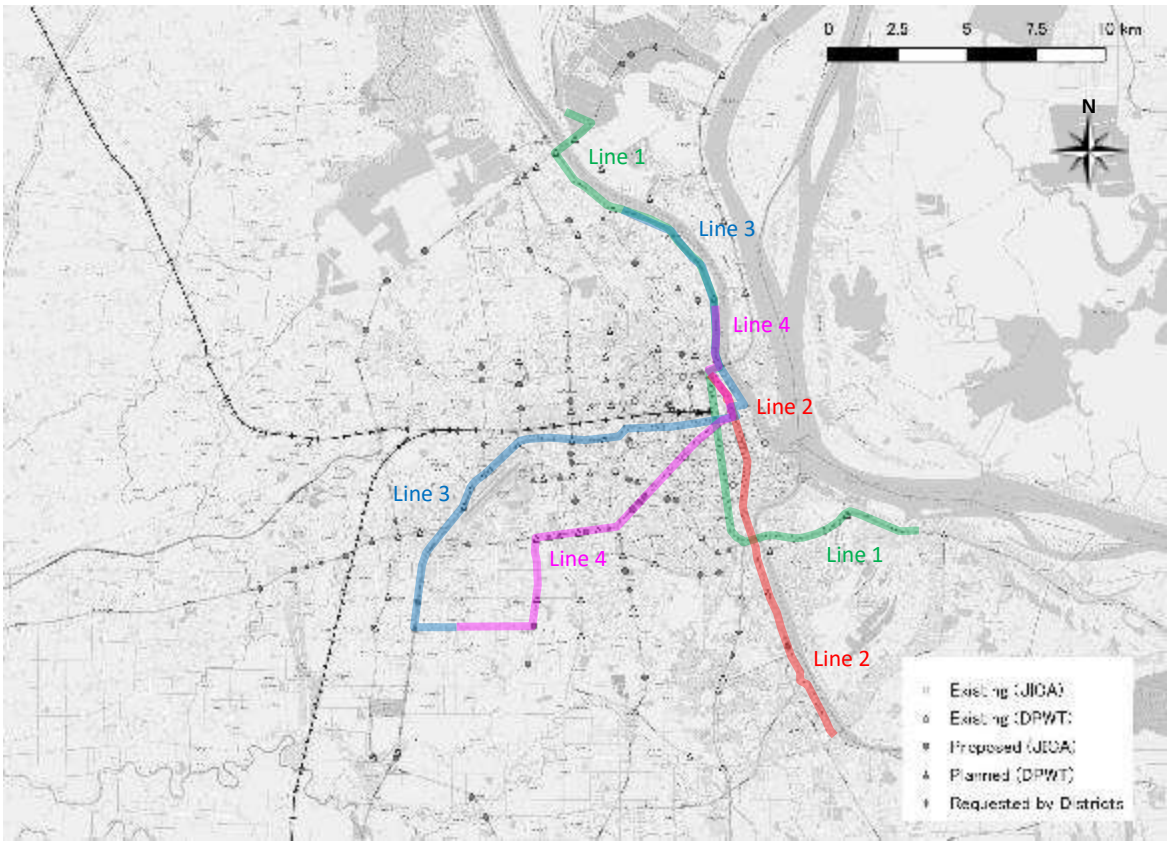
Source: JICA Study Team

Figure 7.23 Example of Inappropriate Road Marking near AEON III

(4) Consideration of Upper Plans Related to Road Infrastructures

When signalizing intersections, it is important to check higher-level plans related to the area where the intersections are located, and plan and design the signalization through communication with relevant agencies to those plans and coordination with other projects for the efficiency of the implementation of road traffic infrastructure development. For example, in an ADB project, the introduction of BRT system is proposed for Phnom Penh City Bus Lines 1 to 4 as candidates (Figure).

BRT development requires the conversion of part of the roadway to be dedicated to buses, widening of roadways and possibly roads, and relocation or new construction of road structures and facilities for BRT system and underground structures or facilities if exist. These may affect improvements of intersections located on that road, installation of traffic lights and traffic signal controllers, connection to telecommunication cables, etc. It is important to coordinate the project schedule depending on the situation. Furthermore, in plans where bus-dedicated or bus-priority signals are to be installed, signal control method of the intersection may be more complicated with more signal phases than at regular signalized intersections, and it may be necessary to examine installing signal controllers capable of such complicated signal control. Other projects being considered in Phnom Penh include the grade-separation of intersections and urban rail transport, probably as well as raised or depressed roads or railways considered as a countermeasure to traffic congestion caused by railway crossings. Thus, it is recommended that these plans also be confirmed in advance.



Source: JICA Study Team *Map data: OpenStreetMap (https://www.openstreetmap.org/)

Figure 7.24 Signalized Intersections and Phnom Penh City Bus Line 1, 2, 3, and 4

7.3 OTHER MEASURES FOR BETTER URBAN TRAFFIC FLOW

7.3.1 Traffic Management on Sections between Intersections

Generally, the traffic capacity of signalized intersection is larger than that of unsignalized intersection, and the signalization of intersections may reduce the traffic congestion caused by intersections that are bottlenecks on the road network. However, if the intersection is not the cause of the traffic congestion and unsmooth traffic flow, it is unlikely that traffic congestion will be mitigated by signalization of the intersection. In addition, while intersection signalization should improve traffic congestion, the effect is likely to be limited if a bottleneck on a road section between two adjacent intersections exists. The following is a description of the main causes of traffic congestion on road sections between two adjacent intersections in Phnom Penh. It is recommended that measures be implemented in conjunction with intersection signalization.

(1) **Major Issues on Arterial Road Sections between Intersections in Phnom Penh**

1) Traffic to and from Local Streets

Right/left turns from minor streets connected to arterial roads and left turns from arterial roads to minor streets are considered major causes of unsmooth traffic flow on arterial roads in Phnom Penh. In particular, minor streets connected to the arterial roads near intersections are one of the causes of significant reduction in traffic capacity at intersections.

One example is shown in Figure 7.25. There is a street connected to the approach of the west side leg of Intersection #59. During the morning peak hours, the street is used by many vehicles to merge into the approach of the intersection, and they obviously increase the traffic congestion and significantly decrease the traffic capacity. It is not easy to reduce the traffic from the street or close it, but it might be a solution to close it or operate it as one-way road from north to south.

Source: JICA Study Team *Map data: OpenStreetMap (https://www.openstreetmap.org/)

Figure 7.25 Street Connected to Intersection #59

2) Median Openings on Arterial Roads

To prevent U-turns and left turns from minor streets and improve traffic flow on the arterial roads, as well as to improve traffic safety, physical dividers such as concrete barriers are installed in the median strip of many arterial roads. However, the openings of divider installed for left turns from minor streets, left turns from arterial roads to minor streets, or U-turns are considered more than necessary, and are thought to be one cause of worsening traffic flow on the arterial roads.

Source: JICA Study Team

Figure 7.26 Median Openings on Arterial Roads

3) U-Turn Traffic

In areas where U-turns are common, U-turn traffic as well as right/left turns and thru traffic from minor streets worsen the traffic flow on arterial roads (also see Figure 7.26).

4) Pedestrian Crossings on Road Sections between Two Adjacent Intersections

There are few examples in Phnom Penh of traffic signals installed only for pedestrians at crosswalks on road sections between two adjacent signalized intersections. However, on arterial roads with high traffic volume, there are fewer opportunities for safe road crossing, and the risk of traffic accidents due to dangerous road crossing is high.

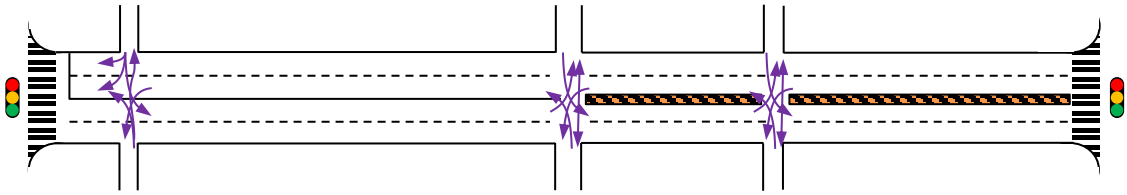
5) On-Street Parking and Illegal Road Space Occupation

Even on streets where stopping or parking is not prohibited, on-street parking is one cause of reduced traffic capacity of arterial roads. However, there is no active enforcement of no-stopping or parking or any traffic controls that prohibit stopping or parking on congested arterial roads. The same can be said for illegal occupancy of roads.

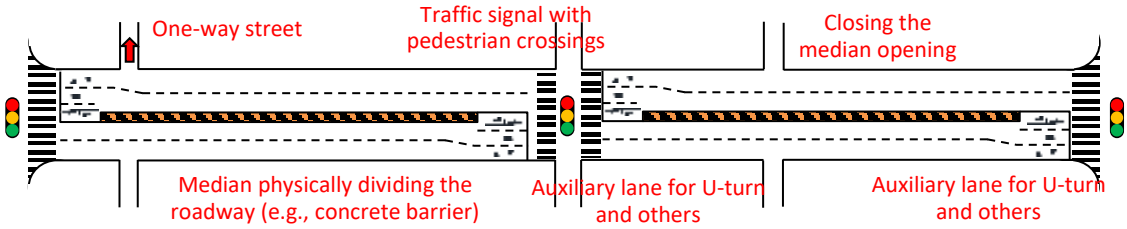
(2) Examples of Solutions

In relation to issues such as traffic from (to) minor streets, crosswalks, etc. on arterial roads, it might be a good solution to signalize one or more intersections with minor streets with particularly high traffic volumes when the arterial road section between two adjacent signalized intersections is long. This measure would not only improve the safety of pedestrians crossing the roads but also reduce traffic congestion caused by those minor streets with high traffic volume. At the same time, the arterial roadway should be physically separated by direction, using such as a concrete barrier, so that left turns from the minor street and from the arterial road to the minor street are not possible. This measure is expected to improve flow on the arterial road. If necessary, the minor street could be operated as a one-way street to prevent merging from the minor street to the arterial road. In this case, U-turn lanes should be properly installed on the arterial roads for the traffic to/from the minor streets to improve the overall efficiency of traffic flow.

(a) Example of Current Traffic Operation



(b) Image of a Solution for the Above Example



Source: JICA Study Team

Figure 7.27 Example of Traffic Operation for Road Sections between Intersections

7.3.2 Clear Indication of Vehicular Path

There are many road sections in Phnom Penh where lane markings have disappeared. It is recommended that they be repaired immediately to improve traffic safety.

Source: JICA Study Team

Figure 7.28 Veng Sreng Blvd. without Lane Marking

7.3.3 Continuous Public Relations (P/R) Activities for Better Road Traffic

Various traffic safety campaigns have been conducted under this project, which have attracted a great deal of interest from the public, including drivers. It is considered that such campaigns, together with traffic enforcement, will raise drivers' awareness of the need to obey traffic rules and regulations, and will greatly contribute to reducing traffic congestion and traffic accidents in Phnom Penh.

Source: JICA Study Team

Figure 7.29 Campaign for Traffic Rules Held in Phnom Penh in September 2024

8. 8. PRELIMINARY WORK PLAN OF THE TRAFFIC CONTROL SYSTEM EXPANSION PLAN FROM 2025 TO 2035

8.1 Introduction

The current traffic control system of Phnom Penh was handed over to Cambodia about five years ago. Its Japanese traffic control system's lifespan is usually said to be approximately 15 years, so it will be necessary to replace it with a new traffic control system by 2035. Therefore, the next 10 years will be a critical time to decide on the next system and ensure the sustainability of Phnom Penh's traffic control system. The issues to be addressed during this period are (1) how to solve problematic signalized intersections in the western suburbs where urbanization is rapidly progressing, and (2) how to upgrade to the next traffic control systems that will cover both central Phnom Penh and the suburbs.

8.2 Issues of Traffic Control System Expansion Plan in Phnom Penh

(1) How to cope with problematic signalized intersections in the western suburbs of Phnom Penh
Traffic is concentrating on major roads such as Russian Blvd., Veng Sleng Blvd., and Hanoi Road in the western suburbs of Phnom Penh, where urbanization is rapidly progressing. However, the traffic phasing and timing of stand-alone signals at major intersections along these corridors do not match the traffic flow; road markings at intersections are invisible; and incorrect road signs are left on the sides of the road. Therefore, appropriate signal installations and implementation of related traffic management measures are important elements for improving the signalized intersections. In addition, most sections of main corridors have median strips, and at the many median openings, the through traffic of the main roads and the U-turn traffic at these points, causing also traffic congestion. Currently, all signals in the suburbs are stand-alone, but by keeping them as stand-alone with replacing equipment such as controllers for the time being and implementing the improvement plan below, sufficient improvement effects can be expected. It is also important that the Cambodian side takes the initiative by making full use of the results of the pilot project by TCC staff. The main contents of the improvement plan for stand-alone signalized intersections in the western suburbs are as follows:

1) As the reliability of the current traffic control system is highly appreciated by Phnom Penh citizens based on its performance over the last six years, the basic approach will be to use new stand-alone signals. In the future, these standalone signal controllers will eventually be replaced at intersections in the suburbs when the traffic control system is updated.
2) The target intersections will be decided in the discussion among the relevant parties such as TCC staff, DPWT staff and JICA experts.
3) A topographical survey and traffic volume survey of the target intersections will be carried out.
4) A detailed design (setting signal parameters such as signal phase and timing, intersection improvement plan).
5) Selection of traffic signal manufacturer (designated by competitive bidding).
6) Selection of local signal installation company by the designated signal manufacturer.
7) Dispatch of signal manufacturer's engineers and consultants.
8) Implementation of signal installation work and intersection improvement work.

Figure 1 shows the locations of problematic signalized intersections in the western suburbs of Phnom Penh that were selected by on-site inspections and discussions between the C/Ps of the PPTMTC Project.

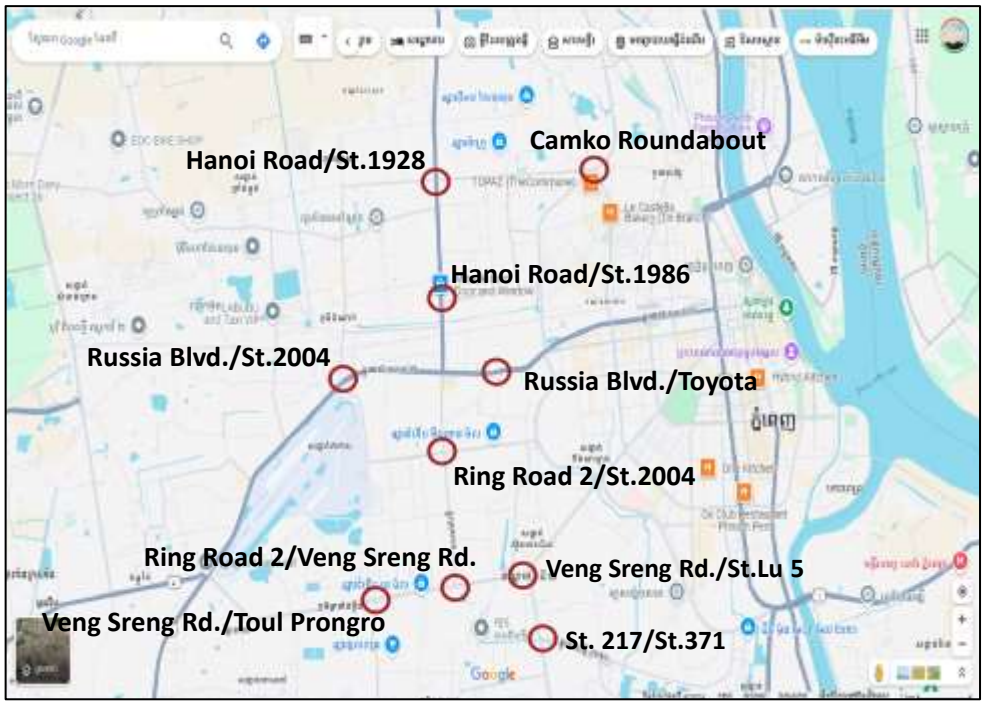


Figure 8.1 Target Signalized Intersections in the Western Suburbs of Phnom Penh

(2) Upgrading the Traffic Control System

The primary goal of Phnom Penh's urban traffic management plan is to update the traffic control system within the current system's lifespan taking into account both the system's lifespan and advancements in information technology. This project is large in scale and is expected to take nearly 10 years from project preparation to completion. Basically, it is assumed that the current system will be updated.
The followings are considered for the next generation traffic control system.

1) A new central server under the new signal system and the installation or replacement of traffic signals at 268 intersections (traffic signal installation at 140 intersections; replacement of 118 signal controllers; and installation or replacement of standalone traffic signals at around 10 intersections).

2) As all construction and activities in this project are basically carried out within the right-of-way od road space, it is thought that there will be fewer issues than with regular infrastructure development, which has to address social and environment issues, including resident relocation.

3) Traffic volume data collected and stored by the Traffic Control Center is useful for various traffic management measures such as planning new roads, installing traffic lights, and optimizing public transportation. However, with the current system, it is not possible to easily share traffic volume data with related organizations. When the system is updated, it is possible to review such operational issues and expand the beneficiaries.

Table 8.1 Current System and Upgrade System Overview

	Current Traffic Control System	Upgrading Traffic Control System
Signalized intersection	118 intersections	258 intersections
Covered area	Urban area	Entire city
Signal control method	Area traffic control	Area traffic control
Adaptive control	Actuation control	Actuation control MODERATO
Vehicle Detector	Image Detector	Image Detector Ultrasonic Detector
CCTV Camera	26 locations in urban area	50 locations in entire city
Communication System	Optical fiber cable network Wireless network (test on the pilot project)	Optical fiber cable network Wireless network (TYPE-A)

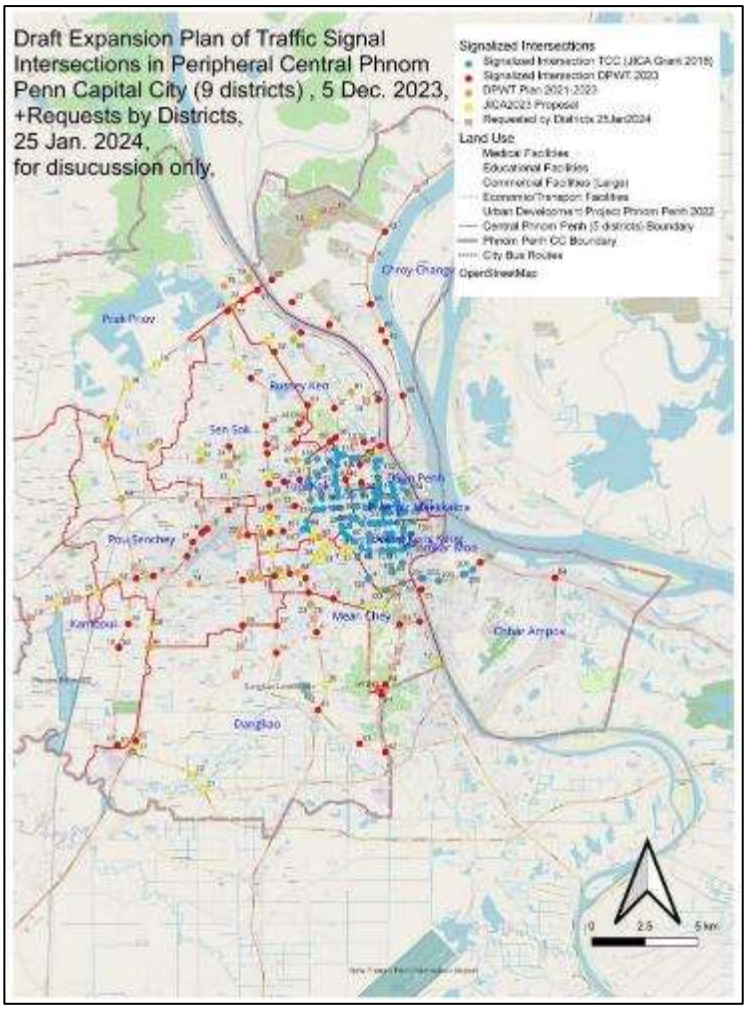


Figure 8.2 Location of Signalized Intersections in the Traffic Control System Expansion Plan

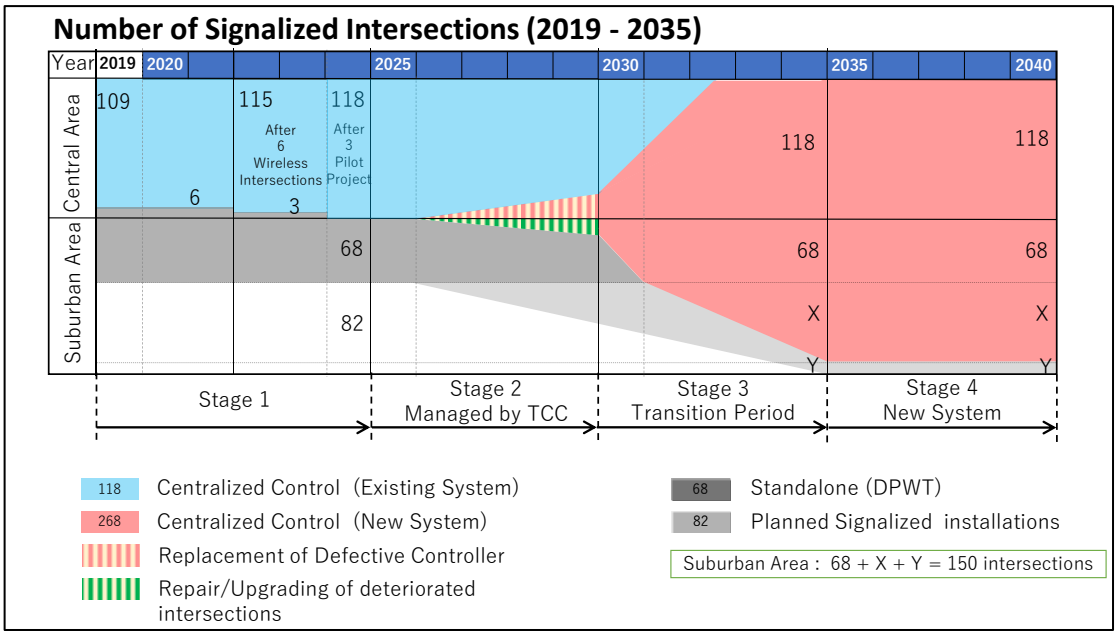


Figure 8.3 Number of signalized intersections in Phnom Penh (from 2019 to 2035)

(3) Schedule

The outline schedule for the above two projects is shown in Figure 8.4. If this schedule is followed, traffic congestion in suburban areas will be improved, and the renewal of the traffic control system throughout Phnom Penh will be completed within the next 10 years. In addition, if the TCC staff properly operates and maintains the system, the sustainability of the traffic control system can be guaranteed until around 2050.

Table: Work Plan of (1) Improvement of 10 Signalized Intersections in the Suburban Area and (2) Replacement of New Traffic Control System in the Whole Phnom Penh Area

Items	Year	2025				2026				2027				2028				2029				2030				2031				2032				2033				2034				2035				2036			
	Quarter	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th

1. INTERSECTION IMPROVEMENT PROJECT BY LOCAL FUND

Improvement of 10 Stand-alone Signalized Intersections

- Planning — (Decide the location the target intersections)
- Traffic Survey — (Topographic survey and traffic survey)
- Design
- Procurement
- Installation Work
- Dispatch Engineers — (Despatch Short-term Experts)

2. REPLACEMENT OF CURRENT TRAFFIC CONTROL SYSTEM

Replacement of New Traffic Control System in Whole Phnom Penh Area

- Preparatory Survey — (Including Request Survey of CDC)
- Fact Finding Mission
- Appraisal Mission
- Signing
- Consultant Selection
- Detailed Design
- EIA/RAP & Land Acquisition — (within the road space)
- Procurement of Contractor (with PQ)
- Construction Works — 42 months (Tentative); DLP: 12 Months

Note: DLP (Defect Liability Period)

Outline of Improvement of the 10 Signal Intersection

1. 10 Intersections improvement
2. Procurement of 10 controllers (standalone), signal lanterns and signal poles.
3. Installation Work of 10 Signalized Intersections

Outline of the Construction Work

1. Replace new center server
2. Installation of 150 new company's controllers
3. Replace 150 conyrollers from current system to new company
4. Improvement of 160 signalized intersections.

Figure 8.4 Preliminary Schedule of the Projects (2025 - 2035)

Project for Capacity Development on Comprehensive Traffic Management Planning and Traffic Control Center Operation and Maintenance in Phnom Penh Capital City (PPTMTC)

PART I: TRAFFIC ENFORCEMENT MANUAL
AND
PART II: TRAFFIC SAFETY EDUCATION MANUAL

FEBRUARY 2025

Japan International Cooperation Agency (JICA)

Mets Research & Planning, Inc.
International Development Center of Japan
Oriental Consultants Global Co., Ltd.

Preface

This manual is basically divided into two parts.

Part I is called “Traffic Enforcement Manual”, which is a compilation of materials used by the head of the traffic enforcement division of the Tokyo Metropolitan Police Department in a lecture to Phnom Penh traffic police officers during the pilot project traffic safety campaign. After the lecture, there was a high demand for copies of the instructional materials from the Phnom Penh Traffic Police and National Traffic Police officers who attended the lecture, so the slides from the lecture were compiled.

Part II is named “Traffic Safety Education Manual”, which is a compilation of important points for engineers from the DPWT Road Safety Division. The division’s main responsibility is to promote traffic safety in Phnom Penh and to establish traffic safety education programs later on. The key point is that in many countries, motorbike and car users are required to have their licenses reissued after a certain number of years have passed from their license issuance. However, because of the basics, and staying informed of updates to the Road Traffic Act to address shifts in traffic conditions and accident characteristics.

This manual also provides a summary of traffic accidents and traffic conditions in Whole Cambodia and Phnom Penh on the latest data.

PART I: TRAFFIC ENFORCEMENT MANUAL

PART I TRAFFIC ENFORCEMENT MANUAL

1. INTRODUCTION

1.1 Traffic Accidents in Tokyo/Japan

Since Japan's defeat in World War II, Japan has struggled to prevent traffic accidents amidst chaos and scarcity.

As the number of automobiles increased during the post-war economic recovery, the number of traffic accident fatalities increased sharply, and this resulted, in the strengthening of the preparation of accident statistics, safety education, and guidance and enforcement. Consequently, these measures brought down the number of traffic accident deaths after peaking in 1960.

Furthermore, another period of increase started, and peaked in 1992, but this coincided with the shift to a 24-hour society and the economic bubble period.

Each country has a different system and scale, making it difficult to make a simple comparison, but Japan currently has one of the lowest traffic accident fatalities per 100,000 people in the world.

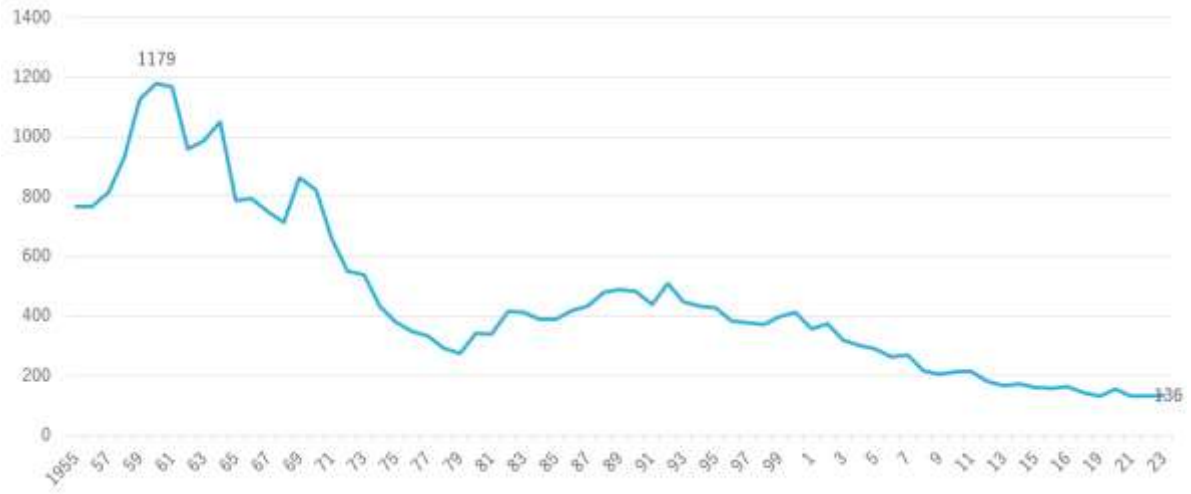


Figure 1.1 Fatalities by Traffic Accident in Tokyo

Nationwide, the number peaked in 1970, 10 years later than in Tokyo, but it follows the same pattern of rapid growth, decline, and period of re-increase in the middle. One of the characteristics is that the capital, which is the center of political and economic activity, takes the lead first.

It seems likely that Cambodia will follow a similar pattern, with Phnom Penh taking the lead, but there are some differences from Japan’s time.

One is improving vehicle safety performance - improving safety devices and predictive sensors such as airbag protectors.

Second, external factors have led to the rapid development of SNS, which is an extremely effective means of public relations and enlightenment.

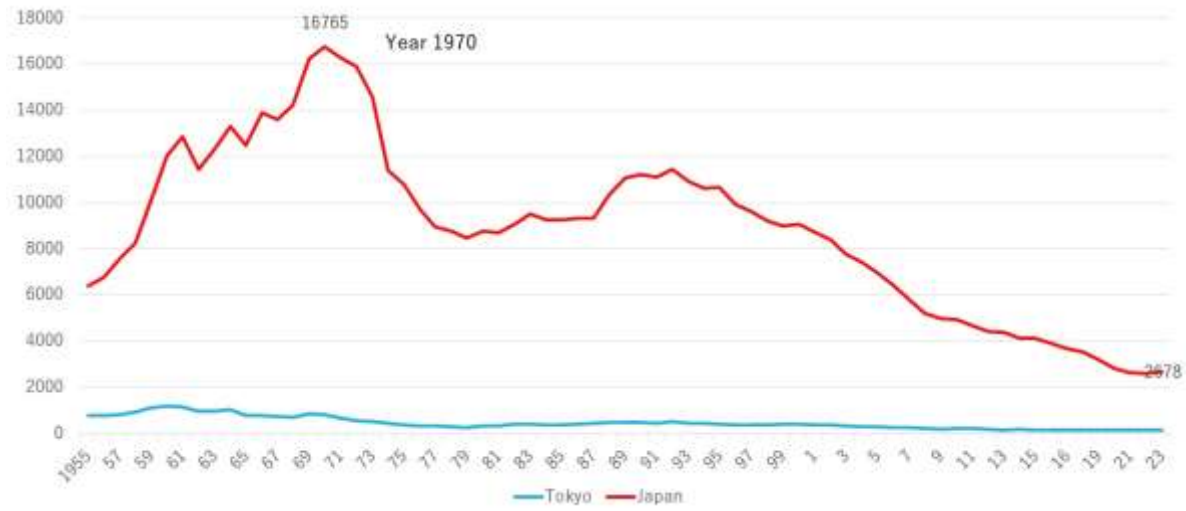


Figure 1.2 Fatalities by Traffic Accident in Japan

1.2 Traffic Accident in Phnom Penh/Cambodia

Figures for Cambodia are based on the National Road Safety Committee Road Crash Victim & Information System (RCVIS) report by the National Road Safety Committee (NRSC).
According to reports, traffic fatalities are steadily decreasing in Cambodia.
In terms of deaths per 100,000 people, Phnom Penh is currently around the peak of Tokyo.
In Cambodia as a whole, it is lower than the peak in Japan.
It took Tokyo 60 years to reach its current level from its peak in 1960, but Cambodia can catch up more quickly by selectively adopting the strengths of the early runners.

Table 1.1 Traffic Accident in Phnom Penh/Cambodia

Year 2020

	Area	Population	Auto Mobile	Fatality	Fatality per 100000	1960 Peak Fatality per 100000
Phnom Penh	678㎢	2.7M		335	12.40	
Tokyo	2,194㎢	13.9M	4.9M	155	1.11	12.12
	Area	**Population**	**Auto Mobile**	**Fatality**	**Fatality per 100000**	**1970 Peak Fatality per 100000**
Cambodia	181,035㎢	16.5M	5.9M	1,794	10.90	
Japan	377,973㎢	126.1M	91.4M	2,839	2.25	16.33

1.3 Comparison of Traffic Accident Characteristics in the Two Countries

The table below shows the percentage of fatalities and injuries from traffic accidents, and the high proportion of fatalities in Cambodia, especially those caused by motorcycles, stands out. It is clear that these are the most important issues for Cambodia.

Table 1.2 Comparison of Road Traffic Accidents between Cambodia and Japan

Year 2020

Percentage of Casualties			Fatalities by Motorbike(%)	
	Cambodia	Japan	Cambodia	Japan
Dead	15	0.8	78	18.5
Serious	31	7.5		
Slight	54	91.7		

☆Heinrich's Law in Occupational Accidents 1-29-300
This is the law that states that behind one serious accident there are 29 accidents with minor injuries, and behind each of these there are 300 unsafe actions.

☆Next is Frank Bird's research study based on traffic accidents.
Car collisions are classified into four types: fatal, serious injury, minor injury, and property damage, and these are applied to the ratios shown in the triangle on the right.
As is clear from the two principles, the natural structure of industrial accidents and traffic accidents, from serious accidents to minor accidents and careless actions, is a triangular hierarchy with the more minor ones forming the lower layer. This is generally the case in Japan as well.
Traffic accident statistics in Cambodia show a trapezoidal shape, and its accuracy needs to be verified.
From this triangle, it is apparent that two countermeasures should be taken: countermeasures against the apex and reduction of the base.
For the most serious accidents, statistics is used to clarify the causes and focus on cracking down on malicious and dangerous violations that are likely to lead to accidents.
Deterrence through police monitoring and guidance and enforcement on the streets as an activity to reduce the base
By deterring violations of traffic rules and duty of care, which are the causes of accidents, the base will become smaller and the top will naturally become smaller as well.

Percentage of Casualties

	Cambodia	Japan	Number of Japan
Dead	15	0.8	2,839
Serious	31	7.5	27,774
Slight	54	91.7	341,702

Figure 1.3 Percentage of Casualties and Heinrich's Law

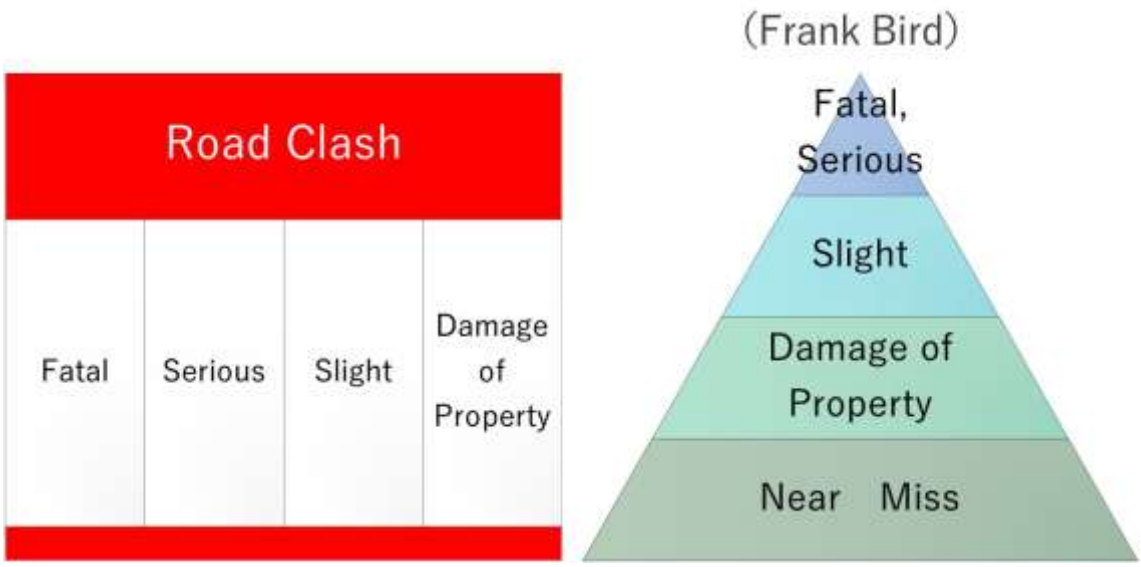


Figure 1.4 Percentage of Casualties and Heinrich's Law

2. ENFORCEMENT IN 3Es

2.1 About 3Es

The three Es (3Es) are Engineering, Education and Enforcement: and combining them results in the three elements of road traffic: people, roads, and vehicles.
Enforcement mainly involves measures against people (drivers, riders and pedestrians) and vehicles, It is an activity led by the police.

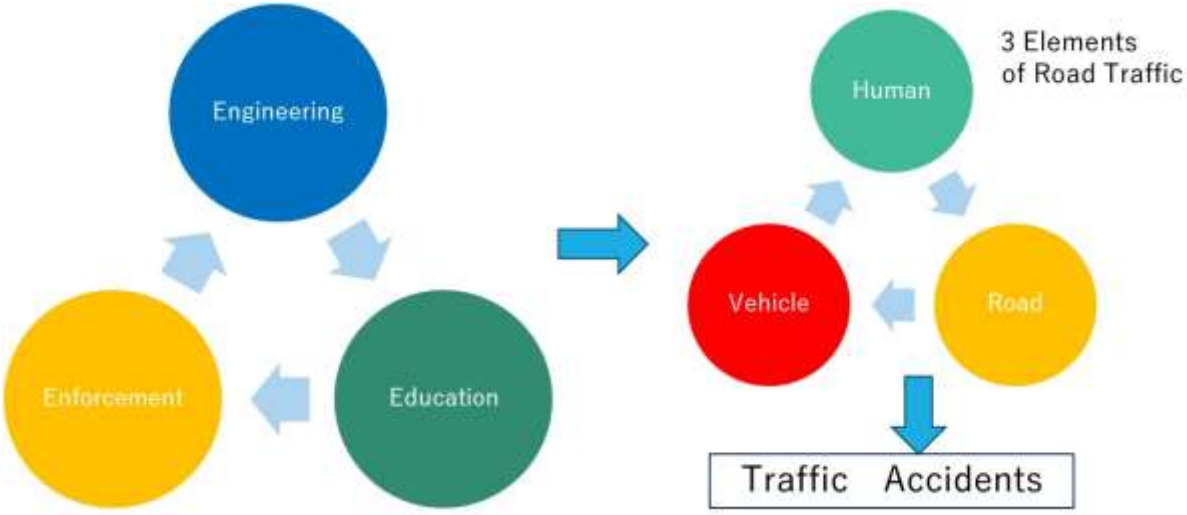


Figure 2.1 Image About 3Es

2.2 3Es in Tokyo Metropolitan Police Department (TMPD)

The basic concept of the 3Es in the Tokyo Metropolitan Department (TMPD) is shown in Figure 2.2.

Figure 2.2 Basic Concept of 3Es in Tokyo Metropolitan Police Department (TMPD)

The Metropolitan Police Department has nine divisions, with 102 police stations under them.
The Traffic Bureau is divided into eight sections, and the difference from Phnom Penh is that traffic regulation, traffic control, and driver's license headquarters belong to the police.
The Traffic Bureau is a headquarters organization, and actual field activities are carried out by members of the 102 police stations established in each ward, town, and village.
Traffic sections have been established at 102 police stations in Tokyo.
There are approximately 300 police-officers and 40 traffic section staff per station.
And the 3Es in TMPD are performed by the following:
Engineering: Traffic Control Section, Traffic Regulation Section
Education: Traffic Administration Section, Driver's License Headquarters
Enforcement: Traffic Enforcement Section, Traffic Riot Police, Parking Control Section, Traffic Investigation Section,
In addition to the above, the Traffic Administration Section is responsible for traffic accident statistics and analysis, which are essential for promoting the 3Es.

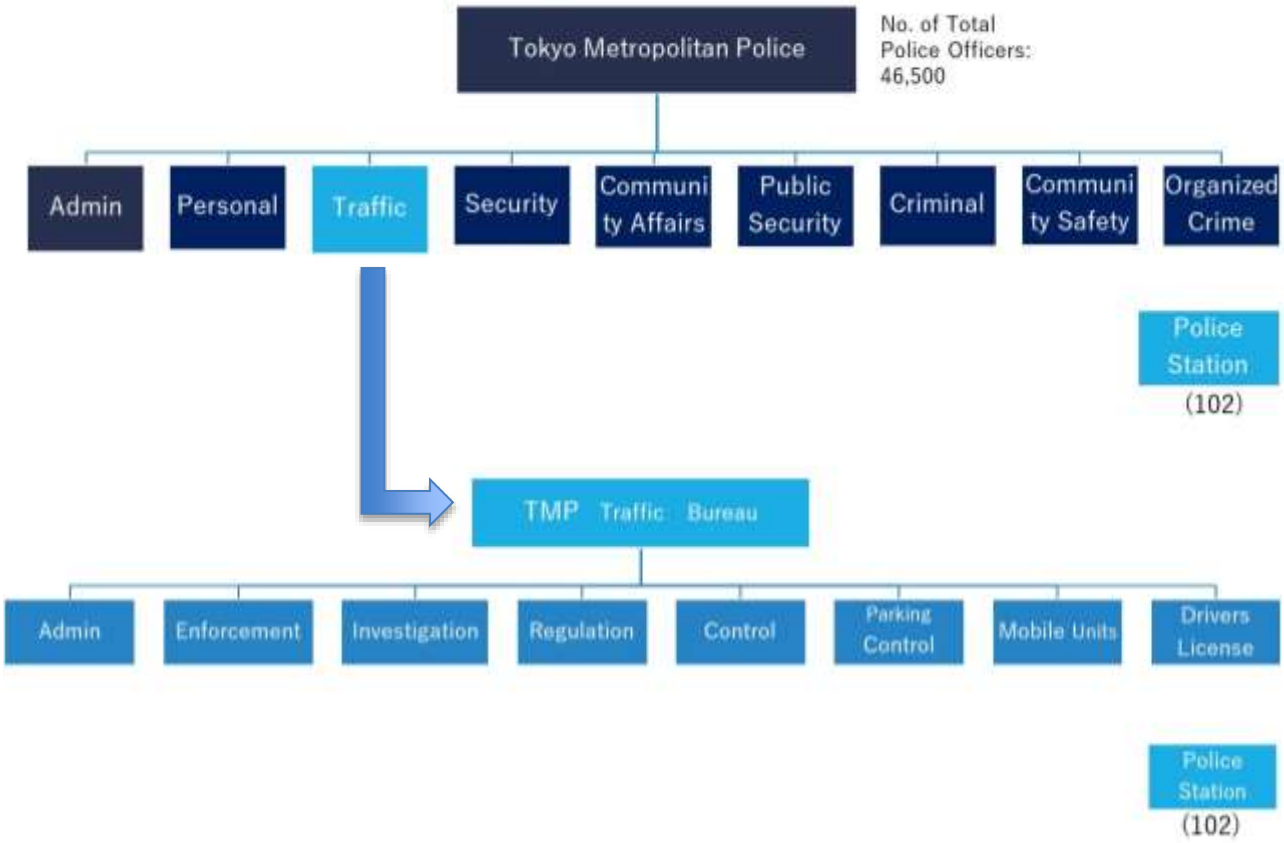


Figure 2.3 Organization of Tokyo Metropolitan Police Department (TMPD)

2.3 Comparison of Police Organization between Phnom Penh and Tokyo

Based on the organizations between Tokyo Metropolitan and Phnom Penh, each division has a similar structure.

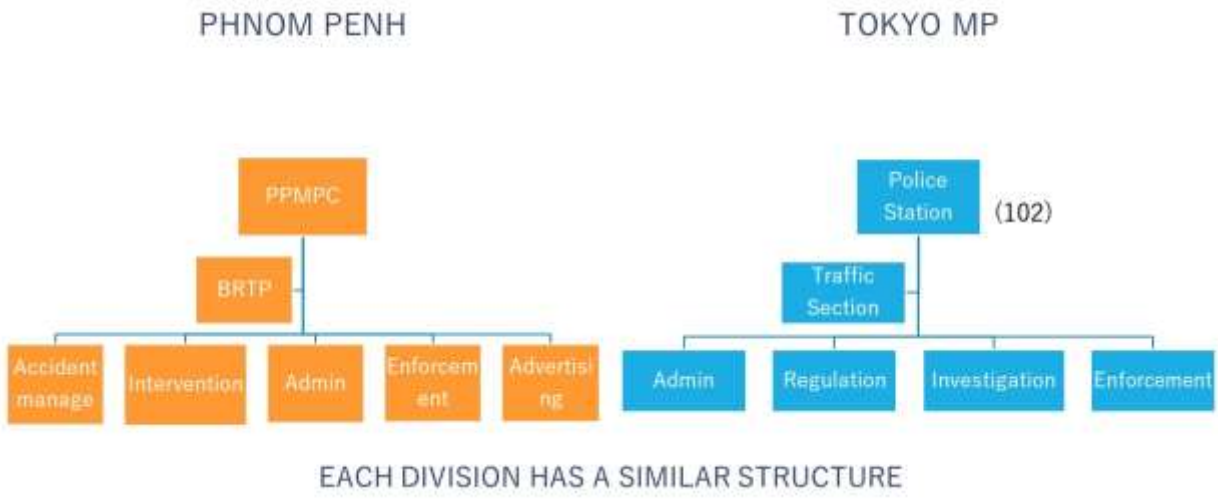


Figure 2.4 Comparison of Police Organization between Phnom Penh and Tokyo Metropolitan

3. TRAFFIC ENFORCEMENT MANUAL

■ Contents

3.1 Basic Thinking

Enforcement has a powerful legal background, so it must be operated appropriately to avoid misdirection. It is important to gain the understanding, cooperation, and sympathy of the people who are road users. This will lead to gaining trust in the traffic police and make it easier to implement various measures.

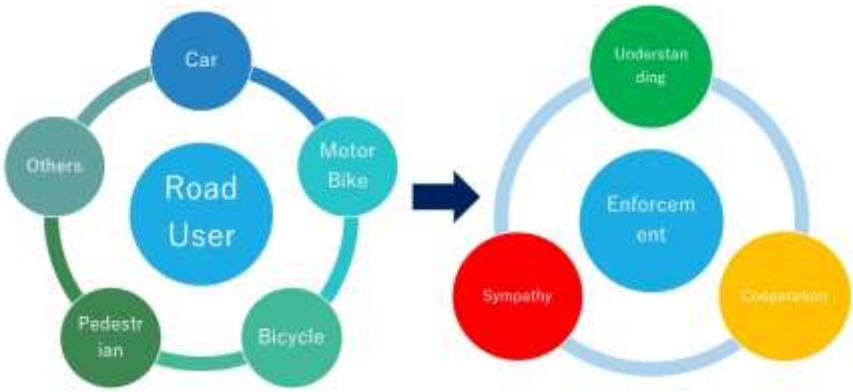


Figure 3.1 Basic Thinking of Traffic Enforcement

3.2 Meaning of Enforcement

Enforcement authority is granted to achieve the objectives of ensuring road traffic safety and order and protecting life and property.

The core of traffic enforcement is apprehension of traffic violators, but it also includes a wide range of other activities, including guidance, warnings, and corrective measures to prevent traffic violations and accidents.

Figure 3.2 Meaning of Enforcement

3.3 Constitution

A. Monitoring activities: The very presence of police officers on the streets alerts road users and gives them a sense of security.

The basis of guidance and enforcement activities is street placement, patrols, and other monitoring activities to prevent dangerous acts and violations from occurring.

B. Guidance: Activities that encourage correct behavior by providing verbal and gestural guidance to road users who engage in dangerous behavior.

C Warning: The basic idea of guidance and enforcement is to first issue a warning orally or in writing to encourage voluntary improvement in the event of danger or violation.

D. Apprehension: This is the central activity of traffic enforcement, and involves imposing fines on violators by notifying them in writing of the violation or catching them red-handed, and encouraging them to follow traffic law and guidelines in the future.

E. Instructions/orders: Similar to the above, it performs necessary measures and inspections for dangerous and illegal acts, and issues legally binding instructions and orders. Examples: Suspension of driver's license, prohibition or restriction of vehicle use, etc.

Figure 3.3 Constitution

3.4 Duty Flow

Understanding the actual situation means ``knowing the current situation'' and serves as the premise and standard for implementing countermeasures. Specifically, it is understanding the current situation of people, roads, and vehicles, and the situation within the jurisdiction.

In particular, accident statistics require accurate tabulation, as numerical analysis reveals causes and trends and serves as a standard for comparison.

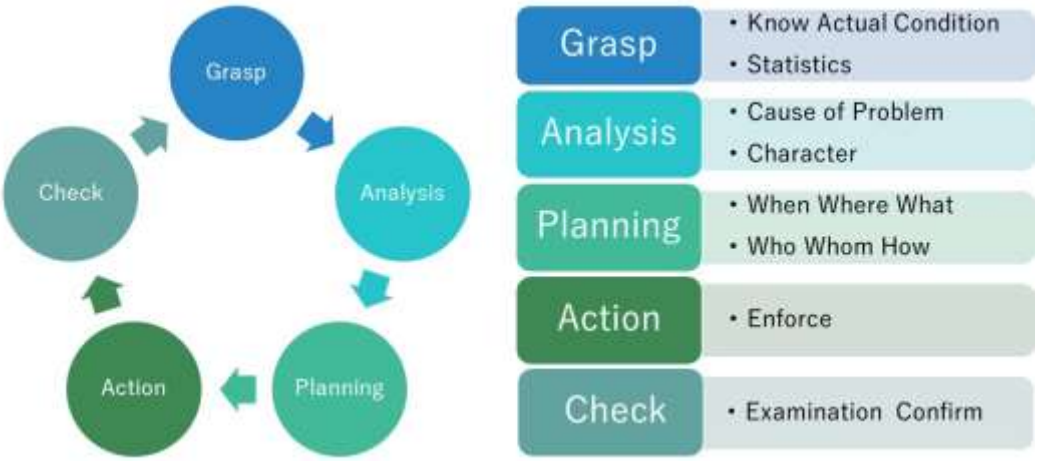


Figure 3.4 Duty Flow

3.5 Management

A. Importance of enforcement management
In order to properly operate traffic enforcement in accordance with its objectives and policies, executives must accurately grasp and analyze the progress of enforcement activities, implementation results, occurrence of traffic accidents, citizen requests, opinions, etc. There should be thorough enforcement management by effectively utilizing personnel

B Quality control
Enforcement activities need to be well-balanced to avoid bias, and enforcement locations, times, targets, etc. need to be selected based on actual traffic conditions.
There are a wide variety of traffic violations that are subject to enforcement: and in order to be effective, it is necessary to implement enforcement in a balanced manner on all of them. A basic enforcement plan will be formulated in line with the actual situation of traffic accidents, such as setting a month to focus on serious violations, for example, drunk driving.

C. Quantitative management
For traffic enforcement to be effective, there must be a sufficient amount of enforcement to influence the traffic behavior of drivers, pedestrians, etc.
Quantitative management factors include activity time, number of employees, number of enforcement actions, number of guidance enforcement actions, etc.

Figure 3.5 Management

3.6 Method

Overt and covert enforcement: There are two types of traffic enforcement: open enforcement, which discloses information such as the date, time, location, and target, and secret enforcement, which does not disclose information.

- Public enforcement allows more people to drive with awareness of traffic rules by disclosing enforcement information in advance.
  By disclosing the information, the purpose is to make it known that the police are carrying out appropriate enforcement, to educate people about observing traffic rules, and to raise awareness of safe driving.
- Confidential enforcement is carried out without disclosing enforcement information: and as drivers cannot be aware of it in advance, they cannot avoid the area in advance and maintain a certain sense of tension.
  Enforcement effectiveness can be increased by combining both overt and covert methods.

Figure 3.6 Method

3.7 Plan

A. Formulation of a plan

Based on higher-level policies and plans. Comprehensive analysis and consideration of the occurrence and mode of traffic accidents and trends in traffic conditions within the country. Select policies, routes, targets, etc.

B. Education on related laws and skills training

- Efforts will be made to disseminate traffic-related laws and regulations so that traffic guidance enforcement is carried out properly and lawfully in accordance with laws and regulations.
- Improve law enforcement skills by providing the necessary education and training to become familiar with the handling of measurement and detection equipment used for enforcement on excessive speeding, drunk driving, etc.

C. Establishment of a system

- Secure the personnel necessary for enforcement activities and prepare equipment and materials.
- Inspect the functions and operating conditions of the equipment in advance and keep a record of the inspection.
- Securing means of transportation for personnel and equipment.

Figure 3.7 (1) Plan 1

D. Plan by Time Period

- Annual plan: This plan utilizes enforcement statistics and traffic accident statistics from the past five years. In accordance with the basic policy, plan is formulated that includes special months based on the traffic situation and accident situation in the jurisdiction throughout the year.
- Monthly plan: Based on the annual plan, draw up the priority targets, placement, group enforcement, night enforcement, education/training, holidays, etc.
- Plan for the day: Based on the monthly plan, specifically determine each personnel's activity type, location/route, equipment, materials, and activity priorities, etc.

Figure 3.7 (2) Plan 2

3.8 Traffic Enforcement Do's

A. Assignment of specific duties

- Inform each staff member of the day's mission, priority targets, location, etc.
- In the case of group enforcement, designate a person in charge of the scene, assign duties to each person, and instruct them on the equipment they should carry.
- Concerning duties during group enforcement, specific instructions will be given to each person, such as stopping and guiding vehicles, questioning and interrogation, measuring equipment, and tracking fleeing vehicles, as well as conducting functional checks of measuring equipment and other equipment in advance.

B. Apprehension of violator

- Accurately confirm the requirements for the violation and notify the other party of the violation.
- Collection of evidence necessary for proof

C. Prevention of injuries to police officers

- Enforcement activities are conducted in a crowded environment with vehicles, etc., so choose a location where you can avoid harm in an emergency.

- Do not stand in front of the violating vehicle when it stops.
- In the case of group enforcement, the on-site supervisor must effectively deploy equipment, keep an eye on the whole situation, and designate a supervisor as necessary.

Figure 3.8 Traffic Enforcement Do's at a Glance

3.9 Report preparation and Checking

- After enforcement, the person in charge of examination will examine and check whether there are any errors in the fact finding regarding the detected violation, etc., and whether there are sufficient proofs and evidence materials, etc., in preparation for referral to a court, etc.
- To contribute to proper enforcement management, daily inspection results are compiled and organized and reported to superiors.

Guidance and enforcement do not end once it is implemented; it is necessary to constantly verify its effectiveness and reflect it in future activities.

Figure 3.9 Report Checking at a Glance

Public safety and the maintenance of public order are the best services that the government provides to the people, but traffic safety and the maintenance of traffic order are an important part of this. They are essential for the steady and continued development of the country.

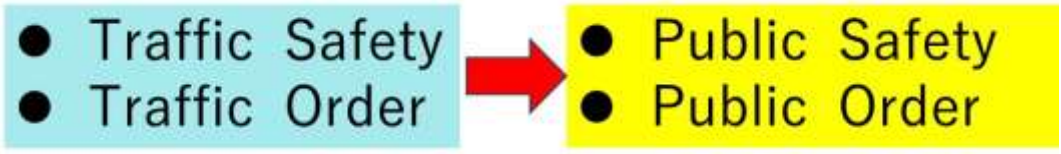


Figure 3.10 Foundation of Progress

PART II: TRAFFIC SAFETY EDUCATION MANUAL

PART II TRAFFIC SAFETY EDUCATION MANUAL

1. INTRODUCTION

After a driver receives his/her valid license, it is a duty by law that such license must be renewed after a certain number of years (renewal period differs depending on the type of license, age group or history of traffic offences). The renewal of expired licenses is an opportunity for the authority to conduct a 'refresher' course on traffic safety. Lectures on traffic safety for these drivers will be conducted again with a greater focus on traffic situations and current city conditions including advancements in traffic management and new facilities that may impact driving behavior. However, the present ***Law on Road Traffic*** does not require such compulsory education for license renewals.
Therefore, this manual presumes that traffic safety education will become compulsory by order of the Government of Cambodia for all drivers applying at the Ministry of Public Works and Transport (MPWT) to renew their driving licenses for motorcycles and 4-wheel vehicles.

2. TRAFFIC CONDITIONS AND FEATURES

2.1 Traffic Accident in Phnom Penh and in Cambodia

2.1.1 Number of Accidents/Fatalities

The number of fatalities in Cambodia and Phnom Penh has remained unchanged and constant.
The number of serious injuries in Cambodia is decreasing, but in Phnom Penh, it is increasing.

Source: Road Crash and Victims Information System (2019, 2020, 2021 and 2022)

Figure 2.1.1 Number of Accidents/Fatalities in Cambodia (2013 – 2022)

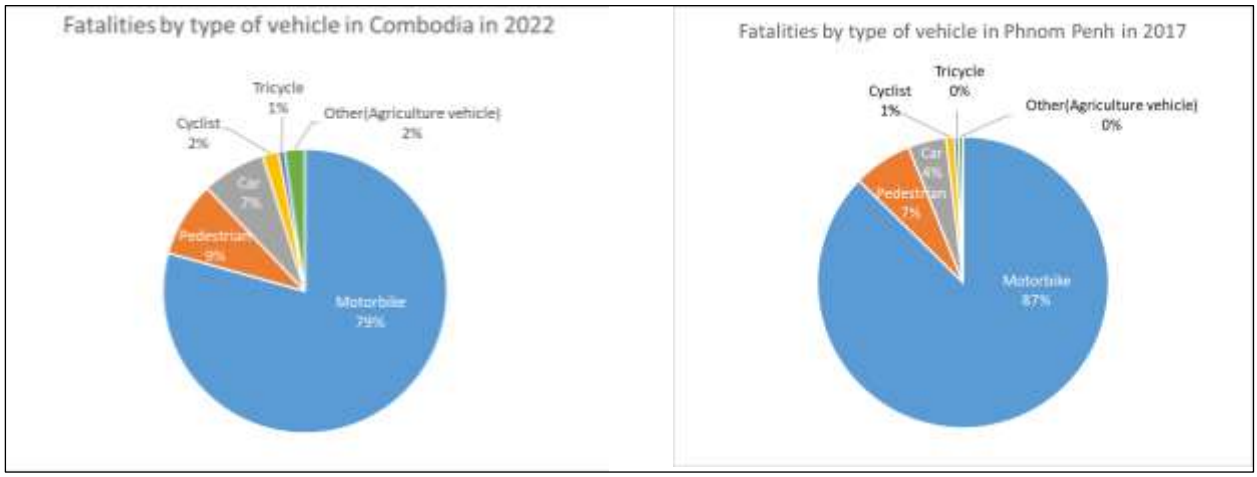
Source: Phnom Penh Traffic Police Office (PPTP)

Figure 2.1.2 Number of Accidents/Fatalities in Phnom Penh (2013 – 2022)

2.1.2 Number of Fatalities by Type of Vehicle

Motorbike and cars are responsible for the majority of fatalities not only in Phnom Penh but also across the entire country of Cambodia. In Phnom Penh, motorbike fatalities account for about 90% of the total, which is about 10% higher than in Cambodia.

Pedestrian deaths associated with traffic incidents in 2017 and 2022 are 7% and 9% of total fatalities of the respective years.



Source: RCVIS (Cambodia) and PPTP (Phnom Penh)

Figure 2.1.3 Traffic Accidents by Type of Vehicle (2017 and 2022)

2.1.3 Causes of Traffic Fatalities

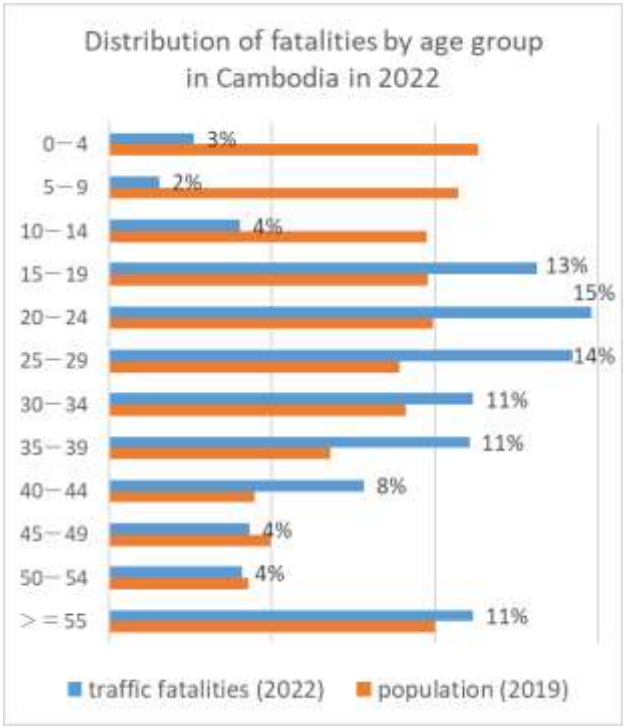
The most serious cause of fatal accidents both in Cambodia and in Phnom Penh is “speeding”. “Driving against flow of traffic” is the second frequent case of fatal accidents in both Cambodia and Phnom Penh but very few in Cambodia as a whole.

Source: RCVIS (Cambodia) and PPTP (Phnom Penh)

Figure 2.1.4 Causes of Traffic Fatalities (2017 and 2022)

2.1.4 Fatalities by Age Group

About half of all accidents occur between the ages of 15 and 29.
Fatality rates per population are outstandingly high in this age group.

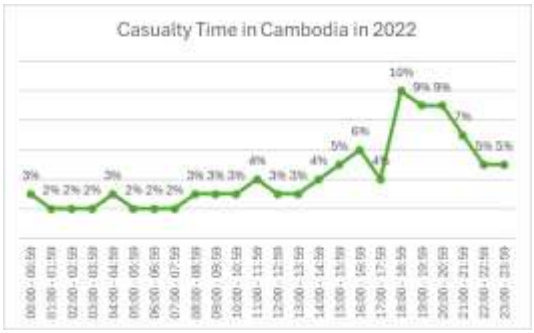


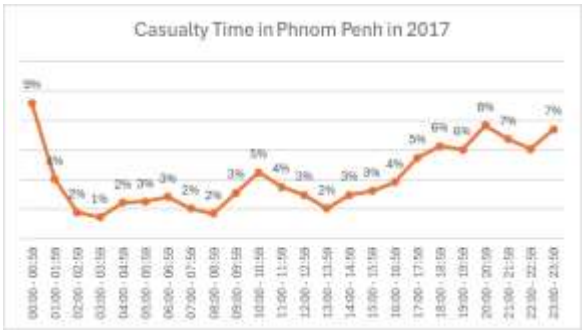
Source: RCVIS (Cambodia) and PPTP (Phnom Penh)

Figure 2.1.5 Fatalities by Age Group in 2022

2.1.5 Casualty by Time

In Cambodia as a whole, the peak time for fatal accidents is from around 6 p.m. to 9 p.m., whereas in Phnom Penh, the peak time is from around 8 p.m. to 1 a.m.





Source: RCVIS (Cambodia) and PPTP (Phnom Penh)

Figure 2.1.6 Casualty by Time (2017 and 2022)

2.1.6 Fatalities per 100,000 Population and per 10,000 Registered Vehicles

Fatalities per 100,000 population in Cambodia in 2021 was 10.5 and per 10,000 registered vehicles was 2.8.

Fatalities per 10,000 registered vehicles have decreased by about 75 % over the last decade and fatalities per 100,000 population have decreased by about 30 % compared to the peak period over the last decade. Due to a sharp increase in vehicle ownership, fatalities per 10,000 registered vehicles showed a significant decrease.

According to the Road Safety Database of International Traffic Safety Data and Analysis Group (IRTAD), fatalities per 100,000population in Japan and in France in 2021 were 2.6 and 4.5, respectively. Although it is decreasing, Cambodia's figure remains high at 10.5.

Source: RCVIS (Cambodia)

Figure 2.1.7 Fatalities per 100,000 Population and per 10,000 Registered Vehicles

2.2 Traffic Conditions in Phnom Penh

2.2.1 Introduction of the Traffic Control System in 2018

Phnom Penh's traffic control system, which was developed with the assistance of Japan Grant Aid in 2018, connects 118 intersections in central Phnom Penh with the traffic control center (TCC), controlling traffic according to morning and evening traffic flow. In order to examine the effectiveness of the traffic control system, the JICA project team conducted a survey of travel speed on Monivong Blvd. before and after the completion of the traffic control system, and found that the travel speed rose from 11 km/h before the completion of the traffic control system (2017) to 15 km/h after completion. This reduced the travel time cost of Phnom Penh residents who used Monivong Blvd. by USD2.5 million, and also led to a behavioral change in drivers to be more compliant with traffic signals and traffic laws, greatly contributing to the improvement of Phnom Penh's urban traffic environment.

2.2.2 Major Output of the Traffic Survey in PPTMTC Pilot Project

The traffic survey (2023 and 2024) was conducted by the PPTMTC project approximately five years after the completion of the traffic control system. The traffic survey locations and main outputs are as follows.

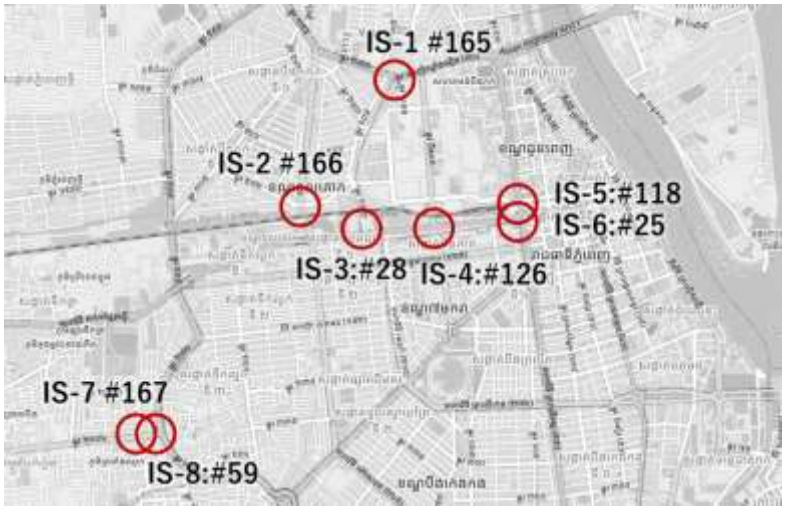


Figure 2.2.1 Pilot Project Traffic Survey Locations

(1) **Traffic Volume**

Based on the results of the traffic surveys conducted before (2023) and after (2024) the pilot project, the total traffic volume (2 hours) during the morning and evening peak hours at the seven target intersections is as follows.

- Overall, the traffic volume increased by 7.8% from 82,993 pcu/2 hrs. in 2023 to 88,665 pcu/2 hrs. in 2024.

- When this is divided into the four intersections along Russian Blvd. in central Phnom Penh and the three intersections at the fringe of the said central area, the increase traffic volume in central Phnom Penh was 2.2% (=56,097 (year 2024)/54,912 (year 2023)), but the three intersections at the fringe recorded a large increase of 15.6% (=32,568 (year 2024)/28,081 (year 2023)). This is because of the growing urbanization in the suburban area, with a new road being connected to IS-1 intersection and a pilot project having been carried out to coordinate the neighboring traffic signals of IS-7 and IS-8, allowing traffic to flow more smoothly. As a result, traffic that was previously dispersed on the surrounding local roads has begun to concentrate at these intersections.

(2) **Vehicle Composition**

The vehicle type composition based on vehicle numbers in 2024 was motorbikes: 72%, private cars: 17%, Tuk-tuk, etc.: 10%, and others (buses and trucks): 1%.

(3) **Travel Speed**

Daily average of travel speed survey results along 3 major corridors in central Phnom Penh in 2023 and in 2024 are not different as shown below.
Before Pilot Project (2023): 13.3 km/h.
After Pilot Project (2024): 13.2 km/h.

(4) **Congestion Queue Length**

The intersection queue length survey result is given below. Queue length decreased by 15.4% after the pilot project.
Before Pilot Project: 40 m (Average queue length of each Inflow)
After Pilot Project: 34 m (Average queue length of each Inflow)

(5) **Violation of Traffic Rules**

The Pilot Project Traffic Survey results on the number of traffic offenders of Traffic Rules at Pilot Project Intersections are as follows. The results show a decrease of about 21% after the Pilot Project.
Before Pilot Project in 2023: 1,592 drivers/intersection/3 hours
After Pilot Project in 2024: 1,256 drivers/intersection/3 hours

2.3 Outline of the Law on Road Traffic

Road safety remains a public health challenge for Cambodia, as borne out by the numbers of fatalities and disability resulting from traffic crashes. The National Road Safety Committee (NRSC) developed the first 5-Year National Road Safety Action Plan (2006-2010), which consists of 15 important components, is aimed at preventing and reducing the number of casualties and economic losses resulting from road traffic crashes.

Figure 2.3.1: Road crash collisions, fatalities and serious injuries (2005 – 2009)

The introduction of Cambodia's road traffic law signaled the country's serious efforts to regulate and improve road safety and facilitate effective implementation of the aforementioned national action plan. The enactment of the law in 2007 was also turning point in Cambodia's efforts at reducing the growing

incidence of road traffic collisions, fatalities and injuries by implementing more extensive aspects include:

- Mandatory helmet use among motorbike riders,
- Speed limits and seat belts use for cars, which are defined in accordance with road type and area,
- Alcohol limits for drivers, and
- Licensing requirements for 5 main categories of drivers

Despite being passed in 2007 and seen as a significant milestone, the law's enforcement only started on January, 1st 2009 and continued to be a challenge due to insufficient resources such as expertise, equipment and tools.

Based on road crash data from 2005-2011, it is seen that the number of fatalities doubled as it continued its upward trend while the population increased by 10%. Moreover, the number of registered motor vehicles surged 231%, and 84% of those registered vehicles were motorcycles. As a result, the Cambodian Government urged all relevant government ministries/institutions, development partners, UN agencies, NGOs and private sectors to collaborate urgently in enhancing public education and awareness campaigns on risk factors.

With government's commitment, NRSC, stakeholders and partners have reviewed, updated and developed the National Decade Road Safety Action Plan 2011 - 2020 that well align with the Inter-Ministerial Transport Meeting on Decade of Action for Road Safety and Commitment, to reduce 50% of road crash fatalities by 2020. If the target is achieved, at least 7,350 lives will be saved.

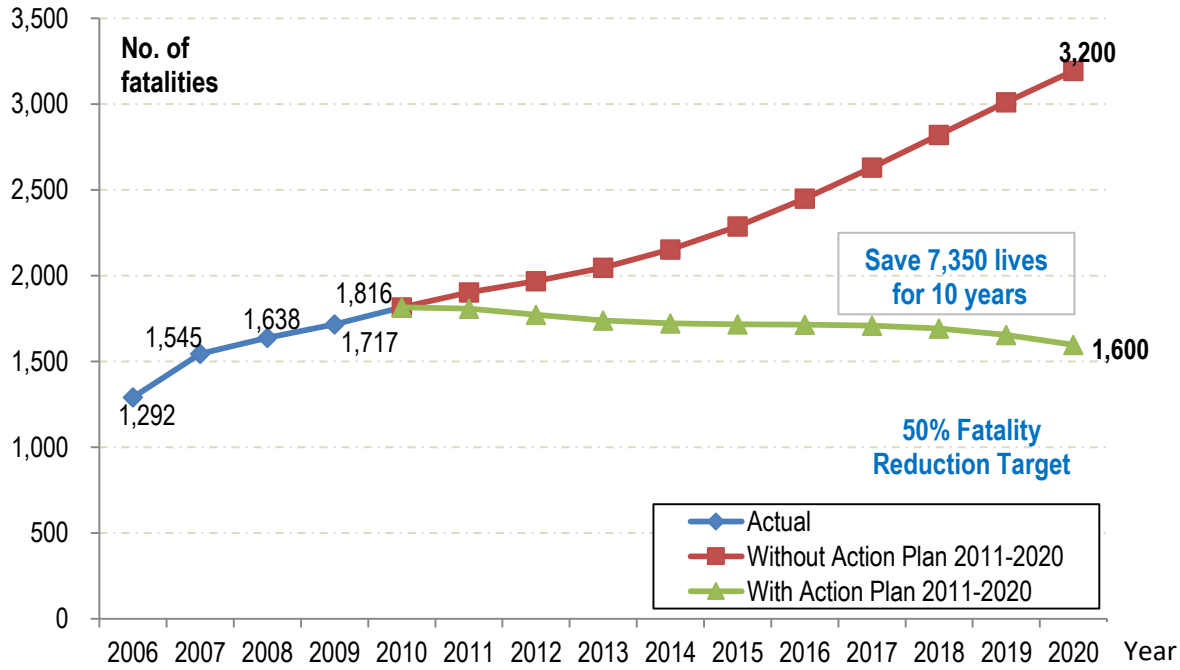


Figure 3: Potential of the National Road Safety Action Plan (2011 – 2020)

On January, 9th 2015, the Road Traffic Law of 2007 was expanded to introduce stronger levels of fines and punishments for traffic offenses such as speeding, careless driving, driving under the influence of alcohol and drugs, using phone while driving, no helmet, unfastened seat-belt, unregistered vehicle and no driving license.

The 2015 expanded law encountered some popular opposition, particularly in rural areas where helmet wearing compliance and licensing were less widespread. Nonetheless, it was still seen as a turning point in Cambodia's road safety efforts, and public education initiatives were continued to promote understanding of the road traffic law.

Amendments were deemed necessary for 9 articles of 2015 road traffic law to better reflect the road crash status in Cambodia.

For details of the revision of the road traffic law from 2007 to 2015 (first revision) and 2019 (second revision) refer to the Appendix of the Traffic Safety Education Manual.

3. GOOD DRIVING MANNERS AND ATTIDUDES

The city bus introduced in 2016 is Phnom Penh's first public transport system. However, due to the lack of punctuality, and safe and access to bus stops, couples with the convenience of door-to-door paratransit such as tuk-tuk, it is not an attractive transportation option. Daily bus users account for only 26,000, or 1.0%, of total city population. As a result, residents in the city depend heavily on use of private cars, paratransit or motorcycles for their daily activities. It is vital, therefore, that all motorcycles and car drivers exercise good and safe driving behavior.

Unfortunately, many precious lives are still lost to traffic accidents, according to the Annual Report of Road Crashes and Casualties in Cambodia in 2020 (2020 RCVIS, National Road Safety Committee)

It is important, therefore, to examine the driving behavior and attitudes among all drivers, so that everyone can contribute toward a safer and more comfortable society.

(1) Value human lives

There is no replacement to human lives. However, the reality is that one human life is lost every day in Phnom Penh City alone.

Traffic accidents not only take away precious lives of those involved in the accidents, but also adversely affect the happiness of their families.

If drivers approach driving with the mentality that every road user is a family member, then it is quite possible to decrease of frequency of traffic accident.

(2) Be considerate and always give way to other users

The *Law on Land Traffic* aims to promote a smooth operation of all roads. The law covers mainly the technical aspect of road usage. But actually, many aspects of safe and smooth traffic operation cannot adequately be covered by law. These involve human behavior and manners. The concept of "consideration" to other road users and attitude of "give way" to other drivers and pedestrians or cyclists are all essential behavior while driving for creating a safe and smooth road traffic environment.

(3) Know your own driving ability

Most drivers tend to drive carefully just after they get their licenses. However, after the days or weeks go by, many drivers become careless, driving recklessly and dangerously. "Self-conceitedness" (feeling proud and self-important) is a very bad habit among licensed drivers. All drivers must remind themselves at all times to be calm, and to behave as if they are still beginners in driving.

(4) Stay in good physical condition

Sickness and worries can seriously affect a person's level of concentration and judgment which, in turn, can easily affect the person's ability to drive safely. Poor judgment and slow reactions are the common causes of serious traffic accidents. Fatigue is another physical condition a driver must look out for to avoid traffic accidents.

The following is common signs of fatigue:

・Feeling "troublesome" when a judgment is call for,

- Eyes-lids feeling heavy, and slow in moving the eye-balls,
- Abrupt maneuvers of the steering wheel,
- Rushed pressing of the accelerator pedals, and
- Slow reactions to one's surroundings.

(5) Always maintain a feeling of calmness

Inside the vehicle, the driver is detached from direct contact with normal surroundings. In such circumstances, it is believed that driver may lose self-control and exhibit heightened self-centeredness. In other words, that person will likely experience the following psychologically imbalanced feelings of instability, irrationality, rage and impatience.

1) Impatience and feeling rushed

When the driver is hard pressed for time, he becomes very impatient and feel rushed and anxious to get to destination, thus taking chances like frequent changing of lanes, speeding, overtaking and exhibiting other dangerous driving behaviors.

Under this state of mind, the driver's focus is entirely on the vehicle in front of him/her, paying very little or no attentions to surrounding traffic. Such a state of self-centeredness is very dangerous.

2) Feelings of rage, anxiety and irritation

The feeling of rage or anxiety or irritation (or all of them) could well up in the following situations: could not maneuver in the manner driver wants; is stuck in traffic for a long period of time; is overtaken by another vehicle; is overwhelmed by other drivers honking their vehicle; or even just a trivial thing. Anyone of the aforementioned feeling could trigger an aggressive behavior, reckless driving or the need to "fight back".

3) Self-centeredness

A driver under stress tends to view traffic rules that do not suit him/her to be inconveniences, and not rules to prevent accidents. Once the driver thinks this way, the outcome is the driver that is self-centered and selfish.

There are several ways to overcome the undesirable psychological feelings of "Being rushed", "Impatience" and "Rage".

To return to stability from state of instability, one has to objectively view the behavior from an unbiased perspective of a third party.

Once a person realized such behavior is nothing more than just impatient, irrational, and agitated. Then the person may be able to think rationally and return to a more stable state of mind.

To relax one's agitated state of mind and get over the feelings of the need to rush and actin an irrational manner, the following are helpful tips:

- Take a deep breath,
- Maintain a fixed distance from the vehicle in front of you and drive for some distance, and
- Pull over somewhere safe and take a break from driving.

One must discover his/her own way of maintaining calmness when driving.

4. BASIC KNOWLEDGE ON SAFE DRIVING BEHAVIOR

This chapter aims at reconfirming a person's basic knowledge of safe driving as one would apply them to actual driving.

4.1 Obey the Speed Limit

When driving along a road section, bear in mind the following regulations at all times:

・Maximum speed limit is 40km/hour for cars and 30km/hour for motorcycles and tuk-tuk in central Phnom Penh.

・Stopping distance

Stopping distance of a moving vehicle is generally 2 – 3 times of the travel speed. However, when the speed increases, the stopping distance increases exponentially to 4 times. As shown in the following table, as the travel speed increases from 50 km/hour to 100 km/hour, the stopping distance increases not from 25 m to 50 m but quadruples from 25m to 100 m.

In other words, the higher the travel speed, the longer the stopping distance. It is very important to observe the speed limit and drive at a speed where one is capable of controlling vehicle safety vis-a-vis the road traffic situation.

Table 4.1.1 Stopping Distance

Speed	Distance running + Braking distance in reaction time	Stopping distance
30 km/hr.	9m 6m	15m
50 km/hr.	14m 18m	32m
80 km/hr.	22m 54m	76m
100 km/hr.	28m 84m	112m

Source: Matsuyama City, Ehime Prefecture in Japan
Note: The above distances are just stopping during an emergency. However, these distances are not enough to stop safely ahead of the emergency location.
Also, never forget that these distances become much longer when the pavement is wet because the coefficient of friction between the tires and pavement is low.

4.2 Safe Driving Behavior along Road Section

When driving along an individual road section, bear in mind the following regulations at all times:
(1) Drive on the right-hand side of the road at all times,
(2) Keep to the right-hand side when cruising,
(3) Keep to the lane as much as possible,
(4) When an ambulance approaches, slow down and move to the right-hand side and give way to such vehicle, and
(5) When passing a pedestrian, either slow down or keep a safe distance away from the pedestrian.

4.3 Safe Driving Behaviour at Intersection

4.3.1 Type of Accidents at Intersections

Traffic accidents that occur at intersections are usually of the following types:
(1) Head on collision,
(2) Rear-end collision,
(3) Lateral collision between a left and a right turning vehicle,
(4) Right turn collision, and
(5) Collision while overtaking.

4.3.2 Cautionary Actions at Intersections (Signalized intersection)

(1) Actions are prohibited at/around intersection
- Overtaking at an intersection or within 30 meters before intersection, and
- Parking/stopping at an intersection or within 15 meters from the intersection.

(2) Cautionary actions at intersection

- When turning right, move toward the right edge of the road in advance and turn slowly while following the road's edge.
- When turning left, move toward the center of the road in advance and turn slowly while following the intersection's center.
- When turning left from a one-way road, move toward the right edge of the road in advance and turn slowly while following the intersection's center.
- When turning right or left, follow arrows or other signs that specify how to pass.
- When turning left, do not obstruct the progress of vehicles going straight or turning right.
- On roads with vehicle lanes, follow signs or markings that specify traffic divisions for each direction of travel at the intersection.
- If signs specify the direction of travel, follow them.
- If the vehicle in front of you signals that it is changing lanes to turn right or left or to use the vehicle lane, do not obstruct the vehicle's change of lane.
- If there is congestion ahead and you may be stopped in the intersection, do not enter the intersection.

(3) How to drive safely at signalized intersection

1) Meaning of traffic signal lantern

Most people know who has the right-of-way at intersections controlled by traffic signals, but they may not understand how to correctly respond to these traffic signal lanterns.

Here are some points that will help the driver stay safe at intersections:

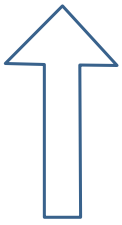
- Red lantern: A red lantern means that the driver must come to a complete stop. The driver must wait for the lantern to turn green before going straight ahead.
- Green lantern: Green means go only if the intersection is clear, and it is safe to do so.
- Yellow lantern: Yellow means that the signal is about to turn red. The driver must stop before entering the intersection unless it is impossible to safely stop in time.
- Separate left arrow lantern: Some intersections have designated left-turn lanes controlled by its own set of traffic lights. A green arrow at the left side of a separate set of traffic signals will tell the driver when to turn left. Traffic in the straight-through and right-turn lanes will be stopped by a red light on a different set of lanterns.

Once the green arrow has turned yellow, the driver must stop and wait for the next green arrow before turning.

2) Road Signs and Lane Markings

- Road Signs: Signs which give information or instructions to road users. Example are the No U-Turn sign, No Left-Turn sign, etc.
- Road Signs: Signs which give information or instructions to road users. Examples are the No U-Turn sign, No Left-Turn sign, etc.
- Lane Markings: Are markings on roads which is used to convey messages to road users. They indicate which part of the road to use, provide information about conditions ahead, and indicate where passing is allowed. Examples are the Arrow Signs, Yellow lines, etc.

No U-Turn Sign



Go Through Road Marking

Figure 4.3.1 Road Sign and Road Marking

4.4 Do Not Drive under the Influence of Alcohol

4.4.1 Type of Accidents Caused by Drink Driving

- Unable to complete the turning at a curved section, skid over and collide with road side objects (single vehicle accident).
- Unaware of pedestrians crossing the road and crashes into them (vehicle to person accident).
- Ignoring traffic signal lantern or unaware of the intersection ahead and cause a frontal collision accident (vehicle to vehicle accident).
- Mistake in steering the wheel and cause a head-on collision accident with the vehicle from the opposite direction (vehicle to vehicle accident).

4.4.2 Danger of Drink Driving

As far as driving a vehicle is concerned, alcohol consumption is and must be prohibited. Even though different persons have different levels of tolerance for alcohol, once alcohol is consumed, the concentration of alcohol in the blood goes up. Such a condition will cause the following physical reactions to the driver:

- Numbing of the central nervous system,
- Lowering the ability to reason and self-control,
- Reducing visibility and narrowing of sight angles,
- Sluggishness and loss of concentration, and
- Upheaval to body's balancing movements.

These phenomena will further lead to the following outcomes and finally cause serious traffic accidents.

- Loss of quick reflexes, causing sluggish movements in controlling the brakes, accelerators and steering wheel, and
- As slow reflexes set in, all movements become slow and even hampered.

Therefore, do not drive when drinking and one should not encourage or push anyone else to drink if that person is driving. This is a social responsibility that all drivers in the country must observe.

4.5 Safe Driving Behavior at Night

4.5.1 Controlling the Speed

When driving at night, the sight distance is greatly reduced compared to driving in the day time, even with good road lightings. It is important therefore to drive at a controlled speed, so that the driver is able to respond promptly and safely to any unexpected incident or danger that may occur.

4.5.2 Maintain a Longer Headway

Maintain a longer headway when following a vehicle at night, compared to the day time. This is because it is relatively harder to judge the safe distance between vehicles at night time. Moreover, refrain from unnecessary overtaking at night. In this manner, always drive with ample leeway at night than in the day time to ensure safety.

4.5.3 Beware of all Objects in Front

When driving at night, drivers must look out for any obstructions, such as parked vehicles, motorcycles or bicycles without tail lights and pedestrians. Therefore, when driving at night in the city, all drivers must make sure that they can see with a wide view of the road they are traveling. They have to look out for the various objects using the illumination afforded by street lightings, maintain a lower speed and use the headlights to detect any objects and drive safely.

5. DRIVING BEHAVIOR IN RESPONSE TO IMPROVEMENTS IN TRAFFIC FACILITIES AND TRAFFIC CONTROL

5.1 Driving Technique in Conjunction with Improvements to Traffic Management

Although the traffic situation has deteriorated less rapidly due to the impact of COVID-19, progress in the development of traffic facilities and traffic management measures is still unsatisfactory. Such a problem is not only happening in Phnom Penh. Many of the other developing cities face the same issues where urban areas are heavily built up with high rise business buildings but transport facilities within such urban area are lacking.

Many of these cities therefore opted to maximize the use of the existing road transport facilities and to promote more efficient ways of utilizing them so as to preserve the urban living environment. In addition to these measures, other strategies are also tried in an effort to reduce the passenger vehicle travel demand. Depending on the scale of these cities and their special features, various types and combinations of traffic management measures are being introduced in a "trial and error" manner.

To break out from the current worsening situation in Phnom Penh, it is inevitable that such kind of new traffic management measures be introduced to the city as much as possible.

The following sections describe the type of traffic management measures that can be introduced in Phnom Penh. When such measures are introduced, new information on driving has to be acquired by all drivers. They have to fully comprehend the contents of any such new measures implemented by their respective authorities or agencies and the status of their implementation. It is vital that drivers are mentally prepared in adapting to any such new requirement or traffic rules that may arise due to the implementation of the new traffic management measures. Drivers have to drive using their already acquired skills and obeying the new rules as various new measures are implemented progressively.

5.1.1 Traffic Regulation and Control for the Improvement of Vehicular Traffic Flow and Safety

Traffic regulations and control measures that can be implemented to improve vehicular traffic flow and the level of traffic safety may include the following:

(1) One-way operation
Select two streets within 300m as a pair of one-way streets. On-street parking space can be installed. This has already been introduced at several local roads

(2) Left and right turning prohibition
Introduction of left turning prohibition along the major road is quite effective to maintain the large volume of traffic flow along major roads.

(3) Structural improvement of intersection
Flyovers, which cater to the main traffic flow as free flow at intersection, have already been built at four intersections in central Phnom Penh and one is currently under construction. In particular, the Stueng Mean Chey Flyover has free-flow control in all directions (no need to stop at traffic lights, etc.).

Many such measures have, in fact, being implemented to certain road sections of central Phnom Penh. With such new improvement or measures, appropriate signages and markings must be installed or applied to warn car and motorcycle drivers of these new measures and to guide them in obeying the new rulings.

Furthermore, in response to change in traffic situations, new or changes to the traffic management measures may become necessary. Under such circumstances, drivers must understand the contents of such measures as publicized by authorities in the mass media/SNS and to drive safely by obeying these new rules.

5.1.2 Pedestrian Priority and Measures for their Protection

There are various measures of bus operation that can be used to protect the safety of pedestrians, for example, segregation of pedestrian walkways from roadways, pedestrian only streets, sidewalks for pedestrian and bicycle only, pedestrian overpass and others.

5.1.3 Public Transport (City Bus) Priority

Phnom Penh City Buses have been in service since 2015, but their utilization is low because of the following reasons:
(1) Lack of punctuality of bus operation,
(2) Lack of safety and comfortable access to the bus stop, and
(3) Many door-to-door paratransit such as PassUp and Grab

To address these problems, bus priority measures should be introduced such as bus priority signals, bus priority lane and BRT in coordination with Park- and- Bus ride.

5.2 Important Matters on Parking and Stopping

5.2.1 Definition of Parking and Stopping

Parking refers to a situation where the vehicle is stopped for a long period of time and the driver has left the vehicle, and is not able to drive or move the vehicle with short notice. On the other hand, if a vehicle is stopped temporarily to allow persons to get in or out, or to load goods within 5 minutes, such situation is defined as stopping, and do not amount to parking. Hence, stopping refers to a short temporary stop of the vehicle where the driver is still in the vehicle or is nearby loading goods and is able to drive away or move the vehicle in short notice.

5.2.2 Parking and Stopping Prohibition

(1) Illegal parking within major intersections is a common phenomenon that is frequently noticed in Phnom Penh. Such illegal parking within areas of the intersection often resulted in messy traffic congestions at the vicinity of such intersections. Furthermore, these illegally parked vehicles often reduce the visibility within the intersection, which can cause traffic accidents. Such parked vehicles may also obstruct the passing of such emergency vehicles as police patrol cars, ambulances and fire fighting vehicles.

When it becomes necessary to park or stop the vehicle, it should be done at the legal and properly designated areas.

(2) Do not park or stop in areas where the “No Parking or Stopping” signs have been installed; or within 5 meters of any intersection and pedestrian crossing; and within specified distance (for example, 10 meters) from a bus stop.

5.2.3 Correct Parking and Stopping Procedure

When parking or stopping the vehicle, the following procedure should be observed:
(1) When parking or stopping along roads that have no pedestrian sidewalks or road shoulder, park or stop along the right side of the road beyond the pavement.
(2) When parking or stopping along roads that have sidewalks or road shoulder, park or stop along the right edge of the road pavement.
(3) Do not double-park your vehicle, that is, do not park parallel to another row of parked vehicles along a road.
(4) Obey all the parking signs (for example, parking signs are installed along minor streets in Phnom Penh, stating whether roadside parking along certain road sections is allowed on any “even” or “odd” day of the month), and the allowable methods of parking in the city.
(5) In the future, more and more streets in the city will have parking or stopping prohibitions as traffic volume increases. Parking or stopping will only be limited to areas where there are parking meters installed or where parking tickets are issued.

5.3 Driving near Bus Stops

When driving near bus stops where bus passengers are expected to board or alight, the following points must be observed to ensure safety.

5.3.1 Some Examples of Major Potential Dangers (See below figure)

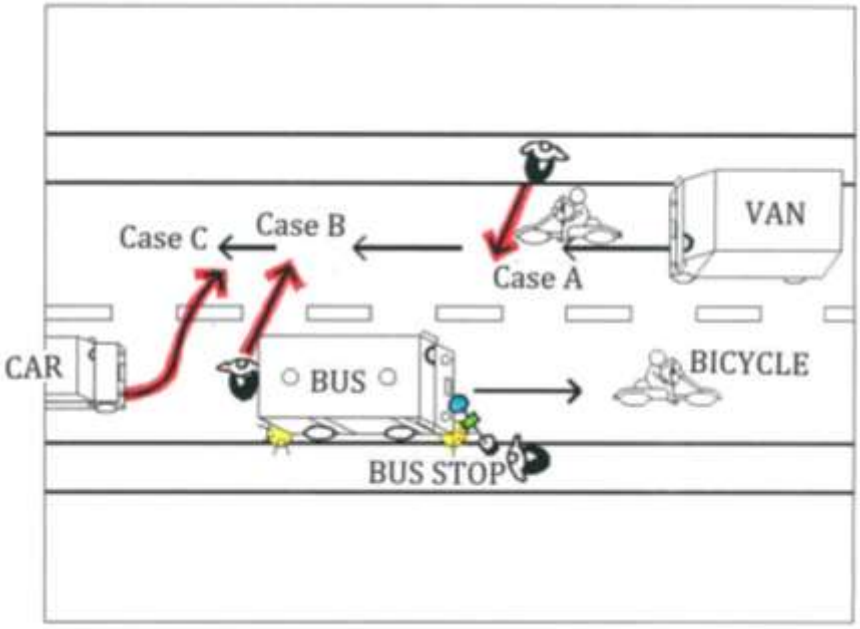


Figure 5.3.1 Some Examples of Major Potential Dangers near Bus Stop

Referring to three potential hazards in the figure above.

(1) Case A: Be alert and aware of the possibility that pedestrians may try to dash across the street to board the bus. If you proceed without this awareness, an accident will happen.
(2) Case B: In this case, be alert of pedestrian behind the bus, who may have just alighted from the bus and is planning to dash across the street, putting himself in danger of being hit by your car.
(3) Case C: The vehicle in the opposite direction behind the bus may intend to overtake the stopping bus, hence creating a danger of colliding with your car.

5.3.2 Examples of Safe Driving

When you notice a bus is stopping at a bus stop across the street from you, pay special attention to pedestrians who may suddenly dash across the street in front of you in their attempt to board the bus. Many pedestrians behave this way when they are over focused on catching the bus but become careless and unaware of on-coming vehicles.

Also pay sufficient attention to the possibility that there are alighting bus passengers who may be hidden from your view behind the bus and who may suddenly dash across the street in front of you. Vehicles travelling behind the bus may also suddenly decide to overtake the bus and they may lose control and collide with your vehicle.

If a bus is stopping in front of you on the same road, slow down and stop. Do not attempt to overtake the bus unnecessarily. Instead, wait for the bus to pull out before moving on.

During commuting or school going hours in particular, there are many potential dangers near the vicinity of a bus stop. Pay good attention and be cautious during such time periods.

6. CONCLUSION

In the near future, it will become evident to most drivers that compliance with traffic law and rules will bring about benefits such as reduced traffic accidents, quicker travel time and more comfortable driving. At the same time, Cambodia can save a large sum in economic cost from loss of lives and goods due to traffic accidents. There are also economic gains from reduced travel time loss while increasing productivity time. It is expected that it would not be long before many citizens become aware of these potential benefits.

Appendix: Outline of Cambodian Road Traffic Law

Road safety remains a public health challenge for Cambodia. The numbers of fatalities and disability resulting from traffic crashes remain significant. The National Road Safety Committee (NRSC) developed the first 5-Year National Road Safety Action Plan (2006-2010) containing 15 important components, which are intended to prevent and reduce the number of casualties and economic losses resulting from road traffic crashes.

Figure 1: Road crash collisions, fatalities and serious injuries (2005 – 2009)

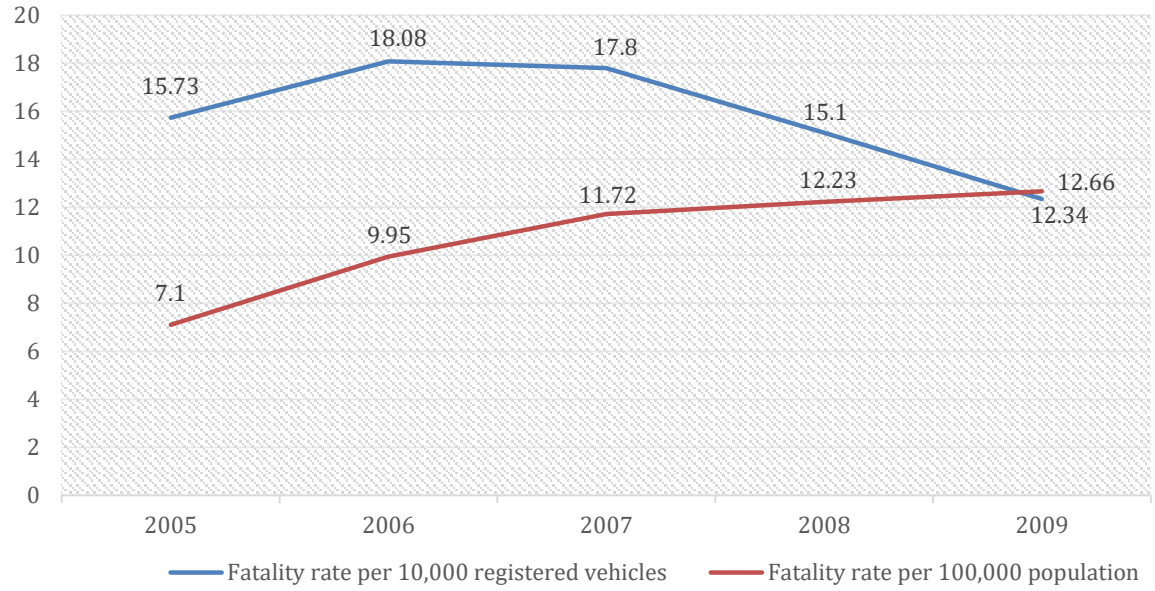


Figure 2: Road crash fatalities comparison in 10,000 registered vehicles and 100,000 population, (2005 – 2009)

Cambodia's road traffic law represents the country's ongoing efforts to regulate and improve road safety and facilitate effective implementation of the aforementioned national action plan. The introduction of the road traffic law of 2007 also marked as turning point in Cambodian road traffic law aimed at reducing the growing incidence of road traffic collisions, fatalities and injuries by implementing more extensive aspects including:

- Mandatory helmet use among motorbike riders

- Chapter III, Article 9.4 – Drivers of motorcycles, tricycles and motorcycles with trailers must wear safety helmets.

- Chapter X, Article 88/1.b – A motorbike or motor-tricycle driver not wearing safety helmet shall be fined 3,000 riels or USD 0.75.

- Speed limits and seat belt use for cars, which are defined by type of vehicle and location:
  - In towns – The speed limit for motorcycles and tricycles is 30km per hour; and the maximum speed for cars is 40 km per hour.

  - Outside towns – All kinds of vehicles have a maximum speed limit of 90 km per hour but trucks with a net weight of over 3.5 tons are limited to 70 km per hour and the maximum speed of vehicles with trailers is limited to 60km per hour.

- Alcohol limits for drivers.
  - Chapter III, Article 9.10 – An individual who is driving with an alcohol rate from 0.25 mg per liter of breath or 0.5 g per liter of blood is considered drunk and should not drive.

  - Chapter IX, Article 65/1.a – An individual who is driving with an alcohol rate of 0.4 mg per liter of breath or 0.8 grams per liter of blood onward or is under the influence of drugs, or refuses to take a breathalyzer test shall be taken to court by the traffic police.

  - Chapter X, Article 76 – Drivers found to be driving under the under the influence of alcohol from 0.4 mg per liter of breath or 0.8 grams per liter of blood upward shall be sentenced from six days to six months of jail time and fined from 25,000 to 1,000,000 riels (USD 6.25 – USD 250.00).

  - Chapter X, Article 88/4.g – Driving with an alcohol rate from 0.25 to 0.39 mg per liter of breath or from 0.5 to 0.79 gram per liter of blood, shall be fined 30,000 riels or USD 7.5 for motorbikes or motor-tricycles.

- Licensing requirements for different categories of drivers – Chapter VII, Article 40 indicated 5 main categories as follows:
  - **Type A** for motorcycles and tricycles with (1) cylindrical size 49 to 125 cm^3 and (2) over 125 cm^3.
  - **Type B** for vehicles transporting passengers not over 9 people including the driver, and can tow a trailer with a total weight of not over 0.75 tons.

  - **Type C** for goods loading vehicles with a maximum weight of 3.5 tons and allowed to have trailers with a total weight of not over 0.75 tons.

  - **Type D** for passenger vehicles with (D1) loading 10 – 20 people including the driver, and might have trailers not over 0.75 tons; (D2) loading more than 20 people including the driver, and might also have trailers not over 0.75 tons.

  - **Type E** for vehicles in Type B, C and D with trailers having a total weight of more than 0.75 tons must be classified into 3 types – Type E (B), Type E (C) and Type E (D).

Although the law was promulgated in **2007** and considered as an important step forward, its enforcement started on **January 1st, 2009** and remained a challenge due to inadequate resources such as knowledge and skill sets, equipment and tools.

Over the seven years period (2005-2011), it was determined that the number of fatalities continued to increase double while the population increased by 10%, and the number of registered motor vehicles surged 231%, and 84% of those registered vehicles were motorcycles. Thus, the Cambodian Government called for urgent and joined efforts from all the relevant government ministries/institutions, development partners, UN agencies, international organizations, NGOs and private sectors to educate the public on the increasing risks of traffic accidents through awareness campaigns.

Various urgent stakeholder meetings were organized, and technical inputs and success experiences from other countries were shared by key lead organizations such as the World Health Organization (WHO), Global Road Safety Partnership (GRSP), Handicap International Belgium (HIB), and Johns Hopkins University (JHU) via the Bloomberg Philanthropies funded project called road safety in 10 countries (RS10). The comprehensive project implementation covered capacity strengthening on public education, awareness raising, safety and efficient enforcement operations on speeding, helmet use and drink-driving provided to officers-in-charge and young volunteers; action plans, practical training curriculums, standard operating procedure (SOPs) for measurable enforcement developed; data monitoring and evidence-based research studies generated.

With government's commitment, NRSC, stakeholders and partners have reviewed, updated and developed the National Decade Road Safety Action Plan 2011 - 2020 that well align with the Inter-Ministerial Transport Meeting on Decade of Action for Road Safety and Commitment, to reduce 50% of road crash fatalities by 2020. If the target is achieved, at least 7,350 lives will be saved.

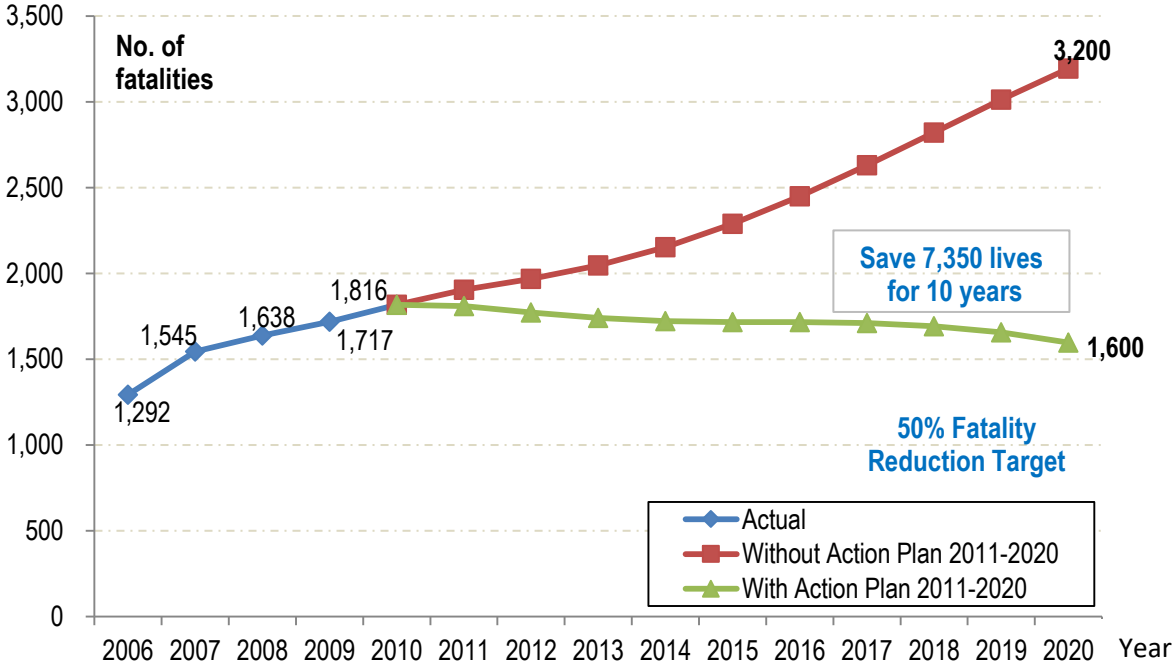


Figure 3: Potential of the National Road Safety Action Plan (2011 – 2020)

Recognizing the seriousness of this preventable epidemic, Cambodia has tried harder to implement and establish the new road traffic law promulgated on **January 9th, 2015,** expanding on the 2007 law. It introduced stronger levels of fines and punishments for traffic offenses and targeted key points including applying higher fines for violations such as speeding, careless driving, driving under the influence of alcohol and drugs, using a phone while driving, not wearing a helmet and fastening seat belt, and other non-compliance with safety regulations on vehicle registration requirements, driving licenses and vehicle identifications.

The 2015 law encountered some popular opposition, particularly in rural areas where helmet-earning compliance and licensing were less widespread. However, it was seen as a turning point in Cambodia's road safety efforts, accompanied by public education initiatives to promote understanding of road traffic law.

Therefore, the 2015 road traffic law was reviewed including a consultation meeting with stakeholders again, at which 9 articles were required to be amended to better reflect the present situation of road crashes in Cambodia. See below table:

Article No.	Current RTL promulgated on 9 Jan 2015	Newly Proposed for Amendment	Remark
8	- Require a driving license for drivers who drive a motorbike from 49 to 125 cc cylinder	- No mention on driving license for motorbike driver and motor-tricycle less than 125 cc cylinder	- Omit the requirement of driving license for drivers of motorcycle and motor-tricycle with less than 125cc. Thus it affects to other articles: 1. Article 40 (categories of driving license) 2. Article 41 (age of driver).
40	- There are two types of driving licenses for Motorbike drivers. Type A1 for motorcycle driver from 49-125 cc, and A2 for exceeding the 125 cc.	- No mention about the driving license from 49-125 cc. - States only one type of driving license (Type A) for motorbike driver and motor-tricycle of over 125 cc	- Only one type of motorcycle driver—Type A.
41	- Age of drivers for driving license type A1(49-125cc) should be 15 years old and above.	No mention on the age of drivers of motorcycle below 125 cc.	- No mention about the age of drivers of motorcycle below 125 cc.
47	- States that vehicle is the property of the Ministry of Interior and the Ministry of Defense and should be registered by the Ministry of Interior or the Ministry of Defense.	- All vehicles should be registered by the Ministry of Public Works and Transport.	- Reduce the responsibility of the Min. of Interior and Defense on providing registration service of vehicles. - Only the MPWT is authorized to provide vehicle registration service in Cambodia.
48	- Transferring vehicle ownership should be completed in 90 days after purchasing date.	- All sales or donation of motor vehicle and other forms of exchange that result in change in vehicle ownership shall apply for ownership transfer. - Application and procedures for vehicle registration, identification, ownership transfer and removal from the vehicle list shall be defined by the MPWT.	- No limit of time for completion of vehicle ownership transfer. However, there are still suggestions on vehicle ownership.
75	- Driver who drives without driving license or during the time when driving license was confiscated or	- Driver who drives without driving license or during the time when driving license was confiscated or suspended shall be subject to being punished with fines in	- Lessen the punishment for those driving without a driving license.

	suspended shall be subjected to being imprisoned from 6 days to 1 month and fined from 100,000 to 800,000 Riels, except for motorcycle or motor-tricycle drivers	accordance with the sub-decree on provisional fines. - Those violations with drivers shall being kkkkimprisoned from 1 to 6 months and fined from 800,000 to 4,000,000 Riels, when re-violation happened within 6 months from the first violation. - The second paragraph will not be applied for motorcycle or motor-tricycle drivers.	1. From being imprisoned from 6days to 1 month to be provisional fined. 2. In case of re-violation within 6 months from the first violation, then being imprisoned from 1 to 6 months and fined from 800,000 to 4,000,000 Riels 3. The second paragraph will not be applied for motorcycle or motor-tricycle drivers.
77	Any person, who drives under the influence with alcohol rate of 0.40 mg or above per liter of breath, or 0.80 g or above per liter of blood shall be subjected to being imprisoned from 1 to 6 months and being fined from 800,000 to 4,000,000 Riels.	- Any person, who drives under the influence with alcohol rate of 0.40 mg or above per liter of breath, or 0.80 g or above per liter of blood shall be subjected to being punished with fines in accordance with the sub-decree on provisional fines. - Those violations shall carry imprisonment from 1 to 6 months and fines from 800,000 to 4,000,000 Riels, when the violation happened within 6 months from the first violation.	- Lessen the punishment for those who drive under influence. 1. From being imprisoned from 1 to 6 months to be provisional fined. 2. In case re-violation happened within 6 months from the first violation, then being imprisoned from 1 to 6 months and fined from 800,000 to 4,000,000 Riels
82	- Any person, who drives without a vehicle identification card or number plate, shall be subjected to being imprisoned from 6 days to 1 month and fined from 100,000 to 800,000 Riels.	- Any person, whos drive without vehicle identification card or number plate, shall be subjected to being fined fin accordance with the sub-decree on provisional fines. - Those violations shall carry punishments of being imprisoned from 6 days to 1 month and fined from 400,000 to 1,000,000 Riels, when the violation happened within 6 months from the first violation. - The second paragraph will not be applied for motorcycle or motor-tricycle drivers.	- Lessen the punishment for those who drive without a vehicle identification card or number plate. 1. From being imprisoned from 6 days to 1 month to being provisional fined. 2. In case re-violation happened within 6 months from the first violation, then being imprisoned from 6 days to 1 month and fined from 400,000 to 1,000,000 Riels. 3. The second paragraph will not be applied for

			motorcycle or motor-tricycle drivers.
90	- In towns/ densely populated areas, the drivers and all passengers in a motor vehicle with loading capacity of more than nine people, including the driver, shall wear their safety seat belts; and the provisions stipulated in Para 2 of Article 7, and in 11 and 12 of Article 8 of this law shall be implemented five years following the date when this law comes into effect all over the country.	- All rear passengers in a motor vehicle should be obliged to wear a seat belt outside the town/densely populated areas; and the provisions stipulated in Para 2 of Article 7, and in 11 and 12 of Article 8 of this law shall be implemented five years following the date when this law comes into its effect nationwaide.	- Change: 1. Size of vehicle: From passengers of a motor vehicle of over 9 seats and up to wear seat belts to obliging all passengers to wear seat belts, regardless of the number of seats of the vehicle. 2. Enforcement: Will be in effect 5 years from the date when this law comes into effect nationwaide.

After the amendments were made, they were implemented on January 26th, 2017. Revisions were also made on the amended articles under sub-decree 44 concerning violations of road traffic regulations. The table below offers a detailed summary of the recently enacted sub-decree 39, which focuses on violations of road traffic statutes and was ratified by the Cambodian Government on March 17, 2020.

Article	ORIGINAL STATEMENT	PROPOSED AMENDMENT
Former Article 2	**Article 1** This law aims to maintain safety, order of road traffic, and to prevent health impact on human and animal lives, properties and environment.	
	Article 2 The objectives of this law are: • Providing awareness of road traffic law • Managing road traffic safety • Preventing road use violation	
Former Article 1	**Article 2** The road traffic law governs all road users in the Kingdom of Cambodia	

Article 4	In order to carry out the traffic law, the following terms have to be defined: • The word "Road" refers to the whole size of the trunk/torso of the road and the roadsides. • The word "Trunk of the road" is part of the road left for all kinds of vehicles to traffic. • Roadsides are parts of both sides of the trunk of the road located outside the cities and towns (densely populated area) and that it can be parked if necessary • Sidewalks are the roadsides in cities or towns, which are prepared for pedestrians. • The sidewalks are not allowed for vehicles to park • The word "Traffic Lane" is part of the road separated by dotted or long lines along the road, with enough width for all kinds of vehicles to traffic in one row. • The word "Town" refers to a place where buildings or houses are closely constructed with each other and where the exit or entrance are installed with signs or names of cities or towns to show the entry or names of cities or towns with red lines to show the exit from cities or towns via roads and with a lot of pedestrian traffic. • The word "junctions" refers to the places where two or more roads converge with one flat surface and are not defined by the angle of the axis of the road. The junctions have different shapes such as **+, X, T, Y, or roundabout**. • The word "Roundabout" refers to the junctions of two or more roads, and that in the central part, it has a terrace or sculpture or other monuments and has a one-way road surrounded with arrow signs for traffic direction. • The word "public road" refers to roads offered for public traffic. • The word "private road" is a road built by the private sector, which is divided into two types: ○ A private road for public traffic is a road which is open for general traffic and is built or repaired by the private sector according to a contract with the state.	**New/improved paragraphs and definitions:** • The word "Road" refers to the whole trunk/torso of the roadsides, bridge, skyway, overpass, underground, and ferry dock connected to a road. • The word "Expressway" is the road for automobiles to travel in high-speed designed with a road divider, having few or no intersection, and equipped with all road facilities to ensure safety, reduced travel time, and traffic flow at high speed. • The word "Road Facilities" refers to parking, traffic lights, road signs and markings, barriers, and other facilities such as dividers, roundabouts, curbs, and poles. • The word "helmet" is a kind of hat for covering/wearing on head to reduce risk of head injury when travelling on the road. • The word "technical tool" is a tool for measuring speed, alcohol rate or drug use, or is a tool for collecting pictures and so on. • The word "light automobile" is an automobile with a maximum total weight of less than 3.5 tons. • The word "medium automobile" is an automobile with a maximum total weight from 3.5 to 7.5 tons. • The word "heavy automobile" is an automobile with a maximum total weight of more than 7.5 tons. • The word "renovated agricultural automobile" is any vehicle which is renovated and installed for the purpose of transporting agricultural products or goods. • The word **"Stop"** refers to the momentary state of motionlessness of vehicles to load goods at the site of the road or to allow pedestrians to pass or on/off, while the vehicle's driver stays the wheel or near the vehicle.

	○ A private road, which is not open for public traffic, is a road preserved for the activities in any compounds of a house, factory, enterprise, building, or square. • The word "trail" refers to a path or a small road connecting national/provincial roads to villages or communes in rural areas. • The word **"Stop"** refers to the momentary state of motionlessness of vehicles on the road, while the drivers is still behind the wheel or nearby the vehicle to allow passengers or other vehicles to pass or to stop for loading and unloading goods or passengers. • The word "Parking" refers to the leaving of a vehicle in a state of motionlessness for a long or short period by the driver. • The word "Driver" refers to the person who has command of a vehicle including an animal rider and animal carrier on the road. • The word "Vehicle" refers to the vehicles for transporting/carrying people or goods on the rood or for towing or being towed by another. • The word "Motor vehicle" refers to any vehicles powered by an engine which runs on the road, such as motorbikes, tri-wheel motorbike, cars, tractors, and tools equipped trucks. • The word "tools equipped trucks" refers to special trucks equipped with additional mechanical tools without loading any person or goods out of the driver's cab such as cement mixing trucks or any trucks used for the construction of roads, bridges, etc. • The word "road user" refers to the vehicle drivers or any pedestrians who are traveling on the road. • The word "net weight" of vehicle refers to the pure weight of vehicle regardless of human or goods weights but including fuels to support engines, repairing tools and spare tires. • The word "maximum loading weight" of vehicle refers to the sum of loading weights of both human and goods which was defined by vehicle manufacturing factories.	

	• The word "total maximum weight" of vehicle is the sum of the net weight of vehicle and the maximum loading weight of the vehicle. If the vehicle has a cart, the total maximum weight of the vehicle is the sum total of maximum weight of each vehicle (weight of vehicle plus weight of cart). • The word "total permitted maximum weight" of vehicle is the sum of the net weight of the vehicle with the weight of human or goods loads. If the vehicle has a cart, the total permitted maximum weight of the vehicle is the sum total of maximum weight of each vehicle. • The word "total actual weight" of vehicle is the sum of net weight of the vehicle with the actual weight of human and goods loads. • The word "remorque or cart" refers to the vehicle which is towed by a motor vehicle. • The word "semi-remorque" refers to the vehicle which is towed with a motor vehicle engine.	
Former Article 9	• Figure No. 4: Drivers who drive motorcycles, tricycles and motorcycles with trailers/ remorque must wear safety helmets.	**Article 8** **Revised Paragraph** • Figure No. 8: The motorcycle can only be loaded with **two adults** and **one child**. The motorcycle drivers, their passengers including children must wear safety helmets **in accordance with the national standard**. Drivers who drive motorcycles and trailers/remorque-towing motorcycles must wear safety helmets in accordance with the national standard.
Former Article 17	1. The driving speeds for vehicles in general are: A. In towns: Drivers of all motorcycles and tricycles must not exceed the maximum speed of 30 km per hour - All kinds of cars can only be driven at a maximum speed of 40 km per hour. B. Outside towns: Drivers of all kinds of vehicles must not exceed the maximum speed of 90 km per hour, except trucks with a net weight of over 3.5 tons, which can only run at 70 km per hour at the most and trailers which have a limit of 60 km per hour.	**Article 16** **Revised Paragraph** 1. The speed for vehicles on rural road: A. In town, maximum speed is limited to: - 30 km per hour for all kinds of automobiles - 20 km per hour for motorcycles, tricycles, trailer-towing motorcycles, remorque or cart, tractors and renovated agricultural trucks. B. Outside towns, maximum speed is limited to: - 50 km per hour for light automobiles and passenger automobiles. - 40 km per hour for motorcycles, light automobiles, medium and heavy automobiles carrying general goods or hazardous materials, which use the

	2. The driving speeds for vehicles carrying with dangerous substances: A. In towns: - The maximum speed for drivers of motorcycles or tricycles is 30 km per hour. - The maximum speed for drivers of vehicles is 40km per hour. B. Outside towns: - The maximum speed for drivers is 70 km per hour for vehicles with a net weight not over 3.5 tons and vehicles with a net weight over 3.5 tons using the braking system to hold the tires from stiffness. - The maximum driving speed of vehicles with a maximum net weight of over 3.5 tons and no braking system to hold the tires from stiffness is 60 km per hour. 3. The driving speeds for vehicles driving on the motorways: A. In towns: Drivers of all types of vehicles must keep to the speed limit of 60km per hour. B. Outside towns: The maximum of 100 km per hour applies to all types of vehicles, except trucks with a maximum net weight over 3.5 tons, which will be limited to 80 km per hour and vehicles with trailers, which will be limited to 70 km per hour. 4. Driving speed for vehicles with priorities: The regulations stated in Point 1 and 2 of the Article do not apply to drivers of police, military and military police vehicles, and fire engines, ambulances, and some other vehicles equipped with sirens and special light signs on duty.	braking system to hold the tires from stiffness. 2. The speed for vehicles on national road: C. In town, maximum speed is limited to: - 40 km per hour for all kinds of automobiles - 30 km per hour for motorcycles, tricycles, trailer-towing motorcycles, remorque or cart, tractors and renovated agricultural trucks. D. Outside towns, maximum speed is limited to: - 80 km per hour for light automobiles and passenger automobiles. - 70 km per hour for motorcycles, light automobiles, medium and heavy automobiles carrying general goods or hazardous materials which use the braking system to hold the tires from stiffness. - 60 km per hour for medium and heavy automobiles carrying general goods which tow trailers or semi-trailers, or carry hazardous materials and have no braking system to hold the tires from stiffness. - 40 km per hour for tricycles, trailer-towing motorcycles, tractors and renovated agricultural trucks. 3. The driving speeds for automobiles on automobile road: Need to be identified by the PRAKAS of Minister of MPWT. The regulations stated in Point 1 and 2 of the Article do not apply to the drivers of police, military and military police vehicles, and delegation and high representative vehicles, fire engines, ambulances, and some other vehicles equipped with sirens and special light signs on duty.
Former Article 24	• Parking on public road beyond 72 hours is prohibited.	**Article 23** **<u>Revised Paragraph</u>** • Parking on public road beyond 24 hours is prohibited.
Former Article 26	• Turning to the left has to be made by skirting on the right-hand side. This means to start turning after the vehicle from opposite direction, unless instructed otherwise by traffic police.	**Article 25** **<u>Revised Paragraph</u>** • Turning to the left has to be made by skirting on the left-hand side, unless instructed otherwise by traffic police.
Former		**<u>Adding New Paragraph</u>**

Article 28		• Daytime light: is used during daytime for other vehicles to see easily.
New Article 34	Point B: • Use of the road for purposes that will impact traffic order is prohibited unless permission is given in advance by competent authorities. The procedure for granting permission shall be determined by PRAKAS of the Ministry of Interior.	
Former Article 37	• If the accident incurs only material damage, the two parties could settle with each other without asking the intervention from the traffic police	**Article 36** **<u>Revised Paragraph</u>** • If the accident has only damaged to property, the two parties could settle with each other without asking the intervention from the traffic police.
Former Article 40	• The national and international driving license for all types of vehicles will be issued by the Ministry of Public Works and Transport. The Ministry of Interior or Ministry of National Defense will issue the driving license for the drivers of special vehicles serving in the specific areas of skill such as tanks, armored vehicles, military equipped vehicles, racing vehicles, tricycles, and convoy motorcycles which are the state properties. • There are 5 types of driving license for the road vehicles of the Kingdom of Cambodia as follows: ▪ Type A: For motorcycle and tricycles A1: - For motorcycles with a cylindrical size from 49 to 125 cm3 A2: - For motorcycles with a cylindrical size over 125 cm3 - Vehicles with trailers and tricycles. ▪ Type B: - For vehicles transporting not over 9 passengers including the driver. - Goods loading vehicles with a total weight in maximum of not over 3.5 tons. - Vehicles in type B can tow trailers with a total weight of not over 0.75 tons. ▪ Type C: - For goods loading vehicles with a total weight in maximum of over 3.5 tons and might probably have trailers with a total weight in maximum of not over 0.75 tons.	**Article 39** **<u>Revised Paragraph</u>** • The national and international driving license for all types of vehicles will be issued by the Ministry of Public Works and Transport. The Ministry of Interior or Ministry of National Defense will issue the driving license for the drivers of special vehicles serving in the specific areas of skill such as tanks, armored vehicles, military equipped vehicles, racing vehicles, tricycles, and convoy motorcycles which are the state properties. The Ministry of Public Works and Transport should monthly provide the Ministry of Interior with the statistic of issuance of driving licenses to all kinds of vehicles. • There are 5 types of driving license for the road vehicles of the Kingdom of Cambodia as follows: ▪ **Type 1**: For motorcycles and tricycles with no backward transmission: **A1**- For motorcycles with a cylindrical size from 49 to 125 cm^3 or electrical motorcycles with the power of less than 11 kw and no pedal as bicycles. **A-** For motorcycles with a cylindrical size over 125 cm^3 or electrical motorcycles with a power of more than 11 KW. - Vehicles with trailers and tricycles with no backward transmission. ▪ **Type 2**: Light vehicles: **B1**- For tricycles with backward transmission. **B**- For vehicles transporting not over 9 passengers including the driver.

	▪ Type D: Passenger Vehicles: D1 - For vehicles loading 10 to 20 passengers including the driver and might have trailers with a total weight in maximum of not more than 0.75 tons. D2 - For vehicles loading more than 20 passengers including the driver and might have a trailer with a total weight in maximum of not more than 0.75 tons. ▪ Type E: - For vehicles in Type B, C and D with trailers in total weight of more than 0.75 tons must divide into 3 types - Type E (B), Type E (C) and Type E (D).	- Goods-loading vehicles with a total weight in maximum of not more than 3.5 tons. - Automobiles in **B** can tow trailers with a total weight of not over 0.75 tons. ▪ **Type 3**: For good-loading vehicles: **C1:** - For goods-loading vehicles with a total weight in maximum of over 3.5 tons to 7.5 tons and might probably have trailers with a total weight in maximum of not over 0.75 tons. **C:** -For the goods-loading vehicle with a total weight in maximum of over 7.5 tons and might probably have trailers with a total weight in maximum of not over 0.75 tons. ▪ **Type 4:** medium and heavy Passenger Vehicles: **D1:** - For vehicles loading 10 to 20 passengers including the driver and might have trailers with a total weight in maximum of not more than 0.75 tons. **D:** - For vehicles loading more than 20 passengers including the driver and might have trailers with a total weight in maximum of not more than 0.75 tons. ▪ **Type 5: Vehicle with trailers** **E:** - For vehicles in Type B, C and D with trailers in the maximum total weight of more than 0.75 ton must divide into 3 types – Type B (E), Type C (E) and Type E (E). For the international driving license need to be in accordance with the International Convention on Road Traffic, Vienna 1949. The international driving license has to be issued by the PRAKAS of the Minister of MPWT.
Former Article 41	1. Drivers can only drive vehicles based on the types of driving licenses they are holding. Disabled people have the rights to drive a special vehicle and have a special driving license for only the disabled people. 2. The driving license holders must apply for the renewal of the validation before the expiry date of the driving license. Failure to apply for the renewal of the validation will be fined as set by the law.	**Article 40** **<u>Revised Paragraph</u>** 1. Drivers can hold only one type of driving license, and can only drive the vehicle based on the type of driving licenses they are holding. The disabled people obtain the rights to drive a special vehicle and have the special driving license for the disabled people only. 2. The driving license holders must apply for the renewal of the validation before the expiry date of the driving license. Failure

	3. The age of drivers must be determined in accordance with the types of the driving license as follows: ▪ At least 16 years old for type A1 ▪ At least 18 years old for type A2 and B ▪ At least 22 years old for type C and D1 ▪ At least 24 years old for type D2 and E 4. Those who have the driving license type A2 can drive the vehicle in type A1 5. Those who have the driving license type B can drive the vehicle in type A1, agricultural vehicles or vehicles equipped with usable tools with the maximum speed of not over 40km/h, but cannot drive the vehicle in Type A2 or C or D1 or D2 or E. 6. Those who drive a vehicle equipped with the usable tools with a maximum speed of over 40 km/h must hold the driving license in Type C. 7. To obtain the driving license in Type C, the drivers must have either the driving license in Type B or D1 first. 8. Those who drive the vehicles in Type C or D1 or D2 can drive the vehicles in Type B. 9. Those who have the driving license in Type C cannot drive the vehicles in Type D2, but those who have the driving license in Type D2 can drive the vehicles in Type B or C or D1. 10. To obtain the driving license in Type D1, the drivers must have the driving license in Type B first. 11. To obtain the driving license in Type D2, the drivers must have the driving license in Type B or C or D1 first. 12. To obtain the driving license in Type E, the drivers must have the driving license in Type B or C or D1 or D2 first. 13. The drivers who have the driving license in Type E, can have the rights to drive the vehicles with trailers with a total weight of over 0.75 tons at maximum based on the types of their driving licenses such as E(B) or E(C) or E(D1) or E(D2).	to apply for the renewal of the validation will be fined as set by the law. 3. The age of drivers must be determined in accordance with the types of the driving license as follows: ▪ At least 16 years old for type A1 ▪ At least 18 years old for type B1 and B ▪ At least 22 years old for type C1, C and D1 ▪ At least 24 years old for type D, A (E), B (E) and D (E) 4. Those who have the driving license type A can drive the vehicle in type A1 5. Those who have the driving license type **B1** can drive the vehicle in type **A1**, but cannot drive a vehicle in other types. 6. Those who have the driving license Type **B** can drive the vehicle in Type **A1** or **B1**, agricultural vehicles or tool-equipped vehicles with the maximum speed of not over 40km/h, but cannot drive the vehicle in others types. 7. Those who drive the tool-equipped vehicle with the maximum speed over 40 km/h must hold the driving license in Type **C**. 8. To obtain the driving license in Type **C1**, the drivers must have the driving license in Type **B** first. 9. To obtain the driving license in Type **C**, the drivers must have the driving license in Type **B, C1,** or **D1** first. 10. Those who drive the vehicles in Type **C** or **D** can drive the vehicles in Type **B**. 11. Those who have the driving license in Type **C** cannot drive the vehicles in Type **D**, but those who have the driving license in Type **D** can drive the vehicles in Type **B** or **C** or **D1**. 12. To obtain the driving license in Type **D1**, the drivers must have the driving license in Type **B** first. 13. To obtain the driving license in Type **D**, the drivers must have the driving license in Type **B** or **C** or **D1** first. 14. To obtain the driving license in Type **E**, the drivers must have the driving license in Type **B** or **C** or **D** first. 15. The drivers who have the driving license in Type **E**, can have the rights to drive vehicles with trailers with a total weight of over 0.75 tons at maximum based on the types of their driving licenses such as **B (E)** or **C (E)** or **D (E)**.
Former	• Driving license types A and B are valid until the holders reach the age of 65, but	**Article 41** **<u>Revised Paragraph</u>**

Article 42	must undergo a physical check-up and extend the driving license every 5 years. • Driving license types C, D and E are valid for three years. The license holder shall extend the validity every three years after a physical check-up to prove that they can still drive.	• Driving license holders of all types have the right to drive until the age of 65. Beyond the age of 65, the driver will be permitted to drive unless passing medical check-up and changing driving license every two years. • Driving license type **A, B, C, D** and **E** is valid for **10** years, but the driver must extend the driving license every 5 years after the medical check-up proves the ability to drive. • Driving license holder type **A** and **B** is valid for 10 years, but must do medical check-up every 5 years. • Driving license types **C**, **D** and **E** are valid for 5 years, but holders must undergo physical check-ups every 30 months. Physical examination result must be certified by a medical doctor at a health center, or a referral hospital recognized by the Ministry of Health.
Former Article 45	• Except when there is a bilateral or multinational agreement or international convention recognized by two countries or more with the Kingdom of Cambodia, legal immigrants who want to drive on the road of the Kingdom of Cambodia could obtain a Cambodian license in two ways	**Article 44** **<u>Revised Paragraph</u>** • Except when there is a bilateral or multinational agreement or international convention recognized by two countries or more with the Kingdom of Cambodia, legal immigrants who want to drive on the road of the Kingdom of Cambodia could obtain a Cambodian license in two ways
Former Article 46	• All driving schools should possess a permit to operate and should be under the control and management of the Ministry of Public Works and Transport. • All driving instructors shall have certificates proving their ability which were issued by the Ministry of Public Works and Transport. The Ministry of Public Works and Transport shall issue PRAKAS of the procedure of issuing a driving license, the setting up of driving schools, the setting up of testing criteria for driving instructors to certify their ability and driving school program.	**Article 47** **<u>Revised Paragraph</u>** • All driving schools shall be registered and granted authorization for operating a driving school and should be under the control and management of the Ministry of Public Works and Transport. • All driving instructors and the driving license examination committee at the municipal-provincial department of public works and transport must have certificates proving their ability which were issued by the Ministry of Public Works and Transport. The Ministry of Public Works and Transport shall issue PRAKAS of the procedure for issuing driving license, the setting up of driving schools, the setting up of testing criteria for driving teachers and a driving license examination committee to certify their ability and driving school program. The Ministry of Interior has the legal authority to check all private driving schools if it is necessary.

Former Article 47	• All Vehicles and trailers or semi-trailers with a total weight of over 750 kg onward that have been previously allowed on road shall register and apply for a vehicle identification card and with the number plate at the Ministry of Public Works and Transport. All vehicles that are not yet registering for the identification card and without the number plate must be transported by the vehicles bearing the number plate when moving on the road.	**Article 46** **<u>Revised Paragraph</u>** • All vehicles registered to travel on roads shall have a vehicle identification card and number plate issued by the Ministry of Public Works and Transport. All vehicles that are not yet registered for the identification card and without a number plate must be transported by the vehicles bearing number plates when on the road. All trailers or semi-trailers with a total weight of over 750 kg must be registered for identification cards and number plates as other vehicles.
New Article 47	• All owners of automotive sales shops must complete the vehicle registration form and obtain a number plate for the vehicle before hanging over the vehicle to the buyer. • Regarding selling, handing over and transferring ownership in other modes, the completion of the transfer of vehicle ownership form must be done within 90 (ninety) days from the date of sale-purchase or handing-over. • Vehicle owners must request the deletion of the unuse unused vehicle from the registration book. The procedure for transferring vehicle ownership shall be identified by PRAKAS of the Ministry of Public Works and Transport.	
New Article 49	• The owner of vehicle types requiring insurance must purchase insurance in accordance with the insurance law and guidelines if the vehicle is operated on public road.	
Former Article 49	• All garages where vehicles are repaired, and where installation and renovation are performed must obtain business permit certificate issued by the Ministry of Public Works and Transport, in case it is necessary, check will be conducted by the Ministry of Interior.	**Article 50** **<u>Revised Paragraph</u>** • All garages, where vehicles are repaired, installed and renovated, must be registered and granted business authorization issued by the Ministry of Public Works and Transport and will be checked by the Ministry of Interior if necessary. • The procedure of issuing the permit for the garages on its repairing and installation including the technical standard of vehicle renovation shall be determined by sub-decree.
Former Article 50	• **3)** The management of goods and passenger transportation is defined by sub-decree • **4)** The transportation of dangerous goods and produce that spoil easily is defined by sub-decree.	**Article 51** **<u>Revised Paragraph</u>** • **3)** The in-country transportation management of goods and passengers and/or tourists is defined by sub-decree. • **4)** The contract of transporting goods, passengers and/or tourists on land shall be written in a separated law. • **5)** The international transportation on land shall follow the international agreement while the Kingdom of Cambodia joined as a member.
Former Article 54	• The weight of automobiles, automobiles with trailers or semi-trailers that are not identified in the abovementioned points	**Article 55** **<u>Revised Paragraph</u>**

	shall obtain special authorization from the Ministry of Public Works and Transport. ▪ Maximum length of automobiles towing semi-trailers shall not exceed 16 meters.	• The maximum size of automobiles, automobiles with trailers or semi-trailers that are not identified in the abovementioned points shall obtain special authorization from the Ministry of Public Works and Transport. ▪ Maximum length of automobiles towing semi-trailers loading retail goods shall not exceed 6 meters. ▪ Maximum length of automobiles towing semi-trailers loading containers shall not exceed 18.5 meters.
Former Article 56	• The National Road Safety Committee shall be created in order to coordinate, gather force, enhance cooperation between the Ministry of Public Works and Transport and other concerned ministries, transport associations, NGOs, and private institutions for the purpose of reducing traffic accidents in the goal of protecting citizen's life, preventing public or private property damage and guaranteeing the security, public order and safety on the road. • Composition, duty, organization, and function of the National Road Safety Committee shall be determined by sub-decree.	**Article 57** **<u>Revised Paragraph</u>** **(Chapter 8 – Implementation Mechanism of RTL)** • In order to reduce road traffic crashes in the goal of protecting citizen's life, preventing the damages of public or private properties and guaranteeing the security, public order and road safety, the Royal Government of Cambodia shall create the National Road Safety Committee to coordinate, gather force, and enhance cooperation between the Ministry of Public Works and Transport and other concerned ministries, transport associations, insurance associations, NGOs, and private institutions. • Composition, duty, organization, and function of the National Road Safety Committee shall be determined by sub-decree.
Former Article 57	• The National Road Safety Committee shall have a separate budget which is the annex of Ministry of Public Works and Transport and the budget from partners of Road Traffic Safety for use on traffic accident reduction measures.	**Article 58** **<u>Revised Paragraph</u>** • In order to enhance RTL implementation and effectiveness of relevant documents the Royal Government of Cambodia shall create the steering committee for monitoring the implantation of RTL by gathering the involvement of relevant ministries/institutions.

Former Article 58	• Officers implementing the traffic law are divided into two groups: entity of traffic police and the mixed monitoring groups. **1)** Entity of traffic police whose duty is to maintain the traffic order shall: ▪ Maintain traffic order ▪ Follow up, patrol and check the act of traffic offenses ▪ Report on traffic-order situation, traffic law violation and traffic accident occurred. ▪ Fine petty crimes which are to be punished with interim penalty ▪ Handle traffic accident cases, as stated in article 64. ▪ Monitor and make reports of accidents and if necessary, confiscate the driving license temporarily and keep the vehicle in place based on article 61, article 65 and article 66. ▪ Make reports attaching pertinent documents to be submitted to the court if defined by this law. ▪ The mixed monitoring groups which consist of officers from the Ministry of Public Works and Transport and other concerned ministries shall have a duty to check traffic offenses, if necessary. The duty of the mixed monitoring groups shall be determined by sub-decree.	**Article 59** **<u>Revised Paragraph</u>** • Officers implementing the traffic law are divided into two groups: **1)** First group: entity of traffic police whose duty is to maintain the traffic order shall: ▪ Maintain traffic order ▪ Follow up, patrol and check the act of traffic offenses by officials and specialized equipment ▪ Report on traffic-order situation, traffic law violation and traffic accident occurred. ▪ Fine petty crimes which are to be punished with interim penalty ▪ Handle traffic accident cases, as stated in article 64. ▪ Monitor and make reports of accidents and if necessary, confiscate the driving license temporarily and keep the vehicle in place based on article 61, article 65 and article 66.
Former Article 62	• In the case of traffic accident, based on the respective cases, the keeping of driver and vehicle for question and making a report is the responsibility of traffic police officers at the scene of the accident. In the case that the driver is under the influence of alcohol or drug, the task has to be handed over to a hospital for checkup and issuance of a letter to specify the rate of blood alcohol content or drug to be enclosed with the report on the traffic accident to the court.	**Article 62** **<u>Revised Paragraph</u>** • In the case of traffic accident, based on the respective cases, the keeping of driver and vehicle for question and making a report is the responsibility of traffic police officers at the scene of the accident. In the case that the driver is under the influence of alcohol or drug, the traffic police or hospital has to require a checkup and issuance of a letter specifying the rate of blood alcohol content or drug to be enclosed with the report on the traffic accident to the court.
Former Article 63	• The traffic offenses that are to be punished by putting in the jail time or fine shall be the duty of the court. In this case, the provincial and town traffic police officers have to send the report on the traffic accident through hierarchy to the tribunal by enclosing the driver's and the victim's answers or witness's answers gathered by traffic police officers. The documents to be sent to	**Article 63** **<u>Revised Paragraph</u>** • The traffic offenses that are to be punished by jail time or fine shall be the duty of the court. In this case, traffic police office at town, district, Khan, municipal and provincial levels have to send the report on the traffic accident through hierarchy to the tribunal.

	court should contain clear and as much information as possible.	
New Article 78	• Traffic police officers who detain a vehicle that has insurance and causes traffic accident damaging only property shall release the vehicle after receiving an official letter from the insurance company agreeing to pay the victim for the property damage.	
Former Article 73	• In the case the driving license has to be suspended or nullified and the driver refuses to surrender the driving license by the defined time, the driver shall be punished by jail time of one (1) day to five (5) days and fine of five thousand (5,000) Riels to twenty-five thousand (25,000) Riels.	**Article 79** **<u>Revised Paragraph</u>** • In the case the driving license has to be suspended or nullified and that the drivers disagree to give the driving license in accordance with the defined time, shall be punished by jailing from one (1) day to Six (6) days and fined from twenty-five thousand (25,000) Riels to one hundred and twenty-five thousand (125,000) Riels
Former Article 75	• Those who hamper or interfere with the stop of vehicles or do not stop their vehicles as ordered by traffic police or refused to be checked or disagree from doing the breathalyzer test or drug test shall be punished by jailing for six days to one month and fined from 25,000 Riels to 200,000 Riels.	**Article 81** **<u>Revised Paragraph</u>** • Those who hamper or interfere with the stop of vehicles or do not stop their vehicles as ordered by traffic police or refused to be checked or disagree from doing the breathalyzer test or drug test shall be punished by jailing for six days to one month and fined from 125,000 Riels to 1,000,000 Riels.
Former Article 78	• Those who are using the means to provoke obstacle to public traffic will be punished by being in prison for one month to one year and fined from 200,000 Riels to 2,000,000 Riels.	**Article 84** **<u>Revised Paragraph</u>** • Those who are using the means to provoke obstacle to public traffic or disrespect the order of traffic police guarding the journey of high delegation and causing property damage will be punished by being in prison for one month to one year and fined from 1,000,000 Riels to 10,000,000 Riels and must compensate the cost of repairing also.
Article 80	• Those who are driving by causing injuries to others unintentionally or disabled others from doing their work equal to or more than eight days shall be imprisoned from six days to one year, and/or fined from 25,000 Riels to 2,000,000 Riels.	**Article 86** **<u>Revised Paragraph</u>** • Those who are driving carelessly, less attention or violate the road traffic law causing injuries to others unintentionally or disabled others from doing their work equal to or more than eight days from the day of causing the accident shall be imprisoned from six months to two years, and/or fined from 1,000,000 Riels to 4,000,000 Riels including other punishments stated in Article 53 of the Criminal Code. The drivers shall be punished at maximum level when they commit offenses as mentioned above in the following cases: **a)** Driving without driving license or with driving license but is not properly used as defined;

		b) Driving when they are drunk with an alcohol rate from 0.40 mg per liter of breath, or 0.80 g per liter of blood; **c)** Provoking injuries to many people; and **d)** Escaping from the scene of the accident for irresponsibility.
New Article 89	The legal entity who is declared to be responsible for the crime as stated in article 42 (responsibility of criminal code of legal entity) by the Criminal Code on violation stated in Article 86 and Article 87 of the law. The legal entity will be fined 5,000,000 Riels to 20,000,000 Riels including one or more punishments as follows: • **1)** Termination based on Article 170 (termination and liquidation of legal entity) of the Criminal Code. • **2)** Keeping under the inspection of the court based on a determined measure of Article 171 (keeping under inspection of the court) of the Criminal Code. • **3)** Prohibit in taking one or more action(s) based on a determined measure of Article 172 (Prohibit in taking action) of the Criminal Code. • **4)** Close down buildings used for a violation based on a determined measure of Article 176 (close down building) of the Criminal Code. • **5)** Prohibit on using public building or the building use for the general public based on the determined measure of Article 176 (Prohibit on using public building) of the Criminal Code. • **6)** Post the announcement decision of conviction based on a determined measure of Article 180 (Announcement decision) of the Criminal Code. • **7)** Proclaim the decision of conviction via written news or radio telecommunication system based on a determined measure of Article 181 (proclamation of decision via radio telecommunication system) of the Criminal Code.	
Former Article 83	• Those who are willingly driving and causing injuries, disabilities, or death to others will be punished in compliance with the Penal Code.	**Article 90** **<u>Revised Paragraph</u>** • Those who are driving and willingly causing injuries, disabilities, or death to others will be punished in accordance with the Criminal Code.