MINISTRY OF TRANSPORT
VIETNAM

STUDY FOR ITS INTEGRATION PROJECT IN NORTHERN AREA OF VIETNAM

APPENDIX 2

- BASIC DESIGN REPORT

NOVEMBER 2015

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS GLOBAL CO., LTD.
METROPOLITAN EXPRESSWAY CO., LTD.
NEXCO EAST ENGINEERING CO., LTD.
TRANSPORTATION RESEARCH INSTITUTE CO., LTD.
ABEAM CONSULTING LTD.

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PROJECT OUTLINES

TABLE OF CONTENTS

1. Introduction

1.1 Background

The number of vehicle ownership has been growing at an annual rate of nearly 10% and the designing and construction of expressway network have been propelled nationwide in order to address the rapid increase of traffic and promote the expansion of industries in Vietnam. Especially in the Hanoi Metropolitan Area in Northern Vietnam, the road network consists of the expressways in radial directions and the Ring Road 3 bundles them has been constructed.

However, the lack of the Variable Message Signs (VMS) to disseminate an incident occurrence to the drivers en route and the means to identify the situation of incident are obstructing the restriction of incoming traffic to the incident site and requiring a long time to clear it. Also, the effective use of the system of Electronic Toll Collection (ETC) has delayed and the congestion at the tollgates is likely to become frequent. For such reasons, it has become an urgent issue to implement the Traffic Control System, which enables instant identification of an incident, close monitoring of its situation, prompt decision for traffic restrictions and information dissemination, and the system of Electronic Toll Collection.

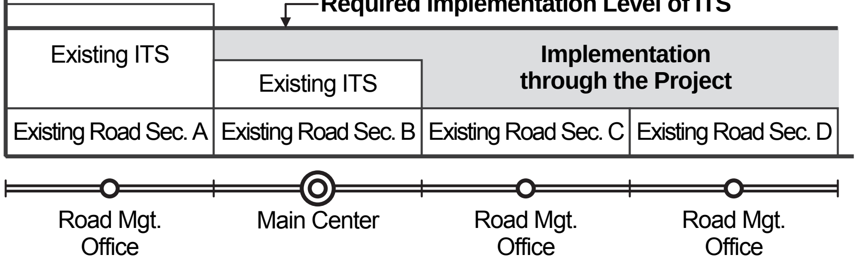
On the other hand, it is discussed to promote ITS implementation in a standardized/integrated form for actualizing an efficient road operation; however, in Vietnam, the Standards has not been developed for ITS so far and the connectivity and inter-operability are likely to become obstructed by the pieces of hardware selected independently by the road operators of respective sections.

In such situations, it is strongly required to implement the Project for ITS integration, in consideration of the expressways to be constructed in future and the conformity with the ITS Standards under development, and to enhance the capability of processing expressway traffic through ITS.

1.2 Objective of Project

The Project aims to build up the Northern Regional Main Center, to implement ITS to secure the required implementation level covering the target road network, to establish a procedure for integrating ITS, to initiate expressway operation/maintenance (O&M) using ITS and to show the way to utilize ITS for solving traffic problems in the metropolitan areas.

Figure 1.1 Securing of Required Implementation Levels of ITS through the Project



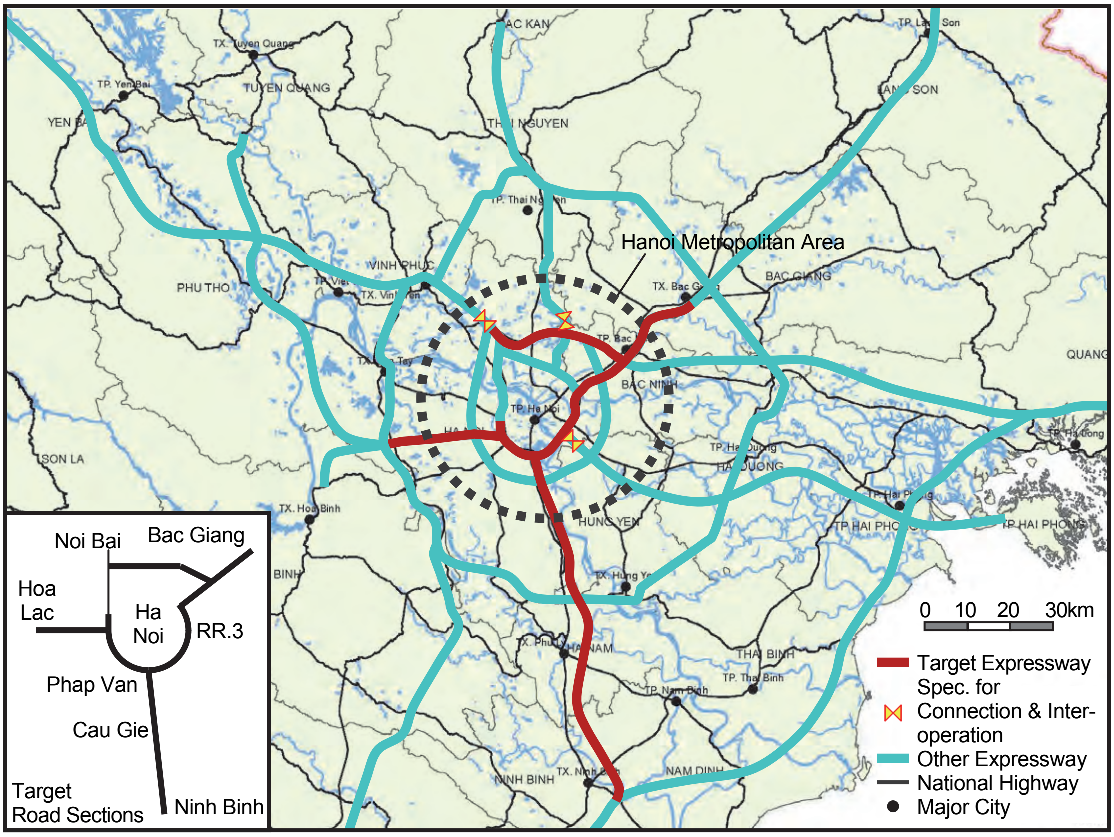
Source: ITS Standards & Operation Plan Study Team

1.3 Scope

1) Project Area

The area, which includes Hanoi city and neighboring provinces, is defined as the scope of the Study.

Figure 1.3 Study Area including Target Road Sections of the Project



Target Expressway	Length
Mai Dich–Thanh Tri (Ring Road 3)	27 km
Lang–Hoa Lac	28 km
Phap Van–Cau Gie	30 km
Cau Gie–Ninh Binh	50 km
Ha Noi–Bac Giang	46 km
Noi Bai–Ca Lo Bridge	16 km
Ca Lo Bridge–Bac Ninh	17 km
Total	214 km

Source: The Study Team

2) Systems to be Implemented

The following four systems are to be implemented in the Project:

- Traffic information/control system (←System for road traffic information/control)
- Toll collection/management system (←System for non-stop toll collection, For Reference)
- Vehicle weighing system (←System for heavy truck control, For Reference)
- Communication system.

1.4 Standards and Regulations

The results of the basic design of the Project are shown in the APPENDIX-4 and APPENDIX-5. The basic design is based on the Project implementation plan aforementioned and the following regulations:

- ITU-T G. 107: The E-Model, a computational model for use in transmission planning
- ITU-T Y. 2012: Functional Requirements and Architecture of Next Generation Networks
- ITU-T Y. 1541: Network performance objectives for IP-based services
- ITU-T H. 264 and ISO/IEC 14496-10: (MPEG4-Part 10)
- ITU-R M.1453: DSRC at 5.8 GHz (Physical Layer)
- ITU-T G.652: Characteristics of single-mode optical fibre cable
- ITU-T G.655: Characteristics of a non-zero dispersion shifted single-mode optical fibre cable
- IETF, RFC 3261 SIP: Session Initiation Protocol
- IETF, RFC 3550 RTP: A Transport Protocol for Real-+Time Applications
- IETF, RFC 4566 SDP: Session Description Protocol
- ISO 14813-1:2007 Intelligent transport systems – Reference model architecture(s) for the ITS sector
- ISO 15628: DSRC Applications
- ISO 14906: Application Interface Definition for DSRC
- ISO/IEC 14496-2: (MPEG4-Part 2)
- ISO/IEC 14496: (Coding of audio-visual objects)
- ISO/IEC 11179: Information technology – specification and standardization of data elements
- ISO/IEC 14443: Contact-less Integrated Circuit Cards
- ISO/IEC 18092: Near Field Communication – Interface and protocol
- ISO/IEC 13818-1:2000 Information Technology – Generic coding of moving pictures and associated audio information
- ISO/DIS 14817: Transport information and control systems – requirements for an ITS/ TICS central data registry and ITS/TICS data dictionaries
- ISO/CD 24533: Data directory and Message set for tracking of freight and It's intermodal transfer
- IEC 60529: Degrees of Protection provided by Enclosure (IP Code)
- IEEE 802.3af: Power over Ethernet
- IEEE 802.3at: 10BASE-T/100BASE-TX PoE Plus
- IEEE 802.3: Ethernet (Carrier Sense Multiple Access with Collision Detection)
- WMO-No.544 Manual on the Global Observing System (WMO)
- EN 12253:2004: Road transport and traffic telemetric – Dedicated short range communication: – Physical Layer using microwave at 5.8 GHz
- EN 13372:2004: Road transport and traffic telematics (RTTT) – Dedicated short range communication – Profiles for RTTT application
- EN 15509:2007: Road transport and traffic telematics (RTTT) – Electronic fee collection interoperability application profile for DSRC
- TCVN 5729

- TCVN 2737:1995
- TCVN 4054
- TVCN 6384:1998: Code/Bar Code on items - UPC-A Code - Technical Requirements
- TVCN 6513:1999: Code/Bar Code on items - Barcode ITF - Technical Requirements
- TVCN 6755:2008 ISO/IEC 15417:2007: Code/Bar Code on items - Barcode EAN-UCC 128 - Technical Requirements
- 22TCN331-05: Documents on message/signs for highways
- 22TCN237-01: Regulation on Road Signs
- TCCS 01:2008/VRA: One-stop Charging Toll Gate using Printed Barcodes
- Decree No. 24/2004/ND-CP dated January 14, 2004: Detailing the Implementation of a Number of Articles of the Ordinance on Post and Telecommunications Regulating Radio Frequencies
- Decree No. 34/2010/ND-CP: Processing for measured overload heavy truck
- Circular No. 36/2009/TT-BTTTT dated December 3, 2009: Stipulating Specifications and Exploiting conditions of short range Radio Frequency Devices of conditional use
- Circular No 06/2009/TT-BCB(C11)
- Circular 07/2010/TT-BGTVT: Legal regulation for measurement of overloaded heavy truck

2. General Notes

(1) The drawings, specifications and reports developed in the Study are the results of basic design of the Project, and that of detailed design shall be prepared by the Contractor of the Project Implementation in compliance with the results of the basic design.

(2) In the case regulations are updated, the specifications shall be updated in the detailed design by the Contractor of the Project Implementation in compliance with the latest regulations.

(3) Modifications on the drawings and supplementary drawings shall be prepared by the Contractor of Project Implementation based on the actual conditions and in compliance with the latest regulations at the point in time of the Project Implementation.

(4) The drawings and reports for the Noi Bai – Viet Tri Section are included in the results of the Study only for reference; however, the results of this Section are not included in the quantity table and cost estimation of the Project.

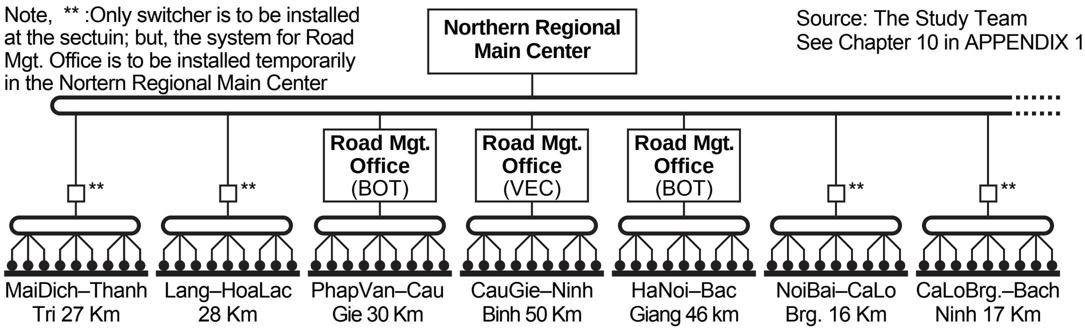
(5) The drawings of architecture are shown only for reference. The drawings of detailed design of architecture shall be prepared additionally in other study.

3. Center Equipment

1) Location of Northern Regional Main Center and Road Management Offices

The structure and location of the Northern Regional Main Center and the road management offices are shown in the figures below. The center equipment for all of the Northern Regional Main Center and the road management offices needs to be implemented in the Project. The building of the Northern Regional Main Center is to be constructed in the Project as well. And the equipment and functions of the road management offices for the road sections of Phap Van – Cau Gie, Cau Gie – Ninh Binh and Ha Noi – Bac Giang are to be installed their own buildings; however, that of Mai Dich – Thanh Tri, Lang – Hoa Lac, Noi Bai – Ca Lo Bridge and Ca Lo Bridge – Bac Ninh are to be installed temporarily in the Northern Regional Main Center.

Figure 3.1 Northern Regional Main Center and Road Management Offices



Source: The Study Team

The systems are to be installed in the respective toad sections in the Project and the respective systems include the Functional Packages as shown in the tables below.

Table 3.1 Systems for Each Section in the Project

Systems to be Installed	MaiDich–ThanhTri	Lang–HoaLac	PhapVan–CauGie	CauGie–NinhBinh	HaNoi–BachGiang	HaNoi–CaLoBrg.	CaLoBrg.–BacNinh
Traffic Information/Control	XX	XX	XX	XX	XX	XX	XX
Toll Collection/Management	**		***	***	***		**
Vehicle Weighing	**		***	***	***		**
Communication System	XX	XX	XX	XX	XX	XX	XX

Note, ** : Road section where tollgates are removed responding to application of the road maintenance fund.
***: Road section where toll collection is implemented by other funds.

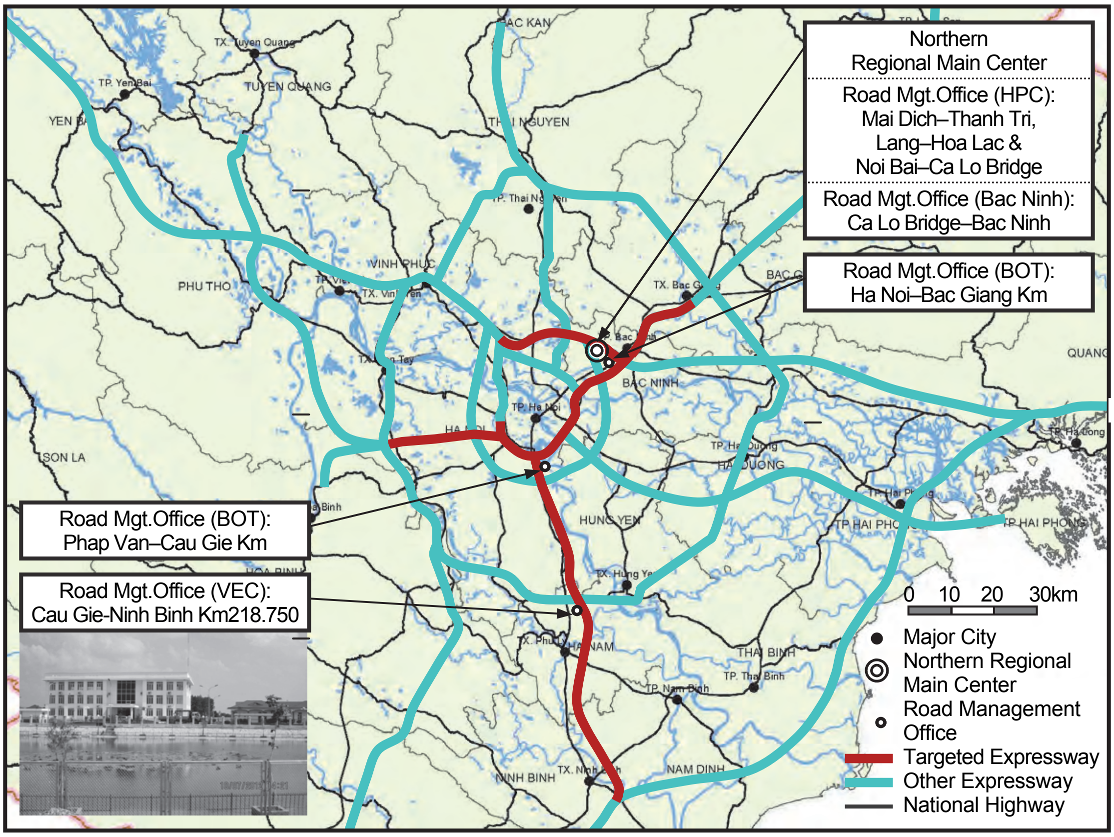
Source: The Study Team

Table 3.2 Functional Packages included in the System

System	Functional Package	System	Functional Package
Traffic Information /Control System	(1) Voice Communication	Toll Collection /Management System (For Reference)	(13) Tollgate Lane Monitoring
	(2) CCTV Monitoring		(14) Vehicle/Class Identification
	(3) Event Detection (by Image)		(15) Lane Control
	(4) Vehicle Detection		(16) Road-to-Vehicle Communication
	(5) Traffic Analysis		(17) IC-card Recording
	(6) Weather Monitoring		(18) Toll Data Management
	(7) Traffic Event Data Management		(19) OBU Management
	(8) Traffic Supervision	Vehicle Weighing System (For Reference)	(20) Axle Load Measurement
	(9) VMS Indication		(21) Measurement Lane Monitoring
	(10) Mobile Radio Communication		
	(11) Traffic Information		
	(12) Integrated Data Management		

Source: The Study Team

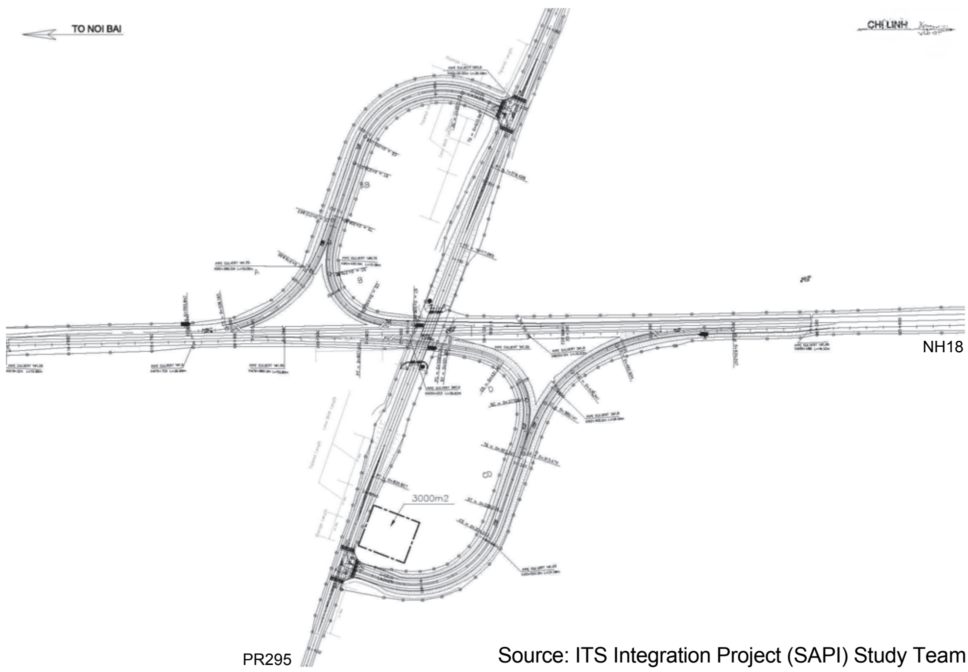
Figure 3.2 Location of Northern Regional Main Center and Road Management Offices



Source: The Study Team

The Northern Regional Center, which requires the site of 3000 m^2, is to be constructed in the area surrounded by the ramps in the interchange between Noi Bai – Bac Ninh and the Provincial Road 295 in the Project as shown in the following figure.

Figure 3.3 Location of Northern regional Main Center



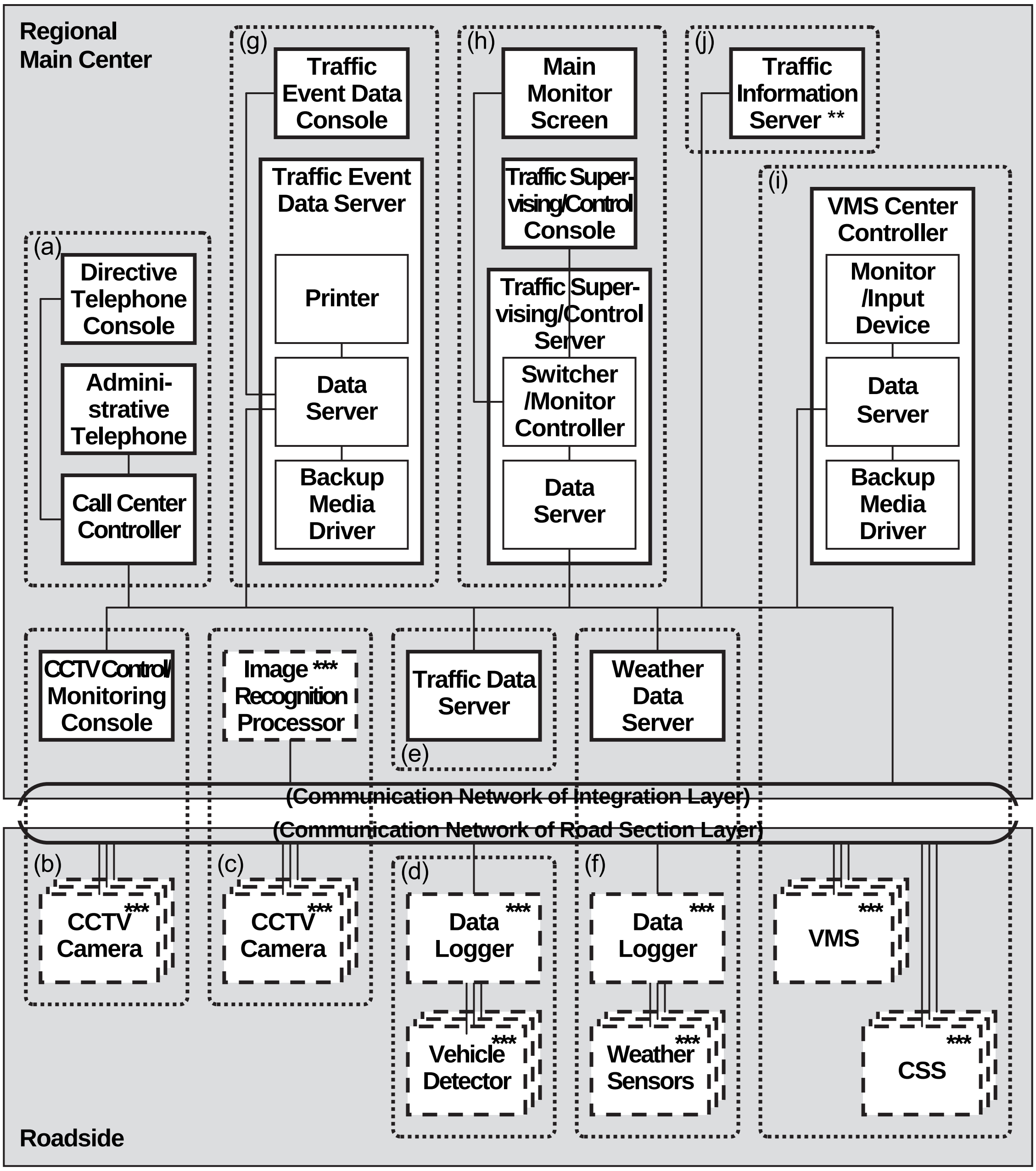
Source: ITS Integration Project (SAPI) Study Team

2) Northern Regional Main Center

Traffic information/control is to be conducted totally from the Regional Main Center using the following functional packages:

(a) Voice Communication	(f) Weather Monitoring
(b) CCTV Monitoring	(g) Traffic Event Data Management
(c) Event Detection (by Image)	(h) Traffic Supervision
(d) Vehicle Detection	(i) VMS Indication
(e) Traffic Analysis	(j) Traffic Information

Figure 3.4 System Architecture for Northern Regional Main Center

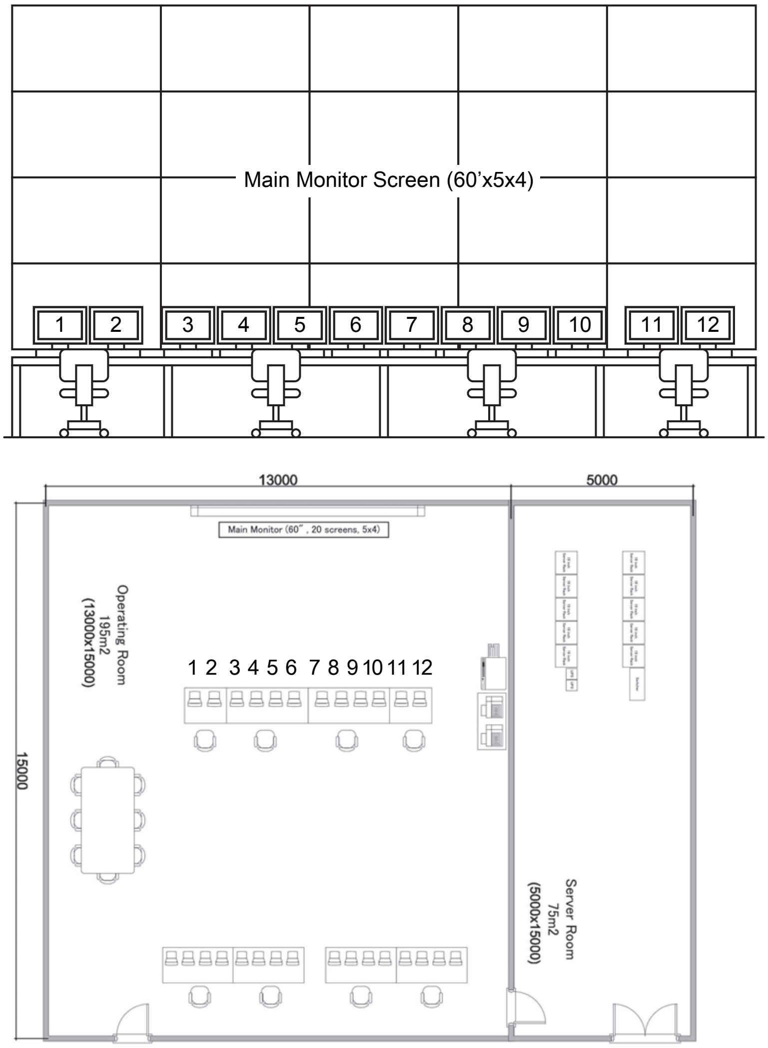


Note, [dotted box] : Functional package, ** : To be connected to the Internet with protection by a firewall and stored data in it is to be copied from the traffic event data server, *** : To be installed at roadside or in the road management office.

Source: The Study Team

For actualising the functions aforementioned, pieces of the center equipment are to be installed in the Regional Main Center as shown in the figure below. The data from vehicle detectors and weather sensors are to be processed in the Regional Main Center, and VMSs and CCTV cameras are to be controlled directly from the Regional Main Center as well as the road management office for integrating traffic information dissemination.

Figure 3.5 Equipment Overview in Regional Main Center



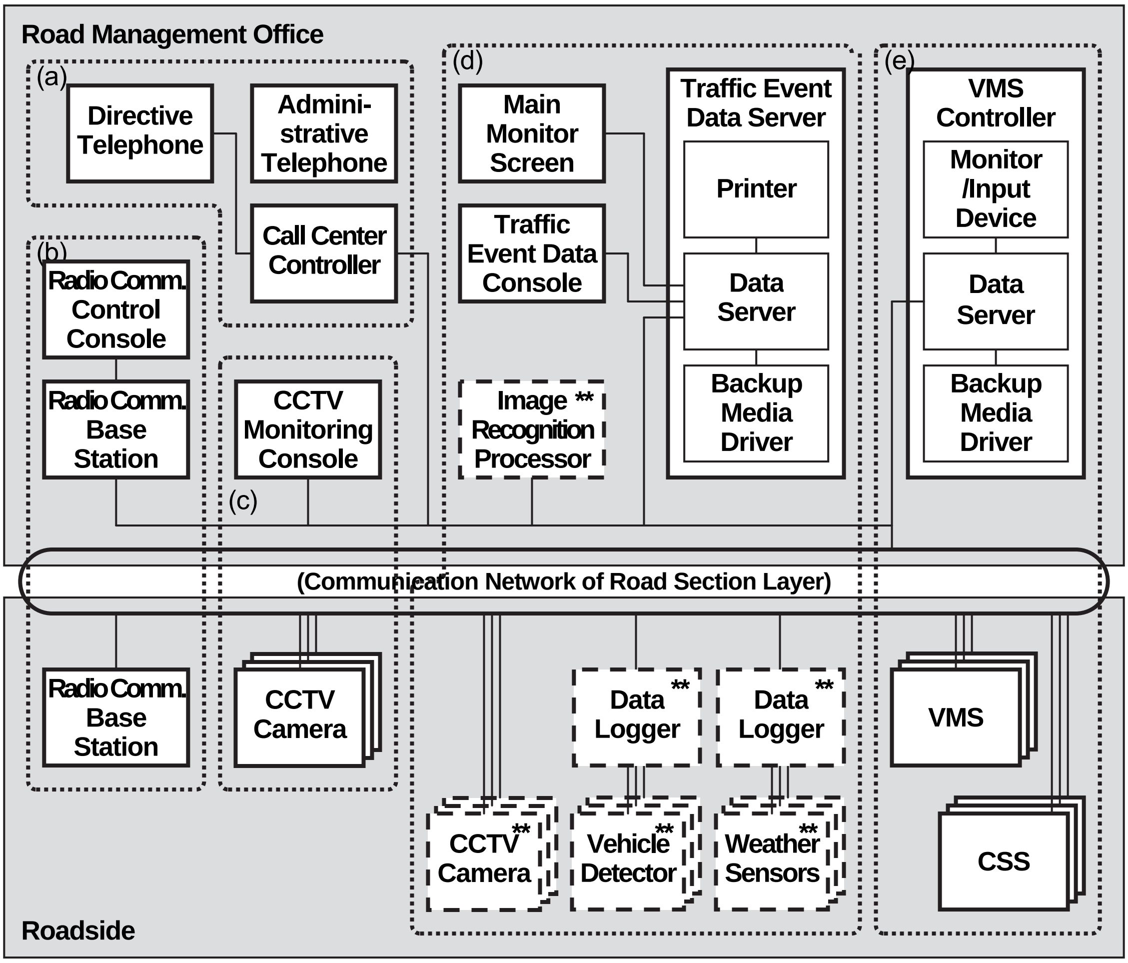
Source: The Study Team

3) Road Management Office

A part of center equipment is to be installed in the road management offices for expressway operation. CCTV cameras are to be controlled and the traffic event data are to be input from the road management office as well for handling and clearing incidents. The traffic event data is to be input from the road management office; however, prioritisation of the traffic event data is to be done in the Regional Main Center and guidance based on it is to be sent to the operators in road management offices for to input the data to be indicated by VMS/CSS.

(a) Voice Communication
(b) Mobile Radio Communication
(c) CCTV Monitoring
(d) Traffic Event Data Management
(e) VMS Indication

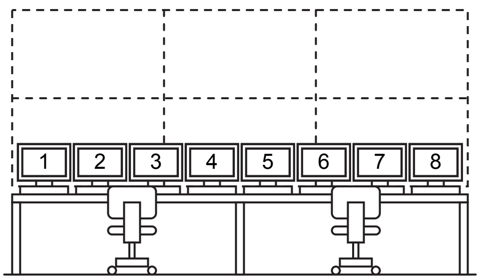
Figure 3.6 System Architecture for Road Management Office



Note, [dotted box] : Functional package, ** : Components of the functional packages to be coordinated with Traffic Event Data Management.

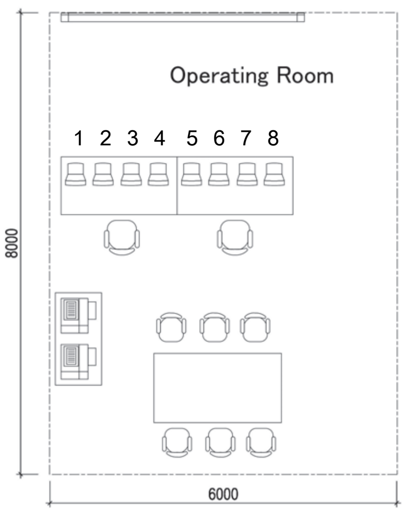
Source: The Study Team

Figure 3.7 Equipment Overview in Road Management Office



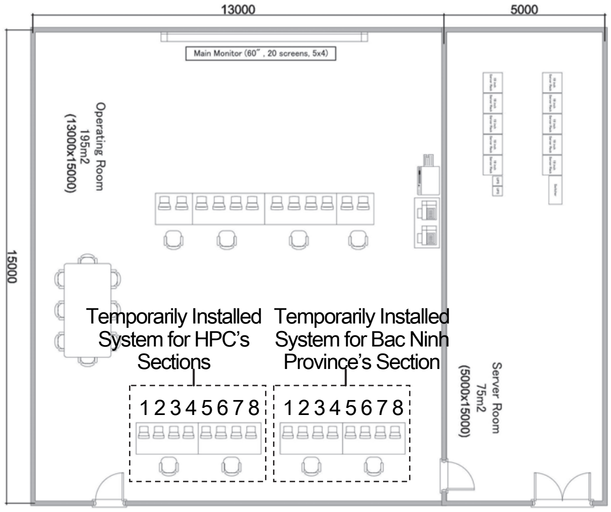
1. Mobile Communication Control Console
2. CCTV Control/Monitoring Console
3. Traffic Event Data Console
4. VMS Controller Monitor/Input Device
5. Mobile Communication Control Console
6. CCTV Control/Monitoring Console
7. Traffic Event Data Console
8. VMS Controller Monitor/Input Device

Note: Main monitor screen can be omitted if it is not necessary in the road management office.



Source: The Study Team

Figure 3.8 Equipment Overview Temporarily installed in Regional Main Center



Source:
The Study Team

4) Data Integration Center

The integrated data server is to be installed in the Data Integration Center for actualizing its function. The data are to be acquired from the data servers in the Regional Main Center and the toll offices, and to be managed by the operator.

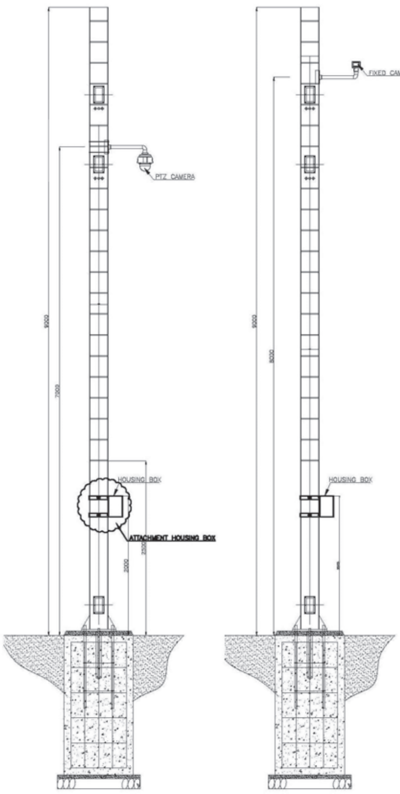
4. Roadside Equipment

In the Project, roadside equipment components below are to be installed for the 1st stage of stepwise implementation.

- CCTV camera (for monitoring and for event detection)
- Vehicle detector
- VMS (Variable Message Sign)
- CSS (Changeable Speed Limit Sign)
- ETC (Electronic Toll Collection) (→For Reference)
- Touch&Go/manual (→For Reference)
- Axle load scale (→For Reference).

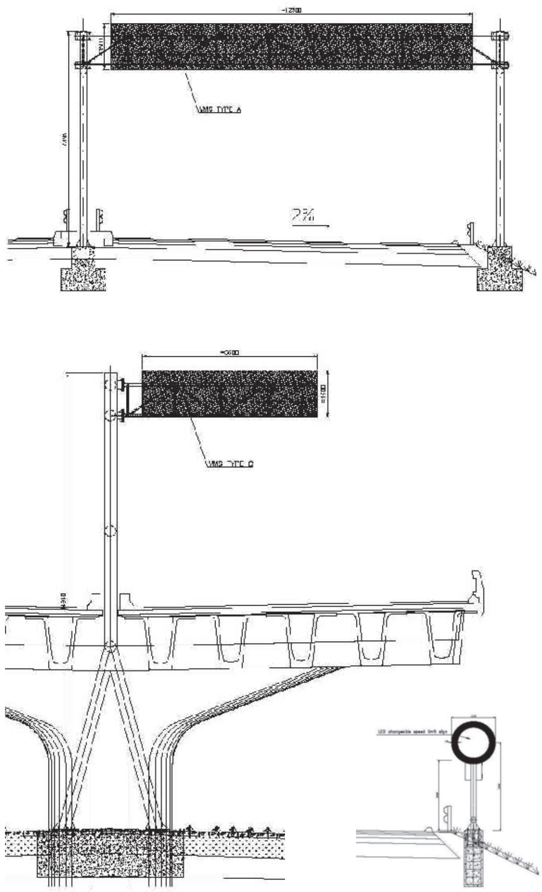
Typical installation of roadside equipment components are shown in the following figures and the arrangement on the road network is shown in the following tables.

Figure 4.1 Installation of CCTV Camera



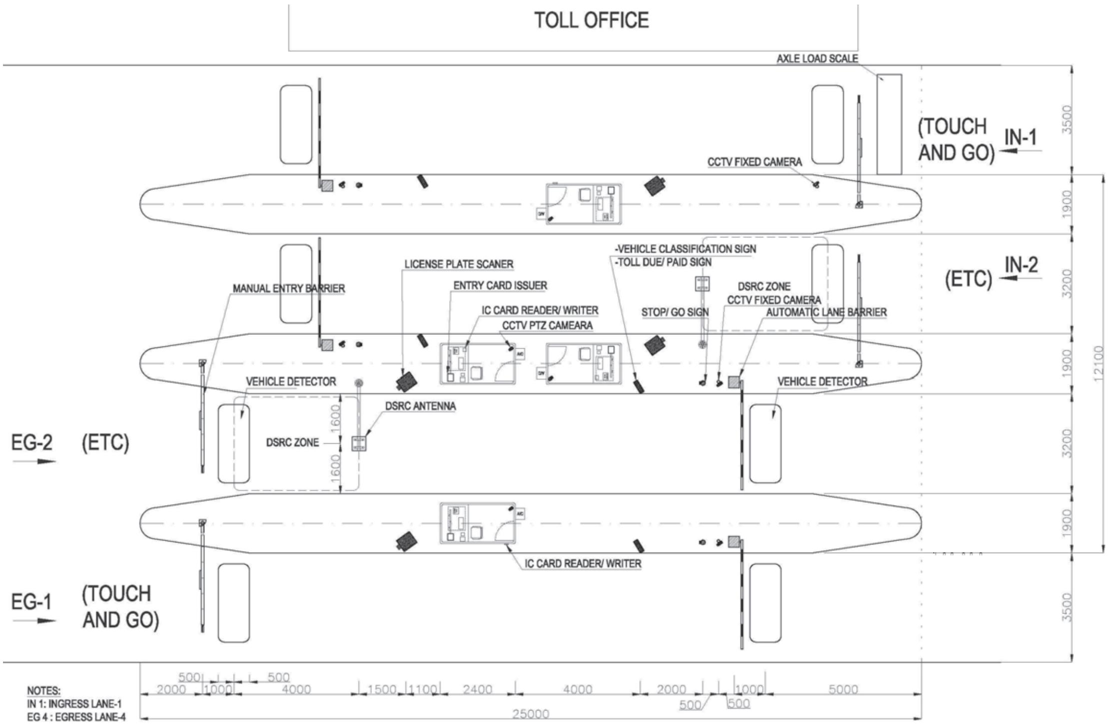
Source: ITS Integration Project (SAPI) Study Team

Figure 4.2 Installation of VMS/CSS



Source: ITS Integration Project (SAPI) Study Team

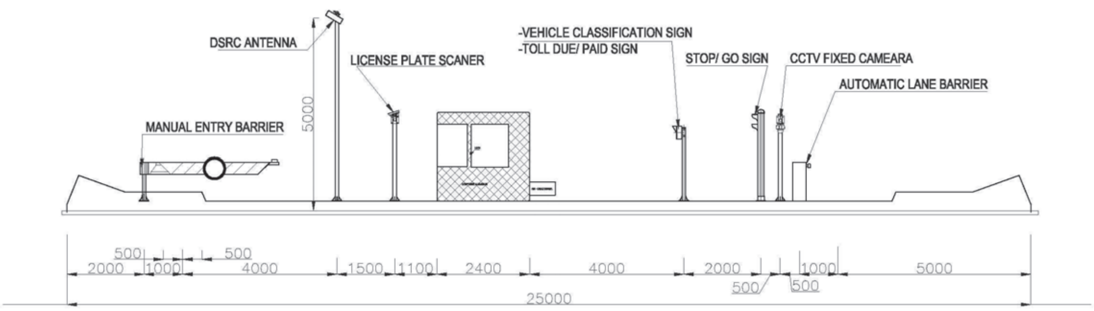
Figure 4.3 Installation of Roadside Equipment for Toll Collection (For Reference)



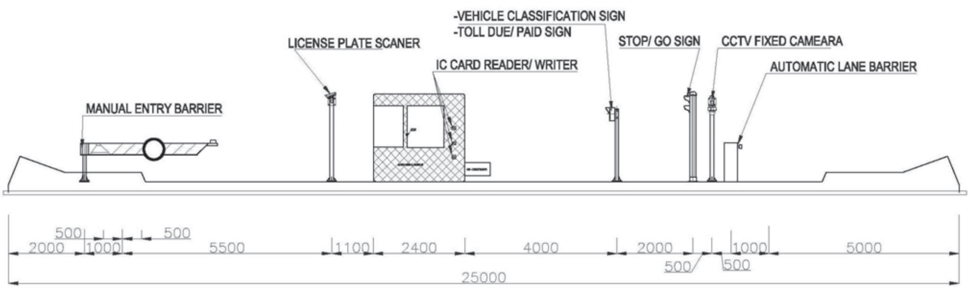
Source: ITS Integration Project (SAPI) Study Team

Figure 4.4 Installation of Roadside Equipment (For Reference)

(ETC)

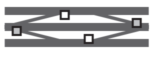
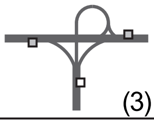
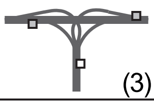
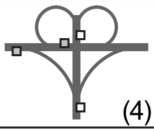
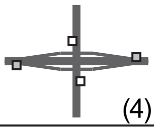
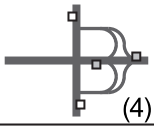
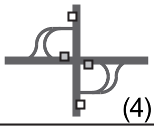
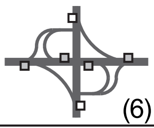
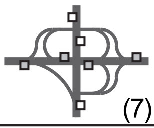
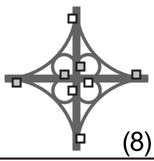
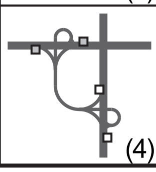


(Touch&Go/Manual)



Source: ITS Integration Project (SAPI) Study Team

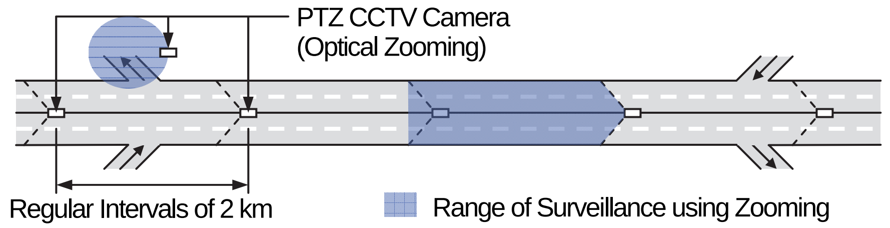
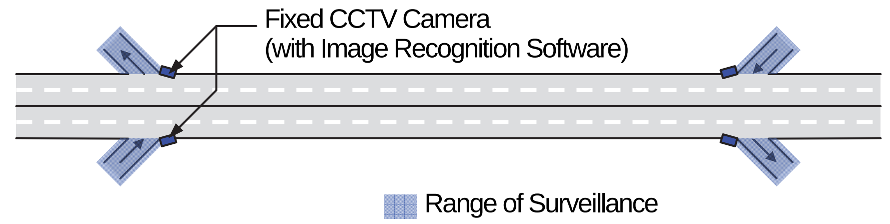
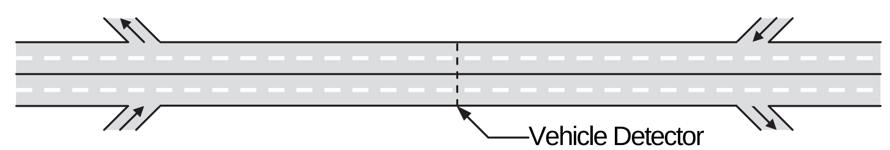
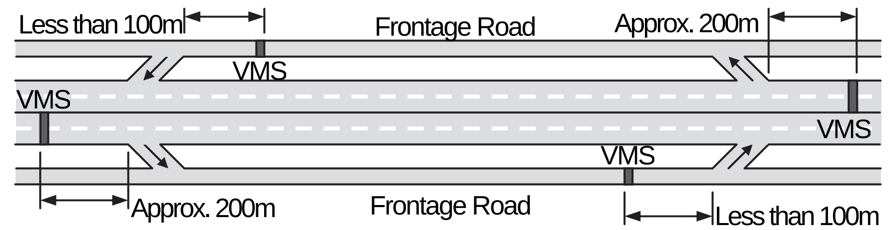
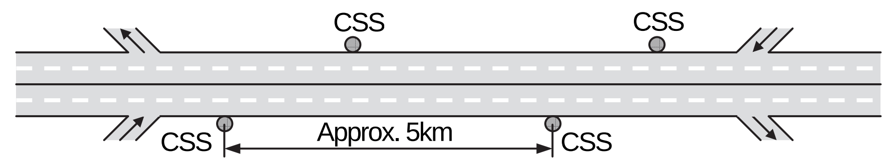
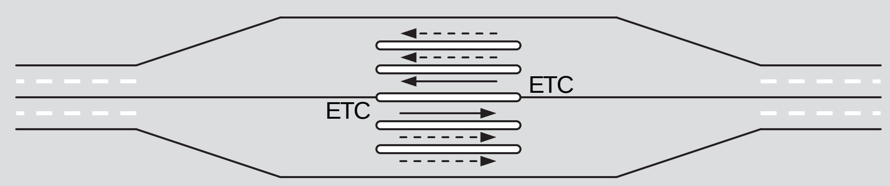
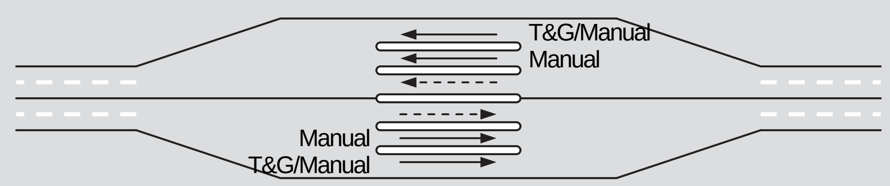
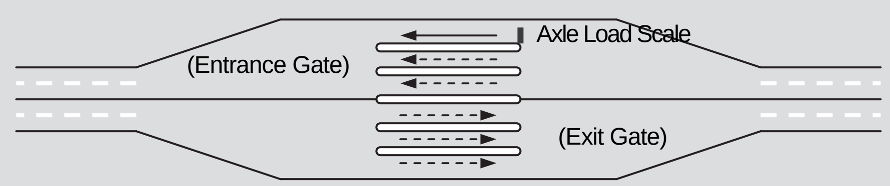
Table 4.1 Interchanges and VMS Arrangement

Type of Interchange/ Arrangement of VMS		Mai Dich–Thanh Tri Section	Lang–Hoa Lac Section	Phap Van–Cau Gie –Ninh Binh Section	Ha Noi–Bac Ninh Section	Noi Bai–Bac Ninh Section
Diamond	 (4)	3.5	3	3		
Trumpet	 (3)			1	2	1
Directional T	 (3)					
Half Clover	 (4)					
Diamond	 (4)					
Folded Diamond	 (4)	2		1		
Partial Cloverleaf	 (4)				1	1
6 Ramp Partial Cloverleaf	 (6)			1		
7 Ramp Partial Cloverleaf	 (7)				1	
Cloverleaf	 (8)		1		1	
Double Trumpet	 (4)	1				1

□ : VMS at entrance gate ▫ : VMS at exit gate

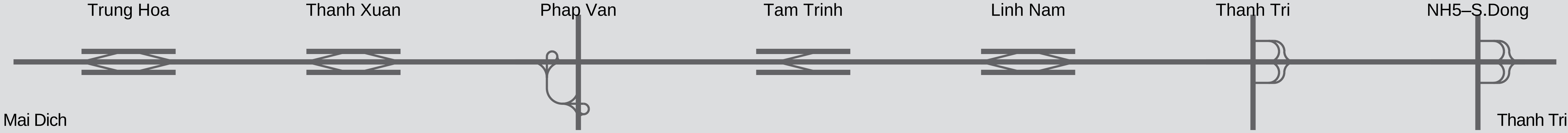
Source: ITS Integration Project (SAPI) Study Team

Table 4.2 Total Arrangement of Roadside Equipment Components by the Project

System	Arrangement of Roadside Equipment		Mai Dich –Thanh Tri	Lang –Hoa Lac	Phap Van –Cau Gie	Cau Gie –Ninh Binh	Ha Noi –Bac Giang	Noi Bai –Ca Lo Bridge	Ca Lo Bridge –Bac Ninh
Traffic Information/ Control System	1. PTZ Camera: for Monitoring At regular intervals of 2 km (in practical use)		22 sets Excluding 12 sets installed by JICA Grant	40 sets	-- Excluding 14 sets to be installed by BOT, 22 sets by JICA Grant, and others by CadPro	-- Excluding items installed by Cadpro	13 sets Excluding 32 sets to be installed by BOT	22 sets	20 sets
	2. Fixed Camera: for Event Detection At all the ramps (in trial use)		21 sets Excluding 5 sets installed by JICA Grant	20 sets	-- Excluding 6 sets to be installed by BOT, 6 sets by JICA Grant, and others by CadPro	-- Excluding items installed by Cadpro	27 sets Excluding 18 sets to be installed by BOT	8 sets	4 sets
	3. Vehicle Detector: At the middle point between a pair of interchanges (in practical use)		14 sets	6 sets	-- Excluding 6 sets to be installed by BOT	--	6 sets Excluding 10 sets to be installed by BOT	4 sets	2 sets
	4. VMS: for Traffic Information At 100 m back from the diverge to the entrance gate and at 200 m back from the diverge to exit gate (in practical use)		21 sets Excluding 5 sets installed by JICA Grant	16 sets	-- Excluding 7 sets to be installed by BOT, and 2 sets by JICA Grant	10 sets Excluding items installed by CadPro	18 sets Excluding 18 sets to be installed by BOT	8 sets	4 sets
	5. CSS: for Speed Limitation At regular intervals of 5 km (in practical use)		15 sets	9 sets	-- Excluding 15 sets to be installed by BOT	--	16 sets Excluding 9 sets to be installed by BOT	6 sets	11 sets
Toll Collection/ Management System (For Reference)	6. ETC: for Toll Collection At a median-side lane of the tollgate which has the lanes more than two (in practical use)		--	--	8 sets	--	2 sets	--	--
	7. Touch&Go/Manual: for Toll Collection At a roadside lane of all the tollgates (in practical use)		--	--	40 sets	9 sets	8 sets	--	--
Vehicle Weighing System (For Reference)	8. Axle Load Scale: Overloading Regulation At a roadside lane of the entrance tollgate (in practical use)		--	--	6 sets	--	2 sets	--	--

Source: The Study Team

Table 4.3 Arrangement of Roadside Equipment Components on Mai Dich – Thanh Tri Section



System	Roadside Equipment	Mai Dich	Trung Hoa		Thanh Xuan		Phap Van		Tam Trinh		Linh Nam		Thanh Tri		NH5–S.Dong	Thanh Tri
Traffic Information/ Control System	1. PTZ Camera: for Monitoring (in Practical Use)	6 sets		2 sets		8 sets		2 sets		1 set (+3 sets ***)		1 set (+2 sets ***)		1 set (+1 set ***)		2 sets
			--		--		(+2 sets ***)		--		--		(+2 sets ***)		(+2 sets ***)	
	2. Fixed Camera: for Event Detection (in Trial Use)		4 sets		4 sets		2 sets		1 set (+1 set ***)		2 sets (+2 sets ***)		1 set (+1 set ***)		3 sets (+1 set ***)	
	3. Vehicle Detector (in Practical Use)	2 sets		2 sets		2 sets		2 sets		2 sets +2 sets :Loop-coil		2 sets		2 sets		
	4. VMS: for Traffic Information (in Practical Use)		4 sets		4 sets		1 set (+3 sets ***)		1 set (+1 set ***)		4 sets		4 sets		2 sets (+1 set ***)	
	5. CSS: for Speed Limitation (in Practical Use)	1 set		2 sets		2 sets		4 sets		2 sets		3 sets		1 set		
Toll Collection/ Management System (For Reference)	6. ETC: for Toll Collection (in Practical Use)															
	7. Touch&Go/ Manual: for Toll Collection (in Practical Use)															
Vehicle Weighing System (For Reference)	8. Axle Load Scale: for Overloading Regulation (in Practical Use)															

Note, *** : Installed by JICA Grant as the preceding part of the ITS Interation Project.

Source: The Study Team

Table 4.4 Arrangement of Roadside Equipment Components on Lang – Hoa Lac Section

System	Roadside Equipment	Hoa Lac	Hoa Lac – Phu Cat	Phu Cat	Phu Cat – Dong Mo	Dong Mo	Dong Mo – Dai Mo	Dai Mo	Dai Mo – Trung Hoa	Trung Hoa	Trung Hoa – Lang
Traffic Information/ Control System	1. PTZ Camera: for Monitoring (in Practical Use)		2 sets		14 sets		16 sets		4 sets		4 sets
		--		--		--		--		--	
	2. Fixed Camera: for Event Detection (in Trial Use)	8 sets		2 sets		4 sets		4 sets		2 sets	
	3. Vehicle Detector (in Practical Use)		--		2 sets		2 sets		2 sets +2 sets: Loop-coil		2 sets
	4. VMS: for Traffic Information (in Practical Use)	5 sets		1 sets		4 sets		4 sets		2 sets	
	5. CSS: for Speed Limitation (in Practical Use)		2 sets		3 sets		2 sets		2 sets		--
Toll Collection/ Management System (For Reference)	6. ETC: for Toll Collection (in Practical Use)										
	7. Touch&Go/ Manual: for Toll Collection (in Practical Use)										
Vehicle Weighing System (For Reference)	8. Axle Load Scale: for Overloading Regulation (in Practical Use)										

Source: The Study Team

Table 4.5 Arrangement of Roadside Equipment Components on Phap Van – Cau Gie Section & Cau Gie – Ninh Binh Section

System	Roadside Equipment	Phap Van	Phuong Nhi		Khe Hoi		Van Diem		Dai Xuyen	Cau Gie		Vuc Vong		Liem Tuyen		Cao Bo Ninh Binh
Traffic Information/ Control System	1. PTZ Camera: for Monitoring (in Practical Use)	-- (+4 sets *) (+4 sets ***)		-- (+1 set *) (+3 sets ***)		-- (+6 sets *) (+5 sets ***)		-- (+3 sets *) (+3 sets ***)			**		**		**	
			(+1 sets ***)		(+2 sets ***)		(+2 sets ***)		(+2 sets ***)			**		**		**
	2. Fixed Camera: for Event Detection (in Trial Use)		--		-- (+2 sets *) (+2 sets ***)		-- (+2 sets *) (+2 sets ***)		-- (+2 sets *) (+2 sets ***)			**		**		**
	3. Vehicle Detector (in Practical Use)	--		-- (+2 sets *) (+2 sets * :Loop-coil)		-- (+2 sets *)		-- (+2 sets *)			2 sets		2 sets		2 sets	
	4. VMS: for Traffic Information (in Practical Use)		--		-- (+3 sets *) (+1 set ***)		-- (+4 sets *)		-- (+1 set *) (+1 set ***)			4 sets		4 sets		2 sets
	5. CSS: for Speed Limitation (in Practical Use)	-- (+3 sets *)		-- (+3 sets *)		-- (+6 sets *)		-- (+4 sets *)			4 sets		6 sets		11 sets	
Toll Collection/ Management System (For Reference)	6. ETC: for Toll Collection (in Practical Use)		2 sets		4 sets		4 sets		2 sets	**		**		**		**
	7. Touch&Go/ Manual: for Toll Collection (in Practical Use)		18 sets		8 sets		8 sets		9 sets	6 sets		4 sets		4 sets		4 sets
Vehicle Weighing System (For Reference)	8. Axle Load Scale: for Overloading Regulation (in Practical Use)		1 set		2 sets		2sets		1 set	1 set		**		**		**

Note, * : To be onstalled by BOT, ** : Installed by Cadpro as the 1st stage of ITS, *** : Installed by JICA Grant as the preceding part of the ITS Interation Project.

Source: The Study Team

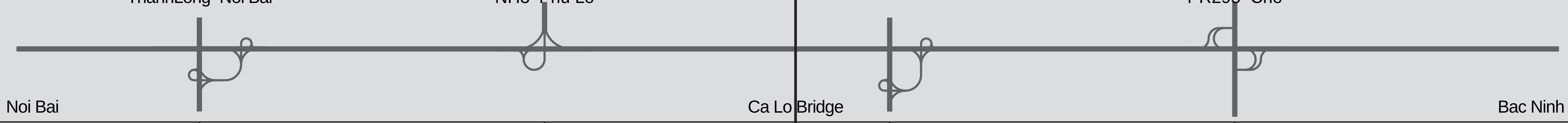
Table 4.6 Arrangement of Roadside Equipment Components on Ha Noi – Bac Giang Section

System	Roadside Equipment	Ha Noi	Phuc Loi		Den Do		Tu Son		Tien Son		Lien Bao		Nam Bac Ninh									Bac Giang
Traffic Information/ Control System	1. PTZ Camera: for Monitoring (in Practical Use)			--		2 sets		--		2 sets		4 sets		-- (+2 sets *)		-- (+2 sets *)		-- (+10 sets *)		-- (+8 sets *)		-- (+4 sets *)
			--		--		--		--		--		5 sets		-- (+2 sets *)		-- (+2 sets *)		--		-- (+2 sets *)	
	2. Fixed Camera: for Event Detection (in Trial Use)		--		7 sets		4 sets		4 sets		8 sets		4 sets		-- (+6 sets *)		-- (+4 sets *)		-- (+4 sets *)		-- (+4 sets *)	
	3. Vehicle Detector (in Practical Use)			--		2 sets		2 sets		2 sets		2 sets +2 sets :Loop-coil		--		--		-- (+2 sets *)		-- (+2 sets *)		-- (+2 sets *)
	4. VMS: for Traffic Information (in Practical Use)		--		4 sets		4 sets		3 sets		4 sets		3 sets		-- (+4 sets *)		-- (+4 sets *)		-- (+4 sets *)		-- (+4 sets*)	
	5. CSS: for Speed Limitation (in Practical Use)			1 set		2 sets		2 sets		2 sets		2 sets		--		-- (+3 sets *)		-- (+4 sets *)		-- (+4 sets *)		-- (+2 sets *)
Toll Collection/ Management System (For Reference)	6. ETC: for Toll Collection (in Practical Use)		2 sets																			
	7. Touch&Go/ Manual: for Toll Collection (in Practical Use)		8 sets																			
Vehicle Weighing System (For Reference)	8. Axle Load Scale: for Overloading Regulation (in Practical Use)		2 sets																			

Note, * : To be onstalled by BOT.

Source: the Study Team

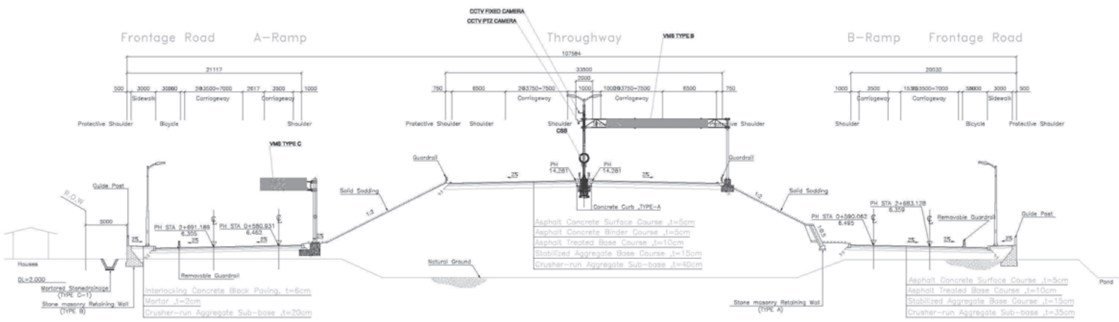
Table 4.7 Arrangement of Roadside Equipment Components on Noi Bai – Ca Lo Bridge Section & Ca Lo Bridge – Bac Ninh Section

<table>
<tr><th>System</th><th>Roadside Equipment</th><th colspan="7">
ThanhLong–Noi Bai
NH3–Phu Lo
Noi Bai
Ca Lo Bridge</th><th colspan="7">PR295–Cho
Bac Ninh</th></tr>
<tr><td rowspan="6">Traffic Information/ Control System</td><td rowspan="2">1. PTZ Camera: for Monitoring (in Practical Use)</td><td colspan="2">4 sets</td><td colspan="3">10 sets</td><td colspan="2">8 sets</td><td colspan="2"></td><td colspan="3">8 sets</td><td colspan="2">12 sets</td></tr>
<tr><td></td><td colspan="2">4 sets</td><td></td><td colspan="2">2 sets</td><td></td><td></td><td colspan="2">2 sets</td><td></td><td colspan="2">2 sets</td><td></td></tr>
<tr><td>2. Fixed Camera: for Event Detection (in Trial Use)</td><td></td><td colspan="2">4 sets</td><td></td><td colspan="2">4 sets</td><td></td><td></td><td colspan="2">4 sets</td><td></td><td colspan="2">4 sets</td><td></td></tr>
<tr><td>3. Vehicle Detector (in Practical Use)</td><td colspan="2">--</td><td colspan="3">2 sets</td><td colspan="2">2 sets
+2 sets :Loop-coil</td><td colspan="2"></td><td colspan="3">2 sets</td><td colspan="2">2 sets
+2 sets :Loop-coil</td></tr>
<tr><td>4. VMS: for Traffic Information (in Practical Use)</td><td></td><td colspan="2">4 sets</td><td></td><td colspan="2">4 sets</td><td></td><td></td><td colspan="2">3 sets</td><td></td><td colspan="2">4 sets</td><td></td></tr>
<tr><td>5. CSS: for Speed Limitation (in Practical Use)</td><td colspan="2">--</td><td colspan="3">3 sets</td><td colspan="2">3 sets</td><td colspan="2">1 sets</td><td colspan="3">2 sets</td><td colspan="2">8 sets</td></tr>
<tr><td rowspan="2">Toll Collection/ Management System (For Reference)</td><td>6. ETC: for Toll Collection (in Practical Use)</td><td colspan="7"></td><td colspan="7"></td></tr>
<tr><td>7. Touch&Go/ Manual: for Toll Collection (in Practical Use)</td><td colspan="7"></td><td colspan="7"></td></tr>
<tr><td>Vehicle Weighing System (For Reference)</td><td>8. Axle Load Scale: for Overloading Regulation (in Practical Use)</td><td colspan="7"></td><td colspan="7"></td></tr>
</table>

Source: The Study Team

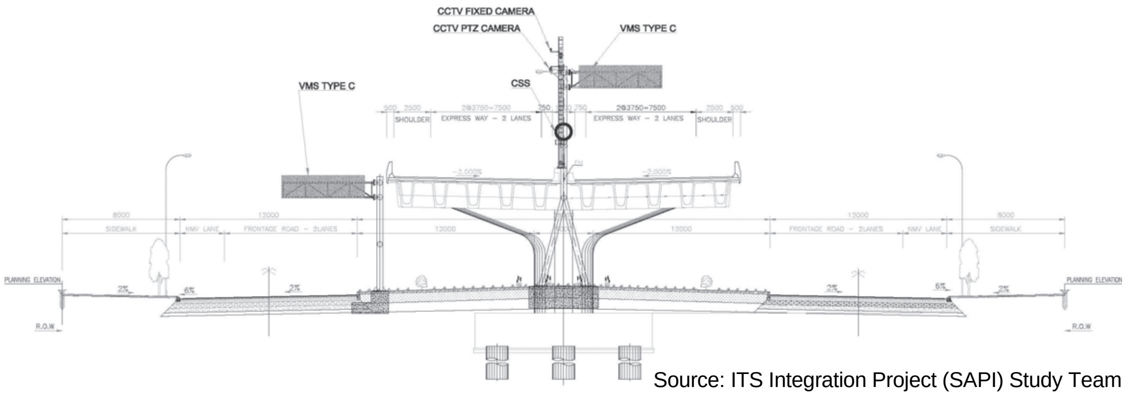
Typical cross sections of the installation of VMS, CSS and CCTV camera respectively at earthwork section, viaduct section and bridge section are shown in the following figures.

Figure 4.5 Typical Cross Section of Roadside Equipment Installation at Earthwork Section



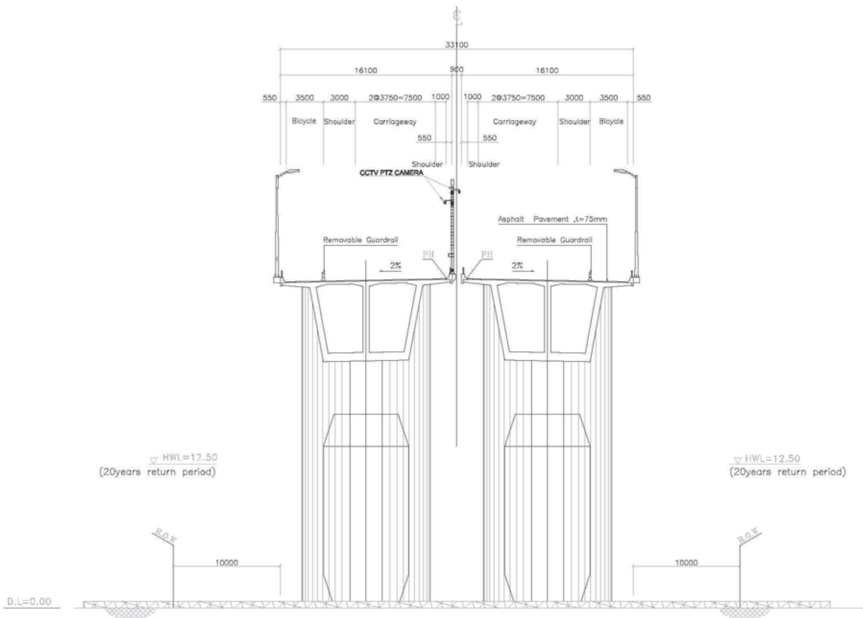
Source: ITS Integration Project (SAPI) Study Team

Figure 4.6 Typical Cross Section of Roadside Equipment Installation at Viaduct Section



Source: ITS Integration Project (SAPI) Study Team

Figure 4.7 Typical Cross Section of Roadside Equipment Installation at Bridge Section



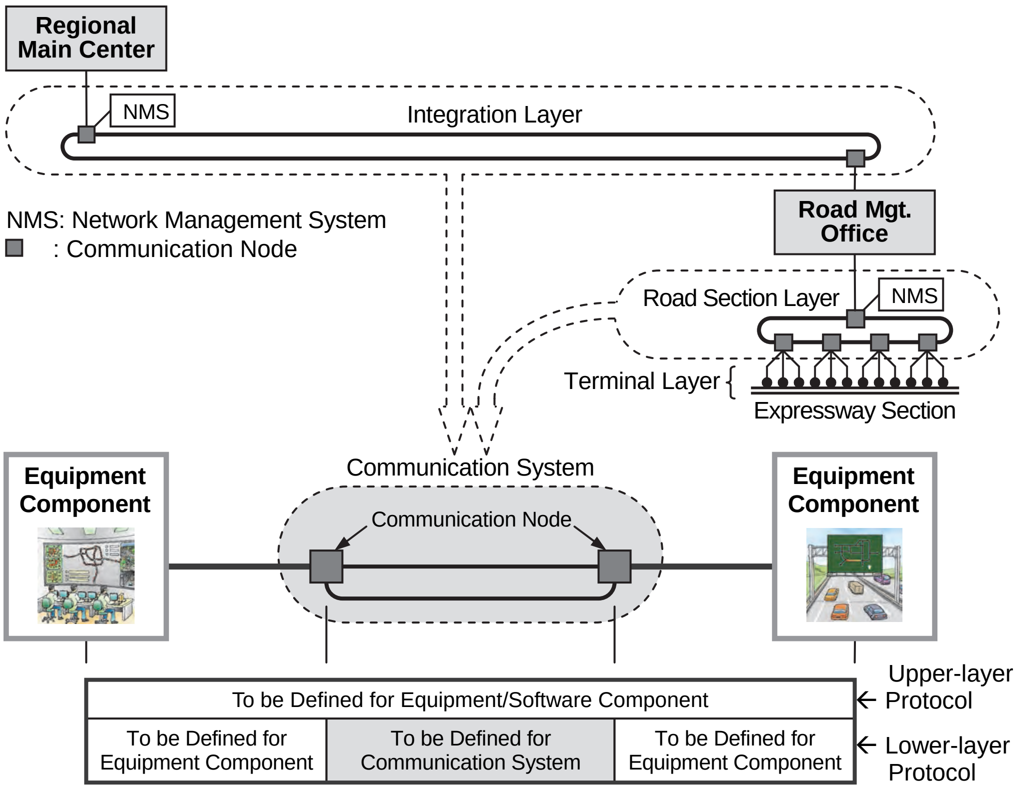
Source: ITS Integration Project (SAPI) Study Team

5. Communication System

In the Study, scope of communication system is defined for discussion as below. That is responding to the following features of wired communications to be used for ITS, and in the discussion of the Study, lower-layer protocol, which is to be used among nodes, is the most important subject:

- Upper-layer Protocol: To be unchanged continuously between a pair of equipment components, and to be discussed based on a logical system architecture
- Lower-layer Protocol: To be changed at a midway communication node and shared by many different applications (i.e. functional packages), and to be discussed based on a physical system architecture.

Figure 5.1 Scope of Communication System and Definitions of Communication Protocol



Source: ITS Integration Project (SAPI) Study Team

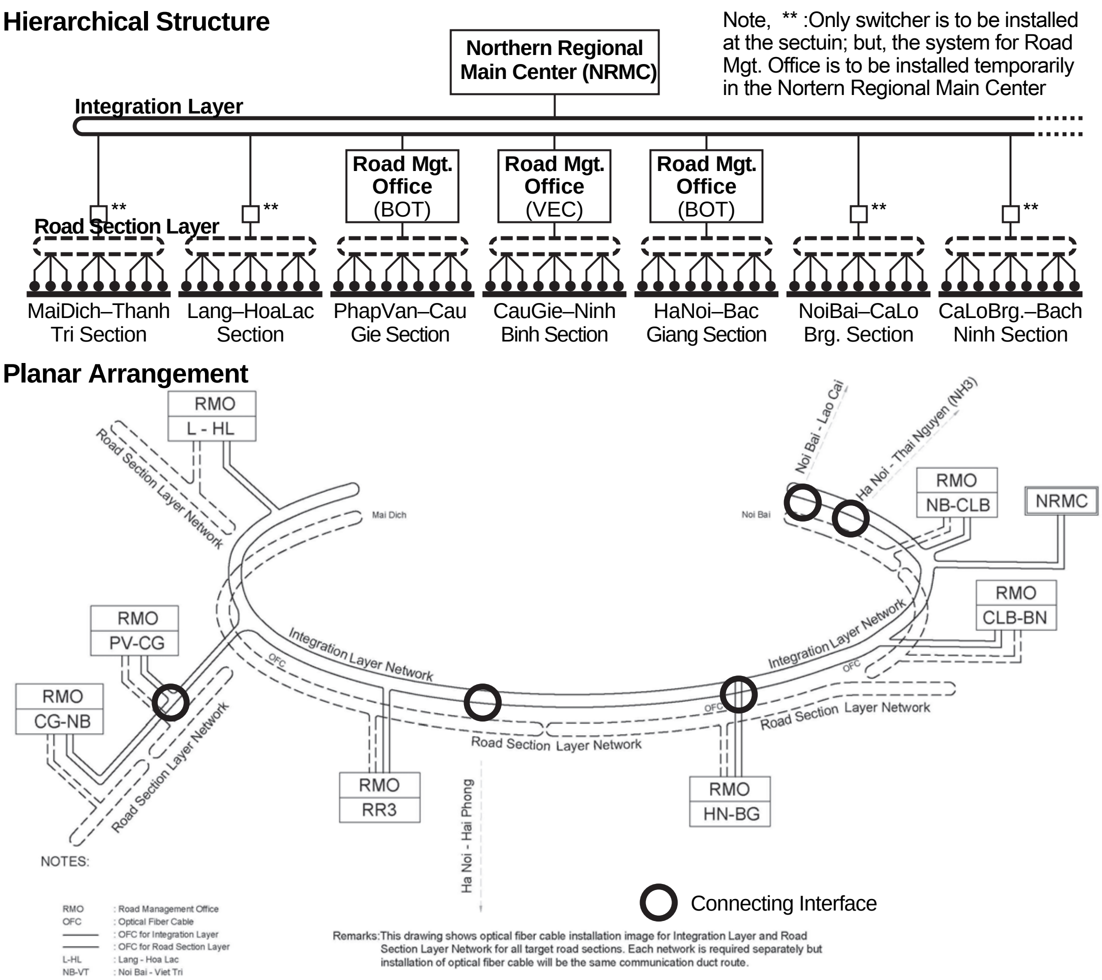
Discussion items on the communication system (only in the case wired) are as follows:

- Communication network layers
- Appropriate transmission system for ITS
- Applicable protocol
- IP version
- Network configuration overview for ITS integration project
- Equipment component of voice communication
- Numbering plan
- Directive telephone set
- Administrative telephone set

- Equipment component of mobile radio communication
- Radio communication system
- Speech quality
- Radio wave propagation
- Antenna supporting pole
- Equipment component of communication system
- Transmission distance
- Number of optical fiber cores
- Number of optical fiber cables
- Network management system.

Communication network is to be implemented in ring shape along the expressway network as shown in the figure below.

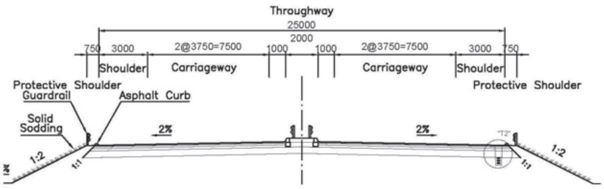
Figure 5.2 Outline of Communication Network

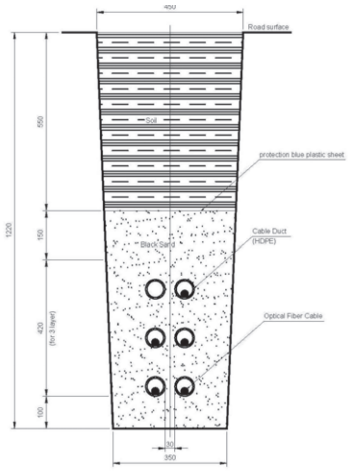


	Expressway Section	Installation	Operation
1	RR3	Contractor	HDOT or O&M Company
2	Phap Van – Cau Gie	Contractor and VTN (not yet fixed)	BOT Investor or O&M Company
3	Cau Gie – Ninh Binh	Contractor and VTN (not yet fixed)	VEC O&M
4	Ha Noi – Bac Giang	Contractor and VTN	BOT Investor or O&M Company
5	Noi Bai – Ca Lo Bridge	Contractor	HDOT or O&M Company
6	Ca Lo Bridge – Bac Ninh	Contractor	BNDOT or O&M Company
7	Lang – Hoa Lac	Contractor	HDOT or O&M Company
8	Integration Layer Network	Contractor	O&M Company

Source: The Study Team

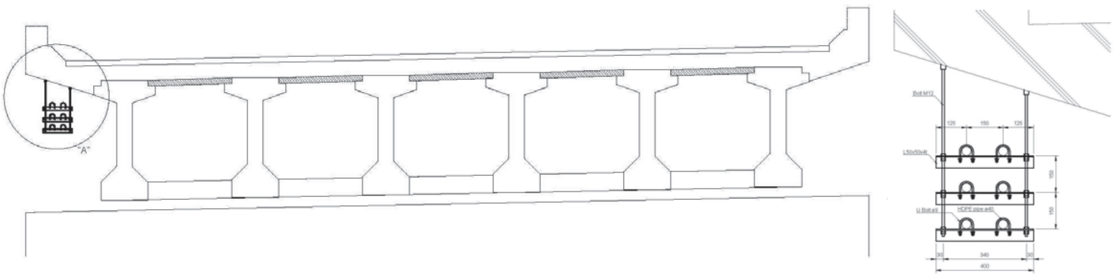
Figure 5.3 Installation of Communication Duct at Earth Section





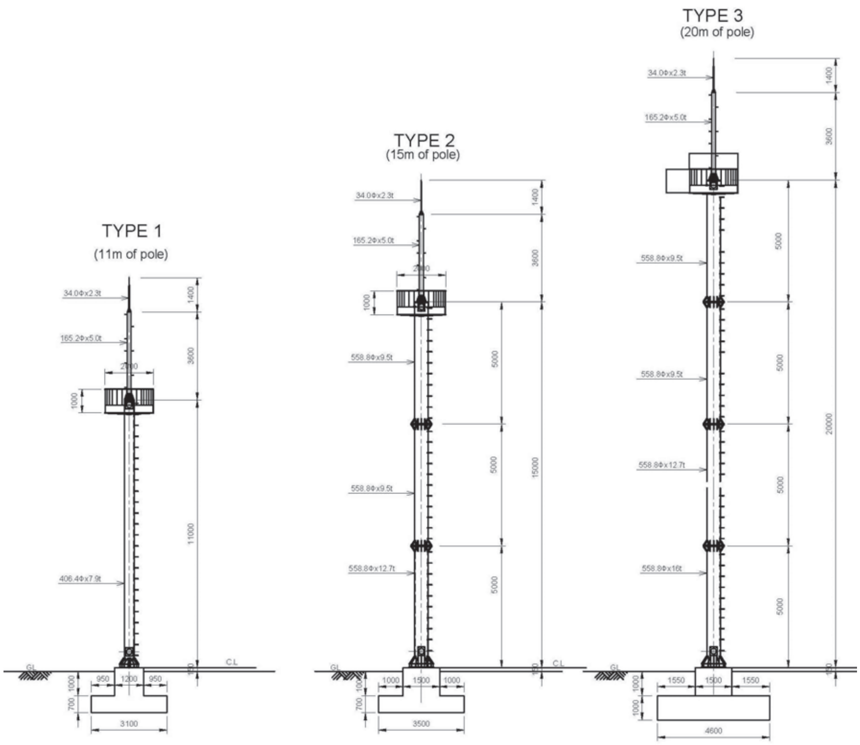
Source: ITS Integration Project (SAPI) Study Team

Figure 5.4 Installation of Communication Duct at Bridge Section



Source: ITS Integration Project (SAPI) Study Team

Figure 5.5 Installation of Radio Communication Antenna



Source: ITS Integration Project (SAPI) Study Team

6. Structures and Others

6.1 Communication Duct Design

The following discussion results are to be shown for the design of communication ducts.

- Plan arrangement
- Earthwork sections
- Box culverts and crossing pipes
- Bridge sections
- Chamber.

6.2 Base Structure Design

The following discussion results are to be shown for the design of base structures.

- Pole for CCTV
- Pole for changeable CSS
- Pole for weather observation equipment
- Gantry for VMS
- Tower for mobile radio communication
- Works for axle load scale.

6.3 Building Plan

(1) Northern regional main center

A building is to be constructed for the Northern Regional Main Center with the features below.

- 3-Storied Building : 720 m^2 x3 (720 m^2 for Building Lot Area)
- Structure : SRC (Steel-framed Reinforced Concrete)
- Foundation : RC Pile Foundation
- Parking/Passage Area : 1500 m^2
- Total Area : 3000 m^2 (including Green Area)

(2) Road management office

Space of 30 m^2 is to be secured in all existing road management offices for ITS.

The following values are “For Reference” in the case constructing a building of the Road Management Offce:

- 2-Storied Building : 360 m^2 x2 (360 m^2 for Building Lot Area)
- Structure : SRC (Steel-framed Reinforced Concrete)
- Foundation : RC Pile Foundation
- Parking/Passage Area : 750 m^2
- Total Area : 3000m^2 (including Green Area)

(3) Toll office

Space of 20 m^2 is to be secured in all existing toll offices for ITS.

6.4 Electric Power Supply Plan/Design

The following discussion results are to be shown for the plan/design of power supply.

- Basic principle for design
- The survey on power supply status
- Responsibility demarcation point
- Power receiving capacity
- Voltage drop
- Northern Regional Main Center
- Road management office
- Toll office
- Roadside equipment

7. Summary of Specifications

The equipment components defined in the system architecture are to be installed respectively in the centers, offices and other places, based on the Functional Packages, as shown in the figure and table below.

Table 7.1 Location of Equipment Components based on Functional Packages

Functional Packages		Center Subsystem						Roadside Subsystem	On-board Subsystem	Mobile Subsystem	In-door Subsystem
		Regional Main Center	Data Integration Center	Road Management Office	Toll Office	Road Owner's Head Office	OBU Registration Office				
1	Voice Communication	XX		XX	XX			XX			
2	CCTV Monitoring	XX		XX				XX			
3	Event Detection (by Image)							XX			
4	Vehicle Detection							XX			
5	Traffic Analysis	XX									
6	Weather Monitoring	XX						XX			
7	Traffic Event Management	XX		XX							
8	Traffic Supervision	XX									
9	VMS Indication	XX						XX			
10	Mobile Radio Communication			XX				XX		XX	
11	Traffic Information	XX									XX
12	Integrated Data Management	XX	XX		XX	XX					
13	Tollgate Lane Monitoring				XX			XX			
14	Vehicle/Class Identification							XX			
15	Lane Control							XX			
16	Road-to-Vehicle Communication							XX	XX		
17	IC-card Recording							XX		XX	XX
18	Toll Data Management				XX	XX					
19	OBU Management			XX			XX				XX
20	Axle Load Measurement							XX			
21	Measurement Lane Monitoring				XX						
Communication System		XX	XX	XX	XX			XX			
Communication Ducts		XX		XX	XX			XX			
Base Structures		XX		XX	XX			XX			
Electric Power Supply		XX	XX	XX	XX			XX			

Greyed out area is "For Reference". Source: The Study Team

The system for traffic information/control is composed of the twelve Functional Packages as shown below and the system architecture of each Functional Package is shown in the following figures.

Figure 7.1 Function Configuration for Traffic Information/Control

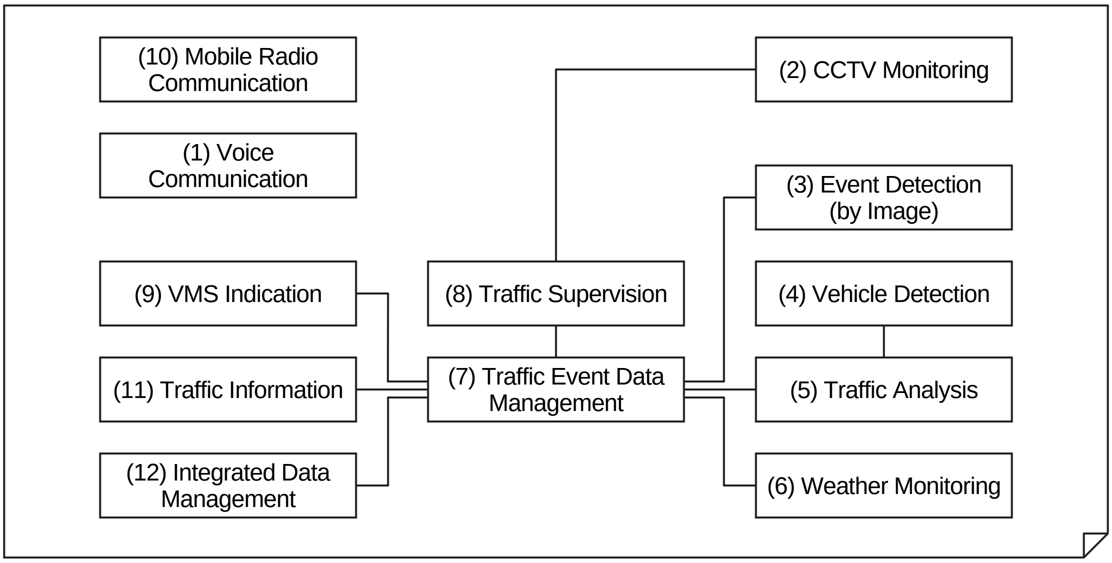
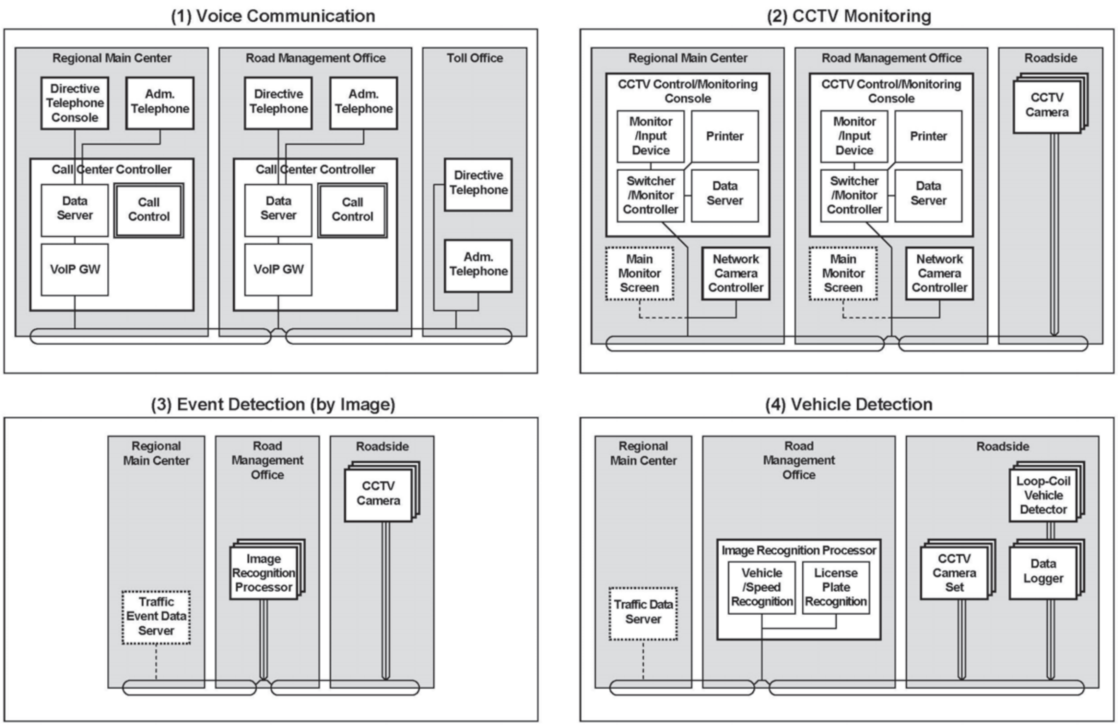


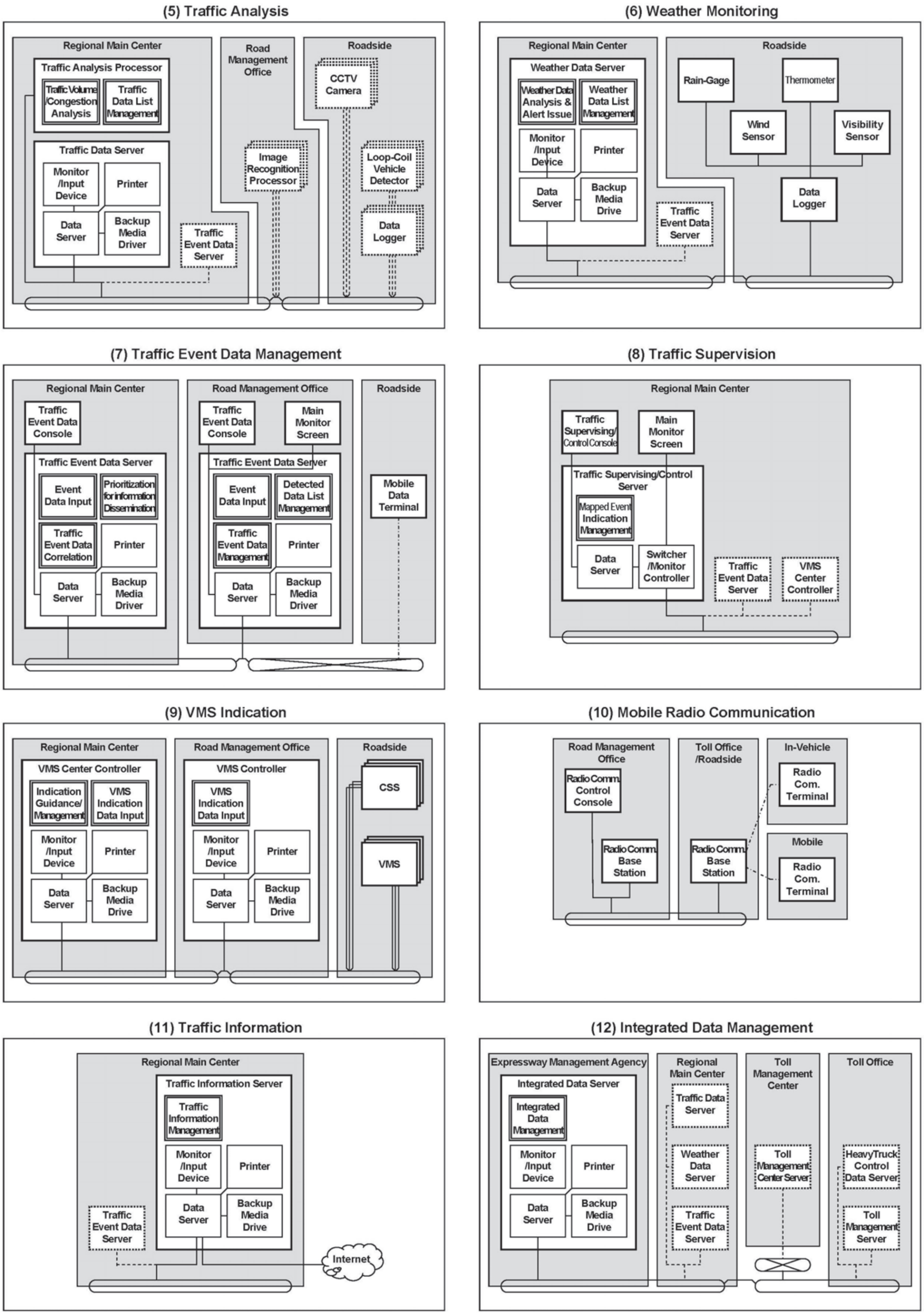
Figure 7.2 Detailed System Architectures of Functional Packages (1)-(4)



: Location
: Equipment component
: Detailed Device
Broken Lines: Outside of This Functional Package
: Wireless communication
: Software

Source: The Study Team

Figure 7.3 Detailed System Architectures of Functional Packages (5)-(12)



: Location
: Equipment component
: Detailed Device

Broken Lines: Outside of This Functional Package
: Wireless communication
: Software

Source: The Study Team

The system for toll collection/management is composed of the seven Functional Packages as shown below and the system architecture of each Functional Package is shown in the following figures.

Figure 7.4 Function Configuration for Toll Collection/Management (For Reference)

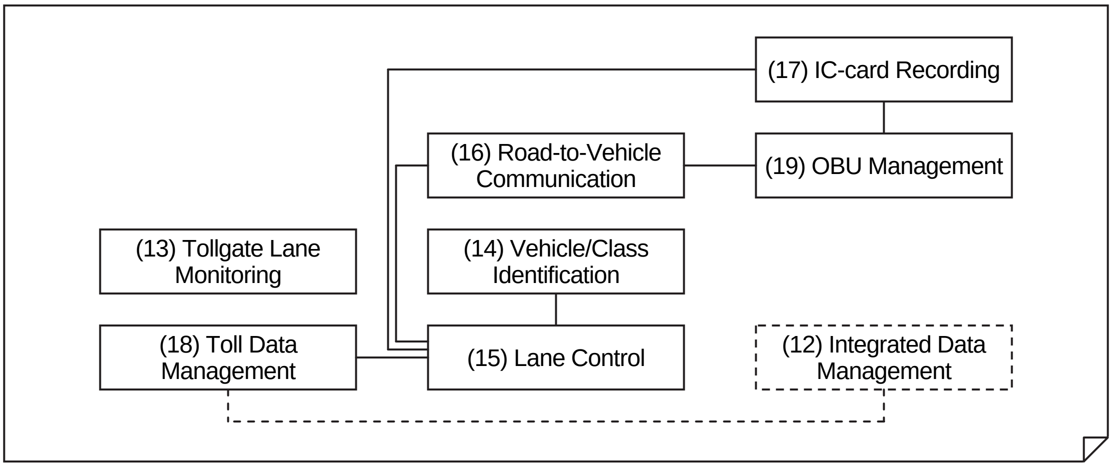
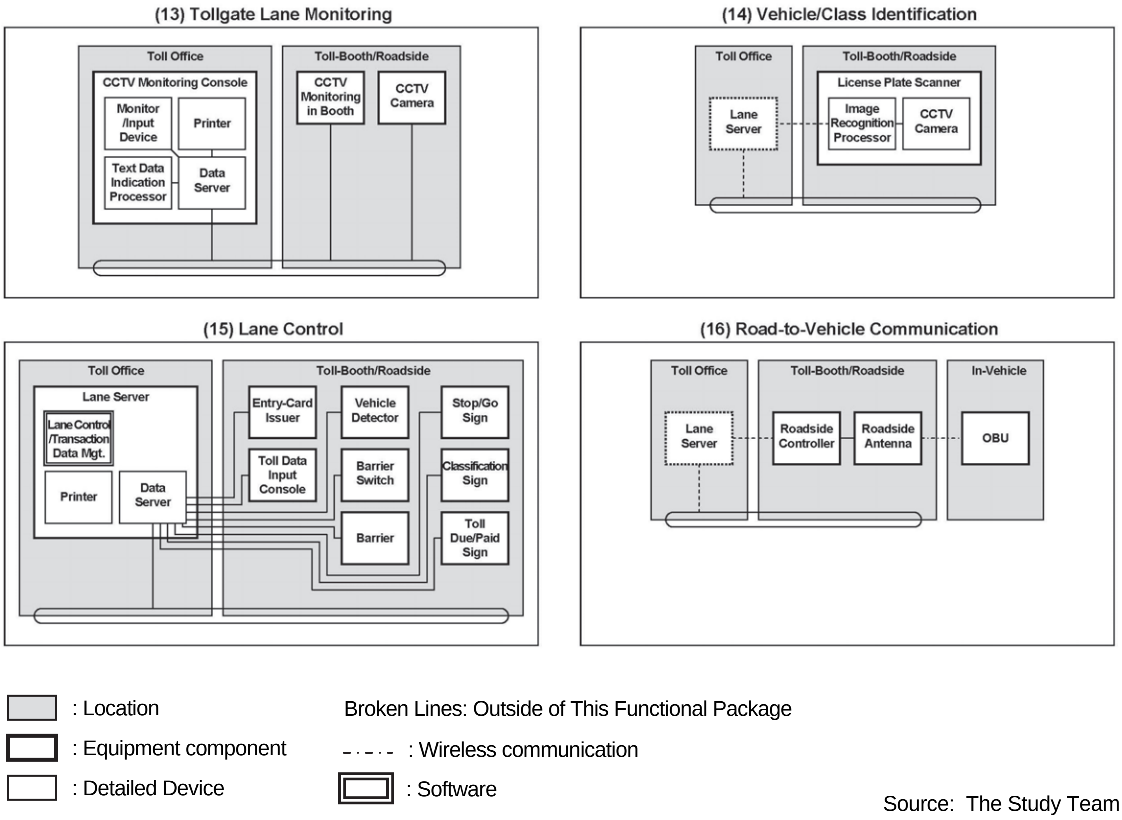
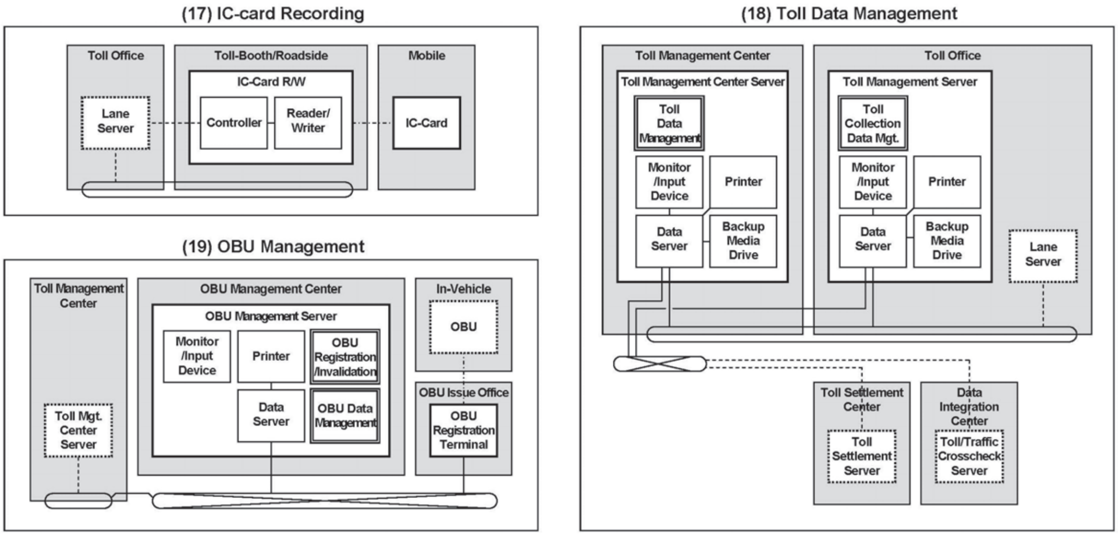


Figure 7.5 Detailed System Architectures of Functional Packages (13)-(16) (For Reference)



Source: The Study Team

Figure 7.6 Detailed System Architectures of Functional Packages (17)-(19) (For Reference)



: Location
: Equipment component
: Detailed Device
Broken Lines: Outside of This Functional Package
: Wireless communication
: Software

Source: The Study Team

The system for vehicle weighing is composed of the two Functional Packages as shown below and the system architecture of each Functional Package is shown in the following figures.

Figure 7.7 Function Configuration for Vehicle Weighing (For Reference)

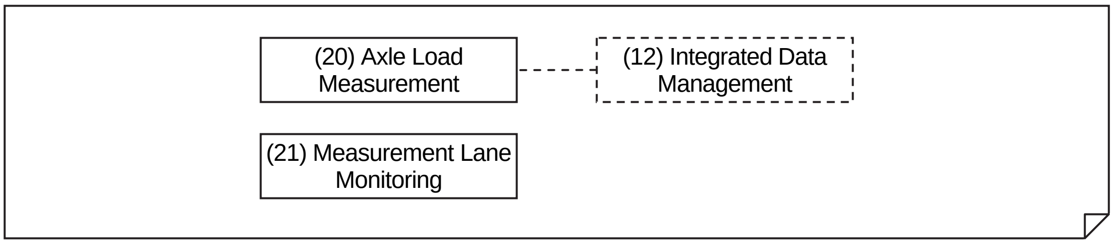
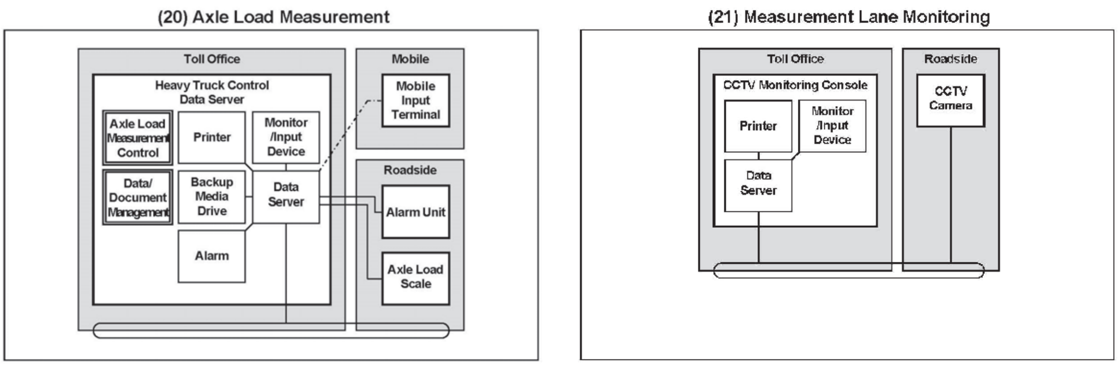


Figure 7.8 Detailed System Architectures of Functional Packages (20)-(21) (For Reference)



: Location
: Equipment component
: Detailed Device
Broken Lines: Outside of This Functional Package
: Wireless communication
: Software

Source: The Study Team

The requirements for the specification of functional packages and other items are listed in the following tables.

Table 7.2 Requirements for Specification of Functional Packages and Other Items (1)

<table>
<tr><th colspan="2">Traffic Information/Control System</th></tr>
<tr><th colspan="2">(1) Voice Communication</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• To receive notification of incident occurrence promptly from road user and to identify the user’s location on the expressway.
• To receive report of current traffic conditions on the expressways and of incident occurrence promptly from the operators in the Toll Office.
• To switch and connect the interactive voice and emergency directives among the Regional Main Center, the Road Management Offices and the Toll Offices.
• To send directives to the units concerned simultaneously and with top-priority at any time for clearing incidents and enforcing traffic regulations.
• To receive notification of incident occurrence generally within 20 minutes, and to send road operation vehicles to the incident site generally within 1 hour.
• In case, part or whole of procurement and operation and maintenance related to the voice communication is to be outsourced to another organization such as telecommunications carrier or operator.</td><td>Regional Main Center
Directive Telephone Console
Administrative Telephone
Call Center Controller

Road Management Office
Directive Telephone
Administrative Telephone
Call Center Controller

Toll Office
Directive Telephone
Administrative Telephone</td></tr>
<tr><th colspan="2">(2) CCTV Monitoring</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• To recognize incident occurrences on the road and their type, such as traffic accidents, breakdown vehicles, left obstacles, reverse driving, vandalism, flood, road damage, and natural disaster, by remote monitoring at the Regional Main Center and the Road Management Office.
• To recognize the severity of incidents through identifying types of vehicles involved (such as trucks, buses and sedans) and identifying smoke or fire by appearance.
• To identifying the place of incident occurrence at the Regional Main Center and the Road Management Office.
• To control roadside equipment remotely from the Regional Main Center in real time and from the Road Management Office at an occurrence of incident.
• To store the needed video images, such as the video image of traffic accident occurrence.</td><td>Roadside
CCTV Camera

Road Management Office
CCTV Control/Monitoring Console
Network Camera Controller

Regional Main Center
CCTV Control/Monitoring Console
Network Camera Controller</td></tr>
<tr><th colspan="2">(3) Event Detection (by Image)</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• Automatically and promptly to detect incident occurrences and their types, such as traffic accidents, breakdown vehicles, left obstacles, reverse driving, vandalism and natural disaster, by image analysis.
• To notify the detected results automatically and promptly to the Regional Main Center and the Road Management Office.
• To monitor original video image remotely at the Regional Main Center and the Road Management Office.
• To identify the time and place of incident occurrence at the Regional Main Center and the Road Management Office.</td><td>Roadside
CCTV Camera

Road Management Office
Image Recognition Processor</td></tr>
<tr><th colspan="2">(4) Vehicle Detection</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• To measure number of vehicles and vehicle speed at a specific point on the road.
• To notify the measured results automatically and promptly to the Regional Main Center and the Road Management Office.
• To identify the time and place of measured values at the Regional Main Center road and management office.</td><td>Roadside
Loop Coil Vehicle Detector
Data-Logger
CCTV Camera

Road Management Office
Image Recognition Processor</td></tr>
</table>

Source: The Study Team

Table 7.3 Requirements for Specification of Functional Packages and Other Items (2)

Requirements	Major Equipment Component
(5) Traffic Analysis	
Requirements	Major Equipment Component
• To calculate the traffic volume of each vehicle size (large vehicle and normal vehicle) on expressway based on the results obtained from vehicle detection installed in appropriate points. • To calculate the average speed and traffic congestion status with the precision usable for traffic information provision based on the results obtained from Vehicle Detection installed in appropriate points. • To compile the calculation results and the measured results by vehicle detectors as statistic values.	<u>Regional Main Center</u> Traffic Analysis Processor ** Traffic Data Server **
(6) Weather Monitoring	
Requirements	Major Equipment Component
• To measure rainfall, wind speed, visibility, and air temperature. • Automatically to send the measured results to the Regional Main Center. • To allow identifying the time and place of measured values at the Regional Main Center. • To store the measured results as the data for every 5 minutes in a database. • Automatically and promptly to send a warning to the Regional Main Center in case that a measured result is beyond the limit defined in advance.	<u>Roadside</u> Rain Gauge Wind Sensor Visibility Sensor ** Thermometer <u>Regional Main Center</u> Weather Data Server **
(7) Traffic Event Data Management	
Requirements	Major Equipment Component
• To generate information in the form of traffic event from the results of CCTV monitoring, event detection, traffic analysis and weather monitoring. • To generate the traffic event including traffic accidents, reverse driving, broken-down vehicle, left obstacle, natural disaster, vandalism, construction work, bad weather and congestion. • To generate the traffic event including traffic restriction such as closure and speed limitation. • To identify the generated events by kilo-meter post of the road sections and date/time. • To correlate a traffic event to its causal traffic event. • To set priorities on generated/correlated traffic events by their place/ seriousness. • To indicate the categorized events in Vietnamese and English. • To store the categorized events as the data for every 1 minutes in a database.	<u>Roadside</u> Mobile Data Terminal <u>Road Management Office</u> Traffic Event Data Console Traffic Event Data Server Main Monitor Screen <u>Regional Main Center</u> Traffic Event Data Console Traffic Event Data Server
(8) Traffic Supervision	
Requirements	Major Equipment Component
• To allow inputting the necessary data for generating/managing information for traffic control. • To indicate the road network that is object of operation and management by the road traffic operator. • To indicate the information categorized as traffic events with specific time and /place of their occurrences for the operators in the Regional Main Center and the Road Management Office.	<u>Regional Main Center</u> Traffic Supervising/Control Console Traffic Supervising/Control Server Main Monitor Screen

Source: The Study Team

Table 7.4 Requirements for Specification of Functional Packages and Other Items (3)

Requirements	Major Equipment Component
(9) VMS Indication	
Requirements	Major Equipment Component
• To disseminate information in the form of traffic events which includes traffic accidents, reverse driving, breakdown vehicles, left obstacle, natural disaster, vandalism, construction work, bad weather, flood, fire, traffic congestion and traffic restriction. • To indicate information in Vietnamese and English. • To indicate textual information to the drivers to read in their vehicles at the maximum speed 120 km/h. • To indicate the image such as pictographs in full-color. • To disseminate the textual information which is directly input from the Regional Main Center and the Road Management Office, irrespective of traffic event.	<u>Roadside</u> VMS CSS <u>Road Management Office</u> VMS Controller ** <u>Regional Main Center</u> VMS Center Controller **
(10) Mobile Radio Communication	
Requirements	Major Equipment Component
• Promptly to receive reports of current traffic conditions on the expressways and of incidents from the operators in the Toll Office or patrol crew to the Road Management Office. • To send directives to the units concerned simultaneously for clearing incidents and enforcing traffic regulations from the Road Management Office even though the receiving side using the terminal as normal communication. • To apply a full duplex communication method for interactive voice communication. • To obtain necessary license from Radio Frequency Directorate of Ministry of Information and Communication.	<u>Toll Office/Roadside</u> Radio Communication Base Station <u>Road Management Office</u> Radio Communication Control Console Radio Communication Base Station <u>In-Vehicle</u> Radio Communication Terminal <u>Mobile</u> Radio Communication Terminal
(11) Traffic Information	
Requirements	Major Equipment Component
• To disseminate information on traffic and road condition of the expressway network to the Internet Users. • To disseminate information based on the traffic event data stored in the server. • To disseminate information, which includes the contents of incidents, traffic conditions, traffic congestion, bad weather, construction work and traffic restrictions. • To allow operators to control the type of data and frequency for disseminating information.	<u>Regional Main Center</u> Traffic Information Server
(12) Integrated Data Management	
Requirements	Major Equipment Component
• To integrate the recorded data for traffic information/control and vehicle weighing. • To integrate the data sets of incident, traffic volume, traffic congestion, bad weather, construction work, traffic restriction, hourly toll collection and axle load management into a form of historical data records. • To sort/display/output the historical data records in the form of list, table and graph as electronic data. • To search/calculate values required for checking validity of toll revenue in comparison with traffic data.	<u>Regional Main Center</u> Integrated Data Server **

Source: The Study Team

Table 7.5 Requirements for Specification of Functional Packages and Other Items (4)

<table>
<tr><th colspan="2">Automated Toll Collection/Management System (For Reference)</th></tr>
<tr><th colspan="2">(13) Tollgate Lane Monitoring</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• To monitor vehicles passing through a tollgate lane, at the tollbooths and the Toll Office, and to identify their type of vehicle such as trailer, semi-trailer, bus and passenger car by visual observation.
• To monitor toll payment/receipt transaction between a driver and a toll collector at the Toll Office.
• To control the roadside equipment remotely at the Toll Office.
• To store the needed video images such as the video image of violation/ vandalisation occurrence.</td><td><u>Toll Booth/Roadside</u>
CCTV Monitoring in Booth
CCTV Camera

<u>Toll Office</u>
CCTV Monitoring Console</td></tr>
<tr><th colspan="2">(14) Vehicle Identification</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• To monitor vehicles passing through a tollgate lane at the Toll Booth and the Toll Office, and identifying their type of vehicle such as trailer, semi-trailer, bus and passenger car by visual ovservation.
• To measure the number of vehicles and the vehicle speed at a specific point on the road.
• To recognize vehicle number plate, to convert textural information.
• To display the image and the textural number plate of the vehicle on the monitor console in the Toll Booth, when the vehicle enter a tollgate lane.
• To store the image and textural information of vehicle number plate.
• To measure number of vehicles by trailers, semi-trailers and another type of vehicle by using number plate information.
• To control the roadside equipment remotely at the Toll Office.</td><td><u>Toll-Booth/Roadside</u>
License Plate Scanner</td></tr>
<tr><th colspan="2">(15) Lane Control</th></tr>
<tr><th>Requirements</th><th>Major Equipment Component</th></tr>
<tr><td>• To generate/process the data appropriate for collecting tolls based on the data sent from IC-card and OBU based on the regulated toll rate system.
• To generate/process the data appropriate for collecting tolls based on the data from Entry-Card with the results of vehicle class identification and the regulated toll rate system.
• To secure an average service-time by non-stop less than 4.5 sec/vehicle and by one-stop less than 9.0 sec/vehicle.
• To process the data for collecting tolls and giving the vehicle class by OBU/IC-card, in case of electric toll collection.
• To process the data for collecting tolls and giving the vehicle class recognized by toll collector a higher priority, in case of manual toll collection.
• To accept the settlement method such as by cash, prepaid and post-paid.
• To check the prepaid balance of IC-card at Toll Booth.
• To notify a driver, in case of prepaid balance shortage for required toll amount, the necessity to recharge prepaid balance before the next passage at the tollgate lane, indicating the amount due.
• To control Barrier automatically according to the processing result of toll collection.
• To block the vehicles without normal completion of toll collection by using Barrier and Barrier Switch.
• To generate/store identification data of the vehicles without normal completion of toll collection.
• To allow toll collector to collect the proper toll manually in case the registered vehicle type of OBU is obviously judged as error compared with the visually checking by toll collector.</td><td><u>Toll-Booth/Roadside</u>
Entry-Card Issuer
Toll Data Input Console
Vehicle Detector
Barrier Switch
Barrier
Stop/Go Sign
Classification Sign
Toll Due/Paid Sign

<u>Toll Office</u>
Lane Server</td></tr>
</table>

Source: The Study Team

Table 7.6 Requirements for Specification of Functional Packages and Other Items (5)

Requirements	Major Equipment Component
(16) Road to Vehicle Communication	
Requirements	Major Equipment Component
• To transmit the data recorded in OBU and IC-card for collecting toll and the results of processing the data. • To secure an average non-stop service-time of less than 4.5 sec/vehicle. • To secure undisturbed conditions despite disturbance/tapping from outside and to restrict the error ratio to less than 1%. • To accept the settlement method such as by prepaid and post-paid IC-card.	In-Vehicle OBU Toll-Booth/Roadside Roadside Antenna Roadside Controller
(17) IC Card Recording	
Requirements	Major Equipment Component
• To notify the data for collecting toll and the results of processing the data. • To allow securing an average service-time by one-stop collection of less than 9.0 sec/vehicle. • To make the payment promptly and credibly, without being disturbed by outside noise or eavesdropping. • To allow prepayment and storing prepaid balance in the IC-card.	Toll-Booth/Roadside IC-Card Reader/Writer Mobile IC-Card
(18) Toll Data Management	
Requirements	Major Equipment Component
• To store all transaction data between OBU and roadside equipment for toll collection in a database. • To generate the data of forms for toll management and to store them in a database.	Toll Office Toll Management Server Toll Management Center Toll Management Center Server
(19) OBU Management	
Requirements	Major Equipment Component
• To write the information (such as OBU ID, Date of issue, License number, Vehicle class) of a vehicle which is equipped with OBU. • To write the information credibly and securely when it is written into OBU. • To provide a unique ID for any OBU which is registered any place in the country. • To transmit the OBU ID which is registered, to Toll Management Server of each Road operator.	OBU Issue Office OBU Registration Terminal
Vehicle Weighing System (For Reference)	
(20) Axle Load Measurement	
Requirements	Major Equipment Component
• To measure the number of axles and axle loads of vehicles in the high speed range, 10 -100 km/h. • To notify the detection of overloaded vehicle by using Alarm unit, Monitor and Mobile Input Terminal to the operator who monitors the measurement results in the Toll Office and other staff who monitors the measurement result at the roadside. • To generate/store identification data of overloaded vehicles. • To synchronize the measurement result and the image which is the front side of the vehicle include number plate. • To show the measurement result and the image to the driver for, the evidence of overload at the roadside by using Mobile Input Terminal. • To store the image which is the front side of the vehicle include number plate, and the measurement result of axle load, in case the overloaded vehicle.	Mobile Mobile Input Terminal Roadside Alarm Unit Axle Load Scale Toll Office Heavy Truck Control Data Server
(21) Measurement Lane Monitoring	
Requirements	Major Equipment Component
• To monitor vehicles passing through a tollgate lane at the Toll Office, and identifying their type such as trailer, semi-trailer, bus and passenger car by visual observation. • To control the roadside equipment remotely at the Toll Office. • To store the needed image which is the front side of the vehicle include number plate, and the measurement result of axle load, in case the overloaded vehicle.	Roadside CCTV Camera Toll Office CCTV Monitoring Console

Source: The Study Team

Table 7.7 Requirements for Specification of Functional Packages and Other Items (6)

Communication System	
Requirements	Major Equipment Component
• To exchange data among roadside equipment on the expressways, the Regional Main Center and the Road Management Offices. • To transmit video images from roadside equipment to the Road Management Office and the Regional Main Center. • To transmit interactive voice communications among the Regional Main Center, Road Management Offices and the Toll Offices. • To transmit directives to the units concerned simultaneously and with top-priority at any time for clearing incidents and enforcing traffic regulations. • To identify location of fault that occur on communication network.	Regional Main Center L3SW Road Management Office L3SW Toll Office L2SW
Communication Ducts	
Requirements	Major Materials
• To secure the space/route for installing optical fiber cable for building communication network continuously through the earthwork sections and the bridge sections • To protect installed optical fiber cable and its joint from external factor such as traffic accident • To provide easy addition of optical fiber cable or replacement of the installed cable	Roadside HDPE Pipe Cement Fine Aggregate Coarse Aggregate Reinforcing Bar Spacer for Ducts
Base Structures	
Requirements	Major Materials
• To provide stable support for installing roadside equipment; such as CCTV camera, weather sensors, VMS, CSS and antenna for radio communication even under the condition of strong wind and on embankment slope. • To keep the roadside equipment in the original/proper position keeping the structure clearance from the road surface and in the original/proper direction for radio communication.	Roadside Structural Steel Cement Fine Aggregate Coarse Aggregate Reinforcing Bar

Source: The Study Team

The basic design specifications of the functional packages and other items are shown in Appendix-5 and the specifications of electric power supply are shown respectively in the functional packages and other items. The specifications of buildings shall be prepared in the detailed design to be conducted complementarily after the Study.

8. Quantities

Quantities of the project are shown in the table below categorized by equipment components.

Table 8.1 Quantity Table of Project

1. Traffic Information/Control System

Item No.	Equipment Component	Unit	Q'ty (a)
(1)	**Voice Communication**		
	Regional Main Center		
	Directive Communication Console	set	1
	Administrative Telephone	set	20
	Call Center Controller	set	1
	Call Control (Software)	set	1
	Road Management Office		
	Directive Telephone and Console	set	4.5
	Administrative Telephone	set	90
	Call Center Controller	set	4.5
	Call Control (Software)	set	4.5
	Toll Office		
	Directive Telephone	set	25
	Administrative Telephone	set	5
(2)	**CCTV Monitoring**		
	Roadside		
	CCTV Camera (PTZ type for Outside)	set	119
	Streamer	set	17
	Road Management Office		
	Network Camera Controller	set	1
	CCTV Control/Monitoring Console	set	1
	Regional Main Center		
	Network Camera Controller	set	4.1
	CCTV Control/Monitoring Console	set	4.1
(3)	**Event Detection (by Image)**		
	Roadside		
	CCTV Camera (Network Camera (Fix type for Image Recognition)	set	84
	Image Recognition Processor	set	84
(4)	**Vehicle Detection**		
	Roadside		
	Loop Coil Vehicle Detector	set	11
	Data Logger		11
	CCTV Camera	set	114
	Image Recognition Processor	set	114
(5)	**Traffic Analysis**		
	Regional Main Center		
	Traffic Analysis Processor	set	1
	Traffic Volume/Congestion Analysis (Software)	set	1
	Traffic Data List Management (Software)	set	1
	Traffic Data Server	set	1
(6)	**Weather Monitoring**		
	Regional Main Center		
	Weather Data Server	set	1
	Weather Data Analysis & Alert Issue (Software)	set	1
	Weather Data List Management	set	1

(7)	**Traffic Event Data Management**		
	Roadside		
	Mobile Input Terminal	set	25
	Road Management Office		
	Traffic Event Data Console	set	5.1
	Traffic Event Data Server	set	5.1
	Event Data Input (Software)	set	5.1
	Prioritization for Information Dissemination (Software)	set	5.1
	Traffic event Data Correlation (Software)	set	5.1
	Regional Main Center		
	Main Monitor Screen	set	1
	Traffic Event Data Console	set	1
	Traffic Event Data Server	set	1
	Event Data Input (Software)	set	1
	Prioritization for Information Dissemination (Software)	set	1
	Traffic event Data Correlation (Software)	set	1
(8)	**Traffic Supervision**		
	Regional Main Center		
	Main Monitor Screen	set	1
	Traffic Supervising/Control Console	set	1
	Traffic Supervising/Control Server	set	1
	Mapped Event Indication Management (Software)	set	1
(9)	**VMS Indication**		
	Roadside		
	VMS-type A	set	27
	VMS-type B	set	36
	VMS-type C	set	17
	CSS	set	50
	Road Management Office		
	VMS Center Controller	set	5.1
	VMS Indication Data Input (Software)	set	5.1
	Regional Main Center		
	VMS Center Controller	set	1
	Indication Guidance/Management (Software)	set	1
	VMS Indication Data Input (Software)	set	1
(10)	**Mobile Radio Communication**		
	Road Management Office		
	Radio Communication Base Station	set	2
	Radio Communication Control Console	set	2
	Toll Office		
	Radio Communication Base Station	set	5
	Mobile		
	Radio Communication Terminal	set	20
(11)	**Traffic Information**		
	Regional Main Center		
	Traffic Information Server	set	1
	Traffic Information Management (Software)	set	1
(12)	**Integrated Data Management**		
	Regional Main Center		
	Integrated Data Server	set	1
	Integrated Data Management (Software)	set	1

2. Automated Toll Collection/Management System (For Reference)

Item No.	Equipment Component	Unit	Q'ty (a)
(13)	**Tollgate Lane Monitoring**		
	Roadside		
	CCTV Camera (Fix Type)	set	48
	Toll Booth		
	CCTV Monitoring in Booth	set	48
	Toll Office		
	CCTV Monitoring Console	set	5
(14)	**Vehicle Identification**		
	Roadside		
	License Plate Scanner	set	57
(15)	**Lane Control**		
	Roadside		
	Vehicle Detector	set	57
	Entry-Card Issuer	set	57
	Toll Due/Paid Sign	set	57
	Stop/Go Sign	set	57
	Classification Sign	set	57
	Barrier	set	57
	Toll Booth		
	Toll Data Input Console	set	57
	Toll Office		
	Lane Server	set	5
	Lane Control/Transaction Data Management (Software)	set	5
(16)	**Road to Vehicle Communication**		
	In-Vehicle		
	OBU	set	5000
	Roadside		
	Roadside Antenna	set	10
	Roadside Controller	set	10
(17)	**IC-Card Recording**		
	Roadside		
	IC-Card Reader/Writer	set	10
	Mobile		
	IC-card	set	5000
(18)	**Toll Management**		
	Toll Office		
	Toll Management Server	set	5
	Toll Collection Data Management (Software)	set	5
	Toll Management Center		
	Toll Management Center Server	set	2
	Toll Data Management (Software)	set	2
(19)	**OBU Management**		
	OBU Issue Office		
	OBU Registration Terminal	set	1
	OBU Management Center		
	OBU Management Server	set	1
	OBU registration/Invalidation (Software)	set	1
	OBU Data Management (Software)	set	1

3. Vehicle Weighing System (For Reference)

Item No.	Equipment Component	Unit	Q'ty (a)
(20)	Axle Load Measurement		
	Roadside		
	Axle Load Scale	set	8
	Alarm Unit	set	8
	Toll Office		
	Heavy Truck Control Data Server	set	5
	Axle Load Measurement Control	set	5
	Data/Document Management	set	5
(21)	Measurement Lane Monitoring		
	Mobile		
	Mobile Input Terminal	set	10
	Roadside		
	CCTV Camera	set	8
	Toll Office		
	CCTV Monitoring Console	set	5

4. Communication system

Item No.	Equipment Component	Unit	Q'ty (a)
	Communication System (Center/Roadside)		
	Optical Fiber Cables		
	Optical Fiber Cable (Duct Cable) – 42,28,24,etc.	km	327.84
	Cable Termination	set	18
	Regional Main Center		
	L3SW	set	3
	L2SW	set	7
	Network Management System	set	1
	Road Management Office		
	L3SW	set	20
	L2SW	set	40
	Network Management System	set	6.6

5. Communication Ducts

Item No.	Equipment Component	Unit	Q'ty (a)
	Communication Ducts		
	Duct for Earthwork section	km	111.40
	Duct for Bridge Attachment	km	68.00
	Cable Chamber	Each	825

6. Base Structure

Item No.	Equipment Component	Unit	Q'ty (a)
	Pole		
	Pole for CCTV	each	97
	Pole for CSS	each	41
	Gantry Type G1	each	71
	Gantry Type G2	each	5
	Gantry Type G3	each	17
	Tower	each	13

7. Buildings

Item No.	Equipment Component	Unit	Q'ty (a)
	Building Construction		
	Northern Regional Main Center	m^2	2160
	Road Management Office for Lang – Hoa Lac	m^2	720

8. Electric Power Supply (Back-up)

Item No.	Equipment Component	Unit	Q'ty (a)
	Electric Power Supply (Back-up)		
	Back-up Power Supply Facilities	Set	12

9. O&M Vehicle

Item No.	Equipment Component	Unit	Q'ty (a)
	O&M Vehicle		
	Patrol Vehicle	set	5
	Towing Car	set	5

Source: The Study Team

9. Exclusion of Items from System to be installed in Project

1) Proposed Equipment Components to be substituted with Existing System

In the foregoing discussions up to the section of "9.9 Quantities", some of the equipment components which can be substituted by the components of the existing system installed in the sections as shown below have been excluded from the Scope of the Project, although they are located in the target road network of the Project:

- Mai Dich – Thanh Tri and Phap Van – Cau Gie Sections: System installed by JICA Grant
- Cau Gie – Ninh Binh Section: System installed by other projecy by CadPro.

2) Traffic Information/Control System of BOT Sections

Similarly in the foregoing discussions, all parts of the Traffic Information/Control System excluding the parts shown in 1) have been assumed as the system to be installed in the Project.

However, it has become clear through the Study that the BOT companies, which have been assigned to operate the sections included in the target road network of the Project, have decided to install their Traffic Infoamation/Control Systems by their own investment without government financial assistance and MOT agreed it.

Accordingly, this parts of Traffic Information/Control System for the two BOT sections are to be excluded from the Project Scope and from the discussions in the following chapters in principle; however, the components necessary for securing connectivity, inter-operability and functional continuity among the systems of the BOT Sections and of the other parts of the target road sections need to be installed in the Project. It is concluded that the Traffic Information/Control System of BOT sections are to be installed in the following manner:

- Phap Van – Cau Gie Section: The components for connection/inter-operation

- Ha Noi – Bac Giang Section: The roadside equipment components, ducts and power supply between Ha Noi and Bac Ninh, and the components for connection/inter-operation.

Whereby the system integration for the whole target road network can be established. And in addition, the components and systems installed in the BOT Sections need to be investigated just prior to the commencement of the Project and the results are to be described in the Contract as the preconditions of existing system for the Detailed Design of the Project.

3) Toll Collection/Management System

In the foregoing sections, the Toll Collection/Management System has been discussed as an item of the system to be installed in the Project.

However, it has become clear through the Study that installation of the toll collection is to be limited to the two sections operated by BOT companies and that these companies have decided to install their Toll Collection/Management Systems including ETC, which are to be provided by a domestic private company, by their own investment without government financial assistance. Additionally, MOT has agreed that the BOT companies install and operate the Toll Collection/Management Systems respectively and that a type of ETC system appropriate for this country is to be selected eventually through the market competition process.

It is concluded accordingly that our proposed Toll Collection/Management System is to be excluded from the Project Scope and from the discussions in the following chapters.

4) Vehicle Weighing System

In the foregoing sections, the Vehicle Weighing System has been discussed as an item of the system to be installed in the Project. However, it has become clear through the Study that installation of this system is in the same condition as that of the Toll Collection/Management System.

It is concluded accordingly that our proposed Vehicle Weighing System is to be excluded from the Project Scope and from the discussions in the following chapters.

10. Project Cost

Project cost is to be estimated, based on the results of basic design foregoing, in consideration of the main points below.

- Each price of equipment and installation works adopted in this project were set based on the result of quotations by Vietnamese companies and Japanese companies.
- Regarding the Items that some companies prepared a quotation, the Study Team decided an adopted price from the viewpoints of a price and experience of that company.
- The Study Team conducted assessments according to the situation.
- 10% of equipment including installation cost and test and inspection cost was added as the cost for spare parts for two years.
- The result of cost estimation was summarized in each Functional Package for each expressway/section.
- The Items pertaining to all sections such as "design and construction management" were independently calculated in common cost.

- And furthermore, the costs of "Guideline and manual preparation" and "Initial operation training" were calculated in the common cost.
- Price Escalation: Foreign currency 2.0%-Local currency 4.9%, Physical Contingency: 5.0% These values were applied in accordance with JICA's policy and instruction.

Required cost of the Project is estimated as shown in the table below in the following manner:

- The values of Toll Collection/Management and of Vehicle Weighing are shown only for reference
- The Project Cost is divided into the part to be implemented directly by the Project and the part to be implemented by the budget of BOT in consideration of the requests by MOT.
- The values of "Cost for Reference" shows all results estimated in the Study.

Table 10.1 Project Cost

No.	Category	Project Cost (To be implemented directly by Project)		Project Cost (To be implemented by Budget of BOT)		Cost for Reference	
		Value in JPY (Million JPY)	Value in VND (Billion VND)	Value in JPY (Million JPY)	Value in VND (Billion VND)	Value in JPY (Million JPY)	Value in VND (Billion VND)
1	Traffic Information/Control	2,990.4	536.9	696.0	124.9	3,686.4	661.8
2	Toll Collection/Management	--	--	1,373.8	249.3	1,373.8	249.3
3	Vehicle Weighing	--	--	423.0	75.9	423.0	75.9
4	Communication System	279.5	50.2	26.5	4.7	306.0	54.9
5	Communication Ducts	832.4	149.4	72.1	13.0	904.5	162.4
6	Building (NRMC)	144.7	26.0	--	--	144.7	26.0
7	Building (RMO)	--	--	--	--	50.2	9.0
8	Back-up Power Supply	451.3	81.0	51.7	9.3	503.0	90.3
9	O&M Vehicle	56.4	10.1	22.6	4.1	79.0	14.2
10	Subtotal (1+2+3+4+5+6+7+8+9)	4,754.7	853.6	2665.7	481.2	7,470.6	1,343.8
11	Consulting Service	544.0	97.7	--	--	621.9	111.7
12	Subtotal (10+11)	5,298.7	951.3	2665.7	481.2	8,092.5	1,455.5
13	Price Escalation	658.9	118.3	--	--	--	--
14	Physical Contingency	297.9	53.5	--	--	--	--
15	Subtotal (12+13+14)	6,255.6	1,123.1	--	--	--	--
16	Tax (10%, to be paid by LC)	625.6	112.3	--	--	--	--
17	Grand Total (15+16)	6,881.1	1,235.4	--	--	--	--

Exchange Rate (June 2015): 1US$ = JPY 120.70, 1US$ = VND 21,673,
NRMC: Northern Regional Main Center, RMO: Road Management Office for Lang – Hoa Lac

Source: The Study Team

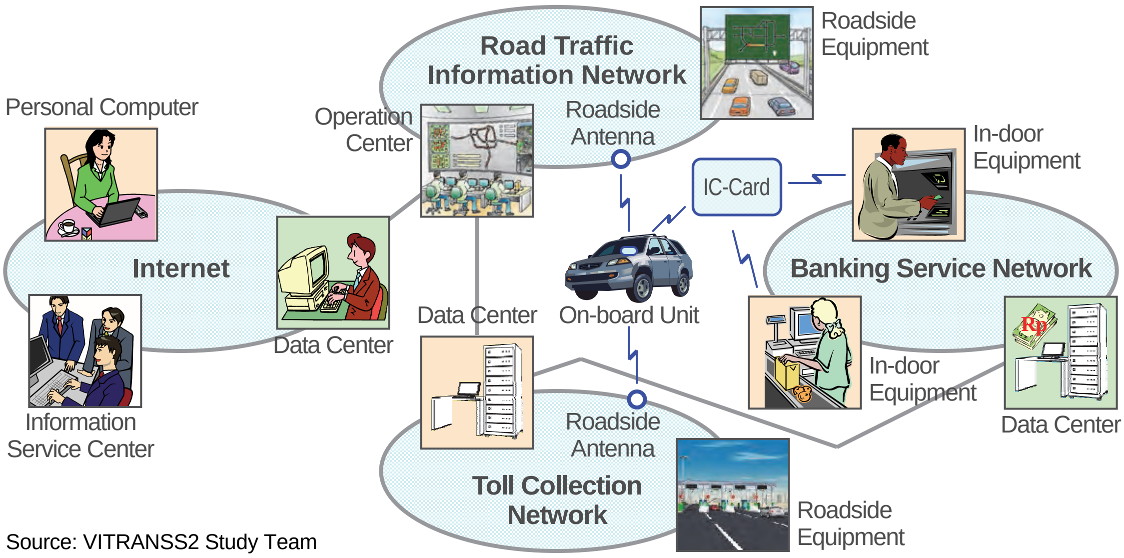
PART 2 : SYSTEM ANALYSIS BASED ON ITS MASTER PLAN

TABLE OF CONTENTS

1. Introduction

ITS is realised by using communication network operated by many different organizations, as well as various kinds of information services. ITS services can be provided by exchanging the required data among many pieces of equipment through the communication network.

Figure 1.1 Conceptual Illustration of ITS



Source: VITRANSS2 Study Team

ITS will provide the road users with advanced services through the communication network. It will be composed of various subsystems and operated by many organizations. Issues on ITS are to be discussed from following three viewpoints:

- Transport service
- Operation framework
- Communication system.

2. ITS User Service and Road Map

2.1 General

At the beginning of the discussion of ITS, user services are to be proposed. In the first stage, the discussion is to be focused on the following priority ITS user services. Then, in the later stages, additional user services are to be introduced and the scope is to be enhanced.

2.2 Traffic Information/Control

Service Descriptions: This service provides accurate surveillance of traffic conditions on expressway and adjacent arterial roads. This service assists prompt action of the road operator and the emergency vehicles by notifying occurrence of traffic accidents, broken-down vehicles and other obstacles. This service allows drivers en route and in advance to avoid the influence of the incidents by providing accurately updated information. This service also allows appropriate interchange/route selection by providing drivers en route with information;

such as crowdedness and travel-time. This service makes it possible to measure actual traffic volume continuously for developing rational road construction/improvement plan.

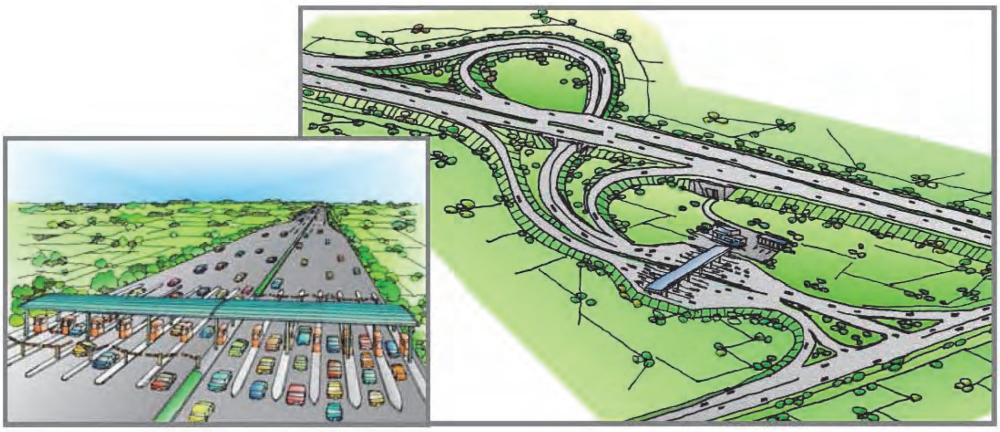
Figure 2.1 Traffic Information/Control

Source: Southern Vietnam Expressway FS by JETRO

2.3 Non-stop Toll Collection

Service Descriptions: This service enables toll collection without stopping vehicles: ETC (Electronic Toll Collection). This service relieves bottlenecks at the tollgates and allows smooth incoming and outgoing at the interchanges. This service reduces the number of tollbooths and solves the problem of land acquisition for the tollgates in suburban areas where traffic congestion will become an issue in near future. This service realizes simple vehicle inspection at the border crossings, and provides road or vehicle operators with the time of vehicle passage at the tollgates. Computerized toll management can vastly reduce uncollected toll revenue due to the failure in counting/classifying vehicles and can realize appropriate sharing of the toll revenue among different road operators.

Figure 2.2 Non-stop Toll Collection

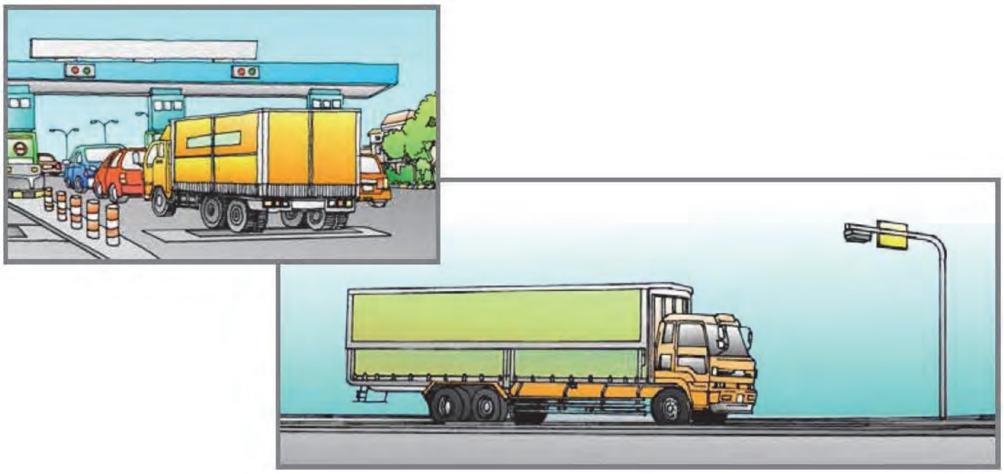


Source: Southern Vietnam Expressway FS by JETRO

2.4 Heavy Truck Control

Service Descriptions: This service eliminates overloading of heavy trucks by automatic execution of vehicle weighing at interchanges. It restrains damage to the road structure and extends its durable lifetime. This service restrains congestion caused by heavy trucks and allows freight trans-port to improve safety by eliminating overloading. This service allows prompt action of the road operator at the occurrence of serious accidents caused by heavy trucks and hazardous-material trucks and appropriate vehicle operation by keeping track of the trucks on the expressway network.

Figure 2.3 Heavy Truck Control



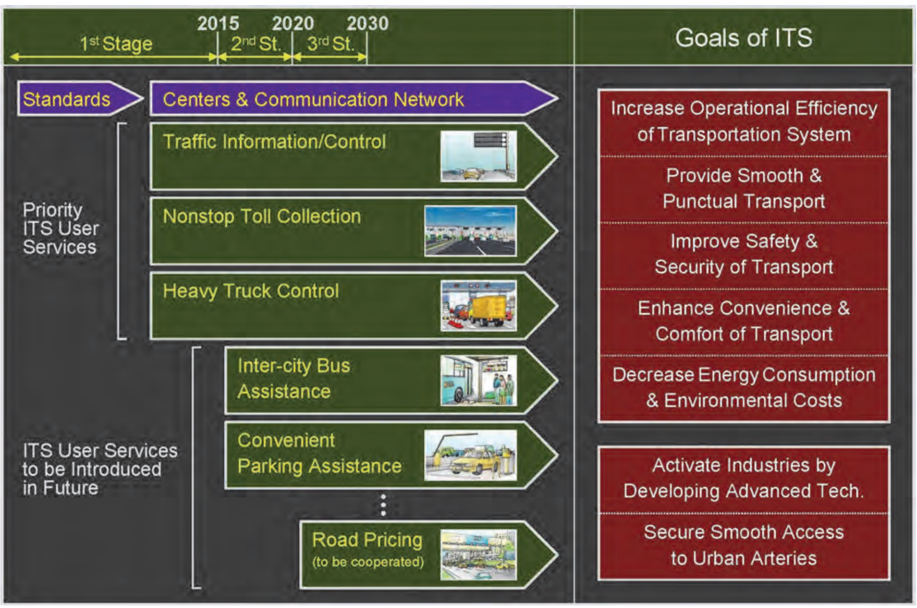
Source: Southern Vietnam Expressway FS by JETRO

2.5 Road Map of ITS

For the Road Map, time period of ITS implementation on the inter-city road network in Vietnam is to be divided into the following three stages:

- 1st Stage: up to 2015
- 2nd Stage: from 2015 to 2020
- 3rd Stage: from 2020 to 2030.

Figure 2.4 Road Map of ITS for Inter-city Road Network



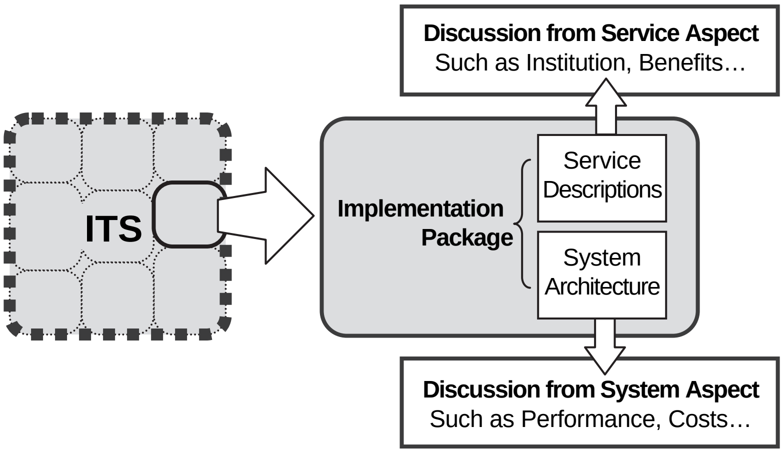
Source: VITRANSS2 Study Team

3 Implementation Packages and System Architecture

3.1 General

In order to prepare a common ground for discussing ITS from the both aspects of service and system and to realize the stepwise system implementation, the implementation packages are to be defined combining a system architecture to service descriptions broken down from the ITS User Service.

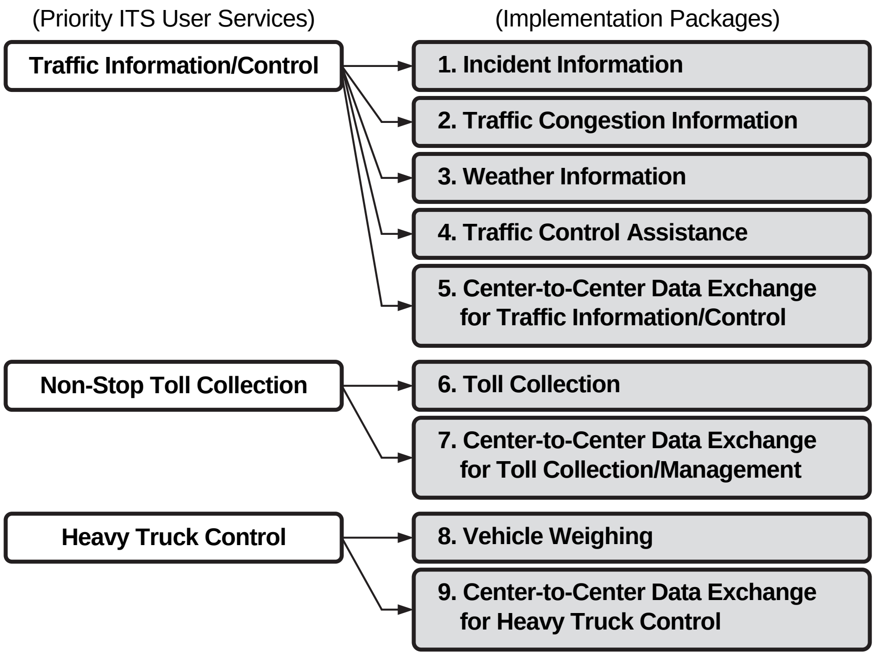
Figure 3.1 Conception of Implementation Package



Source: ITS Integration project (SAPI) Study Team

The three Priority ITS User Services above can be broken down into the Implementation Packages shown in the figure below and the System, which actualizes the Priority ITS User Services, is to be composed of the subsystems required for these Packages.

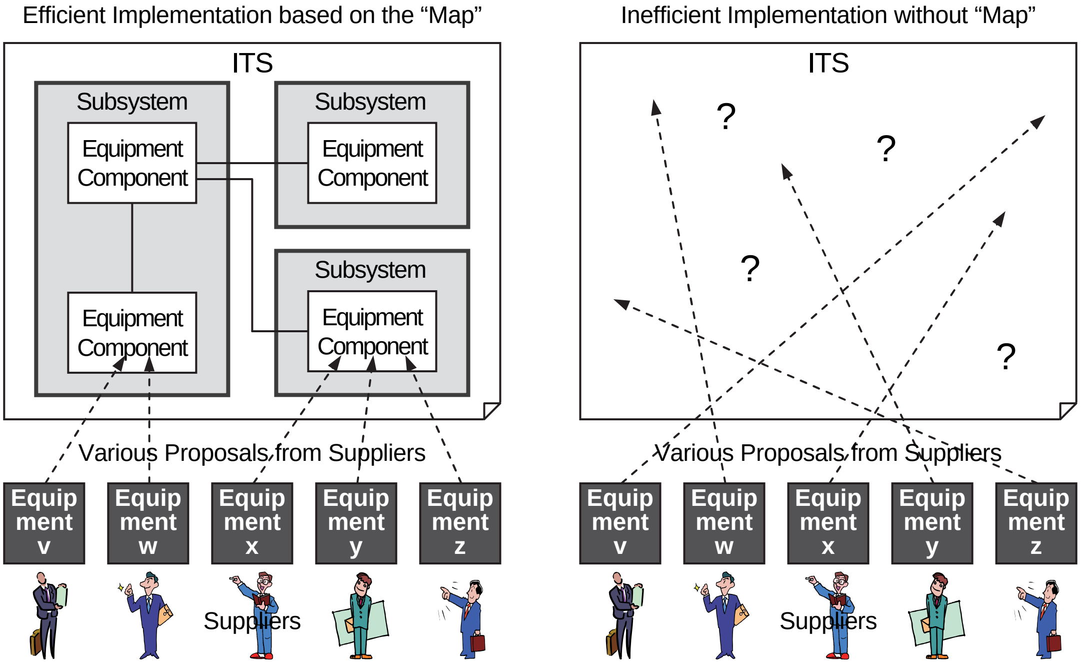
Figure 3.2 Implementation Packages for Priority ITS User Services



Source: ITS Integration project (SAPI) Study Team

During study/implementation period of ITS, various kinds of equipment and systems will be proposed by many different suppliers. For that reason, the system architecture has been prepared, in the series of studies up to SAPI, as a "Map" which presents the whole picture of ITS using simple graphical symbols with texts and to share correct understanding on the system among all parties concerned.

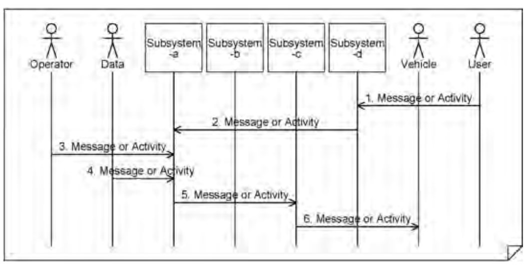
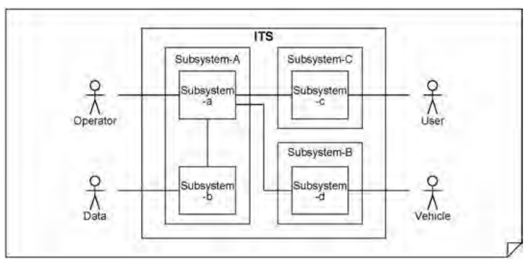
Figure 3.3 "Map" for Discussion/Implementation of ITS



Source: ITS Integration project (SAPI) Study Team

Notation of the system architecture is to conform to UML (Unified Modelling Language), which is adopted for the reference model architecture for the ITS sectors shown in ISO/CD 14813, and its major elemental documents are the sequence diagrams and the communication diagrams. The procedure for actualizing an ITS User Service (e.g. service descriptions of an Implementation Package, more specifically) is to be represented by a sequence diagram and a communication diagram is to be constructed based on it.

Table 3.1 Major Elemental Documents of System Architecture

Sequence Diagram	Communication Diagram (Collaboration Diagram)
 This diagram indicates a sequence of exchanging messages, actions and their required data elements in order to assist discussions on interoperability of the data.	 This diagram indicates a system by combination of subsystems and interfaces in order to clarify the basic understanding of the system.

Note, Sequence Diagram and Communication Diagram consist of subsystems. Lowest one of them is called as an Equipment Component.

Source: The Study Team

3.2 System Policies Selected for Implementation Packages

In the studies from the ITS Master Plan to SAPI, comparisons have been performed among many different alternative system policies, for preparation to specify the Functional Packages required for actualizing the Implementation Packages, and the best suited policies have been selected considering harmonization with the needs and operation frameworks in Vietnam.

Table 3.2 Alternative System Policies Proposed/Selected for Implementation Packages

Implementation Package	Alternative System Policies	
1. Incident Information	(a) by Monitoring at Roadside	using Telephones at Reg. Intervals along Expy.
		using CCTVs at Small Intervals along Expy.
		using CCTVs at Reg. Intervals along Expy.
		using CCTVs at Bottleneck Spots
	(b) by Image Recognition	using CCTVs at Small Intervals along Expy.
		using CCTVs at Reg. Intervals along Expy.
		using CCTVs add. at Incident-prone Spots
		using CCTVs on Ramps
2. Traffic Congestion Information	(a) by Monitoring at Roadside	using CCTVs at Small Intervals along Expy.
		using CCTVs at Reg. Intervals along Expy.
		using CCTVs at Bottleneck Spots
	(b) by Image Recognition	using CCTVs at Small Intervals along Expy.
		using CCTVs at Reg. Intervals along Expy.
		using CCTVs add. at Congestion-prone Sections
		using CCTVs on Ramps
	(c) by Vehicle Detection	using Detectors at Small Intervals along Expy.
		using Detectors at Midway between a pair of ICs.
		using Detectors at Congestion-prone Sections
	(d) by DSRC Probe	
	(e) by GPS/WL Probe	
3. Weather Information	(a) by Weather Sensors	
4. Traffic Control Assistance	(a) by Integrated Information	Using Organized/Prioritized Traffic Event Data
5. C-to-C Data Exchange	(a) by Fibre-optic/WL Comm.	using IP over ATM
		using IP over G-Ethernet
		using IP over SDH
		using IP over ATM/DWDM
		using IP over SDH/DWDM
6. Toll Collection/ Management (For Reference)	(a) by Touch&Go/Manual	using Contact-less IC-card Type A (Mifare)
		using Contact-less IC-card Type A
		using Contact-less IC-card Type B
		using Contact-less IC-card Type Fellica
	(b) by ETC at Toll-island	using 2-piece Type OBU
	(c) by ETC at Toll-island	using 1-piece Type OBU
	(d) by ETC on Free-flow	using 2-piece Type OBU
7. C-to-C Data Exchange	(a) by Fibre-optic/WL Comm.	using IP over G-Ethernet
8. Vehicle Weighing	(a) by Weighing at Parking	
	(b) by Weighing in Motion	using Axle Load Scales in front of Ent. Tollgates
		using Axle Load Scales behind Ent. Tollgates
		using Axle Load Scales in front of Exit Tollgates
9. C-to-C Data Exchange	(a) by Fibre-optic/WL Comm.	using IP over G-Ethernet

Note, ▭ : System policies rejected in the studies, C-to-C: Center-to-Center, WL: Wireless, Expy.: Expressway.

Source: The Study Team

The system architecture is to be prepared for actualizing each implementation package being based on the selected system policy and composed of the subsystems shown later.

3.3 System Architecture Diagrams for Implementation Packages

The service descriptions and the system architecture diagrams for respective implementation packages are shown in the pages in the table below.

Table 3.3 System Architecture Diagram List for Implementation Packages

Implementation Package	Alternatives	Service Requirements	Use Case Diagram	Sequence Diagram (SD)	Collaboration Diagram (CD), Functions & Installation
1. Incident Information	1-(a): by Monitoring at Roadside	3.4	Fig3.4	Fig3.5	Fig3.7
	1-(b): by Image Recognition			Fig3.6	Fig3.8
2. Traffic Congestion Information	2-(a): by Monitoring at Roadside	3.5	Fig3.9	Fig3.10	Fig3.15
	2-(b): by Image Recognition			Fig3.11	Fig3.16
	2-(c): by Vehicle Detection			Fig3.12	Fig3.17
3. Weather Information	3-(a): by Weather Sensors	3.6	Fig3.16	Fig3.17	Fig3.18
4. Traffic Control Assistance	4-(a): by Integrated Information	3.7	Fig3.19	Fig3.20	Fig3.21
5. Center-to-Center Data Exchange	9-1: for Incident Notification	3.10	Fig3.32	Fig3.33	Fig3.39
	9-2: for Traffic Information			Fig3.34	Fig3.40
6. Toll Collection	6-(a): by T&G/Manual	3.8	Fig3.22	Fig3.23	Fig3.27
	6-(b): by ETC at Toll Island (2p-OBU)			Fig3.25	Fig3.28
7. Center-to-Center Data Exchange	9-3: for Toll Settlement	3.10	Fig3.32	Fig3.35	Fig3.41
	9-4: for IC-card Operation			Fig3.36	Fig3.42
	9-5: for OBU Management			Fig3.37	Fig3.43
8. Vehicle Weighing	8-(a): by Measurement in Motion	3.9	Fig3.29	Fig3.30	Fig3.31
9. Center-to-Center Data Exchange	9-6: for Heavy Truck Control	3.10	Fig3.32	Fig3.38	Fig3.44

Note: Greyed out area is "For Reference".

Source: The Study Team

3.4 Incident Information

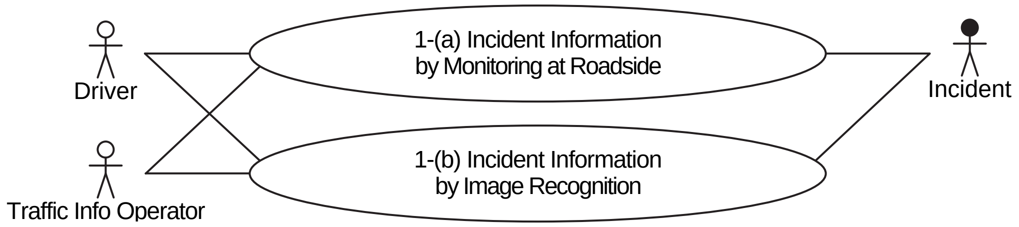
1) Service Descriptions and Use Cases

< from the 1st Stage >
- Receiving information of incident occurrence/place/situation, including left obstruction and natural disaster on the road, from the person concerned or the witness by 10 minutes at the latest,
- Round-the-clock surveillance at the incident-prone spots,
- Notification to the road operation vehicles immediately after receiving the information of incident,
- Arrival of the road operation vehicles at the site by 1 hour at the latest from the incident occurrence,
- Decision/implementation of traffic restriction immediately after arrival of the road operation vehicles,
- Incident/restriction information dissemination to the drivers en-route on adjacent section immediately after the decision of restriction, and prevention of the secondary incidents,
- Information update every 15 minutes for dissemination,
- Prompt incident/restriction information dissemination to the drivers en-route for reducing vehicles to the concerned section,
- Prompt incident/restriction information dissemination to the drivers in advance.

< from the 3rd Stage >
- Round-the-clock surveillance on the selected continuous road sections,
- Compiling/storing/providing data for incident information.

The following two alternatives of Use Case are to be considered in the discussion.

Figure 3.4 Alternatives of Use Case for Incident Information

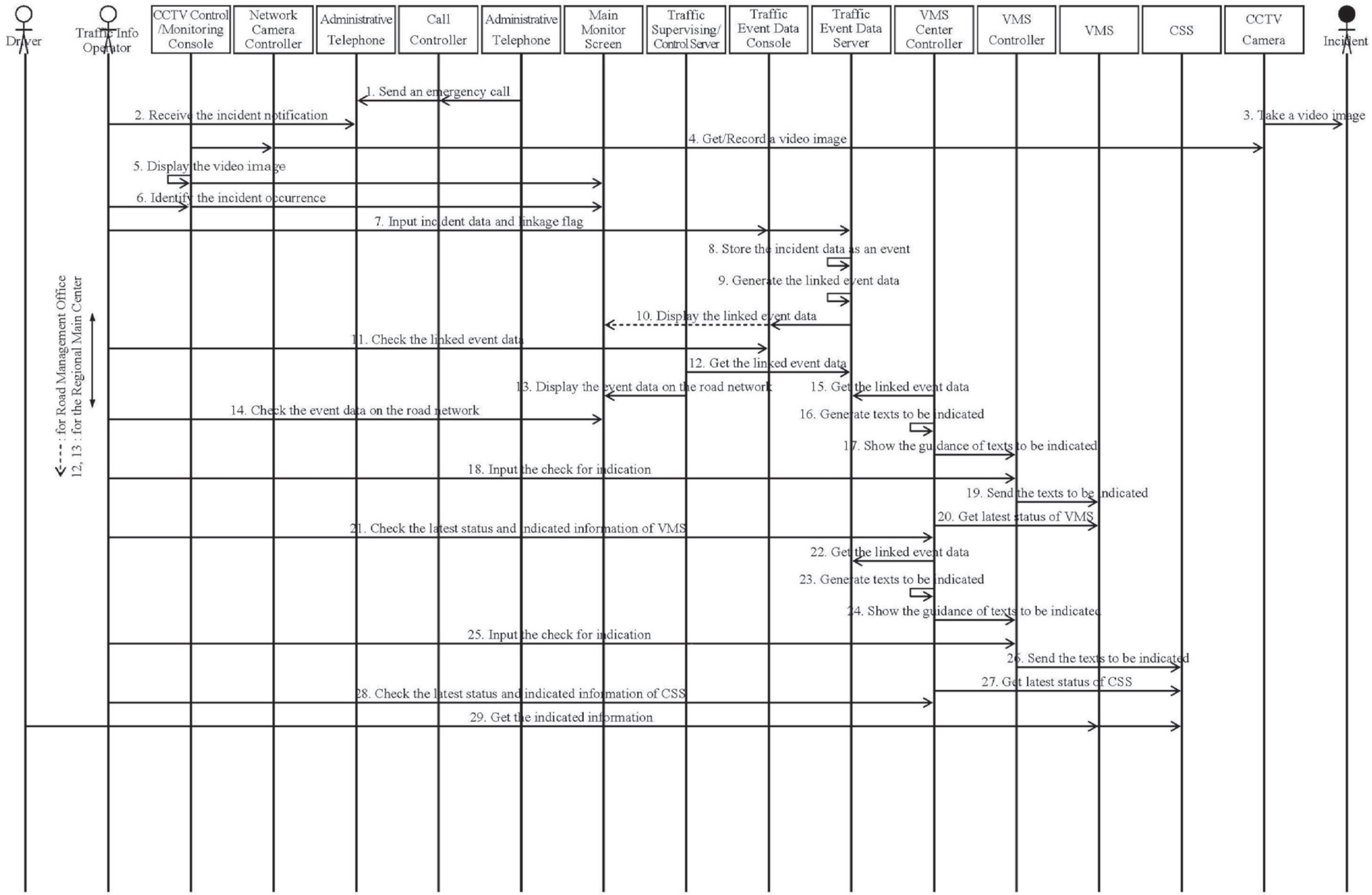


Source: VITRANSS2 Study Team

2) Sequence Diagram

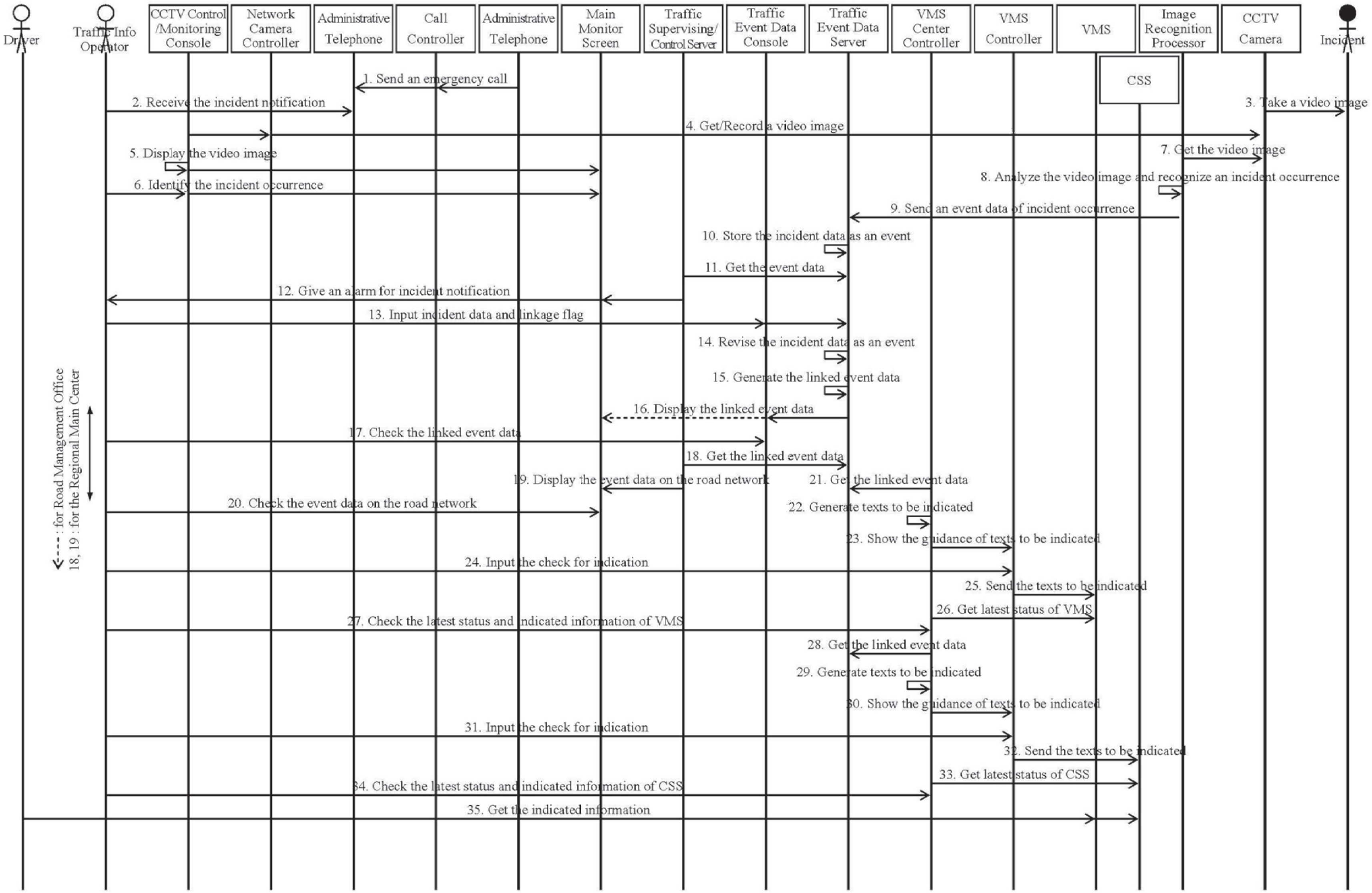
The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.5 Incident Information: 1-(a) by Monitoring at Roadside



Source: The Study Team

Figure 3.6 Incident Information: 1-(b) by Image Recognition

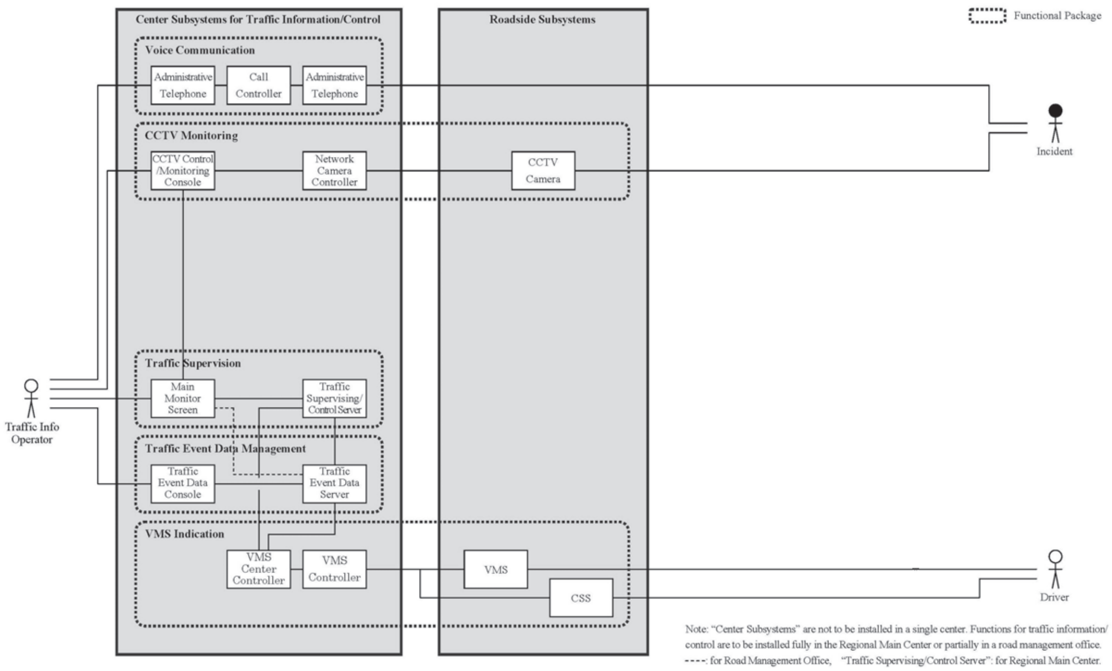


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagrams (CD) for incident information are derived respectively from the Sequence Diagrams foregoing.

Figure 3.7 1-(a) Incident Information by Monitoring at Roadside
(Graded as "Useful as a Complement")

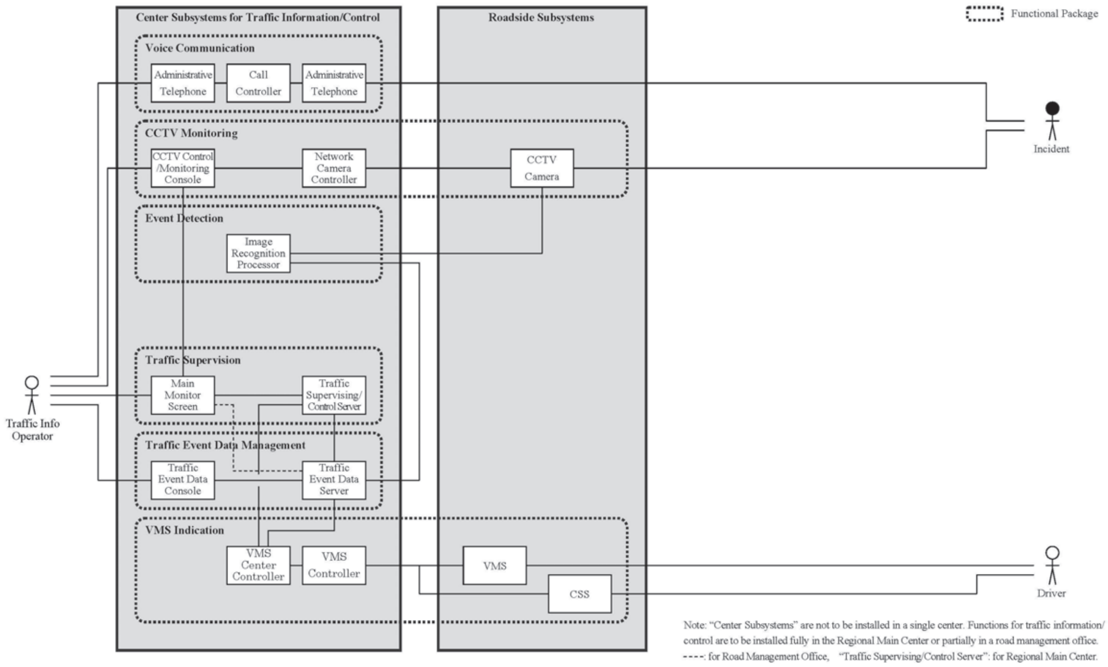


Functions & Installation: 1-(a) by Monitoring at Roadside		
Functional Package	Equipment Component	Installation
Voice Communication	Call Controller	Traffic Information/Control Center **
	Administrative Telephone	Traffic Information/Control Center **
CCTV Monitoring	Network Camera Controller	Traffic Information/Control Center **
	CCTV Monitoring Console	Traffic Information/Control Center **
	CCTV Camera	Roadside
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Controller	Traffic Information/Control Center **
	VMS	Roadside
	CSS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

Figure 3.8 1-(b) Incident Information by Image Recognition (Graded as "Recommended")



Functions & Installation: 1-(b) by Image Recognition		
Functional Package	Equipment Component	Installation
Voice Communication	Call Controller	Traffic Information/Control Center **
	Administrative Telephone	Traffic Information/Control Center **
CCTV Monitoring	Network Camera Controller	Traffic Information/Control Center **
	CCTV Monitoring Console	Traffic Information/Control Center **
	CCTV Camera	Roadside
Event Detection	Image recognition Processor	Traffic Information/Control Center **
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Controller	Traffic Information/Control Center **
	VMS	Roadside
	CSS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

3.5 Traffic Congestion Information

1) Service Descriptions and Use Cases

< from the 1st Stage >

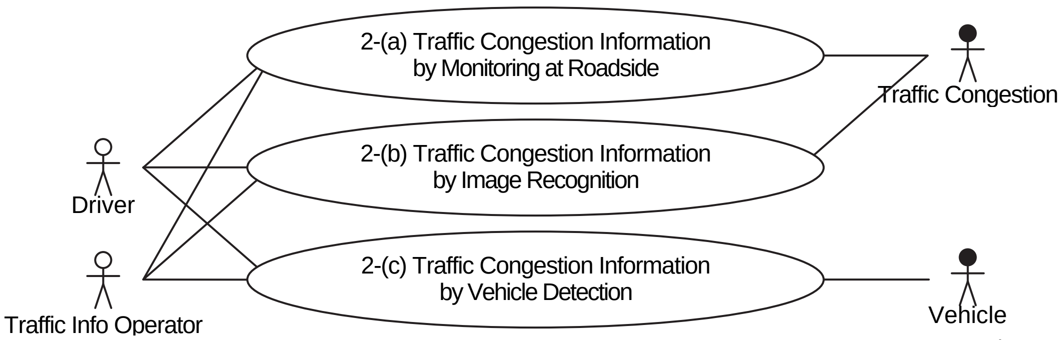
- Receiving information of congestion caused by an incident from the road operation vehicle,
- Round-the-clock surveillance at the congestion-prone section,
- Detecting the congestion with length of 1 km or further,
- Analyzing property of existing traffic excluding disturbing factors,
- Decision/implementation of the restriction of incoming traffic as needed at the interchange,
- Traffic congestion information dissemination to the drivers en-route on adjacent section immediately after grasping the congestion for prevention of the collision from behind, and to the drivers en-route/in-advance as needed,
- Prompt restriction information dissemination to the drivers en-route/in-advance.
- Information update every 15 minutes for dissemination.

< from the 3rd Stage >

- Round-the-clock surveillance on the selected continuous road sections,
- Analyzing property of traffic, and forecasting the congestions,
- Congestion forecast information dissemination to the drivers en-route/in-advance.
- Compiling/storing/providing data for traffic congestion information.

The following five alternatives of Use Case are to be considered in the discussion.

Figure 3.9 Alternatives of Use Case for Traffic Congestion Information

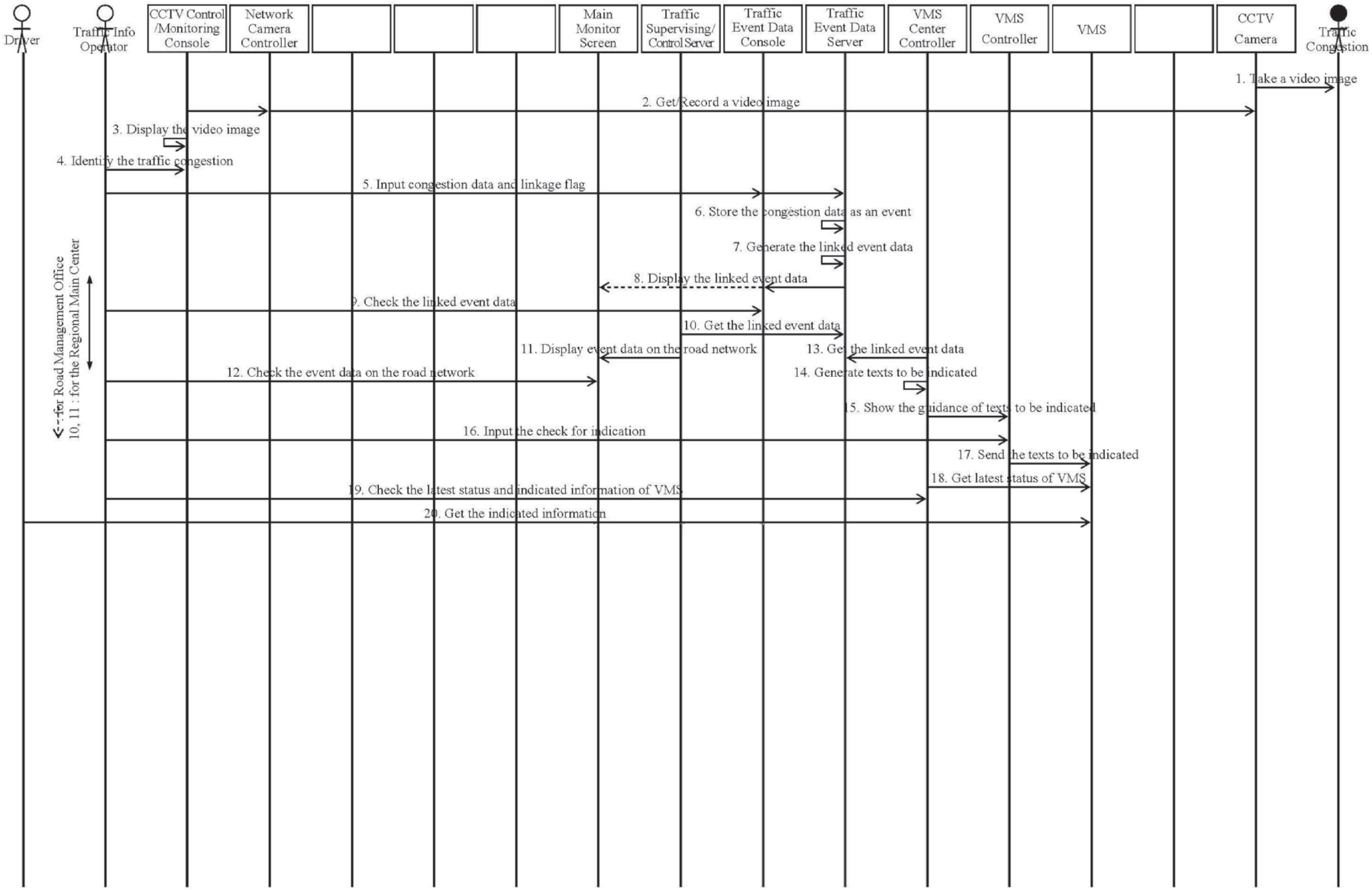


Source: VITRANSS2 Study Team

2) Sequence Diagram

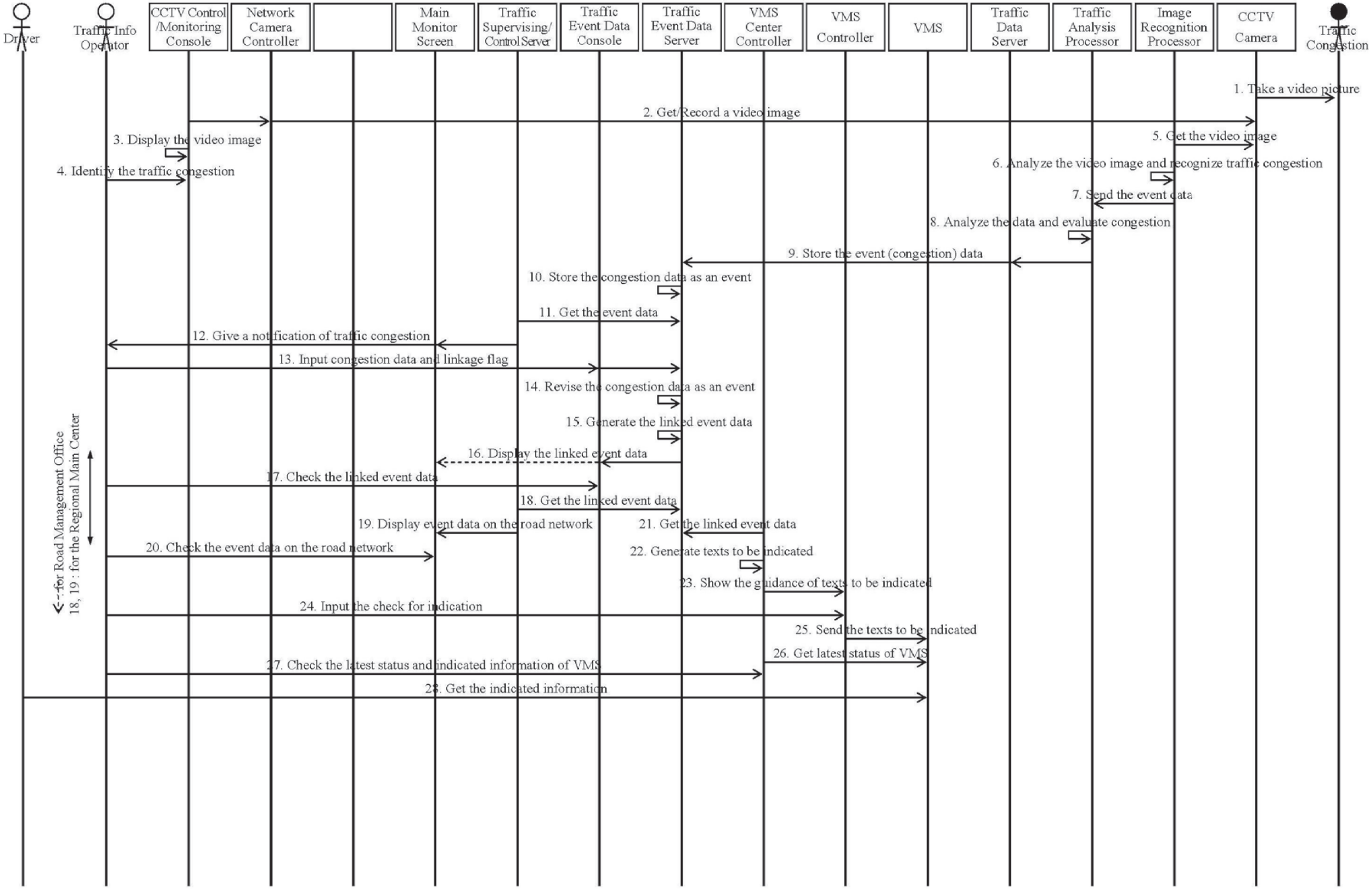
The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.10 Traffic Congestion Information: 2-(a) by Monitoring at Roadside



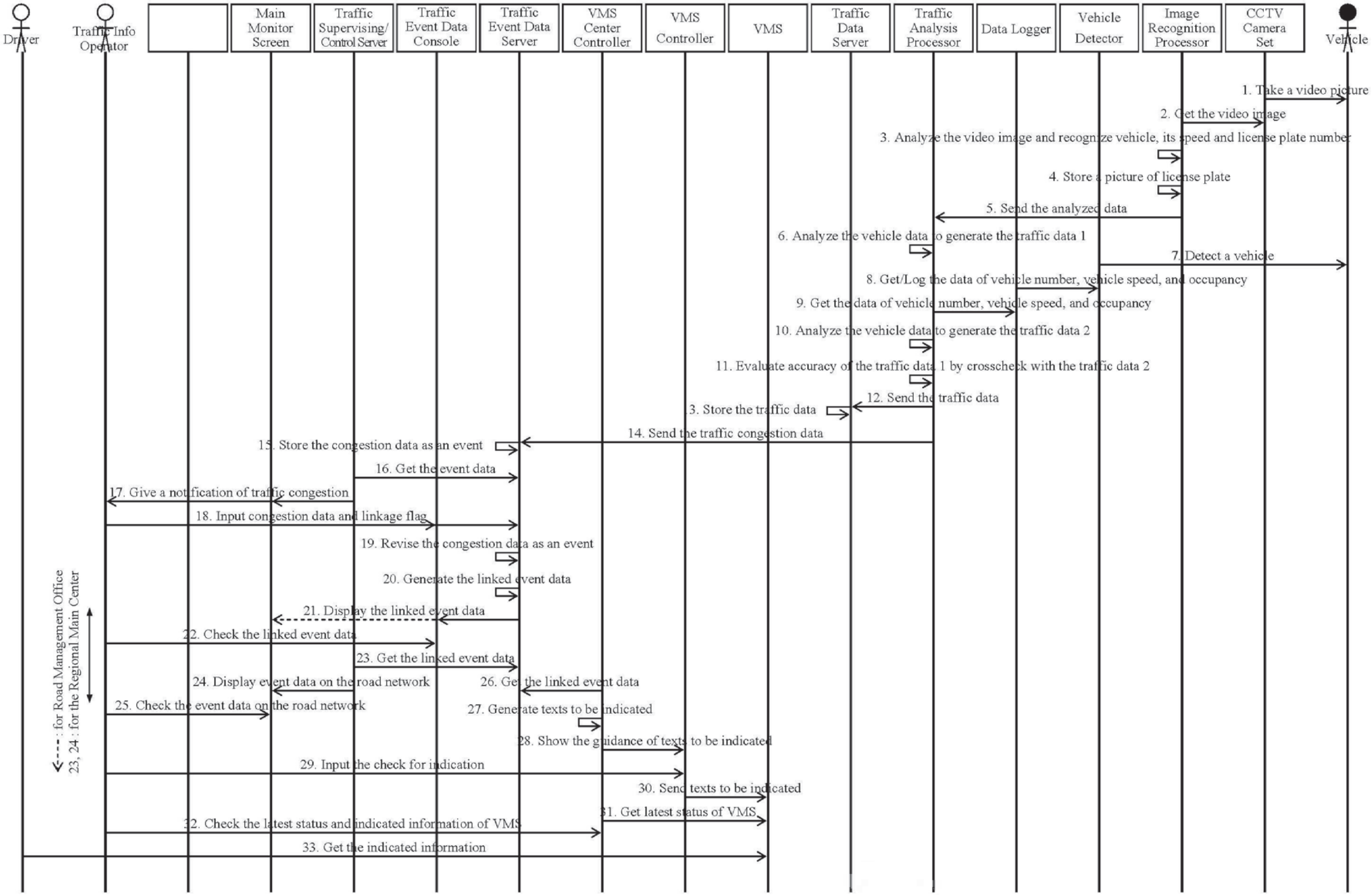
Source: The Study Team

Figure 3.11 Traffic Congestion Information: 2-(b) by Image Recognition



Source: The Study Team

Figure 3.12 Traffic Congestion Information: 2-(c) by Vehicle Detection

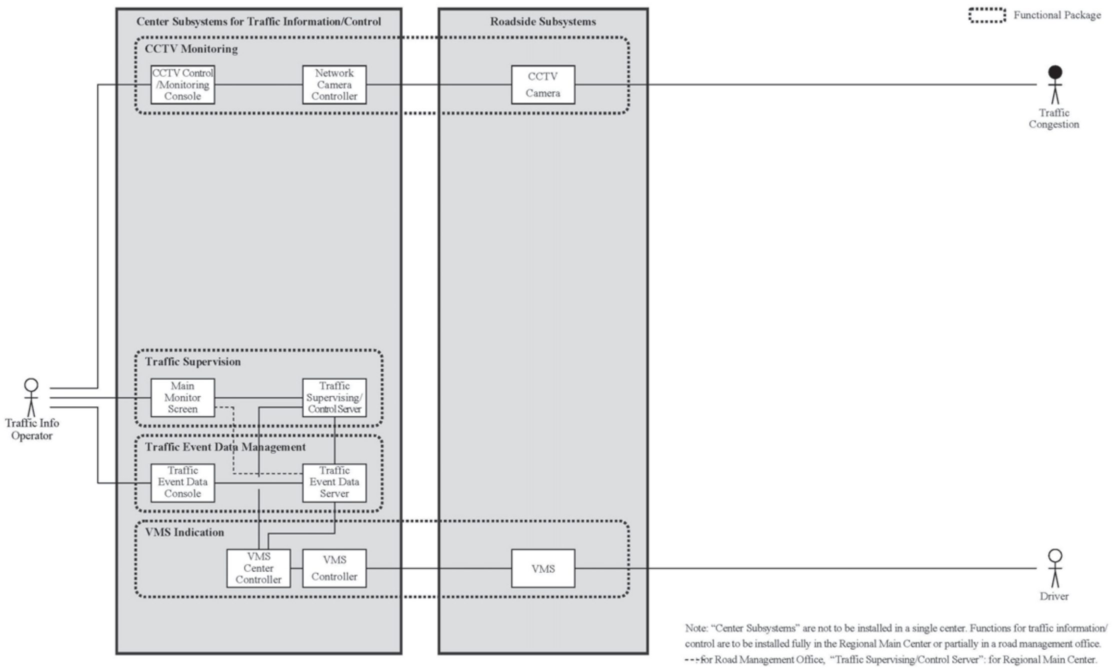


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagrams (CD) for traffic congestion information are derived respectively from the Sequence Diagrams foregoing.

Figure 3.13 2-(a) Traffic Congestion Information by Monitoring at Roadside
(Graded as "Useful as a Complement")

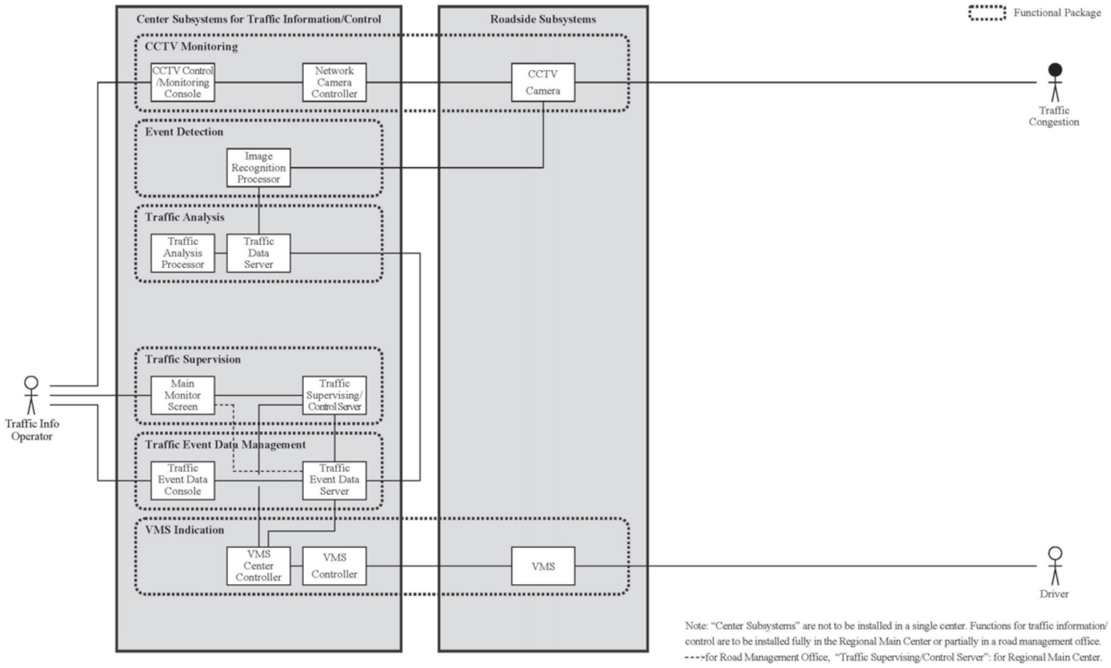


Functions & Installation: 2-(a) by Monitoring at Roadside		
Functional Package	Equipment Component	Installation
CCTV Monitoring	Network Camera Controller	Traffic Information/Control Center **
	CCTV Monitoring Console	Traffic Information/Control Center **
	CCTV Camera	Roadside
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Controller	Traffic Information/Control Center **
	VMS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

**Figure 3.14 2-(b) Traffic Congestion Information by Image Recognition
(Graded as "Useful as a Complement")**

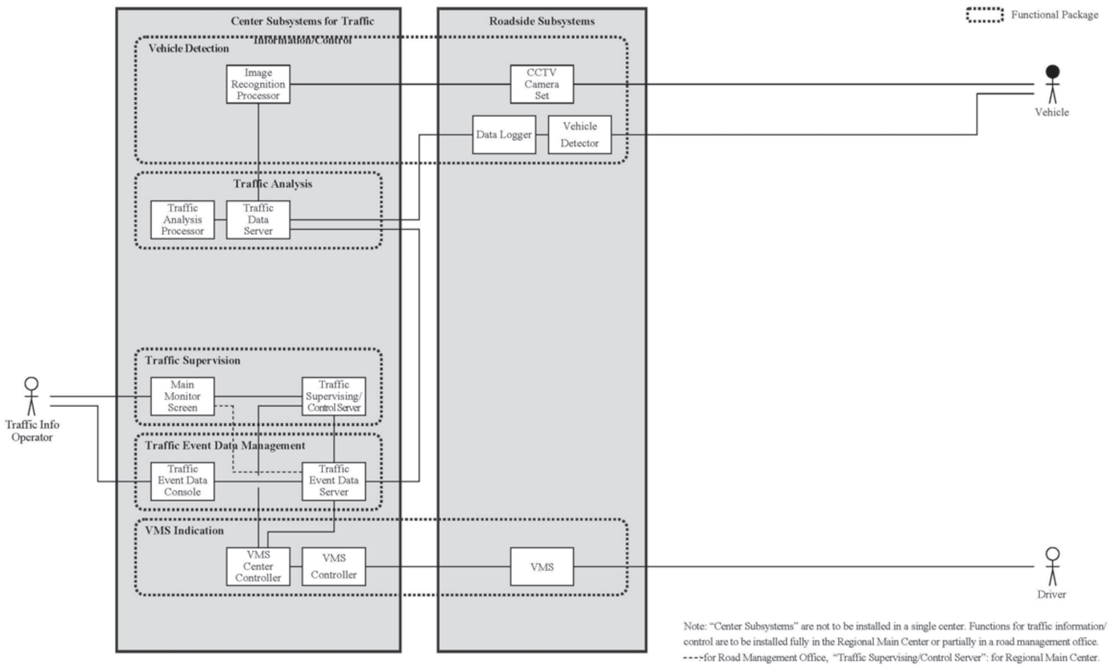


Functions & Installation: 2-(b) by Image Recognition		
Functional Package	Equipment Component	Installation
CCTV Monitoring	Network Camera Controller	Traffic Information/Control Center **
	CCTV Monitoring Console	Traffic Information/Control Center **
	CCTV Camera	Roadside
Event Detection	Image recognition Processor	Traffic Information/Control Center **
Traffic Analysis	Traffic Data Server	Traffic Information/Control Center **
	Traffic Analysis Processor	Traffic Information/Control Center **
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Controller	Traffic Information/Control Center **
	VMS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

Figure 3.15 2-(c) Traffic Congestion Information by Vehicle Detection
(Graded as "Recommended")



Functions & Installation: 2-(c) by Vehicle Detection		
Functional Package	Equipment Component	Installation
Vehicle Detection	CCTV Camera Set	Roadside
	Image Recognition Processor	Traffic Information/Control Center **
	Vehicle Detector	Roadside
	Data Logger	Roadside
Traffic Analysis	Traffic Data Server	Traffic Information/Control Center **
	Traffic Analysis Processor	Traffic Information/Control Center **
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Controller	Traffic Information/Control Center **
	VMS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

3.6 Weather Information

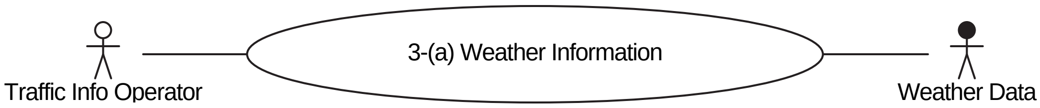
1) Service Descriptions and Use Cases

< from the 1st Stage >

- Round-the-clock monitoring of rainfall, wind direction/velocity and temperature at every interchange on the expressway network,
- Weather information dissemination, as needed, to the drivers en-route/in-advance,
- Information update every 15 minutes for dissemination,
- Compiling/storing/providing data for weather information.

A mandatory Use Case is to be considered in the discussion.

Figure 3.16 Mandatory Use Case for Weather Information

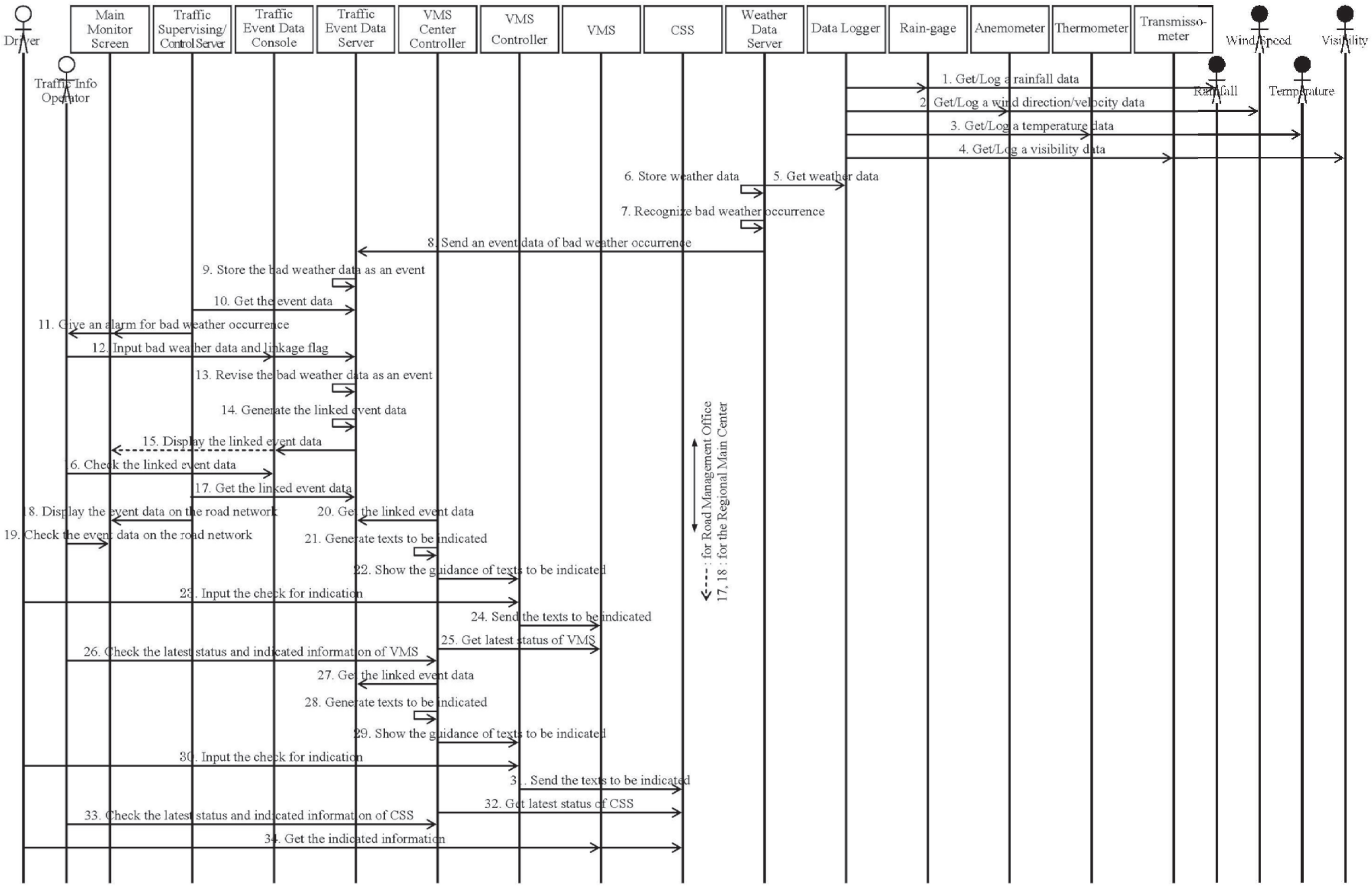


Source: VITRANSS2 Study Team

2) Sequence Diagram

The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.17 Weather Information: 3-(a) by Weather Sensors

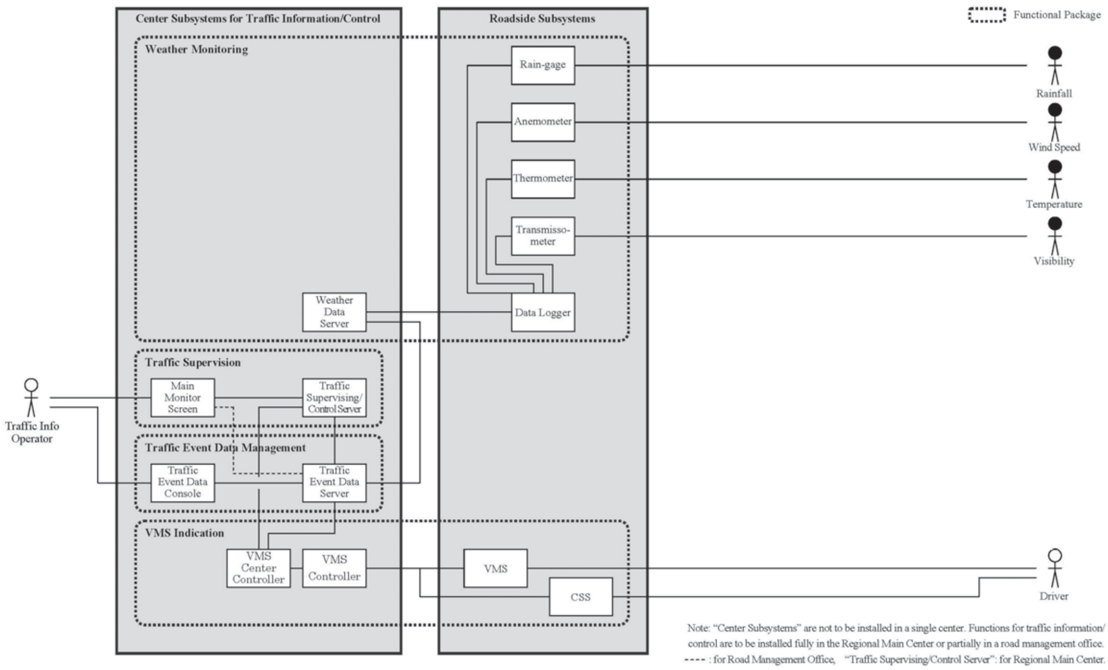


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagram (CD) for weather information is derived respectively from the Sequence Diagram foregoing.

Figure 3.18 3-(a) Weather Information by Weather Sensors
(Graded as "Necessary")



Functions & Installation: 3-(a) by Weather Sensors		
Functional Package	Equipment Component	Installation
Weather Monitoring	Weather Data Server	Traffic Information/Control Center **
	Rain-gage	Roadside
	Anemometer	Roadside
	Thermometer	Roadside
	Transmissometer	Roadside
	Data Logger	Roadside
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Controller	Traffic Information/Control Center **
	VMS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

3.7 Traffic Control Assistance

1) Service Descriptions and Use Cases

< from the 1st Stage >

- Notification to the road operation vehicles immediately after receiving the information of incident,
- Arrival of the road operation vehicles at the site by 1 hour at the latest from the incident occurrence,
- Decision/implementation of traffic restriction immediately after arrival of the road operation vehicles,
- Incident/restriction information dissemination to the drivers en-route on adjacent section immediately after the decision of restriction, and prevention of the secondary incidents,
- Prompt incident/restriction information dissemination to the drivers en-route for reducing vehicles to the concerned section,
- Traffic congestion information dissemination to the drivers en-route on adjacent section immediately after grasping the congestion for prevention of the collision from behind,
- Decision/implementation of the restriction of incoming traffic at the interchange as needed,
- Prompt restriction information dissemination to the drivers en-route,
- Information update every 15 minutes for dissemination.

< from the 2nd Stage >

- Travel-time/weather information dissemination to the drivers en-route.

< from the 3rd Stage >

- Congestion forecast information dissemination to the drivers en-route.

The following five mandatory Use Case is to be considered in the discussion.

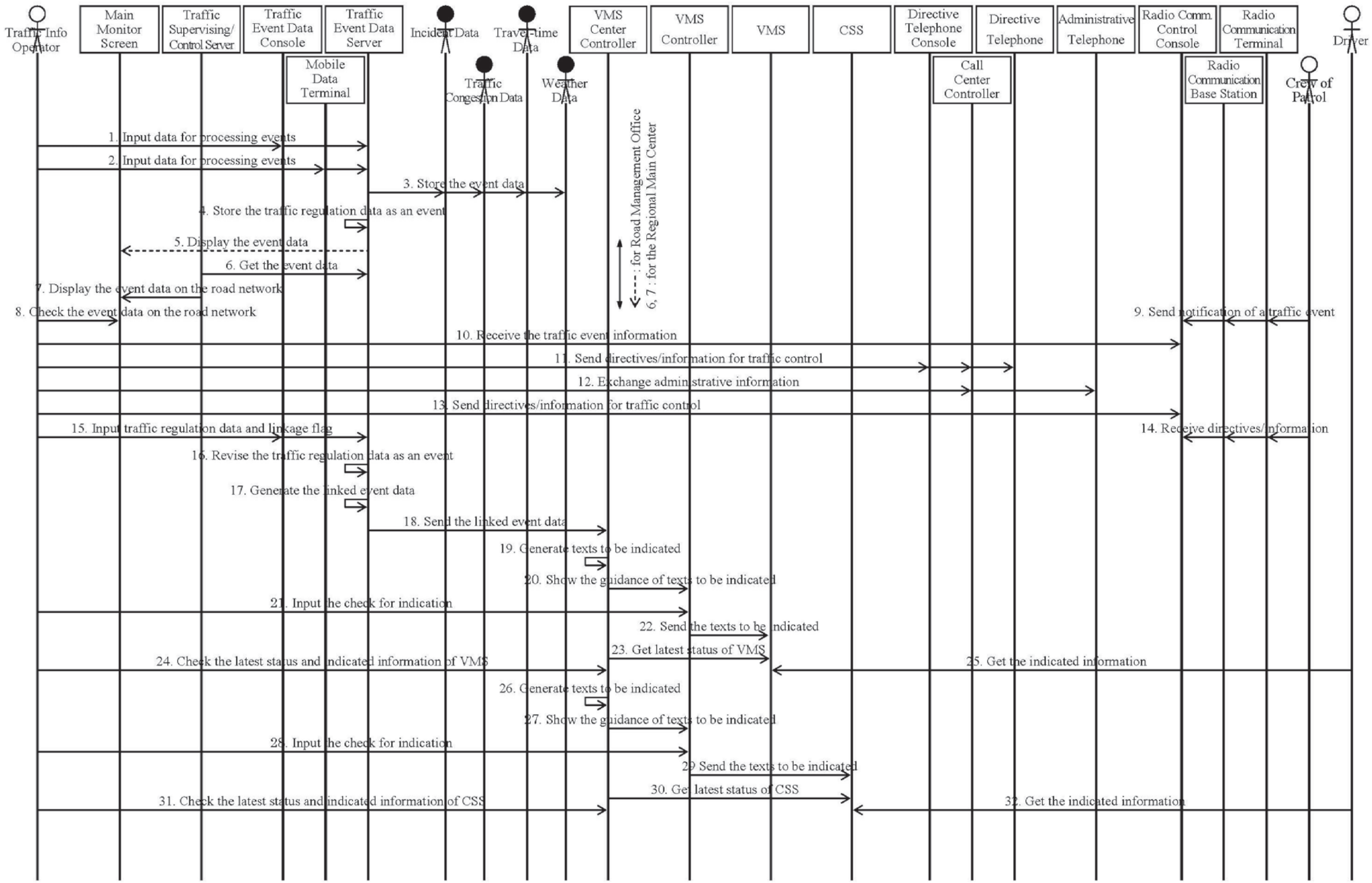
Figure 3.19 Mandatory Use Case for Traffic Control Assistance

Source: VITRANSS2 Study Team

2) Sequence Diagram

The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.20 Traffic Control Assistance: 4-(a) by Integrated Information

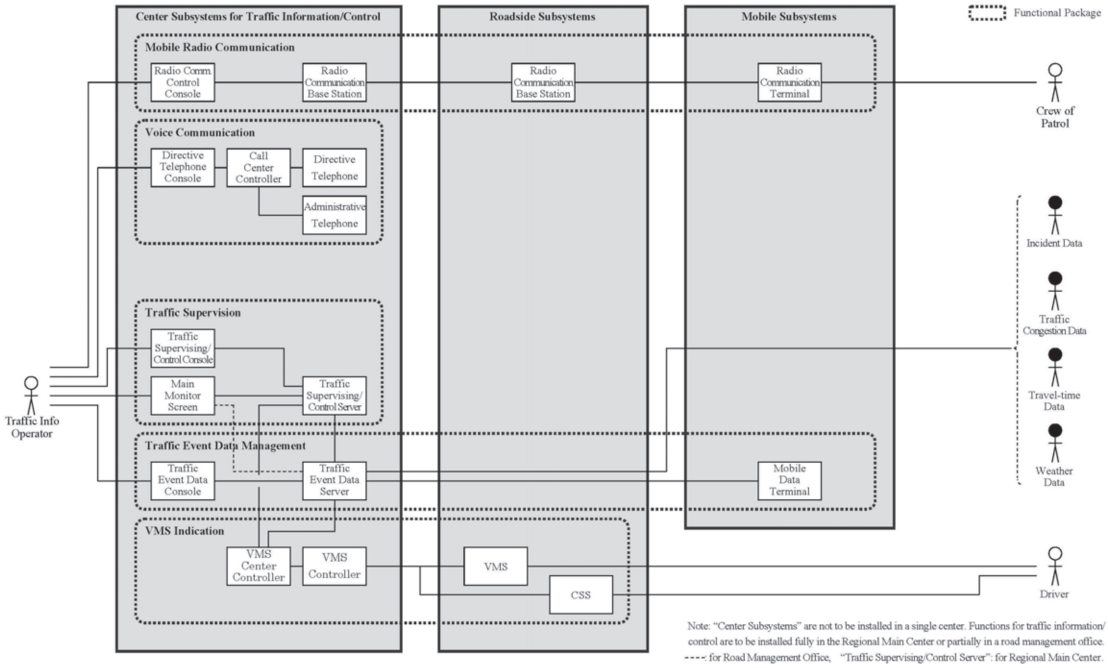


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagram (CD) for traffic control assistance is derived respectively from the Sequence Diagram foregoing.

Figure 3.21 4-(a) Traffic Control Assistance by Integrated Information
(Graded as "Useful as a Complement")



Functions & Installation: 4-(a) by Integrated Information		
Functional Package	Equipment Component	Installation
Mobile Radio Communication	Radio Communication Controller	Traffic Information/Control Center **
	Radio Communication Console	Traffic Information/Control Center **
	Radio Communication Base Station	Roadside
	Radio Communication Terminal	Mobile
Voice Communication	Call Controller	Traffic Information/Control Center **
	Directive Telephone	Traffic Information/Control Center **
	Directive Telephone Console	Traffic Information/Control Center **
CCTV Monitoring	Network Camera Controller	Traffic Information/Control Center **
	CCTV Monitoring Console	Traffic Information/Control Center **
	CCTV Camera	Roadside
Traffic Supervision	Traffic Supervising/Control Server	Traffic Information/Control Center **
	Main Monitor Screen	Traffic Information/Control Center **
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
	Traffic Event Data Console	Traffic Information/Control Center **
VMS Indication	VMS Center Controller	Traffic Information/Control Center **
	VMS Center Controller	Traffic Information/Control Center **
	VMS	Roadside
	CSS	Roadside

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

3.8 Toll Collection (For Reference)

1) Service Descriptions and Alternative Use Cases

< from the 1st Stage >

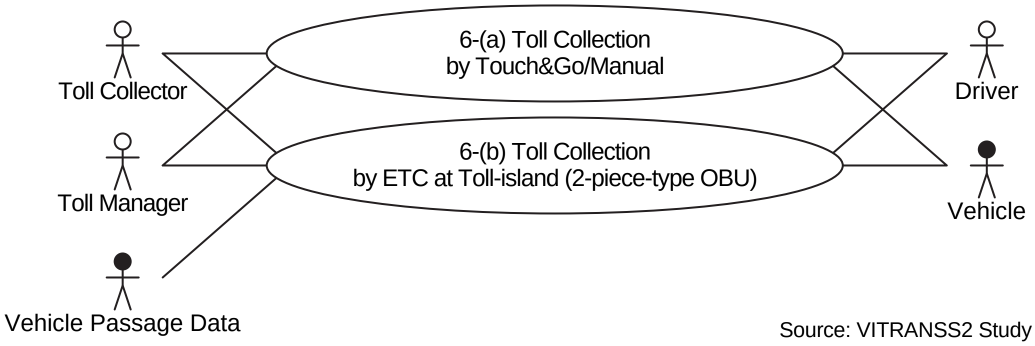
- Non-stop toll collection responding to the distance-proportional/sectional/flat tariff system,
- Capability of combined use of non-stop toll collection and one-stop toll collection for efficient implementation of roadside equipment: in-coming by non-stop and out-going by one-stop, and in-coming by one-stop and out-going by non-stop as well,
- Average service-time less than 4.5sec/vehicle by non-stop toll collection such as ETC,
- Average service-time less than 6.0sec/vehicle by one-stop toll collection such as Touch&Go,
- Toll payment by prepayment,
- Capability of checking sufficiency/shortage of prepaid balance by the driver in advance or en-route using OBU and contact-less IC-card: balance-in-card,
- Shared use of OBU among different road sections under the different road operators for convenience of the user,
- Achieving a low error ratio (less than 0.01%) of treating the short prepaid balance as sufficient, and the sufficient prepaid balance as short,
- Achieving a low error ratio (less than 0.01%) of falling into inoperable situation by system errors, and easy procedure to recover the system errors,
- Conformance to the vehicle classification defined by the Vietnamese Government,
- Identifying vehicle class without costly detectors, and easy system modification for revision of the vehicle classification,
- Capability of sure prevention of unlawful passage including violation,
- Simple roadside equipment component for non-stop/one-stop toll collection to be connected to existing system for manual toll collection by the stepwise implementation.

< from the 3rd Stage >

- Shared use of OBU and contact-less IC-card with ERP (Electronic Road Pricing) in the urban area.

The following four alternatives of Use Case are to be considered in the discussion.

Figure 3.22 Alternatives of Use Case for Toll Collection

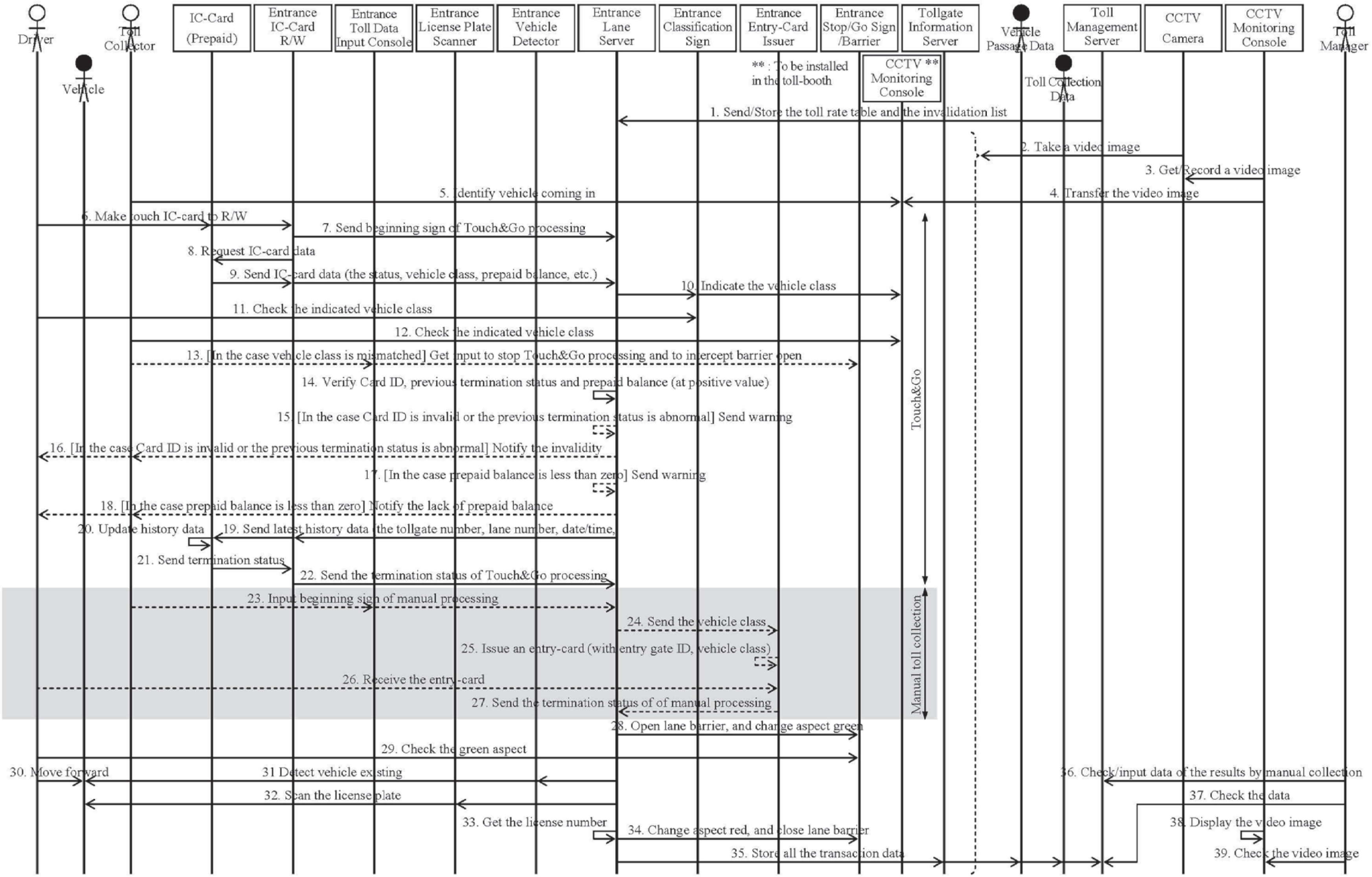


Source: VITRANSS2 Study Team

2) Sequence Diagram

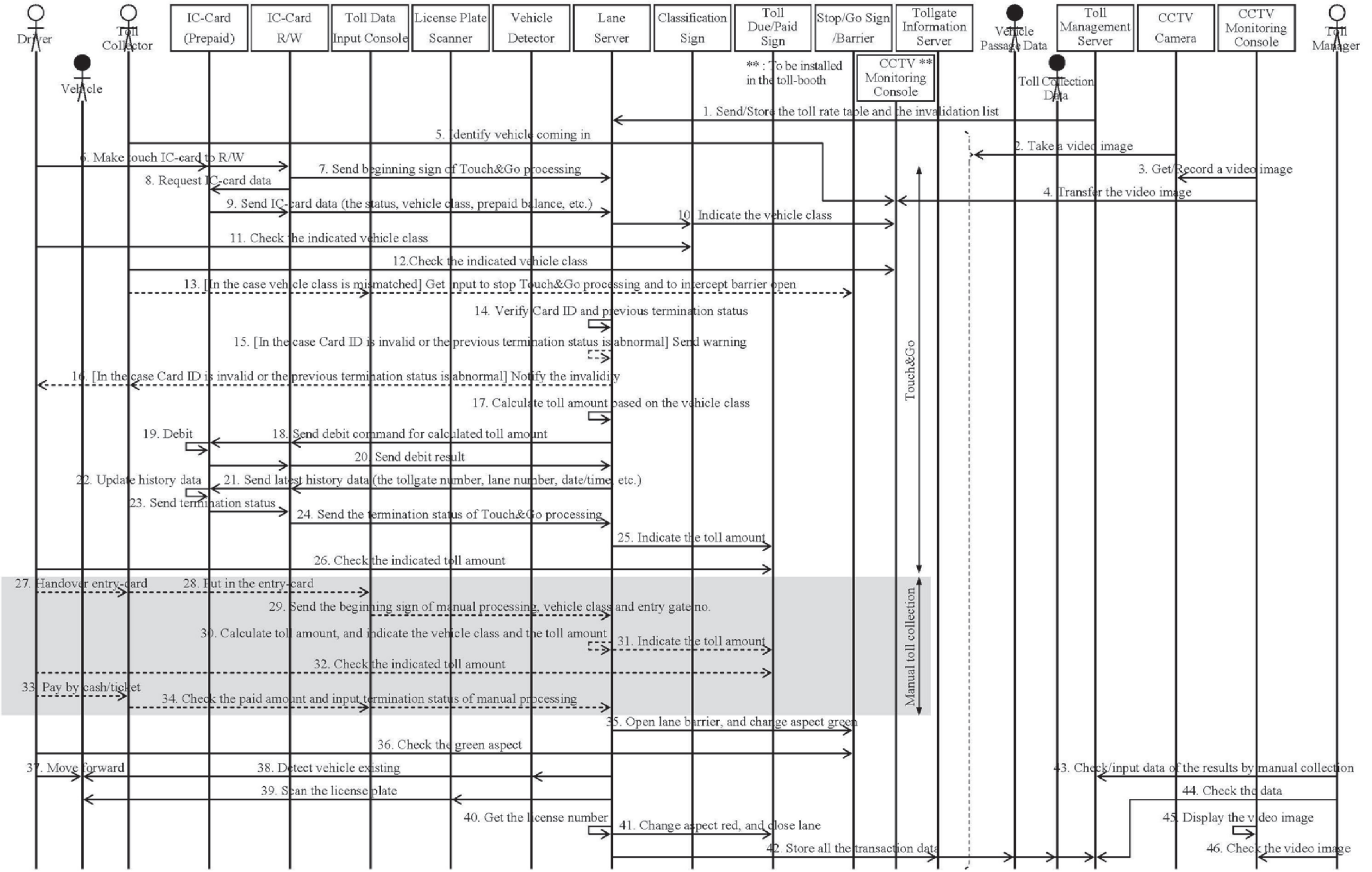
The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.23 Toll Collection: 6-(a) by Touch&Go/Manual (1)



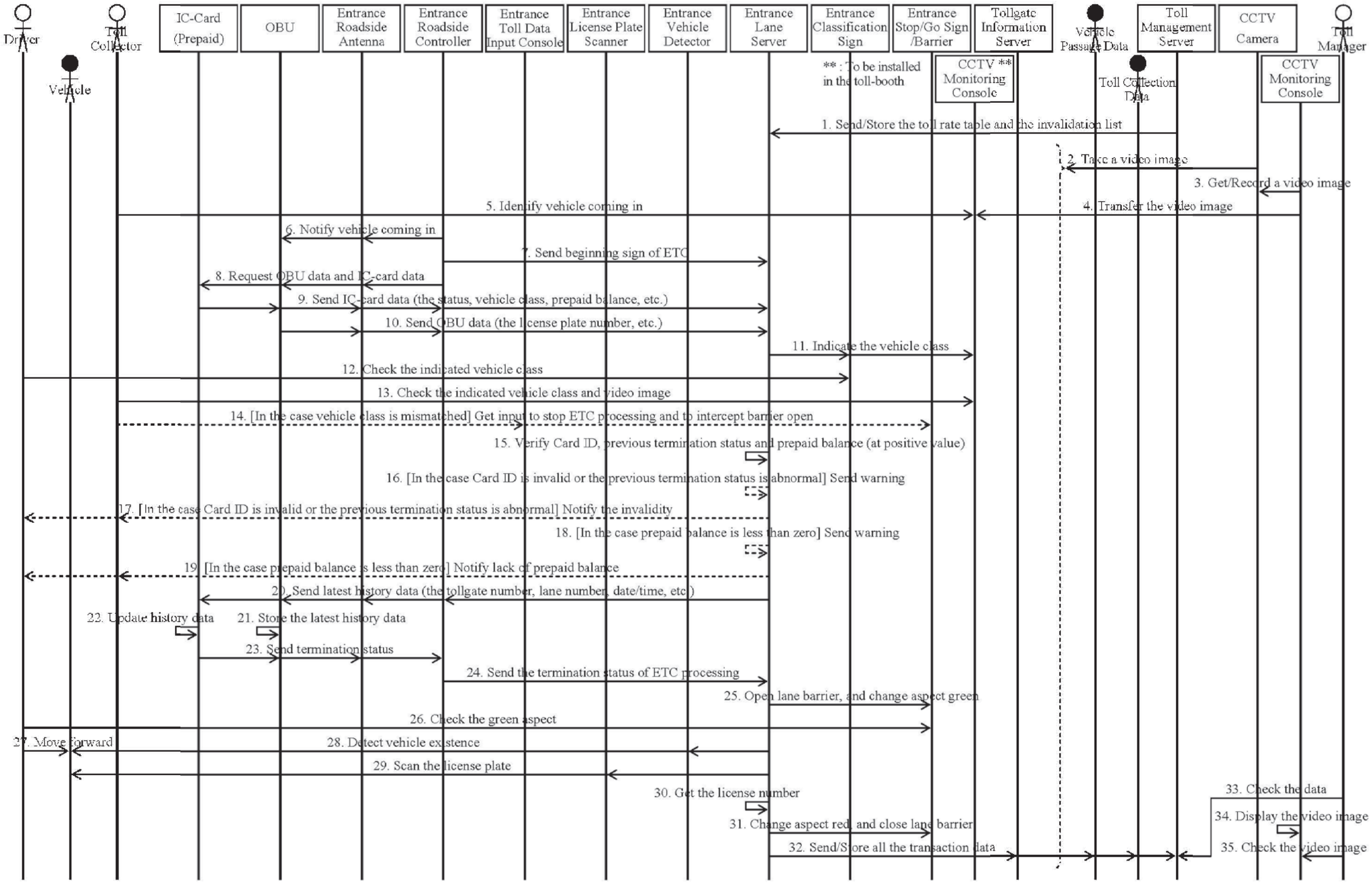
Source: The Study Team

Figure 3.24 Toll Collection: 6-(a) by Touch&Go/Manual (2)



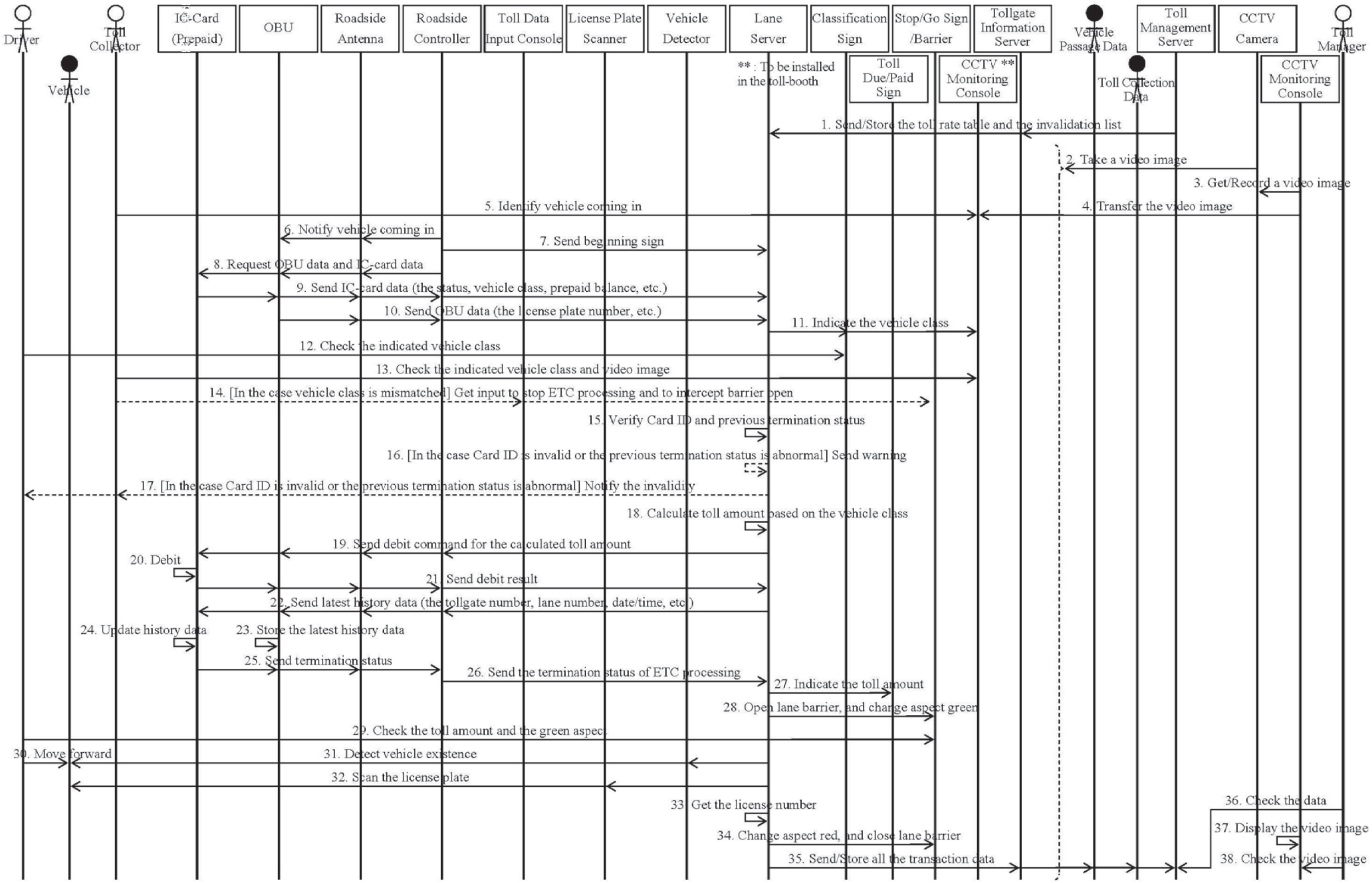
Source: The Study Team

Figure 3.25 Toll Collection: 6-(b) by ETC at Toll-island (2p-OBU) (1)



Source: The Study Team

Figure 3.26 Toll Collection: 6-(b) by ETC at Toll-island (2p-OBU) (2)

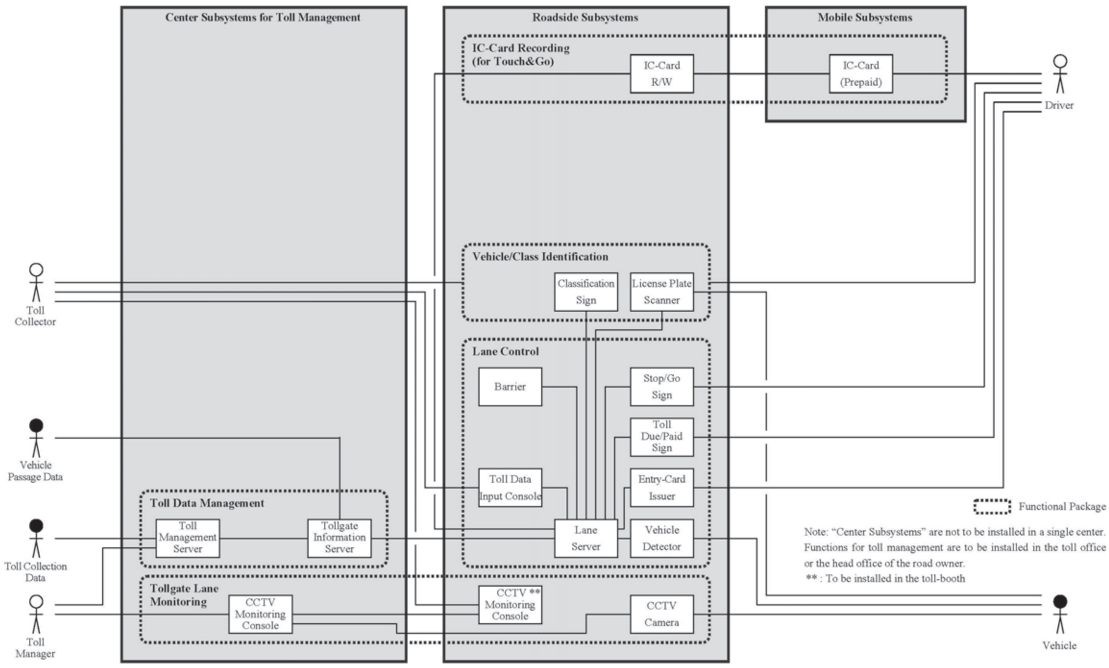


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagrams (CD) for toll collection are derived respectively from the Sequence Diagrams foregoing.

Figure 3.27 6-(a) Toll Collection by Touch&Go/Manual
(Graded as "Useful as a Complement")

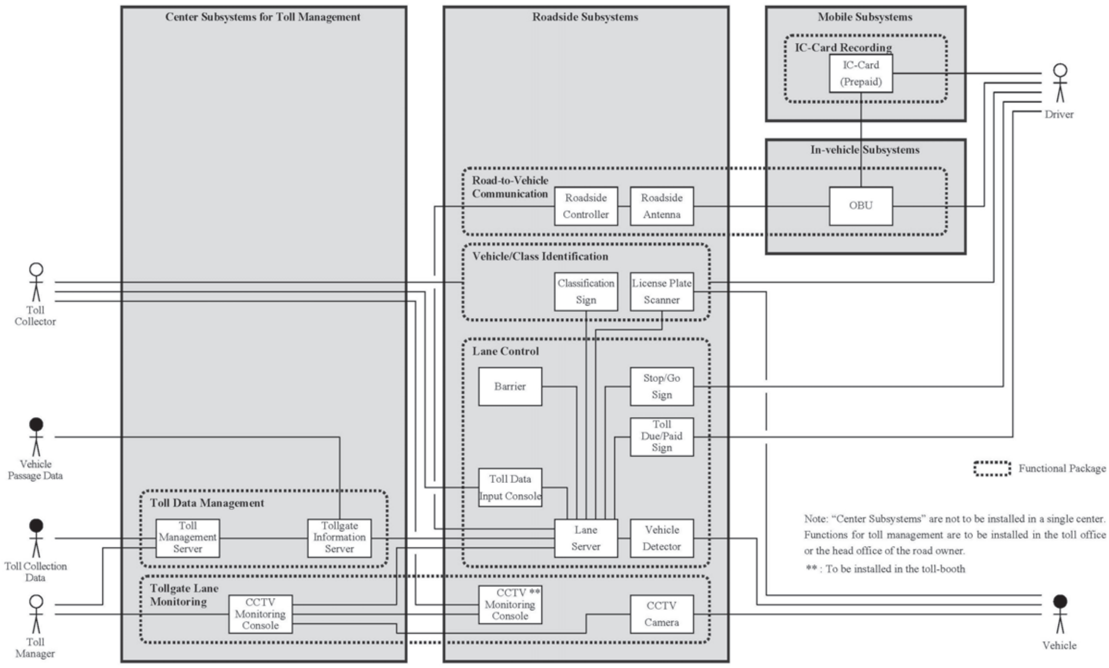


Functions & Installation: 6-(a) by Touch&Go/Manual		
Functional Package	Equipment Component	Installation
IC-card Recording	IC-card R/W	Roadside
	IC-card (Prepaid)	Mobile
Vehicle/Class Identification	License Plate Scanner	Roadside
	Classification Sign	Roadside
Lane Control	Lane Server	Roadside
	Toll Data Input Device	Roadside
	Toll Due/Paid Sign	Roadside
	Entry-card Issuer	Roadside
	Stop/Go Sign	Roadside
	Barrier	Roadside
	Vehicle Detector	Roadside
Toll Data Management	Toll Management Server	Toll Management Center **
	Tollgate Information Server	Toll Management Center **
Tollgate Lane Monitoring	CCTV Monitoring Console	Toll Management Center **
	CCTV Monitoring in Booth	Roadside
	CCTV Camera	Roadside

Note, ** : Actual installation place can be changed to Toll Office.

Source: The Study Team

Figure 3.28 6-(b) Toll Collection by ETC at Toll Island (2-piece Type OBU) (Graded as "Recommended")



Functions & Installation: 6-(b) by ETC at Toll-island (2-piece Type OBU)		
Functional Package	Equipment Component	Installation
Road-to-Vehicle Communication	Roadside Controller	Roadside
	Roadside Antenna	Roadside
	OBU	In-vehicle
IC-card Recording	IC-card (Prepaid)	Mobile
Vehicle/Class Identification	License Plate Scanner	Roadside
	Classification Sign	Roadside
Lane Control	Lane Server	Roadside
	Toll Data Input Device	Roadside
	Toll Due/Paid Sign	Roadside
	Stop/Go Sign	Roadside
	Barrier	Roadside
	Vehicle Detector	Roadside
Toll Data Management	Toll Management Server	Toll Management Center **
	Tollgate Information Server	Toll Management Center **
Tollgate Lane Monitoring	CCTV Monitoring Console	Toll Management Center **
	CCTV Monitoring in Booth	Roadside
	CCTV Camera	Roadside

Note, ** : Actual installation place can be changed to Toll Office.

Source: The Study Team

3.9 Vehicle Weighing (For reference)

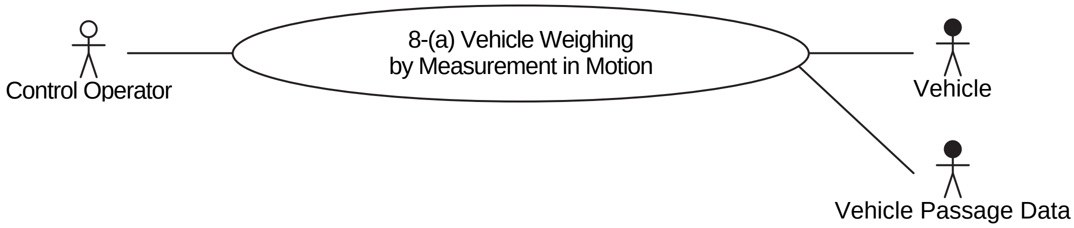
1) Service Descriptions and Use Cases

< from the 1st Stage >

- Weighing heavy trucks with/without stopping them,
- Identification of illegally loading (including/excluding the vehicle weight according to the standardization),
- Assist the regulation of illegally loading (according to the standardized procedure of the standalone method to weigh/reject the overloaded trucks at roadside, or of the online method to store overloading records in the negative database for the penalty later on).

The following two alternatives of Use Case are to be considered in the discussion.

Figure 3.29 Alternatives of Use Case for Vehicle Weighing

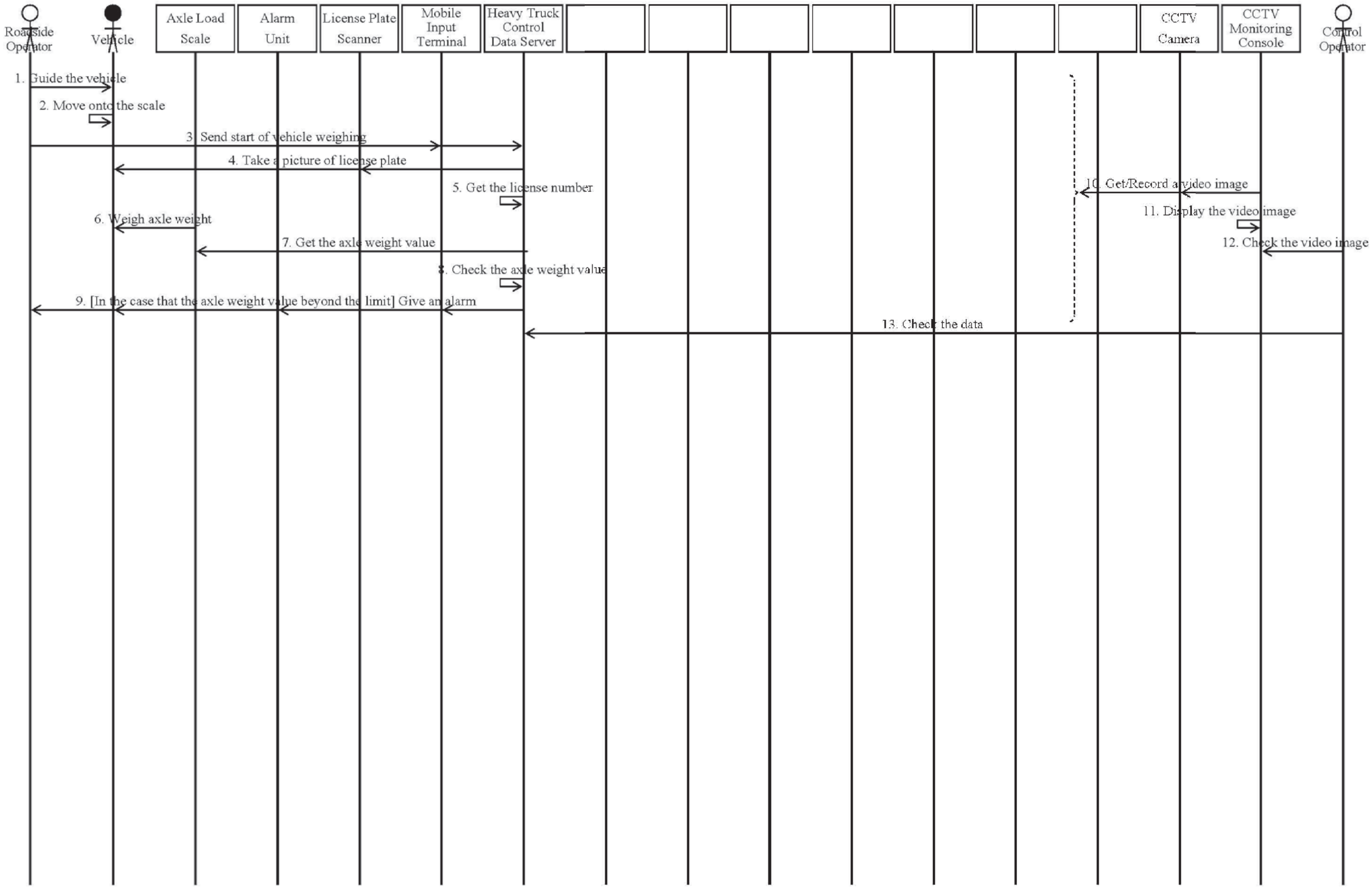


Source: VITRANSS2 Study Team

2) Sequence Diagram

The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.30 Vehicle Weighing: 8-(a) by Measurement in Motion

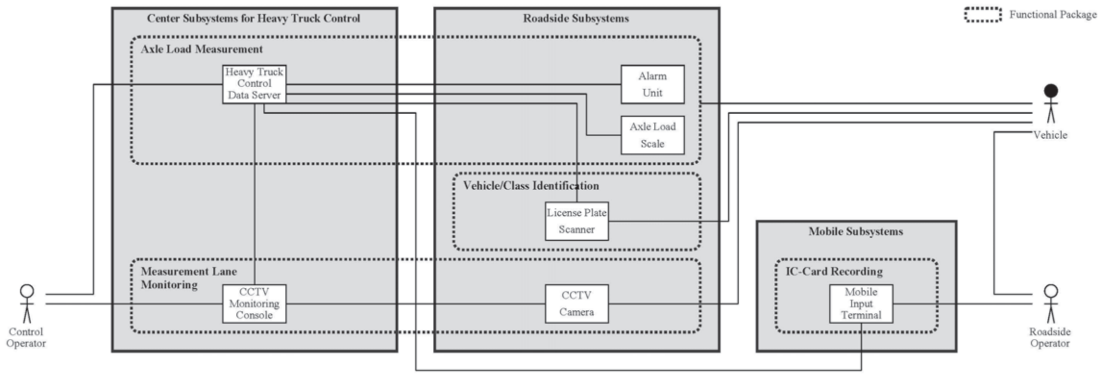


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagrams (CD) for vehicle weighing are derived respectively from the Sequence Diagrams foregoing.

Figure 3.31 8-(a) Vehicle Weighing by Measurement in Motion
(Graded as "Recommended")



Functions & Installation: 8-(a) by Measurement in Motion		
Functional Package	Equipment Component	Installation
Axle Load Measurement	Heavy Truck Control Data Server	Heavy Truck Control Center **
	Axle Load Scale	Roadside
	Alarm	Roadside
Vehicle/Class Identification	License Plate Scanner	Roadside
Measurement Lane Monitoring	CCTV Monitoring Console	Heavy Truck Control Center **
	CCTV Camera	Roadside

Note, ** : Actual installation place can be changed to Toll Office.

Source: The Study Team

3.10 Center-to-center Data Exchange

1) Service Descriptions and Use Cases

9-1 Center-to-center Data Exchange for Incident Notification

< from the 1st Stage >

- Round-the-clock information reception of incident occurrence/situation/place at the traffic information/control center from the traffic police operation center,
- Round-the-clock prompt information provision of incident occurrence/situation/place from the traffic information/control center to the traffic police operation center and the emergency vehicle operation center.

< from the 2nd Stage >

- Provision of weather information from the traffic information/ control center to the traffic police operation center and the emergency vehicle operation center.

9-2 Center-to-center Data Exchange for Traffic Information

< from the 1st Stage >

- Provision of traffic information (including incident, congestion and restriction) from the traffic information/control center to the traffic police operation center, the information provider center and the TV/Radio broadcasting center.

< from the 3rd Stage >

- Provision of congestion forecast information from the traffic information/control center to the traffic police operation center, the information provider center and the TV/Radio broadcasting center.

9-3 Center-to-center Data Exchange for Toll Settlement **(For Reference)**

< from the 1st Stage >

- Toll settlement to be prepared for many different road operators over the whole expressways and other toll roads
- Toll settlement by using contact-less IC-card for prepayment,
- Issue/recharge of contact-less IC-card to be utilized conveniently in the city as well as the roadside,
- Adequate data exchange for toll settlement between the toll management center of the road operator and the prepayment service center such as the center of the bank,
- Appropriate and reliable apportionment of the toll revenue among the road operators preventing unfair billings to the prepayment service center for establishing the sustainable toll settlement system,
- Stepwise establishment of the toll settlement system for enhancing convenience for the users.

9-4 Center-to-center Data Exchange for IC-card Operation **(For Reference)**

< from the 1st Stage >

- Storage of the IC-card issue/recharge data in the prepayment service center for prevention of illegal recharge,
- Reception of the notification of lost IC-card from the user to the prepayment service center,

- Transmission of the lost IC-card list from the prepayment service center to the toll management centers of the road operators (through the clearing center) for invalidating the lost IC-card over the whole expressways and other toll roads.

9-5 Center-to-center Data Exchange for OBU Management (For Reference)

< from the 1st Stage >

- Storage of the OBU registration data in the center, which is transferred from the OBU shop where OBU is issued to the user and installed in the vehicle,
- Reception of the notification of lost OBU from the user to the OBU registration center,
- Transmission of the lost OBU list from the OBU registration center to the toll management centers of the road operators for invalidating the lost OBU over the whole expressways and other toll roads.

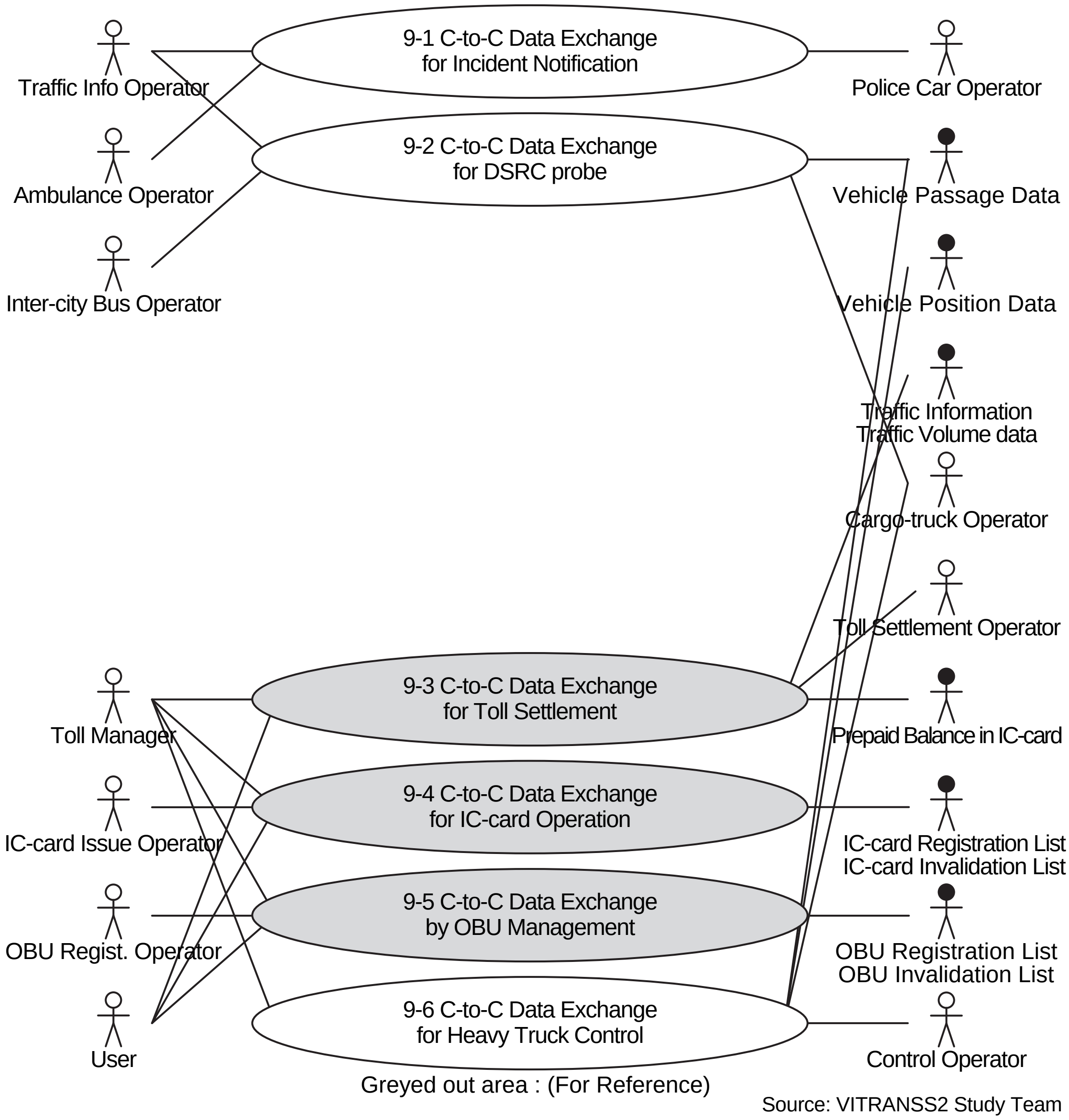
9-6 Center-to-center Data Exchange for Heavy Truck Control (For Reference)

< from the 2nd Stage >

- Actual positioning data of the heavy/hazmat (hazardous-material) trucks generated in the centers of DSRC probe and GPS/WL probe,
- Provision of the positioning data to the centers of heavy truck control and cargo-truck operation.

The nine Use Cases responding to the service descriptions above are to be considered in the discussion.

Figure 3.32 Use Case for Center-to-center Data Exchange



Source: VITRANSS2 Study Team

2) Sequence Diagram

The Sequence Diagram (SD) of the Use Cases above are shown in the following pages.

Figure 3.33 C-to-C Data Exchange: 9-1 for Incident Notification

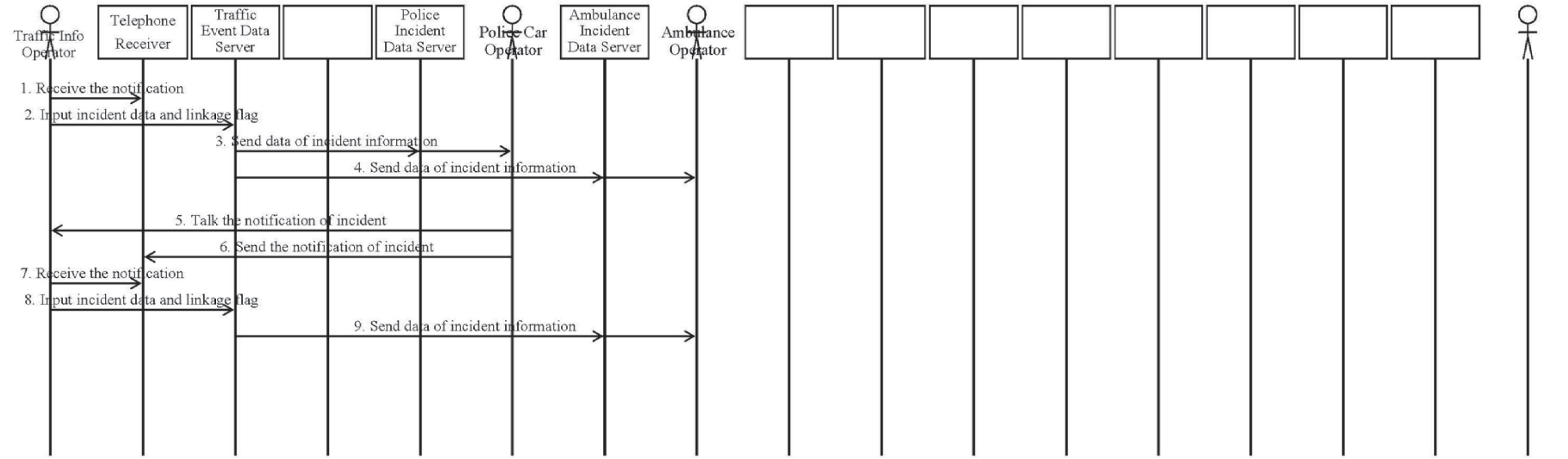
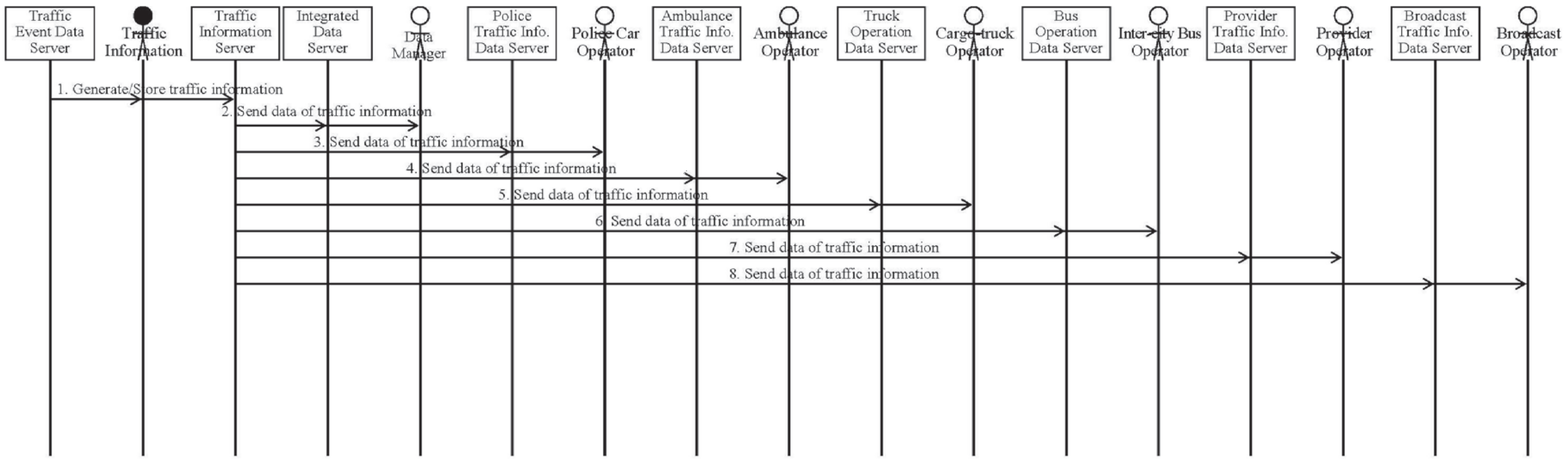
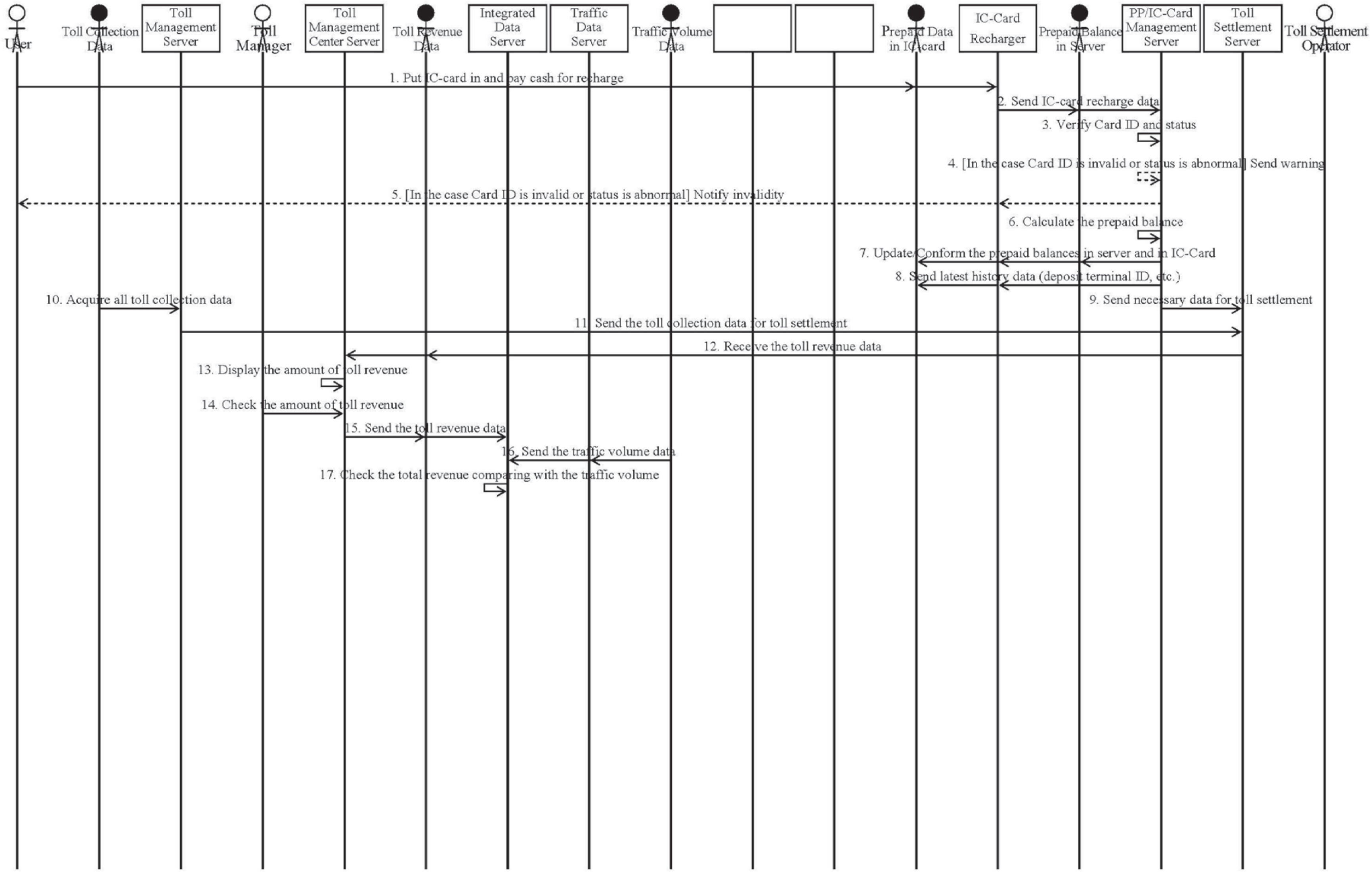


Figure 3.34 C-to-C Data Exchange: 9-2 for Traffic Information



Source: The Study Team

Figure 3.35 C-to-C Data Exchange: 9-3 for Toll Settlement (For Reference)



Source: The Study Team

Figure 3.36 C-to-C Data Exchange: 9-4 for IC-card Operation (For Reference)

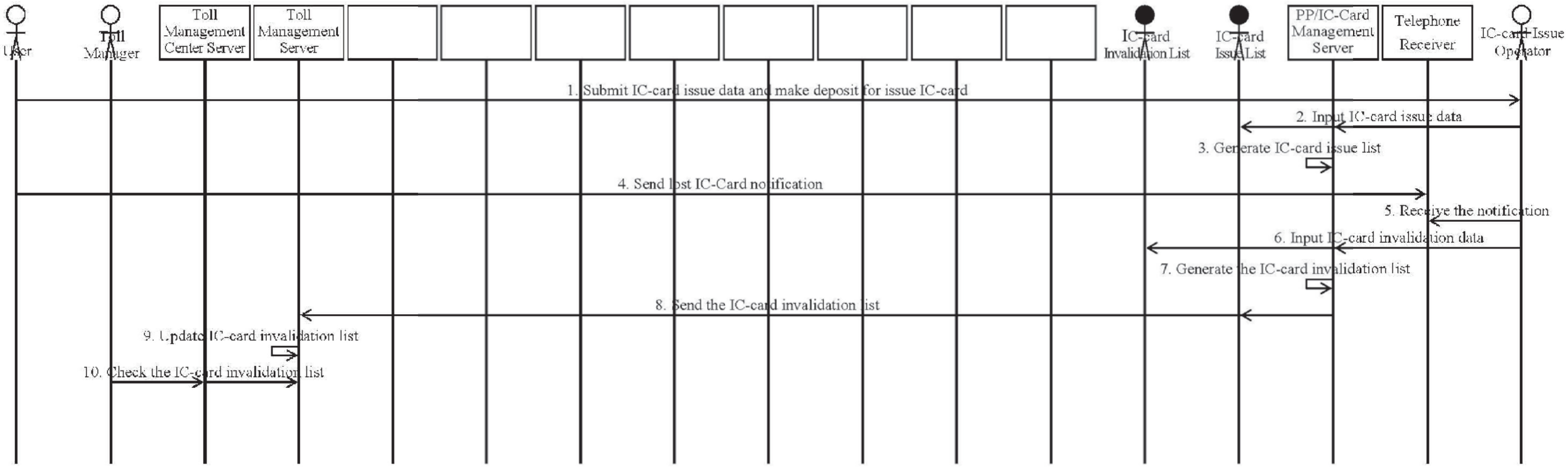
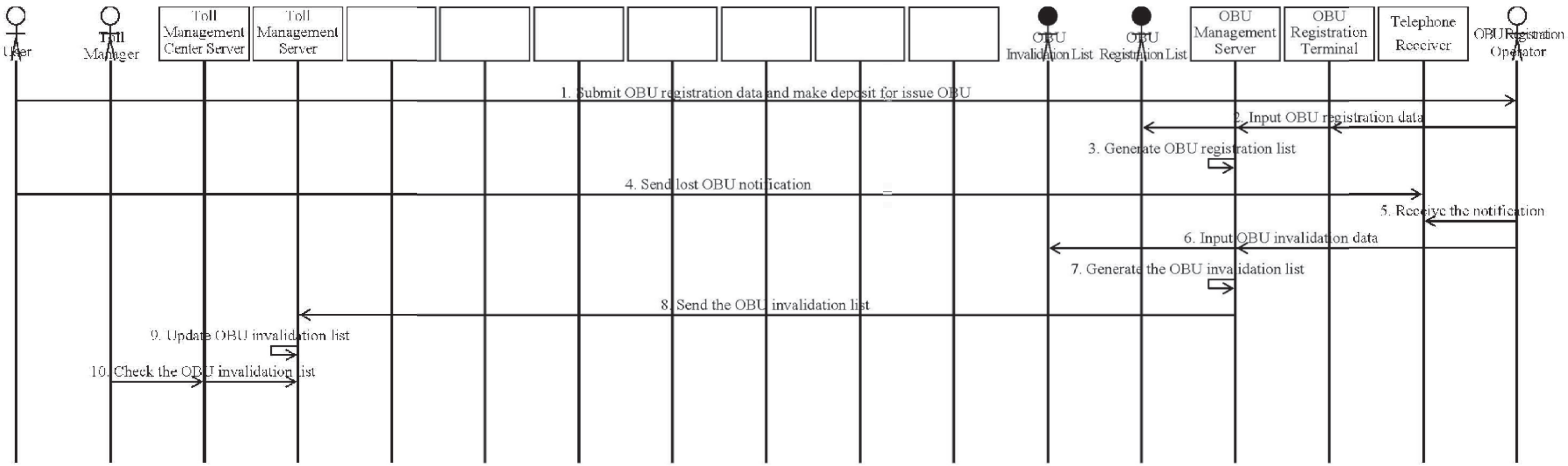
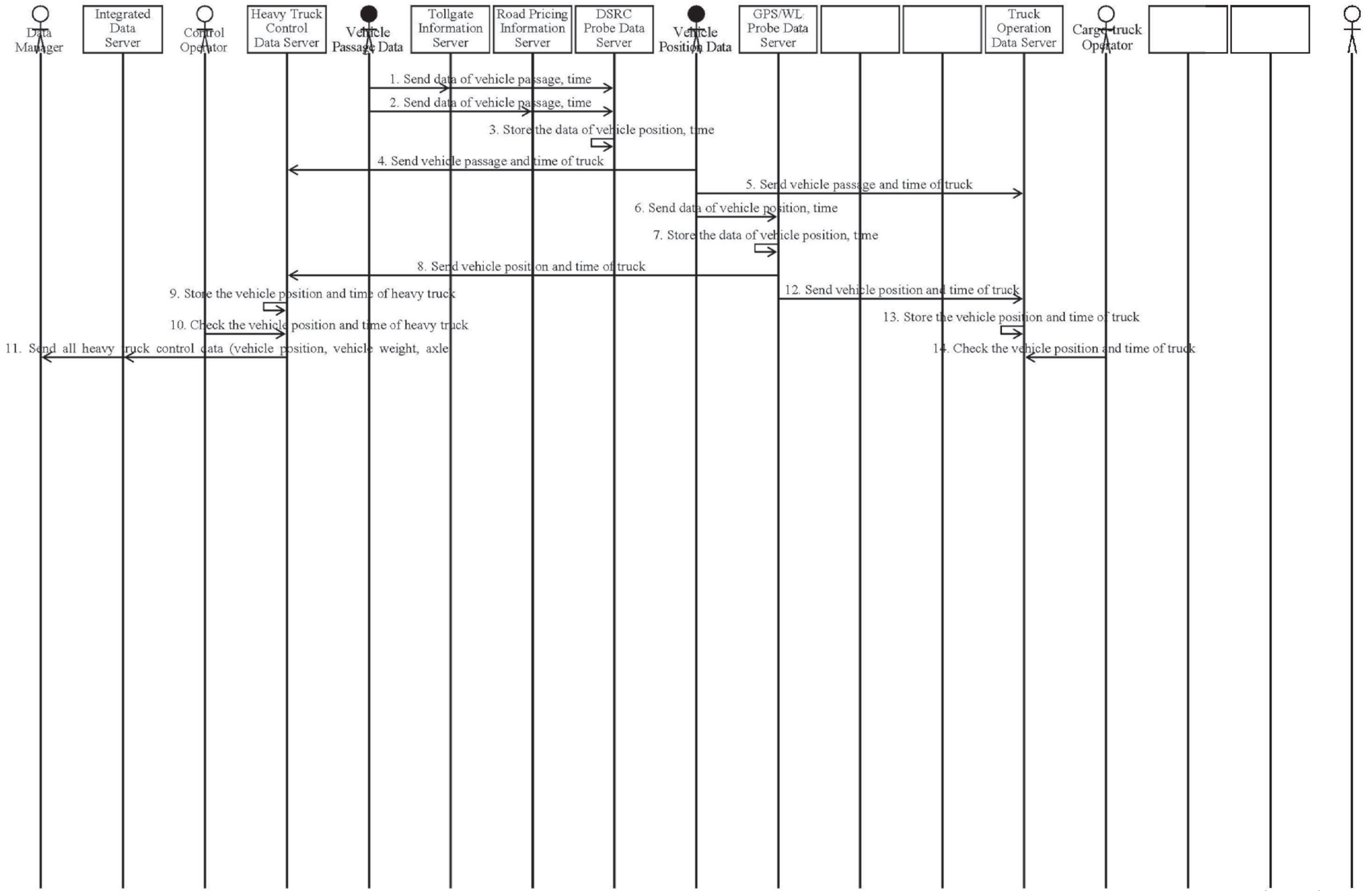


Figure 3.37 C-to-C Data Exchange: 9-5 for OBU Management (For Reference)



Source: The Study Team

Figure 3.38 C-to-C Data Exchange: 9-6 for Heavy Truck Control (For Reference)

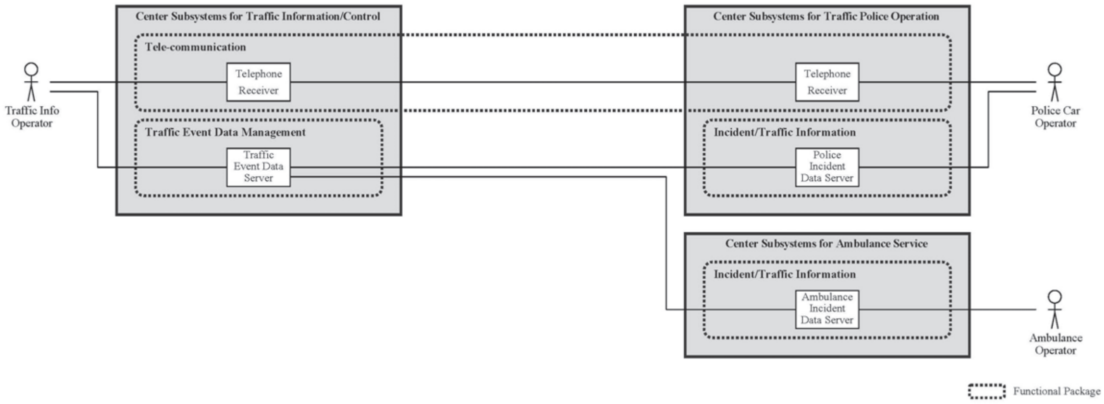


Source: The Study Team

3) Collaboration Diagram with Functions/Installation

The Collaboration Diagrams (CD) for center-to-center data exchange are derived respectively from the Sequence Diagrams foregoing.

Figure 3.39 9-1 Center-to-center Data Exchange for Incident Notification (Graded as "Necessary")

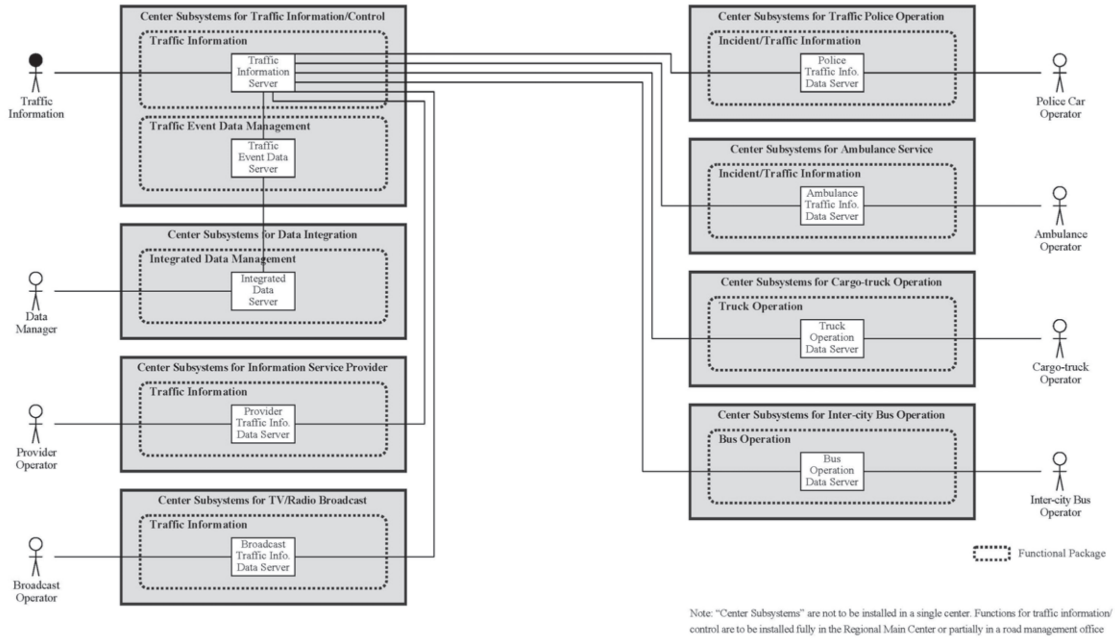


Functions & Installation: 9-1 for Incident Notification		
Functional Package	Equipment Component	Installation
Tele-communication	Telephone Receiver	Traffic Information/Control Center **
	Telephone Receiver	Traffic Police Operation Center
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
Incident/Traffic Information	Police Incident Data Server	Traffic Police Operation Center
Incident/Traffic Information	Ambulance Incident Data Server	Ambulance Service Center

Note, ** : Actual installation place can be Regional Main Center and/or Road Management Office.

Source: The Study Team

Figure 3.40 9-2 Center-to-center Data Exchange for Traffic Information (Graded as "Necessary")

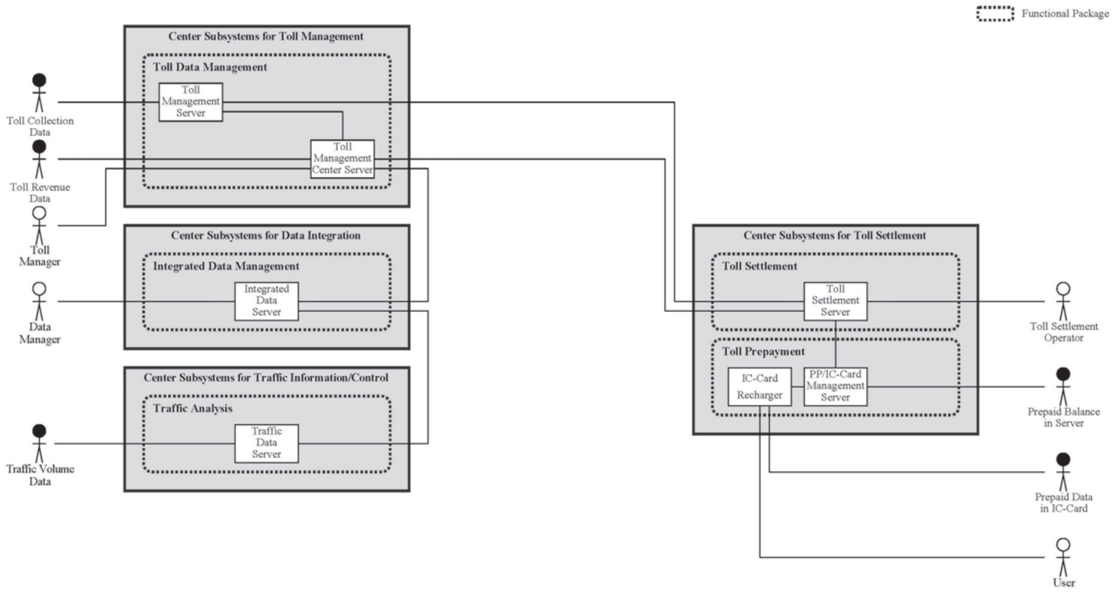


Functions & Installation: 9-2 for Traffic Information		
Functional Package	Equipment Component	Installation
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center **
Traffic Information	Traffic Information Server	Traffic Information/Control Center **
Integrated Data Management	Integrated Data Server	Data Integration Center ***
Incident/Traffic Information	Police Traffic Info. Data Server	Traffic Police Operation Center
Incident/Traffic Information	Ambulance Traffic Info. Data Server	Ambulance Service Center
Traffic Information	Provider Traffic Info. Data Server	Information Service Provider Center
Traffic Information	Broadcast Traffic Info. Data Server	TV/Radio Broadcast Center
Truck Operation	Truck Operation Data Server	Cargo-truck Operation Center
Bus Operation	Bus Operation Data Server	Inter-city Bus Operation Center

Note, ** : Actual installation place can be Regional Main Center.
*** : Actual installation place can be an office of Governmental Organization.

Source: The Study Team

Figure 3.41 9-3 Center-to-center Data Exchange for Toll Settlement (Graded as "Necessary": For Reference)



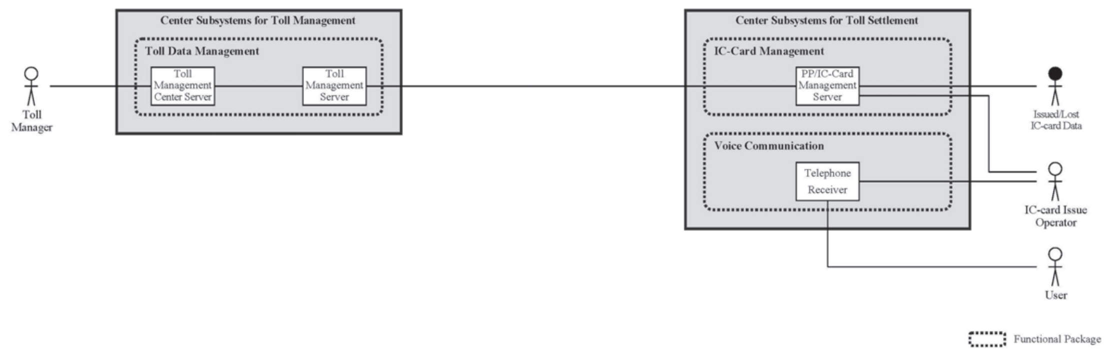
Note: "Center Subsystems" are not to be installed in a single center. Functions for traffic information/ control are to be installed fully in the Regional Main Center or partially in a road management office Functions for toll management are to be installed in the toll office or the head office of the road owner.

Functions & Installation: 9-3 for Toll Settlement		
Functional Package	Equipment Component	Installation
Toll Data Management	Toll Management Center Server	Toll Management Center
	Toll Management Server	Toll Management Center **
Integrated Data Management	Integrated Data Server	Data Integration Center ***
Traffic Event Data Management	Traffic Event Data Server	Traffic Information/Control Center ****
Toll Settlement	Toll Settlement Server	Toll Settlement Center *****
Toll Payment	PP/IC-card Management Server	Toll Settlement Center *****
	IC-card Recharger	Toll Settlement Center *****

Note, ** : Actual installation place can be changed to Toll Office
*** : Actual installation place can be an office of Government Organization
**** : Actual installation place can be Regional Main Center
***** : Actual installation place can be an office of Bank.

Source: The Study Team

Figure 3.42 9-4 Center-to-center Data Exchange for IC-card Operation
(Graded as "Necessary" : For Reference)

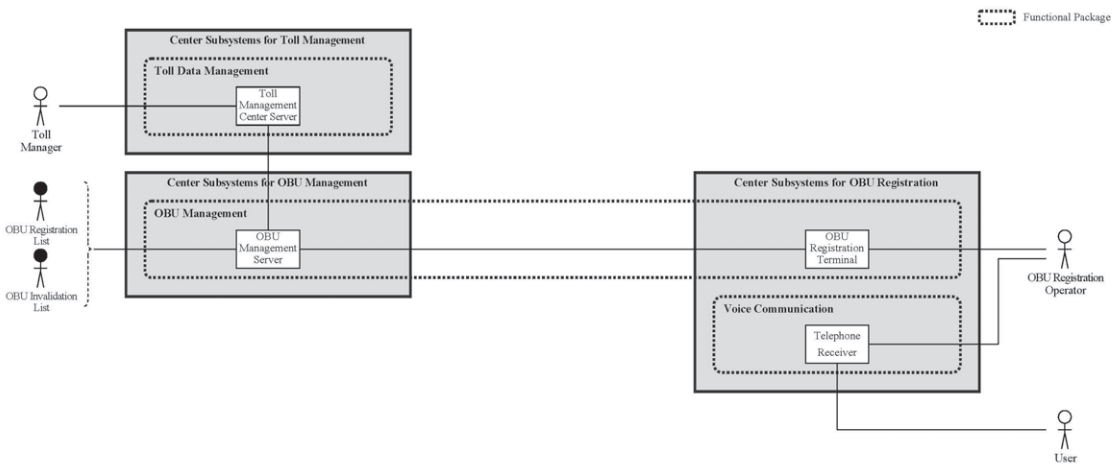


Functions & Installation: 9-4 for IC-card Operation		
Functional Package	Equipment Component	Installation
Toll Data Management	Toll Management Center Server	Toll Management Center
	Toll Management Server	Toll Management Center **
Toll Settlement	Toll Settlement Server	Toll Settlement Center ***
Tele-communication	Telephone Receiver	Toll Settlement Center ***

Note, *** : Actual installation place can be an office of Bank.

Source: The Study Team

Figure 3.43 9-5 Center-to-center Data Exchange for OBU Management
(Graded as "Necessary" : For Reference)

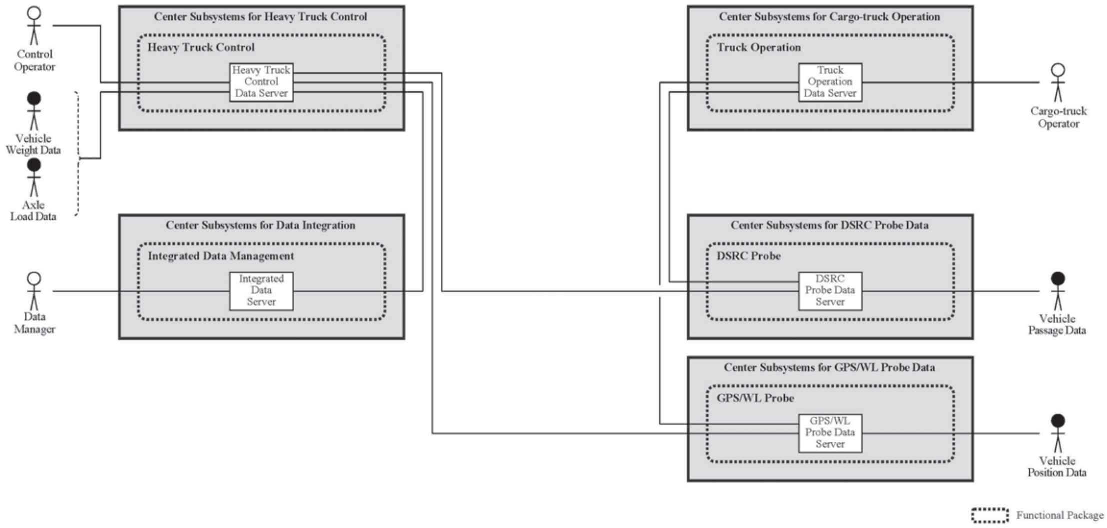


Functions & Installation: 9-5 for OBU Management		
Functional Package	Equipment Component	Installation
Toll Data Management	Toll Management Center Server	Toll Management Center
OBU Management	OBU Management Server	OBU Management Center ***
	OBU Registration Terminal	OBU Issue Office
Tele-communication	Telephone Receiver	OBU Issue Office

Note, *** : Actual installation place can be an office of Semi-governmental Organization.

Source: The Study Team

Figure 3.44 9-6 Center-to-center Data Exchange for Heavy Truck Control (Graded as "Necessary" : For Reference)



Functions & Installation: 9-6 for Heavy Truck Control		
Functional Package	Equipment Component	Installation
Heavy Truck Control	Heavy Truck Control Data Server	Heavy Truck Control Center **
Integrated Data Management	Integrated Data Server	Data Integration Center ***
DSRC Probe	DSRC Probe Data Server	DSRC Probe Data Center
GPS/WL Probe	GPS/WL Probe Data Server	GPS/WL Probe Data Center
Truck Operation	Truck Operation Data Server	Cargo-truck Operation Center

Note, ** : Actual installation place can be changed to Toll Office.
*** : Actual installation place can be an office of Government Organization.

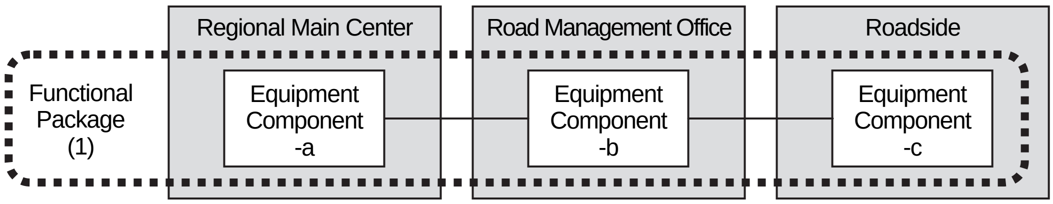
Source: The Study Team

4. Functional Package

4.1 General

Each implementation package consists of several functional packages which are indicated by using in Collaboration Diagrams of the system architecture in the foregoing chapter. As is evident from the diagrams, each functional package consists of several equipment components which can be installed separately in different locations and operated/managed by different organizations. However, independently from such condition, it is important to fulfill the specifications defined totally for all equipment components in each functional package in order to achieve its required function.

Figure 4.1 Functional Package



The functional packages for the Priority ITS User Services are shown in the table below. Based on the functional packages, the roles of organizations for implementing/operating/ maintaining ITS are to be discussed, the quantities required for the Project are to be calculated and the costs are to be estimated.

Table 4.1 List of Functional Packages

	Functional Packages
Traffic Information/Control	(1) Voice Communication
	(2) CCTV Monitoring
	(3) Event Detection (by Image)
	(4) Vehicle Detection
	(5) Traffic Analysis
	(6) Weather Monitoring
	(7) Traffic Event Data Management
	(8) Traffic Supervision
	(9) VMS Indication
	(10) Mobile Radio Communication
	(11) Traffic Information
	(12) Integrated Data Management
Non-stop Toll Collection	(13) Tollgate Lane Monitoring
	(14) Vehicle/Class Identification
	(15) Lane Control
	(16) Road-to-Vehicle Communication
	(17) IC-card Recording
	(18) Toll Data Management
	(19) OBU Management
Heavy Truck Control	(20) Axle Load Measurement
	(21) Measurement Lane Monitoring

Note: Greyed out area is "For Reference".
Source: The Study Team

These twenty-one functional packages are corresponding to the ITS user services and the implementation packages aforementioned as shown in the following table.

Figure 4.2 Correspondence of Functional Packages to User Services and Implementation Packages

User Service	Implementation Package	Functional Package	Physical System
Logical Discussion using UML based on ITS Master Plan			**(Design-build)**
➢ Service Descriptions ➢ Road Map	➢ Service Descriptions ➢ System Architecture (on Logical Equipment Components) • Sequence Diagram • Collaboration Diagram	➢ System Architecture (on Logical Equipment Components) • Sequence Diagram • Collaboration Diagram ➢ Performance Specifications ➢ Messages/Data ➢ Communication System Plan	➢ System Architecture (on Physical Devices) ➢ Specifications ➢ Messages/Data ➢ Communication System Plan
1. Traffic Information/Control	1. Incident Information	(1) Voice Communication	1. Traffic Information/ Control System
		(2) CCTV Monitoring	
		(7) Traffic Event Data Management	
		(8) Traffic Supervision	
		(9) VMS Indication	
	2. Traffic Congestion Information	(2) CCTV Monitoring	
		(3) Event Detection (by Image)	
		(4) Vehicle Detection	
		(5) Traffic Analysis	
		(7) Traffic Event Data Management	
		(8) Traffic Supervision	
		(9) VMS Indication	
	3. Travel-time Information		
	4. Weather Information	(6) Weather Monitoring	
		(7) Traffic Event Data Management	
		(8) Traffic Supervision	
		(9) VMS Indication	
	5. Traffic Control Assistance	(1) Voice Communication	
		(7) Traffic Event Data Management	
		(8) Traffic Supervision	
		(9) VMS Indication	
		(10) Mobile Radio Communication	
	6. Center-to-Center Data Exchange	(1) Voice Communication	
		(11) Traffic Information	
		(12) Integrated Data Management	
2. Nonstop Toll Collection (For Reference)	7. Toll Collection/Management	(13) Tollgate Lane Monitoring	2. Automated Toll Collection/ Management System
		(14) Vehicle/Class Identification	
		(15) Lane Control	
		(16) Road-to-Vehicle Communication	
		(17) IC-card Recording	
		(18) Toll Data Management	
	8. Center-to-Center Data Exchange	(12) Integrated Data Management	
		(18) Toll Data Management	
		(19) OBU Management	
3. Heavy Truck Control	9. Vehicle Weighing	(20) Axle Load Measurement	3. Vehicle Weighing System
		(21) Measurement Lane Monitoring	
	10. Heavy/Hazmat Truck Tracking		
	11. Center-to-Center Data Exchange	(12) Integrated Data Management	
4. Inter-city Bus Assistance			
5. Convenient Parking Assistance			
6. Road Pricing			

: Undefined items, Light-colored texts : Redundant items

Source: The Study Team

The twenty-one functional packages, which details are to be shown in the following, are to be installed in the locations shown below.

Table 4.2 Installation Location of Functional Packages

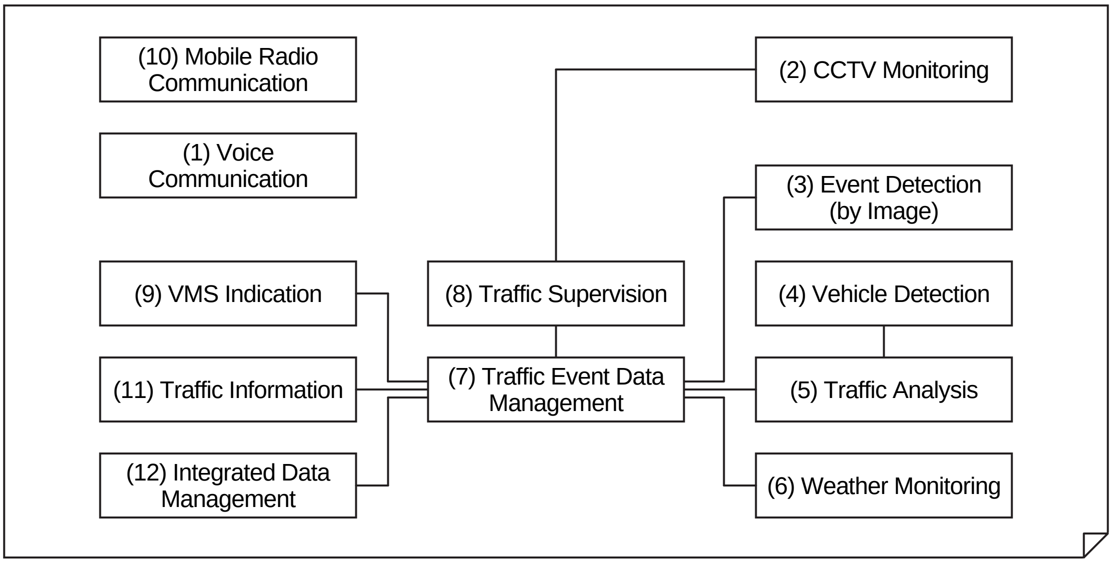
Functional Packages		Center Subsystem					Roadside Subsystem	On-board Subsystem	Mobile Subsystem	In-door Subsystem
		Regional Main Center	Road Management Office	Toll Office	Road Owner's Head Office	OBU Registration Office				
1	Voice Communication	XX	XX	XX			XX			
2	CCTV Monitoring	XX	XX				XX			
3	Event Detection (by Image)						XX			
4	Vehicle Detection						XX			
5	Traffic Analysis	XX								
6	Weather Monitoring	XX					XX			
7	Traffic Event Management	XX	XX							
8	Traffic Supervision	XX								
9	VMS Indication	XX					XX			
10	Mobile Radio Communication		XX				XX		XX	
11	Traffic Information	XX								XX
12	Integrated Data Management	XX		XX	XX					
13	Tollgate Lane Monitoring			XX			XX			
14	Vehicle/Class Identification						XX			
15	Lane Control						XX			
16	Road-to-Vehicle Communication						XX	XX		
17	IC-card Recording						XX		XX	XX
18	Toll Data Management			XX	XX					
19	OBU Management					XX				XX
20	Axle Load Measurement						XX			
21	Measurement Lane Monitoring			XX						

Note: Greyed out area is "For Reference".

Source: The Study Team

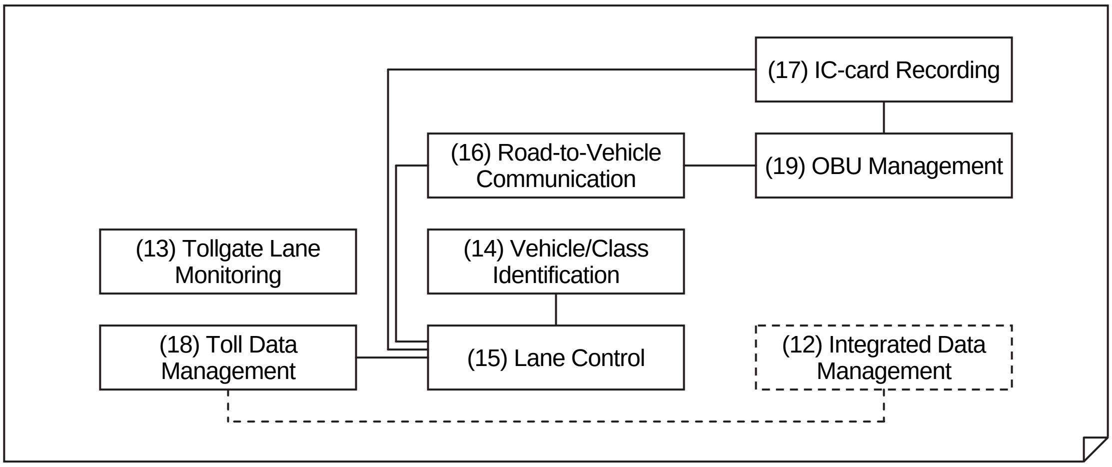
The system for traffic information/control, toll collection/management and vehicle weighing are composed respectively of the twelve, seven and two Functional Packages with the connections (or relations) shown in the following figures. Additionally, the system architectures of respective Functional Packages are shown in the following sections.

Figure 4.3 Function Configuration for Traffic Information/Control



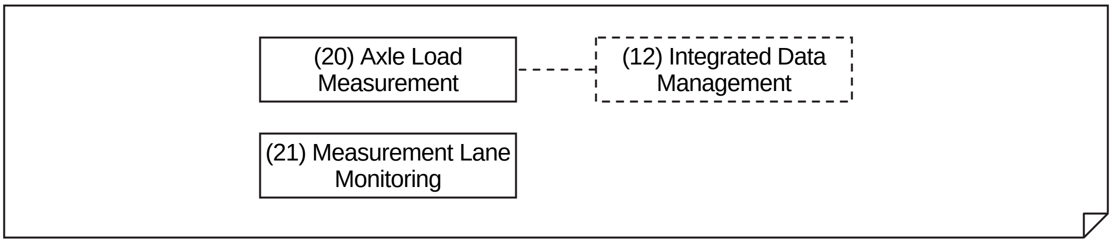
Source: The Study Team

Figure 4.4 Function Configuration for Non-stop Toll Collection (For Reference)



Source: The Study Team

Figure 4.5 Function Configuration for Heavy Truck Control (For Reference)



Source: The Study Team

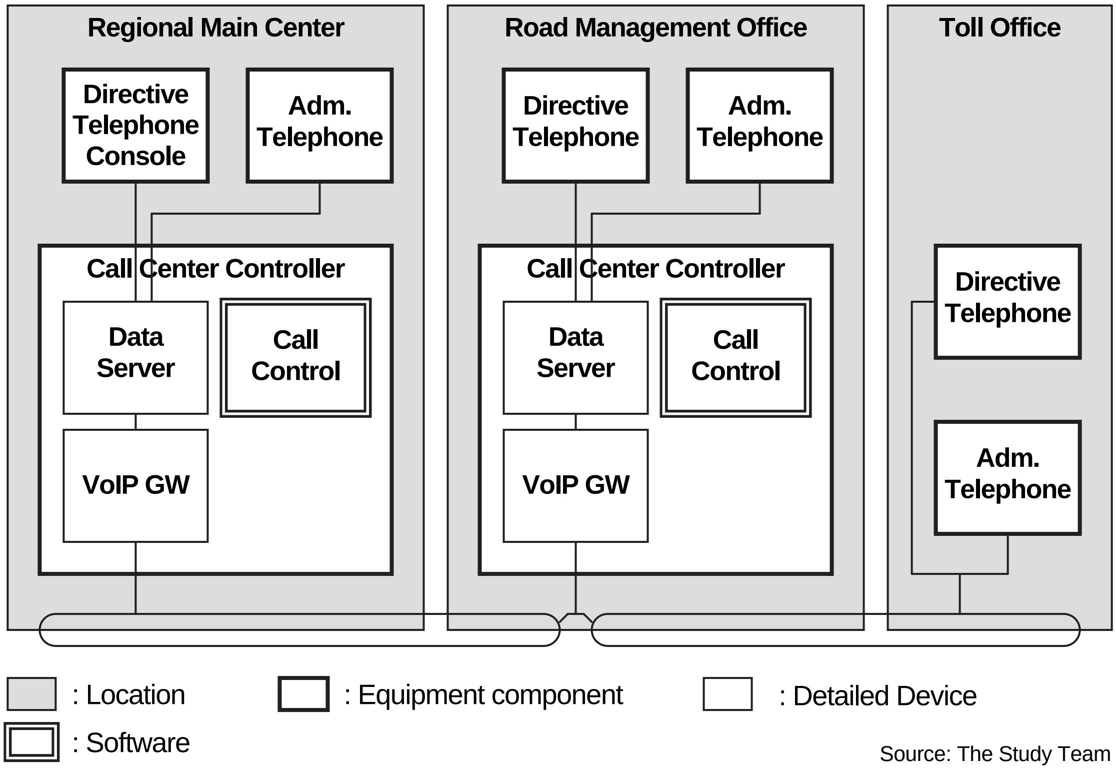
4.2 Traffic Information/Control

1) Voice Communication

This functional package that allows to send an emergency call and a request for help to the Main Centers and road management offices at an incident occurrence using telephones installed at roadsides, rest areas and tunnel sections and by administrative telephones installed at the toll management offices. It also allows instantly sending instructions to the units concerned for clearing incidents and enforcing traffic regulations.

The detailed system architecture for the functional package of voice communication is shown below.

Figure 4.6 Detailed System Architecture for Voice Communication



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Call center controller (for call control)
- Directive telephone console
- Directive telephone
- Administrative telephone.

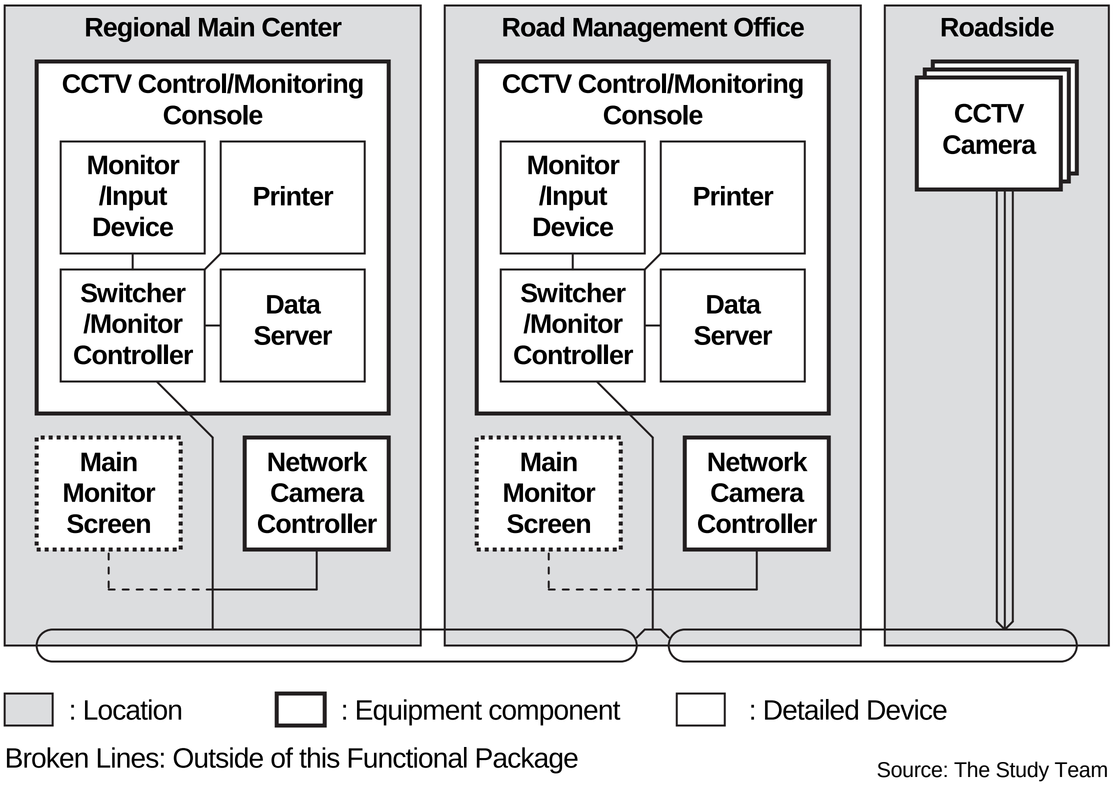
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of call controller being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

2) CCTV Monitoring

This functional package allows road operators to capture the current situation of traffic accidents, broken-down vehicles, left obstacles, driving in the reverse direction, vandalism, natural disaster and traffic conditions on the expressways and to monitor the video image at the Main Centers and road management offices by using cameras installed at road sections where traffic can get stuck easily by incidents and at long tunnel sections.

The detailed system architecture for the functional package of CCTV monitoring is shown below.

Figure 4.7 Detailed System Architecture for CCTV Monitoring



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- CCTV camera
- Network camera controller
- CCTV monitoring console.

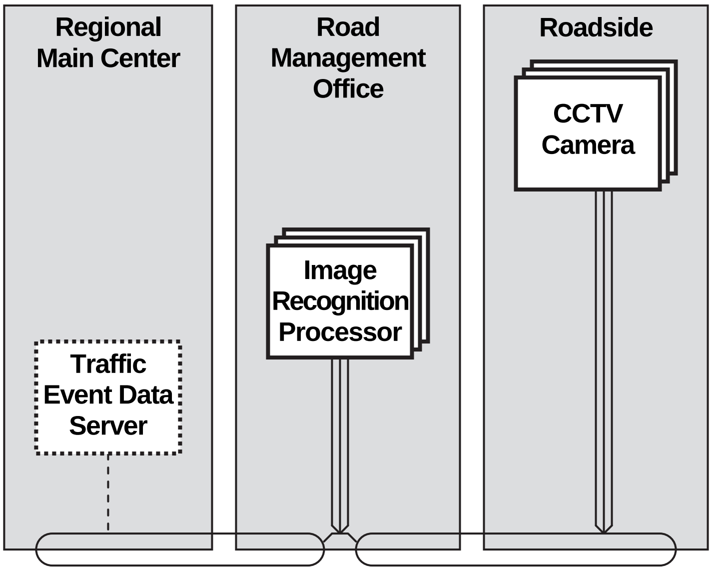
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of CCTV monitoring console being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

3) Event Detection

This functional package allows road operators to automatically recognize occurrence of traffic accidents, broken-down vehicles and left obstacles on the expressways and to send notifications to the Main Centers and road management offices by analysing video images from cameras installed at bottleneck spots where traffic can be easily stuck and at long tunnel sections.

The detailed system architecture for the functional package of event detection is shown below.

Figure 4.8 Detailed System Architecture for Event Detection



: Location : Equipment component : Detailed Device

Broken Lines: Outside of this Functional Package

Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- CCTV camera
- Image recognition processor.

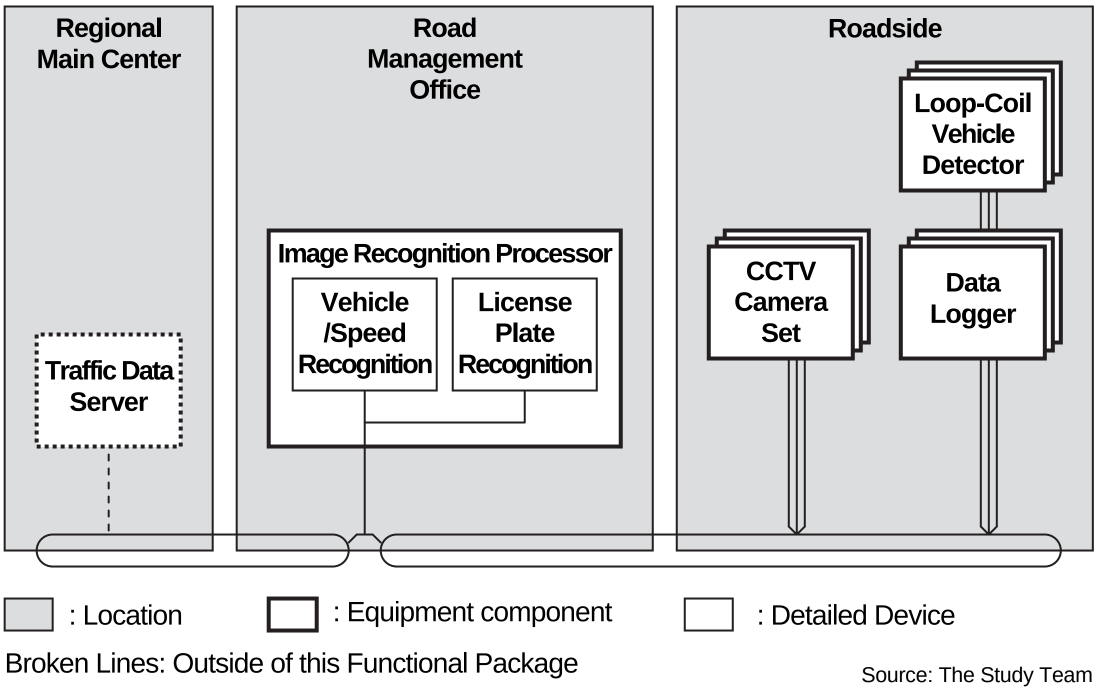
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of image recognition processor being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

4) Vehicle Detection

This functional package allows road operators to measure actual traffic volume, heavy vehicle ratio and vehicle velocity on the expressways for developing road operation/improvement plans by using vehicle detectors installed at important points on the through lanes and at the tollgates.

The detailed system architecture for the functional package of vehicle detection is shown below.

Figure 4.9 Detailed System Architecture for Vehicle Detection



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- CCTV camera set
- Image recognition processor
- Loop-coil vehicle detector
- Data logger.

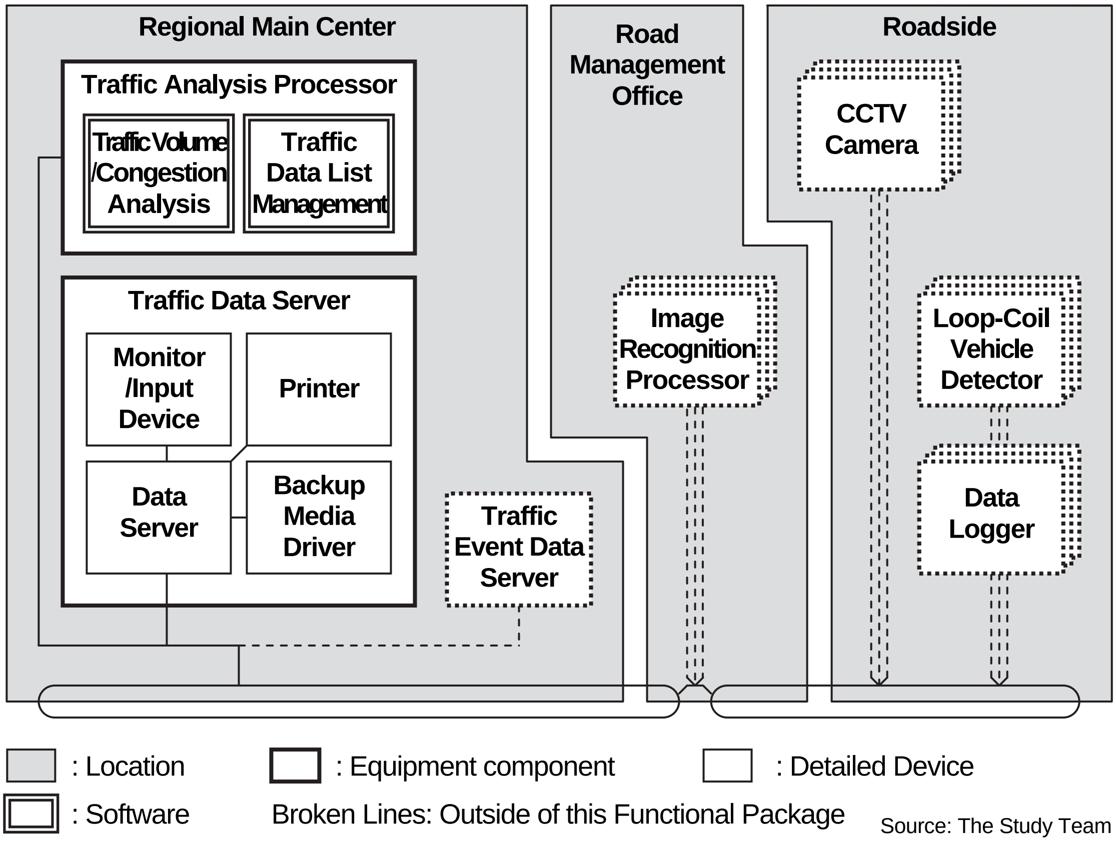
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of image recognition processor being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

5) Traffic Analysis

This functional package allows road operators to track traffic conditions on the expressways, such as crowdedness and vehicle velocity, by processing and analysing the data captured by vehicle detectors.

The detailed system architecture for the functional package of traffic analysis is shown below.

Figure 4.10 Detailed System Architecture for Traffic Analysis



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Traffic analysis processor (for traffic volume/congestion analysis and traffic data list management)
- Traffic data server.

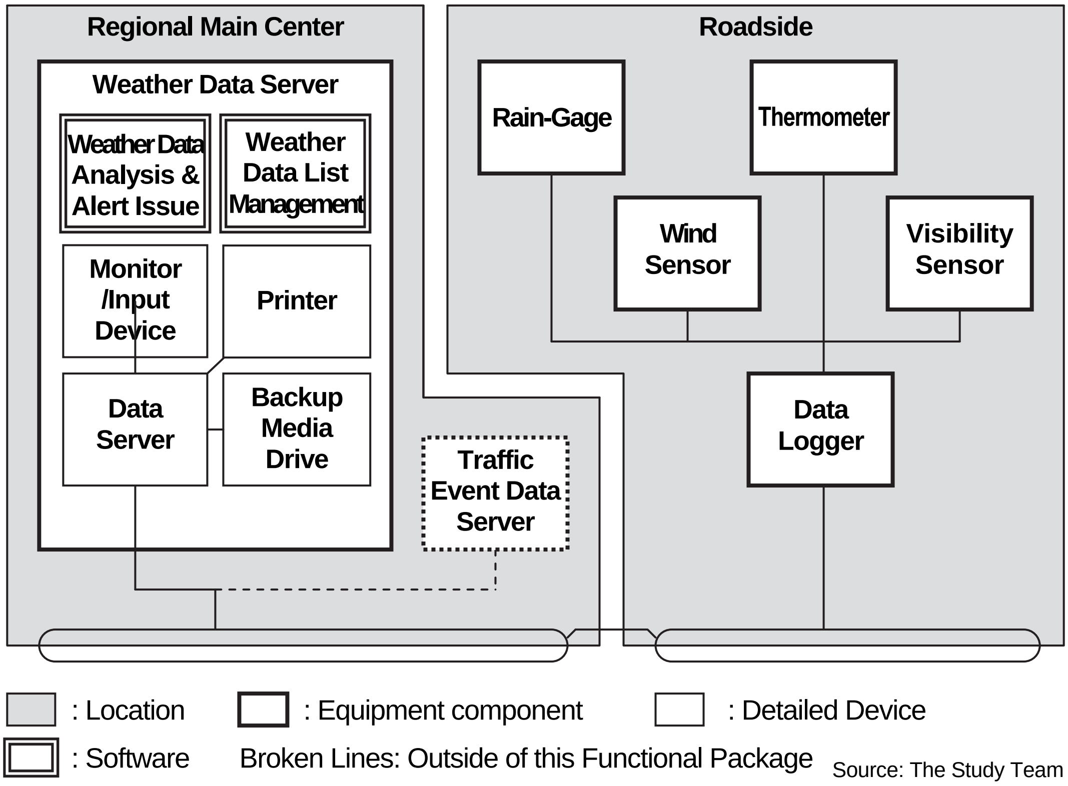
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of traffic analysis processor being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

6) Weather Monitoring

This functional package allows road operators to estimate dangerous conditions for road traffic on the expressways by using data acquired by the sensors installed at the interchanges and at the road sections where undesired weather conditions frequently affect traffic safety.

The detailed system architecture for the functional package of weather monitoring is shown below.

Figure 4.11 Detailed System Architecture for Weather Monitoring



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Rain gauge
- Wind sensor
- Thermometer
- Visibility sensor
- Data logger
- Weather data server (for weather data analysis, alert issue and weather data list management).

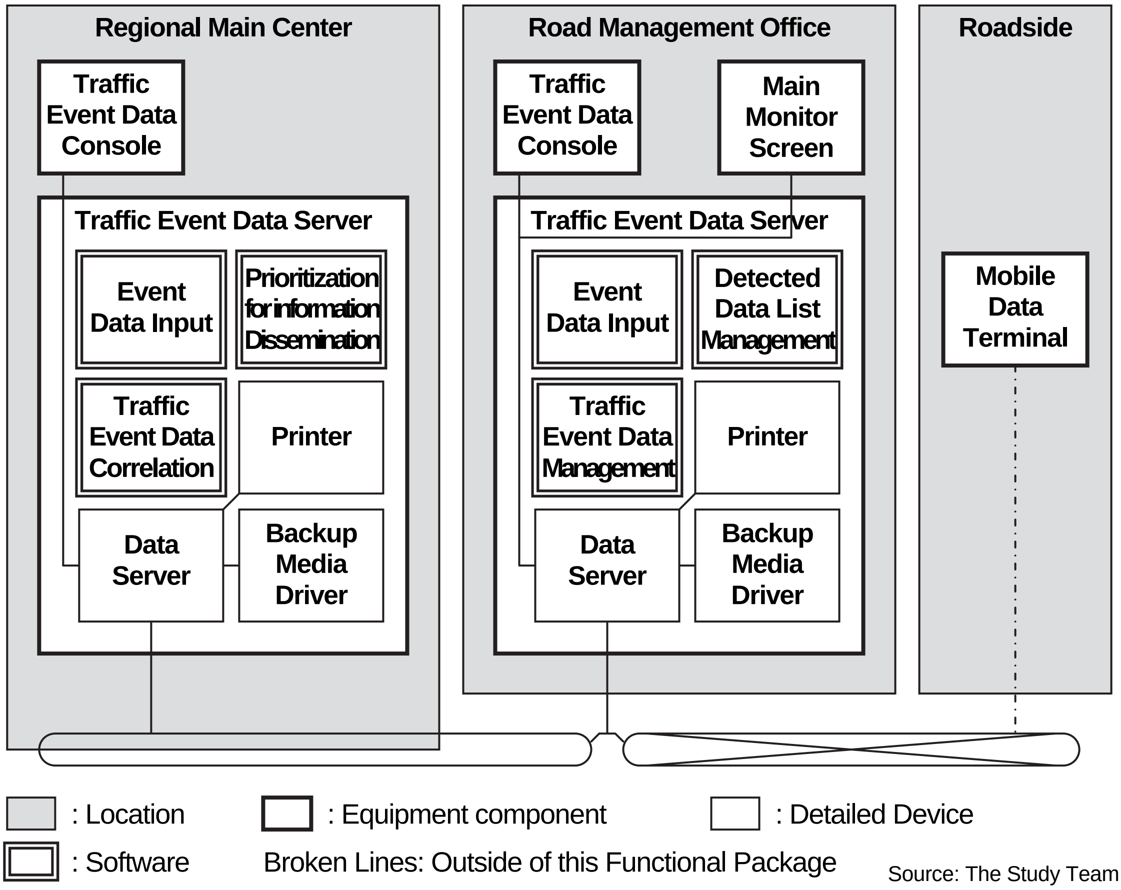
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of weather data server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

7) Traffic Event Data Management

This functional package allows road operators to conduct traffic control, regulation and information dissemination on the expressway, in a unified/integrated form, by categorizing the results (acquired through emergency telephones, mobile radio communication, event detection, traffic analysis and weather monitoring) and by organizing them as the data of traffic events specified by the place/time of occurrence and the priority.

The detailed system architecture for the functional package of traffic event data management is shown below.

Figure 4.12 Detailed System Architecture for Traffic Event Data Management



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Traffic event data server (for event data input, traffic event data correlation, prioritization for information dissemination, traffic data management and detected data list management)
- Traffic event data console
- Main monitor screen
- Mobile data terminal.

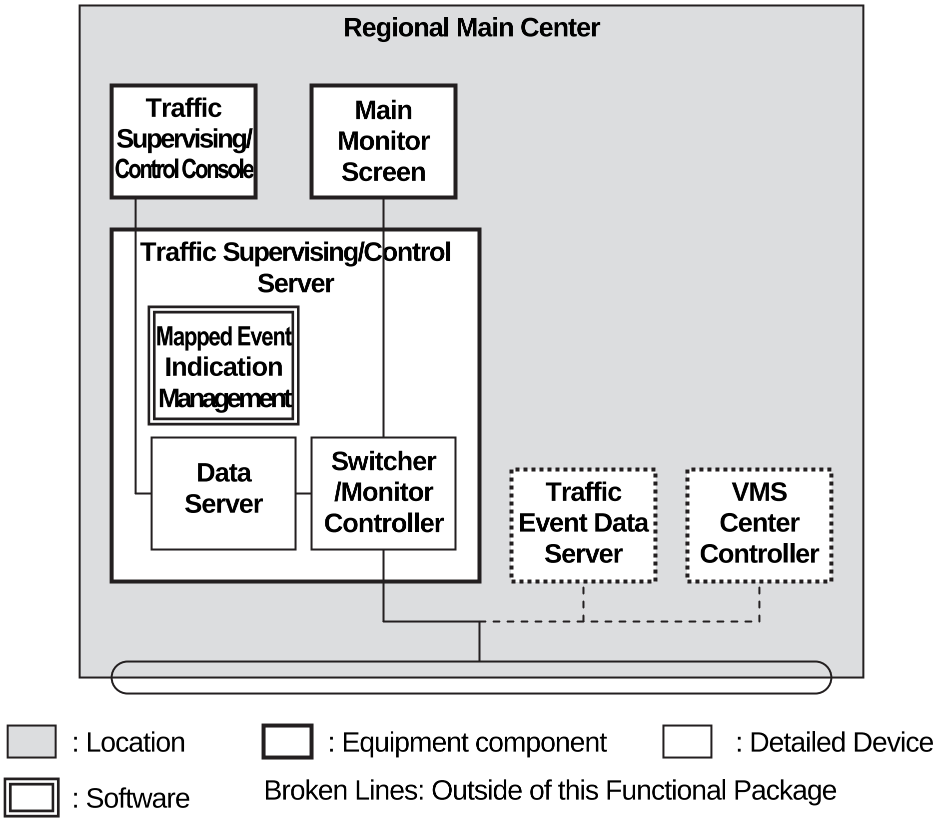
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of traffic event data server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

8) Traffic Supervision

This functional package allows road operators at the Main Center and road management office to totally supervise, visually monitor the current traffic conditions on the expressways and have the information organized as traffic events.

The detailed system architecture for the functional package of traffic supervision is shown below.

Figure 4.13 Detailed System Architecture for Traffic Supervision



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Traffic supervising/control server (for mapped event indication management)
- Traffic supervising/control console
- Main monitor screen.

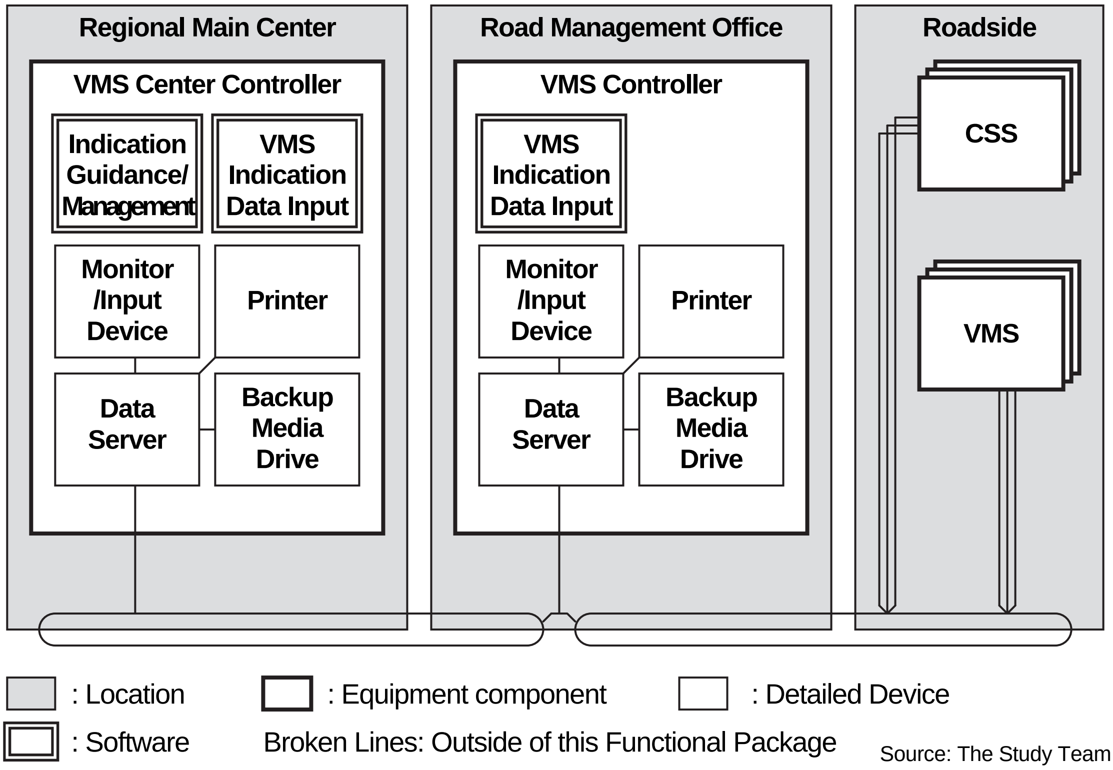
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of traffic supervising/monitor console being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

9) VMS Indication

This functional package allows road operators to provide road users on the expressways with the information organized as traffic events by using VMS (Variable Message Sign) installed at locations short of entrances, exits, tollgates, junctions and tunnels.

The detailed system architecture for the functional package of VMS indication is shown below.

Figure 4.14 Detailed System Architecture for VMS Indication



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- VMS center controller (for VMS indication data input and indication guidance/management).
- VMS controller (for VMS indication data input)
- VMS (Variable message sign)
- CSS (Changeable speed-limit sign).

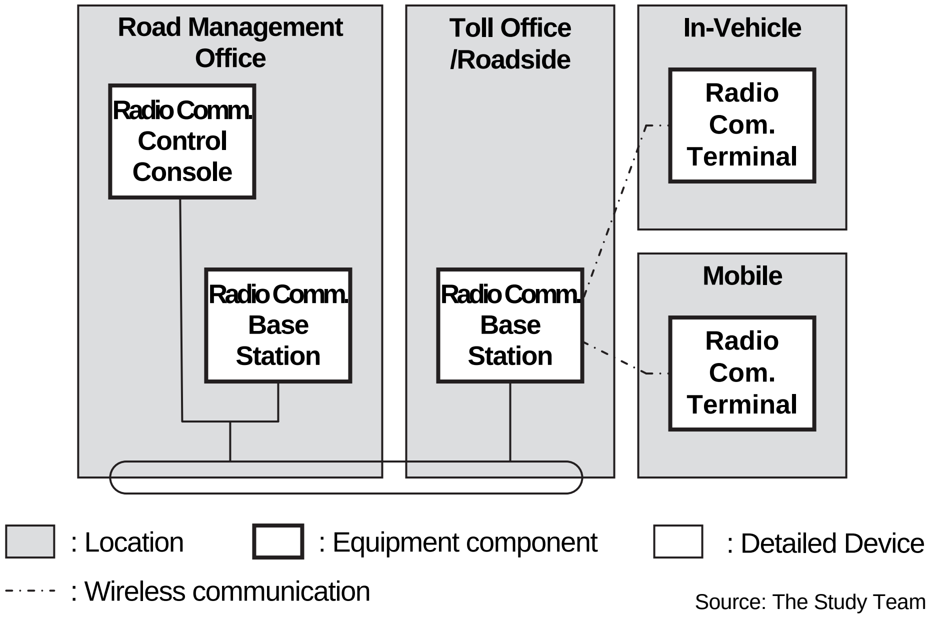
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of VMS center controller being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

10) Mobile Radio Communication

This functional package allows road operators to exchange information between road operation vehicles/workers on the expressway and the road management office by using radio communication.

The detailed system architecture for the functional package of mobile radio communication is shown below.

Figure 4.15 Detailed System Architecture for Mobile Radio Communication



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Radio communication base station
- Radio communication control console
- Radio communication terminal.

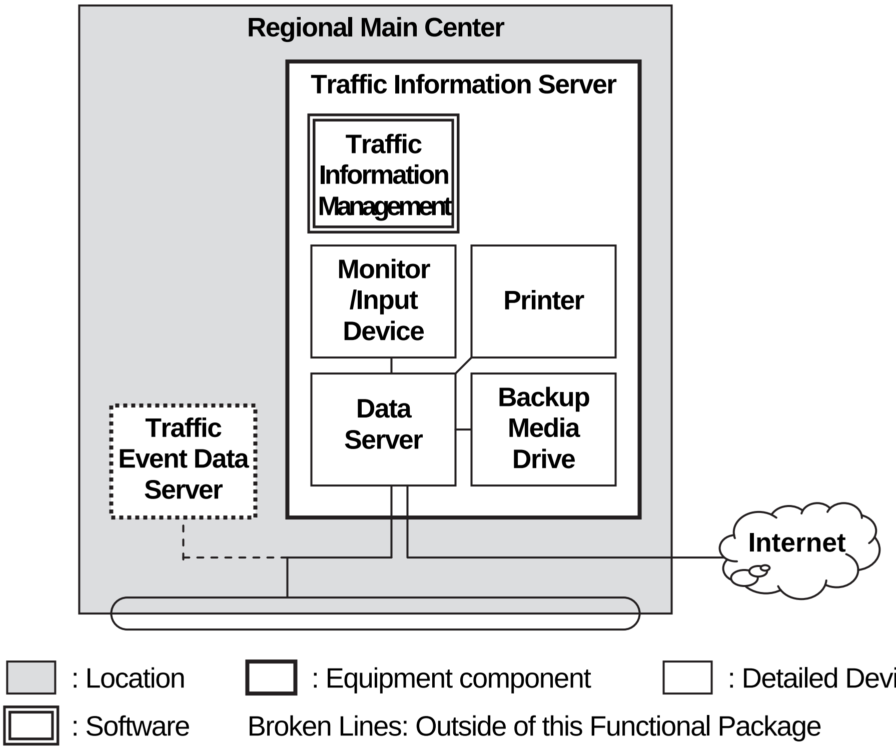
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of call controller being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

11) Traffic Information

This functional package allows road operators to provide other organizations with the information organized as traffic events on the expressways through the Internet.

The detailed system architecture for the functional package of traffic information is shown below.

Figure 4.16 Detailed System Architecture for Traffic Information



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Traffic information server (for traffic information management).

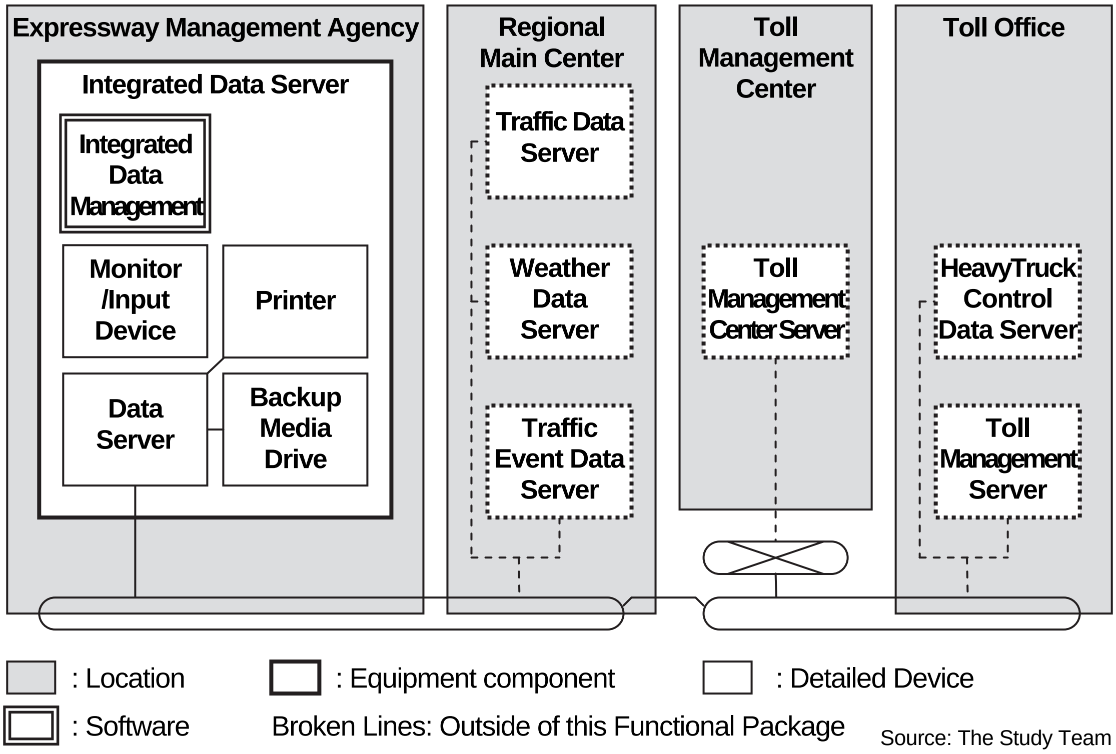
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of traffic information server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

12) Integrated Data Management

This functional package allows road operators to utilize acquired data such as traffic events, traffic volume, large vehicle ratio and measured axle loads of heavy trucks for developing inspection and budget plan of road maintenance and to check validity of toll revenue in comparison with traffic data.

The detailed system architecture for the functional package of integrated data management is shown below.

Figure 4.17 Detailed System Architecture for Integrated Data Management



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Integrated data server (for integrated data management).

The Processing/Screen Transition Diagram is to be illustrated for the subsystem of integrated data server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

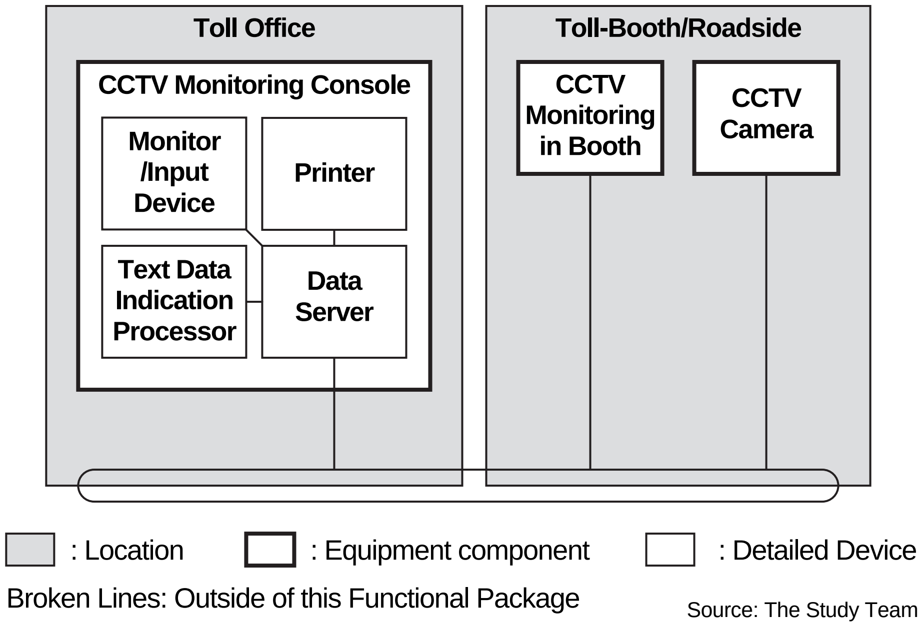
4.3 Non-stop Toll Collection (For Reference)

1) Tollgate Lane Monitoring

This functional package allows road operators to monitor current conditions of vehicle passage and operations by workers by using cameras installed in a separated lane such as a tollgate lane of the expressway.

The detailed system architecture for the functional package of toll gate lane monitoring is shown below.

Figure 4.18 Detailed System Architecture for Tollgate Lane Monitoring



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- CCTV camera
- CCTV monitoring in booth
- CCTV monitoring console.

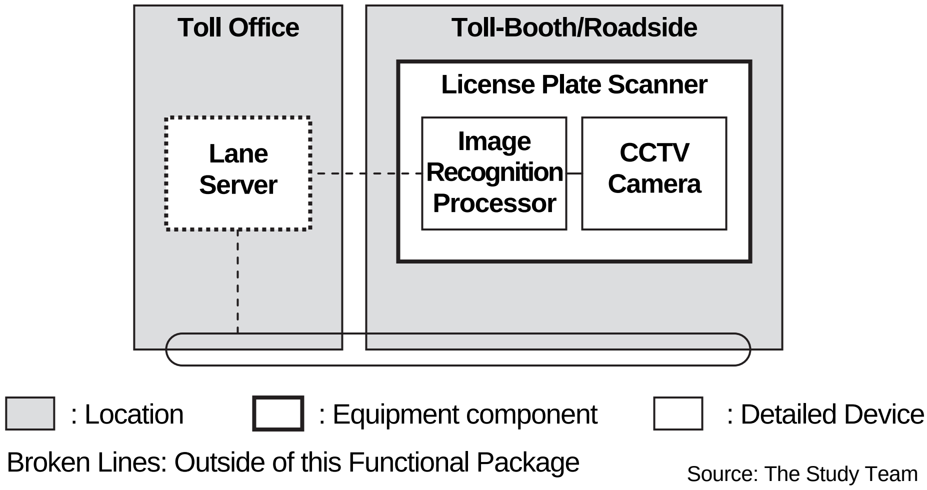
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of CCTV monitoring console being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

2) Vehicle/Class Identification

This functional package allows road operators to identify an individual vehicle by using a license plate scanner and other equipment installed in a separated lane such as a tollgate lane of the expressway.

The detailed system architecture for the functional package of vehicle/class identification is shown below.

Figure 4.19 Detailed System Architecture for Vehicle/Class Identification



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- License plate scanner (including CCTV camera and image recognition processor).

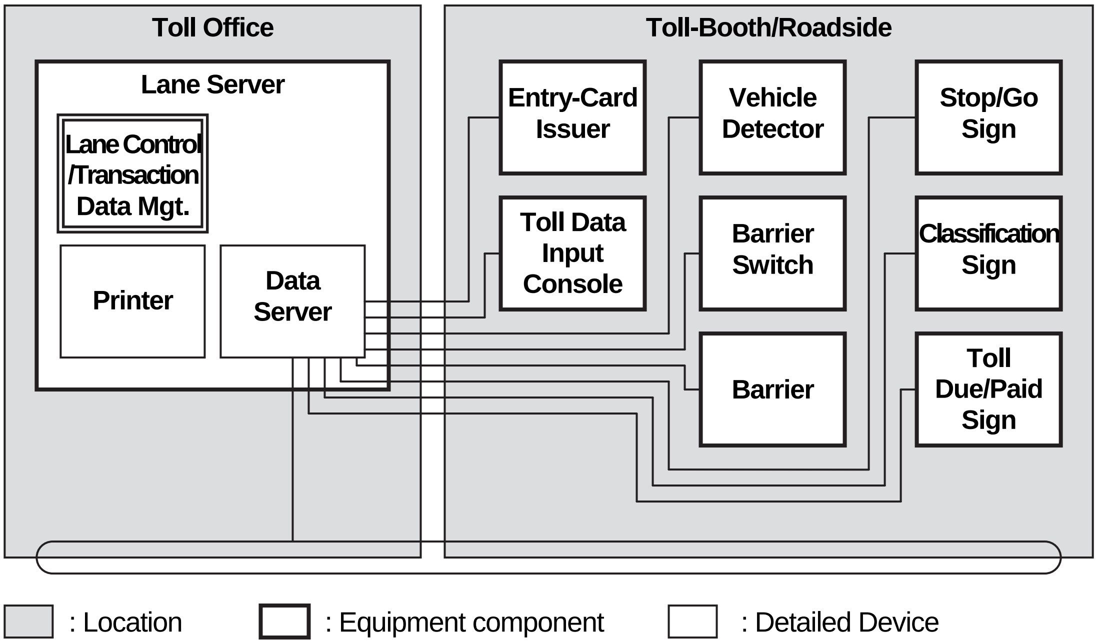
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of lane server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

3) Lane Control

This functional package allows road operators to block vehicle passage without adequate toll collection by using a computer, vehicle detectors, signs and a barrier installed in a separated tollgate lane of the expressway.

The detailed system architecture for the functional package of lane control is shown below.

Figure 4.20 Detailed System Architecture for Lane Control



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Lane server (for lane control/transaction data management)
- Toll data input console
- Entry-card issuer
- Vehicle detector
- Barrier switch
- Barrier
- Stop/go sign
- Classification sign
- Toll due/paid sign.

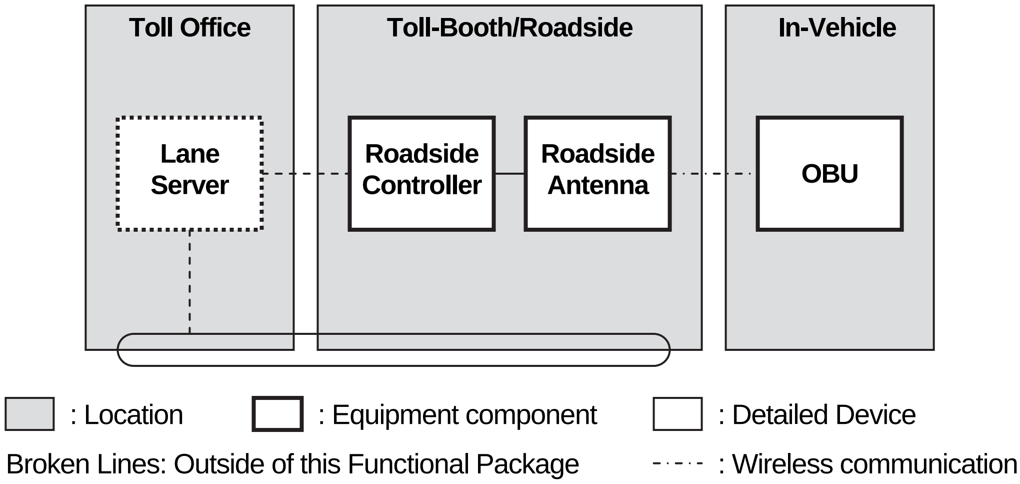
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of lane server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

4) Road-to-Vehicle Communication

This functional package allows road operators to exchange data for toll collection and other services on the expressways by radio communication between antennas installed at roadside and on-board units installed in the vehicles.

The detailed system architecture for the functional package of road-to-vehicle communication is shown below.

Figure 4.21 Detailed System Architecture for Road-to-Vehicle Communication



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- OBU (on-board unit)
- Roadside antenna
- Roadside controller.

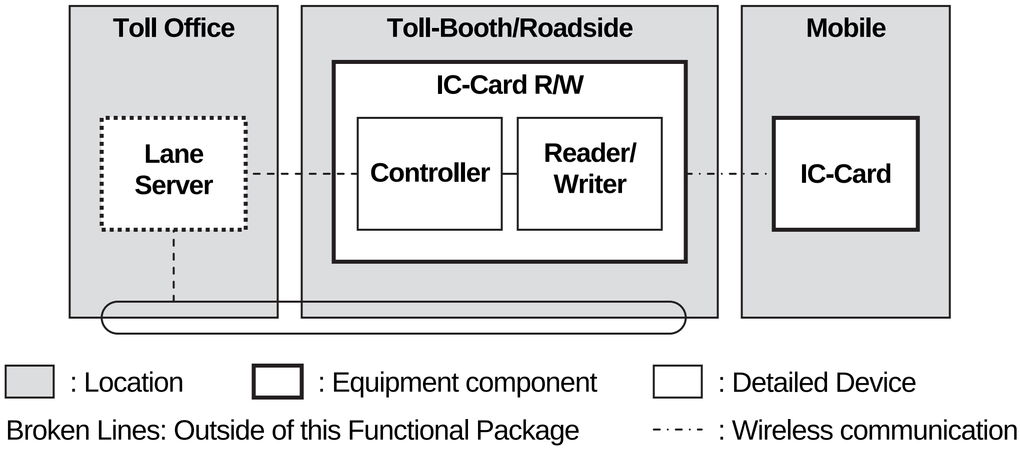
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of roadside controller being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

5) IC-card Recording

This functional package allows road operators to deduct from prepaid balance of IC-cards for collecting toll by using equipment installed at tollgates on the expressways.

The detailed system architecture for the functional package of IC-card recording is shown below.

Figure 4.22 Detailed System Architecture for IC-card Recording



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- IC-card
- IC-card R/W (reader writer).

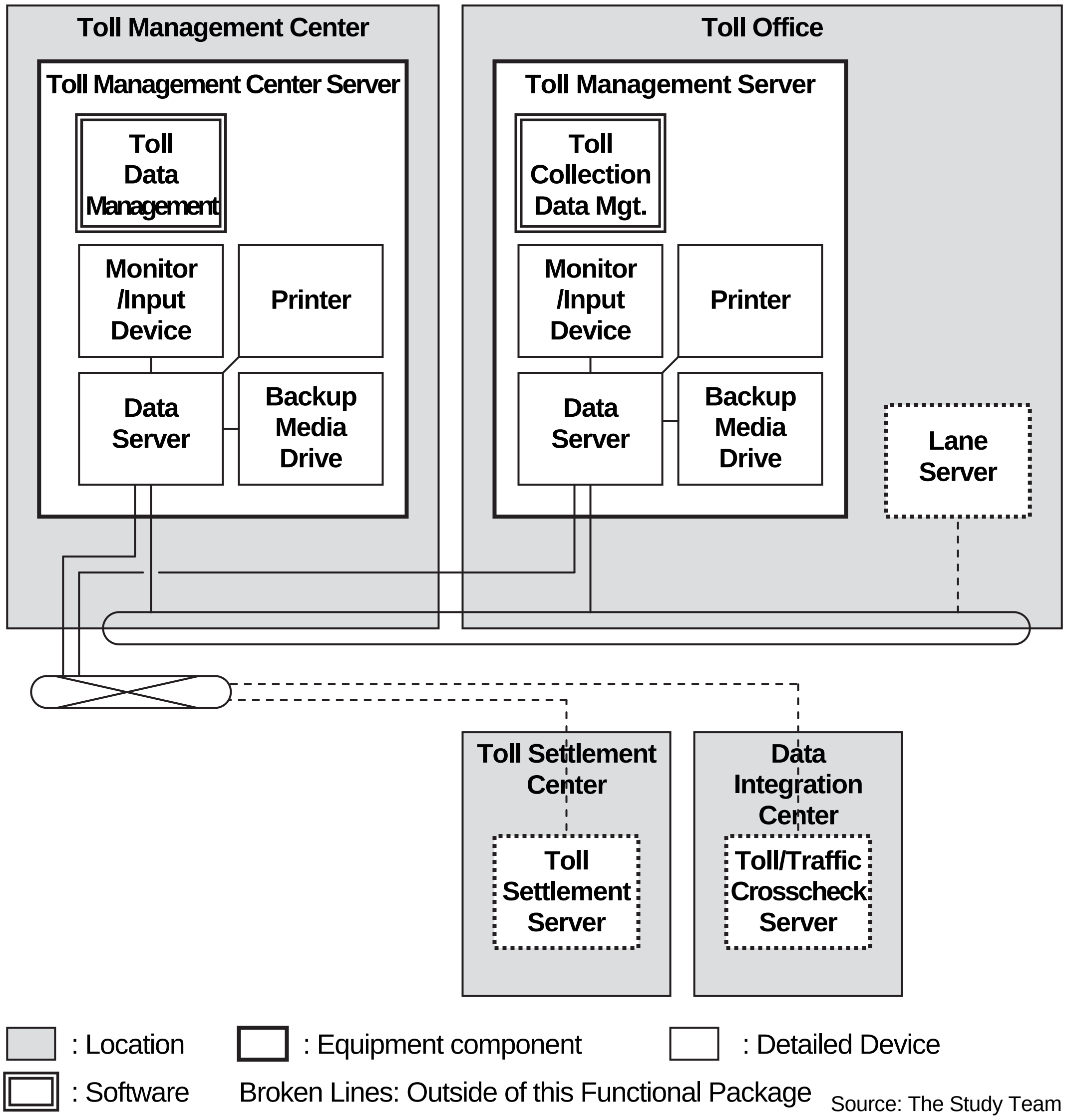
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of IC-card R/W being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

6) Toll Data Management

This functional package allows road operators to maintain all data of toll collection, to manage the invalidation list on the usage of on-board units and IC-cards, and to manage toll revenue of the expressways with a high reliability by using computers and software installed in the road management office.

The detailed system architecture for the functional package of toll data management is shown below.

Figure 4.23 Detailed System Architecture for Toll Data Management



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Toll management center server (for toll revenue data management)
- Toll management server : (for toll collection data management).

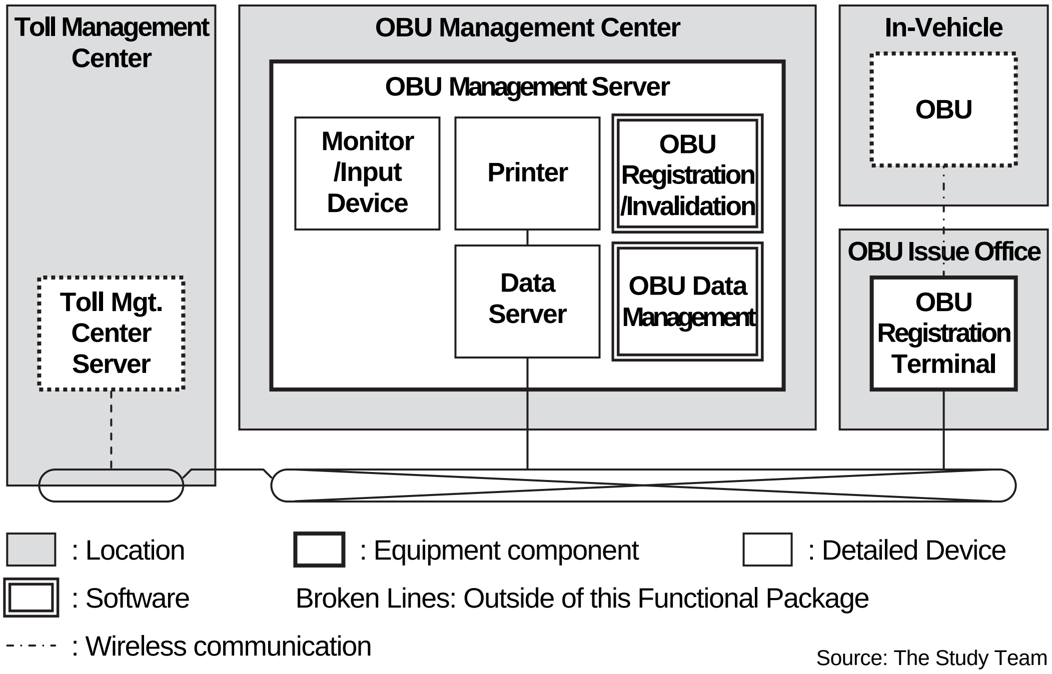
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of toll management server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

7) OBU Management

This functional package allows registering of on-board units by using equipment installed in OBU issue offices, and allows to generate/manage the registration list and the invalidation list of on-board units by using computers and software installed in the OBU registration center.

The detailed system architecture for the functional package of OBU management is shown below.

Figure 4.24 Detailed System Architecture for OBU Management



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- OBU management server (for OBU registration/invalidation and OBU data management).
- OBU registration terminal

The Processing/Screen Transition Diagram is to be illustrated for the subsystem of OBU management server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

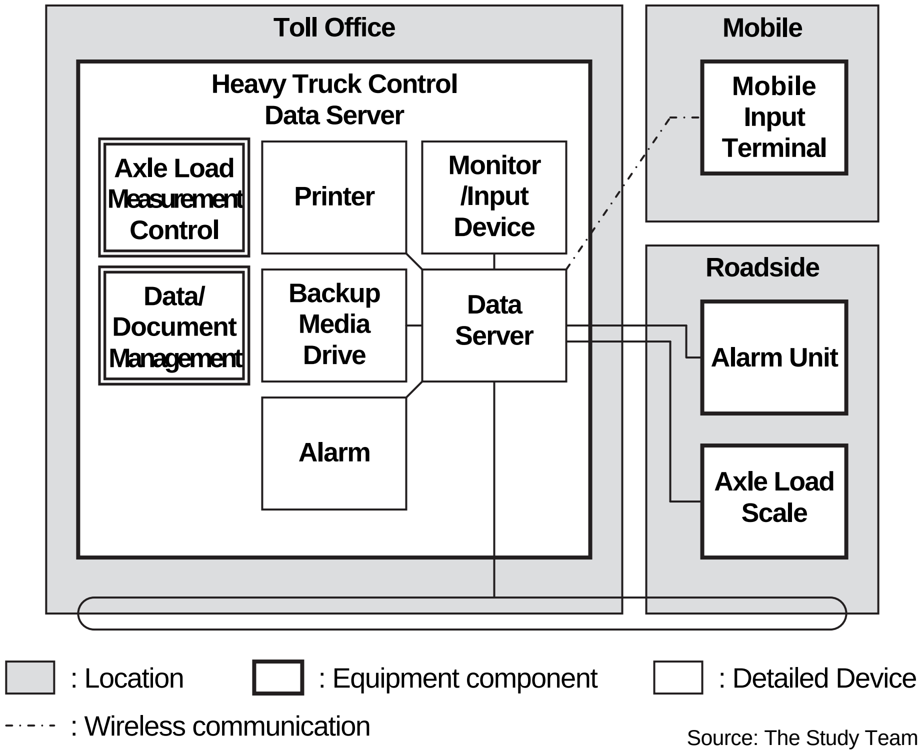
4.4 Heavy Truck Control (For reference)

1) Axle Load Measurement

This functional package allows road operators to detect/regulate overloaded heavy trucks on the expressways by using axle load scale installed in the exit tollgate lane exclusively for large-size vehicles.

The detailed system architecture for the functional package of axle load measurement is shown below.

Figure 4.25 Detailed System Architecture for Axle Load Measurement



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- Heavy truck control data server (for axle load measurement control and data/document management)
- Axle load scale
- Alarm unit
- Mobile input terminal.

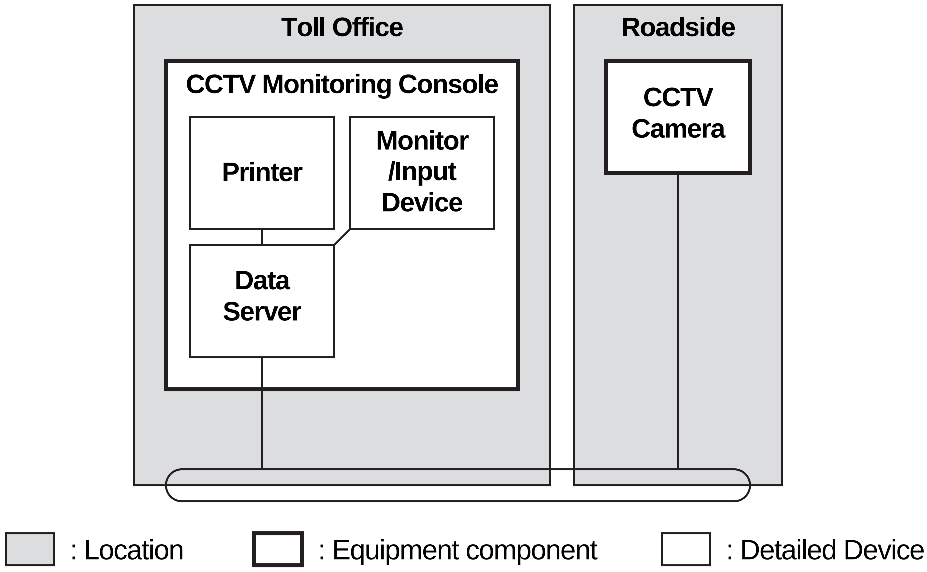
The Processing/Screen Transition Diagram is to be illustrated for the subsystem of heavy truck control data server being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

2) Measurement Lane Monitoring

This functional package allows the road operators to monitor current conditions of vehicle passage and operations by workers by using cameras installed in a separated lane for axle load measurement of the expressway.

The detailed system architecture for the functional package of measurement lane monitoring is shown below.

Figure 4.26 Detailed System Architecture for Measurement Lane Monitoring



Source: The Study Team

Specifications are to be prepared for the following subsystems (=equipment components):

- CCTV camera
- CCTV monitoring console.

The Processing/Screen Transition Diagram is to be illustrated for the subsystem of CCTV monitoring console being reasoned out from the Sequence Diagrams foregoing and the Event Trace Diagrams discussed separately in the System Operation/Management Plan.

PART 3: TRAFFIC INFORMATION/CONTROL SYSTEM

TABLE OF CONTENTS

1. Introduction

Service descriptions:

This service provides accurate surveillance of traffic conditions on expressway and adjacent arterial roads. This service assists prompt action of the road operator and the emergency vehicles by notifying occurrence of traffic accidents, broken-down vehicles and other obstacles. This service allows drivers en route and in advance to avoid the influence of the incidents by providing accurately updated information. This service also allows appropriate interchange/route selection by providing drivers en route with information; such as crowdedness and travel-time. This service makes it possible to measure actual traffic volume continuously for developing rational road construction/improvement plan.

Functional packages to be included in the system:

(1) Voice communication
(2) CCTV monitoring
(3) Event detection (by image)
(4) Vehicle detection
(5) Traffic analysis
(6) Weather monitoring
(7) Traffic event data management
(8) Traffic supervision
(9) VMS indication
(10) Mobile radio communication
(11) Traffic information
(12) Integrated data management.

2. Use Case and General System Architecture

Use cases and general system architecture are illustrated for the following implementation packages of traffic information/control:

(1) Incident Information
(2) Traffic Congestion Information
(3) Weather Information
(4) Traffic Control Assistance
(5) Center-to-Center Data Exchange.

Relationships between the system and users/operators/other-systems are illustrated by the following use case diagrams in the design drawings:

Road traffic supervision

- Incident reporting by mobile phone
- Incident identification
- Bad weather identification
- Traffic restriction
- Routine patrol
- Traffic event management at regional main center
- Traffic event management at road management office
- Traffic event management by patrol crew
- Traffic information by VMS
- Traffic information for internet
- Traffic information cancellation

- Integrated data management
- Routine monitoring in regional main center.

The general system architecture is sown using collaboration diagrams and message sequence diagrams titled as below in the design drawings:

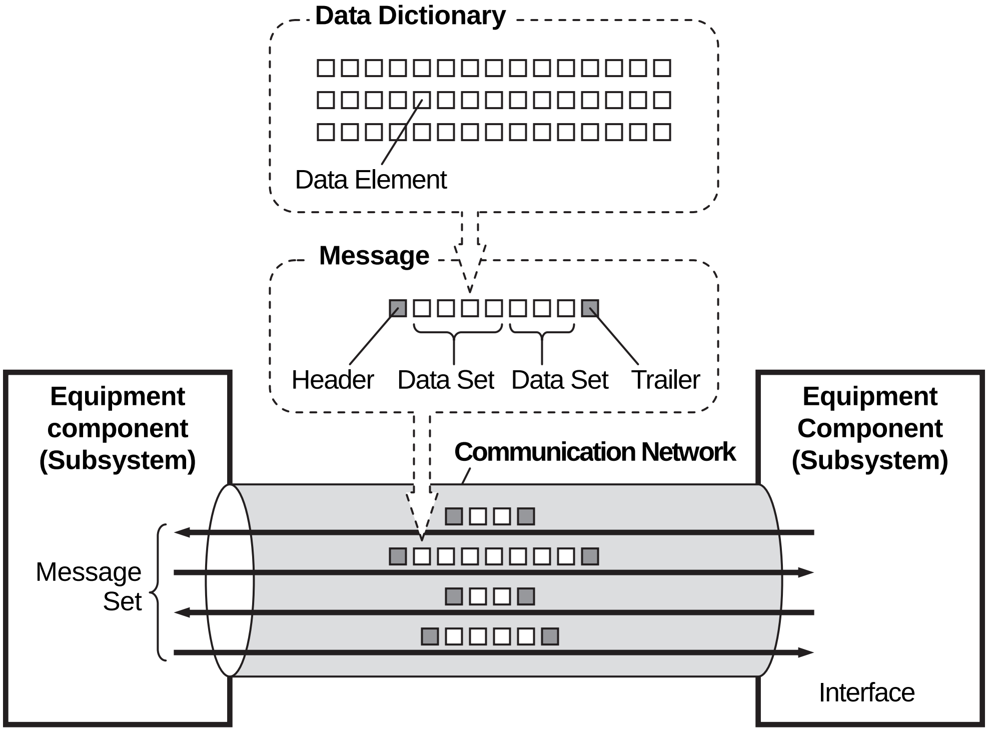
(1) Incident Information by monitoring at roadside
(2) Incident Information by image recognition
(3) Traffic congestion information by monitoring at roadside
(4) Traffic congestion information by image recognition
(5) Traffic congestion information by vehicle detection
(6) Weather information by weather sensors
(7) Traffic control assistance by traffic event data
(8) Center-to-center data exchange for incident notification
(9) Center-to-center data exchange for traffic information.

3. Message/Data Design

3.1 General

ITS consists of many pieces of equipment, which are illustrated as the equipment components in the diagrams of system architecture. The equipment components need to be connected with each other by communication network in order to exchange messages and data between them, to actualise the system and to provide intended services.

Figure 3.1 Conceptual Illustration of Message/Data Exchange



Source: The Study Team

3.2 Major Message List

The major message list for traffic information/control system is shown in the following table.

Table 3.1 Message List of Traffic Information/Control System

Name of Message	A Pair of Equipment Components on Both Side of Interface through Which Message is Exchanged		Name of Include Data Sets
Event Input Message	Data Input Device	Traffic Event Data Server	Traffic Event Data Set Image Recognition Result Data Set
	Traffic Event Data Server	Traffic Information Server	Traffic Event Data Set Image Recognition Data Set
Vehicle Detection Message	Vehicle Detector	Traffic Analysis Processor	Vehicle Detection Data Set
	Traffic Analysis Processor	Traffic Event Data Server	Vehicle Detection Data Set
Traffic Congestion Message	Traffic Analysis Processor	Traffic Event Data Server	Traffic Congestion Data Set
Traffic Congestion Input Message	Data Input Device	Traffic Event Data Server	Traffic Congestion Data Set
Image Data Message	CCTV Center Control Server	Traffic Supervising/Control Server	Event Image Data Set
Weather Observation Message	Weather Sensor	Weather Monitor Server	Weather Monitoring Dataset
Bad Weather Input Message	Data Input Device	Traffic Event Data Server	Bad Weather Data Set
	Traffic Event Data Server	Traffic Information Server	Bad Weather Data Set
	Weather Monitor Server	Traffic Event Data Server	Bad Weather Data Set
Weather Observation Message	Weather Monitor Server	Traffic Event Data Server	Weather Monitoring Dataset
Construction Work Input Message	Data Input Device	Traffic Event Data Server	Construction Work Data Set
	Traffic Event Data Server	Traffic Information Server	Construction Work Data Set
Traffic Restriction Input Message	Data Input Device	Traffic Event Data Server	Traffic Restriction Data Set
	Traffic Event Data Server	Traffic Information Server	Traffic Restriction Data Set
Traffic Event Message	Traffic Supervising/Control Server	Traffic Event Data Server	Traffic Event Data Set
VMS Indication Message	Traffic Event Data Server	VMS Center Controller	VMS Indication Data Set
	Traffic Event Data Server	Traffic Information Server	VMS Indication Data Set
VMS Control Input Message	Data Input Device	VMS Center Controller	VMS Control Input Data Set
VMS Control Message	VMS Center Controller	VMS	VMS Control Data Set
CSS Control Input message	Data Input Device	VMS Center Controller	CSS Control Input Data Set
CSS Control message	VMS Center Controller	CSS	CSS Control Data Set

Source: The Study Team

3.3 Primary Data Dictionary

Primary data dictionary for traffic information/control system is shown in the table below.

Figure 3.2 Primary Data Dictionary for Traffic Information/Control System

	Major Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin	Definition
1	Incident Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year	An unique identifier of a road management office
		Road Section ID	INT*	4	1			An unique identifier of the road section where an incident occurred (Jurisdiction of a Road Management Office)
		Lane ID	INT*	2	1			An unique identifier of the lane where an incident occurred (Numbered from the median)
		Place ID	INT*	4	1			An unique identifier of the place where an incident occurred (For information dissemination)
		Beginning Kilometer Post	TXT	6	1			The beginning kilometer post of the place where an incident occurred
		Ending Kilometer Post	TXT	6	1			The ending kilometer post of the place where an incident occurred
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CCTV camera
		Incident Status	INT*	2	1			Class of incident input referring to the video image: - 1: Traffic Accident - 2: Incident in Tunnel - 3: Reverse Driving - 4: Broken-down Vehicle - 5: Left Obstacle - 6: Natural Disaster - 7: Vandalism
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
2	Image Recognition Result Data Set <G - Image Processor >	Road Management Office ID	INT*	4	1	When an event occurs	Latest	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CCTV camera
		Image Recognition Result Status	INT*	2	1			Status analyzed by image recognition processor (Values are to be proposed by contractor including traffic accidents, breakdown vehicles, left obstacles, reverse driving, vandalism and natural disaster)
		Video Image Address	TXT	60	1			The network address of where the video image file is stored
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
3	Vehicle Detection Data Set <G - Vehicle Detector>	Road Management Office ID	INT*	4	1	Every 5 minutes	Latest	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CCTV camera
		Cumulative Number of Vehicles	INT*	4	1			Cumulative number of vehicles detected by vehicle detector
		Vehicle Speed	FLOAT	5	N			Vehicle speed detected by vehicle detector (unit: km/h)
		Vehicle Length	FLOAT	4				Vehicle length detected by vehicle detector (unit:: m)
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
4	Traffic Volume Data Set <G - Traffic Analysis Processor >	Road Management Office ID	INT*	4	1	Every 5 minutes	1 year	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CCTV camera
		Total Traffic Volume per Day	INT	5	1			Total traffic volume per day
		Large Vehicle Ratio	FLOAT	5	1			Percentage of large vehicles to the total number of vehicles
		Traffic Volume per Day of vehicle class 1	INT	5	1			Traffic volume per day vehicle class 1: Ordinary vehicle
		Traffic Volume per Day of vehicle class 2	INT	5	1			Traffic volume per day vehicle class 2: Large vehicle
		Traffic Volume per Day of vehicle class 3	INT	5	1			Traffic volume per day vehicle class 3: Trailer vehicle
		Traffic Volume per Day of vehicle class 4	INT	5	1			Traffic volume per day vehicle class 4: Reserved
		Traffic Volume per Day of vehicle class 5	INT	5	1			Traffic volume per day vehicle class 5: Reserved
		Total Traffic Volume per Hour	INT*	4	1			Total traffic volume in the latest one hour
		Large Vehicle Ratio	FLOAT	5	1			Percentage of large vehicles to the total number of vehicles
		Traffic Volume per Hour of vehicle class 1	INT*	4	1			Traffic volume in the latest one hour of vehicle class 1: Ordinary vehicle
		Traffic Volume per Hour of vehicle class 2	INT*	4	1			Traffic volume in the latest one hour of vehicle class 2: Large vehicle
		Traffic Volume per Hour of vehicle class 3	INT*	4	1			Traffic volume in the latest one hour of vehicle class 3: Trailer vehicle
		Traffic Volume per Hour of vehicle class 4	INT*	4	1			Traffic volume in the latest one hour of vehicle class 4: Reserved
		Traffic Volume per Hour of vehicle class 5	INT*	4	1			Traffic volume in the latest one hour of vehicle class 5: Reserved
		Total Traffic Volume per 15 minutes	INT*	3	1			Total traffic volume in the latest 3 sets of 5 minutes
		Traffic Volume per 15 minutes of vehicle class 1	INT*	3	1			Traffic volume in the latest 3 sets of 5 minutes of vehicle class 1: Ordinary vehicle
		Traffic Volume per 15 minutes of vehicle class 2	INT*	3	1			Traffic volume in the latest 3 sets of 5 minutes of vehicle class 2: Large vehicle
		Traffic Volume per 15 minutes of vehicle class 3	INT*	3	1			Traffic volume in the latest 3 sets of 5 minutes of vehicle class 3: Trailer vehicle
		Traffic Volume per 15 minutes of vehicle class 4	INT*	3	1			Traffic volume in the latest 3 sets of 5 minutes of vehicle class 4: Reserved
		Traffic Volume per 15 minutes of vehicle class 5	INT*	3	1			Traffic volume in the latest 3 sets of 5 minutes of vehicle class 5: Reserved
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
5	Traffic Congestio	Road Management Office ID	INT*	4	1	Every 5	1 year	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CCTV camera

	n Data Set <G - Traffic Analysis Processor >	Cumulative Number of Vehicles	INT*	4	1	minutes		Cumulative number of vehicles detected by vehicle detector in the latest 3 sets of 5 minutes
		Average Vehicle Speed	INT*	4	1			Average value of detected vehicle speed in the latest 3 sets of 5 minutes
		Traffic Congestion Status	INT*	2	1			Class of traffic congestion generated referring to the results - 1: Congestion on Trough Lanes 1 - 2: Congestion on Trough Lanes 2 - 3: Congestion on Trough Lanes 3 - 4: Crowdedness on Trough Lanes - 5: Congestion at Exit 1 - 6: Congestion at Exit 2 - 7: Congestion at Exit 3
		Beginning Kilometer Post	TXT	6	1			The beginning kilometer post of vehicle queuing
		Ending Kilometer Post	TXT	6	1			The ending kilometer post of vehicle queuing
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
6	Weather Monitoring Data Set <G - Weather Sensor>	Road Management Office ID	INT*	4	1	Every 5 minutes	Latest	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a weather monitoring device
		Precipitation	FLOAT	2	1			Accumulated precipitation during specific 5 minutes (unit:: mm)
		Wind Speed	FLOAT	2	1			Average, minimum, and maximum observed wind speed during specific 5 minutes (unit:: m/s)
		Visibility	FLOAT	2	1			Average, minimum, and maximum observed visibility during specific 5 minutes (unit:: m)
		Temperature	FLOAT	2	1			Average, minimum, and maximum observed temperature during specific 5 minutes (unit:: Celsius degree)
		Alarm Status of Precipitation	INT*	2	1			Alarm to be issued when specific level of precipitation aforementioned is detected
		Alarm Status of Wind Speed	INT*	2	1			Alarm to be issued when specific level of wind speed aforementioned is detected
		Alarm Status of Visibility	INT*	2	1			Alarm to be issued when specific level of visibility aforementioned is detected
		Alarm Status of Temperature	INT*	2	1			Alarm to be issued when specific level of temperature aforementioned is detected
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
7	Bad Weather Data Set <G - Weather Server>	Road Management Office ID	INT*	4	1	When a bad weather occurs	1 year	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a weather monitoring device
		Precipitation	FLOAT	2	1			Precipitation (converted from 10 min. data) measured by rain gauge. (unit:: mm/h)
		Wind Speed	FLOAT	2	1			Wind speed (10 min. average) measured by wind sensor (unit:: m/s)
		Visibility	FLOAT	2	1			Visibility (10 min. average) measured by visibility sensor (unit:: m)
		Temperature	FLOAT	2	1			Temperature (10 min. average) measured by thermometer (unit: Celsius degree)
		Heavy Rain Status	INT*	2	1			Specifying bad weather in traffic event category and corresponding class of heavy rain in traffic event class: - 1: Heavy Rain 1 - 2: Heavy Rain 2 - 3: Heavy Rain 3
		High Wind Status	INT*	2	1			Specifying bad weather in traffic event category and corresponding class of high wind in traffic event class: - 1: High Wind 1 - 2: High Wind 2 - 3: High Wind 3
		Low Visibility Status	INT*	2	1			Specifying bad weather in traffic event category and corresponding class of lowering of visibility in traffic event class: - 1: Dense Fog 1 - 2: Dense Fog 2 - 3: Dense Fog 3
		High Temperature Status	INT*	2	1			Specifying bad weather in traffic event category and corresponding class of high temperature in traffic event class: - 1: High Temperature
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
8	Constructi on Work Data Set <I - Server>	Road Management Office ID	INT*	4	1	When a constructi on work is schedule d	1 year after end of constru ction	An unique identifier of a road management office
		Road Section ID	INT*	4	1			An unique identifier of the road section where a construction work applied (Jurisdiction of a Road Management Office)
		Lane ID	INT*	2	1			An unique identifier of the lane where a construction work applied (Numbered from the median)
		Place ID	INT*	4	1			An unique identifier of the place where a construction work applied (For information dissemination)
		Beginning Kilometer Post	TXT	6	1			The beginning kilometer post of the place where a construction work applied
		Ending Kilometer Post	TXT	6	1			The ending kilometer post of the place where a construction work applied
		Construction Work Status	INT*	2	1			Status of construction work: - 1: Scheduled - 2: Under construction - 3: Finished
		Number of document	TXT	20	1			Official number of permission document
		Permission Date	TXT	8	1			The date (Day/month/year) of permission of construction work
		Date/Time Begin	TXT	≥14	1			The begin time (Day/month/year/hour/minutes/second) of construction work
		Date/Time End	TXT	≥14	1			The end time (Day/month/year/hour/minutes/second) of construction work
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
9	Traffic	Road Management Office ID	INT*	4	1	When an	1 year	An unique identifier of a road management office

	Restriction Data Set <I - Server>	Road Section ID	INT*	4	1	event occurs	after end of restriction	An unique identifier of the road section where a construction work applied (Jurisdiction of a Road Management Office)
		Lane ID	INT*	2	1			An unique identifier of the lane where a construction work applied (Numbered from the median)
		Place ID	INT*	4	1			An unique identifier of the place where a construction work applied (For information dissemination)
		Beginning Kilometer Post	TXT	6	1			The beginning kilometer post of the place where a traffic restriction applied
		Ending Kilometer Post	TXT	6	1			The ending kilometer post of the place where a traffic restriction applied
		Construction Work Status	INT*	2	1			Status of construction work: - 1: Scheduled - 2: Under construction - 3: Finished
		Permission Date	TXT	8	1			The date (Day/month/year) of permission of traffic restriction
		Date/Time Begin	TXT	≥14	1			The begin time (Day/month/year/hour/minutes/second) of traffic restriction
		Date/Time End	TXT	≥14	1			The end time (Day/month/year/hour/minutes/second) of traffic restriction
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
10	Traffic Event Data Set <G/C - Server>	Traffic Event Data ID	INT	8	1	When an event occurs	1 year	An unique identifier of the traffic event data
		Road Management Office ID	INT*	4	1			An unique identifier of a road management office
		Road Section ID	INT*	4	1			An unique identifier of the road section where a traffic event occurred (Jurisdiction of a Road Management Office)
		Road Link ID	INT*	4	1			An unique identifier of a segmentation of road network divided by diverging/ merging points at interchanges/ junctions or barrier tollgates
		Lane ID	INT*	2	1			An unique identifier of the lane where a traffic event occurred (Numbered from the median)
		Place ID	INT*	4	1			An unique identifier of the place where a traffic event occurred (For information dissemination)
		Traffic Event Category ID	INT*	4	1			An unique identifier of traffic event data category: - 1: Special Event - 2: Incident - 3: Construction Work - 4: Bad Weather - 5: Traffic Congestion - 6: Traffic - 7: Restriction
		Traffic Event Class ID	INT*	4	1			An unique identifier of traffic event data class 01: Special Event 19: High Temperature 02: Traffic Accident 20: Congestion on Trough Lanes 1 03: Incident in Tunnel 21: Congestion on Trough Lanes 2 04: Reverse Driving 22: Congestion on Trough Lanes 3 05: Broken-down Vehicle 23: Crowdedness on Trough Lanes 06: Left Obstacle 24: Congestion at Exit 1 07: Natural Disaster 25: Congestion at Exit 2 08: Vandalism 26: Congestion at Exit 3 09: Construction Work 27: Entry Closure 10: Heavy Rain 1 28: Closure 11: Heavy Rain 2 29: Exit Closure 12: Heavy Rain 3 30: Lane Closure 13: High Wind 1 31: Speed Limitation 1 14: High Wind 2 32: Speed Limitation 2 15: High Wind 3 16: Dense Fog 1 17: Dense Fog 2 18: Dense Fog 3
		Causal Traffic Event Data ID	INT	8	1			An unique identifier of the causal traffic event data
		Beginning Kilometer Post	TXT	6	1			The beginning kilometer post of the place where a traffic event occurred
		Ending Kilometer Post	TXT	6	1			The ending kilometer post of the place where a traffic event occurred
		Input Person	TXT	32	1			Name of the person who input traffic event data set
		Event Status	TXT	4	1			Status of traffic event
		Video Image address	TXT	60	1			The network address of where the Video image file is stored
		Main Center Check Status	INT*	4	1			Approval status by the main center: - 0: Not yet approved - 1: Approved
		Road Management Office Check Status	INT*	4	1			Approval status by the road management office: - 0: Not yet approved - 1: Approved
		Status of Traffic Event	INT*	2	1			Status of traffic event: - 1: Occurred and existing - 2: Removed
		Date/Time End	TXT	≥14	1			Day/month/year/hour/minutes/second of the traffic event input by operator
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
11	Event Image Data Set <G - Server>	Road Management Office ID	INT*	4	1	When an event is checked	1 year	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CCTV camera
		Place ID	INT*	4	1			An unique identifier of the place where the traffic event occurred (For information dissemination)
		Video Image ID	INT	8	1			An unique identifier of the video image
		Event Video Image	IMG	var	1			Video image data during time interval from 5 min before incident to 10 min after incident
		Traffic Event Data ID	INT	8	1			An unique identifier of the traffic event data
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
12	Integrated Data Sed <G - Server>	Date/Time	TXT	≥14	1	Every 1 hour	1 year	Date and time for the reference of a data set
		Road Section ID	INT*	4	1			An unique identifier for the reference of a data set (Jurisdiction of a Road Management Office)
		Kilometer Post	TXT	6	1			Kilometer post for the reference of a data set
		Lane ID	INT*	2	1			An unique identifier of the lane for the reference of a data set (Numbered from the median)

		Data Set ID	INT*	2	1			An unique identifier of the kind for the reference of a data set - 1: Incident Data Set - 2: Traffic Volume Data Set - 3: Traffic Congestion Data Set - 4: Bad Weather Data Set - 5: Construction Work Data Set - 6: Traffic Restriction Data Set - 7: Traffic Event Data Set - 8: Hourly Toll Collection Data Set - 9: Axle Load Management Data Set
		Data Set	Set	var	1			A data set corresponding to Date/time, Road Section ID, Kilometer Post, Lane ID and Data Set ID
13	VMS Check /Indication Data Set <G/C - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 month	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a VMS
		Traffic Event Class ID	INT*	4	1			An unique identifier of the traffic event class
		Place ID	INT*	4	1			An unique identifier of the place where a traffic event occurred (For information dissemination)
		Place Name	TXT	28	1			Name of the place where a traffic event occurred
		Traffic Event ID	INT	8	1			An unique identifier of the traffic event (including indication of "Under Repair")
		Traffic Event Name	TXT	20	1			Name of the traffic event occurred
		Causal Place ID	INT*	4	1			An unique identifier of the place where the causal traffic event occurred (For information dissemination)
		Causal Place Name	TXT	28	1			Name of the place where the causal traffic event occurred
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
14	VMS Input/Indication Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 month	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a VMS
		Traffic Event Class ID	INT*	4	1			An unique identifier of the traffic event class
		Place ID	INT*	4	1			An unique identifier of the place where a traffic event occurred (For information dissemination)
		Place Name	TXT	28	1			Name of the place where a traffic event occurred
		Traffic Event ID	INT	8	1			An unique identifier of the traffic event (including indication of "Under Repair")
		Traffic Event Name	TXT	20	1			Name of the traffic event occurred
		Causal Place ID	INT*	4	1			An unique identifier of the place where the causal traffic event occurred (For information dissemination)
		Causal Place Name	TXT	28	1			Name of the place where the causal traffic event occurred
		Free Text	TXT	var	1			The characters input using data input device
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set
15	CSS Indication Data Set <G/C - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 month	An unique identifier of a road management office
		Roadside Equipment ID	INT*	4	1			An unique identifier of a CSS
		Speed Limit	INT*	3	1			The limit speed input using data input device
		Date/Time	Datetime	≥14	1			Year/month/day /hour/minutes/second of generating data set

Note: INT*: Short integer; I: Input; G: Generated; C: Checked; R: Recorded

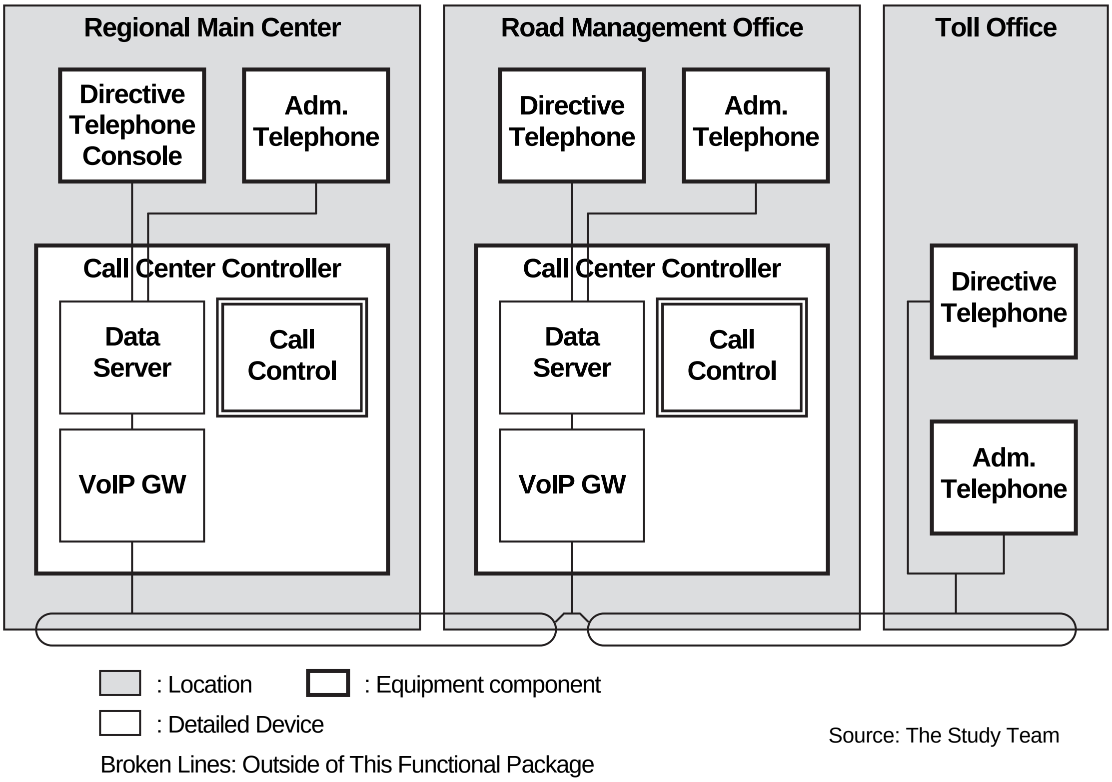
Source: The Study Team

4. Voice Communication

4.1 Outline and System Architecture

This functional package allows connecting interactive voice communication among Regional Main Center, Road Management Offices, and Toll Offices, and allows sending directives to the units concerned simultaneously for clearing incidents and enforcing traffic restrictions. In addition, this functional package allows connecting PSTN.

Figure 4.1 System Architecture for Voice Communication



Source: The Study Team

4.2 Required Function of Voice Communication

The communication network of ITS will be developed on the basis of Internet Protocol, therefore interactive voice communication will be realized with Voice over IP with in the ITS network.

In the planned voice communication, two types are recommended to introduce. The one is directive and the other is administrative telephone.

The directive is used for the communication under event occurrence and so on. The directive is made from Regional Main Center to all Road Management Offices and Toll Offices simultaneously or used from Regional Main Center to concerned Road Management Offices and Toll Offices simultaneously. The directive communication should be connected 100% whenever required without calling loss.

In Regional Main Center, the Directive Communication Console is required to install, and directive telephone set is required to install for all Road Management Offices and Toll Offices. The detailed number of telephone set is to be mention later.

As for the administrative telephone, it is used for normal expressway operation and maintenance business activities, and it is realized to connect between Regional Main Center and Road Management Office or between Road Management Office and Toll Office, and between an administrative telephone within the ITS network and a telephone in Public Switched Telephone Network (PSTN). For the administrative telephone, the calling loss is allowed. The detailed number of administrative telephone is also shown later.

The call control is made with SIP Server and connection with PSTN is realized by using VoIP Gateway.

The SIP Server should equip the function of registrar, proxy server and redirect server. The Server is also required to control VoIP Gateway.

The VoIP Gateway is required to convert voice packet which can be transmit in IP network, into voice traffic in PSTN which is encoded into digital signal, and vice versa. In addition, it is also required to convert call control signal in PSTN into call control signal in IP network, and vice versa, and it is required to interconnecting between administrative telephone in ITS network and telephone set in PSTN.

4.3 Numbering Plan

(1) General

There are two different numbering plan for Directive Telephone and Administrative Telephone shown as follows. The code allocation such as office code is required to determine referring the following samples.

As for the connection of the Road management Offices which are implemented prior to effectiveness of this Design Standard, the connection may be made through the public switched telephone network for temporary basis. If such implementation will be made for the specific road management office, it is recommended to connect according to the code to be determined when the timing of equipment component renewal of such road management office.

(2) Numbering Plan for Directive Telephone

Directive Telephone number is composed of the following five (5) digits. The Directive Telephone is effective only One Regional Main Center Area. Therefore there is no number to distinguish another Regional Main Center.

L AB CD

Where

L: Directive Class (The specific number is shown as sample.)

8: Downstream directive from Directive Communication Console in Regional Main Center to individual Directive Telephones

6: Downstream directive from Directive Communication Console in the Regional Main Center to ALL Directive Telephones

3: Upstream directive from Directive Telephone in the Road Management Office to Directive Communication Console in Regional Main Center

AB: Office Code for Regional Main Center and Road Management Offices (The specific number is shown as sample.)

Specific number is allocated for Regional Main Center and individual Road Management Offices. The number is recommended to utilize commonly with Administrative Telephone number. The sample is shown below;

20: Ha Noi Regional Main Center

21 – 79: Road Management Offices under management of Ha Noi Regional Main Center

40: Da Nang Regional Main Center

21 – 79: Road Management Offices under management of Da Nang Regional Main Center

60: Ho Chi Minh Regional Main Center

21 – 79: Road Management Offices under management of HCM Regional Main Center

C: Interchange Number

The Interchange number is required to allocate for the expressway section managed by one (1) Road Management Office. The number is recommended to allocate from North or East to South or West in ascending order.

D: Duty category Number (The specific number is shown as sample.)

1: Road Management Office (Administrative Office)

2: Operator in charge who monitor the traffic condition

3: Traffic Management (manager of patrolling staff and vehicles)

4: Toll Office

5: Information Desk (it will be required when Service Area is developed.)

6-9: spare number

(3) Numbering Plan for Administrative Telephone

Administrative Telephone number is composed of the following seven (7) digits.

A B CD EF

Where

A: Calling Category (The specific number is shown as sample.)

0: Outgoing call connecting to PSTN

1: Reserved as special number

8: Outgoing call number for Another Regional Main Center Management Region

9: Reserved as maintenance use

B: Number for Regional Main Center Management Region (The specific number is shown as sample.)

2: Ha Noi Region

4: Da Nang Region

6: Ho Chi Minh Region

CD: Office Code for Regional Main Center and Road Management Offices (The specific number is shown as sample.)

Specific number is allocated for Regional Main Center and individual Road Management Offices. Code C is able to allocate from 2 to 7 except for 0, 1, 8, 9, and Code D is able to allocate from 0 to 9 respectively. The applicable number for code C and D is shown in the following tale. One Road Management Office will manage approx. 50 km expressway ~~s~~ section, and in future, the number of Road Management Offices will be estimated approx. 40 in one Regional Main Center. Therefore the code CD from 20 to 79 is considered to be enough to cover future developed conditions. The allocatable number as CD code is shown in the following table.

Figure 2.2 Number Allocation Plan for Administrative Telephone

C╲D	0	1	2	3	4	5	6	7	8	9
0										
1										
2										
3				Allocatable Area of CD Code						
4										
5										
6										
7										
8										
9										

The sample CD code is shown below;
20: Ha Noi Regional Main Center
21–79: Road Management Offices under management of Ha Noi RMC
40: Da Nang Regional Main Center
21-79: Road Management Offices under management of Da Nang RMC
60: Ho Chi Minh Regional Main Center
21–79: Road Management Offices under management of HCM RMC

EF: Number in one Road Management Office
Numbers are allocated for One Road Management Office including its related Toll Offices. The number is recommended to allocate from North or East to South or West in ascending order.

(4) Connection Method of Administrative Telephone

The administrative telephone should be capable to connect in the following method;

(i) Call within One Road Management Office

It should be capable to connect by sending the numbers of EF.

(ii) Call between Regional Main Center and Road Management Office or between Road Management Offices under One Regional Main Center Management Region

It should be capable to connect by sending the numbers of CDEF.

(iii) Call from a Regional Main Center to another Regional Main Center or between Road Management Offices under different Regional Main Centers

It should be capable to connect by sending the numbers of A (=8) + BCDEF.

(iv) Call to PSTN

It should be capable to connect by sending the number of 0+ (the number of PSTN).

4.4 Directive Telephone Set

The number of telephone set and installation location of Directive Telephone is shown in the following table.

Table 4.1 Location/Quantity of Directive Telephones

Location	Q'ty	Remarks
Regional Main Center		
General Director Room	1	
Others (Police Officer Room, Meeting Room, Resting Room, Mess Hall, etc.)	6	
Road Management Office		
Administrative Office	1	
Operator in charge who monitor the traffic condition	1	
Manager desk for patrolling staff and vehicles	1	
Traffic Police Office	1	
Toll Office		
Manager	1	
Service Area		Assumption of future development condition
Information Desk	2	To be installed one set for each direction.

The Directive Telephone set shall be capable to notify it to the receiver as directive by buzzer or flashing light.

It is also required to equip the function to transmit the acknowledgement to the sender of directive.

4.5 Administrative Telephone Set

The number of telephone set and installation location of Administrative Telephone is shown in the following table.

Table 4.2 Location/Quantity of Administrative Telephone

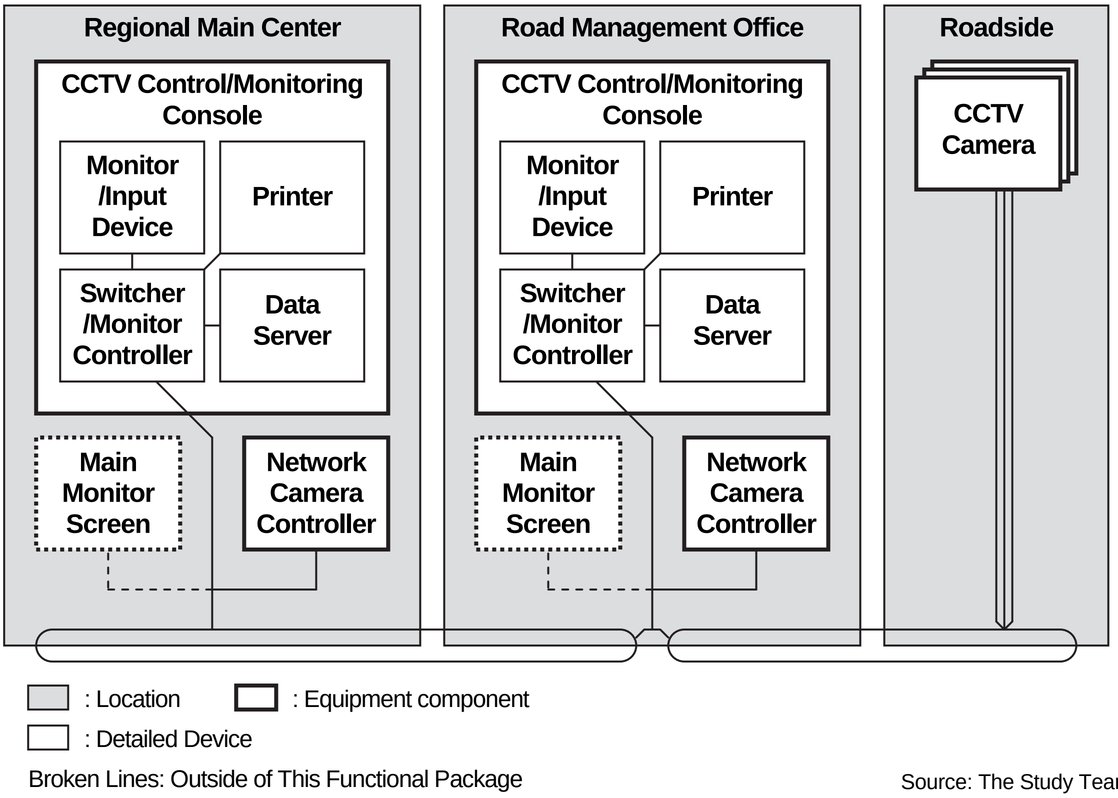
Location	Q'ty	Remarks
Regional Main Center		
General Director Room	1	
Traffic Control Operating Room	2	
Server Room	1	
Police Room	1	
Meeting Room	1	
Machine Room	1	
Visitor Room	1	
Depositary	1	
Resting Room	1	
Mess Hall	1	
Office Room	5	
Others		
Road Management Office		
Administrative Office	1+N	N: Except for the manager, one set per two staff is to be planned.
Traffic Condition Monitoring Room	2	
Manager desk for patrolling staff and vehicles	1	
Traffic Police Office	1	
Ambulance Office	1	
Meeting Room	1	
Room for maintenance staff	2	
Rest Area in Road Management Office	1	
Toll Office		
Administrative Office	1+N	N: Except for the manager, one set per two staff is to be planned.
Rest Area	1	
Service Area		Assumption of future development condition
Administrative Office	2	To be installed one set for each direction.
Information Desk	2	To be installed one set for each direction
Rest Area for staff	2	To be installed one set for each direction

5. CCTV Monitoring

5.1 Outline and System Architecture

This functional package allows the road operators to capture current situation of traffic accidents, broken-down vehicles, left obstacles, driving in the reverse direction, vandalism, natural disaster and traffic conditions on the expressways and to monitor the captured video image at the Main Center and road management offices by using cameras installed at road sections where traffic can be stuck easily after incidents and at long tunnel sections.

Figure 5.1 System Architecture for CCTV Monitoring



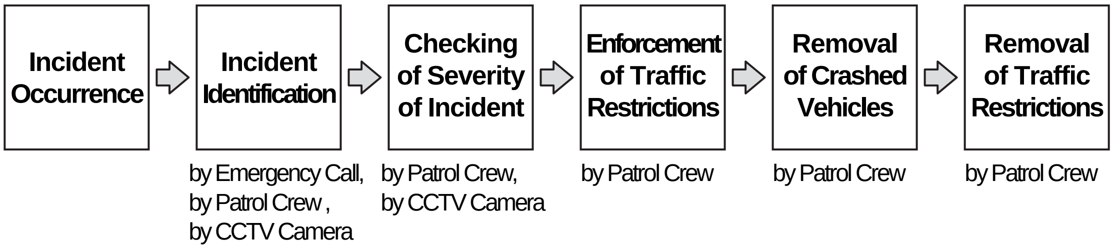
Source: The Study Team

5.2 Traffic Event to be Monitored

CCTV camera can be used for various different purposes on the expressway; however, installed location and condition corresponding to the intended purpose. In this study, discussion on the usage of CCTV cameras focuses on incident identification.

Incidents are addressed generally by the procedure shown in the figure below.

Figure 5.2 Procedure of Addressing Incidents



by Emergency Call	X				
by Patrol Crew	X	X	X	X	X
by CCTV Camera	X	X			

Source: The Study Team

As shown in the figure, CCTV cameras can be effective only for identifying incidents and checking severity of incidents. Enforcement/removal of traffic restrictions and removal of crashed vehicles must be done by patrol crews. Hence, even when CCTV cameras are installed on the expressway, sufficient number of crews and vehicles are necessary to address incidents.

5.3 Required Function/Performance of CCTV Camera

(1) Types of Camera

There are two types of CCTV camera: PTZ Type and Fixed Type. PTZ Type has the functions Panning, Tilting and Zooming. Fixed Camera does not have these functions.

In addition, sometime Fixed Type has zooming function but they do not have the capability of Tilting and Panning. Therefore, a focal point is one point only, which is not good for surveillance.

The following table shows an example of the Specification for Fixed Camera and PTZ Type.

Figure 5.3 Type of CCTV camera

Fixed camera

PTZ camera

Source: The Study Team

PTZ Camera: The camera shall have mechanical capability of panning, tilting and zooming for focusing the objective of interest for traffic surveillance.

Fixed camera: The camera does “Not” have mechanical capability of panning and tilting for focusing the objective of interest for traffic surveillance.

(2) Mechanical Functions

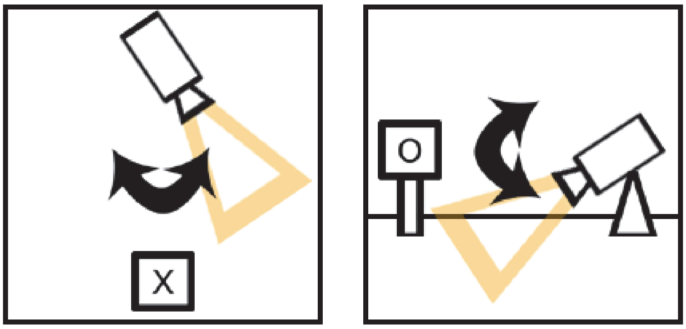
Panning:

Panning refers to the rotation in a horizontal plane of a video camera. Panning a camera results in a motion similar to that of someone shaking their head "no”.

Tilting:

Tilting refers to the stationary and rotation in a vertical plane (or tilting plane). A rotation in a horizontal plane is known as panning. Tilting the camera results in a motion similar to someone nodding their head "yes".

Figure 5.4 Panning and Tilting



Panning function   Tilting function

Source: The Study Team

Zooming:

Zoom adjusts the Angle of View. It is a magnification of image as a result. The function of zooming, there are two type of zoom such as Digital Zoom and Optical Zoom. For our purpose, digital zoom is not really zoom, in the strictest definition of the term. What digital zoom does is enlarge a portion of the image, thus ‘simulating’ optical zoom. In other words, the camera crops a portion of the image and then enlarges it back to size.

Against that, optical zoom is really zoom, It is capable a magnification of image by extend the focal length of between lens and image sensor. Optical zoom doesn’t make a deterioration of images compare with Digital zoom.

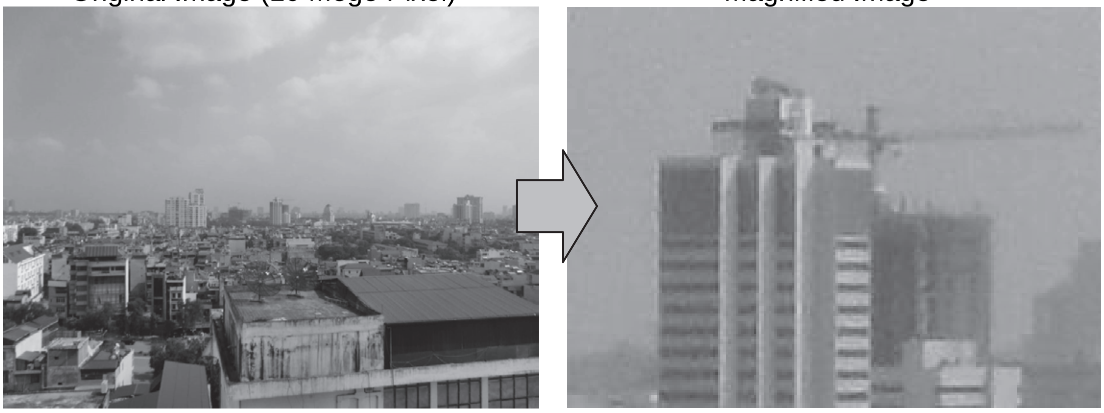
For example, see Figure 4.6. Upper stand, show the magnification of image (10 mega pixel) by using digital zoom function. Lower stand, show the magnification of image (1 mega pixel) by using optical zoom function.

Resolution of the original image is 10 mega pixels on Digital zoom whereas, resolution of the original image is 1 mega pixel on Optical zoom. Optical zoom image is 1/10 times the resolution however, the quality of the image after the magnification is clearer than Digital zoom.

Figure 5.5 Comparison of Digital Zoom and Optical Zoom

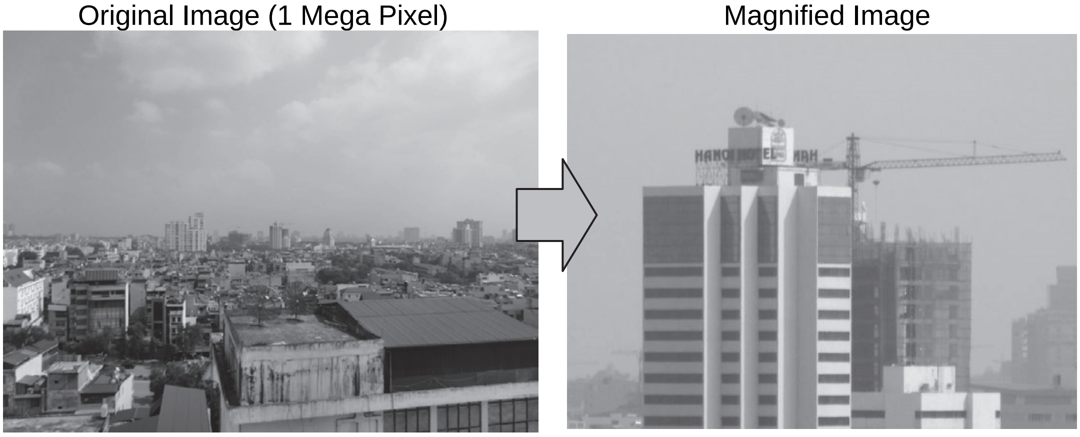
Digital zoom

Original Image (10 Mege Pixel) Magnified Image



Optical zoom

Original Image (1 Mega Pixel) Magnified Image



Source: The Study Team

(3) Optical Functions/Performance

Width of image sensor:

There are two type of image sensor, such as CCD image sensor and CMOS sensor. Both types of sensor accomplish the same task of capturing light and converting it into electrical signals. In previous time, CCD image sensor was better than CMOS sensor. However, CMOS sensor is advance by means of technological innovation in today. CMOS sensor can potentially be implemented with use less power, faster reboot and cheaper than CCD. Therefore, most of CCTV camera are using CMOS sensor.

The meaning of the image Sensor are large, the camera has a larger area per 1pixel in case of the number of pixel is the same. Then, a larger amount of light to be received on 1pixel, collect the light efficiency is increased. Then, there are a lot of light coming into the image sensor, can be stayed on top of the subsequent of image processing, there will be less noise as a result. In other words, it is possible to record images of a more natural state.

Focal length of lens:

It is effect to surveillance range. The focal length of a lens determines the magnification at which it images distant objects. It is equal to the distance between the image plane and a pinhole that images distant objects the same size as the lens in question.

Resolution:

Resolution is the term used to describe the number of pixels, used to display an image. Higher resolutions mean that more pixels are used to create the image, resulting in a crisper, cleaner image. The number of pixel is to provide a more accurate figure for the resolution of the CCTV camera. Recently, the resolution is more than 1 mega pixel in general.

Minimum Illumination:

Minimum illumination is a way to measure the sensitivity of a camera. In another word It is mean, how dark the camera can still see usable image. There is the Day/Night function that colour video image at daytime, switch to black and white video image at night, to provide the best image automatically by determine the brightness of the day or night.

(4) Data and Interface

Encoding:

Encoding is a compression method of video images by using codec. There are several type of codec such as MPEG-2, MPEG-4, H.264 and so on. The quality the codec can achieve is heavily based on the compression format the codec uses. A codec is not a format, and there can be multiple codec that implement the same compression specification. For example, MPEG-1 codec typically do not achieve quality/size ratio comparable to codec that implement the more modern H.264 specification. But quality/size ratio of output produced by different implementations of the same specification can vary.

Frame rate:

Frame rate is the frequency at which an imaging device produces unique consecutive images called frames. Frame rate is most often expressed in frames per second (fps). In case of there are many more frames per second image becomes video image smoothly, as the data size of the video image becomes larger.

Ingress Protection:

The ingress protection or IP Code consists of the letters IP followed by two digits or one digit and one letter and an optional letter. As defined in international standard IEC 60529, IP Code classifies and rates the degrees of protection provided against the intrusion of solid objects, dust, accidental contact, and water in mechanical casings and with electrical enclosures.

CCTV camera shall be protected against dust and water ingress, where it will be installed outdoors in typical road section in accordance with IP66 of the international standards IEC 60529 or equivalent.

First Digit:

The first digit indicates the level of protection that the enclosure provides against access to hazardous parts (e.g., electrical conductors, moving parts) and the ingress of solid foreign objects.

Table 5.1 Meaning of First Digit in IPXX

Level	Object size protected against	Effective against
0	-	No protection against contact and ingress of objects
1	>50 mm	Any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a body part
2	>12.5 mm	Fingers or similar objects
3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, screws, etc.
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; complete protection against contact
6	Dust tight	No ingress of dust; complete protection against contact

Source: The Study Team

Second Digit:

Protection of the equipment inside the enclosure against harmful ingress of water.

Table 5.2 Meaning of Second Digit in IPXX

Level	Protected against	Details
0	Not protected	-
1	Dripping water	Test duration: 10 minutes Water equivalent to 1mm rainfall per minute
2	Dripping water when tilted up to 15°	Test duration: 10 minutes Water equivalent to 3mm rainfall per minute
3	Spraying water	Test duration: 5 minutes / Water volume: 0.7 litres per minute Pressure: 80–100 kN/m²
4	Splashing water	Test duration: 5 minutes / Water volume: 10 litres per minute Pressure: 80–100 kN/m²
5	Water jets	Test duration: at least 3 minutes Water volume: 12.5 litres per minute Pressure: 30 kN/m² at distance of 3m
6	Powerful water jets	Test duration: at least 3 minutes Water volume: 100 litres per minute Pressure: 100 kN/m² at distance of 3m
7	Immersion up to 1 m	Test duration: 30 minutes / Immersion at depth of 1m
8	Immersion beyond 1 m	Test duration: continuous immersion in water Depth specified by manufacturer

Source: The Study Team

Interface:

Each device is assumed to be connected to Ethernet. The device is required to equip Ethernet interface. In addition, in order to streamline the piping and wiring of communication cable and power cable therefore, in order, the device is equipped the PoE (Power over Ethernet) what is power supply through the Ethernet cable. However, in case of the PTZ camera should be equipped a High PoE. It is capable supply a large amount of Power.

(5) Ambient Conditions and Others

Operating temperature / humidity range:

An operating temperature / humidity is the temperature / humidity at which an electrical or mechanical device operates. The device will operate effectively within a specified temperature / humidity range which varies based on the device function and application context, and ranges from the minimum to the maximum operating temperature / humidity.

Consumed power:

That is the amount of power consumed when the device is operating. Keeping the guideline value of the power consumption of the device on the specification, consideration to be required and ensured that electrical equipment does not exceed the electric capacity provided from the road side.

5.4 Range of Surveillance

(1) Basic Parameters/Values

Scope of View of CCTV cameras will be estimated based on the location and height of camera and objective of the monitoring. In the design, the monitoring range and the viewpoint will be calculated based on the case of monitoring through lane and diverging or merging point in ramp of interchanges.

In the case of installation at through lane, the installation interval is dependent on the specification of equipment and other conditions as follows;

Equipment Specifications:

- Size of the screen
- Width and height of image sensor of CCTV Camera
- Focal length of lens

Other conditions :

- Distance from the operator to the screen
- Eyesight of Operator
- Required monitor size of vehicle on the screen
- Height of camera installation, etc

Under ideal circumstances, the calculation results of Maximum Range of surveillance of each display size is shown in Table 4.3. The size of the display to show scenes all the time for each camera is about 20 inches (at least). When a more detailed check on the status is required, switch to a larger display of about 60 inches or more.

Table 5.3 Sample CCTV PTZ / Fixed Cameras specifications

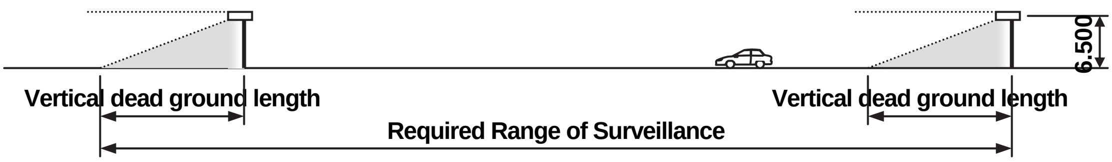
		PTZ Camera	Fixed Camera
Width of image sensor		4.8 mm (1/3" sensor)	4.8 mm (1/3" sensor)
Focal length of lens		4.7 – 84.6 mm	5.0 mm (3.1 – 10 mm (Manually adjustable))
Resolution		1.3 Mega Pixel	1.3 Mega Pixel
		1280 x 720 (16:9)	1280 x 720 (16:9)
Minimum Illumination		0.5 lx (Day mode, colour) 0.06 lx (Night mode, B/W)	0.3 lx (Day mode, colour) 0.05 lx (Night mode, B/W)
Panning		350 degrees	-
Tilting		120 degrees	-
Zooming		x10 optical	-
Maximum range of surveillance	without Zooming	192.52 m	204.81 m
	with Zooming	1,925.24 m *	-

The calculation is done on the following conditions: The aspect ratio of the screen is 0.5625 = 16:9; The width of CCD sensor is 4.8 mm (in case 1/3" CCD sensor); Display size is 60 inch, Distance from the operator to the screen is 5.0 m, Eyesight of Operator is 1.0; Required monitor size of vehicle on the screen is 10.7 mm
Note, *: it is in case of ideal condition, not guaranteed.

Table 5.4 Calculation Results of Maximum Range of Surveillance

Size of Monitoring Screen	Required Horizontal Resolution	Focal Length of Lens (mm)	Maximum Range of Surveillance (m)
20 inches	166 lines	4.7	64.2
		5.0	68.3
		47.0 **	641.7 ****
		84.6 ***	1155.1 ****
30 inches	249 lines	4.7	96.3
		5.0	102.4
		47.0 **	962.6 ****
		84.6 ***	1732.7 ****
60 inches	498 lines	4.7	192.5
		5.0	204.8
		47.0 **	1925.2 ****
		84.6 ***	3465.4 ****
100 inches	830 lines	4.7	320.9
		5.0	341.4
		47.0 **	3208.7 ****
		84.6 ***	5775.7 ****

The calculation is done on the following conditions;
The aspect ratio of the screen is 0.5625 = 16:9 ; The width of CCD sensor is 4.8 mm (in case 1/3" CCD sensor) ; Distance from the operator to the screen is 5.0 m ; Eyesight of Operator is 1.0 ; Required monitor size of vehicle on the screen is 10.7 mm
Note, **: Focal length under 10 times zooming of 4.7 mm,
***: Focal length under 18 times zooming of 4.7 mm.
****: it is in case of ideal condition, not guaranteed.



(2) Maximum Surveillance Range on Through Lanes

PTZ Camera

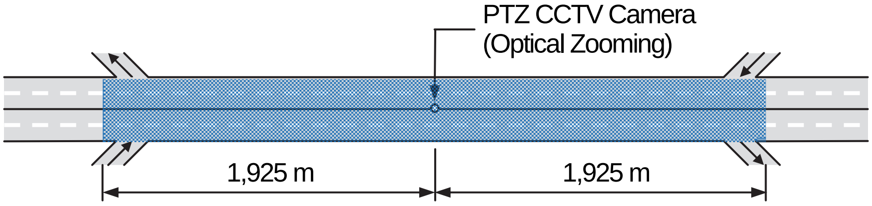
The CCTV camera shall provide image fineness by using a wide-angle lens to secure a sufficient depth of the field. For meeting this requirement, a maximum range of monitoring is calculated at 1,925 m by the following formula:

L=f x (V/V') x (B/0.9b)

Where b: the width of image sensor is 4.8(1/3-inch image sensor)
- 0.9: over-scanning ratio
- V: the width of an actual vehicle is 1,500 mm
- V': the width of the displayed vehicle is 10.6 mm, and
- f: the focal length of lens of the CCTV camera is 47.0 mm

Installation of CCTV PTZ camera: The camera shall be installed attached on the median around the diverging point aimed at the travelling direction of the vehicles. The maximum of surveillance of the CCTV camera is calculated at 1,925 m.

Figure 5.6 Maximum surveillance range of PTZ Camera (Hypothetical Monitoring range)



Source: The Study Team

Fixed Camera

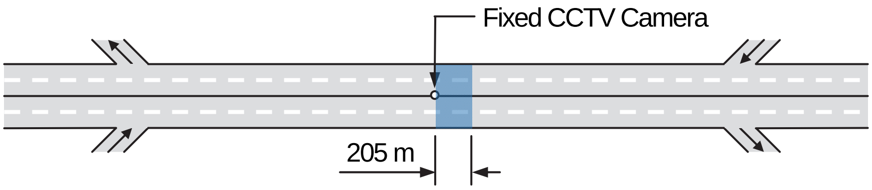
The CCTV camera shall provide image fineness by using a wide-angle lens to secure a sufficient depth of the field. For meeting this requirement, a maximum range of monitoring is calculated at 205 m by the following formula:

L=f x (V/V') x (B/0.9b)

Where b: the width of image sensor is 4.8(1/3-inch image sensor)
- 0.9: over-scanning ratio
- V: the width of an actual vehicle is 1,500 mm
- V': the width of the displayed vehicle is 10.6 mm, and
- f: the focal length of lens of the CCTV camera is 5.0 mm

Installation of CCTV Fixed camera: The camera shall be installed attached on the median around the diverging point aimed at the travelling direction of the vehicles. The maximum of surveillance of the CCTV camera is calculated at 205 m.

Figure 5.7 Maximum surveillance range of Fixed Camera (Hypothetical Monitoring range)



Source: The Study Team

(3) Maximum Surveillance Range on Ramp

<u>Fixed Camera</u>

The CCTV camera shall provide image fineness by using a wide-angle lens to secure a sufficient depth of the field. For meeting this requirement, a maximum range of monitoring is calculated at 205 m by the following formula:

L=f x (V/V') x (B/0.9b)

Where b: the width of image sensor is 4.8(1/3-inch image sensor)

0.9: over-scanning ratio

V: the width of an actual vehicle is 1,500 mm

V': the width of the displayed vehicle is 10.6 mm, and

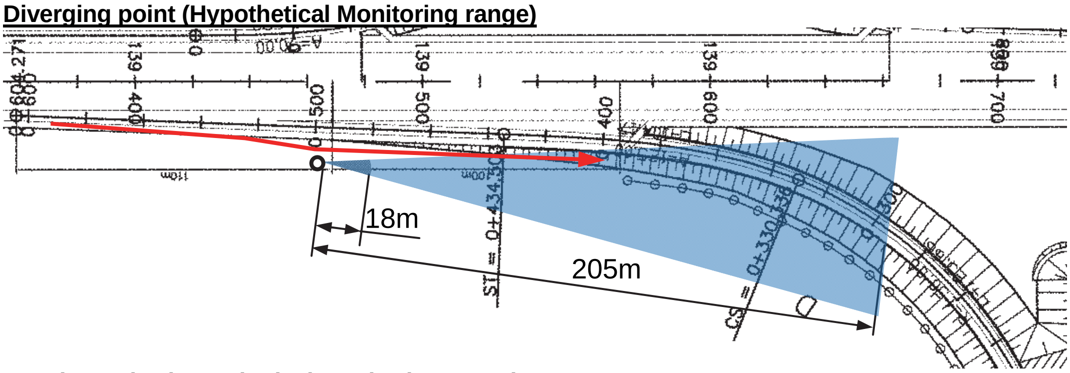
f: the focal length of lens of the CCTV camera is 5.0 mm

Installation of CCTV Fixed camera: The camera shall be installed attached on the median around the diverging point aimed at the travelling direction of the vehicles. The maximum of surveillance of the CCTV camera is calculated at 205 m.

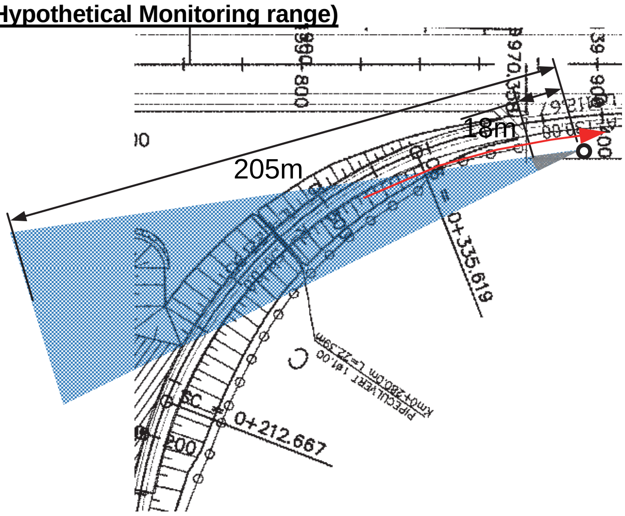
In the design, the monitoring range is assumed as shown in Figure 4.5. CCTV camera will be installed on the roadside for monitoring the ramp of interchanges.

Figure 5.8 Maximum surveillance range of Fixed Camera in an ideal condition

<u>Diverging point (Hypothetical Monitoring range)</u>



<u>Merging point (Hypothetical Monitoring range)</u>

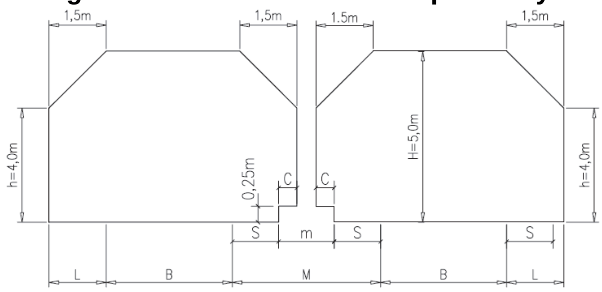


Source: The Study Team

5.5 Installation Height/Angle of CCTV Camera

The height of CCTV camera, PTZ camera should be installed 6-7m above ground level. It is consider about the vertical clearance limit of road (H=5.0m), and make a margin 1.0m from the clearance. Fixed camera should be installed 7-8m above ground level. It is consider that sometimes Fixed camera and PTZ camera are attached the same pole therefore, make a margin 1.0m from the height of PTZ camera installation.

Figure 5.9 Clearance limit of Expressway



Source: TCVN5729 Expressway Standard Design

Figure 5.10 Height of CCTV camera

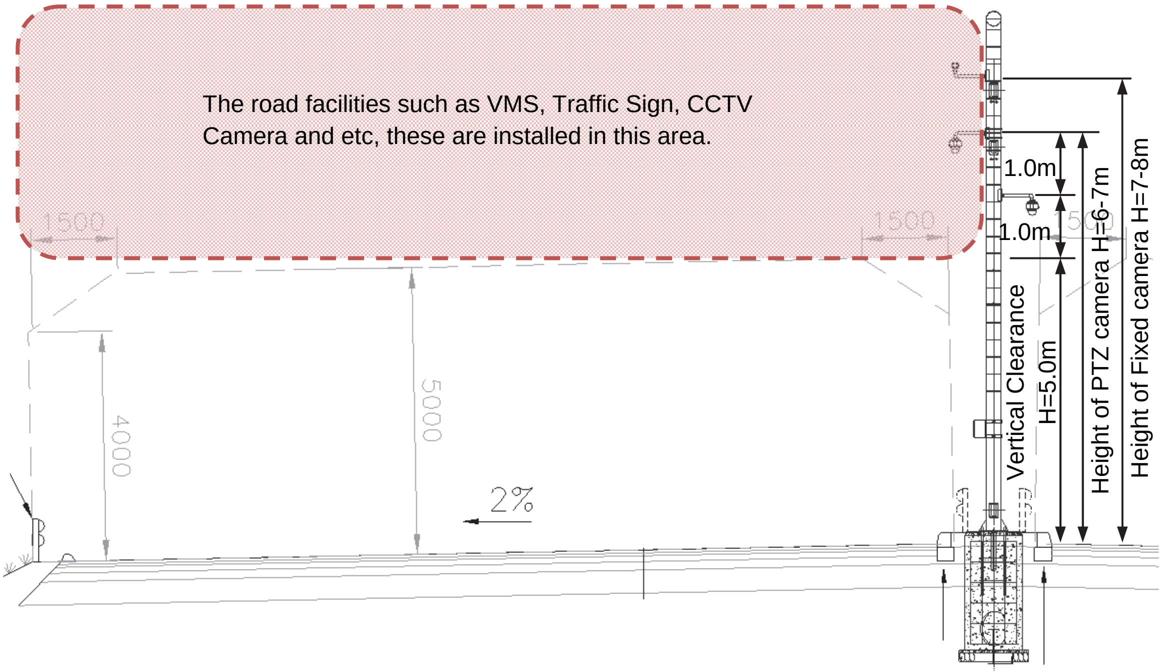


Table 5.5 Height of CCTV Camera

Type of Camera	Height
PTZ Camera	6-7m above Ground level
Fixed Camera	7-8m above Ground level

Field of view of PTZ camera is interrupted by mounting pole as shown Figure 5.11. For example, PTZ camera is located at median, the interrupted width of view is 5,229mm in case of width of one side road is 11,500mm. Also, the interrupted width of view is 8,014mm in case of width of road is 18,000mm. Additionally, Light pole are located continuously, the poles are become the interruption to field of view as shown Figure 5.12.

Therefore, PTZ camera shall be located two cameras for both sides at the location as shown Figure 5.13.

Figure 5.11 Disrupting by Mounting Pole

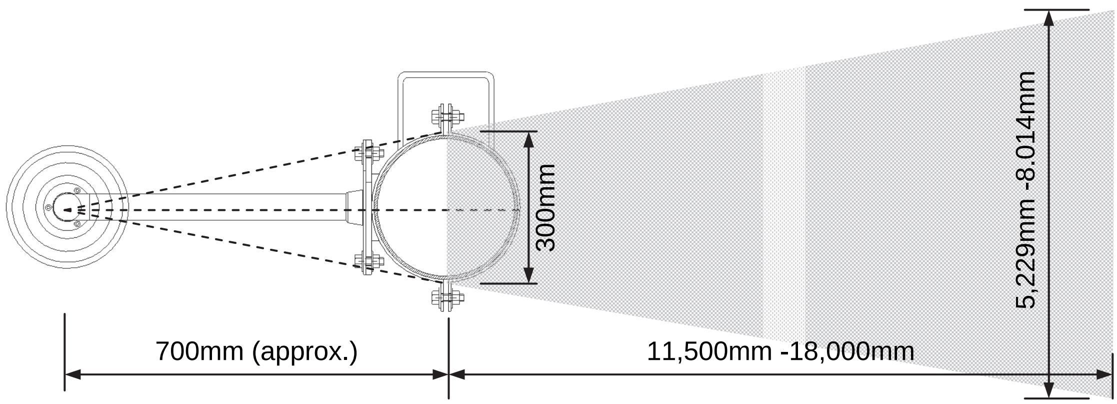


Figure 5.12 Disrupting by Lighting pole

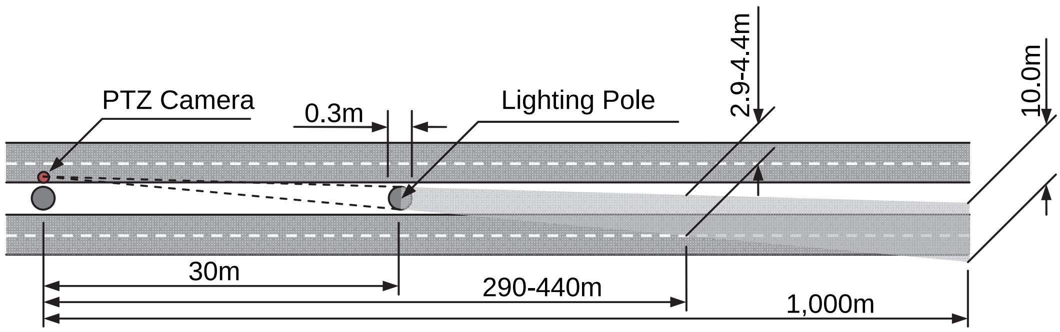
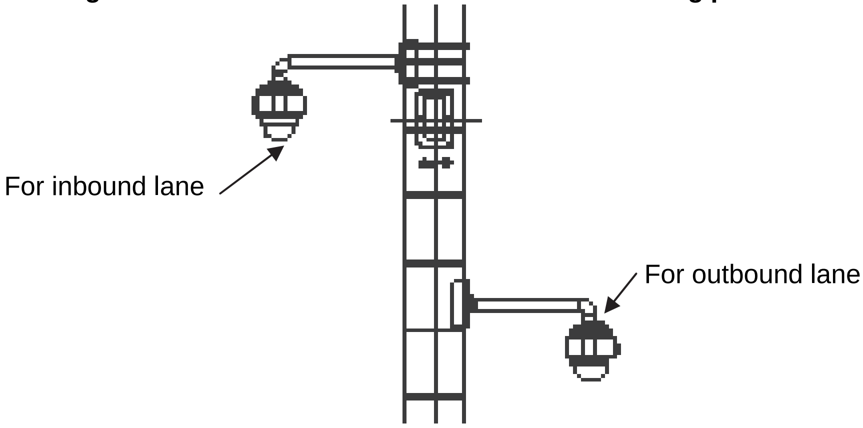


Figure 5.13 Attachment of PTZ camera on mounting pole



5.6 Location of CCTV Camera

(1) Basic Policy

Perform study of operation / monitoring of CCTV Cameras, assuming monitoring the camera image is done at the Regional Main Center or at the Road Management Office.

Have CCTV cameras set up every 2 km on the road section length of 80 km, so the number of cameras will be 40 units in case of ideal condition. Also have many cameras installed in Interchanges and Junctions.

Have PTZ camera complete with Zooming, Tilting and Panning functions for efficient monitoring.

In actual situations, exhaustive monitoring observations will be made without using PTZ functions, since continuous monitoring by the operator is already complex.

Without Zooming function, the maximum range of surveillance is 192.5 m with 4.7 mm lens, or 204.8 m with a 5.0 mm lens (using a 60-inch display). Thus, for approx. 1,800 m distances, it is not able to always observed, in case of installing the camera for every 2 km.

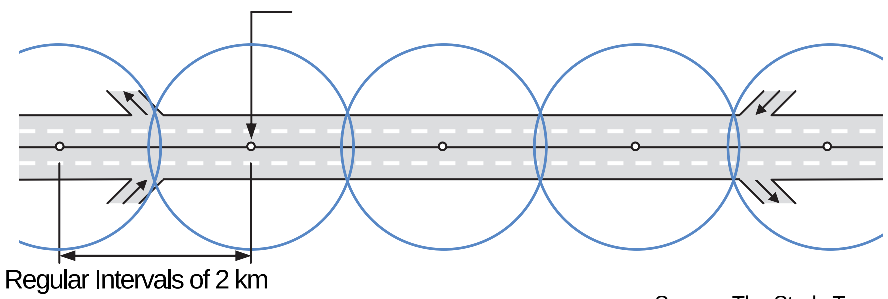
Therefore, the operation / monitoring by CCTV cameras are not constant in the event something occurs, and confirmation will usually be based on incidence reports from drivers and operators.

Hence, in camera location design of our study, to identify the occurrence of incidents reported by telephone, and to identify the severity of incidents by CCTV cameras at any place on the expressway.

(2) Location of CCTV Camera on Through Lanes

CCTV cameras need to be installed continuously along the expressway and are to be utilized only for identifying the severity of incidents through manual panning/zooming of camera. As shown in the foregoing table, if alignment of the expressway can be assumed as completely straight, 2 km spacing between two cameras can perform monitoring using 20-inch display by combination of panning/zooming of camera. If 50-inch display can be used, 2 km spacing can be covered only by zooming.

Figure 5.14 Normal Range of CCTV Camera along the Expressway

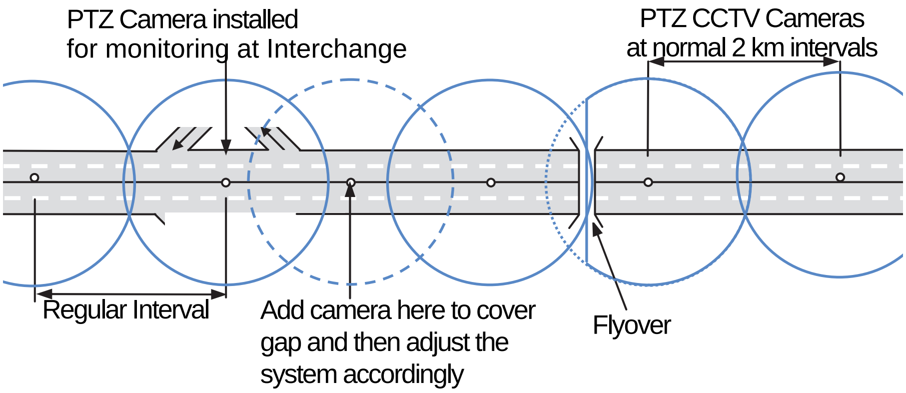


Source: The Study Team

However, in consideration of the actual installation intervals, it is necessary to consider if there are things disrupting the surveillance view of the camera. For example, a physical condition such as longitudinal gradient of road, horizontal alignment of road, flyover bridge and so on.

For example, see Figure 8.6, if there is an Interchange requiring the camera to be installed at its center or if there is a Flyover, then CCTV camera range of surveillance would be insufficient. To solve this situation, another camera should be installed to cover the gap.

Figure 5.15 Adjust CCTV Camera Installation based on actual conditions



Source: The Study Team

Additionally, taking images of distant objects is technically possible by using CCTV camera in case of ideal condition. However, there are many interferences in real condition, such as hard rain, dust, heat haze, damp haze, fog and so on.

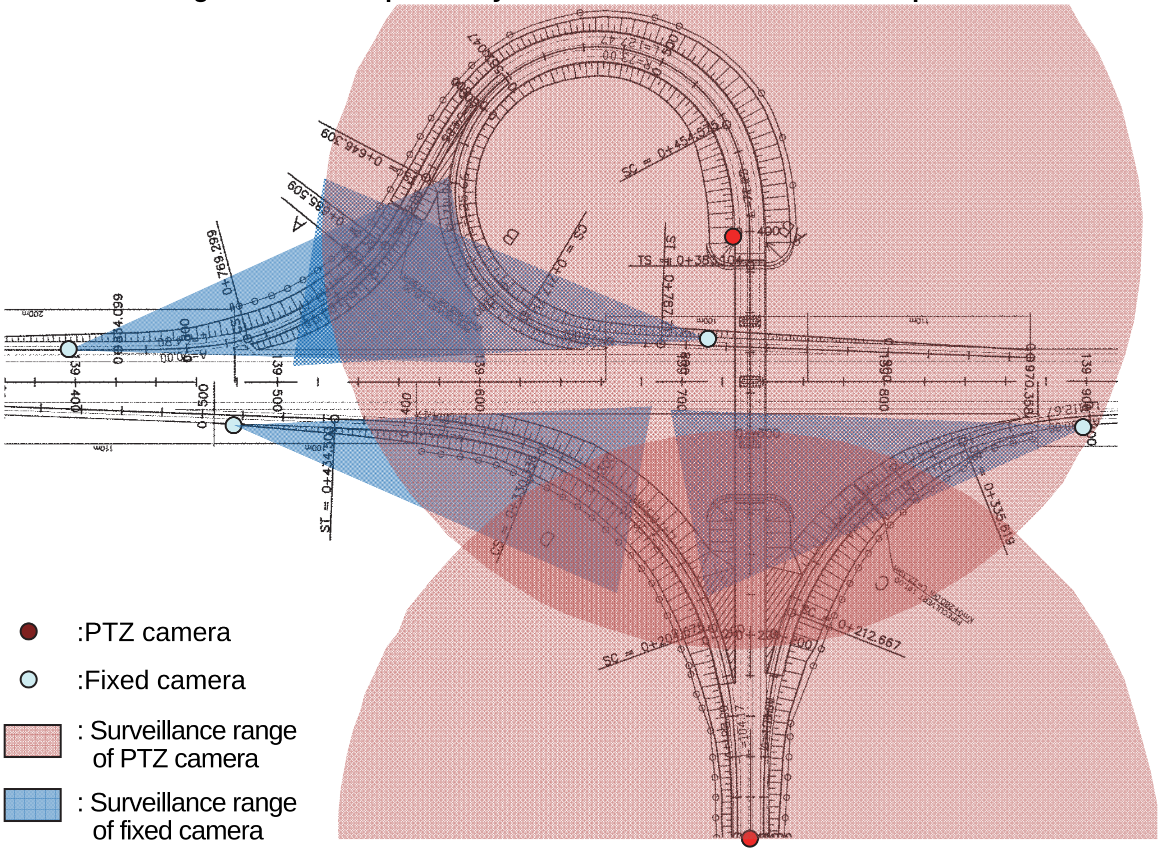
(3) Location of CCTV Camera on Ramp

At the ramp of Interchanges and Junctions, there is a relatively high probability of incident occurrence (such as traffic accidents). The incidents often occur at ramps due to congestion since the ramp has only one lane.

Therefore, CCTV cameras should be installed at the merging and diverging points of Interchanges and Junctions for observation of road traffic.

In addition, there are two types of camera such as Fixed and PTZ Camera. To the consideration as to which camera is capable for observation at ramp of Interchange and Junction. The surveillance range is significant differences in PTZ and Fixed camera as shown figure as follows.

Figure 5.16 Example of Layout for CCTV Camera on the ramp

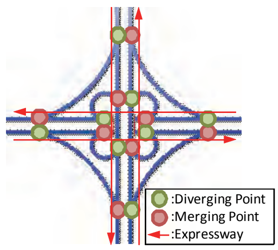
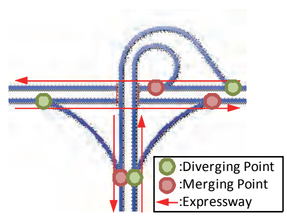


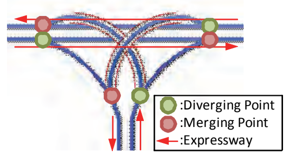
Source: The Study Team

(4) Location of CCTV Camera around Interchange/Junction

Locate a CCTV camera (Fixed type) at each ramp of Junctions.

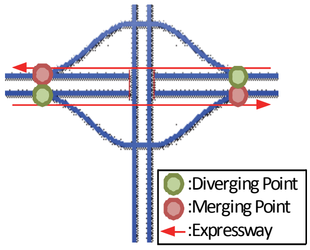
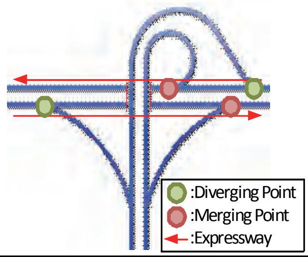
Table 5.6 Location of CCTV Cameras around Interchange/Junction (1)

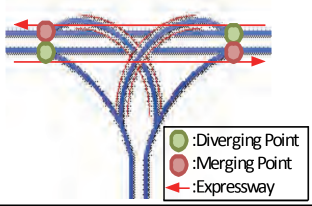
	Junction Type	
	Cloverleaf	Trumpet
		
CCTV Camera (Fixed Type)	16	6

	Junction Type
	Directional T
	
CCTV Camera (Fixed Type)	6

Source: The Study Team

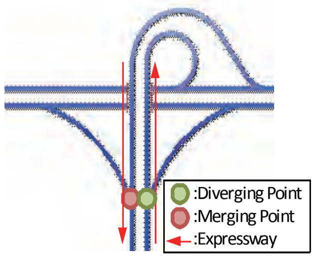
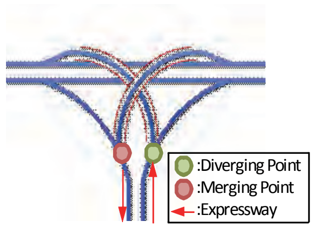
Table 5.7 Location of CCTV Cameras around Interchange/Junction (2)

	Interchange Type	
	Diamond	Trumpet
		
CCTV Camera (Fixed Type)	4	4

	Interchange Type
	Directional T
	
CCTV Camera(Fixed Type)	4

Source: The Study Team

Table 5.8 Location of CCTV Cameras around Interchange/Junction (3)

	Interchange Type (Starting/Ending Point)	
	Diamond	Trumpet
		
CCTV Camera (Fixed Type)	2	2

Source: The Study Team

5.7 Display for CCTV Monitoring at Regional Main Center

(1) Human Machine Interfaces

Video images for traffic surveillance shall be taken by CCTV cameras controlled by the operator using a camera control console in the Main Center. These video images shall be put up on the displays selected automatically or manually in turn by using a monitor console which shall be capable control NVR (Network Video Recorder), and shall be capable being put up on other man-machine displays. The video images shall be monitored also in the road management office and put up on the displays selected manually in turn by using a monitor console at road management office.

Recommended size of monitor screen shall be (approx.) 20 inches or over. All camera images shall be capable of being displayed on Monitor Screen for the operating staff to monitor the traffic conditions.

However, there may be some issues as follows:

- The space of monitoring room may not be sufficient to house all necessary monitor screens
- The number of operators may not be enough for monitoring all CCTV images displayed on Monitor Screens

Therefore, number of monitors should be considered as follows:

- Multi images shall be separately displayed on the same Monitor Screen
- Images of different cameras shall be displayed on the same Monitor Screen in defined rotating interval

(2) Video Data

Since the CCTV camera's picture is standardized by International Standard such as Mpeg 2 and Mpeg 4, shared usage of equipment from different manufacturers is possible.

Especially, since most commercially available IP cameras have video image output based on MPEG-4, the introduction of CCTV cameras complying with ISO/IEC 14496-2 is recommended.

(3) Camera Control Signal

Regarding the control protocol of CCTV camera functions such as zooming, panning, tilting, the following three standards (ONVIF, PSIA, SIA Standards committee) are in competition with each other. At present, there is no one International Standard. They are all discussed below.

Therefore, the CCTV camera can be controlled by the method which is shown in section 2.6 Transmission Design for the time being.

ONVIF: Leaders are Axis, Bosch and Sony; they seem motivated to protect the interests of the largest selling camera manufactures

PSIA: Leader is Cisco and supported by a half dozen camera manufacturers; they seem motivated to protect the interests of manufacturers with lower IP camera market share

SIA Standards Committee:, this committee, the oldest of the three, has actually published standards and looks to be the least political (though not an industry alliance like PSIA and ONVIF, SIA could be the organization that eventually manages the process of standardizing the winning specification)

(4) Transmission Design

The establishment of three Main Centers is considered: one in Hanoi for the northern area, one in Da Nang for the central area, and one in Ho Chi Minh city for the southern area. In case of monitoring roads using CCTV cameras in Main Center, there are some possible issues regarding transmission as follows;

Potential Issues

- If all the Video images from CCTV installed within the area are observed in the Main Center at the same time, the volume of communication online would be excessive
- It is being contemplated that a different manufacturer's CCTV is installed by each road operators for competition. There is no International Standard for Protocol of controlling CCTV functions including Zooming, panning, tilting, it is difficult to control all CCTVs installed within the Main Center Area

Potential Solutions

NVR (Network Video Recorder) is one possible solution. NVR is an internet protocol-based device that sits on network. Because it is IP based, NVR can be managed remotely via LAN or over the Internet giving the user greater flexibility. The basic function of an NVR is the simultaneous recording and remote access of live video streams from IP camera. NVR will feature flexible recording and playback capability, an intuitive remote control unit, a user-friendly GUI, intelligent motion detection, and Panning-Tilting-Zooming camera control.

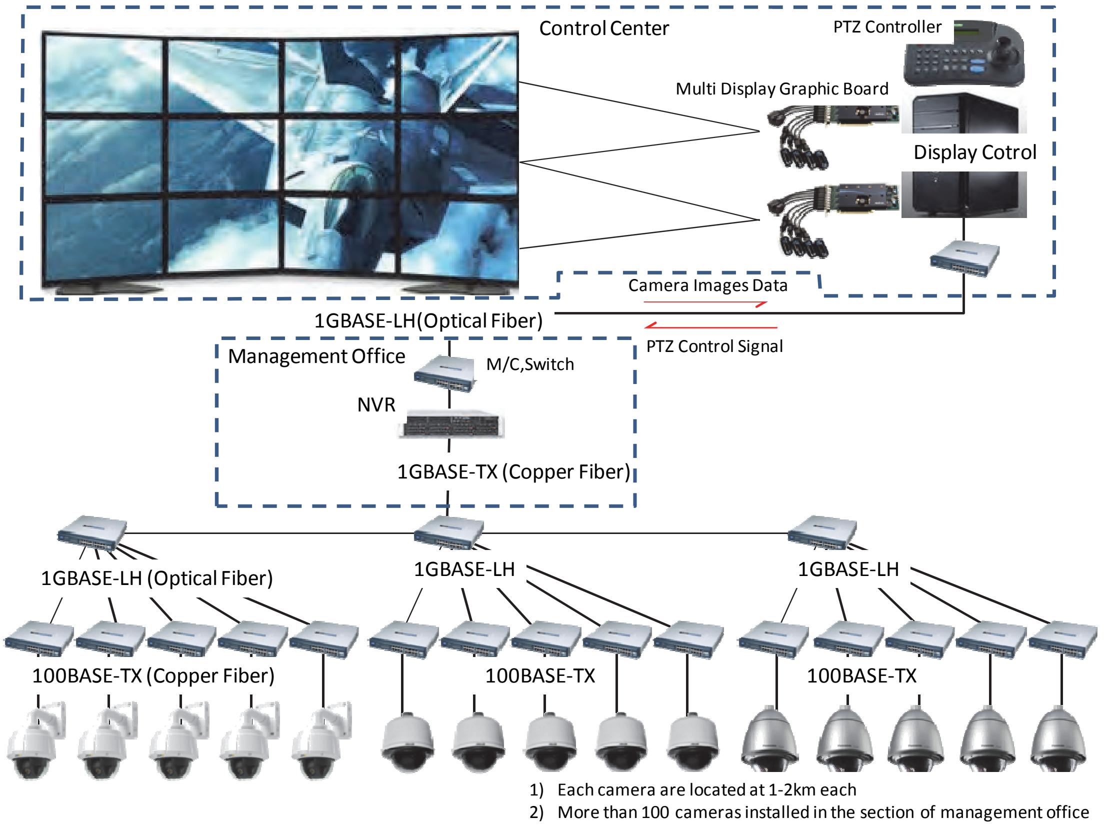
Therefore, by installing one NVR in each interval between Interchanges (or between administrative areas of road operator), the observation of NVR video image from the Main Center and the control of functions such as Panning-Tilting-Zooming are possible. In this case, it is crucial to secure the interoperability of CCTV controlled by different NVRs. (refer to Figure 9.6)

5.8 Display for CCTV Monitoring at Road Management Office

Console equipment is needed for traffic management at Road Management Office. It is implemented for each function of traffic management such as CCTV monitoring, Traffic event management. Normally, the monitoring is not needed at Road Management Office however, it is needed when the incident occur such as traffic accident, disaster, vandalization as so on.

Especially for CCTV monitoring, the console is needed for monitor and PTZ control. At least 2 consoles to be installed for the multiple monitoring and PTZ control at the same time. Additionally, multi display is optional for the monitoring at Road Management Office.

Figure 5.17 Relation of Main Center and NVR on Network

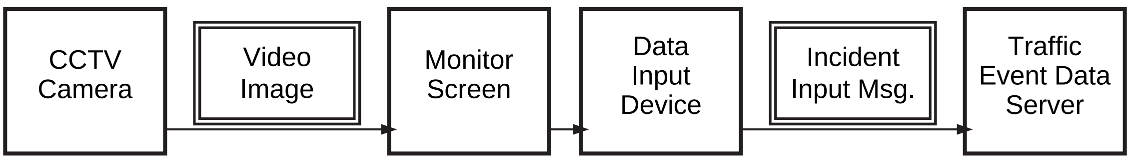


Source: The Study Team

5.9 Data Set for CCTV Image

Major Message Exchanges for generating incident data is shown in the following figure.

Figure 5.18 Major Message Exchanges for Generating Incident Data



Source: The Study Team

1) Video Data

Since the CCTV camera's picture is standardized by International Standard such as Mpeg 2, Mpeg 4, the shared usage of equipment by different manufacturers is possible.

Especially, since most of commercial available IP cameras have video image output based on MPEG-4, the introduction of CCTV cameras complying with ISO/IEC 14496-2 is recommended.

2) Camera Control Signal

Regarding the control protocol of CCTV camera functions such as zooming, panning, tilting, the following 3 standards (ONVIF, PSIA, SIA Standards committee) are in competition with each other. Therefore, at the present stage, it hasn't been standardized by International Standard.

Therefore, the CCTV camera can be controlled by the method which is shown in 2.6 Transmission Design for the time being.

ONVIF: Lead by Axis, Bosch and Sony, they seem motivated to protect the interests of the largest selling camera manufactures

PSIA: Lead by Cisco and supported by a half dozen camera manufacturers, they seem motivated to protect the interests of manufacturers with lower IP camera market share

SIA Standards Committee: the oldest of the 3, this committee has actually published standards and looks to be the least political (though not an industry alliance like PSIA and ONVIF, SIA could be the organization that eventually manages the process of standardizing the winning specification)

3) Incident Data Input

Referring to video image indicated on the monitor screen, a message for generating incident data is to be input by an operator to the traffic event data server.

Table 5.9 Data Set/Elements in Event Input Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Incident Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Roadside Equipment ID	INT*	4	1		
	Incident Status	INT*	2	1		
	Date/Time	Datetime	≥14	1		
Event Image Data Set <G - Server>	Road Management Office ID	INT*	4	1	When an event is checked	1 year
	Roadside Equipment ID	INT*	4	1		
	Place ID	INT*	4	1		
	Video Image ID	INT	8	1		
	Event Video Image	IMG	var	1		
	Traffic Event Data ID	INT	8	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

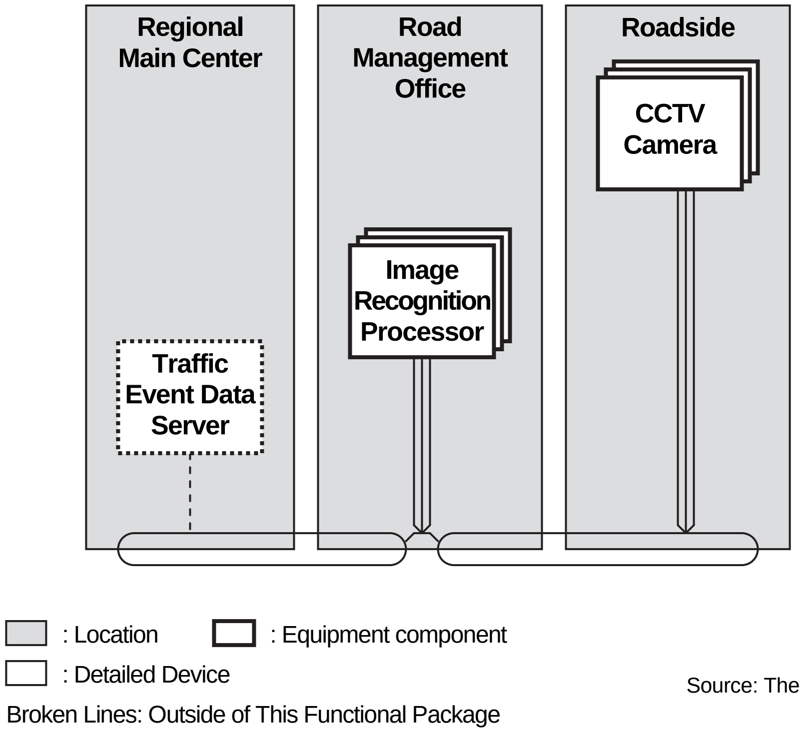
Source: The Study Team

6. Event Detection (by Image)

6.1 Outline and System Architecture

Notification to the Regional Main Centres and road management offices by analyzing video images from cameras installed at bottleneck spots where traffic can be easily stuck and at long tunnel sections.

Figure 6.1 System Architecture for Event Detection



Source: The Study Team

6.2 Traffic Event to be Detected

Event detection equipment is capable of automatically detecting the occurrence of an accident, a broken vehicle or a falling object and give notice to Regional Main Centre and Road Management Office by analyzing pictures taken by cameras which are installed in road side. At the ramp of Interchanges and Junctions, there is a relatively high probability of incident occurrence (such as broken down vehicle, traffic accidents). The incidents often occur at ramps due to congestion since the ramp has only one lane.

Therefore, CCTV cameras should be installed at the merging and diverging points of Interchanges and Junctions with Event detection. Then, shall be capable detection Stopped Vehicle, Wrong-way Vehicle and Speed drop vehicle.

Therefore, CCTV cameras should be installed at the merging and diverging points of Interchanges and Junctions with Event detection. Then, shall be capable detection Stopped Vehicle, Wrong-way Vehicle and Speed drop vehicle.

6.3 Detection Algorithm by Image Recognition

There are multi-categories of analyzing image system. Analyzing image system on highway requires vehicle detection position on the road, and the system requires that the vehicle identification technique shows a suitable image. Image analysis techniques for the last 10 years have met with difficulties in analyzing when having both vehicle and motorcycle objects move on one screen in many different ways. However, with present analysis technique, there is improved accuracy when analyzing image and for many vehicle types.

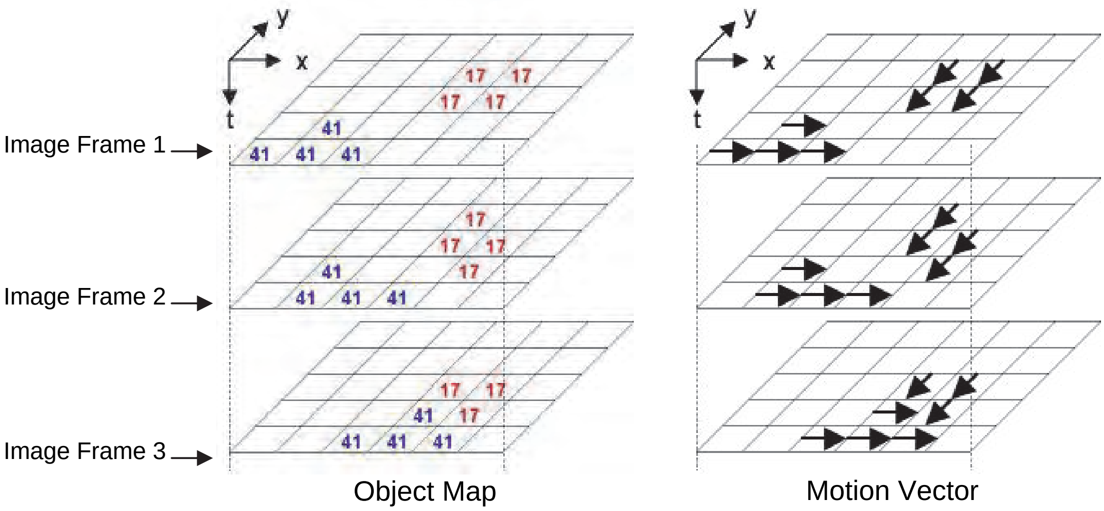
(1) Example of the method

For example, this section presents general information about one image analysis method called "S-T MRF Model (Space-time Markov Random Field Model)". S-T MRF Model is the technology which is invented by Dr.Kamijo laboratory of Institute of Industrial Science, University of Tokyo. (http://kmj.iis.u-tokyo.ac.jp/e_index.html)

The method is a probability model to divide the Space-time image area. S-T MRF Model focus on mutual relationship between time-scale directions of Space-time images enlarged as Space-time model. Normal MRF Model often divides area according to pixels. There is only one principle in S-T MRF Model; however, in case of comparing image frames, a vehicle moves from a few pixels to dozens of pixels; therefore the dividing area according to pixel is very difficult.

Therefore, S-T MRF Model divides the area according to block unit which is defined as 8 × 8 pixels, and as mutual relationship between time scale directions after consulting motion vector of each block by comparing image frames.

Figure 6.2 Recognition Imagery of S-T MRF Model



※Processing image that change gradually of Image Frames1 to 3, analysing, comparing, detecting movement and existing position of object

Source: Dr.Kamijo laboratory of Institute of Industrial Science, University of Tokyo.

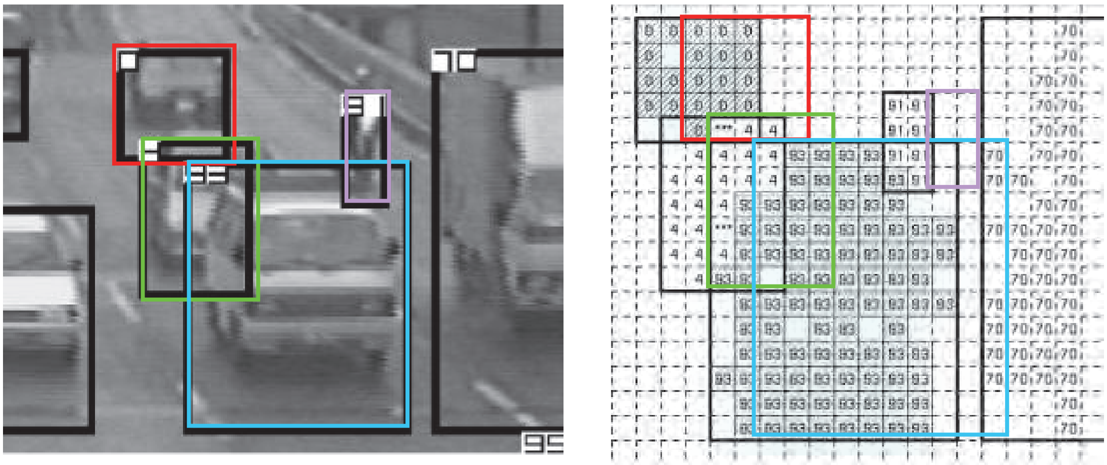
In addition, by applying probabilistic relaxation model, in case of occlusion due to different vehicles, still it is able to analyze the moving object line most suitably. Time/space MRF model only focuses on moving vectors of object in order to divide the area, but not as category of object.

Example: In case monitor is constructed as 640 × 480 pixels then divide into blocks with 8 × 8 pixels, and after that distribute into 80 × 60 blocks.

Followings figure show processing of image on the left, and then status of object identification by object map on the right. Vehicle in green frame is identified in range of 5 x 7 blocks (shown on Object Map as No.4) is overlapped vehicle in blue frame (shown on Object Map as No.93). In spite of occlusion here, exact detection is made.

This image analyzes by improved vehicle detection technique. The received image information can detect incident occurrence by reduced speed or unexpected stopping of vehicle. Therefore, it is possible to detect what happened by image analyzing; however, it is impossible to analyze the reason for the incident such as traffic accident or broken down vehicles. Hence it is necessary to confirm by CCTV or patroller.

Figure 6.3 Recognition Sample of S-T MRF Model



CCTV Image

Object Map

Source: Dr.Kamijo laboratory of Institute of Industrial Science, University of Tokyo.

(2) Notandum in Image Recognition

The accuracy of image processing device depends on angle of view of CCTV camera. In short, images that are difficult to see by human eye also affect the accuracy when analyzing. In order to maintain accuracy of measurement/detector, it is necessary to investigate a site completely before installing event detector to avoid installing at places yielding same image as before installation.

For example, image in the left, a small passenger car is hiding beside the truck. This angle of view is undesirable. On the right image, the skyline may be affected by sunshine depending on time of day or camera direction.

Figure 6.4 Sample of Undesirable Angle of View

Source: SOHATSU System Institute Co., LTD.

Therefore, if PTZ camera is used for surveillance with image recognition, then you need to set image recognition settings each time when resetting the direction of the camera in order to ensure the recognition accuracy. Fixed camera, always the direction is fixed, so it is relatively easy to apply.

There are pros and cons for either type, so the best one should be selected according to the conditions such as the grade of the road, the frequency of patrol and the frequency of incident occurrence and so on.

Table 6.1 Advantage/Disadvantage of Fixed/PTZ Camera

	Fixed Camera	PTZ Camera
Applicability of image recognition for reducing human errors	++ Applicable	+ Impractical
Proper installation point around interchange	Applicable at Diverging and Merging point of the Ramp	Applicable for observation to whole of the Ramp at interchange
Evaluation Grade	Adopted for Event Detection	Insufficient for Event Detection

Source: The Study Team

6.4 Required Function/Performance of CCTV Camera

In case of incident detection by recognition of the camera image, the image recognition is able to perform while PTZ functions are in use according to manufacturer product. Fixed camera is recommended for the accuracy control.

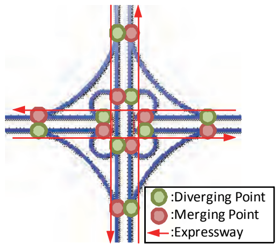
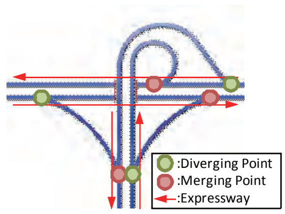
The camera is installed at outdoor, should be capable done waterproof, dustproof. Therefore, the camera should be equipped an ingress protection based on IP66 more, according to ISO/IEC60529.

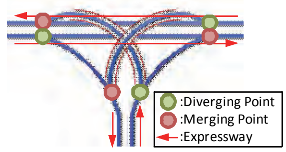
6.5 Location of CCTV Camera

(1) Location of CCTV Camera around Interchange/Junction

Locate a CCTV camera (Fixed type) at each ramp of Interchange. The number of CCTV cameras depends on the connection directions of the main road.

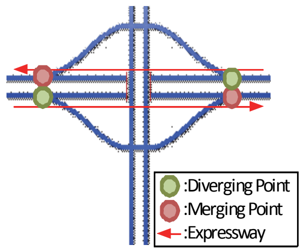
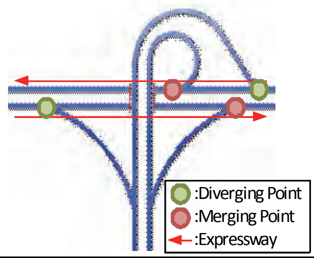
Table 6.2 Location of CCTV Cameras around Interchange/Junction (1)

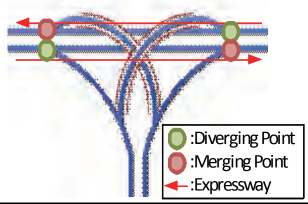
	Junction Type	
	Cloverleaf	Trumpet
		
CCTV Camera (Fixed Type)	16	6

	Junction Type
	Directional T
	
CCTV Camera (Fixed Type)	6

Source: The Study Team

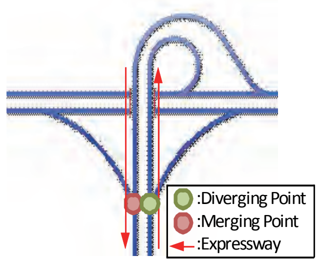
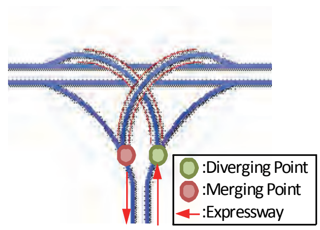
Table 6.3 Location of CCTV Cameras around Interchange/Junction (2)

	Interchange Type	
	Diamond	Trumpet
		
CCTV Camera (Fixed Type)	4	4

	Interchange Type
	Directional T
	
CCTV Camera(Fixed Type)	4

Source: The Study Team

Table 6.4 Location of CCTV Cameras around Interchange/Junction (3)

	Interchange Type (Starting/Ending Point)	
	Diamond	Trumpet
		
CCTV Camera (Fixed Type)	2	2

Source: The Study Team

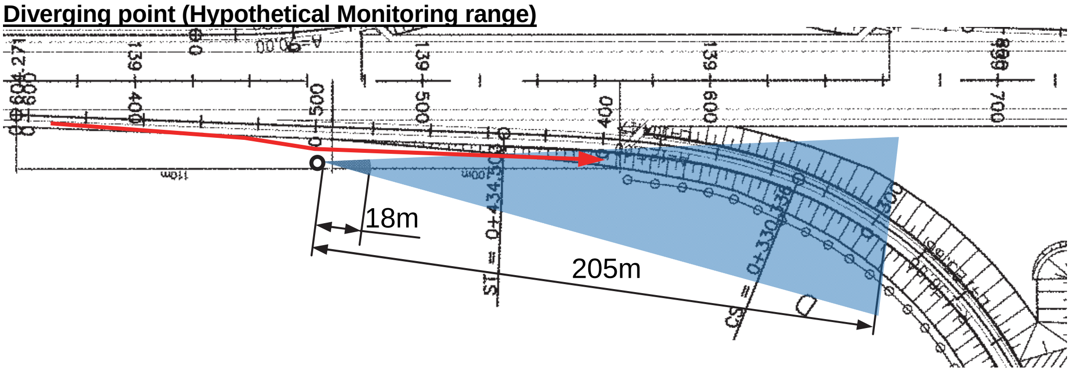
(2) Arrangement of CCTV Camera

Event detection cameras should be installed at the merging and diverging points of the ramp. Then, shall be capable detection Stopped Vehicle, Wrong-way Vehicle and Speed drop vehicle. According to Table 4.2, maximum surveillance range is approx. 200 m long, it is possible by using 60-inch display and the camera has got functions such as 1/4” inch image sensor and 5.0 mm focal length of lens.

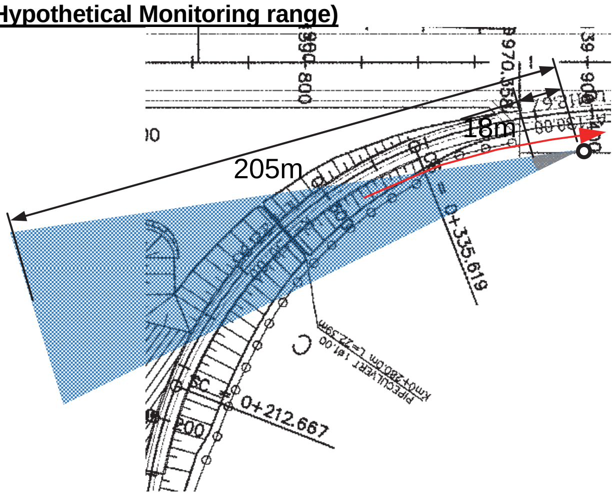
Therefore, the CCTV camera shall be installed on the median or roadside at around begin or end of the curve.

Figure 6.5 Maximum surveillance range of Fixed Camera in an ideal condition

Diverging point (Hypothetical Monitoring range)



Merging point (Hypothetical Monitoring range)

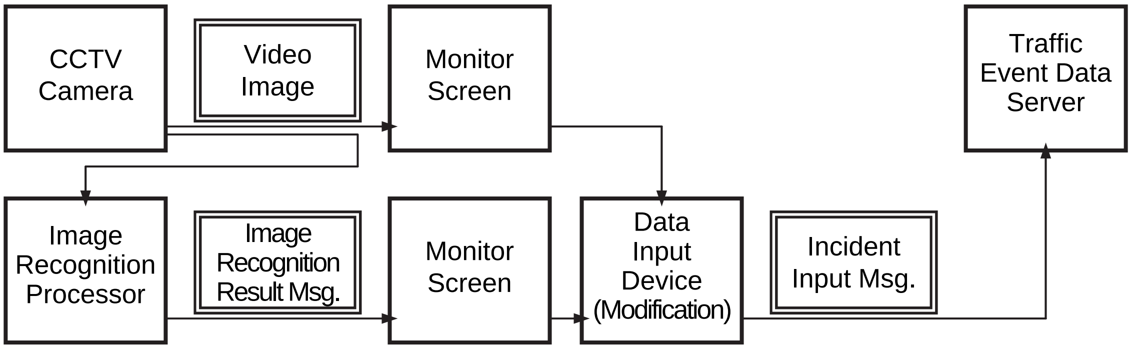


Source: The Study Team

6.6 Data Set for Event Detection

Major Message Exchanges for generating incident data is shown in the following figure.

Figure 6.7 Major Message Exchanges for Generating Incident Data



Source: The Study Team

Captured image by CCTV camera is to be sent automatically to the image recognition processor, analyzed results are to be shown to an operator and a message for generating incident data is to be input to the traffic event data server.

Figure 6.5 Data Set/Elements in Image Recognition Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Image Recognition Result Data Set <G - Image Processor>	Road Management Office ID	INT*	4	1	When an event occurs	Latest
	Roadside Equipment ID	INT*	4	1		
	Image Recognition Result Status	INT*	2	1		
	Video Image Address	TXT	60	1		
	Date/Time	Datetime	≥14	1		
Incident Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Roadside Equipment ID	INT*	4	1		
	Incident Status	INT*	2	1		
	Date/Time	Datetime	≥14	1		
Event Image Data Set <G - Server>	Road Management Office ID	INT*	4	1	When an event is checked	1 year
	Roadside Equipment ID	INT*	4	1		
	Place ID	INT*	4	1		
	Video Image ID	INT	8	1		
	Event Video Image	IMG	var	1		
	Traffic Event Data ID	INT	8	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

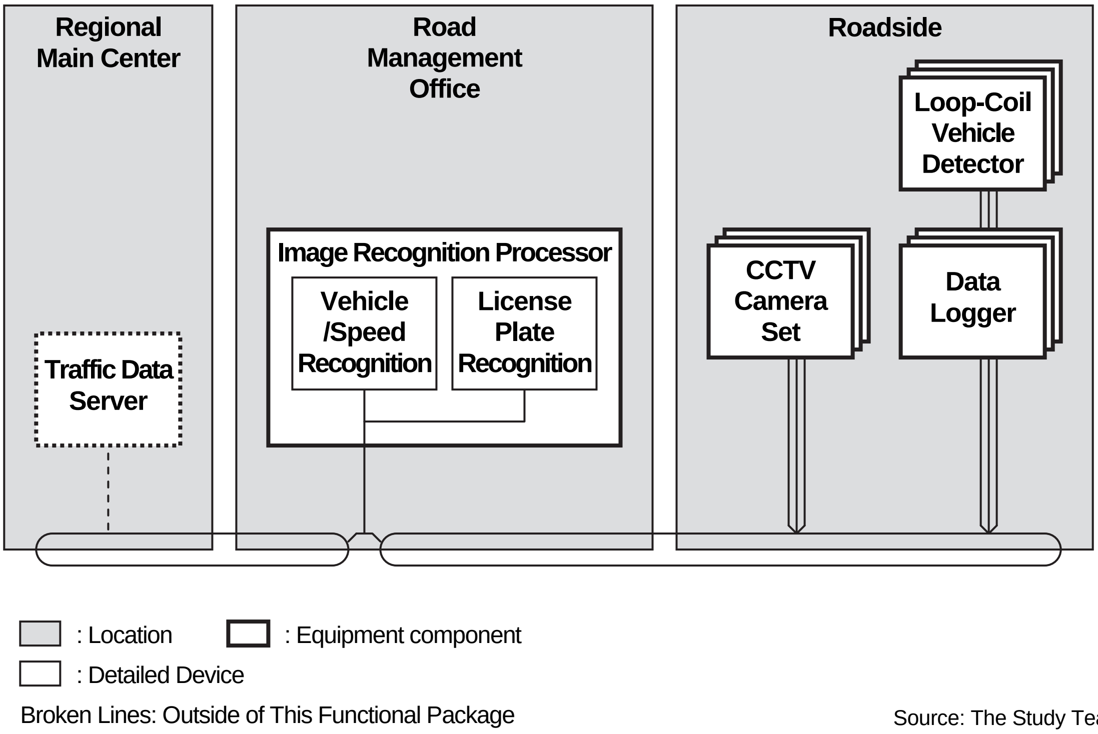
Source: The Study Team

7. Vehicle Detection

7.1 Outline and System Architecture

This functional package allows road operators to measure actual traffic volume, heavy vehicle ratio and vehicle velocity on the expressways for developing road operation/ improvement plans by using vehicle detectors installed at important points on the throughway and the tollgates.

Figure 7.1 System Architecture for Vehicle Detection



Source: The Study Team

7.2 Vehicles/Classes to be Identified

(1) Measurement Data by using Vehicle Detection

Vehicle detection shall be capable detection the traffic volume, vehicle speed and length of vehicle of all vehicles on expressway. Detection for motor cycle is optional function.

At least, following items of measurement is required;

- Number of vehicle
- Vehicle Length
- Vehicle Speed

(2) Method of calculation for required traffic data

a) Average vehicle speed per unit of time

The calculation of average speed per unit of time, it is calculated from the past data of the total number of vehicle and vehicle speed by using following formula;

$AV_{ut} = (Vv_{(1)} + Vv_{(2)} + \cdots\cdots Vv_{(N)}) / Q_{ut}$

AV_{ut} : Average vehicle speed per unit of time

$Vv_{(1)\text{-}(N)}$: Vehicle Speed of each vehicle

Q_{ut} : Number of Vehicle per unit of time (Σ from 1 to N)

N : Number of data per unit of time (it is should be the same of Q_{ut})

b) Occupancy per unit of time

The calculation of occupancy per unit of time, it is calculated from the past data of the vehicle length and vehicle speed by using following formula;

$OC_{ut} = (VLv_{(1)} / Vv_{(1)} + VLv_{(2)} / Vv_{(2)} + \cdots\cdots + VLv_{(N)} / Vv_{(N)}) / UT \times 100$

OC_{ut} : Occupancy per unit of time

$Vv_{(1)\text{-}(N)}$: Vehicle Speed of each vehicle

$VLv_{(1)\text{-}(N)}$: Vehicle Length of each vehicle

UT : Unit of time (ordinary, it is 1 minute and 5 minutes)

N : Number of data per unit of time

c) Calculation Vehicle Speed and Vehicle Length by using Loop-coil data

In case of measuring vehicle velocity, it’s necessary to install two loop coils, calculate vehicle velocity by dividing the distance between two loop coils by the time difference between vehicle detection timing of each loop coil.

$V_V = L_S / TD_S$

V_V : Vehicle Speed

L_S : Distance between each loop coils

TD_S : Time difference between detection timing of each loop coils

In addition, regarding vehicle length, it is necessary to calculate the vehicle length by calculated vehicle velocity multiplied by the reaction of detection time of loop coil.

$VL_V = V_V \times RT_S$

VL_V : Vehicle Length

V_v : Vehicle Speed

RT_S : Reaction Time of loop coil

(3) Vehicle Class for Detecting Traffic Volume

Vehicle class for detecting traffic volume is defined as shown in the table below.

Table 7.1 Vehicle Class for Detecting Traffic Volume

Vehicle Class	Definition
Ordinary Vehicle	Detected Length ≤ 6 m
Large Vehicle	6 m< Detected Length ≤ 12 m
Traler Vehicle	12 m < Detected Length

Source: The Study Team

7.3 Types of Vehicle Detector

There are many types of vehicle detectors which can be categorized into in-road sensors and over-road sensors. a) Loop-coil type is mainly used in in-road sensors whereas b) Ultrasonic type and c) Image recognition type are mainly used in over-road sensors. Characteristics for each type of vehicle detector are described in following Tables.

The focus of attention in this paragraph is on a) Loop-coil type, b) Ultrasonic type and c) Image recognition.

(1) Loop-coil Type

This type detects vehicles passing by using electromagnetic induction. Number of vehicles can be counted with relatively high accuracy. However, it is difficult to install in bridge sections because of difficulty to secure a sufficient distance from steel to the loop-coil.

Advantages: The operation of inductive loop-coil type is well understood and their application for providing basic traffic parameters (volume, presence, occupancy, speed, headway, and gap) represents a mature technology. The equipment cost of loop-coil type may be low when compared to over-road sensors. Another advantage of loop-coil type is their suitability for a large variety of applications due to their flexible design.

Disadvantages: The drawbacks of loop-coil type detectors include disruption of traffic for installation and repair, and failures associated with installations in poor road surfaces and use of substandard installation procedures. In addition, resurfacing of roadways and utility repair can also create the need to reinstall these types of sensors. The wire loops are also subject to the stresses of traffic and temperature. Therefore, installation and maintenance costs significantly increase the life-cycle cost of loop-coil type detectors. In many instances multiple detectors are required to instrument a location.

(2) Ultrasonic Type

This type detects vehicles passing by using arrival time difference of ultrasonic waves reflected from objects on the road and from the road. Number of vehicles can be counted with relatively high accuracy. However, it is difficult to distinguish the vehicles from the other objects on the road.

Advantages: Installation of ultrasonic type does not require an invasive pavement procedure.

Disadvantages: Temperature change and extreme air turbulence may affect the performance of ultrasonic type. Temperature compensation is built into some models. Large pulse repetition periods may degrade occupancy measurement on road with vehicles travelling at moderate to high speeds.

(3) Image Recognition Type

This type detects moving objects in images captured from video cameras according to preset size/speed of the object. The image recognition can be conducted using higher quality images in comparison with that for visual inspection. Number of detected vehicles also can be counted in the system.

Advantages: Allows to detection multiple lanes and multiple detection zones/lane. Easy to add and modify detection zones by setting of recognition processor. Provides wide-area detection when information gathered at one camera location can be linked to another.

Disadvantages: Some disadvantages of the image recognition include its vulnerability to viewing obstructions; inclement weather; shadows; vehicle projection into adjacent lanes; occlusion; day to night transition; vehicle/road contrast; water; salt grime; and cobwebs on camera lens that can affect performance. Image recognition arrangement is generally cost effective only if many detection zones are required within the field of view of the camera.

Table 7.2 Traffic output data of Vehicle Detection

Type	Output Data			Multiple Lane Detection
	Count	Speed	Length	
a) Loop-coil type	Capable	On condition [1)]	On condition [2)]	
b) Ultrasonic type	Capable	—	—	
c) Image Recognition type	Capable	Capable	Capable	Capable

[1)] Speed can be measured by using two sensors a known distance apart.
[2)] Length can be calculated from speed and detected time of sensor.

Source: The Study Team

Accordingly, we recommend that to install vehicle detection by using image recognition type. Additionally, install Loop-coil type at one cross-section for the evaluation of the measured data of image recognition.

Table 7.3 Advantages and Disadvantages of Type of Vehicle Detectors

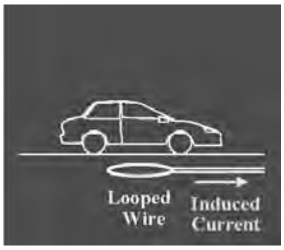
Type	Advantages	Disadvantages
a) Loop-coil type	1) Flexible design to satisfy large variety of applications. 2) Mature, well understood technology. Large experience base. 3) Provides basic traffic parameters (e.g., volume, presence, occupancy, speed, headway, and gap). 4) Insensitive to inclement weather such as rain, fog, and snow. 5) Provides best accuracy for count data as compared with other commonly used techniques. 6) Common standard for obtaining accurate occupancy measurements. 7) High frequency excitation models provide classification data.	1) Installation requires pavement cut. 2) Decreases pavement life. 3) Installation and maintenance require lane closure. 4) Wire loops subject to stresses of traffic and temperature. 5) Multiple detectors usually required to monitor a location. 6) Detection accuracy may decrease when design requires detection of a large variety of vehicle classes.
b) Ultrasonic type	1) Multiple lane operation available. 2) Capable of over-height vehicle detection. 3) Large Japanese experience base.	1) Environmental conditions such as temperature change and extreme air turbulence can affect performance. 2) Temperature compensation is built into some models. 3) Large pulse repetition periods may degrade occupancy measurement on freeways with vehicles travelling at moderate to high speeds.
c) Image Recognition type	1) Monitors multiple lanes and multiple detection zones/lane. 2) Easy to add and modify detection zones. 3) Rich array of data available. 4) Provides wide-area detection when information gathered at one camera location can be linked to another.	1) Installation and maintenance, including periodic lens cleaning, require lane closure when camera is mounted over roadway. (lane closure may not be required when camera is mounted at side of roadway) 2) Performance affected by inclement weather such as fog, rain, and snow; vehicle shadows; vehicle projection into adjacent lanes; occlusion; day-tonight transition; vehicle/road contrast; and water, salt grime, icicles, and cobwebs on camera lens. 3) Some models susceptible to camera motion caused by high winds or vibration of camera mounting structure. 4) Generally cost-effective when many detection zones within the field-of view of the camera or specialized data are required. 5) Reliable nighttimes signal actuation requires street lighting.

Source: The Study Team

There are pros and cons for every type; however, a) Loop-coil type is the most common sensor used in traffic management, and a mature technology. Also, b) Ultrasonic type is common sensor used in traffic management in Japan. Recently, c) Image recognition type is applied in traffic management; however, availability and accuracy of the image recognition is affected from vulnerability to obstructions. Some products avoid the vulnerability. In fact, it is developing technology so, requires further validation.

Therefore, mainly a) Loop-coil type is adopted in this study, also c) Image recognition type is in trial to implement at some point with a) Loop-coil for providing an opportunity for validation.

Table 7.4 Comparison of Vehicle Detection

	a) Loop-coil type	b) Ultrasonic type	c) Image Recognition type
Outline			
Installation	Being buried in a sufficient distance from steels	Being fixed on the structure securing clearance of the road	Being fixed on the stable structure securing sight path
Unsuitable Location	+ Metal bridge section	++ None	++ None
Implementation Cost	+++ Low	++ Average	+ High
Applicability to Traffic Swerved from Lanes	+ Incapable	+ Incapable	++ Capable
Secondary Usage for Visual Judgment	+ Incapable	+ Incapable	++ Capable
Availability	+++ High	+++ High	++ Average
Serviceability	+ Low	++ Average	++ Average
Endurance	++ Average	+++ High	++ Average
Maintenance	Necessary to work on the pavement for mechanical trouble caused by heat	Very rare and not necessary to work on the pavement	Not necessary to work on the pavement
Grading	Adopted	Applicable	Adopted

Grade: +++ = best, ++ = average, + = worst.

Source: The Study Team

7.4 Detection Algorithm by Image Recognition

There are multi-categories of analyzing image system. Analyzing image system on highway requires vehicle detection position on the road, and the system requires that the vehicle identification technique shows a suitable image. Image analysis techniques for the last 10 years have met with difficulties in analyzing when having both vehicle and motorcycle objects move on one screen in many different ways. However, with present analysis technique, there is improved accuracy when analyzing image and for many vehicle types.

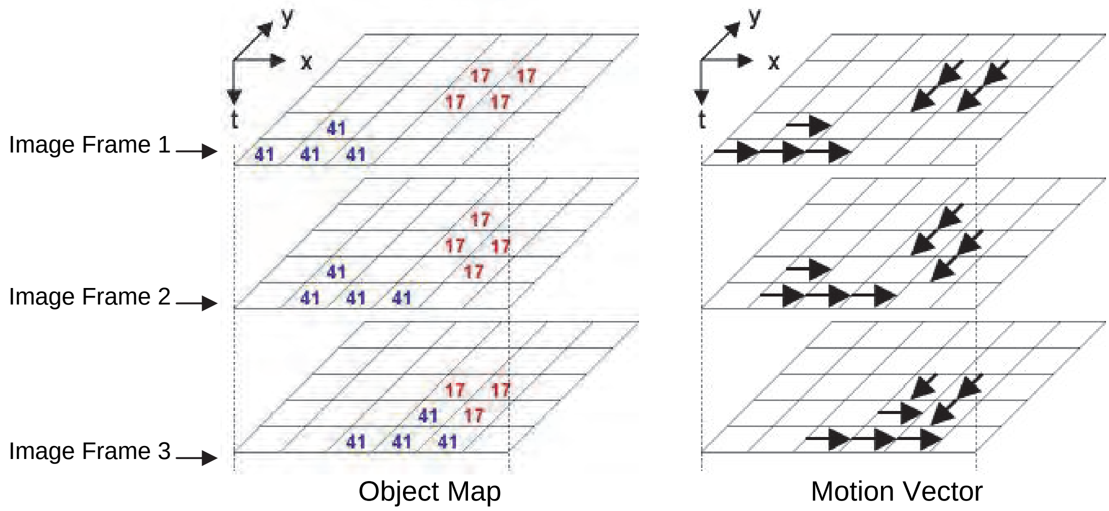
(1) Example of the method

For example, this section presents general information about one image analysis method called "S-T MRF Model (Space-time Markov Random Field Model)". S-T MRF Model is the technology which is invented by Dr.Kamijo laboratory of Institute of Industrial Science, University of Tokyo. (http://kmj.iis.u-tokyo.ac.jp/e_index.html)

The method is a probability model to divide the Space-time image area. S-T MRF Model focus on mutual relationship between time-scale directions of Space-time images enlarged as Space-time model. Normal MRF Model often divides area according to pixels. There is only one principle in S-T MRF Model; however, in case of comparing image frames, a vehicle moves from a few pixels to dozens of pixels; therefore the dividing area according to pixel is very difficult.

Therefore, S-T MRF Model divides the area according to block unit which is defined as 8 × 8 pixels, and as mutual relationship between time scale directions after consulting motion vector of each block by comparing image frames.

Figure 7.2 Recognition Imagery of S-T MRF Model



※Processing image that change gradually of Image Frames1 to 3, analysing, comparing, detecting movement and existing position of object

Source: Dr.Kamijo laboratory of Institute of Industrial Science, University of Tokyo.

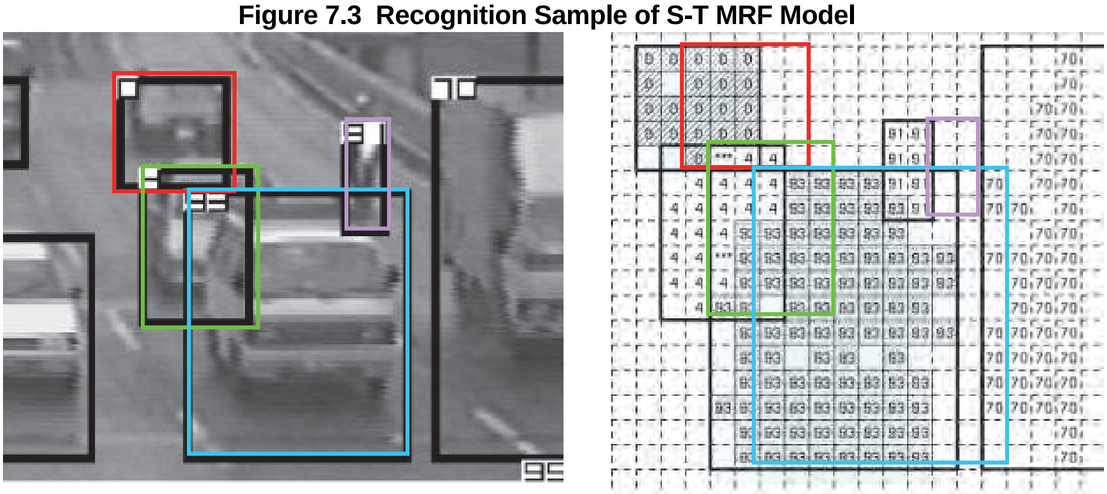
In addition, by applying probabilistic relaxation model, in case of occlusion due to different vehicles, still it is able to analyze the moving object line most suitably. Time/space MRF model only focuses on moving vectors of object in order to divide the area, but not as category of object.

Example: In case monitor is constructed as 640 × 480 pixels then divide into blocks with 8 × 8 pixels, and after that distribute into 80 × 60 blocks.

Followings figure show processing of image on the left, and then status of object identification by object map on the right. Vehicle in green frame is identified in range of 5 x 7 blocks (shown on Object Map as No.4) is overlapped vehicle in blue frame (shown on Object Map as No.93). In spite of occlusion here, exact detection is made.

This image analyzes by improved vehicle detection technique. The received image information can detect incident occurrence by reduced speed or unexpected stopping of vehicle. Therefore, it is possible to detect what happened by image analyzing; however, it is impossible to analyze the reason for the incident such as traffic accident or broken down vehicles. Hence it is necessary to confirm by CCTV or patroller.

Figure 7.3 Recognition Sample of S-T MRF Model



CCTV Image

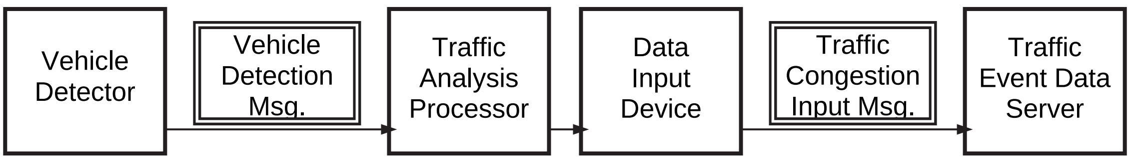
Object Map

Source: Dr.Kamijo laboratory of Institute of Industrial Science, University of Tokyo.

7.5 Data Set for Vehicle/Classes

Major message exchanges for generating traffic congestion data is shown in the following figure.

Figure 7.4 Major Message Exchanges for Generating Traffic Congestion Data



Source: The Study Team

Vehicle category is divided by the vehicle length. It is assumed that if the vehicle length is more than 5.5m then the vehicle is full-sized car. The system be capable of discretionarily setting the unit time of recording volume, average speed, occupancy and traffic flow speed.

Additionally, the system shall have video image output interface to adjust angle of view of camera and control signal receiving interface to check camera operations for setting-up at installation site.

Data set of Vehicle Detection is shown in the table below.

Table 7.5 Data Set/Elements in Vehicle Detection Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Image Recognition Result Data Set <G - Image Processor>	Road Management Office ID	INT*	4	1	When an event occurs	Latest
	Roadside Equipment ID	INT*	4	1		
	Image Recognition Result Status	INT*	2	1		
	Video Image Address	TXT	60	1		
	Date/Time	Datetime	≥14	1		
Vehicle Detection Data Set <G - Vehicle Detector>	Road Management Office ID	INT*	4	1	Every 5 minutes	Latest
	Roadside Equipment ID	INT*	4	1		
	Cumulative Number of Vehicles	INT*	4	1		
	Vehicle Speed	FLOAT	5	N		
	Vehicle Length	FLOAT	4			
	Date/Time	Datetime	≥14	1		
Traffic Congestion Data Set <G - Traffic Analysis Processor>	Road Management Office ID	INT*	4	1	Every 5 minutes	1 year
	Roadside Equipment ID	INT*	4	1		
	Cumulative Number of Vehicles	INT*	4	1		
	Average Vehicle Speed	INT*	4	1		
	Traffic Congestion Status	INT*	2	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Date/Time	Datetime	≥14	1		

Note: INT*: Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

7.6 Required Function/Performance of CCTV Camera

The system shall be capable of monitoring vehicles on the expressway and identifying types of the vehicles by their appearances, shall be capable of taking an image of vehicle license number plate upon control signal. CCTV system shall be capable of automatically correcting brightness of captured image. (That is called the iris function.)

Measurement object speed shall be 0~160 km/h or more.

The system shall be capable of controlling the lens aperture per the brightness of the subject and of outputting suited good video image, shall be capable of zooming, correcting brightness and focusing of the camera according to the control signal.

7.7 Location/Installation of CCTV Camera

(1) Installation / Operation Policies of Vehicle Detector

Vehicle Detection makes it possible for the road operators to measure actual traffic volume, heavy vehicle ratio and vehicle velocity on the expressways based on type of detection technology. Collected data will be utilized for developing road operation / improvement plans.

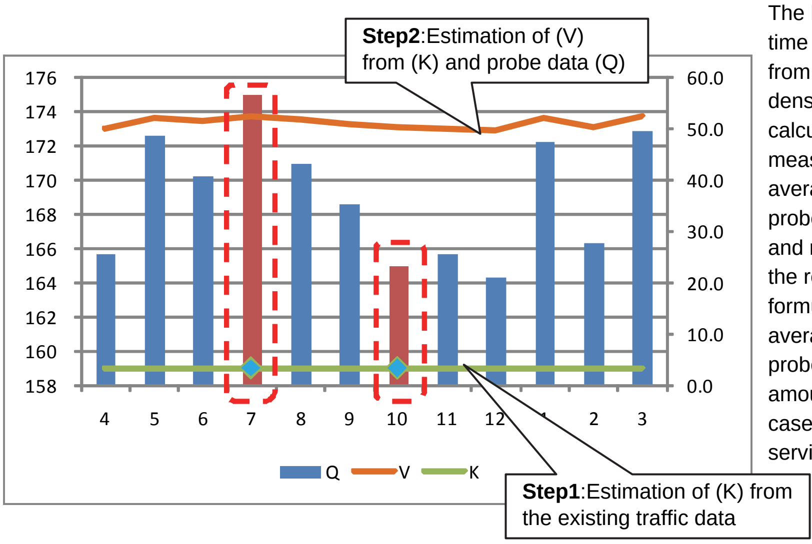
Therefore, traffic data is very important for road operation and management. There are many types and methods of traffic data collection.

The current method of traffic data collection is based on Probe data obtained using GPS equipment installed in the vehicle. However, in order to measure based on the Probe data, true value must be measured as the accumulation of traffic data over a long time.

Of course, it is possible to use the full Probe data; however, first a fixed detection method needs to be implemented for accumulation of traffic data.

Therefore, attention in this paragraph is focused on fixed detection method.

Figure 7.5 Example of utilization of Probe data



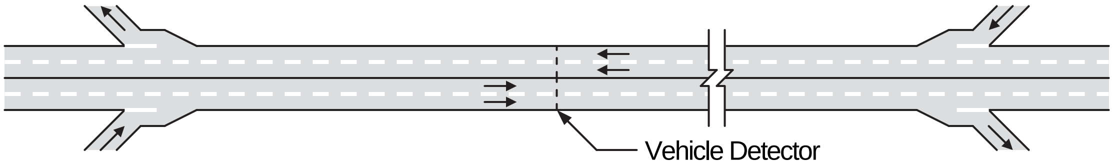
The link travel speed data continuous time and space can be calculated from the probe data. The traffic density of reference value (K) is calculated from the true value of measured traffic volume (V) and the average speed is obtained from the probe data (Q) for each level of road and region. Subsequently the setting the reference value (K), by the formula V = Q / K applied to the average velocity is obtained from the probe data (Q). Then, calculate the amount of link traffic volume (V), in case of "the current situation of road service level" possibly.

(2) Arrangement of Vehicle Detectors

a) Vehicle Detector Arrangement for Policy 1

In the case of the Policy 2, vehicle detectors need to be installed at a midway point between a pair of interchanges on the expressway in order to measure traffic volume on a section between them.

Figure 7.6 Vehicle Detector Installation at Midway between a Pair of Interchanges

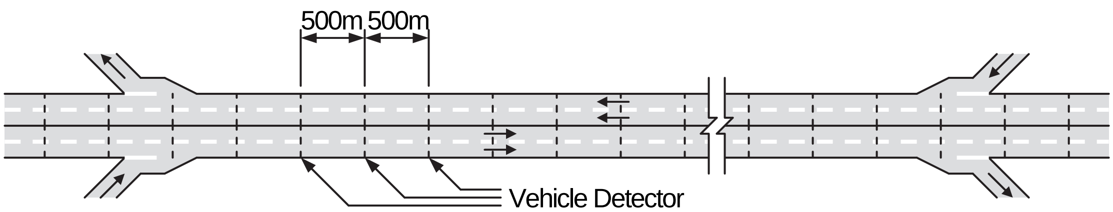


Source: The Study Team

b) Vehicle Detector Arrangement for Policy 2

In the case of the Policy 2, vehicle detectors need to be installed continuously at small spacing (e.g. 500 m) along the expressway in order to measure vehicle velocity at any section on the expressway and positively to identify traffic congestion.

Figure 7.7 Vehicle Detector Installation Continuously at a Short Spacing along the Expressway

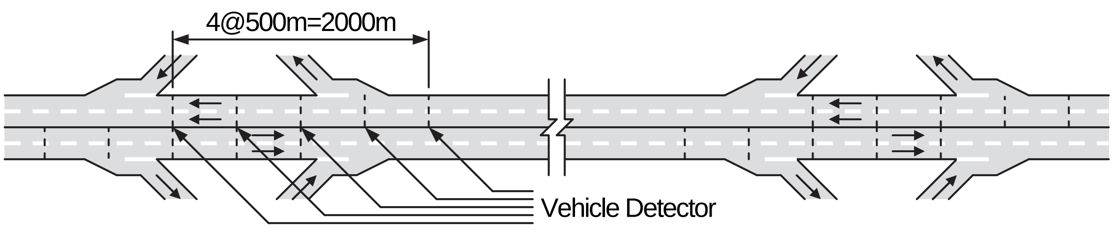


Source: The Study Team

c) Vehicle Detector Arrangement for Policy 3

In the case of the policy 3, vehicle detectors need to be installed at small spacing (e.g. 500 m) in congestion-prone sections on the expressway in order to measure vehicle velocity at the sections and positively to identify traffic congestion.

Figure 7.8 Vehicle Detector Installation at Congestion-prone Sections on the Expressway

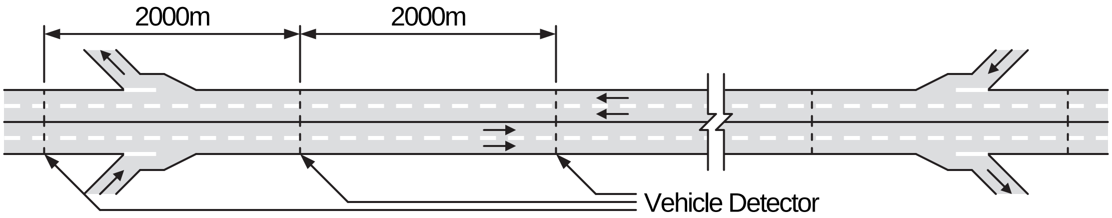


Source: The Study Team

d) Vehicle Detector Arrangement for Policy 4

In the case of the policy 4, vehicle detectors need to be installed continuously along the expressway in order to measure vehicle velocity throughout the expressway and roughly to identify traffic congestion.

Figure 7.9 Vehicle Detector Installation Continuously along the Expressway



Source: The Study Team

(3) Comparison of Installation/Operation Policies

Advantages/disadvantages of the four installation/operation policies of vehicle detector are summarized in the table below.

Table 7.6 Advantages/Disadvantages of Installation/Operation Policies of Vehicle Detector

		Policy 1	Policy 2	Policy 3	Policy 4
Measurement of traffic volume on a section		Capable	Capable	Capable	Capable
Identification of traffic congestion	At any section on the expressway	+ Incapable	+++ Capable (QL=0.5–1km)	+ Incapable	++ Capable (QL>2km)
	At congestion-prone sections on the expressway	+ Incapable	+++ Capable (QL=0.5–1km)	+++ Capable (QL=0.5–1km)	++ Capable (QL>2km)
Required number of equipment implementation for 80km length of the expressway network		** ++++ 12 set	** + 640 set	** +++ 80 set	** ++ 160 set
Evaluation Grading		Adopted	Not suitable	Adopted (2nd Stage)	Applicable

Grade: +++ = best, ++ = average, + = worst.
Note: QL: Minimum detectable queue length.
**: In the case of using Loop-coil type, number of interchange is 4, 1 set has two Loop-coil sensors, Number of merging/diverging point is 8, number of lane is 2 lanes each way.

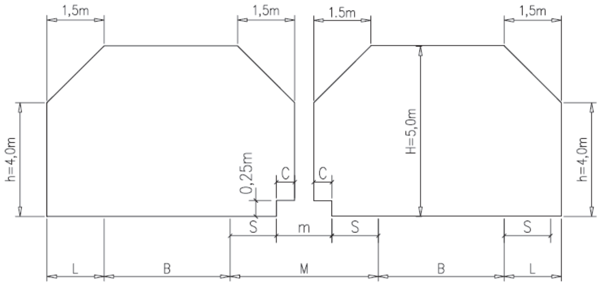
Source: The Study Team

At first stage, Policy 1 is adopted for collection of traffic data and reducing the cost of implementation. However, as shown in the table above, Policy 2 requires large numbers of equipment to be implemented and is not suitable. Policy 4 is can be applicable only to the road sections with large traffic over their length. Hence, according to this comparison, Policy 1 is adopted in this study of 1st stage, and then Policy 2 is adopted in 2nd stage based on the vehicle detector installation at congestion-prone sections on the expressway.

(5) Policy of height of CCTV Camera and the Field of view

The height of CCTV camera for vehicle detection by image, the camera is should Fixed type. Therefore, the height of installation 7-8m above ground level according to CCTV monitoring. It is consider that sometimes Fixed camera and PTZ camera are attached the same pole therefore, make a margin 1.0m from the height of PTZ camera installation.

Figure 7.10 Clearance limit of Expressway



Source: TCVN5729 Expressway Standard Design

Figure 7.11 Height of CCTV camera

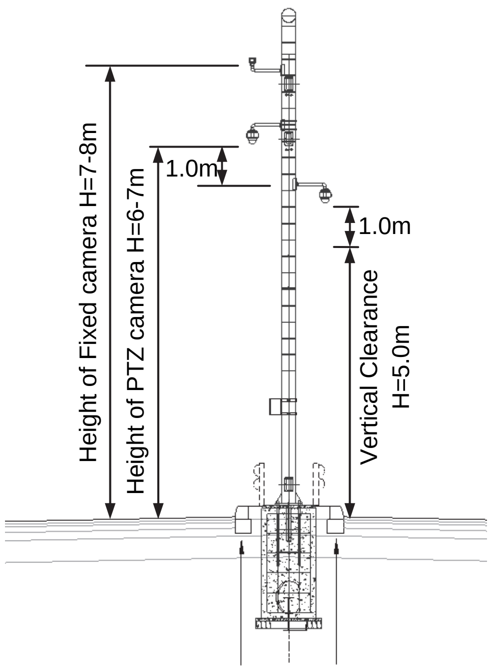


Table 7.7 Height of CCTV Camera

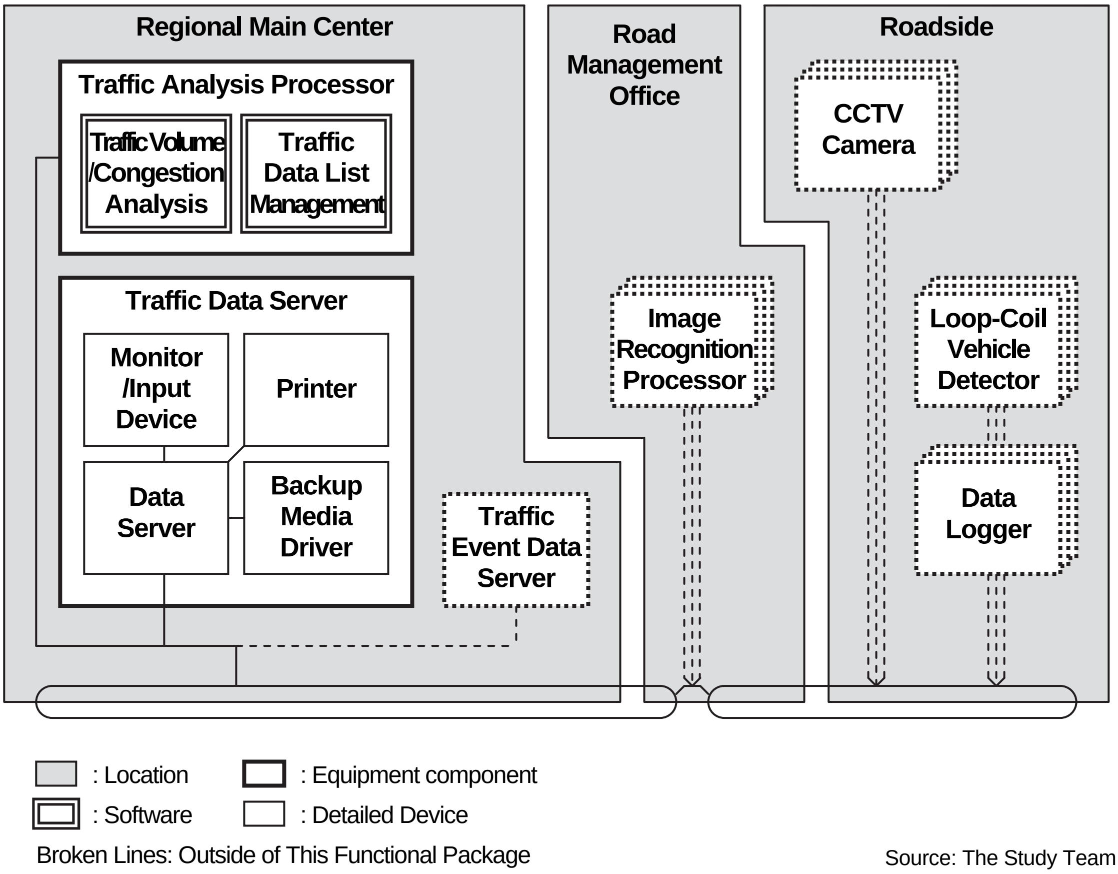
Type of Camera	Height
Fixed Camera	7-8m above Ground level

8. Traffic Analysis

8.1 Outline and System Architecture

This functional package allows the road operators to keep track of traffic conditions on the expressways, such as crowdedness and vehicle velocity, by processing and analyzing the data captured by vehicle detectors.

Figure 8.1 System Architecture for Traffic Analysis



Source: The Study Team

8.2 Values on Traffic/Congestion to be Estimated

Normally, traffic congestion arises when traffic volume increasing beyond the traffic capacity of lane of the road. However, traffic congestion can be caused by an incident, such as a traffic accident, that obstructs the traffic of one or more than one lane. Traffic congestion caused by incident can take place even in the condition the traffic volume is smaller than usual traffic volume.

Hence, it is necessary to measure the traffic volume around congested section for identifying the cause of traffic congestion. It is necessary to catch traffic volume of congestion section before and after arising congestion as catch above content. CCTV cameras need to be installed every 2km in order to monitor incidents.

Table 8.1 Categories/Classes of Traffic Congestion

Traffic Event Category	Traffic Event Class	Definition
Traffic Congestion	Congestion	Condition that an average speed detected in each minute for each lane is ≤40km/h and a vehicle queuing more than 1km at such low speed continues to exist ≥15 minutes.
	Crowdedness	Condition that an average speed detected in each minute for each lane is ≤50km/h and such low speed situation continue to exist ≥15 minutes.
	Normal	Condition without any congestion and crowdedness.

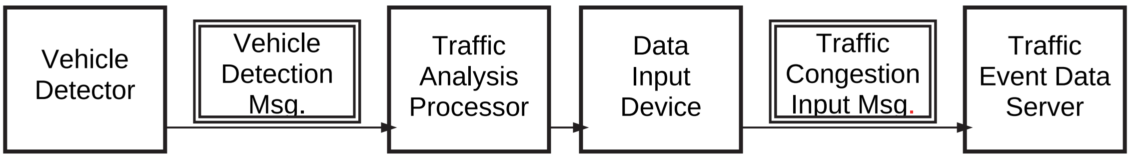
Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

8.3 Data Set for Traffic Analysis

Major Message Exchanges for generating traffic congestion data is shown in the following figure.

Figure 8.2 Major Message Exchanges for Generating Traffic Congestion Data



Source: The Study Team

The results of vehicle detection are to be sent automatically to the traffic analysis processor, and the results of traffic analysis to be indicated on the monitor screen. Referring to that, a message for generating traffic congestion data is to be input by an operator to the traffic event data server.

Table 8.2 Data Set/Elements in Traffic Congestion Input Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Vehicle Detection Data Set <G - Vehicle Detector>	Road Management Office ID	INT*	4	1	Every 5 minutes	Latest
	Roadside Equipment ID	INT*	4	1		
	Cumulative Number of Vehicles	INT*	4	1		
	Vehicle Speed	FLOAT	5	N		
	Vehicle Length	FLOAT	4			
	Date/Time	Datetime	≥14	1		
Image Recognition Result Data Set <G - Image Processor>	Road Management Office ID	INT*	4	1	When an event occurs	Latest
	Roadside Equipment ID	INT*	4	1		
	Image Recognition Result Status	INT*	2	1		
	Video Image Address	TXT	60	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

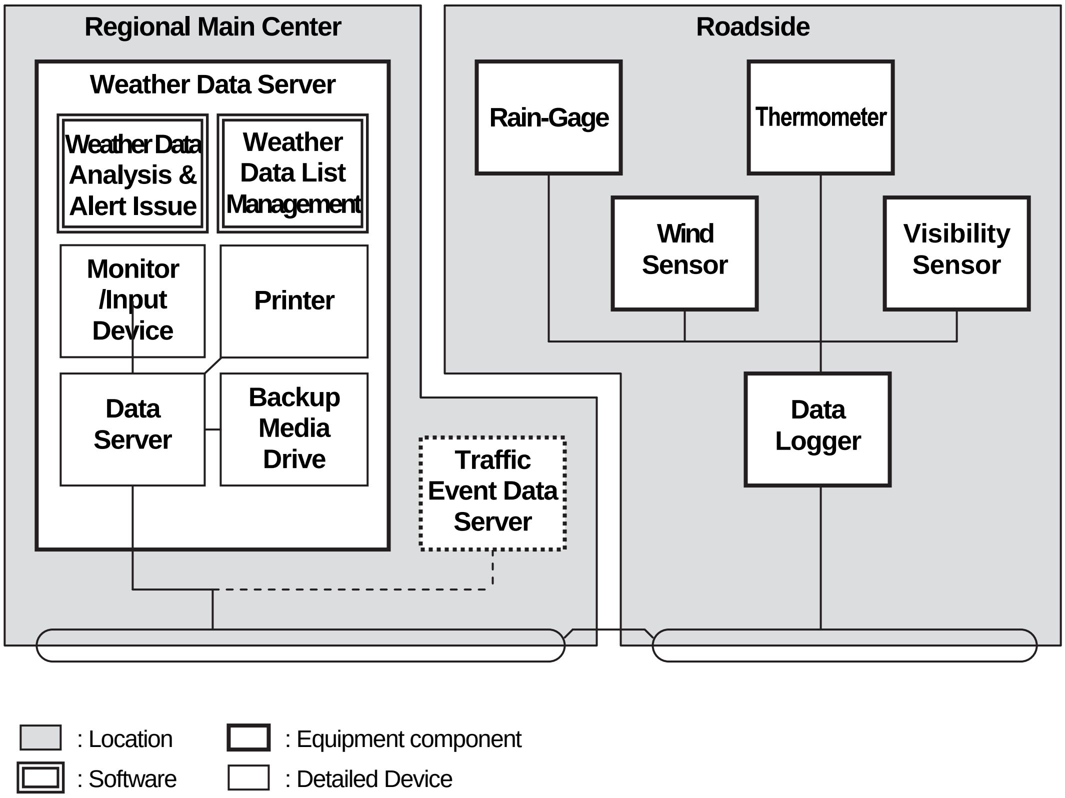
Source: The Study Team

9. Weather Monitoring

9.1 Outline and System Architecture

This functional package allows the road operators to estimate dangerous conditions for road traffic on the expressways by using data acquired by the sensors installed at the interchanges and at the road sections where undesired weather conditions for traffic safety frequently take place.

Figure 9.1 System Architecture for Weather Monitoring



Broken Lines: Outside of This Functional Package

Source: The Study Team

9.2 Observation Elements for Weather Monitoring

The observation element and observation range of each sensor are shown below.

Table 9.1 Observation Elements and Observation Method

Elements	Observation method				Remarks
	Device	Observation range	Unit	Height	
Rainfall	Rain gauge	Enable to measure min. 200mm/h	0.5 mm	Approx. 3.0-3.5 m	Tipping-Bucket Rain Gage
Wind speed	Anemometer	2 ~ 50 m/s	0.1 m/s	3.5 – 5.0 m	
Visibility	Visibility sensor	10 – 2000 m	–	1.5 – 2.5m	MOR[1]
Temperature	Thermometer	-10~60 °C	0.1 °C	1.5 – 2.0 m	Electric thermometer

As for accuracy of censers, it should be verified before delivery.

9.3 Bad Weather Categories

Alert is to be detected in case observed data exceeds the preset threshold. According to the “Standard of issuing traffic restriction” specified in the item of Traffic Event Data Management, the following alert criteria are configured on significant weather.

Table 9.2 Criteria/Levels of Enforcing Traffic Restriction

Traffic Event Categories	Observed Data or Processed Data	Restriction Levels		
		Closure	Lane Closure or Speed Restriction	Warning Information
Heavy rain	Accumulated precipitation	250mm or more	200mm or more	–
	Hourly rainfall	40mm or more after reaching 100mm rainfall in 1 hour	20mm or more	10mm or more
High wind	10 min. average wind speed	25 m/s or more	15 m/s or more	10 m/s
Dense fog	Visibility	50m or less	100m or less	200
High temperature	10 min. average temperature	–	–	40 degree centigrade

Note, Accumulated precipitation is accumulation of precipitation starting from observation of rain fall and continuous rain fall is observed without interruption up to the observing time.
Hourly rainfall is calculated by conversion of 10 minutes accumulated precipitation. It is corresponding to what is called rainfall intensity.

Each threshold is required to configure properly based on the above criteria. The weather data server to be installed at main center collects and updates weather observation data every 5 minutes from data logger of each site. If processed data calculated from the collected data exceeds above threshold for precipitation, wind speed, and temperature, and become lower than above thresholds for visibility, it is required to detect this condition.

The detected result is required to be categorized into corresponding Traffic Event Category and Traffic Event Class shown in the following table. The following table is the extraction of significant weather part from the original one stipulated in item 14 Traffic Event Data Management.

[1] Meteorological Optical Range

Table 9.3 Categories/Class of Bad Weather

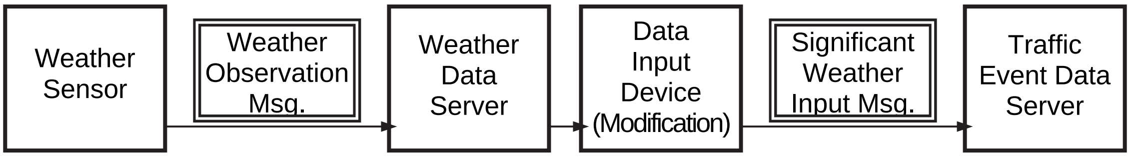
Traffic Event Category	Traffic Event Class		Definition
Significant Weather	Heavy Rain	1	Significantly heavy rain with issuing closure
		2	Heavy rain with issuing lane/speed restriction
		3	Heavy rain with issuing warning information
	High Wind	1	Significantly high wind with issuing closure
		2	High wind with issuing lane/speed restriction
		3	High wind with issuing warning information
	Dense Fog	1	Significantly dense fog with issuing closure
		2	Dense fog with issuing lane/speed restriction
		3	Dense fog with issuing warning information
	High Temperature		High temperature with issuing warning information

Source: The Study Team

9.4 Data Set for Weather Observation and Bad Weather

Major Message Exchanges for generating significant weather data is shown in the following figure.

Figure 9.2 Major Message Exchanges for Generating Significant Weather Data



Source: The Study Team

The weather observation message is to be sent to and stored in the weather data server automatically and the message shall include data shown in the table below.

Table 9.4 Data set/Elements in Weather Observation Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Weather Monitoring Data Set <G - Weather Sensor>	Road Management Office ID	INT*	4	1	Every 5 minutes	Latest
	Roadside Equipment ID	INT*	4	1		
	Precipitation	FLOAT	2	1		
	Wind Speed	FLOAT	2	1		
	Visibility	FLOAT	2	1		
	Temperature	FLOAT	2	1		
	Alarm Status of Precipitation	INT*	2	1		
	Alarm Status of Wind Speed	INT*	2	1		
	Alarm Status of Visibility	INT*	2	1		
	Alarm Status of Temperature	INT*	2	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

Referring to alert status indicated by weather data server, message for generating significant weather data shown below is to be input by an operator to the traffic event data server.

Table 9.5 Data set/Elements in Bad Weather Input Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Bad Weather Data Set <G - Weather Server>	Road Management Office ID	INT*	4	1	When a bad weather occurs	1 year
	Roadside Equipment ID	INT*	4	1		
	Precipitation	FLOAT	2	1		
	Wind Speed	FLOAT	2	1		
	Visibility	FLOAT	2	1		
	Temperature	FLOAT	2	1		
	Heavy Rain Status	INT*	2	1		
	High Wind Status	INT*	2	1		
	Low Visibility Status	INT*	2	1		
	High Temperature Status	INT*	2	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

9.5 Required Function/Performance of Weather Sensors

(1) Rain Gauge

Performance of rain gauge shall be as per the following conditions;

a) Observation range : measurable min. 200 mm/h
b) Sensitivity : 0.5 mm
c) Accuracy : max. +/- 0.5mm (up to 20mm/h)
: max. +/- 3% (more than 20mm/h up to 100mm/h)
d) Funnel diameter : 200mm – 260mm

(2) Wind Sensor

Performance of wind speed sensor shall be as per the following conditions;

a) Measuring range : 2 to 50 m/sec
b) Resolution : 0.1 m/sec
c) Accuracy : within +/- 3%

(3) Visibility Sensor

Performance of visibility sensor shall be as per the following conditions;

a) Measuring range : MOR[2] 10m – 2,000m
b) Accuracy : +/- 10 % (up to 2,000m)

(4) Thermometer

Performance of thermometer shall be as per the following conditions;

a) Measuring range : -10 to 60 degree centigrade
b) Resolution : 0.1 degree -10 to 60 degree centigrade
c) Accuracy : +/- 0.2 degree centigrade (at +20 degree centigrade)
d) Type : Pt 100

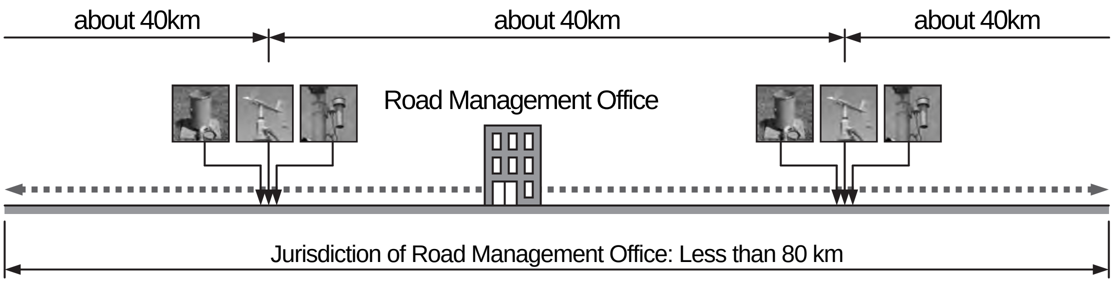
[2] MOR: Meteorological Optical Range

9.6 Location of Weather Sensors

In the manual on global observing system published by WMO (World Meteorological Organization), it is recommended to apply a meteorological observation network of 100 km mesh or less for observation of small-scale weather phenomena, such as thunderstorms. According to this concept, a set of weather sensors is to be installed every 40 km along the expressway network, which is corresponding to 2 sets for a jurisdiction of the road management office as shown below.

At first stage, weather sensors are installed 1 set on a trial basis.

Figure 9.3 Illustration of Advanced Road Operation Using ITS



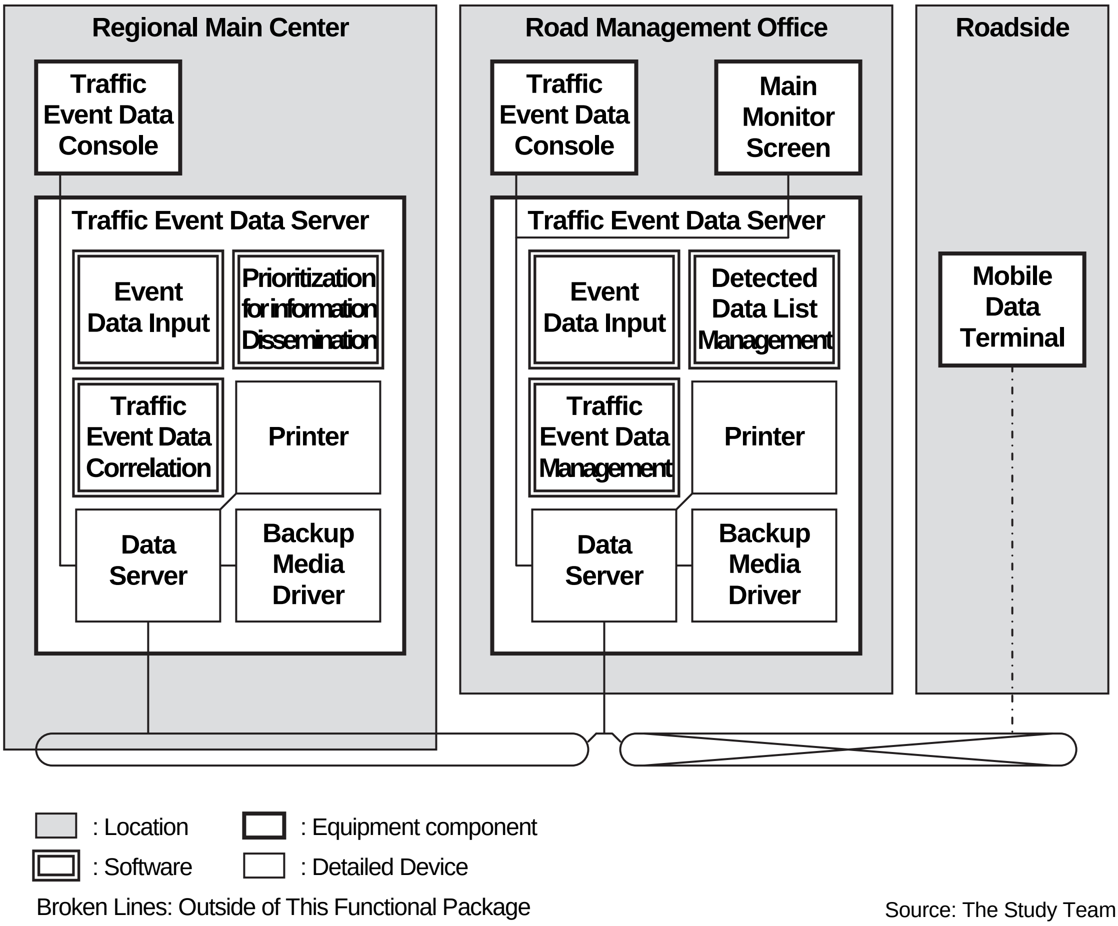
Source: The Study Team

10. Traffic Event Data Management

10.1 Outline and System Architecture

This functional package allows the road operators to conduct traffic control, restriction and information dissemination on the expressway, in the unified/integrated form, by categorizing the results acquired through emergency telephones, mobile radio communication, event detection, traffic analysis and weather monitoring and by organizing them as the data of traffic events corresponding to the place/time of occurrence and the priority.

Figure 10.1 System Architecture for Traffic Event Data Management



Source: The Study Team

10.2 Enforcement of Traffic Restriction

One of important activities of the road operator is to enforce appropriate traffic restriction responding to the occurrences of traffic events.

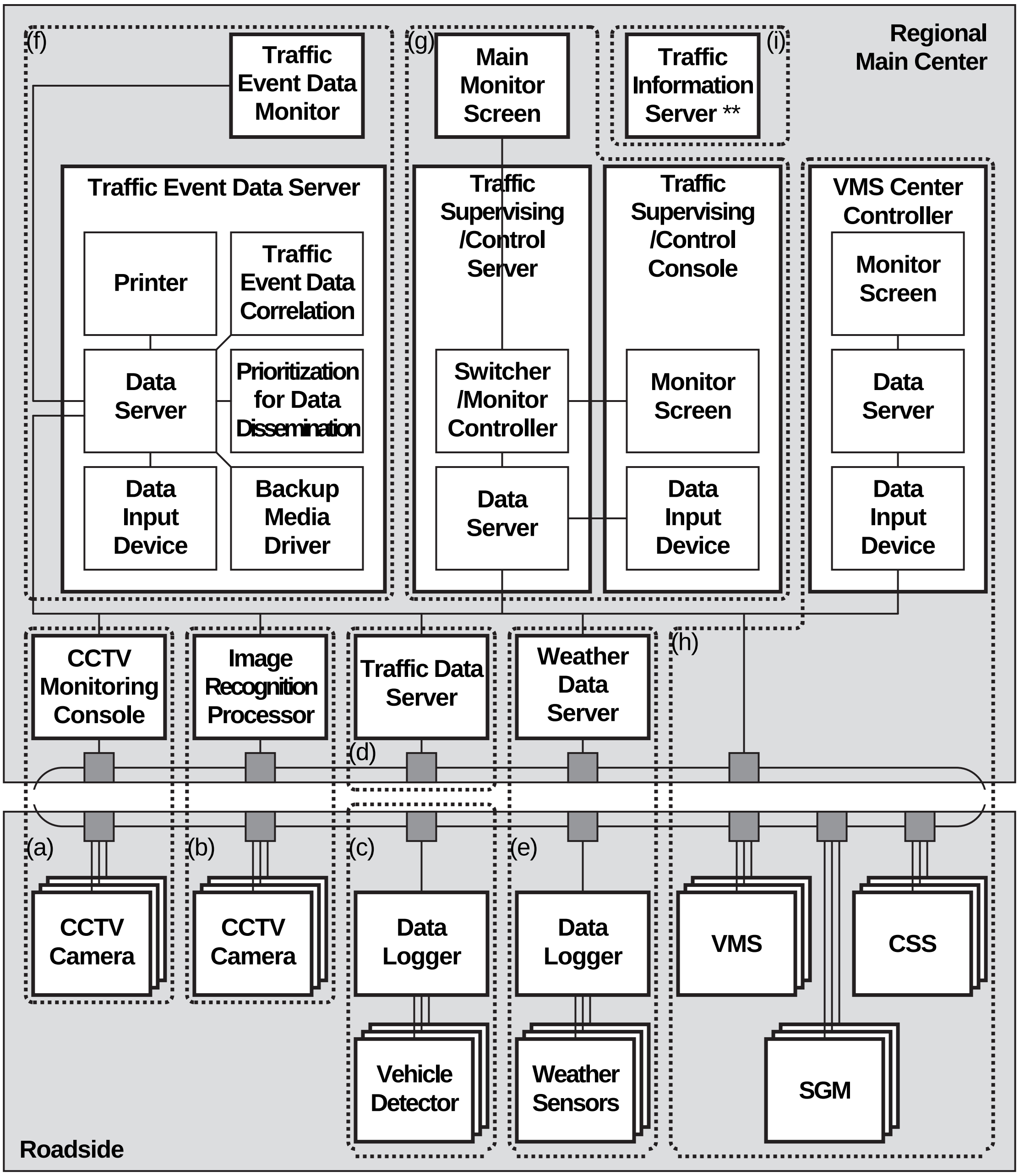
Criteria and levels of enforcing traffic restriction in the case of bad weather mentioned in the foregoing chapter. Levels of enforcing traffic restriction in case of an incident or a construction work depends on each condition.

10.3 System for Traffic Information/Control

Traffic information/control is to be conducted totally from the Regional Main Center using the following functional packages:

(a) CCTV Monitoring
(b) Event Detection (by Image)
(c) Vehicle Detection
(d) Traffic Analysis
(e) Weather Monitoring
(f) Traffic Event Data Management
(g) Traffic Supervision
(h) VMS Indication
(i) Traffic Information

Figure 10.2 System for Traffic Information/Control



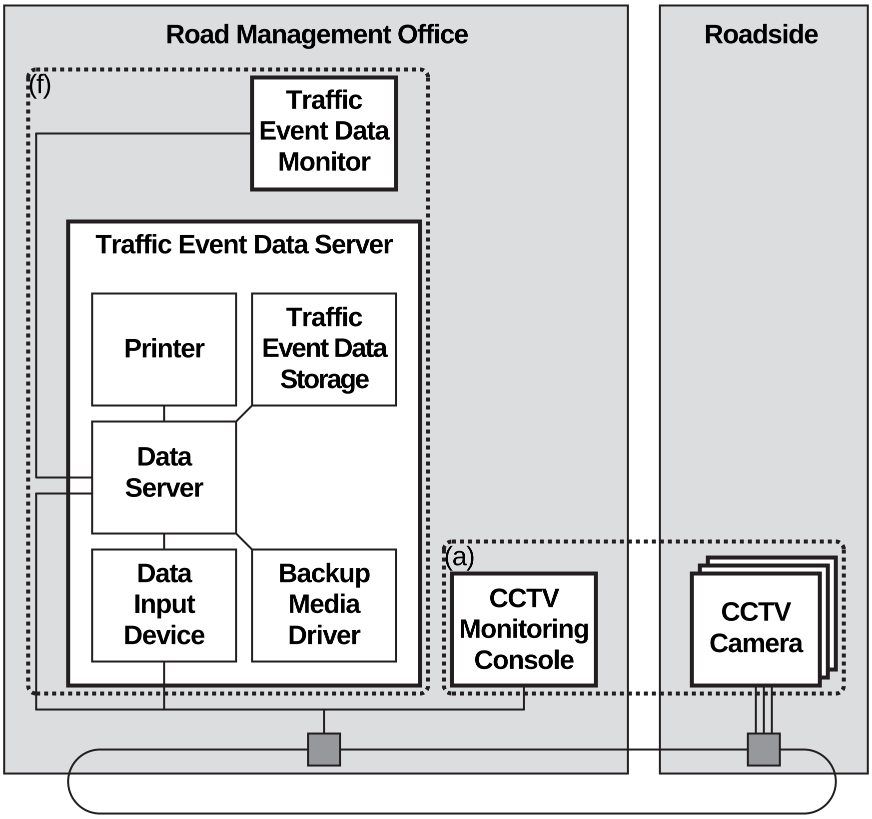
Note, [dotted box]: Functional package, ** : Protected by a firewall for connecting to the Internet and stored data in it is to be copied from the traffic event data server.

Source: The Study Team

Consequently, vehicle detectors, weather sensors and VMSs need to be controlled directly from the Regional Main Center for integrating traffic information dissemination.

A part of center equipment is to be installed in the road management offices for expressway operation. CCTV cameras are to be controlled and the traffic event data are to be input from the road management office as well for handling and clearing incidents. The traffic event data can be input from the road management office; however, prioritisation of the traffic event data is to be done in the Regional Main Center and the result is to be sent directly to the VMS, SGM or CSS.

Figure 10.3 System for Traffic Information/Control



Note: : Functional package

Source: The Study Team

10.4 Definition of Traffic Events

Incidents and other affairs on the expressway network need to be segmentalized as the traffic events for the traffic information/control. Definitions of the traffic events are shown in the table in the following page:

Table 10.1 Definition of Traffic Events including Correlations

Category	Traffic Event		Definition	Traffic Event to be Correlated												
Special Event	Special Event		Special event which may prevent vehicle traffic	X	X	X	X	X	X	X	X	X	X	X	X	X
Incident	Traffic Accident		Serious traffic accident	X	X	X	X	X	X	X	X	X	X	X	X	X
	Incident in Tunnel		Incident in tunnel including fire	X	X	X	X	X	X	X	X	X	X	X	X	X
	Reverse Driving		Vehicle driven in the reverse direction	X	X	X	X	X	X	X	X	X	X	X	X	X
	Broken-down Vehicle		Vehicle stopping on the road	X	X	X	X	X	X	X	X	X	X	X	X	X
	Left Obstacle		Object * on the road which may prevents vehicle traffic	X	X	X	X	X	X	X	X	X	X	X	X	X
	Natural Disaster		Natural disaster which may prevent vehicle traffic	X	X	X	X	X	X	X	X	X	X	X	X	X
	Vandalism		Wilful destruction of facilities or obstruction to traffic on the road	X	X	X	X	X	X	X	X	X	X	X	X	X
Construction Work	Construction Work		Construction work which may prevent vehicle traffic	X	X	X	X	X	X	X	X	X	X	X	X	X
Bad Weather	Heavy Rain	1	Heavy rain more than 40 mm/h**	X	X	X	X	X	X	X	X	X				
		2	Heavy rain more than 20 mm/h**	X	X	X	X	X	X	X					X	
		3	Heavy rain more than 10 mm/h**	X	X	X	X	X	X	X						X
	High Wind	1	High wind more than 25 m/sec** on average	X	X	X	X	X	X	X	X	X				
		2	High wind more than 20 m/sec** on average	X	X	X	X	X	X	X					X	
		3	High wind more than 10 m/sec** on average	X	X	X	X	X	X	X						X
	Dense Fog	1	Dense fog with visibility less than 50 m**	X	X	X	X	X	X	X	X	X				
		2	Dense fog with visibility less than 100 m**	X	X	X	X	X	X	X					X	
		3	Dense fog with visibility less than 200 m**	X	X	X	X	X	X	X						X
	High Temperature		High temperature more than 40 degrees C**													
Traffic Congestion	Congestion on Trough Lanes	1	VS continuously slower than 40 km/h*** on av. with VQ longer than 4 km													
		2	VS continuously slower than 40 km/h*** on av. with VQ longer than 2 km													
		3	VS continuously slower than 40 km/h*** on av. with VQ longer than 1 km													
	Crowdedness on Trough Lanes		VS slower than 50 km/h*** on av. with no or short VQ													
	Congestion at Exit	1	VS continuously slower than 40 km/h*** on av. with VQ longer than 4 km at exit													
		2	VS continuously slower than 40 km/h*** on av. with VQ longer than 2 km at exit													
		3	VS continuously slower than 40 km/h*** on av. with VQ longer than 1 km at exit													
Traffic Restriction	Entry Closure		Restriction to stop inflow traffic at entrance													
	Closure		Restriction to stop traffic on through lanes													
	Exit Closure		Restriction to stop traffic at exit													
	Lane Closure		Restriction to stop through traffic partially on some lanes													
	Speed Limitation	1	Restriction to limit the fastest vehicle speed less than 50 km/h													
		2	Restriction to limit the fastest vehicle speed less than 80 km/h													

Note: VS: Vehicle speed, VQ : Vehicle queuing, * : Excluding vehicles, ** : Specific definition is shown Table 9.2, *** : Specific definition is shown Table 8.1.

Source: The Study Team

10.5 Correlation between Traffic Events

The correlated traffic events in the table below are to be generated by the software “Traffic Event Data Correlation” mainly for indication on VMS.

Table 10.2 Correlated Traffic Event for Indication

Traffic Event	Data	Correlated Traffic Event for Indication																		
Special Event	M																			
Traffic Accident	M																			
Incident in Tunnel	M																			
Reverse Driving	M																			
Broken-down Vehicle	M																			
Left Obstacle	M																			
Natural Disaster	M																			
Vandalism	M																			
Construction Work	M																			
Heavy Rain 1	A																			
Heavy Rain 2	A																			
Heavy Rain 3	A																			
High Wind 1	A																			
High Wind 2	A																			
High Wind 3	A																			
Dense Fog 1	A																			
Dense Fog 2	A																			
Dense Fog 3	A																			
High Temperature	A																			
Emergency 1	M											X	X							X
Emergency 2	M																	X	X	
Bad Weather 1	M				X			X			X									
Bad Weather 2	M		X	X		X	X		X	X										
Warning 1	M											X			X	X	X			
Warning 2	M											X	X	X	X	X	X	X	X	X
Warning 3	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Warning 4	M	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Congestion on TL	M		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Congestion at Exit	M		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Entry Closure	M				X			X			X	X	X	X	X	X	X	X	X	X
Closure	M				X			X			X	X	X	X	X	X	X	X	X	X
Exit Closure	M											X	X	X	X	X	X	X	X	X
Lane Closure	M											X	X	X	X	X	X	X	X	X
Speed Limitation 1	M			X			X			X		X	X	X	X	X	X	X	X	X
Speed Limitation 2	M		X			X			X			X	X	X	X	X	X	X	X	X

Note: TL: Through lanes, M: Manually input, A: Automatically generated.

Source: The Study Team

10.6 Required Documents/Forms

The required Documents/Forms are listed below. The data for these documents can output by CSV format. The item output by CSV is shown in the following tables.

- Incident Report
- Daily Report for Traffic Event
- Monthly Report for Traffic Event
- Yearly Report for Traffic Event
- Daily Report for Traffic Congestion
- Monthly Report for Traffic Congestion
- Yearly Report for Traffic Congestion

Table 10.3 Item for Incident Report

Data Elements	Type
Road Management Office ID	INT*
Road Section ID	INT*
Lane ID	INT*
Place ID	INT*
Beginning Kilometer Post	TXT
Ending Kilometer Post	TXT
Incident Status	INT*
Date/Time	Datetime

Table 10.4 Item for Traffic Event Report

Data Elements	Type
Traffic Event Data ID	INT
Road Management Office ID	INT*
Road Section ID	INT*
Road Link ID	INT*
Lane ID	INT*
Place ID	INT*
Traffic Event Category ID	INT*
Traffic Event Class ID	INT*
Causal Traffic Event Data ID	INT
Beginning Kilometer Post	TXT
Ending Kilometer Post	TXT
Input Person	TXT
Event Status	TXT
Main Center Check Status	INT*
Road Management Office Check Status	INT*
Status of Traffic Event	INT*
Date/Time End	TXT
Date/Time	Datetime

Table 10.5 Item for Traffic Congestion Report

Data Elements	Type
Road Management Office ID	INT*
Cumulative Number of Vehicles	INT*
Average Vehicle Speed	INT*
Traffic Congestion Status	INT*
Beginning Kilometer Post	TXT
Ending Kilometer Post	TXT
Date/Time	Datetime

Note: INT* : Short integer

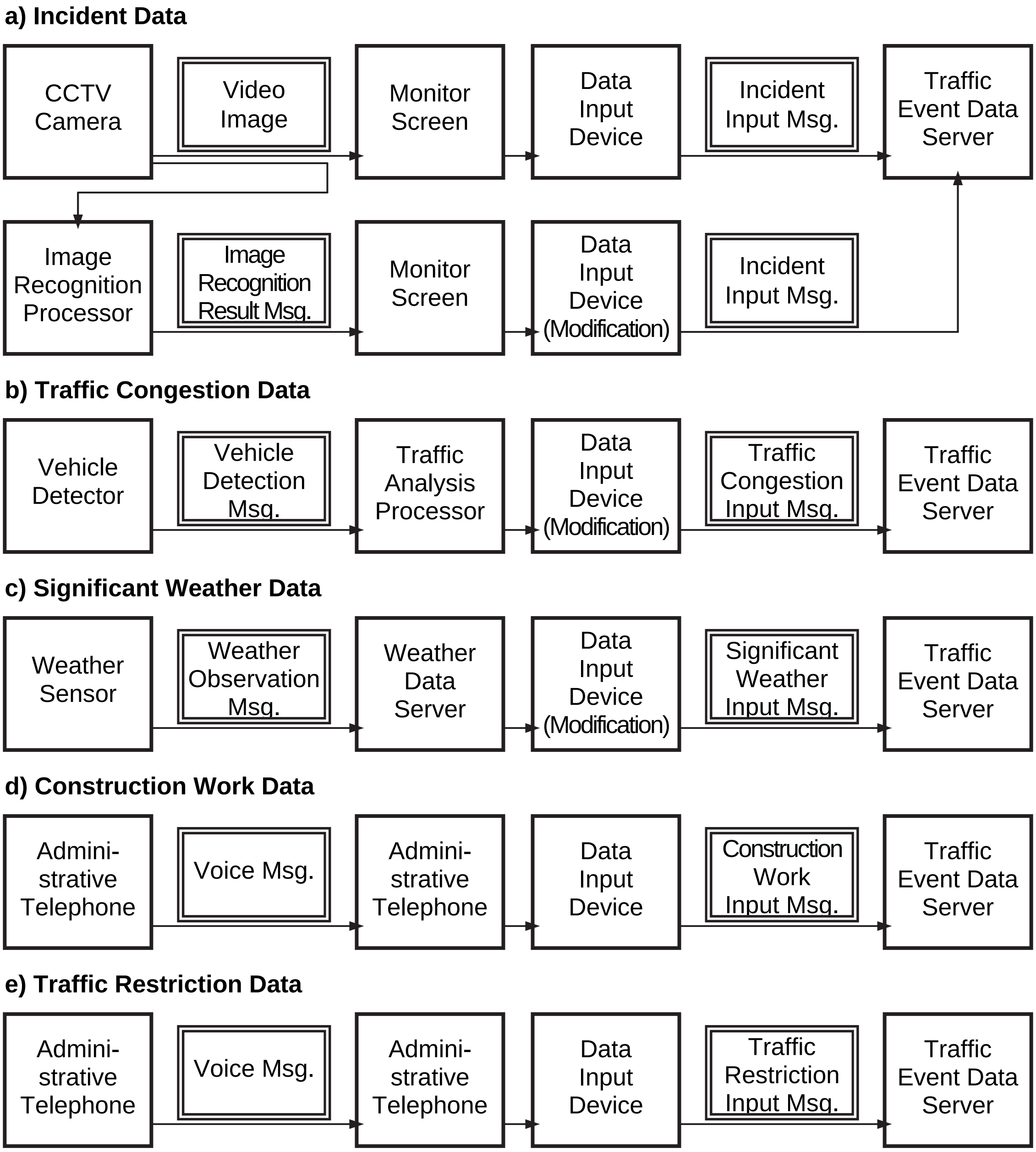
Source: The Study Team

10.7 Data Set for Traffic Events

Traffic event data can be categorized into the following five and the flows of message exchange for generating them can be illustrated as shown in the figure below.

- Incident
- Traffic congestion
- Significant weather
- Construction work
- Traffic restriction

Figure 10.3 Major Message Exchanges for Generating Traffic Event Data



Source: The Study Team

Through the message exchange the traffic event data shown in the following table are to be generated and stored in the traffic event data server.

Table 10.3 Data Sets/Elements in Generated Traffic Event Data

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Image Recognition Result Data Set <G - Image Processor>	Road Management Office ID	INT*	4	1	When an event occurs	Latest
	Roadside Equipment ID	INT*	4	1		
	Image Recognition Result Status	INT*	2	1		
	Video Image Address	TXT	60	1		
	Date/Time	Datetime	≥14	1		
Incident Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Roadside Equipment ID	INT*	4	1		
	Incident Status	INT*	2	1		
	Date/Time	Datetime	≥14	1		
Vehicle Detection Data Set <G - Vehicle Detector>	Road Management Office ID	INT*	4	1	Every 5 minutes	Latest
	Roadside Equipment ID	INT*	4	1		
	Cumulative Number of Vehicles	INT*	4	1		
	Vehicle Speed	FLOAT	5	N		
	Vehicle Length	FLOAT	4			
	Date/Time	Datetime	≥14	1		
Traffic Congestion Data Set <G - Traffic Analysis Processor>	Road Management Office ID	INT*	4	1	Every 5 minutes	1 year
	Roadside Equipment ID	INT*	4	1		
	Cumulative Number of Vehicles	INT*	4	1		
	Average Vehicle Speed	INT*	4	1		
	Traffic Congestion Status	INT*	2	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Date/Time	Datetime	≥14	1		
Construction Work Data Set <I - Server>	Road Management Office ID	INT*	4	1	When a constructi on work is schedule d	1 year after end of construct ion
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Construction Work Status	INT*	2	1		
	Number of document	TXT	20	1		
	Permission Date	TXT	8	1		
	Date/Time Begin	TXT	≥14	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		
Traffic Restriction Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year after end of restrictio n
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Construction Work Status	INT*	2	1		
	Permission Date	TXT	8	1		
	Date/Time Begin	TXT	≥14	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

From the traffic event data above, data set/elements for traffic event dissemination are to be generated automatically and stored in the traffic event data server, which is shown in the following table.

Table 10.4 Data Set/Elements for Traffic Event Dissemination

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Traffic Event Data Set <G/C - Server>	Traffic Event Data ID	INT	8	1	When an event occurs	1 year
	Road Management Office ID	INT*	4	1		
	Road Section ID	INT*	4	1		
	Road Link ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Traffic Event Category ID	INT*	4	1		
	Traffic Event Class ID	INT*	4	1		
	Causal Traffic Event Data ID	INT	8	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Input Person	TXT	32	1		
	Event Status	TXT	4	1		
	Video Image address	TXT	60	1		
	Main Center Check Status	INT*	4	1		
	Road Management Office Check Status	INT*	4	1		
	Status of Traffic Event	INT*	2	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

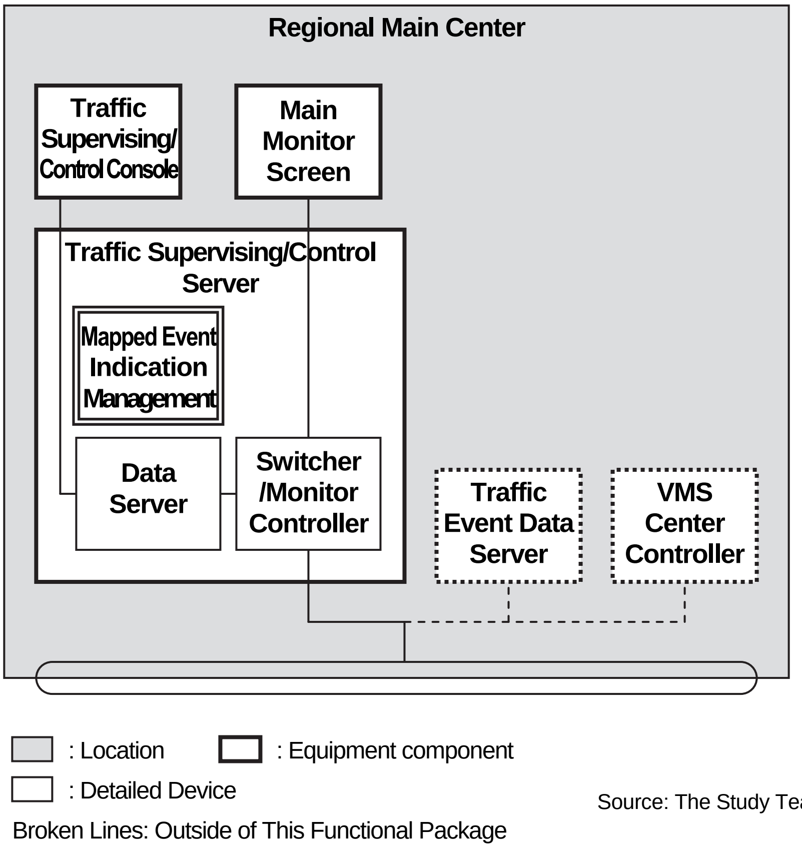
Source: The Study Team

11. Traffic Supervision

11.1 Outline and System Architecture

This functional package allows the road operators at the Main Center and road management office to supervise totally and visually the current traffic conditions on the expressways and the information organized as traffic events

Figure 11.1 System Architecture for Traffic Supervision

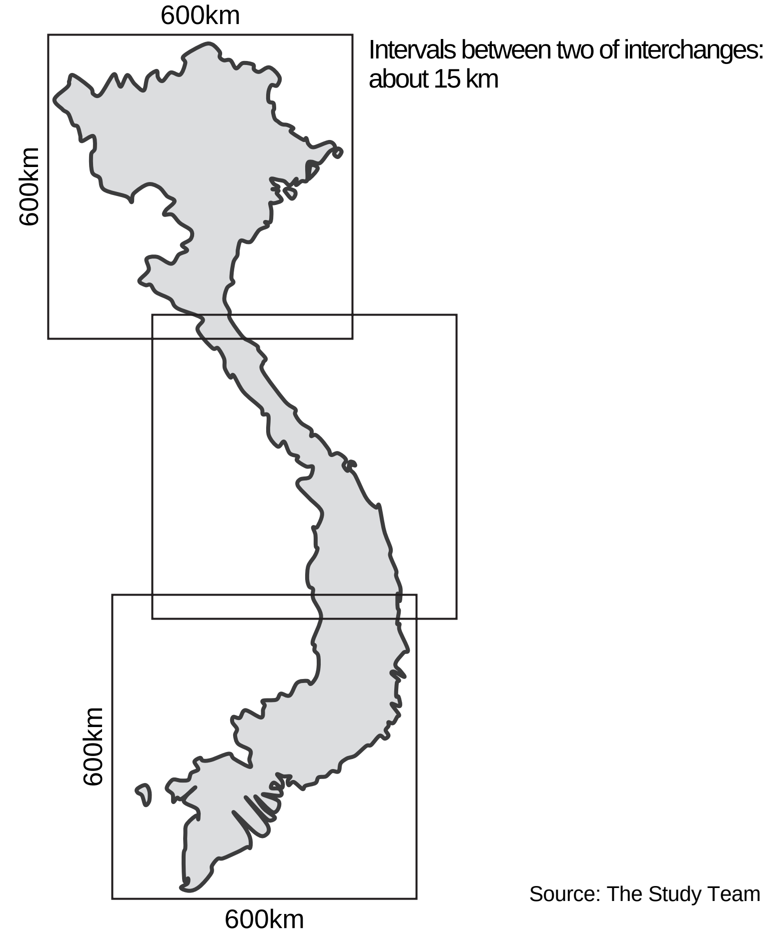


Source: The Study Team

11.2 Required Functions/Performance of Main Monitor Screen

The scope of the main monitor screens in the 3 Main Centers is to be as wide as about 600 km x 600 km on the nationwide scale as shown below.

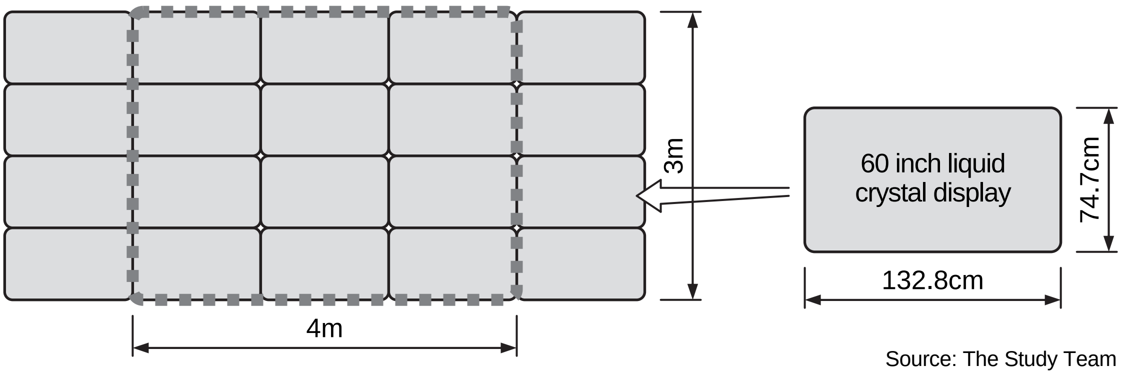
Figure 11.2 Required Size of Required Main Monitor Screen



Source: The Study Team

On the other hand, the interval of interchanges, which can be assumed as 15km, needs to be indicated longer than 10 cm on the main monitor screen in order to show the traffic conditions and restrictions between interchanges. Hence, the main monitor screen's side should be about 4 m.

Figure 11.2 Structure of Main Monitor Screen



Source: The Study Team

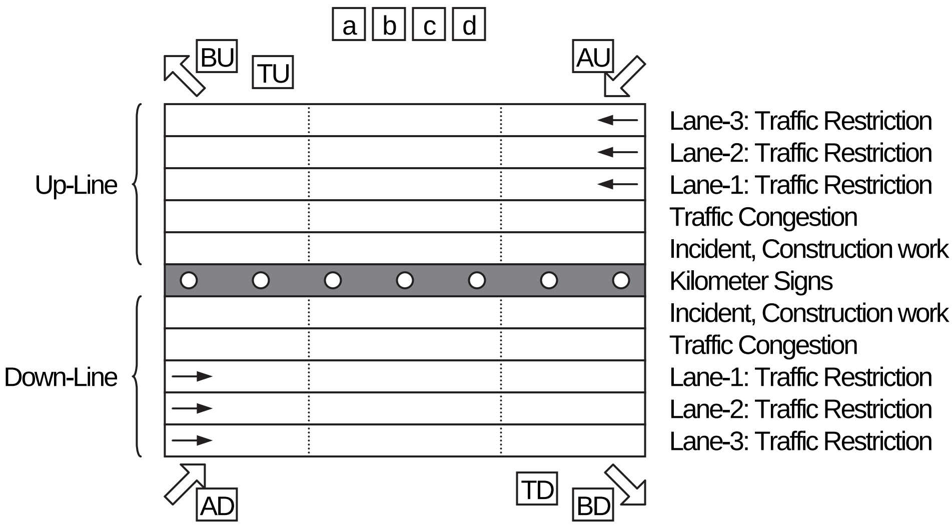
As the expressway network will be patterned on the main monitor screen, the height of patterned network can be compressed to about 75% as compared to the width. Therefore, the main monitor screen can be constructed by combining 60-inch liquid crystal display as shown below.

11.3 Indication Items on Main Monitor Screen

On the main monitor, the expressway network under the jurisdiction is to be divided into sections between two of interchanges, junctions, sections or tollgates and to be indicated with kilometre-posts. In the displayed expressway network or in appropriate places, the following information needs to be indicated.

- Conditions of incident occurrence
- Conditions of traffic congestion
- Conditions of significant weather
- Conditions of conducting construction works
- Conditions of enforcing traffic restriction.

Figure 11.3 Indication Items on Main Monitor Screen (for Each Section)



a: Conditions of heavy rain
b: Conditions of high wind
c: Conditions of dense fog
d: Conditions of high temperature

Conditions of significant weather (a–d)

TU: Conditions of traffic congestion on the up-line (1 or more points)
TD: Conditions of traffic congestion on the down-line (1 or more points)
AU: Indication of VMS short of entrance on the up-line
BU: Indication of VMS short of exit/junction on the up-line
AD: Indication of VMS short of entrance on the down-line
BD: Indication of VMS short of exit/junction on the down-line

Source: The Study Team

Table 11.1 Indicating Methods on Main Monitor Screen

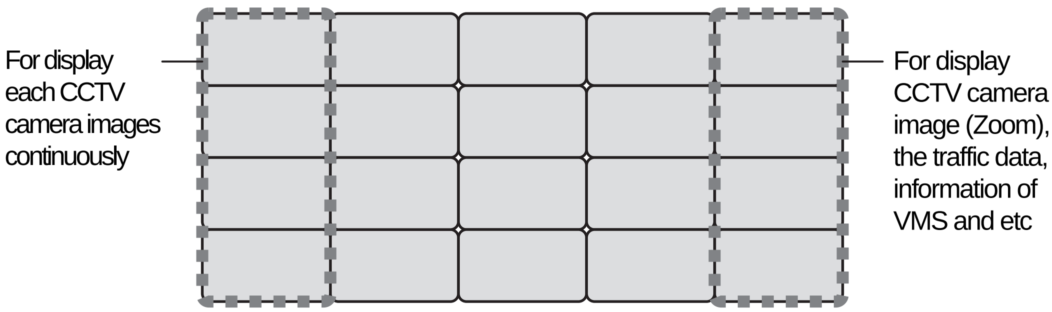
Traffic Event Category	Traffic Event Class	Indicating Methods
Incident	Traffic Accident	1: R (BLK), 2: Y (BLK), 3: G (BLK)
	Broken-down Vehicle	Y
	Left Obstacle	Y
	Reversing Vehicle	Y
	Vandalism	Y
	Natural Disaster	R
Traffic Congestion	Congestion	R
	Crowdedness	Y
Significant Weather	Heavy Rain	1: R, 2: Y, 3: G
	High Wind	1: R, 2: Y, 3: G
	Dense Fog	1: R, 2: Y, 3: G
	High Temperature	G
Construction Work	Construction Work	G
Traffic Restriction	Closure	R
	Entry Closure	R
	Lane Closure	R
	Speed Limitation	Y
	Warning Information	G

Note, R: Red, Y: Yellow, G: Green, BLK: Blinking

Source: The Study Team

In addition, in consideration of the display of CCTV camera images, traffic data, information of VMS into the Main Monitor Screen, example of main monitor screens should be as shown in the following figure.

Figure 11.4 Structure of Main Monitor Screen



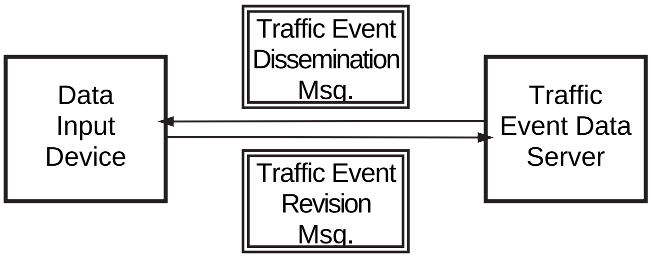
Source: The Study Team

Main monitor screen shall be capable action like one display. CCTV camera images, Traffic Data, the information of VMS, the expressway network are shown at wherever on the display by using moving the window of each information.

11.4 Data Set for Traffic Supervision

Major Message Exchanges for checking/revising traffic event data is shown in the following figure.

Figure 11.5 Major Message Exchanges for Checking/Revising Traffic Event Data



Source: The Study Team

A traffic event data dissemination message is to be sent to and indicated on the data input device. The data elements in the indicated message are to be checked and revised by an operator, and to be sent back to and stored in the traffic event data server.

Table 11.2 Data Set/Elements in Traffic Event Dissemination/Revision Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Traffic Event Data Set <G/C - Server>	Traffic Event Data ID	INT	8	1	When an event occurs	1 year
	Road Management Office ID	INT*	4	1		
	Road Section ID	INT*	4	1		
	Road Link ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Traffic Event Category ID	INT*	4	1		
	Traffic Event Class ID	INT*	4	1		
	Causal Traffic Event Data ID	INT	8	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Input Person	TXT	32	1		
	Event Status	TXT	4	1		
	Video Image address	TXT	60	1		
	Main Center Check Status	INT*	4	1		
	Road Management Office Check Status	INT*	4	1		
	Status of Traffic Event	INT*	2	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

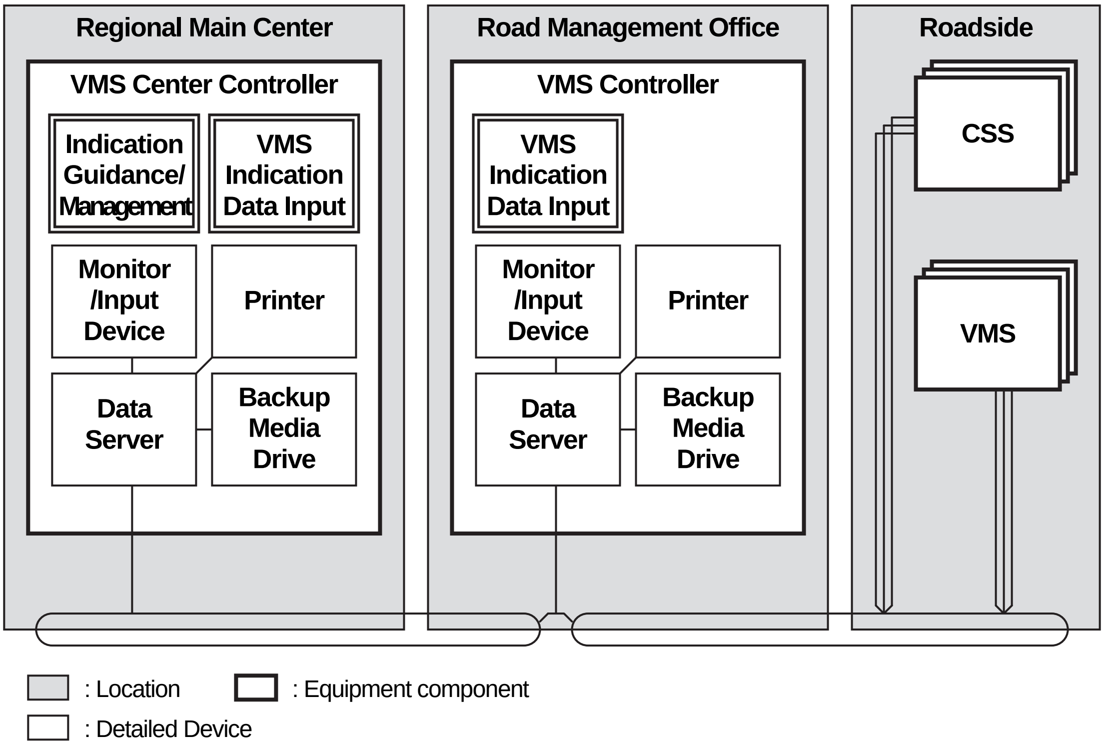
Source: The Study Team

12. VMS Indication

12.1 Outline and System Architecture

This functional package allows the road operators to provide road users on the expressways with the information organized as traffic events by using VMS (Variable Message Sign) installed at the place short of entrances, exits, tollgates, junctions and tunnels.

Figure 12.1 System Architecture for VMS Indication



Broken Lines: Outside of This Functional Package

Source: The Study Team

12.2 Equipment for Indicating Information on Expressway

(1) VMS

VMS allows the road operators to provide road users on the expressways with traffic event information. VMS shall disseminate the traffic situation in the forward direction for road users.

Therefore, it is located near where the users will select and decide their forward direction, such as before merging point where the artery road enters the expressway, before diverging point on the expressway, before Toll barrier on the expressway, or on the main route between Interchanges.

(2) SGM

SGM allows the road operators to provide road users on the expressways with traffic event information. SGM shall disseminate the traffic situation in the forward direction for road users.

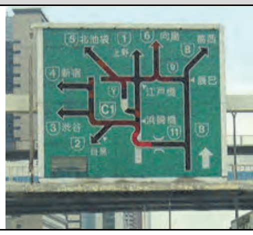
When the road network is complex, it will be installed before the connection to a complex road network. Therefore, it would be located before the junction between inter-city and urban expressway on the main route of inter-city expressway.

(3) CSS

CSS allows the road operators to dynamicaly provide road users on the expressways with spped limit information. CSS shall disseminate the speed limit in the forward direction for road users in case dense fog or heavy rains occurs, and the regulatory speed limit needs to be changed.

The regulatory speed would be applied to the section between Interchanges. Therefore, it is located after the merging point on expressway, on the main route between the Interchanges.

Table 12.1 Reference Data for VMS, SGM and CSS

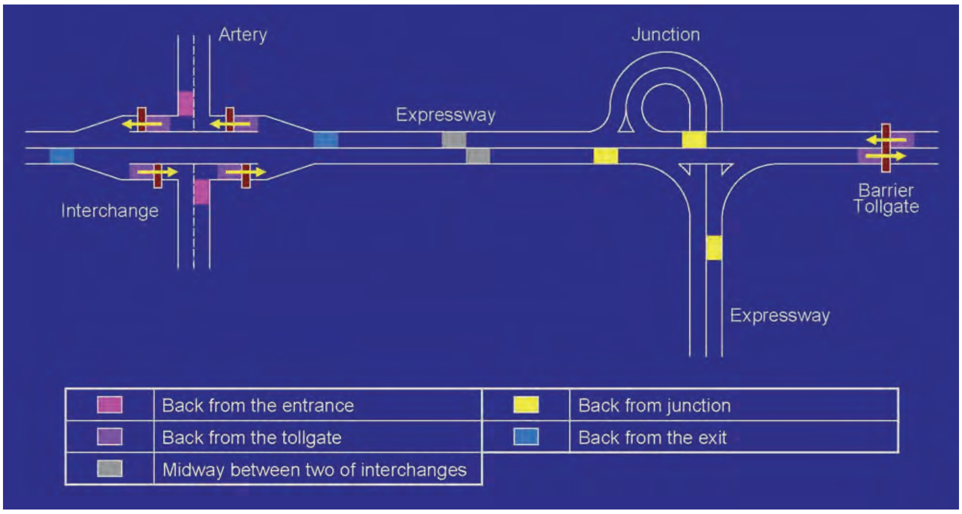
Name	Variable Message Sign	Simple Graphical Message	Changeable Speed limit Sign
Abbreviation	VMS	SGM	CSS
Appearance			
Function	Disseminate the Status of traffic and restrictions (such as traffic accidents and other occurrences) on the expressway using text.	Disseminate the Status of traffic and restrictions (such as traffic accidents and other occurrences) on the expressway using graphics.	Disseminate the speed limit, in case of dense fog and heavy rains, needs to change the regulatory speed.
Location	- Before merging point where the artery road enters the expressway - Before diverging point on the expressway - Before Toll barrier on the expressway - On the main road between the Interchanges.	- Before the junction between inter-city and urban expressway on the main route of inter-city expressway.	- After the merging point on expressway - On the main road between the Interchanges

Source: The Study Team

12.3 Location and Contents to be Indicated on VMS

VMS allows road operators to disseminate traffic information to drivers on the road mainly for assisting their route selection. For this purpose, VMS is to be installed in front of the diversing point where drivers select the direction. VMS arrangement criteria are defined responding to the locations of sections for information dissemination shown in the figure below.

Figure 12.2 Location of Sections for Information Dissemination



Source: The Study Team

(1) Entrance Gate

Entrance VMS shall be installed in the place on the access road to the expressway within 100m back from the diverging point of entrance gate. The distance to the diverging point is longer than the length of deceleration lane. However, considering the fact that the access road is outside of the expressway, VMS can be installed in the nearer place to the expressway depending on the conditions of land aquisition.

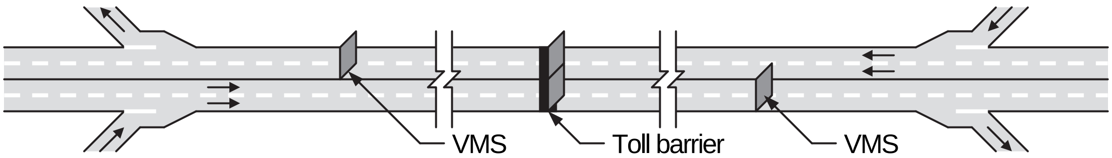
(2) Exit Gate

Exit VMS shall be installed in the place on the expressway about 200m back from the diverging point of exit gate. The distnace to the diverging point is nearly equal to the length of deceleration lane including taper length. It is consideration to be capable change direction in safe when the exit from the interchange by the information of VMS.

(3) Barrier Tollgate and Mid-point (in Future: Next Stage)

Additional VMS shall be installed at the barrier tollgate and at the mid-point between a pair of neighbouring interchanges on the throughlanes, if necessary in the future: the next stage.

Figure 12.3 VMS Installation at Mid-point between a Pair of Interchanges

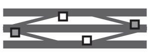
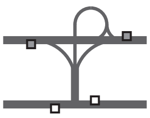
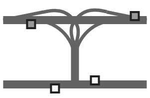
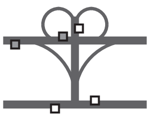
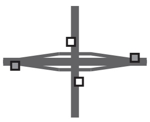
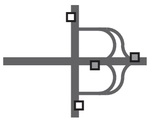
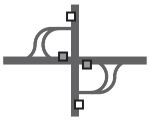
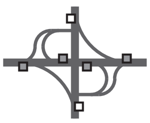
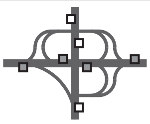
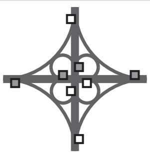
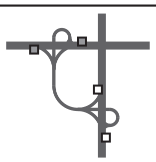


Source: The Study Team

(4) Interchange

VMS is to be installed around interchange as shown below:

Table 12.2 Arrangement of VMS at Interchange

Type of Interchange/ Arrangement of VMS		Number of Entrance	Number of Exit	Number of VMS around Interchange
Diamond		2	2	4
Trumpet		2	2	4
Directional T		2	2	4
Half Clover		2	2	4
Diamond		2	2	4
Folded Diamond		2	2	4
Partial Cloverleaf		2	2	4
6 Ramp Partial Cloverleaf		2	4	6
7 Ramp Partial Cloverleaf		3	4	7
Cloverleaf		4	4	8
Double Trumpet		2	2	4

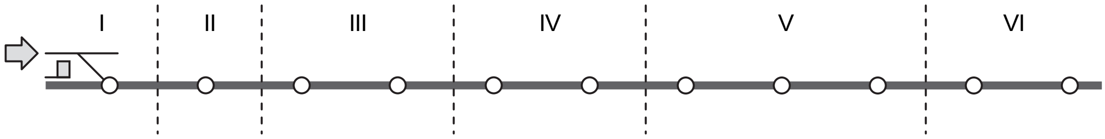
Source: The Study Team

12.4 Prioritisation on Traffic Event for VMS Indication

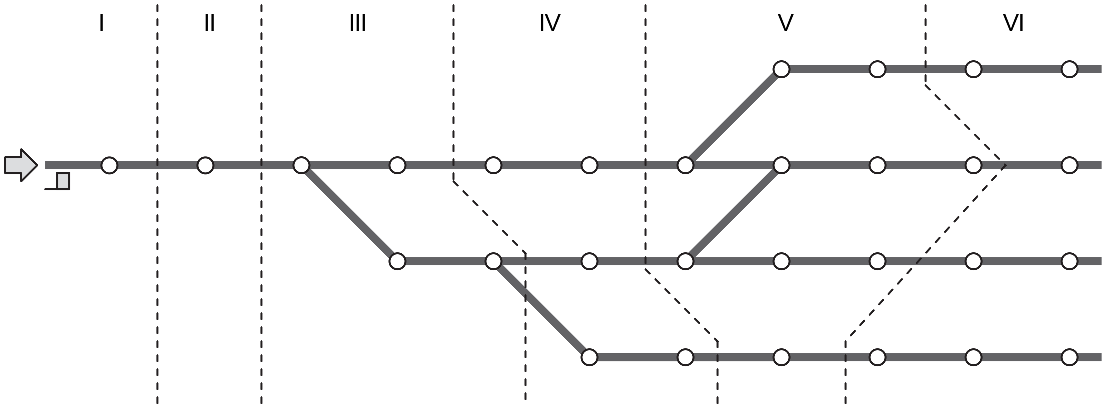
Priority on the traffic event for VMS indication is to be generated by the software "Prioritisation for Data Dissemination".

Figure 12.4 Priority on Traffic Event for VMS Indication

Case of Direct Road



Case of Road Network with Diverging/Merging



Traffic Event	Designated VMS	Ordinary VMS					
		I	II	III	IV	V	VI
Emergency 1		$F_{01}(p_C,p_D,p_V)$ →					
Emergency 2	Tunnel VMS	$F_{02}(p_C,p_D,p_V)$ →					
Bad Weather 1		$F_{03}(p_C,p_D,p_V)$ →					
Bad Weather 2		$F_{04}(p_C,p_D,p_V)$ →					
Warning 1		$F_{05}(p_C,p_D,p_V)$ →					
Warning 2		$F_{06}(p_C,p_D,p_V)$ →					
Warning 3		$F_{07}(p_C,p_D,p_V)$ →					
Warning 4		$F_{08}(p_C,p_D,p_V)$ →					
Congestion on TL		$F_{09}(p_C,p_D,p_V)$ →					
Congestion at Exit	Exit VMS	$F_{10}(p_C,p_D,p_V)$ →					
Entry Closure	Entrance VMS	$F_{11}(p_C,p_D,p_V)$ →					
Closure	Exit VMS	$F_{12}(p_C,p_D,p_V)$ →					
Exit Closure	Exit VMS	$F_{13}(p_C,p_D,p_V)$ →					
Lane Closure		$F_{14}(p_C,p_D,p_V)$ →					
Speed Limitation 1		$F_{15}(p_C,p_D,p_V)$ →					
Speed Limitation 2		$F_{16}(p_C,p_D,p_V)$ →					

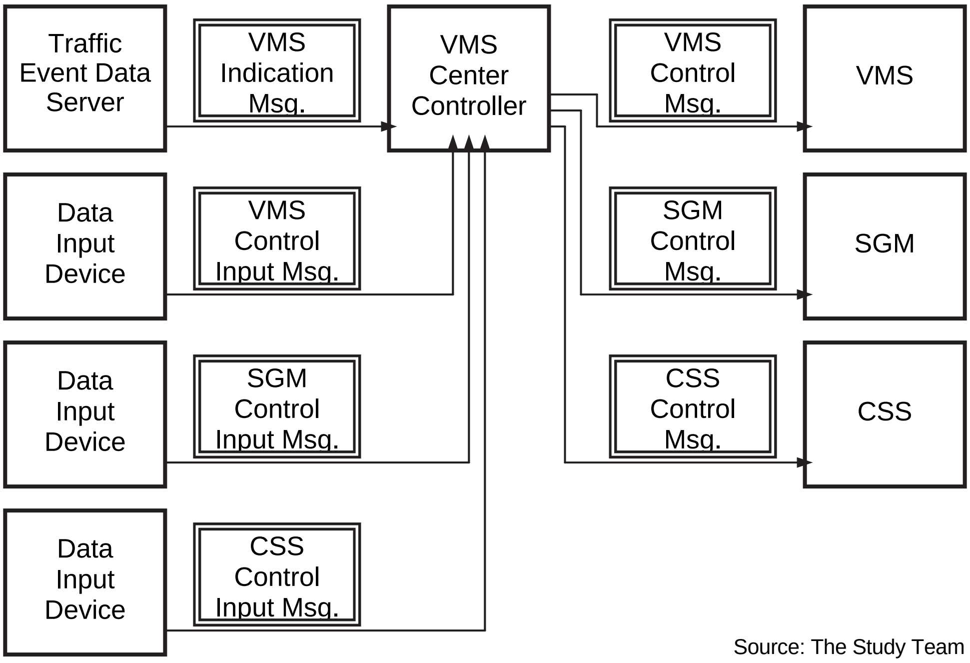
Note: TL: Through lanes.
F_{ii}: Function for generating priority on traffic event for indicating it on VMS in the zones of I, II, III, IV, V, VI
p_C: Parameters for priority depending on the kind of correlated traffic events
p_D: Parameters for priority depending on the distance from VMS to the site of traffic event
p_V: Parameters for priority depending on the traffic volume that will stumble across the traffic event

Source: The Study Team

12.5 Data Set for VMS Indication

Data to be displayed on VMS is generated through the message exchanges shown below.

Figure 12.5 Major Message Exchanges for Generating Data for Indication



Source: The Study Team

The details of these messages are to be mentioned in this section. However, in the Master Plan, SGM is defined to be installed in the later stages, so hereby the details of the messages only for VMS and CSS are shown in the following.

Table 12.3 Data Set/Elements for VMS Indication Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
VMS Check /Indication Data Set <G/C - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 month
	Roadside Equipment ID	INT*	4	1		
	Traffic Event Class ID	INT*	4	1		
	Place ID	INT*	4	1		
	Place Name	TXT	28	1		
	Traffic Event ID	INT	8	1		
	Traffic Event Name	TXT	20	1		
	Causal Place ID	INT*	4	1		
	Causal Place Name	TXT	28	1		
	Date/Time	Datetime	≥14	1		
VMS Input/Indication Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 month
	Roadside Equipment ID	INT*	4	1		
	Traffic Event Class ID	INT*	4	1		
	Place ID	INT*	4	1		
	Place Name	TXT	28	1		
	Traffic Event ID	INT	8	1		
	Traffic Event Name	TXT	20	1		
	Causal Place ID	INT*	4	1		
	Causal Place Name	TXT	28	1		
	Free Text	TXT	var	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

Table 12.4 Data Set/Elements for CSS Indication Message

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
CSS Indication Data Set <G/C - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 month
	Roadside Equipment ID	INT*	4	1		
	Speed Limit	INT*	3	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

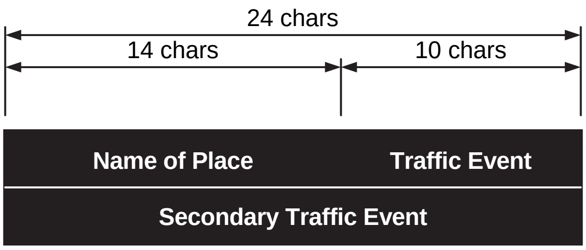
12.6 Indication Layout on VMS

(1) Standard VMS

Standard VMS is composed of two lines to indicate information on board in the consideration of the technical and economic issues in the case installed on the expressway.

- A name of the place where a traffic event of heist priority occurs and the traffic event are to be indicated within 14 and 10 characters each on the first line
- A subsidiary traffic event such as traffic restriction is to be indicated within 10 characters on the second line

Figure 12.6 Indication Layout of Standard VMS



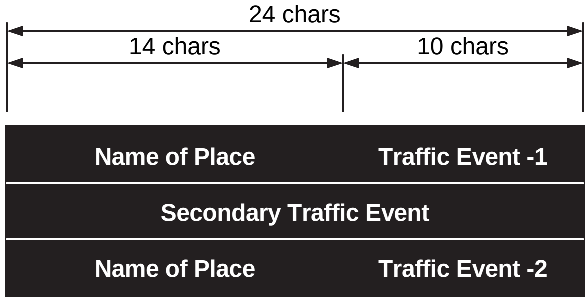
Source: The Study Team

(2) Large VMS

Standard VMS is composed of two lines to indicate information on board in the consideration of the technical and economic issues in the case installed on the expressway.

- A name of the place where a traffic event of heist priority occurs and the traffic event are to be indicated within 14 and 10 characters each on the first line
- A subsidiary traffic event such as traffic restriction is to be indicated within 10 characters on the second line
- A name of the place where a traffic event of second priority occurs and the traffic event are to be indicated within 14 and 10 characters each on the third line

Figure 12.7 Indication Layout of Large VMS



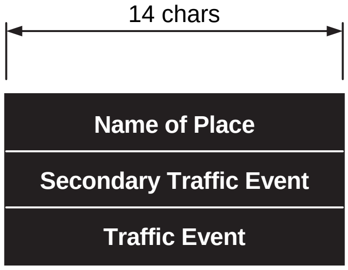
Source: The Study Team

(3) VMS for Viaduct Section

VMS for viaduct section is composed of three lines to indicate information on board in the consideration of the structural conditions in the case installed at viaducts on the expressway.

- A name of the place where a traffic event of heist priority occurs is to be indicated within 14 characters on the first line
- The traffic event is to be indicated within 10 characters on the second line
- A subsidiary traffic event such as traffic restriction is to be indicated within 10 characters on the third line

Figure 12.8 Indication Layout of VMS for Viaducts Section



Source: The Study Team

12.7 Traffic Events and Names of Place to be Indicated on VMS

The contents and the words are chosen to display on VMS need to be considered with the compatibility and suitable of technical and economical issues in VMS installing progress.
The contents and the words need be enough easy to understand and they also need can be shorten to be able to be display with two types of above VMS. With these requirements and with the collection data. This table is proposed as the referent dictionary for words which be shown on VMS.

Table 12.5 Traffic Events and Name of Place to be Indicated on VMS

No	English	Vietnamese	Abbreviation/ Indication
Traffic Event ≤ 10 characters			
1	Special Event	Sự kiện đặc biệt	Sk.Đặc biệt
2	Traffic Accident	Tai nạn giao thông	Tai nạn
3	Incident in Tunnel	Sự cố trong hầm	Sự cố
4	Reverse Driving	Xe đi ngược chiều	Xe Ng.Chiều
5	Broken-down Vehicle	Xe hỏng	Xe hỏng
6	Left Obstacle	Vật cản trên đường – Chướng ngại	Vật cản
7	Natural Disaster	Thiên tai	Thiên tai
8	Vandalism	Trang thiết bị đường bị phá hoại	ĐB.Phá hại
9	Construction Work	Công trường	C.Trường
10	Heavy Rain	Mưa lớn	Mưa lớn
11	High Wind	Gió mạnh	Gió mạnh
12	Dense Fog	Sương mù dầy	Sương dầy
13	High Temperature	Nhiệt độ cao	Nh.độ cao
14	Congestion on Through lane	Tắc trên làn cao tốc	Tắc đường
15	Crowdedness on Trough Lanes	Mật độ cao trên làn cao tốc	Mật độ cao
16	Congestion at Exit	Nghẽn tại lối ra	Tắc lối ra
17	Entry close	Đóng lối vào	Đóng-Vào
18	Closure	Đóng	Đóng
19	Exit Closure	Đóng lối ra	Đóng-Ra
20	Lane Closure	Đóng làn	Đóng làn
21	Speed Limitation	Giới hạn tốc độ	Giới hạn V

Location on Expressway ≤ 3 characters			
1	Expressway	Tên Đường Cao Tốc	CT
2	National Highway	Tên Quốc Lộ	QL.
3	Interchange	Nút giao khác mức	N
4	Junction	Nút giao cao tốc	NC
5	Entrance Gate	Lối vào đường cao tốc	VCT
6	Exit Gate	Lối ra đường cao tốc	RCT
7	Tollgate	Trạm Thu Phí	TTP
8	Parking Area	Khu vực có thể đỗ xe	PA
9	Rest Area	Trạm dừng nghỉ	T.N
10	Bus Station	Vị trí Trạm xe buýt	XB
11	Petrol Station	Trạm xăng	P
12	Medical Station	Trạm y tế - Bệnh viện	Ytế
13	Rescue Station	Trạm cứu hộ	C.H
Name of Place ≤ 14 character			
Expressway			
1	Expressway Ring Road No3	Cao Tốc Vành đai 3 Hà Nội	CTVĐ3
2	Expressway 1A	Cao Tốc 1A (Pháp Vân – Ninh Bình)	CT1A
3	Expressway 1B	Cao Tốc 1B (Hà Nội – Lạng Sơn)	CT1B
4	Expressway 2	Cao Tóc 2 (Nội Bài – Lào Cai)	CT2
5	Expressway 3	Cao Tốc 3 (Hà Nội – Thái Nguyên)	CT3
6	Expressway 5	Cao Tốc 5 (Hà Nội – Hải Phòng)	CT5
7	Expressway 6B	Cao Tốc 6B (Láng – Hoà Lạc)	CT6B
National Highway			
1	National Highway No1	Quốc Lộ 1	QL1
2	National Highway No1A	Quốc Lộ 1A	QL1A
3	National Highway No2	Quốc Lộ 2	QL2
4	National Highway No2A	Quốc Lộ 2A	QL2A
5	National Highway No2B	Quốc Lộ 2B	QL2B
6	National Highway No3	Quốc Lộ 3	QL3
7	National Highway No5	Quốc Lộ 5	QL5
8	National Highway No6	Quốc Lộ 6	QL6
9	National Highway No10	Quốc Lộ 10	QL10
10	National Highway No18	Quốc Lộ 18	QL18
11	National Highway No21	Quốc Lộ 21	QL21

12	National Highway No23	Quốc Lộ 23	QL23
13	National Highway No32	Quốc Lộ 32	QL32
14	National Highway No32C	Quốc Lộ 32C	QL32C
15	National Highway No38	Quốc Lộ 38	QL38
Interchange			
1	Trung Hoa IC	Nút giao Trung Hòa	N.Trung Hòa
2	Thanh Xuan IC	Nút giao Thanh Xuân	N.Thanh Xuân
3	Phap Van IC	Nút giao Pháp Vân	N.Pháp Vân
4	Tam Trinh IC	Nút giao Tam Trinh	N.Tam Trinh
5	Linh Nam IC	Nút giao Lĩnh Nam	N. Lĩnh Nam
6	North Thanh Tri IC	Nút giao Bắc Thanh Trì	N. B.Thanh Trì
7	NH5 IC	Nút giao Quốc Lộ 5 – Sài Đồng	N. QL5-S.Đồng
8	Dai Mo IC	Nút giao Đại Mỗ	N. Đại Mỗ
9	Dong Mo IC	Nút giao Đồng Mô	N. Đồng Mô
10	Phu Cat IC	Nút giao Phú Cát	N. Phú Cát
11	Hoa Lac IC	Nút giao Hòa Lạc	N. Hòa Lạc
12	Khe Hoi IC	Nút giao Khê Hội	N. Khê Hội
13	Van Diem IC	Nút giao Vạn Điểm	N. Vạn Điểm
14	Dai Xuyen IC	Nút giao Đại Xuyên	N. Đại Xuyên
15	Vuc Vong IC	Nút giao Vực Vòng	N. Vực Vòng
16	Liem Tuyen IC	Nút giao Liêm Tuyền	N. Liêm Tuyền
17	Cao Bo IC	Nút giao Cao Bồ	N. Cao Bồ
18	South Bac Ninh IC	Nút giao Nam Bắc Ninh	N.N.Bắc Ninh
19	Lien Bao IC	Nút giao Liên Bảo	N. Liên Bảo
20	Tien Son IC	Nút giao Tiên Sơn	N. Tiên Sơn
21	Tu Son IC	Nút giao Từ Sơn	N. Từ Sơn
22	Den Do IC	Nút giao Đền Đô	N. Đền Đô
23	Thang Long-Noi Bai IC	Nút giao Thăng Long -Nội Bài	N.TL-Nội Bài
24	NH3-Phu Lo IC	Nút giao Quốc lộ 3-Phủ Lỗ	N.QL3-Phủ Lỗ
25	PR295-Cho IC	Nút giao Tỉnh lộ 295-Chờ	N.TL295-Chờ
26	Binh Xuyen IC	Nút giao Bình Xuyên	N. Bình Xuyên
27	NH2B-Kim Long IC	Nút giao Quốc lộ 2B-Kim Long	N. QL2B-KL
28	PR305-Van Quan IC	Nút giao Tỉnh lộ 305-Văn Quán	N. TL305-VQ
29	NH2-Phu Ninh IC	Nút giao Quốc lộ 2-Phù Ninh	N.QL2-P.Ninh
30	NH32C-Sai Nga IC	Nút giao Quốc lộ 32C-Sai Nga	N. QL32C-SN

Junction			
1	Phap Van Junction	Nút Cao tốc Pháp Vân	NC.Pháp Vân
Tollgate			
1	Linh Nam TG	Trạm thu phí Lĩnh Nam	TTP Lĩnh Nam
2	Phuong Nhi TG	Trạm thu phí Phương Nhị	TTP P.Nhị
3	Khe Hoi TG	Trạm thu phí Khê Hội	TTP Khê Hội
4	Van Diem TG	Trạm thu phí Vạn Điểm	TTP Vạn Điểm
5	Dai Xuyen TG	Trạm thu phí Đại Xuyên	TTP Đại Xuyên
6	Vuc Vong TG	Trạm thu phí Vực Vòng	TTP Vực Vòng
7	Liem Tuyen TG	Trạm thu phí Liêm Tuyền	TTP Liêm Tuyền
8	Cao Bo TG	Trạm thu phí Cao Bồ	TTP Cao Bồ
9	Phuc Loi TG	Trạm thu phí Phúc Lợi	TTP Phúc Lợi
10	Ca Lo TG	Trạm thu phí Cà Lồ	TTP Cà Lồ
11	Tan Dan TG	Trạm thu phí Tân Dân	TTP Tân Dân
12	Binh Xuyen TG	Trạm thu phí Bình Xuyên	TTP Bình Xuyên
13	NH2B-Kim Long TG	Trạm thu phí Quốc lộ 2B-Kim Long	TTP QL2B-KL
14	PR305-Van Quan TG	Trạm thu phí Tỉnh lộ 305-Văn Quán	TTP TL305-VQ
15	NH2-Phu Ninh TG	Trạm thu phí Quốc lộ 2-Phù Ninh	TTP QL2-P.Ninh
16	NH32C-Sai Nga TG	Trạm thu phí Quốc lộ 32C-Sai Nga	TTP QL32C-SN
Parking Area			
Rest Area			
Bus Station			
Petrol Station			
Medical Station			
Rescue Station			

Airport			
1	Noi Bai Airport	Sân bay Nội Bài	SB.Nội Bài
2	Gia Lan Airport	Sân bay Gia Lâm	SB.Gia Lâm
Port			
1	Hai Phong Port	Cảng Hải Phòng	C.Hải Phòng
2	Lach Huyen Port	Cảng Lạch Huyện	C.Lạch Huyện
City/District			
1	Bac Ninh City	Thành phố Bắc Ninh	TP.Bắc Ninh
2	Ha Noi Capital	Thành phố Hà Nội	TP.Hà Nội
3	Nam Dinh City	Thành phố Nam Định	TP.Nam Định
4	Ninh Binh City	Thành phố Ninh Bình	TP.Ninh Bình
5	Phu Ly City	Thành phố Phủ Lý	TP.Phủ Lý
6	Viet Tri City	Thành phố Việt Trì	TP.Việt Trì
7	Hai Phong City	Thành phố Hải Phòng	TP.Hải Phòng
8	Hoa Lac	Hòa Lạc	Hòa Lạc
9	Hoa Binh	Hòa Bình	Hòa Bình
10	Hung Yen	Hưng Yên	Hưng Yên
11	Binh Xuyen	Bình Xuyên	Bình Xuyên
12	Huong Canh	Hương Canh	Hương Canh
13	Phuc Yen	Phúc Yên	Phúc Yên
14	Cau Giay	Cầu Giấy	Cầu Giấy
15	Ha Dong	Hà Đông	Hà Đông
16	Hoa Binh	Hòa Bình	Hòa Bình
17	Phu Ly	Phủ Lý	Phủ Lý
18	Giai Phong	Giải Phóng	Giải Phóng
19	Hoang Mai	Hoàng Mai	Hoàng Mai
20	Gia Lam	Gia Lâm	Gia Lâm
21	Cau Chui	Cầu Chui	Cầu Chui
22	My Dinh	Mỹ Đình	Mỹ Đình
23	Nhon	Nhổn	Nhổn
24	Quoc Oai	Quốc Oai	Quốc Oai
25	Thach That	Thạch Thất	Thạch Thất
26	Son Tay	Sơn Tây	Sơn Tây
27	Xuan Mai	Xuân Mai	Xuân Mai
28	Thuong Tin	Thường Tín	Thường Tín
29	Van Tao	Vân Tảo	Vân Tảo
30	Van Diem	Vạn Điểm	Vạn Điểm
31	Phu Minh	Phú Minh	Phú Minh

32	Dong Van	Đồng Văn	Đồng Văn
33	Hoa Mac	Hòa Mạc	Hòa Mạc
34	Liem Tuyen	Liêm Tuyền	Liêm Tuyền
35	Lien Bao	Liên Bảo	Liên Bảo
36	Tien Son	Tiên Sơn	Tiên Sơn
37	Phat Tich	Phật Tích	Phật Tích
38	Tu Son	Từ Sơn	Từ Sơn
39	Phu Chan	Phù Chẩn	Phù Chẩn
40	Tan Dan	Tân Dân	Tân Dân
41	Van Quan	Văn Quán	Văn Quán
42	Sai Dong	Sài Đồng	Sài Đồng
43	Phu Cat	Phú Cát	Phú Cát
44	Dai Xuyen	Đại Xuyên	Đại Xuyên
45	Vuc Vong	Vực Vòng	Vực Vòng
46	Cao Bo	Cao Bồ	Cao Bồ
47	Cho	Chờ	Chờ
48	Soc Son	Sóc Sơn	Sóc Sơn
49	Phu Lo	Phù Lỗ	Phù Lỗ
50	Phu Ninh	Phù Ninh	Phù Ninh
51	Sai Nga	Sai Nga	Sai Nga

Source: The Study Team

12.8 Required Functions/Performance of VMS Indication

(1) Examples of letter size on traffic sign board on highways in other countries.

-USA-
 Letter height: >250 mm
 Letter width: 50-100% of letter height
 Line thickness: 10-20 % of letter height (15% is ideal)
-Germany-
 Letter height: >280 mm
-Japan-
 Letter height: 450 mm
 Letter width: 84% of letter height
 Line 44thickness: 10% of letter height

(2) Letter height of traffic sign in Vietnam

Letter height on traffic sign in Viet Nam is expected to be “22-TCN-331-05 BIỂN CHỈ DẪN TRÊN ĐƯỜNG CAO TỐC”

According to the guideline, drivers would recognize the traffic sign, understand and start action 10 seconds before the sign.

Table 12.6 Correlation with Decipher required distance and Letter height

Decipher required distance	250m	325m	400m
Letter height (Vietnamese)	200mm	300mm	400mm

Source: 22-TCN-331-05 BIỂN CHỈ DẪNTRÊN ĐƯỜNG CAO TỐC

When driving at 120 km/h on Vietnam highway, 10 seconds would require 333.33 m distance from the sign, thus from the Table, letter height needs to be more than 400 mm. However, since VMS displays letters by LED (Light Emitting Diode) dots, letter height should be more than 450 mm considering Vietnamese circumflex representation.

(3) Letter width of traffic sign in Vietnam

Character width on traffic signs in Vietnam must comply with the standard "22-TCN-331-05 ROAD SIGNS ON HIGHWAY which is illustrated in the Table 11 and 12
Width of numbers 0-9 must be 25%-72% of their heights. Letters A-Z comprise circumflex with the width of 16%~86% of their heights.
Therefore, in the case of applying this standard for the width of character on VMS then character height on VMS is 450mm, the width of each character is illustrated in column "For VMS" in the Table 11 and 12.

Table 12.7 Letter Width of Number

	Letter width (mm)							
	22TCN331-05 BIẾN CHỈ DÂN TRÊN ĐƯỜNG CAO TỐC						For VMS / CSS	
Letter height (mm)	**200**	Ratio to Letter Height	**300**	Ratio to Letter Height	**400**	Ratio to Letter Height	**450**	Ratio to Letter Height
1	50	25%	74	25%	98	25%	108	24%
2	137	69%	205	68%	274	69%	306	68%
3	137	69%	205	68%	274	69%	306	68%
4	149	75%	224	75%	298	75%	306	68%
5	137	69%	205	68%	274	69%	306	68%
6	137	69%	205	68%	274	69%	306	68%
7	137	69%	205	68%	274	69%	306	68%
8	137	69%	205	68%	274	69%	306	68%
9	137	69%	205	68%	274	69%	306	68%
0	143	72%	214	71%	286	72%	324	72%
Average	130	65%	195	65%	260	65%	288	64%

Table 12.8 Letter width of Alphabet

	Letter width (mm)							
	22TCN331-05 BIỂN CHỈ DẪN TRÊN ĐƯỜNG CAO TỐC						For VMS	
Letter Height (mm)	200	Ratio to Letter Height	300	Ratio to Letter Height	400	Ratio to Letter Height	450	Ratio to Letter Height
A, Â	170	85%	225	75%	340	85%	378	84%
B	137	69%	205	68%	274	69%	306	68%
C	137	69%	205	68%	274	69%	306	68%
D	137	69%	205	68%	274	69%	306	68%
Đ	155	78%	232	77%	310	78%	342	76%
E, Ê	124	62%	186	62%	248	62%	279	62%
F	124	62%	186	62%	248	62%	279	62%
G	137	69%	205	68%	274	69%	306	68%
H	137	69%	205	68%	274	69%	306	68%
I	32	16%	48	16%	64	16%	72	16%
J	127	64%	190	63%	254	64%	279	62%
K	140	70%	210	70%	280	70%	315	70%
L	124	62%	186	62%	248	62%	279	62%
M	157	79%	236	79%	314	79%	351	78%
N	137	69%	205	68%	274	69%	306	68%
O, Ô, Ơ	143	72%	214	71%	286	72%	315	70%
P	137	69%	205	68%	274	69%	306	68%
Q	143	72%	214	71%	286	72%	315	70%
R	137	69%	205	68%	274	69%	306	68%
S	137	69%	205	68%	274	69%	306	68%
T	124	62%	186	62%	248	62%	279	62%
U	137	69%	205	68%	274	69%	306	68%
Ư	167	84%	250	83%	334	84%	378	84%
V	152	76%	229	76%	304	76%	342	76%
X	137	69%	205	68%	274	69%	306	68%
Y	171	86%	257	86%	342	86%	387	86%
Z	137	69%	205	68%	274	69%	306	68%
Average	133	67%	198	66%	267	67%	297	68%

(4) Distance between disappearance point and sign

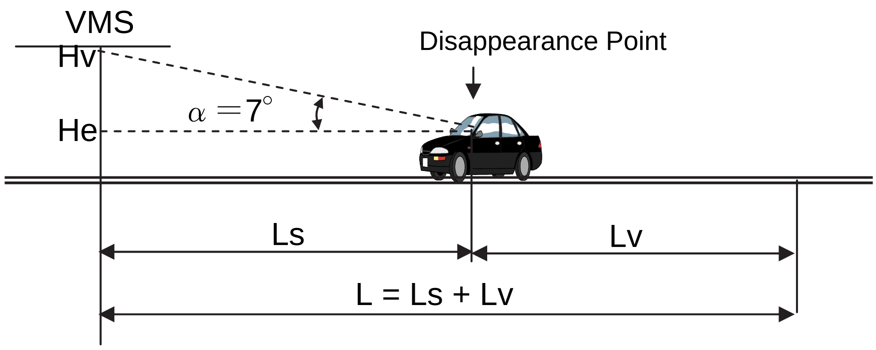
Distance between disappearance point and sign (Ls) can be calculated from driver's visual limit, position of traffic sign (VMS), and size of VMS.
When vertical visual limit is $\alpha = 7^\circ$, eye-level of the driver is 1.2m, height of VMS is 6.25 m, Ls can be calculated to be about 51 m.

The upper-edge of the VMS board was set at 6.25 m to fulfil structural height limit of 4.75 m determined by local guideline, and VMS board height is 1.50 m (3 rows of 450 mm high letters).

Ls = (Hv – He) / tan α

Where Hv: Upper-edge of the VMS board (m)
He: Eye-level of the driver (m)
α : Vertical visual limit (degree)

Figure 12.9 Relation between Hv, He, Ls, Lv and L



(4) Decipher required distance (Lv)

Decipher required distance (Lv) is calculated from decipher required time (or number of letters) and running speed. When decipher required time is t, and running speed is V=120 km/h, Lv would become Lv＝120× ｔ／3.6＝33.3ｔ.

Lv = V x t / 3.6

Where V: Running Speed (km/h)
t: Decipher Required Time (sec)

(5) Visual recognition distance (L)

From (3) and (4), visual recognition distance can be calculated from below:

L=Ls + Lv

Thus, L = 51m + 33.3t

(6) Decipherable letter number

According to Germany standard from the table, the following formulae can be given by the fact 167 m sight distance required at letter height of 450 mm.

t = (L – 51m) / 33.3 = (167m – 51m) / 33.3
= 3.48 sec = 3.5 sec (approx.)

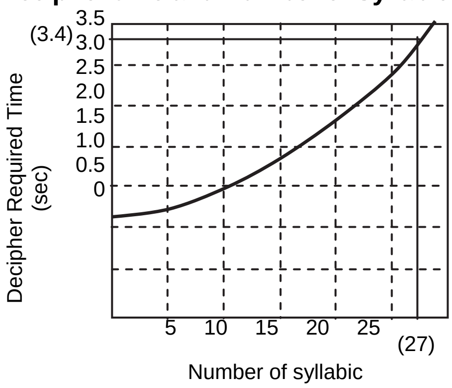
From the Figure graph below, 30 letters are legible in 3.5 second decipher time.

Table 12.9 Relation between Character Height and sight Distance

Alphabet Font Type	Character Height to Sight Distance	Character Height		
		30cm	45cm	60cm
Narrow	300h	90cm	130cm	180cm
Normal	370h	111	167	222
Wide	450h	135	203	270

Source: German Standard

Figure 12.10 Relation between Decipher time and Number of Syllabic



(7) Examination on longevity elongation of LED element

LED element takes 35,000-50,000 hours for its light intensity to decrease for 50%.

The picture represents the example of letter display, assuming the resolution to be 30 pixels vertical vs 16 pixels horizontal.

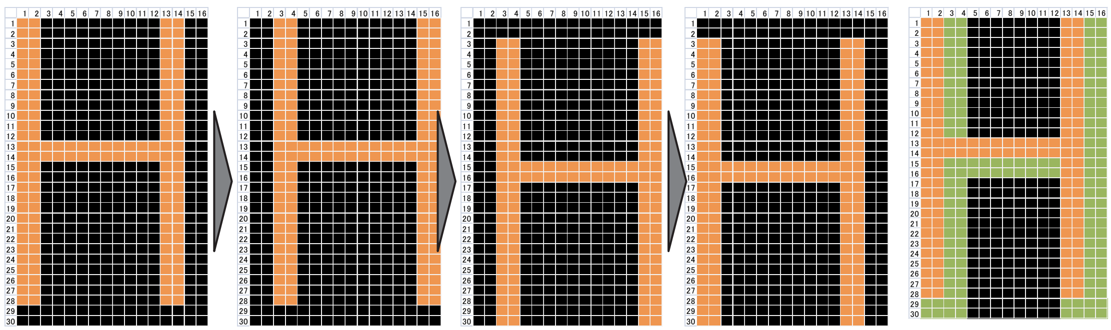
In case of Vietnamese, display will employ alphabets from A to Z, and circumflex in addition. On the display there will be highly frequently used LED elements, and others rarely used.

When LED elements burn out, the replacement will be made not by individual elements but by a unit of certain number of LED elements. For example, if the display is made by 160 x 160 mm LED element unit with 15 mm pitch, replacement is done by unit of 144 dots (12 x 12).

Individual LED elements are ideally degraded equally for VMS to last longer.

For such purpose, shifting lighting LED elements by time to time can equalize the frequency of lighting time of each element. However, it is not the case when all elements are lit for picture display.

Figure 12.11 Example for Longevity elongation of LED element

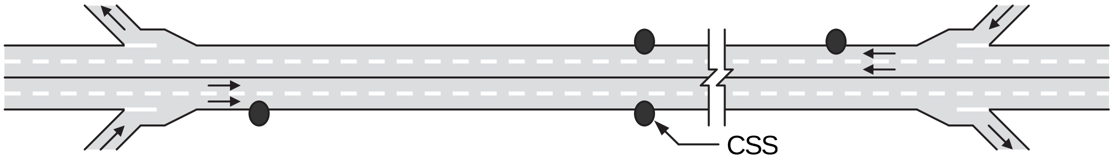


Move 2 columns to right | Move 2 rows downward | Move 2 columns to left | Total LED use

12.9 Location and Indication Criteria of CSS

Locate the CSS after the merging point on expressway, on the main road between the Interchanges.

Figure 12.12 CSS Installation at Mid-point between a Pair of Interchanges



Source: The Study Team

12.10 Required Functions/Performance of CSS Indication

Numerical character for showing speed limit is indicated on CSS in the same performance as the characters on VMS.

13. Mobile Radio Communication

13.1 Outline and System Architecture

(i) Mobile Radio communication system is absolutely required not only for normal operation and maintenance purpose such as patrol, but also for communication method between the site and road management office under emergency cases such as accident or disaster.

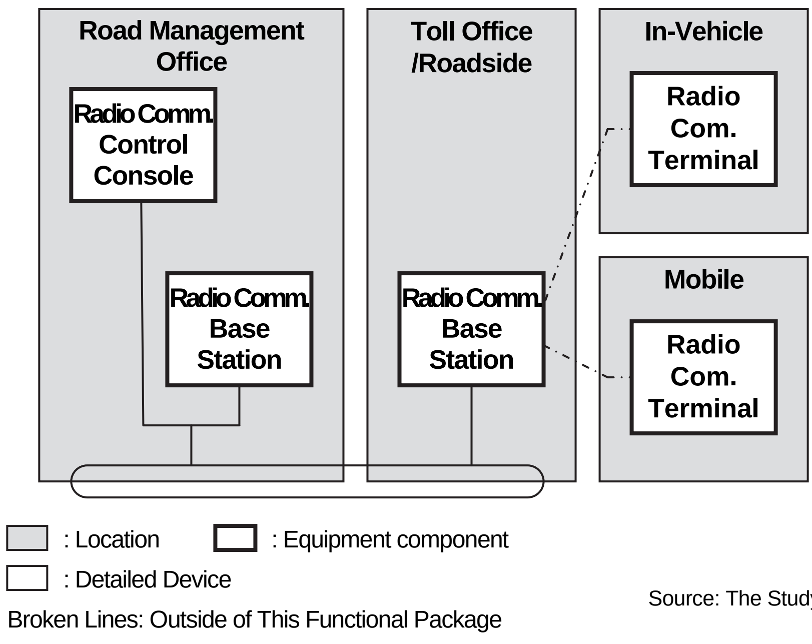
(ii) Mobile Radio communication system is able to actualize interactive voice communication between console in road management office and terminal equipment component holders, and among terminal equipment component holders.

(iii) Mobile radio communication system means the facilities and equipment components from land mobile station such as terminal equipment components to the console in road management office through the base station.

(iv) The interference should be considered to minimize as much as possible.

This functional package allows the road operators to exchange information between road operation vehicles/workers on the expressway and the road management office by using radio communication.

Figure 13.1 System Architecture for Mobile Radio Communication



Source: The Study Team

13.2 Required Function of Mobile Radio Communication

Mobile Radio communication system is able to actualize interactive voice communication between console in road management office and terminal equipment component holders, and among terminal equipment component holders.

The coverage area of mobile radio communication for expressway operation and maintenance shall be capable to communicate on the expressway and related facility areas along the expressway such as outside area within the premises of road management office, interchanges, toll areas, rest areas, parking areas and other premises along the expressway. However it should not be caused interference due to unnecessarily expanded coverage areas.

13.3 System Design Conditions

(1) Coverage Area of Mobile Communication

The coverage area of mobile radio communication for expressway operation and maintenance shall be capable to communicate on the expressway and related facility areas along the expressway such as outside area within the premises of road management office, interchanges, toll areas, rest areas, parking areas and other premises along the expressway. However it should not be caused interference due to unnecessarily expanded coverage areas.

(2) Circuit Configuration

(i) Between base station and mobile terminal under one road management office area, circuit frequency is required two (2) waves.

(ii) The circuit frequency for mobile terminal is needed three (3) waves for communication between console in road management office and terminal, and for receiving directives.

(iii) The base station is able to control from the console of the road management office. However if the coverage area of several consecutive base stations are limited due to several short tunnels, those base stations may be controlled as a group.

(3) Location of Base Station

Base station location within the own road management section is selected in the following priority order. It is preferable to be determined by the characteristics of the radio wave propagation theoretically.

(i) Within the premises of road management office

(ii) Within the premises of toll office

(iii) Within the premises of inter change or toll gate area

(iv) Within the premises of rest area, service area, or parking areas

(v) Other necessary locations

If the base station is required to be outside of the premises of road, the site ownership should be clarified or agreement related to land lease should be made in writing, prior to commencement of installation work at site.

(4) Assignment of mobile terminal equipment component

In-vehicle mobile terminal equipment components are recommended to utilize for expressway patrol vehicles, maintenance vehicles, and vehicles for installation work on the expressway.

The mobile terminals which are to be utilized not in-vehicle purpose, at least four (4) set are required for one road management office.

Necessary number of terminals should be surveyed and determined basically, however, in ITS integration Project, it is planned to deliver 10 sets per one road management office.

(5) Standby of the Radio Equipment Component

Since the transceiver of the base station is core component of the station and it is required to avoid long time operation down due to the component failure, standby transceiver shall be equipped.

(6) Leaky Coaxial Cable

Inside of the tunnel in which the minimum receiving power of the radio wave is not able to obtain by antenna, leaky coaxial cable installation should be considered.

(7) Backup Electric Power Supply Facility

In order to keep the radio communication functions during commercial power failure, the backup electric power supply facility such as UPS, battery and engine generator shall be equipped for the base station equipment component. The backup power supply facility shall cover the capacity of the necessary power of the radio communication system and the conditions are shown below;

- In case the base station equipped with engine generator: ten (10) minutes
- In case the base station not equipped with engine generator: six (6) hours

The engine generator shall be kept the good conditions and amount of fuel for six (6) hours continuous operation shall be stocked within the same premises.

(8) Functions related to Directive communication for mobile radio communication

Directive communication console located in the road management office which is required to control the base stations shall equip the following functions;

(i) Selection function of base station to transmit the directive

(ii) Displaying function (such as flashing light) of reception of directive

(iii) Directive buzzer (twice of approx. 1 sec buzzer)

13.4 Radio Communication System

(1) Radio Frequency Band

Frequency band for expressway mobile radio communication system is recommended to be VHF or UHF, and if necessary, it is required to be licensed by Radio Frequency Directorate of Ministry of Information and Communication in Vietnam prior to the operation.

(2) Communication Method

Full duplex communication method is to be applied for the mobile radio communication system for the following reasons;

- Simultaneous transmission and reception is available
- No proficiency is required for terminal usage

For information sharing purpose, the voice communication made by mobile radio communication system is preferable to be heard by the operator at console and other terminal holders within one road management office area as much as possible.

13.5 Speech Quality

(1) Criteria of Speech Quality

The speech quality design and threshold should be considered as follows;

(i) The speech quality on the expressway should be within 25dB of S/N (Signal-to-Noise) ratio for normal modulation. It means that "the degree of clear voice can be heard fully with some degree of noise".

(ii) During design stage, in order to secure the above S/N ratio, speech quality should be checked by the site survey taking necessary margins into consideration. For example, an obstacle margin of sound abatement shield along the expressway should be considered.

(iii) The terminology of "normal modulation" in item (i) above means ±1.75KHz frequency modulation due to 1 KHz input signal.

(iv) The specified S/N ratio in item (i) is the threshold for the measurement result specified in the next item (v) and taking necessary margins mentioned above item (ii) into account.

(2) Measurement method of input signal strength of receiver and noise intensity

Input signal strength of receiver and noise intensity are measured with the following procedure;

(i) Measurement of input signal strength of the receiver should be made under the condition of transmitting from base station and receiving of mobile terminal.

(ii) Whole measurement result of input signal strength of receiver is required to record along each 100m interval of expressway, and data analysis should be made for lower 25% measured result. In addition, elevated section of expressway such as inter change, road management office area, toll office, rest area, and parking areas is also required to measure.

(iii) Measurement of noise intensity should be made for 10 minutes duration in accordance with the CISPR standard for the above 25% lower signal strength points, and at the same time, number of passing vehicles also should be counted. The noise intensity measurement for base station should be made under the similar conditions of actual antenna installation conditions such as height and location. As for noise intensity measurement for mobile terminal is also made under the similar conditions of actual operation such as utilization of vehicle mounted antenna and parking shoulder part of the expressway.

If there is very few vehicle passage observed during measurement, it is able to refer to the measurement result of in-service expressway section's measurement record.

(iv) Analysis of measurement result of noise intensity is made based on the recorded data, and required to obtain to calculate 50%-value (medium value) and 95%-value. As for 95% -value of noise intensity is obtained based on the condition that the 95% measured data is equal to or less than other measured data of one specific location.

(v) The S/N ratio is obtained for the location where the measured result of input signal strength of receiver is rather low mentioned above item (ii), and the 95%-value of noise intensity explained above item (iv) at the same location is utilized.

13.6 Radio Wave Propagation

After completion of installation of the radio communication equipment component, radio wave propagation from antenna and leaky coaxial cable shall be confirmed with the conditions specified coverage area in item 3 ~~7~~.3 2) (1) under the quality specified in the item 3 ~~7~~.3 4) through the measuring method specified in the item 3 ~~7~~.3 4) (2).

13.7 Antenna Supporting Pole

Antenna supporting pole should be designed taking following conditions into account;

(i) Necessary antenna height is able to set

(ii) Platform for maintenance work of the antenna is necessary to equip at the place where maintenance staff is able to reach the antenna easily

(iii) Enough strength should be kept against the prospective load to the pole

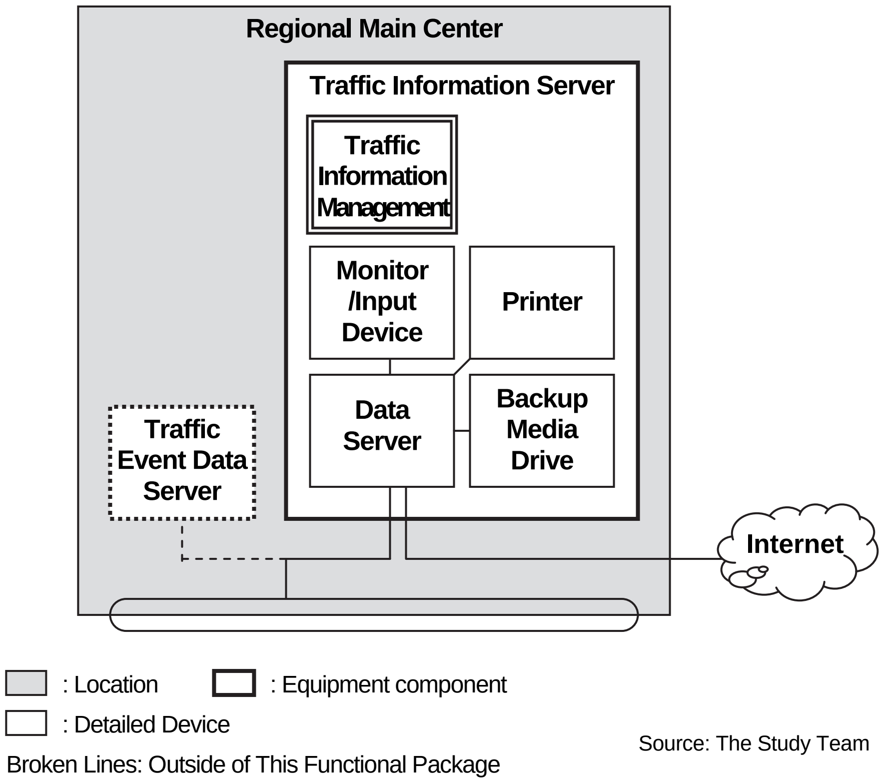
(iv) Counter measures shall be taken to the various environment conditions of Vietnam, such as lightning strike and surge, flood, and storm

14. Traffic Information

14.1 Outline and System Architecture

This functional package allows the road operators to provide other organizations with the information organized as traffic events on the expressways by using the Internet.

Figure 14.1 System Architecture for Traffic Information



Source: The Study Team

14.2 Contents of Traffic Information

System is to disseminate information on traffic and road condition of the expressway network to the Internet Users based on the traffic event data stored in the server.

- Incidents
- Traffic conditions
- Traffic congestion
- Bad weather
- Construction works on the expressways
- Traffic restrictions.

Details of each content are shown in the definition of traffic events aforementioned.

14.3 Data Set for Traffic Information

Table 14.1 Data Set/Elements for Traffic Information

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Traffic Event Data Set <G/C - Server>	Traffic Event Data ID	INT	8	1	When an event occurs	1 year
	Road Management Office ID	INT*	4	1		
	Road Section ID	INT*	4	1		
	Road Link ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Traffic Event Category ID	INT*	4	1		
	Traffic Event Class ID	INT*	4	1		
	Causal Traffic Event Data ID	INT	8	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Input Person	TXT	32	1		
	Event Status	TXT	4	1		
	Video Image address	TXT	60	1		
	Main Center Check Status	INT*	4	1		
	Road Management Office Check Status	INT*	4	1		
	Status of Traffic Event	INT*	2	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

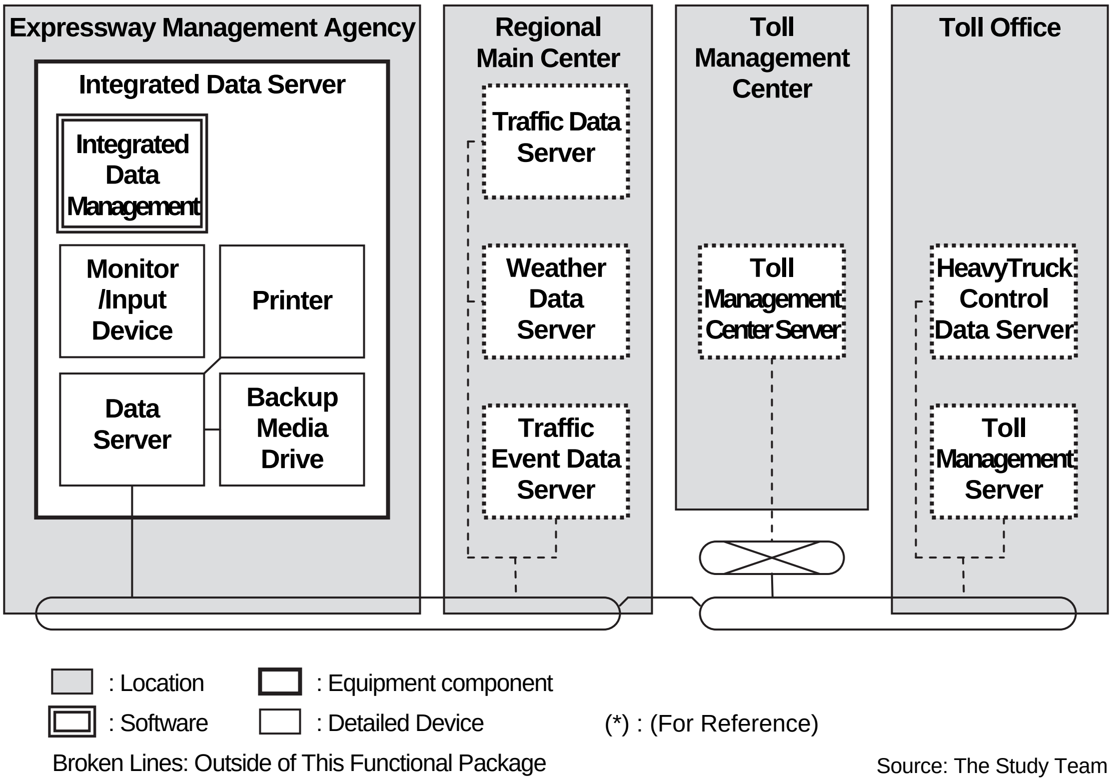
Source: The Study Team

15. Integrated Data Management

15.1 Outline and System Architecture

This functional package allows road operators to utilize acquired data such as traffic events, traffic volume, large vehicle ratio and measured axle loads of heavy trucks for developing inspection and budget plan of road maintenance and to check validity of toll revenue in comparison with traffic data.

Figure 15.1System Architecture for Traffic Information



Source: The Study Team

15.2 Required Function for Integrated Data Management

The system is to compile the following data set corresponding to date/time and kilo-meter post of a road section:

- Incident data set
- Traffic volume data set
- Traffic congestion data set
- Bad weather data set
- Construction work data set
- Traffic restriction data set
- Traffic event data set
- Hourly toll collection data set
- Axle load management data set

15.3 Data for Traffic Information/Control

Table 15.1 Data Sets for Traffic Information Control

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Incident Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Roadside Equipment ID	INT*	4	1		
	Incident Status	INT*	2	1		
	Date/Time	Datetime	≥14	1		
Traffic Volume Data Set <G - Traffic Analysis Processor>	Road Management Office ID	INT*	4	1	Every 5 minutes	1 year
	Roadside Equipment ID	INT*	4	1		
	Total Traffic Volume per Day	INT	5	1		
	Large Vehicle Ratio	FLOAT	5	1		
	Traffic Volume per Day of vehicle class 1	INT	5	1		
	Traffic Volume per Day of vehicle class 2	INT	5	1		
	Traffic Volume per Day of vehicle class 3	INT	5	1		
	Traffic Volume per Day of vehicle class 4	INT	5	1		
	Traffic Volume per Day of vehicle class 5	INT	5	1		
	Total Traffic Volume per Hour	INT*	4	1		
	Large Vehicle Ratio	FLOAT	5	1		
	Traffic Volume per Hour of vehicle class 1	INT*	4	1		
	Traffic Volume per Hour of vehicle class 2	INT*	4	1		
	Traffic Volume per Hour of vehicle class 3	INT*	4	1		
	Traffic Volume per Hour of vehicle class 4	INT*	4	1		
	Traffic Volume per Hour of vehicle class 5	INT*	4	1		
	Total Traffic Volume per 15 minutes	INT*	3	1		
	Traffic Volume per 15 minutes of vehicle class 1	INT*	3	1		
	Traffic Volume per 15 minutes of vehicle class 2	INT*	3	1		
	Traffic Volume per 15 minutes of vehicle class 3	INT*	3	1		
	Traffic Volume per 15 minutes of vehicle class 4	INT*	3	1		
	Traffic Volume per 15 minutes of vehicle class 5	INT*	3	1		
	Date/Time	Datetime	≥14	1		
Traffic Congestion Data Set <G - Traffic Analysis Processor>	Road Management Office ID	INT*	4	1	Every 5 minutes	1 year
	Roadside Equipment ID	INT*	4	1		
	Cumulative Number of Vehicles	INT*	4	1		
	Average Vehicle Speed	INT*	4	1		
	Traffic Congestion Status	INT*	2	1		
	Beginning Kilometer Post	TXT	6	1		

	Ending Kilometer Post	TXT	6	1		
	Date/Time	Datetime	≥14	1		
Bad Weather Data Set <G - Weather Server>	Road Management Office ID	INT*	4	1	When a bad weather occurs	1 year
	Roadside Equipment ID	INT*	4	1		
	Precipitation	FLOAT	2	1		
	Wind Speed	FLOAT	2	1		
	Visibility	FLOAT	2	1		
	Temperature	FLOAT	2	1		
	Heavy Rain Status	INT*	2	1		
	High Wind Status	INT*	2	1		
	Low Visibility Status	INT*	2	1		
	High Temperature Status	INT*	2	1		
	Date/Time	Datetime	≥14	1		
Construction Work Data Set <I - Server>	Road Management Office ID	INT*	4	1	When a construction work is scheduled	1 year after end of construction
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Construction Work Status	INT*	2	1		
	Number of document	TXT	20	1		
	Permission Date	TXT	8	1		
	Date/Time Begin	TXT	≥14	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		
Traffic Restriction Data Set <I - Server>	Road Management Office ID	INT*	4	1	When an event occurs	1 year after end of restriction
	Road Section ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Construction Work Status	INT*	2	1		
	Permission Date	TXT	8	1		
	Date/Time Begin	TXT	≥14	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		
Traffic Event Data Set <G/C - Server>	Traffic Event Data ID	INT	8	1	When an event occurs	1 year
	Road Management Office ID	INT*	4	1		
	Road Section ID	INT*	4	1		
	Road Link ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Place ID	INT*	4	1		
	Traffic Event Category ID	INT*	4	1		
	Traffic Event Class ID	INT*	4	1		
	Causal Traffic Event Data ID	INT	8	1		
	Beginning Kilometer Post	TXT	6	1		
	Ending Kilometer Post	TXT	6	1		
	Input Person	TXT	32	1		
	Event Status	TXT	4	1		
	Video Image address	TXT	60	1		
	Main Center Check Status	INT*	4	1		
	Road Management Office Check Status	INT*	4	1		
	Status of Traffic Event	INT*	2	1		
	Date/Time End	TXT	≥14	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

15.4 Data for Toll Collection/Management (For Reference)

Table 15.2 Data Sets for Toll Collection/Management

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Hourly Toll Collection Data Set <G/C - Server>	Road Owner ID	INT*	4	1	Hourly	1 year
	Toll Office ID	INT*	4	1		
	Date/Hour of Record	TXT	10	1		
	Sum of Toll Amount	FLOAT	12	1		
	Number of Vehicle Passage	INT	8	1		
	Sum of Toll of Vehicle Class 1	FLOAT	12	1		
	Number of Vehicle of Class 1	INT	8	1		
	Sum of Toll of Vehicle Class 2	FLOAT	12	1		
	Number of Vehicle of Class 2	INT	8	1		
	Sum of Toll of Vehicle Class 3	FLOAT	12	1		
	Number of Vehicle of Class 3	INT	8	1		
	Sum of Toll of Vehicle Class 4	FLOAT	12	1		
	Number of Vehicle of Class 4	INT	8	1		
	Sum of Toll of Vehicle Class 5	FLOAT	12	1		
	Number of Vehicle of Class 5	INT	8	1		
	Sum of Toll of Vehicle Class 6	FLOAT	12	1		
	Number of Vehicle of Class 6	INT	8	1		
	Sum of Toll of Vehicle Class 7	FLOAT	12	1		
	Number of Vehicle of Class 7	INT	8	1		
	Sum of Toll of Vehicle Class 8	FLOAT	12	1		
	Number of Vehicle of Class 8	INT	8	1		
	Sum of Toll of Vehicle Class 9	FLOAT	12	1		
	Number of Vehicle of Class 9	INT	8	1		
	Sum of Toll of Vehicle Class 10	FLOAT	12	1		
	Number of Vehicle of Class 10	INT	8	1		
	Sum of Toll of Vehicle Class 11	FLOAT	12	1		
	Number of Vehicle of Class 11	INT	8	1		
	Sum of Toll of Vehicle Class 12	FLOAT	12	1		
	Number of Vehicle of Class 12	INT	8	1		
	Sum of Toll of Vehicle Class 13	FLOAT	12	1		
	Number of Vehicle of Class 13	INT	8	1		
	Sum of Toll of Vehicle Class 14	FLOAT	12	1		
	Number of Vehicle of Class 14	INT	8	1		
	Sum of Toll of Vehicle Class 15	FLOAT	12	1		
	Number of Vehicle of Class 15	INT	8	1		
	Sum of Toll of Vehicle Class 16	FLOAT	12	1		
	Number of Vehicle of Class 16	INT	8	1		
	Sum of Toll of Vehicle Class 17	FLOAT	12	1		
	Number of Vehicle of Class 17	INT	8	1		
	Sum of Toll of Vehicle Class 18	FLOAT	12	1		
	Number of Vehicle of Class 18	INT	8	1		
	Sum of Toll of Vehicle Class 19	FLOAT	12	1		
	Number of Vehicle of Class 19	INT	8	1		
	Sum of Toll of Vehicle Class 20	FLOAT	12	1		
	Number of Vehicle of Class 20	INT	8	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

15.5 Data for Vehicle Weighing (For Reference)

Table 15.3 Data Sets for Vehicle Weighing

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Axle Load Management Data Set <G/C-Server>	Road Owner ID	INT*	4	1	Hourly	1 year
	Road Section ID	INT*	4	1		
	Axle Load Scale Location ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Date/Hour of Record	TXT	10	1		
	Number of Heavy Trucks	INT	5	1		
	Number of Suspicious Trucks	INT	5	1		
	Number of Overloaded Trucks	INT	5	1		
	Axle Load Measurement Data Set	Set	var	N		
	Axle Load Status	INT*	2			
	Serial Number of Vehicle	INT	5			
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

15.6 Data to be Compiled/Generated for Integration

The following data sets are to be integrated being corresponded by data set ID to date/time and kilo-meter post of a road section:

- Data Set ID=1: Incident data set
- Data Set ID=2: Traffic volume data set
- Data Set ID=3: Traffic congestion data set
- Data Set ID=4: Bad weather data set
- Data Set ID=5: Construction work data set
- Data Set ID=6: Traffic restriction data set
- Data Set ID=7: Traffic event data set
- Data Set ID=8: Hourly toll collection data set
- Data Set ID=9: Axle load management data set

Table 15.4 Data Sets for Integration

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Integrated Data Sed <G - Server>	Date/Time	TXT	≥14	1	Every 1 hour	1 year
	Road Section ID	INT*	4	1		
	Kilometer Post	TXT	6	1		
	Lane ID	INT*	2	1		
	Data Set ID	INT*	2	1		
	Data Set	Set	var	1		

PART 4: AUTOMATED TOLL COLLECTION/MANAGEMENT SYSTEM (FOR REFERENCE)

TABLE OF CONTENTS

1. Introduction

Service descriptions:

This service enables toll collection without stopping vehicles: ETC (Electronic Toll Collection). This service relieves bottlenecks at the tollgates and allows smooth incoming and outgoing at the interchanges. This service reduces the number of tollbooths and solves the problem of land acquisition for the tollgates in suburban areas where traffic congestion will become an issue in near future. This service realizes simple vehicle inspection at the border crossings, and provides road or vehicle operators with the time of vehicle passage at the tollgates. Computerized toll management can vastly reduce uncollected toll revenue due to the failure in counting/classifying vehicles and can realize appropriate sharing of the toll revenue among different road operators.

Functional packages to be included in the system:

(13) Tollgate Lane monitoring
(14) Vehicle/class identification
(15) Lane control
(16) Road-to-vehicle communication
(17) IC-card recording
(18) Toll data management
(19) OBU management.

2. Use Case and General System Architecture

Use cases and general system architecture are illustrated for the following implementation packages of toll collection/management:

(1) Toll collection
(2) Center-to-center Data Exchange.

Relationships between the system and users/operators/other-systems are illustrated by the following use case diagrams in the design drawings:

Road traffic supervision
- Toll collection
- Lane control for ETC
- Handling of balance shortage vehicle
- Toll data management
- Toll settlement
- OBU management
- Toll enforcement assistance.

The general system architecture is sown using collaboration diagrams and message sequence diagrams titled as below in the design drawings:

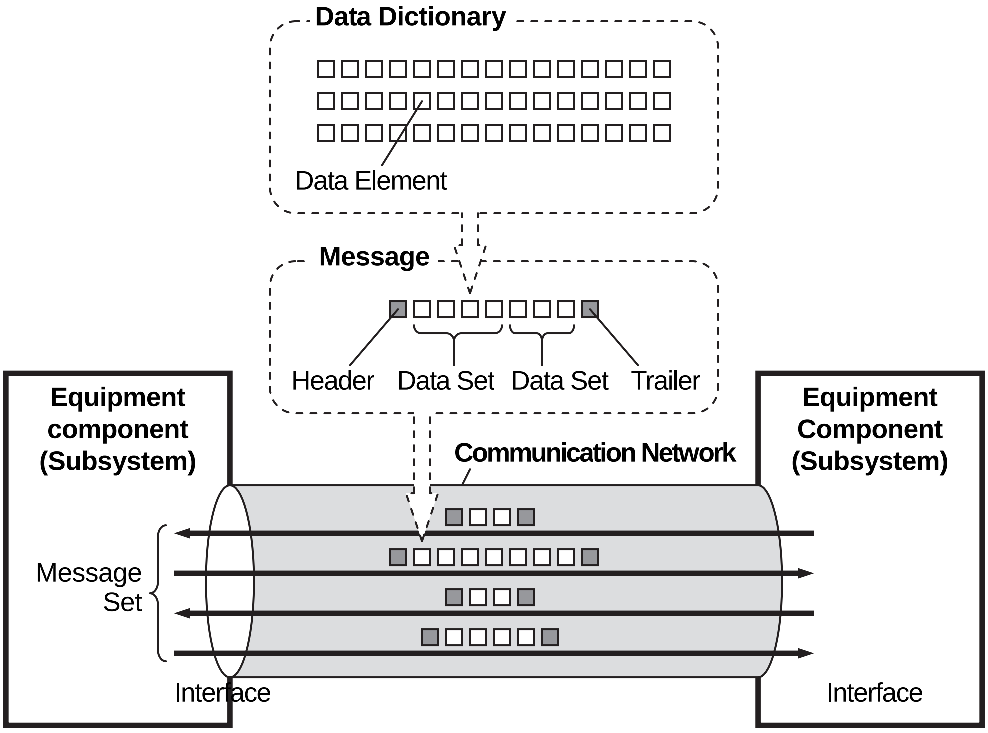
(1) Toll collection by touch&go/manual
(2) Toll collection by ETC at toll-island (2-piece type OBU)
(3) Center-to-center data exchange for toll settlement
(4) Center-to-center data exchange for IC-card operation
(5) Center-to-center data exchange for OBU management.

3. Message/Data Design

3.1 General

ITS consists of many pieces of equipment, which are illustrated as the equipment components in the diagrams of system architecture. The equipment components need to be connected with each other by communication network in order to exchange messages and data between them, to actualise the system and to provide intended services.

Figure 3.1 Conceptual Illustration of Message/Data Exchange



Source: The Study Team

3.2 Major Message List

The major message list for automated toll collection/management system is shown in the following table.

Table 3.1 Major Message List of Automated Toll Collection/Management System

Name of Message	A Pair of Equipment Components on Both Side of Interface through Which Message is Exchanged		Name of Include Data Sets
Toll Price Input Message	Data Input Device	Toll Management Server	Toll Price Information Data Set
Toll Price Message	Toll Management Server	Lane Server	Toll Price Data Set
Toll Price Message	Lane Server	Roadside Controller	Toll Price Data Set
ETC Message	OBU	Roadside Controller	OBU Registration Data Set OBU Passage Data Set IC-Card Contract Data Set IC-Car Passage Data Set Transaction Data Set
Touch & Go Message	IC-Card R/W	Lane Server	IC-Card Contract Data Set IC-Car Passage History Data Set Transaction Data Set
IC-Card recharge Message	IC-Card	IC-Card Recharger	IC-Card Recharge Data Set
Transaction Collection Message	Lane Server	Toll Management Server	Transaction Collection Data Set
Toll Collection Message	Toll Management Server	Toll Management Center Server	Toll Collection Data Set
Invalidation ID Message	Bank Server	Toll Office Server	Invalidation List Data Set
Invalidation ID Message	Toll Office Server	Lane Server	Invalidation List Data Set
Traffic Volume Massage	Toll Office Server	Integrated Data Server	Traffic Volume Data Set
License plate message	License Plate Scanner	Lane Server	License Plate Recognition Data Set
Toll Fare Message	Toll Management Server	Bank Server	Toll Fare Data Set
Traffic Volume Massage	Regional Main Center	Crosscheck Organization	Traffic Volume Data Set
Toll Fare Message	Toll Management Server	Crosscheck Organization	Toll Fare Data Set
Toll Validity Message	Crosscheck Organization	Bank Server	Validity Result Data Set
Toll Settlement Message	Head Office Server	Bank Server	Toll Settlement Data

Source: The Study Team

3.3 Primary Data Dictionary

Primary data dictionary for automated toll collection/management system is shown in the table below.

Figure 3.2 Primary Data Dictionary for Automated Toll Collection/Management System

	Major Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin	Definition
16	Toll Rate Information Data Set <R - Server>	Number of tollgate pair	INT	8	1	Daily	1 year	The number of tollgate pair (N)
		Tollgate Pair ID	INT	8	N			An unique identifier of a pair of tollgate
		Entrance Tollgate ID	INT*	4				An unique identifier of the entrance tollgate
		Exit Tollgate ID	INT*	4				An unique identifier of the exit tollgate
		Toll Rate of Vehicle Class 1	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses
		Toll Rate of Vehicle Class 2	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons
		Toll Rate of Vehicle Class 3	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons
		Toll Rate of Vehicle Class 4	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries
		Toll Rate of Vehicle Class 5	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries
		Toll Rate of Vehicle Class 6	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 6: Military vehicles in the missions
		Toll Rate of Vehicle Class 7	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 7: Public security vehicles in the missions
		Toll Rate of Vehicle Class 8	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 8: Reserved
		Toll Rate of Vehicle Class 9	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 9: Reserved
		Toll Rate of Vehicle Class 10	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 10: Reserved
		Toll Rate of Vehicle Class 11	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 11: Reserved
		Toll Rate of Vehicle Class 12	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 12: Reserved
		Toll Rate of Vehicle Class 13	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 13: Reserved
		Toll Rate of Vehicle Class 14	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 14: Reserved
		Toll Rate of Vehicle Class 15	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 15: Reserved
		Toll Rate of Vehicle Class 16	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 16: Reserved
		Toll Rate of Vehicle Class 17	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 17: Reserved
		Toll Rate of Vehicle Class 18	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 18: Reserved
		Toll Rate of Vehicle Class 19	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 19: Reserved
		Toll Rate of Vehicle Class 20	FLOAT	12				Toll rate from Ent to Exit for Vehicle Class 20: Reserved
		Number of document	TXT	20				Official number of permission document
		Date of Toll Rate Table	TXT	8				Day/month/year of the toll rate information for the pair of tollgate
17	Bar-code Data Set <G - Lane Server>	Toll Office ID	INT*	4	1	Each passage at tollgate	1 month	An unique identifier of a toll office
		Tollgate ID	INT*	4	1			An unique identifier of a tollgate
		Lane ID	INT*	2	1			An unique identifier of the lane where a construction work applied (Numbered from the median)
		Deposit Terminal ID	INT*	4	1			An unique identifier of the deposit terminal
		Ticket Type	INT*	4	1			Type of ticket
		Vehicle Class	INT*	2	1			Vehicle class: - 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses - 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons - 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons - 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries - 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries - 6: Military vehicles in the missions - 7: Public security vehicles in the missions
		Serial Number	INT	12	1			Serial number of the ticket
		Date Issue	Date	8	1			Day/month/year of issuing ticket
		Date of Expiry	Date	8	1			Day/month/year of ticket expiration
18	IC-card Issue Data Set <R - IC-card>	Status	INT*	1	1	IC-card issue	Permanent	Card status: 0: initial, 1: normal, 2: on-road, 3: voided
		Issuer ID	INT*	4	1			An unique identifier of an issuer organization
		Issue Terminal ID	INT	12	1			An unique identifier of an issue terminal equipment
		IC-card ID	INT	12	1			An unique identifier of an IC-card
		IC-card Owner ID	INT	18	1			An unique identifier of IC-card owner
		Amount of Deposit	FLOAT	8	1			The amount of electric money deposited to the account (unit: thousand VND)
		Date/Time of Issue	TXT	≥14	1			Day/month/year/hour/minutes/second of issuing IC-card
		Date/Time of Expiry	TXT	≥14	1			Day/month/year/hour/minutes/second of expiring IC-card
19	IC-card Recharge Data Set <R - IC-card>	Status	INT*	1	N	Each recharge	Permanent	Card status: 0: initial, 1: normal, 2: on-road, 3: voided
		Issuer ID	INT*	4				An unique identifier of an issuer organization
		Deposit Terminal ID	INT	12				An unique identifier of a terminal device
		IC-card ID	INT	12				An unique identifier of an IC-card
		IC-card Owner ID	INT	18				An unique identifier of IC-card owner
		Amount of Deposit	FLOAT	8				The amount of electric money deposited to the prepared account (unit: thousand VND)
		Prepaid Balance	FLOAT	8				The remaining amount of electric money in an IC-card (unit: thousand VND)
		Date/Time	Datetime	≥14				Year/ month/day/hour/minutes/second of generating data set

20	IC-card Passage Data Set <R - IC-card>	Status	INT*	1	N	Each passage at tollgate	Latest	Card status: 0: initial, 1: normal, 2: on-road, 3: voided
		Toll Office ID	INT*	4				An unique identifier of a toll office
		Tollgate ID	INT	8				An unique identifier of a toll gate
		Lane ID	INT	12				An unique identifier of a lane (Numbered from the median)
		Toll Amount	FLOAT	8				A toll charge collected by the system when a vehicle passing through a tollgate using ETC, Touch&Go toll collection or Manual toll collection. (unit: thousand VND)
		Prepaid Balance	FLOAT	8				The remaining amount of electric money in an IC-card (unit: thousand VND)
		Date/Time	Datetime	≥14				Year/ month/day/hour/minutes/second of generating data set
21	IC-card Invalidation List Data Set <G - Server>	Issuer ID	INT*	4	1	Daily + Upon Demand	1 year	An unique identifier of an issuer organization
		Issue Terminal ID	INT	12	N			An unique identifier of an issue terminal equipment
		IC-card ID for Invalidation	INT	12				An unique identifier of an IC-card of invalidation
		IC-card Owner ID	INT	18				An unique identifier of IC-card owner
		Prepaid Balance	FLOAT	8				The remaining amount of electric money in an IC Card (unit: thousand VND)
		Date/Time of Issue	TXT	≥14				Day/month/year/hour/minutes/second of issuing IC-card
		Date/Time of Expiry	TXT	≥14				Day/month/year/hour/minutes/second of expiring IC-card
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
22	OBU Registration Data Set <R - OBU>	Management Organization ID	INT	12	1	OBU registration	Permanent	An unique identifier of OBU management organization
		OBU ID	INT	12	1			An unique identifier of an OBU
		OBU Owner ID	INT	18	1			An unique identifier of OBU owner
		License Plate Number	TXT	12	1			License plate number recorded in OBU
		Vehicle Class	TXT	2	1			Vehicle class recorded in OBU: - 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses - 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons - 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons - 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries - 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries - 6: Military vehicles in the missions - 7: Public security vehicles in the missions
		Date of Issue	TXT	8	1			Day/month/year of issuing OBU
		Date of Expiry	TXT	8	1			Day/month/year of OBU expiration
23	OBU Passage Data Set <R - OBU>	Toll Office ID	INT*	4	3	Each passage at tollgate	Latest	An unique identifier of a toll office
		Tollgate ID	INT*	4				An unique identifier of a tollgate
		Lane ID	INT*	4				An unique identifier of a lane (Numbered from the median)
		IC-card ID	INT	12				An unique identifier of an IC-card
		Toll Amount	FLOAT	4				A toll charge collected by the system when a vehicle passing through a tollgate using ETC, Touch&Go toll collection or Manual toll collection. (unit: thousand VND)
		Prepaid Balance	INT	8				Prepaid balance copied from an IC-card
		Date/Time	Datetime	≥14				Year/ month/day/hour/minutes/second of generating data set
24	OBU Invalidation List Data Set <G - Server>	Management Organization ID	INT	12	1	Daily + Upon Demand	1 year	An unique identifier of OBU management organization
		OBU ID for Invalidation	INT	12	N			An unique identifier of an OBU of invalidation
		OBU Owner ID	INT	18				An unique identifier of OBU owner
		License Plate Number	TXT	12				License plate number recorded in OBU
		Vehicle Class	TXT	2				Vehicle class recorded in OBU - 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses - 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons - 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons - 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries - 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries - 6: Military vehicles in the missions - 7: Public security vehicles in the missions
		Date of Issue	TXT	8				Day/month/year of issuing OBU
		Date of Expiry	TXT	8				Day/month/year of OBU expiration
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
25	Toll Collection License Plate Data Set <G - Image Processor>	Toll Office ID	INT*	4	1	Each passage at tollgate	6 months	An unique identifier of a toll office
		Tollgate ID	INT*	4	1			An unique identifier of a tollgate
		Lane ID	INT*	4	1			An unique identifier of a lane (Numbered from the median)
		Roadside Equipment ID	INT*	4	1			An unique identifier of a license recognition device
		Captured License Plate Number	TXT	12	1			License plate number recognized by image processor
		Captured License Plate Image	IMG	var	1			The license plate image captured by CCTV camera
		Serial Number of Vehicle	INT*	5	1			Daily serial number for a vehicle passing through tollgate. (For reference to other data set)
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
26	Transaction Data Set <R - Lane Server>	Toll Office ID	INT*	4	1	Each passage at tollgate	6 months	An unique identifier of a toll office
		Tollgate ID	INT	8	1			An unique identifier of a toll gate
		Lane ID	INT*	4	1			An unique identifier of a lane (Numbered from the median)
		OBU ID	INT	12	1			An unique identifier of OBU

		Vehicle Class in OBU	INT*	2	1			Vehicle class recorded in OBU - 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses - 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons - 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons - 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries - 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries - 6: Military vehicles in the missions - 7: Public security vehicles in the missions
		License number in OBU	TXT	12	1			License number recorded in OBU
		IC-card ID	INT	12	1			An unique identifier of an IC-card
		Toll Amount	INT	8	1			A toll charge collected by the system when a vehicle passing through a tollgate using ETC, Touch&Go toll collection or Manual toll collection. (unit: thousand VND)
		Prepaid Balance	FLOAT	8	1			The remaining amount of electric money in an IC-card (unit: thousand VND)
		Termination Status	INT*	2	1			Data for indicating a toll collection procedure has finished successfully or not
		Serial Number of Vehicle	INT	5	1			Daily serial number for a vehicle passing through tollgate. (For reference to other data set)
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
27	Toll Collection Data Set <G - Lane Server>	Road Owner ID	INT*	4	1	Every 10 minutes	6 months	An unique identifier of a road owner
		Toll Office ID	INT*	4	1			An unique identifier of a toll office
		Date of Toll Amount	TXT	8	1			Day/month/year of the toll amount
		Sum of Toll Amount	INT*	12	1			A sum of colleted toll amount of vehicles passing through the tollgate
		Number of Vehicle Passage	INT	8	1			Number of vehicles passing through the tollgate
		Transaction Data Set	Set	var	N			Transaction data set of a vehicle passing through the tollgate
		Enforcement Status	TXT	2				Status for indicating the enforcement status: - 0: Successful. - 1: Vehicle passage that has different scanned license plate number compared to OBU. Suspicion of spoofing. - 2: Vehicle passage with continuously negative balance in IC-card. Suspicion of cheating. - 3: Vehicle passage without OBU and/or IC-card.
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
28	Hourly Toll Collection Data Set <G/C - Server>	Road Owner ID	INT*	4	1	Hourly	1 year	An unique identifier of a road owner
		Toll Office ID	INT*	4	1			An unique identifier of a toll office
		Date/Hour of Record	TXT	10	1			Day/month/year/hour of the record
		Sum of Toll Amount	FLOAT	12	1			Total toll amount of vehicles passing through the tollgate (unit: thousand VND)
		Number of Vehicle Passage	INT	8	1			Number of vehicles passing through the tollgate
		Sum of Toll of Vehicle Class 1	FLOAT	12	1			Total toll amount of class 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses (unit: thousand VND)
		Number of Vehicle of Class 1	INT	8	1			Number of vehicles of class 1
		Sum of Toll of Vehicle Class 2	FLOAT	12	1			Total toll amount of class 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons (unit: thousand VND)
		Number of Vehicle of Class 2	INT	8	1			Number of vehicles of class 2
		Sum of Toll of Vehicle Class 3	FLOAT	12	1			Total toll amount of class 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons (unit: thousand VND)
		Number of Vehicle of Class 3	INT	8	1			Number of vehicles of class 3
		Sum of Toll of Vehicle Class 4	FLOAT	12	1			Total toll amount of class 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries (unit: thousand VND)
		Number of Vehicle of Class 4	INT	8	1			Number of vehicles of class 4
		Sum of Toll of Vehicle Class 5	FLOAT	12	1			Total toll amount of class 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries (unit: thousand VND)
		Number of Vehicle of Class 5	INT	8	1			Number of vehicles of class 5
		Sum of Toll of Vehicle Class 6	FLOAT	12	1			Total toll amount of class 6: Military vehicles in the missions (unit: thousand VND)
		Number of Vehicle of Class 6	INT	8	1			Number of vehicles of class 6
		Sum of Toll of Vehicle Class 7	FLOAT	12	1			Total toll amount of class 7: Public security vehicles in the missions (unit: thousand VND)
		Number of Vehicle of Class 7	INT	8	1			Number of vehicles of class 7
		Sum of Toll of Vehicle Class 8	FLOAT	12	1			Total toll amount of class 8: Reserved(unit: thousand VND)
		Number of Vehicle of Class 8	INT	8	1			Number of vehicles of class 8
		Sum of Toll of Vehicle Class 9	FLOAT	12	1			Total toll amount of class 9: Reserved(unit: thousand VND)
		Number of Vehicle of Class 9	INT	8	1			Number of vehicles of class 9
		Sum of Toll of Vehicle Class 10	FLOAT	12	1			Total toll amount of class 10: Reserved(unit: thousand VND)
		Number of Vehicle of Class 10	INT	8	1			Number of vehicles of class 10
		Sum of Toll of Vehicle Class 11	FLOAT	12	1			Total toll amount of class 11: Reserved(unit: thousand VND)
		Number of Vehicle of Class 11	INT	8	1			Number of vehicles of class 11
		Sum of Toll of Vehicle Class 12	FLOAT	12	1			Total toll amount of class 12: Reserved(unit: thousand VND)
		Number of Vehicle of Class 12	INT	8	1			Number of vehicles of class 12
		Sum of Toll of Vehicle Class 13	FLOAT	12	1			Total toll amount of class 13: Reserved(unit: thousand VND)
		Number of Vehicle of Class 13	INT	8	1			Number of vehicles of class 13
		Sum of Toll of Vehicle Class 14	FLOAT	12	1			Total toll amount of class 14: Reserved(unit: thousand VND)
		Number of Vehicle of Class 14	INT	8	1			Number of vehicles of class 14
		Sum of Toll of Vehicle Class 15	FLOAT	12	1			Total toll amount of class 15: Reserved(unit: thousand VND)
		Number of Vehicle of Class 15	INT	8	1			Number of vehicles of class 15
		Sum of Toll of Vehicle Class 16	FLOAT	12	1			Total toll amount of class 16: Reserved(unit: thousand VND)
		Number of Vehicle of Class 16	INT	8	1			Number of vehicles of class 16
		Sum of Toll of Vehicle Class 17	FLOAT	12	1			Total toll amount of class 17: Reserved(unit: thousand VND)
		Number of Vehicle of Class 17	INT	8	1			Number of vehicles of class 17

		Sum of Toll of Vehicle Class 18	FLOAT	12	1			Total toll amount of class 18: Reserved(unit: thousand VND)
		Number of Vehicle of Class 18	INT	8	1			Number of vehicles of class 18
		Sum of Toll of Vehicle Class 19	FLOAT	12	1			Total toll amount of class 19: Reserved(unit: thousand VND)
		Number of Vehicle of Class 19	INT	8	1			Number of vehicles of class 19
		Sum of Toll of Vehicle Class 20	FLOAT	12	1			Total toll amount of class 20: Reserved(unit: thousand VND)
		Number of Vehicle of Class 20	INT	8	1			Number of vehicles of class 20
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
29	Toll Revenue Data Set <G/C - Server>	Road Owner ID	INT*	4	1	Monthly	1 year	An unique identifier of a road owner
		Fiscal Month	TXT	6	1			Number of fiscal month
		Toll Revenue of The Month/Week	FLOAT	16	1			Toll revenue of the fiscal period (unit: thousand VND)
		Number of Vehicle Passage	INT	8	1			Number of vehicles passing through the tollgate
		Sum of Toll of Vehicle Class 1	FLOAT	12	1			Total toll amount of class 1: Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses (unit: thousand VND)
		Number of Vehicle of Class 1	INT	8	1			Number of vehicles of class 1
		Sum of Toll of Vehicle Class 2	FLOAT	12	1			Total toll amount of class 2: Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons (unit: thousand VND)
		Number of Vehicle of Class 2	INT	8	1			Number of vehicles of class 2
		Sum of Toll of Vehicle Class 3	FLOAT	12	1			Total toll amount of class 3: Cars with seats of 31 or more, trucks with a capacity between 4 and 10 tons (unit: thousand VND)
		Number of Vehicle of Class 3	INT	8	1			Number of vehicles of class 3
		Sum of Toll of Vehicle Class 4	FLOAT	12	1			Total toll amount of class 4: Trucks with a capacity between 10 and 18 tons, 20ft-container lorries (unit: thousand VND)
		Number of Vehicle of Class 4	INT	8	1			Number of vehicles of class 4
		Sum of Toll of Vehicle Class 5	FLOAT	12	1			Total toll amount of class 5: Trucks with a capacity of 18 tons or more, 40ft-container lorries (unit: thousand VND)
		Number of Vehicle of Class 5	INT	8	1			Number of vehicles of class 5
		Sum of Toll of Vehicle Class 6	FLOAT	12	1			Total toll amount of class 6: Military vehicles in the missions (unit: thousand VND)
		Number of Vehicle of Class 6	INT	8	1			Number of vehicles of class 6
		Sum of Toll of Vehicle Class 7	FLOAT	12	1			Total toll amount of class 7: Public security vehicles in the missions (unit: thousand VND)
		Number of Vehicle of Class 7	INT	8	1			Number of vehicles of class 7
		Sum of Toll of Vehicle Class 8	FLOAT	12	1			Total toll amount of class 8: Reserved(unit: thousand VND)
		Number of Vehicle of Class 8	INT	8	1			Number of vehicles of class 8
		Sum of Toll of Vehicle Class 9	FLOAT	12	1			Total toll amount of class 9: Reserved(unit: thousand VND)
		Number of Vehicle of Class 9	INT	8	1			Number of vehicles of class 9
		Sum of Toll of Vehicle Class 10	FLOAT	12	1			Total toll amount of class 10: Reserved(unit: thousand VND)
		Number of Vehicle of Class 10	INT	8	1			Number of vehicles of class 10
		Sum of Toll of Vehicle Class 11	FLOAT	12	1			Total toll amount of class 11: Reserved(unit: thousand VND)
		Number of Vehicle of Class 11	INT	8	1			Number of vehicles of class 11
		Sum of Toll of Vehicle Class 12	FLOAT	12	1			Total toll amount of class 12: Reserved(unit: thousand VND)
		Number of Vehicle of Class 12	INT	8	1			Number of vehicles of class 12
		Sum of Toll of Vehicle Class 13	FLOAT	12	1			Total toll amount of class 13: Reserved(unit: thousand VND)
		Number of Vehicle of Class 13	INT	8	1			Number of vehicles of class 13
		Sum of Toll of Vehicle Class 14	FLOAT	12	1			Total toll amount of class 14: Reserved(unit: thousand VND)
		Number of Vehicle of Class 14	INT	8	1			Number of vehicles of class 14
		Sum of Toll of Vehicle Class 15	FLOAT	x	1			Total toll amount of class 15: Reserved(unit: thousand VND)
		Number of Vehicle of Class 15	INT	8	1			Number of vehicles of class 15
		Sum of Toll of Vehicle Class 16	FLOAT	12	1			Total toll amount of class 16: Reserved(unit: thousand VND)
		Number of Vehicle of Class 16	INT	8	1			Number of vehicles of class 16
		Sum of Toll of Vehicle Class 17	FLOAT	12	1			Total toll amount of class 17: Reserved(unit: thousand VND)
		Number of Vehicle of Class 17	INT	8	1			Number of vehicles of class 17
		Sum of Toll of Vehicle Class 18	FLOAT	12	1			Total toll amount of class 18: Reserved(unit: thousand VND)
		Number of Vehicle of Class 18	INT	8	1			Number of vehicles of class 18
		Sum of Toll of Vehicle Class 19	FLOAT	12	1			Total toll amount of class 19: Reserved(unit: thousand VND)
		Number of Vehicle of Class 19	INT	8	1			Number of vehicles of class 19
		Sum of Toll of Vehicle Class 20	FLOAT	12	1			Total toll amount of class 20: Reserved(unit: thousand VND)
		Number of Vehicle of Class 20	INT	8	1			Number of vehicles of class 20
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
30	IC-card History Data Set <R - IC-card>	Status	INT*	1	N	Each event such as passage at tollgate	1 year	Card status: 0: initial, 1: normal, 2: on-road, 3: voided
		Issuer ID	INT*	4				An uniqgate-inue identifier of an issuer organization
		IC-card ID	INT	12				An unique identifier of an issue terminal equipment
		IC-card Owner ID	INT	18				An unique identifier of IC-card owner
		Toll Office ID	INT*	4				An unique identifier of a toll office
		Tollgate ID	INT	8				An unique identifier of a toll gate
		Lane ID	INT	12				An unique identifier of a lane (Numbered from the median)
		Deposit Terminal ID	INT	12				An unique identifier of a terminal device
		Event	INT*	2				0: gate-in, 1: gate-out, 2: recharging
		Date/Time	Datetime	≥14				Year/ month/day/hour/minutes/second of generating data set

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

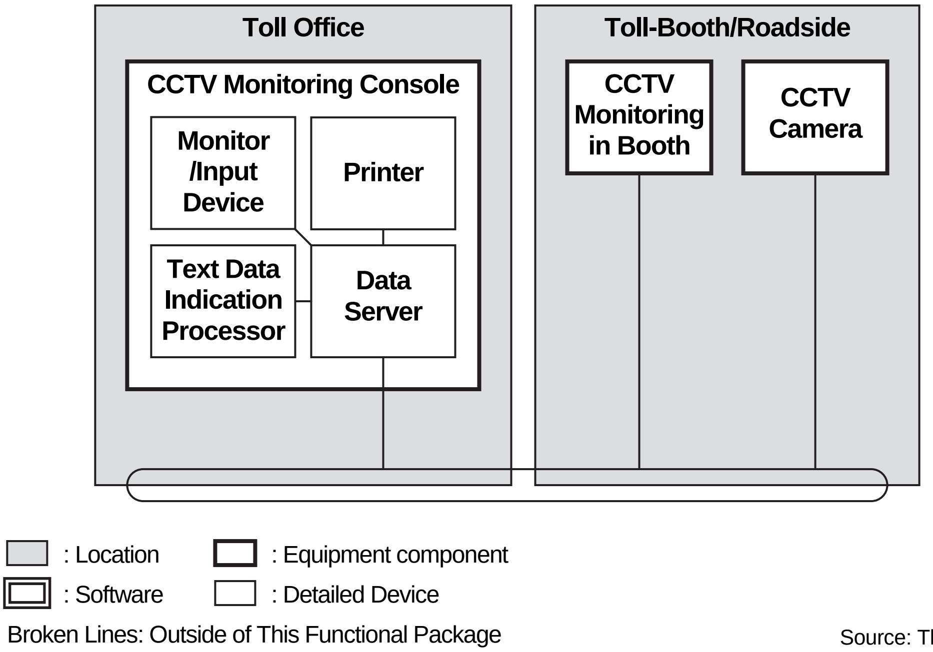
Source: The Study Team

4. Tollgate Lane Monitoring

4.1 Outline and System Architecture

This functional package allows the road operators to monitor current conditions of vehicle passage and operations by workers by using cameras installed in a separated lane such as a tollgate lane of the expressway.

Figure 4.1 System Architecture for Toll Lane Monitoring



Source: The Study Team

4.2 Conditions to be Monitored

CCTV camera is to give assistance for operator to monitor the following conditions:

- Vehicle coming into the tollgate lane
- Class and appearance of the vehicle
- Activities of the driver and the toll collector
- Occurrence of trouble and response to it in the tollgate lane
- Vehicle going out from the tollgate lane

4.3 Required Functions/Performance of CCTV Camera

(1) Types of Camera

There is 1 types of CCTV camera: PTZ Type and Fixed Type. PTZ Type has the functions Panning, Tilting and Zooming. Fixed Camera does not have these functions.

In addition, sometime Fixed Type has zooming function but they do not have the capability of Tilting and Panning. Therefore, a focal point is one point only, which is not good for surveillance.

The following table shows an example of the Specification for Fixed Camera and PTZ Type.

Figure 4.2 Type of CCTV camera

Fixed camera

PTZ camera

Source: The Study Team

PTZ Camera: The camera shall have mechanical capability of panning, tilting and zooming for focusing the objective of interest for traffic surveillance.

Fixed camera: The camera does “Not” have mechanical capability of panning and tilting for focusing the objective of interest for traffic surveillance.

(2) Mechanical Functions

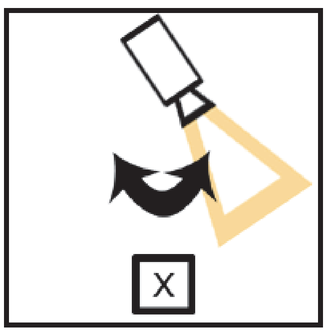
Panning:

Panning refers to the rotation in a horizontal plane of a video camera. Panning a camera results in a motion similar to that of someone shaking their head "no”.

Tilting:

Tilting refers to the stationary and rotation in a vertical plane (or tilting plane). A rotation in a horizontal plane is known as panning. Tilting the camera results in a motion similar to someone nodding their head "yes".

Figure 4.3 Panning and Tilting



Panning function

Tilting function

Source: The Study Team

Zooming:

Zoom adjusts the Angle of View. It is a magnification of image as a result. The function of zooming, there are two type of zoom such as Digital Zoom and Optical Zoom. For our purpose, digital zoom is not really zoom, in the strictest definition of the term. What digital zoom does is enlarge a portion of the image, thus ‘simulating’ optical zoom. In other words, the camera crops a portion of the image and then enlarges it back to size.

Against that, optical zoom is really zoom, It is capable a magnification of image by extend the focal length of between lens and image sensor. Optical zoom doesn’t make a deterioration of images compare with Digital zoom.

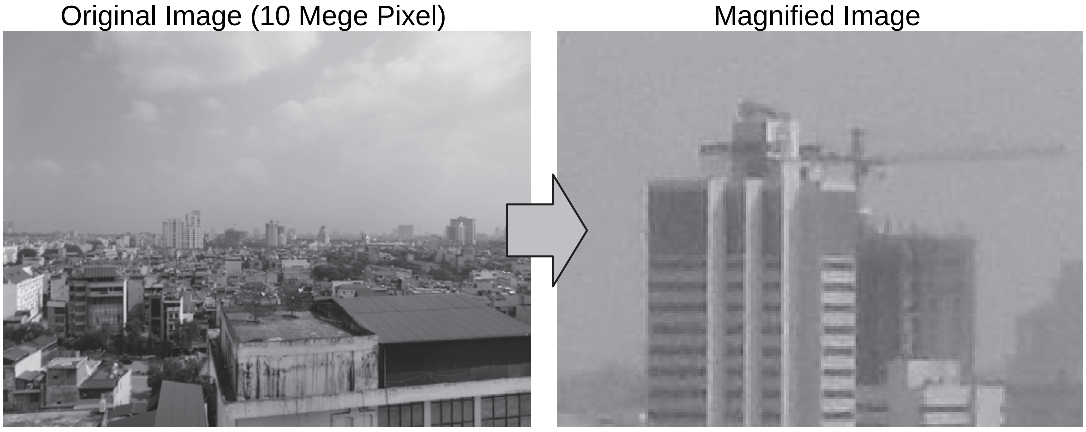
For example, see Figure 4.6. Upper stand, show the magnification of image (10 mega pixel) by using digital zoom function. Lower stand, show the magnification of image (1 mega pixel) by using optical zoom function.

Resolution of the original image is 10 mega pixels on Digital zoom whereas, resolution of the original image is 1 mega pixel on Optical zoom. Optical zoom image is 1/10 times the resolution however, the quality of the image after the magnification is more clear than Digital zoom.

Figure 4.4 Comparison for Digital Zoom and Optical Zoom

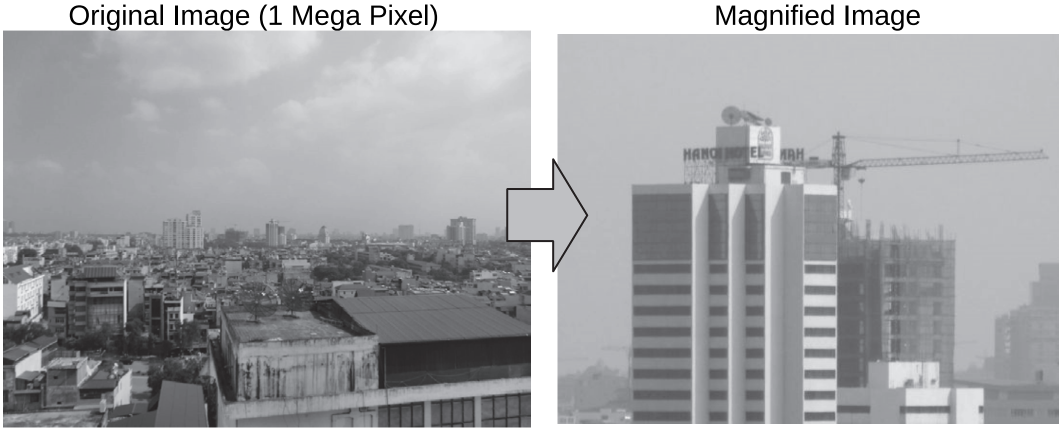
Digital zoom

Original Image (10 Mege Pixel) Magnified Image



Optical zoom

Original Image (1 Mega Pixel) Magnified Image



Source: The Study Team

(3) Optical Functions/Performance

Width of image sensor:

There are two type of image sensor, such as CCD image sensor and CMOS sensor. Both types of sensor accomplish the same task of capturing light and converting it into electrical signals. In previous time, CCD image sensor was better than CMOS sensor. However, CMOS sensor is advance by means of technological innovation in today. CMOS sensor can potentially be implemented with use less power, faster reboot and cheaper than CCD. Therefore, most of CCTV camera are using CMOS sensor.

The meaning of the image Sensor are large, the camera has a larger area per 1pixel in case of the number of pixel is the same. Then, a larger amount of light to be received on 1pixel, collect the light efficiency is increased. Then, there are a lot of light coming into the image sensor, can be stayed on top of the subsequent of image processing, there will be less noise as a result. In other words, it is possible to record images of a more natural state.

Focal length of lens:

It is effect to surveillance range. The focal length of a lens determines the magnification at which it images distant objects. It is equal to the distance between the image plane and a pinhole that images distant objects the same size as the lens in question.

Resolution:

Resolution is the term used to describe the number of pixels, used to display an image. Higher resolutions mean that more pixels are used to create the image, resulting in a crisper, cleaner image. The number of pixel is to provide a more accurate figure for the resolution of the CCTV camera. Recently, the resolution is more than 1 mega pixel in general.

Minimum Illumination:

Minimum illumination is a way to measure the sensitivity of a camera. In another word It is mean, how dark the camera can still see usable image. There is the Day/Night function that colour video image at daytime, switch to black and white video image at night, to provide the best image automatically by determine the brightness of the day or night.

(4) Data and Interface

Encoding:

Encoding is a compression method of video images by using codec. There are several type of codec such as MPEG-2, MPEG-4, H.264 and so on. The quality the codec can achieve is heavily based on the compression format the codec uses. A codec is not a format, and there can be multiple codec that implement the same compression specification. For example, MPEG-1 codec typically do not achieve quality/size ratio comparable to codec that implement the more modern H.264 specification. But quality/size ratio of output produced by different implementations of the same specification can vary.

Frame rate:

Frame rate is the frequency at which an imaging device produces unique consecutive images called frames. Frame rate is most often expressed in frames per second (fps). In case of there are many more frames per second image becomes video image smoothly, as the data size of the video image becomes larger.

Ingress Protection:

The ingress protection or IP Code consists of the letters IP followed by two digits or one digit and one letter and an optional letter. As defined in international standard IEC 60529, IP Code classifies and rates the degrees of protection provided against the intrusion of solid objects, dust, accidental contact, and water in mechanical casings and with electrical enclosures.

CCTV camera shall be protected against dust and water ingress, where it will be installed outdoors in typical road section in accordance with IP66 of the international standards IEC 60529 or equivalent.

First Digit:

The first digit indicates the level of protection that the enclosure provides against access to hazardous parts (e.g., electrical conductors, moving parts) and the ingress of solid foreign objects.

Table 4.1 Meaning of First Digit in IPXX

Level	Object Size Protected against	Effective against
0	-	No protection against contact and ingress of objects
1	>50 mm	Any large surface of the body, such as the back of a hand, but no protection against deliberate contact with a body part
2	>12.5 mm	Fingers or similar objects
3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, screws, etc.
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; complete protection against contact
6	Dust tight	No ingress of dust; complete protection against contact

Source: The Study Team

Second Digit:

Protection of the equipment inside the enclosure against harmful ingress of water.

Table 4.2 Meaning of Second Digit in IPXX

Level	Protected against	Details
0	Not protected	-
1	Dripping water	Test duration: 10 minutes Water equivalent to 1mm rainfall per minute
2	Dripping water when tilted up to 15°	Test duration: 10 minutes Water equivalent to 3mm rainfall per minute
3	Spraying water	Test duration: 5 minutes / Water volume: 0.7 litres per minute Pressure: 80–100 kN/m²
4	Splashing water	Test duration: 5 minutes / Water volume: 10 litres per minute Pressure: 80–100 kN/m²
5	Water jets	Test duration: at least 3 minutes Water volume: 12.5 litres per minute Pressure: 30 kN/m² at distance of 3m
6	Powerful water jets	Test duration: at least 3 minutes Water volume: 100 litres per minute Pressure: 100 kN/m² at distance of 3m
7	Immersion up to 1 m	Test duration: 30 minutes / Immersion at depth of 1m
8	Immersion beyond 1 m	Test duration: continuous immersion in water Depth specified by manufacturer

Source: The Study Team

Interface:

Each device is assumed to be connected to Ethernet. The device is required to equip Ethernet interface. In addition, in order to streamline the piping and wiring of communication cable and power cable therefore, in order, the device is equipped the PoE (Power over Ethernet) what is power supply through the Ethernet cable. However, in case of the PTZ camera should be equipped a High PoE. It is capable supply a large amount of Power.

(5) Ambient Conditions and Others

Operating temperature / humidity range:

An operating temperature / humidity is the temperature / humidity at which an electrical or mechanical device operates. The device will operate effectively within a specified temperature / humidity range which varies based on the device function and application context, and ranges from the minimum to the maximum operating temperature / humidity.

Consumed power:

That is the amount of power consumed when the device is operating. Keeping the guideline value of the power consumption of the device on the specification, consideration to be required and ensured that electrical equipment does not exceed the electric capacity provided from the road side.

4.4 Location/Installation of CCTV Camera

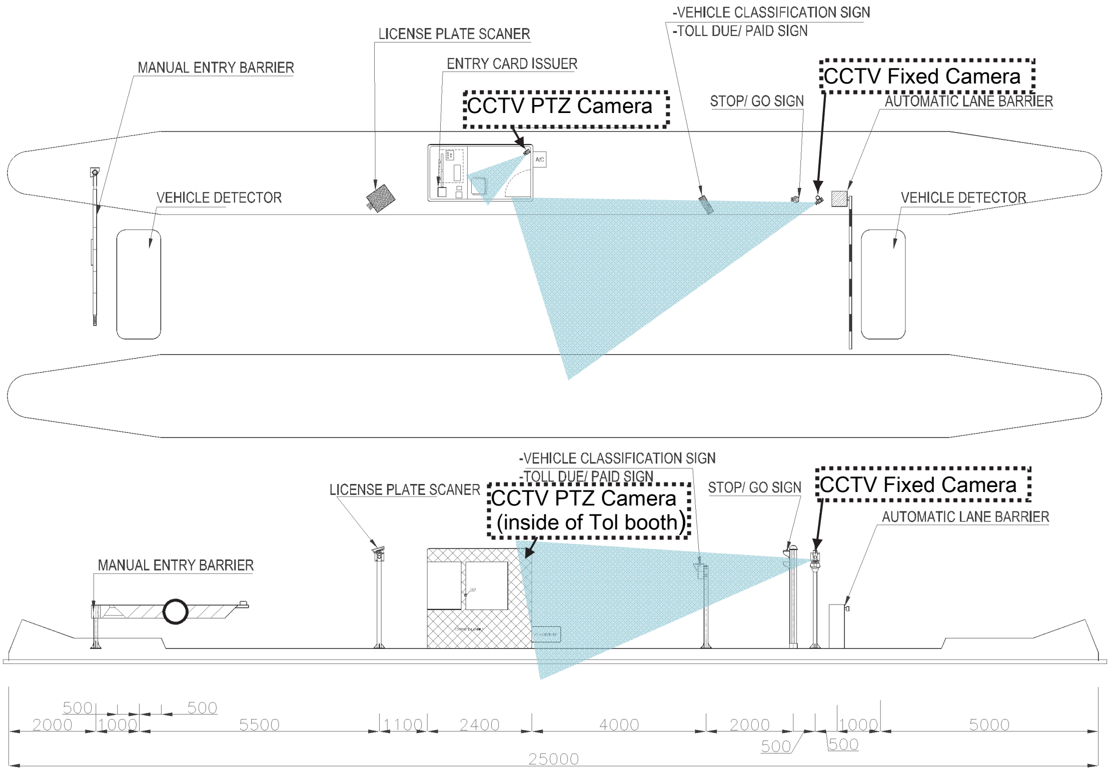
There are 2 types of camera for Tollgate Lane Monitoring. One camera should be installed on Toll Island for the Vehicle coming into and going out the tollgate, confirmation of class and appearance of the vehicle. Other one camera should be installed in Toll booth for the inspection of transfer of fee. And, the camera shall be has PTZ functions for watch toll collector’s hands especially. Type of camera, Intended Purpose and Location are showing as follows,

Additionally, need the communication between toll collector and toll office, to transmit various types of messages, information of card replacement, communication in case of trouble, and warning in case of detecting fraudulent behaviour of toll collector from toll office during operation and management of toll collection. Therefore, Headset communication device has better to be installed for the verbally communication.

Table 4.3 Type of Camera for Tollgate Lane Monitoring

Type	Intended purpose of Monitoring	Location
Fixed Camera	- Vehicle coming into the tollgate lane - Class and appearance of the vehicle - Occurrence of trouble and response to it in the tollgate lane - Vehicle going out from the tollgate lane	Toll Island
PTZ Camera (Indoor type)	- Activities of the driver and the toll collector	Toll Booth

Figure 4.5 Layout Plan of CCTV Camera for Tollgate Lane Monitoring



4.5 Data Set for Toll Lane Monitoring

Table 4.4 Principal Data Elements for Toll Lane Monitoring

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Image Recognition Result Data Set <G - Image Processor>	Road Management Office ID	INT*	4	1	When an event occurs	Latest
	Roadside Equipment ID	INT*	4	1		
	Image Recognition Result Status	INT*	2	1		
	Video Image Address	TXT	60	1		
	Date/Time	Datetime	≥14	1		
Event Image Data Set <G - Server>	Road Management Office ID	INT*	4	1	When an event is checked	1 year
	Roadside Equipment ID	INT*	4	1		
	Place ID	INT*	4	1		
	Video Image ID	INT	8	1		
	Event Video Image	IMG	var	1		
	Traffic Event Data ID	INT	8	1		
	Date/Time	Datetime	≥14	1		
Transaction Data Set <R - Lane Server>	Toll Office ID	INT*	4	1	Each passage at tollgate	6 months
	Tollgate ID	INT	8	1		
	Lane ID	INT*	4	1		
	OBU ID	INT	12	1		
	Vehicle Class in OBU	INT*	2	1		
	License number in OBU	TXT	12	1		
	IC-card ID	INT	12	1		
	Toll Amount	INT	8	1		
	Prepaid Balance	FLOAT	8	1		
	Termination Status	INT*	2	1		
	Serial Number of Vehicle	INT	5	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

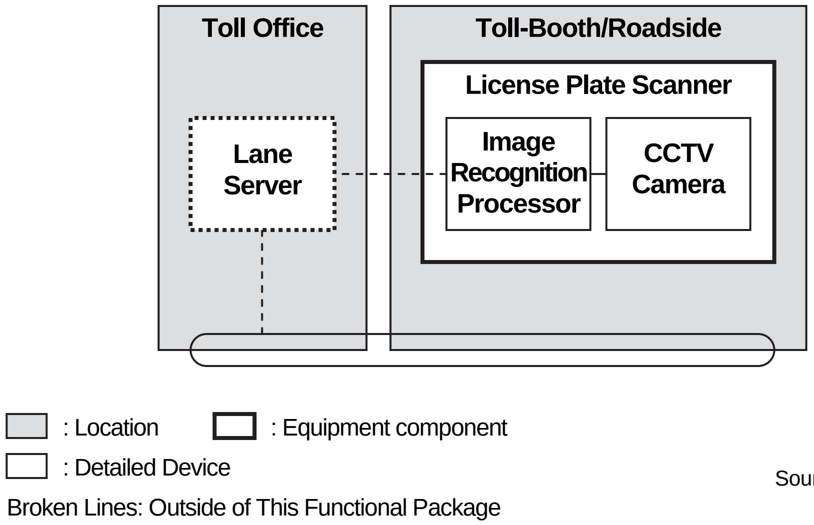
Source: The Study Team

5. Vehicle/Class Identification

5.1 Outline and System Architecture

This functional package allows the road operators to identify individual vehicle by using a license plate scanner and other equipment installed in a separated lane such as a tollgate lane of the expressway.

Figure 5.1 System Architecture for Vehicle/Class Identification



Source: The Study Team

5.2 Identifying Method of Vehicle/Class

Vehicle classification for roll rate of expressway is based on the Circular No.14/2012/TT-BTC of MOF shown in the table below. The vehicle classification is defined by the combination of the number of seats and the loading capacity, focusing on the benefits provided by road use. This classification is to be identified by scanning license plate based on the following license plate system.

Table 5.1 Vehicle Classification in VIETNAM

Vehicle Class		Definition
Ordinary Vehicle	1	Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses
	2	Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons
	3	Cars with seats of 30 or more, trucks with a capacity between 4 and 10 tons
	4	Trucks with a capacity between 10 and 18 tons, 20ft-container lorries
	5	Trucks with a capacity of 18 tons or more, 40ft-container lorries
MOD Vehicle	6	Military vehicles in the missions
Police Vehicle	7	Public security vehicles in the missions

Source: The Study Team

In Vietnam, there is standard for License Plate such as "Decree No. 136/ 2003MD-CP". According to the standards, type of License Plate in Vietnam as follows;

- Vehicles of state administrative agencies, state-power bodies, judicial bodies, procurator offices; police; Communist Party bodies, socio-politic organizations:
  Base colour: blue
  Character and Number: white
  Serial No.: A, B, C, D, E

30A - 2358

- Vehicles of enterprises of all economic sectors; Vehicles of State offices, none-business organization, none-business organization with revenue; Private Vehicle:
  Base colour: white
  Character and Number: black
  Serial No.: F, H, K, L, M, N, P, R, S, T, U, V, X, Y, Z,

30 K - 2358

- Except following special cases:
  Vehicles of economic military bodies: KT
  Vehicles of 100% foreign companies, foreign joint ventures, rental vehicles from foreign companies (having Investment Certificate): LD
  Vehicles of projects funded by foreign fund: DA
  Semi-trailer, trailer: R
  Temporary registered vehicle: T
  Tractor: MK
  Electric motorbike: MĐ

30 LB - 2358

- Vehicles of Specific Economic Zone following the Government Regulation: the symbol of province where that vehicle registered and 2 initial letters of that Zone;
  Base colour: yellow
  Character and Number: Red

- Vehicle of foreign organizations, offices and individuals:

- Diplomatic representative offices, consulate offices and foreign officers who are granted with diplomatic immunity, consulate immunity, working for such organizations and offices:
  Base colour: white
  Number: black
  Serial No.: NG in red colour
  Especially, the vehicles of Ambassador and General Consular: strike line on the middle of letter showing Nationality and Registration Order.

30 NG - 2358

- Representative offices of international organizations, foreign officers who are granted with diplomatic immunity, consulate immunity, working for such organizations:
  Base colour: white
  Number: black
  Serial No.: QT in red colour
  Especially, the vehicles of Chief Representative of international organizations belong to UNDP: strike line on the middle of letter showing that organization vehicle symbol and Registration Order.

30 QT - 2358

- Vehicle of foreign organizations, representative offices, individuals (including foreign students):
  Base colour: white
  Number: black
  Serial No.: NN

30 NN - 2358

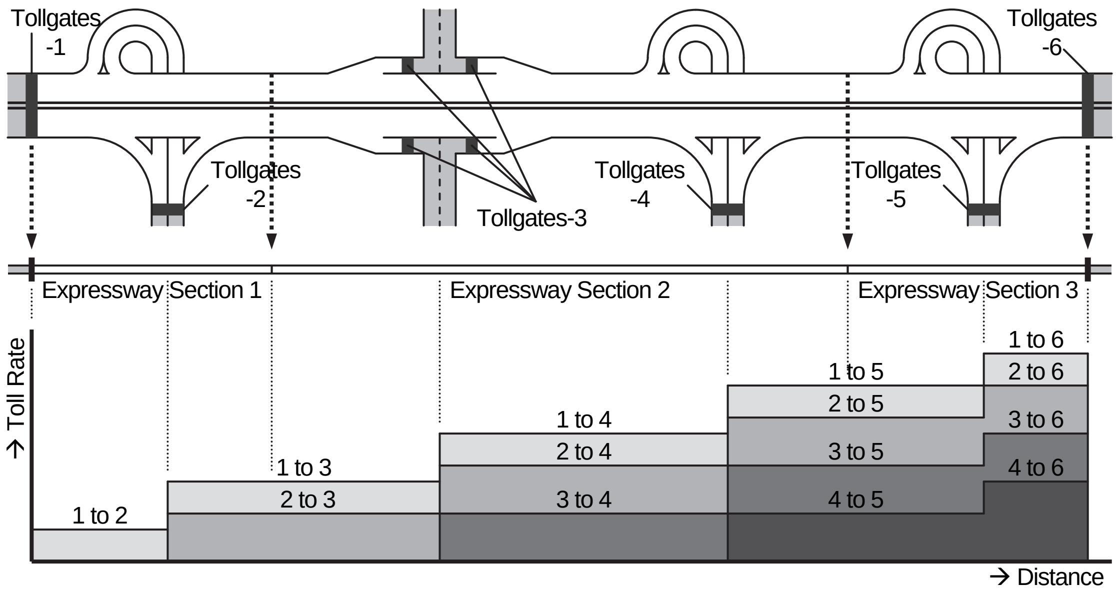
Figure 5.2 Example of Number Plate

Upper: Individuals
Lower Left: Government Agencies
Lower Right: Foreign

Source: The Study Team

5.3 Calculation of Toll Rate

Figure 5.3 Toll Rate Table for Whole Inter-city Expressway Network



Toll Rate Table		Exit					
		Tollgates-1	Tollgates-2	Tollgates-3	Tollgates-4	Tollgates-5	Tollgates-6
Entrance	Tollgates-1	--	1 to 2	1 to 3	1 to 4	1 to 5	1 to 6
	Tollgates-2	2 to 1	--	2 to 3	2 to 4	2 to 5	2 to 6
	Tollgates-3	3 to 1	3 to 2	--	3 to 4	3 to 5	3 to 6
	Tollgates-4	4 to 1	4 to 2	4 to 3	--	4 to 5	4 to 6
	Tollgates-5	5 to 1	5 to 2	5 to 3	5 to 4	--	5 to 6
	Tollgates-6	6 to 1	6 to 2	6 to 3	6 to 4	6 to 5	--

Note: A tollgate-ID is to be defined by using a pair of an expressway-ID and a number of kilometer post.

Source: The Study Team

A method using a toll rate table for the whole expressway network is to be prepared for the expressway network. The figure foregoing shows an example of this method applied to an expressway network consists of three adjacent sections. In the toll rate table, toll amounts are defined respectively for all pairs of tollgates on the whole expressway network.

For this method, the toll rate table shall be revised and maintained when a new expressway section comes into service. Correlation between driving distance and toll rate is to be defined based on the unit toll rate shown in the table below.

Table 5.2 Vehicle Classification in VIETNAM

Vehicle Class		Definition	Unit Toll Rate (VND/km)
Ordinary Vehicle	1	Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses	1000
	2	Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons	1500
	3	Cars with seats of 30 or more, trucks with a capacity between 4 and 10 tons	2200
	4	Trucks with a capacity between 10 and 18 tons, 20ft-container lorries	4000
	5	Trucks with a capacity of 18 tons or more, 40ft-container lorries	8000

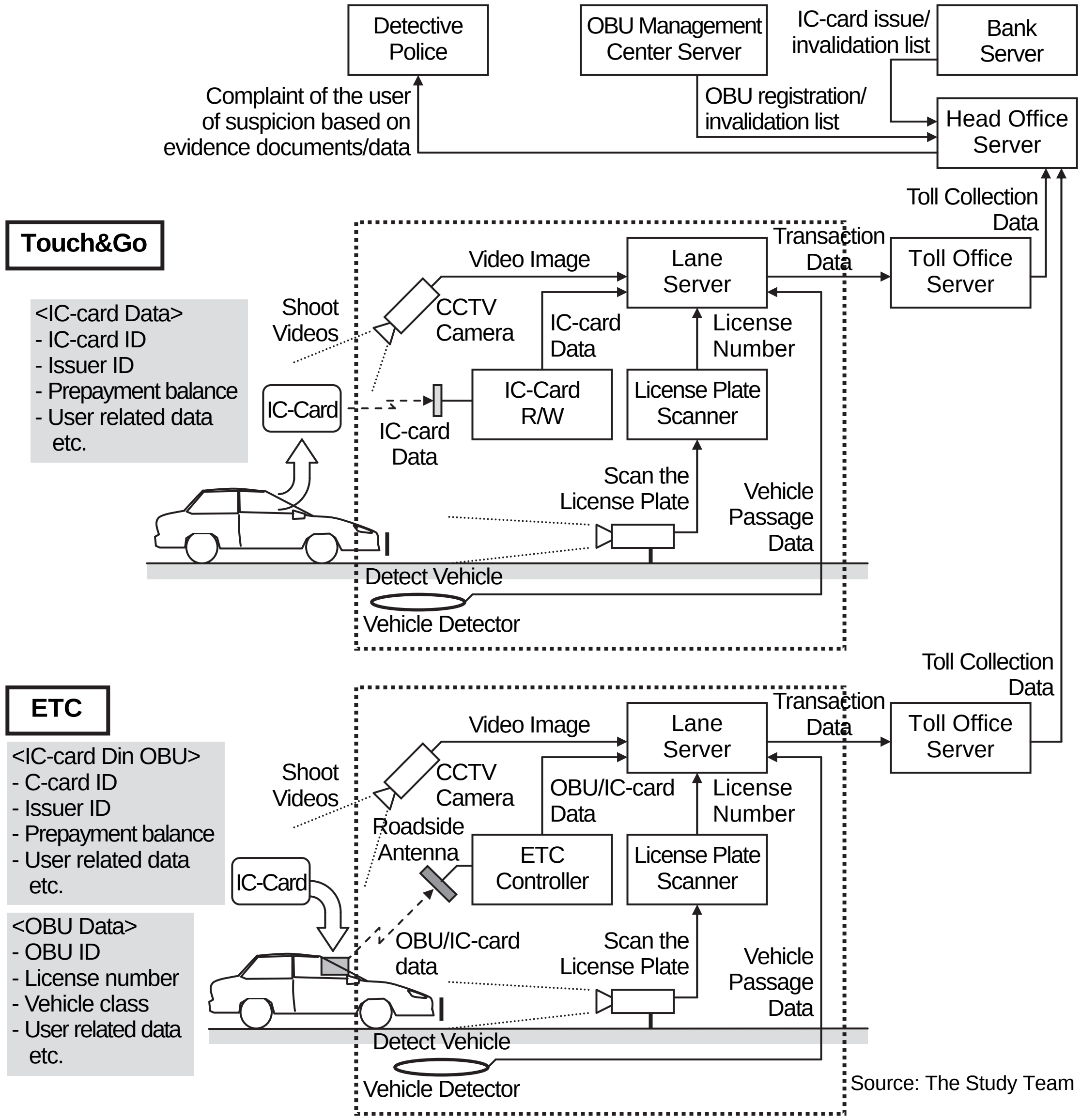
5.4 Data Set for Vehicle/Class Identification

Vehicle class data and vehicle identification data such as licence plate number are primary data for enforcement assistance.

Enforcement shall be conducted based on the data obtained by four ways as shown in figure below. These are the license number data in received from OBU through roadside antenna, the license number obtained by license plate scanner, and the vehicle passage data obtained by vehicle detector.

- Video image of vehicle appearance captured by CCTV
- Vehicle class data received from OBU through roadside antenna
- License number data received from OBU through roadside antenna
- License number data obtained by license plate scanner
- Vehicle passage data obtained by vehicle detector.

Figure 5.4 Major Message Exchanges for Enforcement Assistance



Source: The Study Team

Data frame and principal data elements for toll enforcement are shown in the table below.

Table 5.3 Principal Data Elements for Enforcement Assistance

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Toll Rate Information Data Set <R - Server>	Number of tollgate pair	INT	8	1	Daily	1 year
	Tollgate Pair ID	INT	8	N		
	Entrance Tollgate ID	INT*	4			
	Exit Tollgate ID	INT*	4			
	Toll Rate of Vehicle Class 1	FLOAT	12			
	Toll Rate of Vehicle Class 2	FLOAT	12			
	Toll Rate of Vehicle Class 3	FLOAT	12			
	Toll Rate of Vehicle Class 4	FLOAT	12			
	Toll Rate of Vehicle Class 5	FLOAT	12			
	Toll Rate of Vehicle Class 6	FLOAT	12			
	Toll Rate of Vehicle Class 7	FLOAT	12			
	Toll Rate of Vehicle Class 8	FLOAT	12			
	Toll Rate of Vehicle Class 9	FLOAT	12			
	Toll Rate of Vehicle Class 10	FLOAT	12			
	Toll Rate of Vehicle Class 11	FLOAT	12			
	Toll Rate of Vehicle Class 12	FLOAT	12			
	Toll Rate of Vehicle Class 13	FLOAT	12			
	Toll Rate of Vehicle Class 14	FLOAT	12			
	Toll Rate of Vehicle Class 15	FLOAT	12			
	Toll Rate of Vehicle Class 16	FLOAT	12			
	Toll Rate of Vehicle Class 17	FLOAT	12			
	Toll Rate of Vehicle Class 18	FLOAT	12			
	Toll Rate of Vehicle Class 19	FLOAT	12			
	Toll Rate of Vehicle Class 20	FLOAT	12			
	Number of document	TXT	20			
	Date of Toll Rate Table	TXT	8			

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

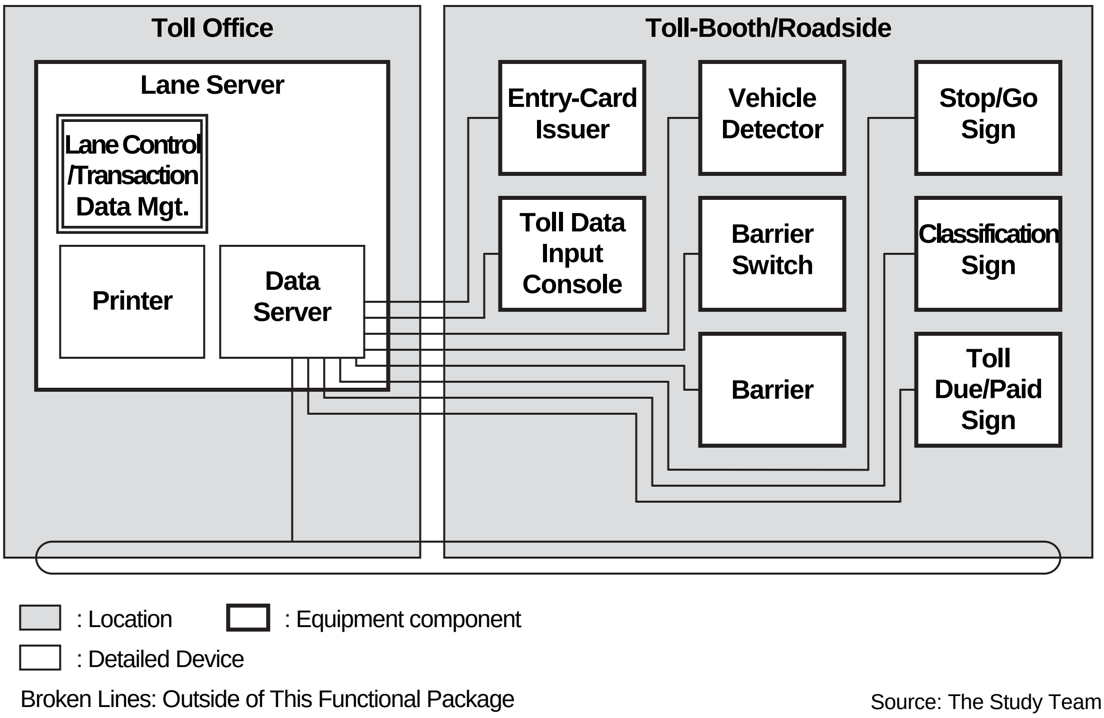
Source: The Study Team

6. Lane Control

6.1 Outline and System Architecture

This functional package allows the road operators to eliminate the vehicle passages without adequate toll collection by using a computer, vehicle detectors, signs and a barrier installed in a separated tollgate lane of the expressway.

Figure 6.1 System Architecture for Lane Control

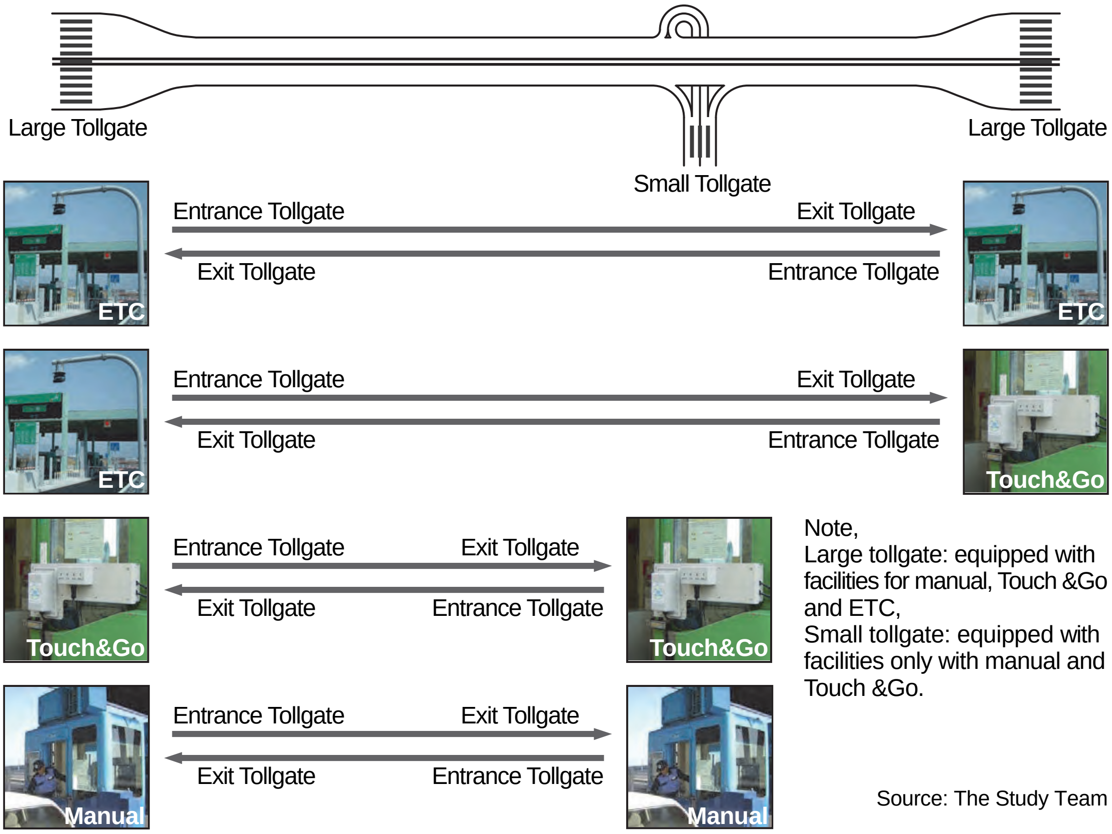


Source: The Study Team

6.2 Tollbooth Arrangement at Tollgate

Available combination of toll collection methods at entrance and exit is shown in the figure below. For reducing the cost of roadside equipment implementation, combination use of ETC and Touch&Go is available.

Figure 6.2 Available Combination of Toll Collection Methods at Entrance/Exit



Note,
Large tollgate: equipped with facilities for manual, Touch &Go and ETC,
Small tollgate: equipped with facilities only with manual and Touch &Go.

Source: The Study Team

Arrangement criteria of tollbooths are defined responding to design traffic volume passes through the tollgate and according to the basic policy that heavy vehicles are to be processed in the tollgate lanes near roadside.

Table 6.1 Arrangement Criteria of Tollbooths for Toll Collection

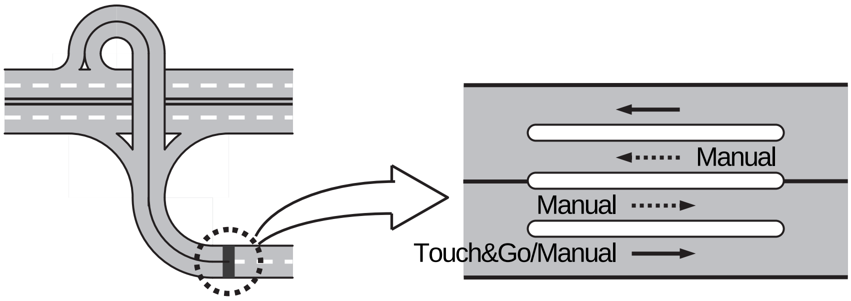
	Small Traffic Volume	Average Traffic Volume	Large Traffic Volume	
For Toll Collection	Tollbooth Arrangement Criteria 1	Tollbooth Arrangement Criteria 2	Tollbooth Arrangement Criteria 3	Tollbooth Arrangement Criteria 4

Source: The Study Team

(1) Tollbooth Arrangement Criteria 1

As the standard arrangement for the tollgate consists of two lanes in each direction at a trumpet-type interchange for small traffic volume, Touch& Go is to be installed on the roadside lane as shown in the figure below. Two kinds of processing of toll collection: Touch&Go and manual are to be carried out in the same lane.

Figure 6.3 Tollbooth Arrangement at Trumpet-Type Interchange for Small Traffic Volume

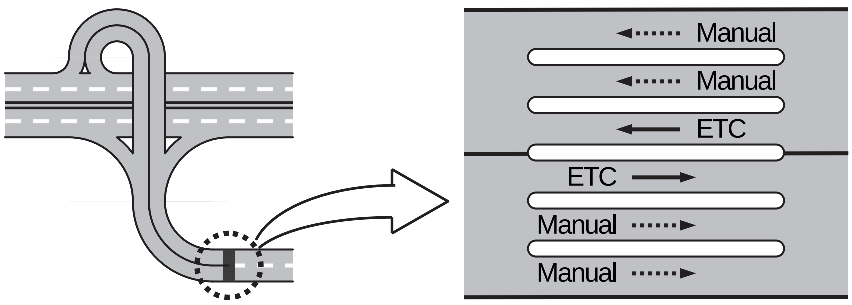


Source: The Study Team

(2) Tollbooth Arrangement Criteria 2

As the standard arrangement for the tollgate consists of three lanes in each direction at a trumpet-type interchange for middle traffic volume, ETC is to be installed on the median-side lane as shown in the figure below. Only the vehicles equipped for ETC are to be processed at the median-side lane exclusively. In the later stage, when many vehicles equipped for ETC and toll processing capacity is not sufficient, ETC is to be installed additionally in other lanes.

Figure 6.4 Tollbooth Arrangement at Trumpet-Type Interchange for Middle Traffic Volume

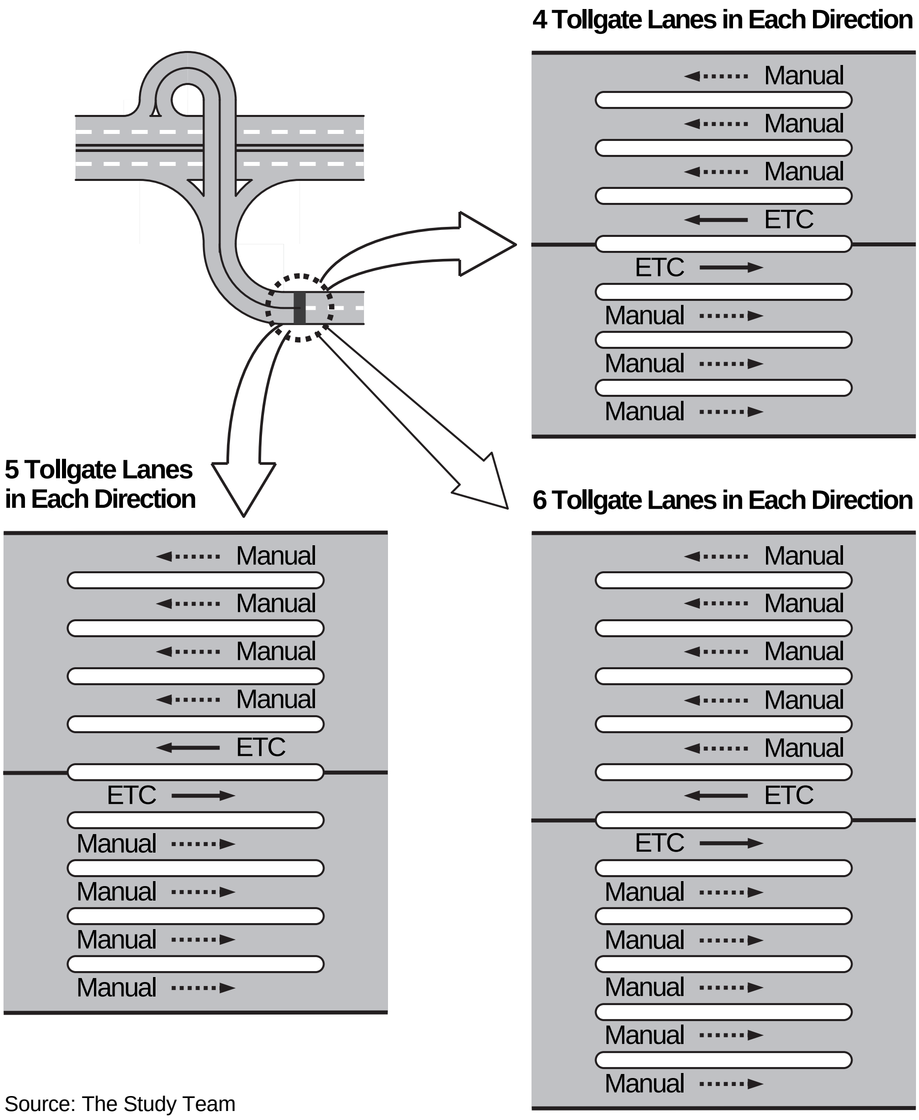


Source: The Study Team

(3) Tollbooth Arrangement Criteria 3

As the standard arrangement for the tollgate consists of four, five or six lanes in each direction at a trumpet-type interchange for large traffic volume, ETC is to be installed on the median-side lane as shown in the figure below. Only the vehicles equipped for ETC are to be processed at these lanes exclusively. In the later stage, when many vehicles equipped for ETC and toll processing capacity is not sufficient, ETC is to be installed additionally in other lanes.

Figure 6.5 Tollbooth Arrangement at Trumpet-Type Interchange for Large Traffic Volume

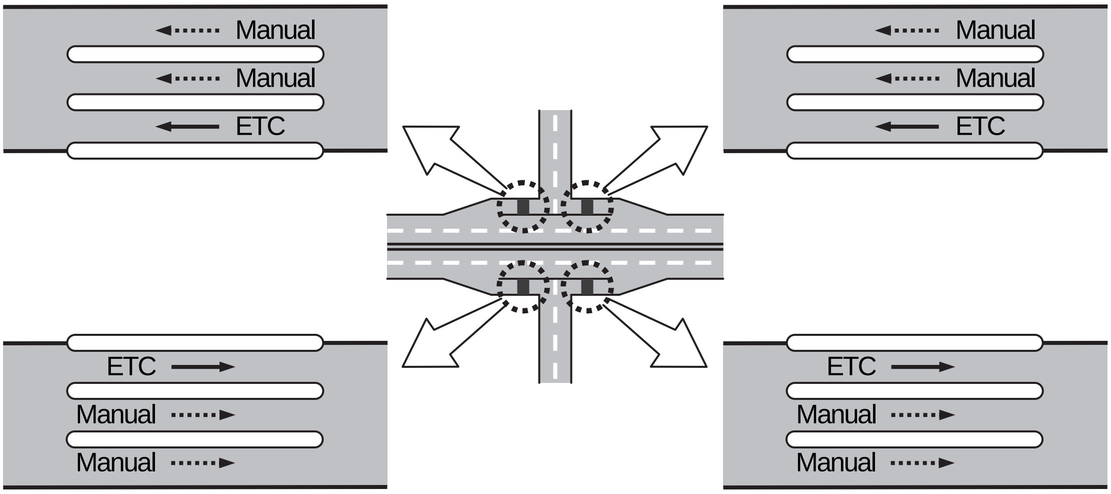


Source: The Study Team

(4) Tollbooth Arrangement Criteria 4

As the standard arrangement for the tollgate consists of three lanes in each direction at a diamond-type interchange for large traffic volume, ETC is to be installed on the left-hand side lane as shown in the figure below. Only the vehicles equipped for ETC are to be processed at these lanes exclusively. In the later stage, when many vehicles equipped for ETC and toll processing capacity is not sufficient, ETC is to be installed additionally in other lanes.

Figure 6.6 Tollbooth Arrangement at Diamond-Type Interchange for Large Traffic Volume



Source: The Study Team

6.3 Capacity and Calculating Number of Tollgate Lanes

(1) Variation of Tollgates

Tollgate is classified into two types according to its installation location.

- Barrier tollgate: The tollgate installed on the through lanes
- Interchange tollgate: The tollgate installed in an interchange

(2) Precautions for Design

Tollgate is a facility which is installed on the road in order to stop vehicles, since it is contradictory by nature to road which is a facility aiming at smooth vehicle traffic, it is necessary to pay special attention to the following precautions in designing tollgate square:

- The existence of a tollgate shall not be the obstacle to safety. In case of a tollgate inside an interchange, the tollgate must avoid any influence on traffic especially in the through lanes. In case of a toll barrier, besides giving prior notice and caution from adequate distance to the coming traffic at the speed on the through lanes, the tollgate must be installed so that it can be seen from long distance. It is necessary to take efforts to avoid installing the tollgate in places where the speed is likely to increase such as on the bottom of a vertical concave line shape.
- The tollgate must be installed in such a way as not be a bottleneck in traffic. This can be achieved only by preparing adequate number of lanes for handling traffic at peak hour. Besides, in case the distance between exit tollgate and connecting road is short, since the congestion in the intersection may surpass the tollgate and results in the congestion on the through lanes, there should be adequate space for tollgate as well as intersection.
- The tollgate must be safe and facile for vehicles to stop or start moving, and convenient for collecting toll. This will require the tollgate square to be as flat and straight as possible.

- It is necessary to consider and implement plan on many issues such as traffic management and toll collection.

(3) Number of Tollgate Lanes

The required number of tollgate lanes can be obtained from Table 17-1 if the traffic volume (interval between coming-in vehicles), average service time and service criteria (average number of queuing vehicles) are determined. Upon separating shuttling roadway (into entry interchange and exit interchange), the required number of lanes adequate for traffic volume of the direction with busy traffic during peak hour must be built in each side.

In case an entry interchange and an exit interchange are located in one place and the lane in central part is utilized as reversible lane, the required number of lanes for entry interchange and exit interchange is calculated based on the direction with busy traffic in case of long service time, or the traffic volume of direction with less traffic in case of short service time, then the total calculated number of lanes shall be built.

Traffic volume, average service time and service criteria are based on following standards:

Standard Hourly Traffic Volume

The traffic volume is determined based on the design hourly traffic volume (DHV), however, the 30th hour is used in this case. The 30th hour traffic volume can be obtained from the following formula with annual average daily traffic volume (ADT):

$$DHV = ADT \times K \times D$$

In the formula above, *K* (the ratio of the 30th hour traffic volume to ADT) and *D* (the ratio of the traffic volume of direction with busy traffic during the 30th hour to total traffic volume of both directions) conform to "The design traffic volume of an interchange" in principal. In some other special cases, *K* and *D* can be determined by using other factors as reference such as the actual measured value of a similar region.

Service Time

In order to calculate required number of lanes, service time is defined in principal as 6 seconds for entry interchange and 14 seconds for exit interchange in case of sectional tariff system, or as 8 seconds in case of flat tariff system. However, in places where these values are anticipated to be obviously different, other average service time can be used.

Service Criteria

Service criteria are determined by average number of queuing vehicles, but in principal it is defined as 1.0 vehicle. In the case it is difficult to base on this value due to some other reasons such as geological formation, and if the traffic is smooth, other value can be used.

Table 6.2 Number of Tollgate Lanes, Service Time, Average Number of Queuing Vehicles and Vehicle Processing Capacity (vehicles/hr)

	Service Time											
	6 sec		8 sec		10 sec		14 sec		18 sec		20 sec	
	1	3	1	3	1	3	1	3	1	3	1	3
1	300	450	230	340	180	270	130	190	100	150	90	140
2	850	1,040	640	780	510	620	360	440	280	350	250	310
3	1,420	1,630	1,070	1,230	850	980	610	700	480	550	430	490
4	2,000	2,230	1,500	1,670	1,200	1,340	860	960	670	740	600	670
5	2,590	2,830	1,940	2,120	1,550	1,700	1,110	1,210	860	940	780	850
6	3,180	3,430	2,380	2,570	1,910	2,060	1,360	1,470	1,060	1,140	950	1,030
7	3,770	4,020	2,830	3,020	2,260	2,410	1,620	1,720	1,260	1,340	1,130	1,210
8	4,360	4,630	3,270	3,470	2,620	2,780	1,870	1,980	1,450	1,540	1,310	1,390
9	4,960	5,220	3,720	3,920	2,980	3,130	2,130	2,240	1,650	1,740	1,490	1,570
10	5,560	5,820	4,170	4,370	3,330	3,490	2,380	2,490	1,850	1,940	1,670	1,750
11	6,150	6,420	4,610	4,820	3,690	3,850	2,640	2,750	2,050	2,140	1,850	1,930
12	6,740	7,020	5,050	5,270	4,040	4,210	2,890	3,010	2,250	2,340	2,020	2,110
13	7,340	7,620	5,510	5,720	4,400	4,570	3,150	3,270	2,450	2,540	2,200	2,290
14	7,940	8,220	5,954	6,170	4,760	4,930	3,400	3,520	2,650	2,740	2,380	2,470
15	8,530	8,820	6,400	6,620	5,120	5,290	3,660	3,780	2,840	2,940	2,560	2,650

(4) Calculation Method of the Number of Tollgate Lanes

The required number of tollgate lanes can be determined upon knowing 3 factors: traffic volume, necessary service time for toll collection, and service criteria (criteria for judging whether the service is good or bad based on average time for keeping customers waiting).

If the traffic volume is high, the larger number of gates shall be needed and if the service time is long, similarly, the larger number of gates shall be needed. In case number of gate is comparatively less than traffic volume, customers shall have to wait longer. In other words, in order to upgrade service criteria and to shorten average waiting time, the number of gates must be increased.

Thus, the issue of handling each coming vehicle one after another can be defined as the waiting line or the issue of keeping waiting in mathematics. It is common sense that the status of waiting line can be obtained based on the relation between above mentioned 3 factors, or to be more accurate, that is the relation between the following 3 factors:

- The statistic distribution of coming vehicles toward the gate in a certain period of time (Interval between coming vehicles)
- The statistic distribution relevant to the time that each vehicle occupies the gate in order to pay the toll (service time)
- The relation between the number of vehicles coming into the tollgate in a certain time and the time that a vehicle occupies the tollgate to pay toll (the interval between coming vehicles and service time)

Now, if a: average interval between vehicles (second)
b: average service time (second)
s: number of lanes (number of gates)

in general, the relation between coming vehicles and service time is defined as follows:

$\rho = b/a$ (traffic intensity)

then, gate per lane is defined as follows:

$u = b/sa$ (traffic intensive of per lane)

In the formula above, $u \geq 1$, this means if service time is longer than incoming interval per lane, of course the tollgate cannot handle all coming vehicles and this shall result in endless line of queuing vehicles. Therefore, upon knowing a and *b, s* must be defined so that *u* becomes less than 1. If *u* is less than 1, the incoming vehicle shall pass the gate after an average time of waiting, but that situation differs according to the status of statistic distribution of coming car interval and service time

The interval between coming vehicles conforms to Poisson distribution law, in case the service time complies with index distribution, (it is common sense that this has been applied in practice based on the actual measurement); however, its relation is given as follows:

Average waiting time: $\omega = \dfrac{\rho^s}{s.s!} \bullet \dfrac{b}{(1-u)^2} \bullet k$

Average number of vehicles (Service criteria): $q = \dfrac{1}{(1-u)^2} \bullet \dfrac{\rho}{s!} \bullet k = \dfrac{\omega}{k} \bullet s$

Average number of queuing vehicles per lane (the length of line) $= \dfrac{q}{s} = \dfrac{\omega}{b}$

However,

$\dfrac{3,600}{b} u \bullet s$ (the possibility that there is no vehicle in the gate)

The average number of queuing vehicles per lane (*q / s*) can be obtained from service criteria, but the relation between this and the traffic intensity per lane (*u*) and number of gates (*s*) can be determined by above mentioned formulas and it is given in Table 17 -2. According to this Table (or Graph 17-1), regarding similar average number of queuing vehicles (service criteria), the larger number of lanes is, the higher the traffic intensity per lane gets. In other words, the vehicle processing capacity per lane is increased. This is because in case one gate is occupied, the next incoming vehicle may take advantage of the other vacant gate, and the efficiency is improved.

The required number of lanes is determined by giving specific values to traffic volume (interval between incoming vehicles) and average service time, then the required number of lanes corresponding to service criteria can be obtained. The determination method of those values and calculation method are given below.

Traffic Volume

The traffic volume, similar to the cases of the through lane and ramp design, shall apply design hourly traffic volume. The design hourly traffic volume is obtained by multiplying Annual average daily traffic volume (ADT) of calculated year by *K* and *D*. However, the determination method of these values varies a great deal so the design hourly traffic volume based on it also varies widely. Since this design hourly traffic volume is the most important factor in determining the number of gates, determination of this factor requires discretion. In determining the final necessary volume, attention must be paid so that the value is not excessive but a certain leeway for period of phased construction must be foreseen.

<u>Service Time</u>

The service time differs according to toll collection method and types of vehicle, but it takes usually an average time of 8 ~ 14 seconds to collect toll. Nowadays, according to experience in many routes such as Meishin, Tomei and Central Road, service time in entry interchange takes 6 seconds (only for card delivery), that in exit interchange takes 14 seconds (in case of sectional tariff system and the tariff system which toll differs according to types of vehicle) as a standard. Besides, in case of flat tariff system, in general, service time is defined as 8 seconds (for toll payment).

<u>Service Criteria</u>

Service criteria are built based on average number of queuing vehicles per gate, as being mentioned in the formula above, average waiting time is the value obtained by multiplying average number of queuing vehicles by average service time. If this standard value (*q / s*) gets bigger, when the temporary traffic volume increases, it is likely to result in long line of queuing vehicles. Besides, according to the assumption of theoretical calculation, vehicles are distributed evenly among all gates, but in fact, vehicle has a character of direction selection, there are many instances where even in situation of busy traffic, vehicles mostly gather in the central gate, both sides of the tollgate are comparatively empty. Therefore, in case of large number of gates, the number of queuing vehicles in the central part is higher than theoretical value. From those aspects, the appropriate standard value of service criteria is defined as 1.0. However, in case it is difficult to base on this value due to some other reasons such as geological formation, and if the traffic is smooth, the value up to 3.0 can be used.

<u>Calculating the Required Number of Lanes</u>

The traffic intensity (ρ) can be obtained from design hourly traffic volume (DHV) and service time (b). This means

$$\rho = \frac{b}{a} = \frac{DHV}{3,600} b$$

Since the traffic intensity of one lane u is ρ / s, the value of s in such a way as to keep the traffic intensity not to exceed the values given in Table 17-12 is the required number of lanes.

The relation between number of tollgate lanes, average number of queuing vehicles and the traffic intensity per lane, which are calculated by above formulas, is given in Table 14.2 and Table 14.3.

Besides, if the traffic intensity per lane (u), service time (b), number of lanes (s) and service criteria (q / s) are stipulated by these calculations, the hypothesis of calculation changes, but

$$\frac{3,600}{b} u \bullet s$$

is the number of process able vehicles per hour of that tollgate.

Table 6.3 Number of Tollgate Lanes (s), Average Number of Queuing Vehicles (q) and Traffic Intensity for a Tollgate Lane (u)

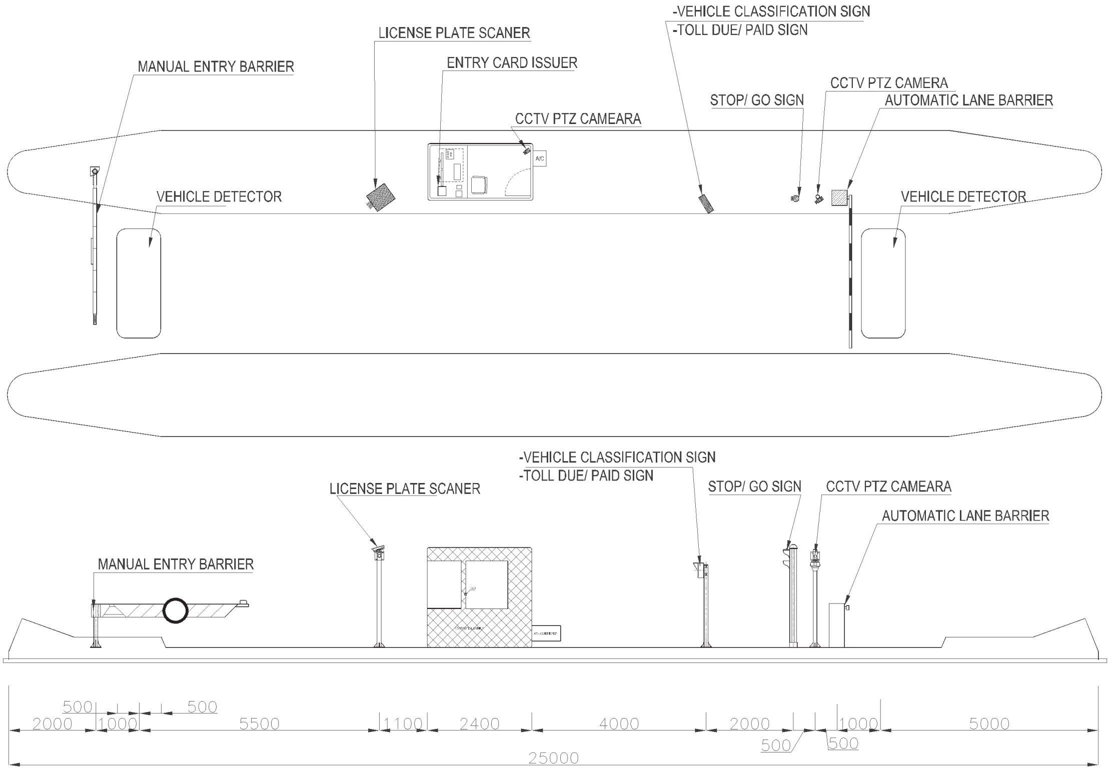
Number of	Average Number of Queuing Vehicles (q/s)							
Tollgate Lanes	0.5	1.0	1.5	2.0	3.0	4.0	5.0	10.0
1	0.333	0.500	0.600	0.667	0.750	0.800	0.833	0.909
2	0.577	0.706	0.775	0.817	0.863	0.895	0.913	0.953
3	0.686	0.791	0.841	0.872	0.908	0.928	0.940	0.969
4	0.748	0.835	0.876	0.902	0.929	0.945	0.955	0.976
5	0.787	0.863	0.899	0.919	0.942	0.955	0.963	0.981
6	0.817	0.883	0.914	0.932	0.952	0.962	0.969	0.984
7	0.838	0.898	0.925	0.940	0.958	0.968	0.974	0.986
8	0.854	0.909	0.933	0.948	0.964	0.972	0.977	0.988
9	0.868	0.919	0.941	0.953	0.967	0.975	0.980	0.989
10	0.878	0.926	0.946	0.957	0.970	0.977	0.982	0.990
11	0.888	0.932	0.950	0.961	0.973	0.979	0.983	0.991
12	0.896	0.936	0.954	0.964	0.975	0.981	0.984	0.992
13	0.903	0.941	0.958	0.967	0.977	0.982	0.986	0.992
14	0.908	0.945	0.961	0.969	0.979	0.983	0.987	0.993
15	0.913	0.948	0.962	0.971	0.980	0.984	0.988	0.993

6.4 Arrangement of Roadside Equipment at Tollgate

(1) Manual Lane

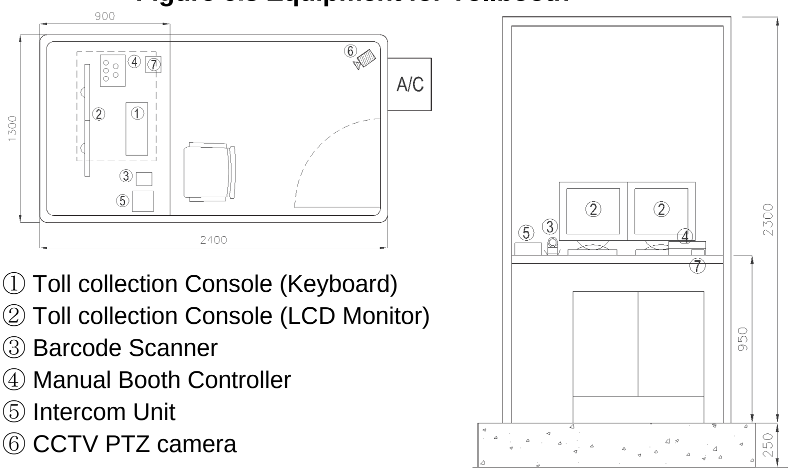
The most of lane type is manual at toll gate. For toll collection, it is done the delivery and receipt operation by using radio-frequency transmission instead of human labour forth in both ETC and Touch&Go. Therefore, the same roadside equipment are installed at the lane, except DSRC antenna, Contactless IC card reader / writer. Layout of roadside equipment at Manual lane is shown in the figures below.

Figure 6.7 Arrangement at Manual Lane



Source: The Study Team

Figure 6.8 Equipment for Tollbooth



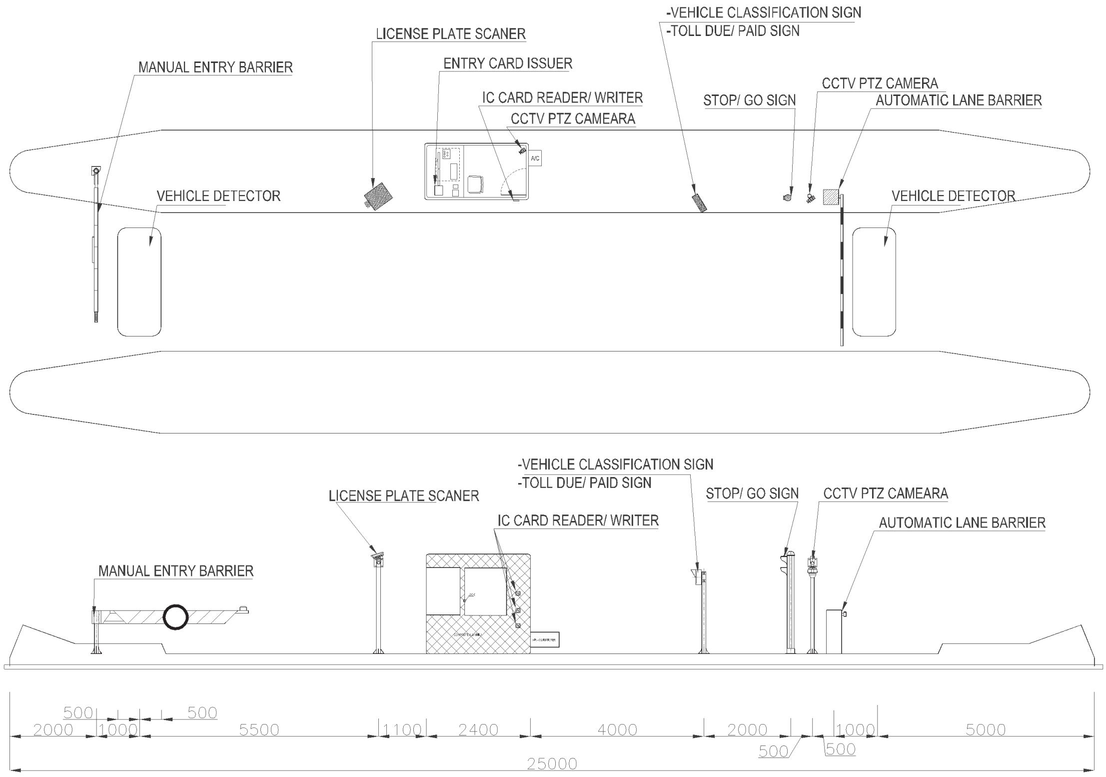
① Toll collection Console (Keyboard)
② Toll collection Console (LCD Monitor)
③ Barcode Scanner
④ Manual Booth Controller
⑤ Intercom Unit
⑥ CCTV PTZ camera

Source: The Study Team

(1) Touch&Go Lane

Touch&Go (by using Contactless IC-Card) toll collection should be used in a first step. Therefore, we recommend that Touch&Go is installed on at least 1 lane at each tollgate / toll barrier. Layout of roadside equipment at Touch and Go lane is shown in the figure below.

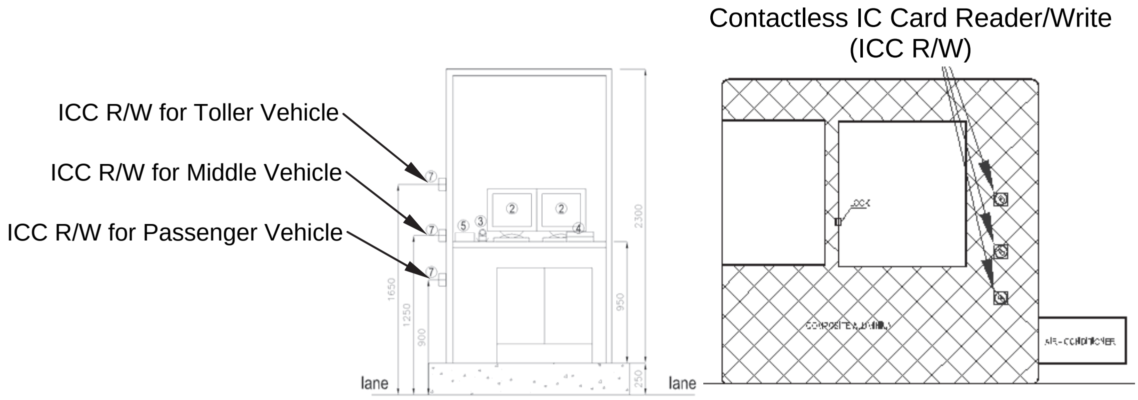
Figure 6.9 Arrangement at Touch&Go Lane



Source: The Study Team

Contactless IC Card Reader / Writer (ICC R/W) are installed at Touch and Go lane. The ICC R/W are attached on the outside wall of toll booth, it is installed three height according to the height of driver seat. The installation is shown in the figure below.

Figure 6.10 IC-card Reader/Writer

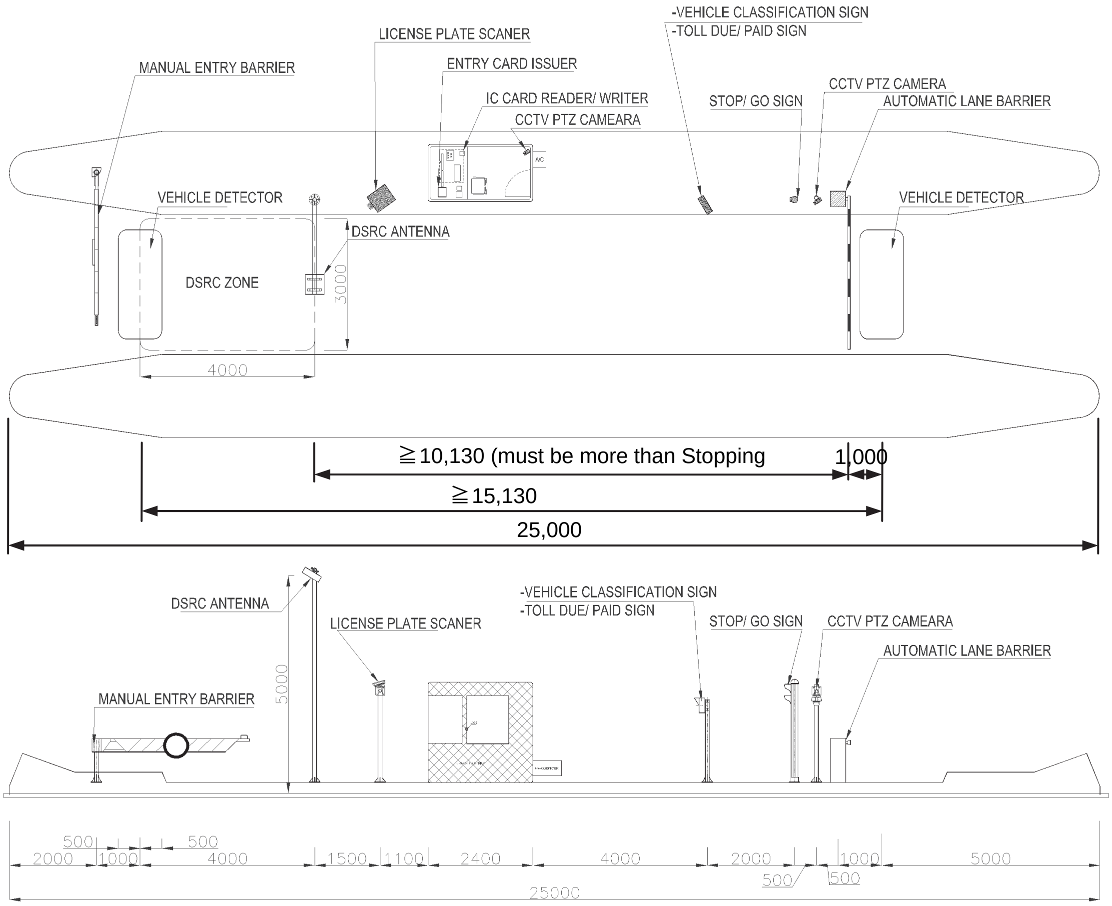


Source: The Study Team

(2) ETC Lane

For distance-based toll collection, the toll amount is calculated by the distance from the entrance interchange to the exit interchange based on which entrance interchange is passed through. The same is true in the case of Electric Toll Collection (ETC). Therefore, ETC is should be installed at both the interchange entrances and exits. Thus, we recommend that ETC is installed on at least 1 lane at each tollgate / toll barrier. Layout of roadside equipment at ETC lane is shown in the figure below.

Figure 6.11 Arrangement at ETC Lane



Source: The Study Team

The length of toll island is 25m mainly in existing design or existing toll gate. In case of the speed of passing vehicles 25km/h at toll lane, layout of toll equipment at the toll island is as shown in Figure as follows, it is sufficient to the length of toll island is 25m.

Table 6.4 Vehicle Speed and Stopping Distance

Vehicle Speed (km/h)	10	15	20	25	30	35	40
Stopping Distance (m)	2.87	4.90	7.32	10.13	13.34	16.94	20.93

Source: The Study Team

6.5 Required Functions of Roadside Equipment

Roadside equipment of toll collection is consists of the following components and functions.

Table 6.5 Components/Functions of Roadside Equipment of Toll Collection

Component	Function
Lane server	Toll fee calculation and control various types of equipment related to toll collection
Data Input Console *	Terminal equipment for input the data such as classification of vehicles, collected toll amount and etc.
IC-card R/W **	To communicate with contact-less IC card, to write/read the entrance gate information, to read/rewrite the balance in the card.
Roadside Antenna ***	To communicate with OBU installed in the vehicle, to receive the recorded information from OBU, to send the information to OBU
ETC Controller ***	To control roadside antenna
License Plate Scanner	To recognize license plate information by image
Barrier	To prevent the entry of vehicles into the lane during maintenance, it is operated by manual.

Note, * : Component for manual toll collection, ** : Component for Touch&Go, *** : Component for ETC

6.6 Data Set for Lane Control

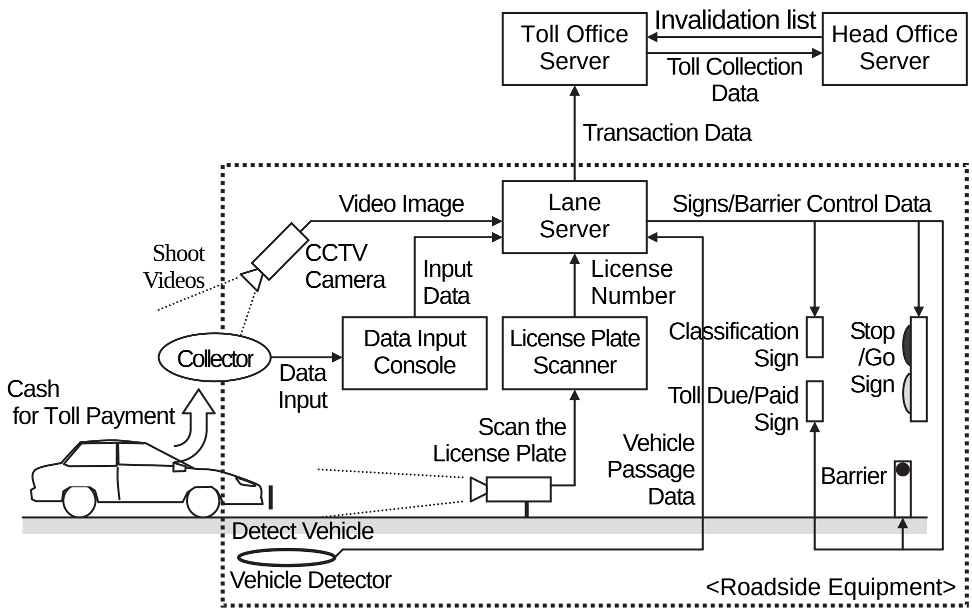
In this chapter the message exchange for lane control is to be illustrated based on the following three toll collection methods.

- Manual Toll Collection
- Touch&Go
- ETC

(1) Manual Toll Collection

Major messages for manual toll collection are to be exchanged as shown in the following figure, and tollgate lanes are to be controlled according to these message exchanges.

Figure 6.12 Major Message Exchanges for Manual Toll Collection

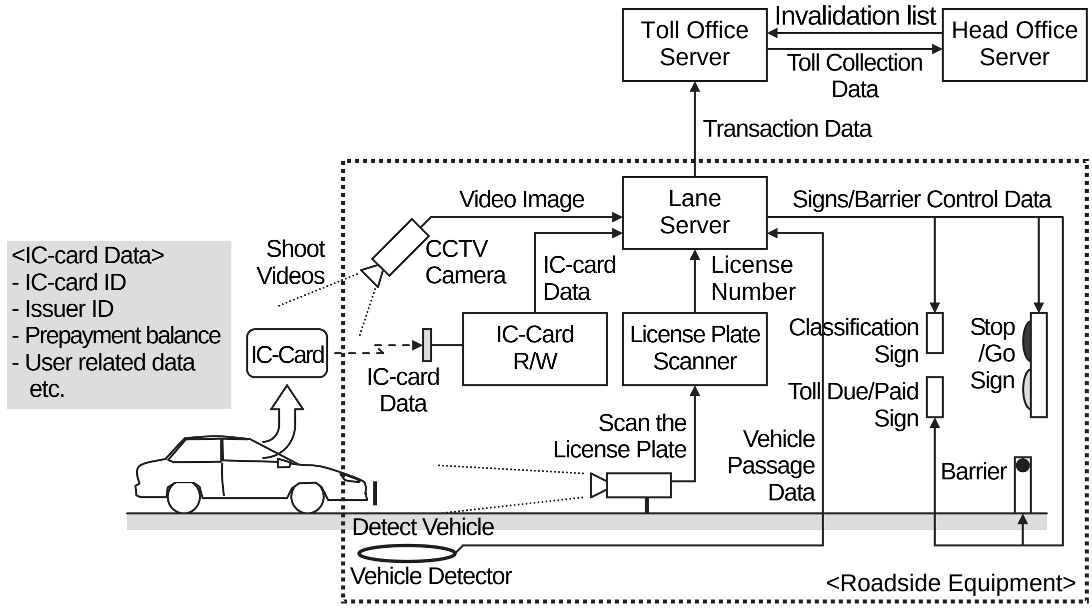


Source: The Study Team

(2) Touch&Go

Major messages for Touch&Go are to be exchanged as shown in the following figure, and tollgate lanes are to be controlled according to these message exchanges.

Figure 6.13 Major Message Exchanges for Touch&Go

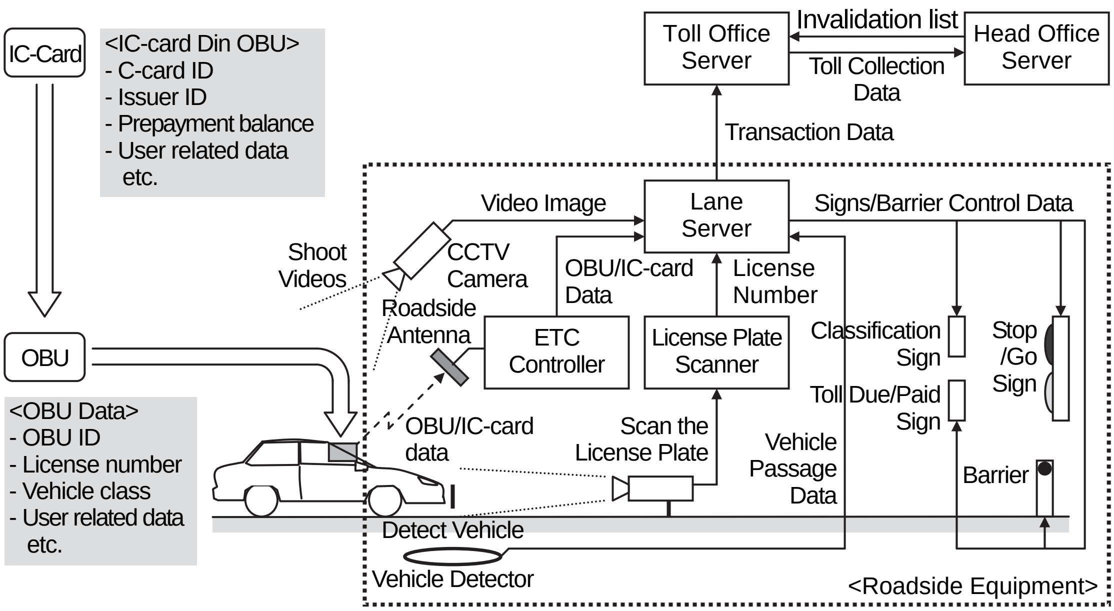


Source: The Study Team

(3) ETC

Major messages for ETC are to be exchanged as shown in the following figure, and tollgate lanes are to be controlled according to these message exchanges.

Figure 6.14 Major Message Exchanges for ETC



Source: The Study Team

(4) Data Set

Data frame and principal data elements for lane control are shown in the table below.

Table 6.5 Principal Data for Lane Control

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Bar-code Data Set <G - Lane Server>	Toll Office ID	INT*	4	1	Each passage at tollgate	1 month
	Tollgate ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Deposit Terminal ID	INT*	4	1		
	Ticket Type	INT*	4	1		
	Vehicle Class	INT*	2	1		
	Serial Number	INT	12	1		
	Date Issue	Date	8	1		
	Date of Expiry	Date	8	1		
IC-card Invalidation List Data Set <G - Server>	Issuer ID	INT*	4	1	Daily + Upon Demand	1 year
	Issue Terminal ID	INT	12	N		
	IC-card ID for Invalidation	INT	12			
	IC-card Owner ID	INT	18			
	Prepaid Balance	FLOAT	8			
	Date/Time of Issue	TXT	≥14			
	Date/Time of Expiry	TXT	≥14			
	Date/Time	Datetime	≥14	1		
OBU Invalidation List Data Set <G - Server>	Management Organization ID	INT	12	1	Daily + Upon Demand	1 year
	OBU ID for Invalidation	INT	12	N		
	OBU Owner ID	INT	18			
	License Plate Number	TXT	12			
	Vehicle Class	TXT	2			
	Date of Issue	TXT	8			
	Date of Expiry	TXT	8			
	Date/Time	Datetime	≥14	1		
Transaction Data Set <R - Lane Server>	Toll Office ID	INT*	4	1	Each passage at tollgate	6 months
	Tollgate ID	INT	8	1		
	Lane ID	INT*	4	1		
	OBU ID	INT	12	1		
	Vehicle Class in OBU	INT*	2	1		
	License number in OBU	TXT	12	1		
	IC-card ID	INT	12	1		
	Toll Amount	INT	8	1		
	Prepaid Balance	FLOAT	8	1		
	Termination Status	INT*	2	1		
	Serial Number of Vehicle	INT	5	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

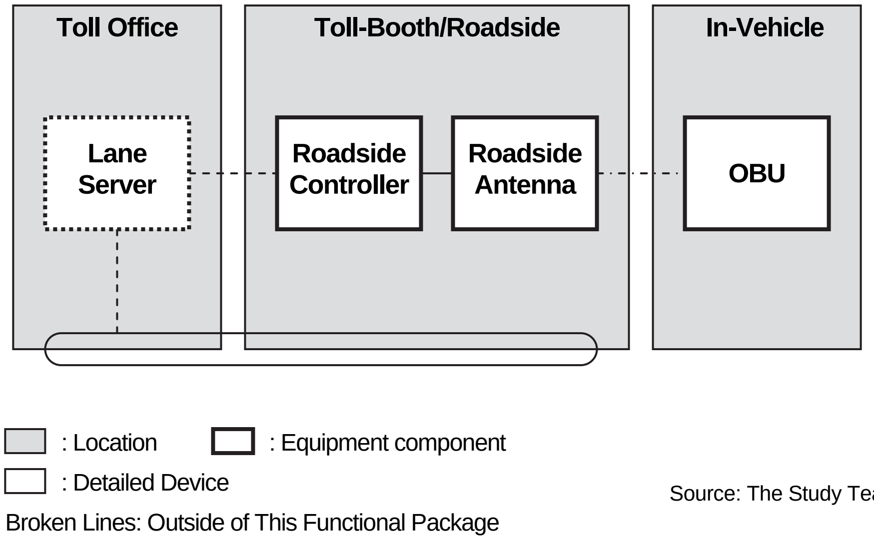
Source: The Study Team

7. Road-to-vehicle Communication

7.1 Outline and System Architecture

This functional package allows the road operators to exchange data for toll collection and other services on the expressways by using radio communication between antennas installed at roadside and on-board units installed in the vehicles.

Figure 7.1 System Architecture for Road-to-Vehicle Communication

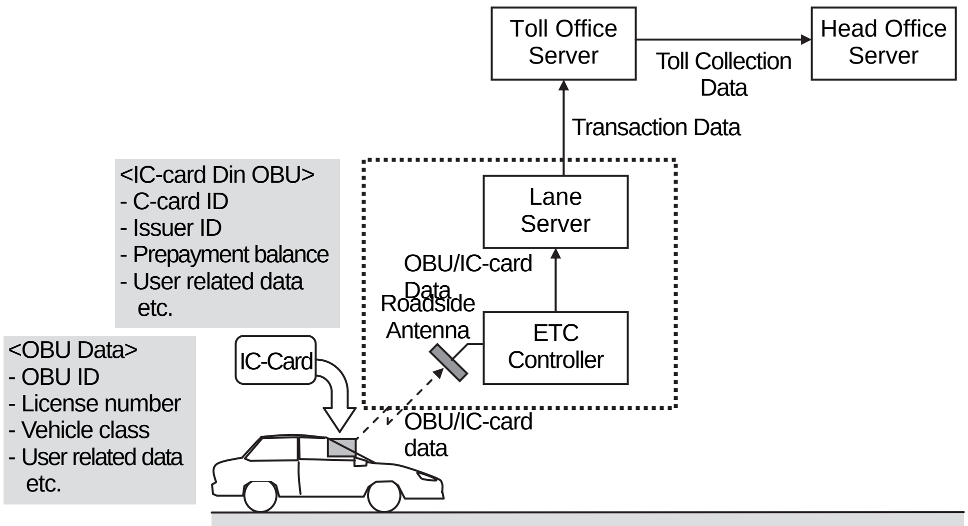


Source: The Study Team

7.2 Procedure of Toll Collection by ETC

Major messages for ETC are to be exchanged as shown in the figure below.

Figure 7.2 Major Message Exchanges for ETC



Source: The Study Team

7.3 Installation of OBU and Roadside Antenna

(1) OBU

OBU communicate the ID number, IC Card ID, Entrance-gate ID and Vehicle classification and etc with Roadside Antenna by using the wireless communication such as Dedicated Short Range Communication (DSRC). Especially, two-piece type OBU should be installed on the front side of the vehicle at dashboard for a favourable environment of wireless communication. The recommendable location is shown below.

Figure 7.3 Installation of OBU in Vehicle

(2) Roadside Antenna

The roadside antenna should be capable of exchange toll transaction data with the On Board Unit (OBU) over the wireless communication. The communication zone for a single lane operation should cover 4m in the longitudinal direction and 3m in the lateral direction at a height of 1m from the road surface. The height and width of the installation area of roadside antenna should be decided by considering the conditions of tollgate.

The design process for the roadside antenna installation is divided into the following steps,

(1) Determine communication areas
(2) Communication zone design
(3) Channel layout in the new system (in the case of multiple lane at the same tollgate)
(4) Verify interference with other systems

(5) Re-design communication zone

An example of installation of roadside antenna is shown in the following page.

Figure 7.4 Communication Zone of Roadside Antenna at Tollgate

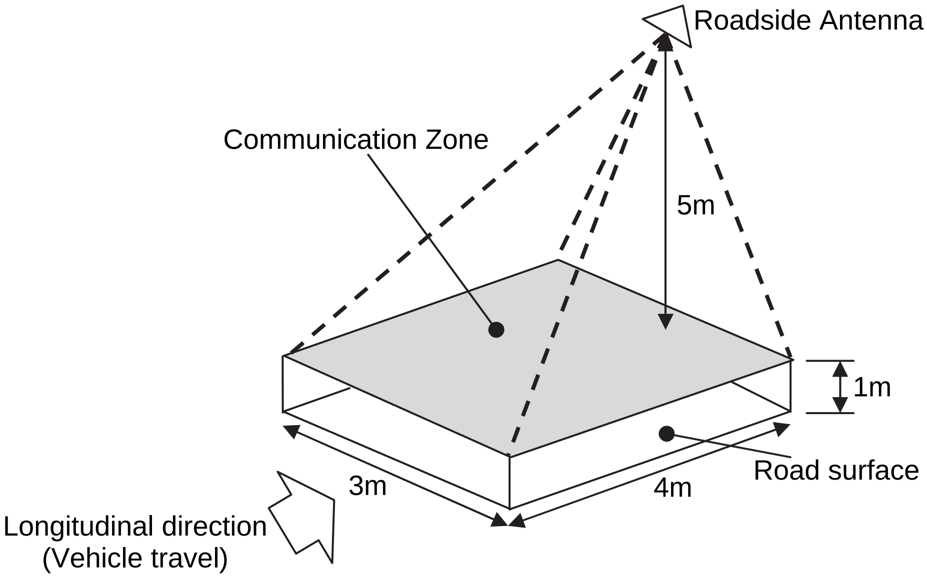
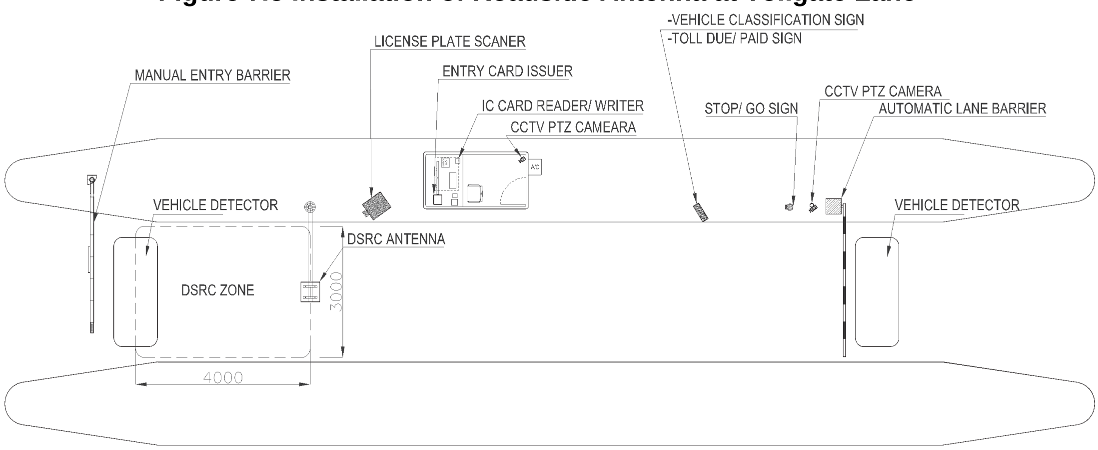


Figure 7.5 Installation of Roadside Antenna at Tollgate Lane



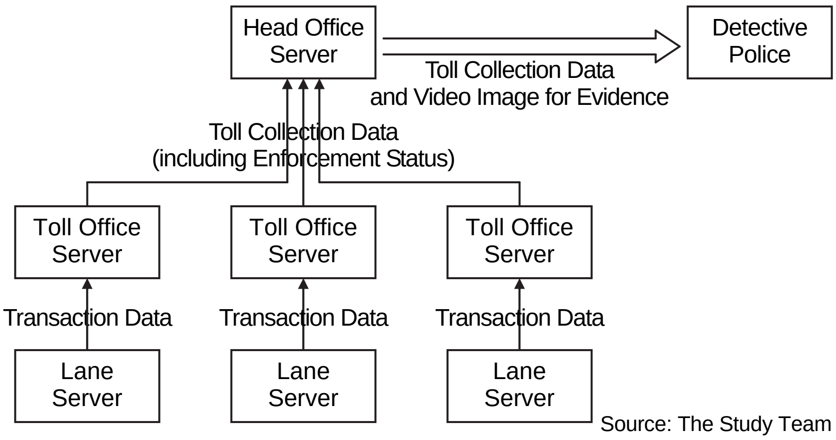
7.4 Procedure of Toll Enforcement Assistance

The following cases are to be considered in the discussion of toll enforcement in the system.

- Spoofing: vehicle passing tollgates by re-installation of OBU
- Cheating: vehicle passing tollgates habitually with negative balance in the IC-card
- Violation: vehicle passing tollgates without OBU.

These unlawful passages are to be checked making comparison among the data received through a vehicle detector, a roadside antenna and a license plate scanner at the tollgate, and enforcement status is to be generated in the toll office server based on the check and to be handover to the detective police as an evidence through the head office. Procedure of enforcement shall be established with completely different meaning of invalidation of an OBU or an IC-card aforementioned.

Figure 7.6 Major Message Exchanges for Toll Enforcement



Source: The Study Team

7.5 Data Set for Toll Enforcement Assistance

Enforcement status can be estimated by verifying the data in the table below.

Table 7.1 Enforcement Status by Estimated Verifying Data

Vehicle Detector	Roadside Antenna				License Plate Scanner		Enforcement Status	CCTV Camera
Vehicle Passage	OBU ID	LN in OBU	IC-card ID	Positive balance	LN	LN Image	Successful	Video Image
Vehicle Passage	OBU ID	LN in OBU	IC-card ID	Positive balance	Different LN	LN Image	Spoofing? *	Video Image
Vehicle Passage	OBU ID	LN in OBU	IC-card ID	Negative balance	LN	LN Image	Cheating? **	Video Image
Vehicle Passage	-	-	-	-	LN	LN Image	Violation? ***	Video Image

Note, LN : License number
* : Suspicion of spoofing: vehicle passing by re-installation of OBU shall be checked making comparison between license plate numbers in OBU received through the roadside antenna and that captured by the license plate scanner.
** : Suspicion of cheating: vehicle passing tollgates habitually with negative balance in the IC-card shall be checked referring to the historical data of IC-card balance stored in the toll office server.
*** : Suspicion of violation: vehicle passing without OBU shall be checked making comparison between data from the vehicle detector and from the roadside antenna.

Source: The Study Team

Table 7.2 Enforcement Status by Estimated Verifying Data

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
IC-card Passage Data Set <R - IC-card>	Status	INT*	1	N	Each passage at tollgate	Latest
	Toll Office ID	INT*	4			
	Tollgate ID	INT	8			
	Lane ID	INT	12			
	Toll Amount	FLOAT	8			
	Prepaid Balance	FLOAT	8			
	Date/Time	Datetime	≥14			
OBU Passage Data Set <R - OBU>	Toll Office ID	INT*	4	3	Each passage at tollgate	Latest
	Tollgate ID	INT*	4			
	Lane ID	INT*	4			
	IC-card ID	INT	12			
	Toll Amount	FLOAT	4			
	Prepaid Balance	INT	8			
	Date/Time	Datetime	≥14			
Transaction Data Set <R - Lane Server>	Toll Office ID	INT*	4	1	Each passage at tollgate	6 months
	Tollgate ID	INT	8	1		
	Lane ID	INT*	4	1		
	OBU ID	INT	12	1		
	Vehicle Class in OBU	INT*	2	1		
	License number in OBU	TXT	12	1		
	IC-card ID	INT	12	1		
	Toll Amount	INT	8	1		
	Prepaid Balance	FLOAT	8	1		
	Termination Status	INT*	2	1		
	Serial Number of Vehicle	INT	5	1		
	Date/Time	Datetime	≥14	1		
Toll Collection Data Set <G - Lane Server>	Road Owner ID	INT*	4	1	Every 10 minutes	6 months
	Toll Office ID	INT*	4	1		
	Date of Toll Amount	TXT	8	1		
	Sum of Toll Amount	INT*	12	1		
	Number of Vehicle Passage	INT	8	1		
	Transaction Data Set	Set	var	N		
	Enforcement Status	TXT	2			
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

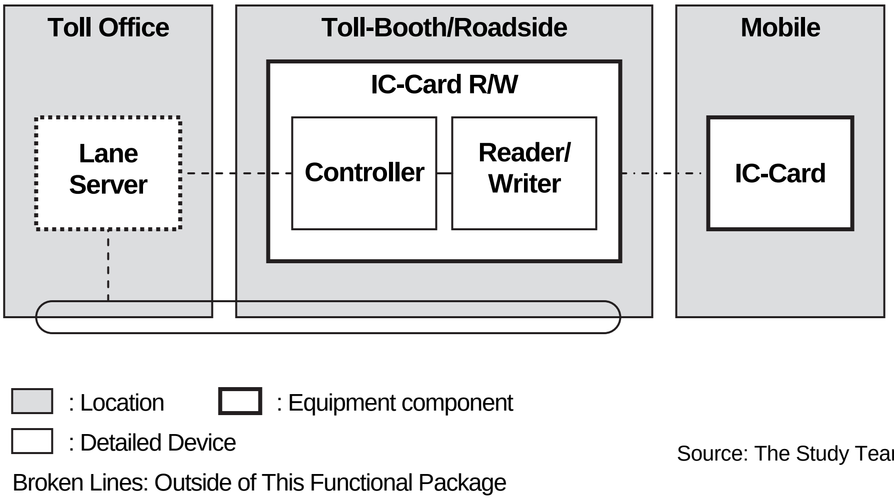
Source: The Study Team

8. IC-card Recording

8.1 Outline and System Architecture

This functional package allows the road operators to deduct prepaid balance of IC-cards for collecting toll by using equipment installed at tollgates on the expressways.

Figure 8.1 System Architecture for IC-Card Recording

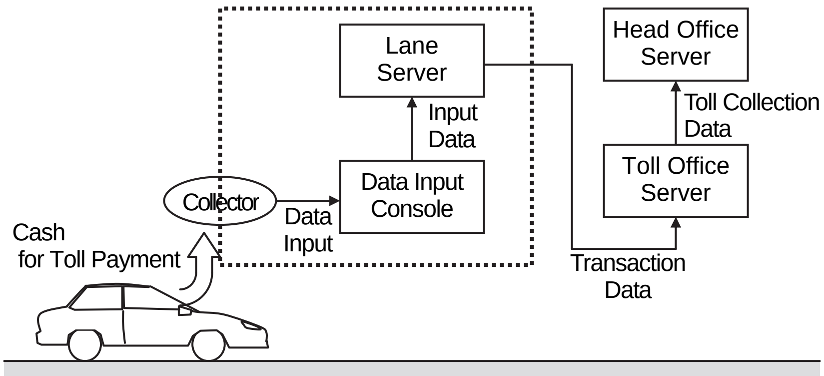


Source: The Study Team

8.2 Procedure of Toll Collection by Manual

Major messages for manual toll collection are to be exchanged as shown in the figure below.

Figure 8.2 Major Message Exchanges for Manual Toll Collection

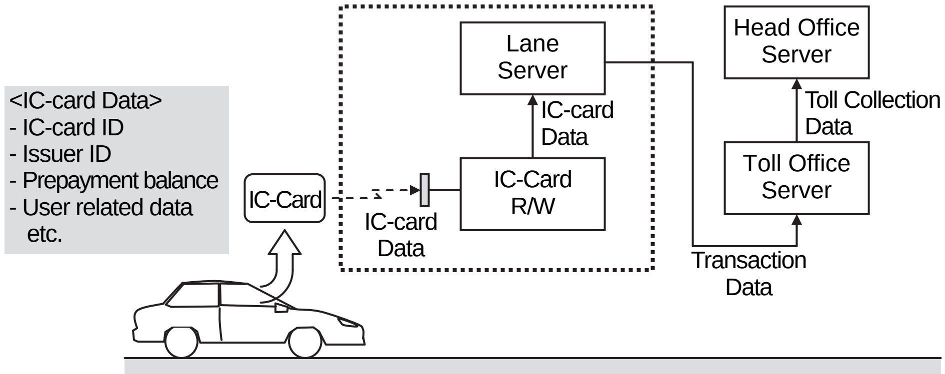


Source: The Study Team

8.3 Procedure of Toll Collection by Touch&Go

Major messages for Touch&Go are to be exchanged as shown in the figure below.

Figure 8.3 Major Message Exchanges for Touch&Go



Source: The Study Team

8.4 Data Set for IC-Card Recording

The data set and principal data elements to be recorded in IC-card are shown in the table below.

Table 8.1 Principal Data to be Recorded in IC-card

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
IC-card Issue Data Set <R - IC-card>	Status	INT*	1	1	IC-card issue	Permane nt
	Issuer ID	INT*	4	1		
	Issue Terminal ID	INT	12	1		
	IC-card ID	INT	12	1		
	IC-card Owner ID	INT	18	1		
	Amount of Deposit	FLOAT	8	1		
	Date/Time of Issue	TXT	≥14	1		
	Date/Time of Expiry	TXT	≥14	1		
IC-card Recharge Data Set <R - IC-card>	Status	INT*	1	N	Each recharge	Permane nt
	Issuer ID	INT*	4			
	Deposit Terminal ID	INT	12			
	IC-card ID	INT	12			
	IC-card Owner ID	INT	18			
	Amount of Deposit	FLOAT	8			
	Prepaid Balance	FLOAT	8			
	Date/Time	Datetime	≥14			
IC-card Invalidation List Data Set <G - Server>	Issuer ID	INT*	4	1	Daily + Upon Demand	1 year
	Issue Terminal ID	INT	12	N		
	IC-card ID for Invalidation	INT	12			
	IC-card Owner ID	INT	18			
	Prepaid Balance	FLOAT	8			
	Date/Time of Issue	TXT	≥14			
	Date/Time of Expiry	TXT	≥14			
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

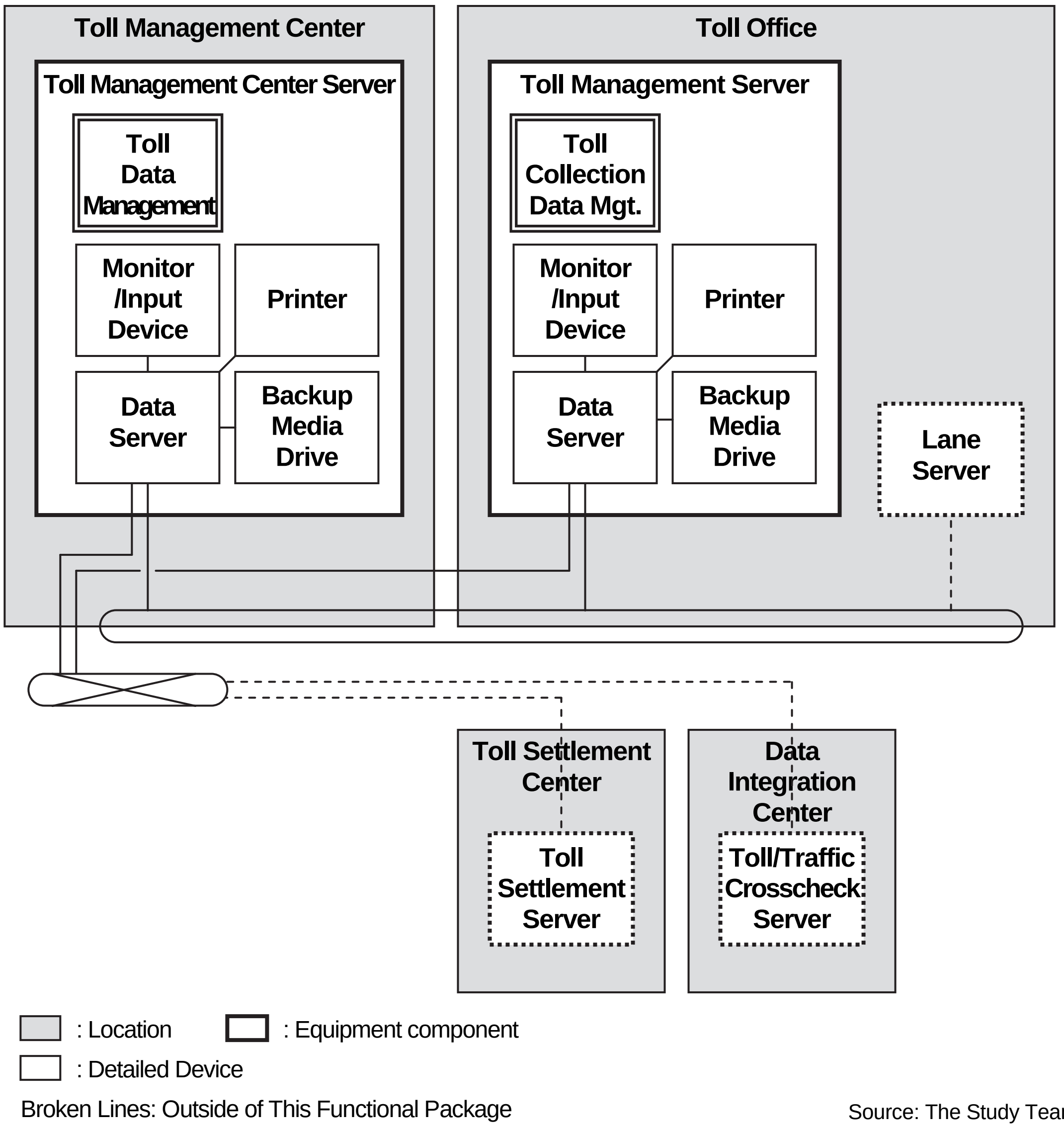
Source: The Study Team

9. Toll Data Management

9.1 Outline and System Architecture

This functional package allows the road operators to keep all data of toll collection, to manage the invalidation list on the usage of on-board units and IC-cards, and to manage toll revenue of the expressways with a high reliability by using computers and software installed in the road management office.

Figure 9.1 System Architecture for Toll Data Management



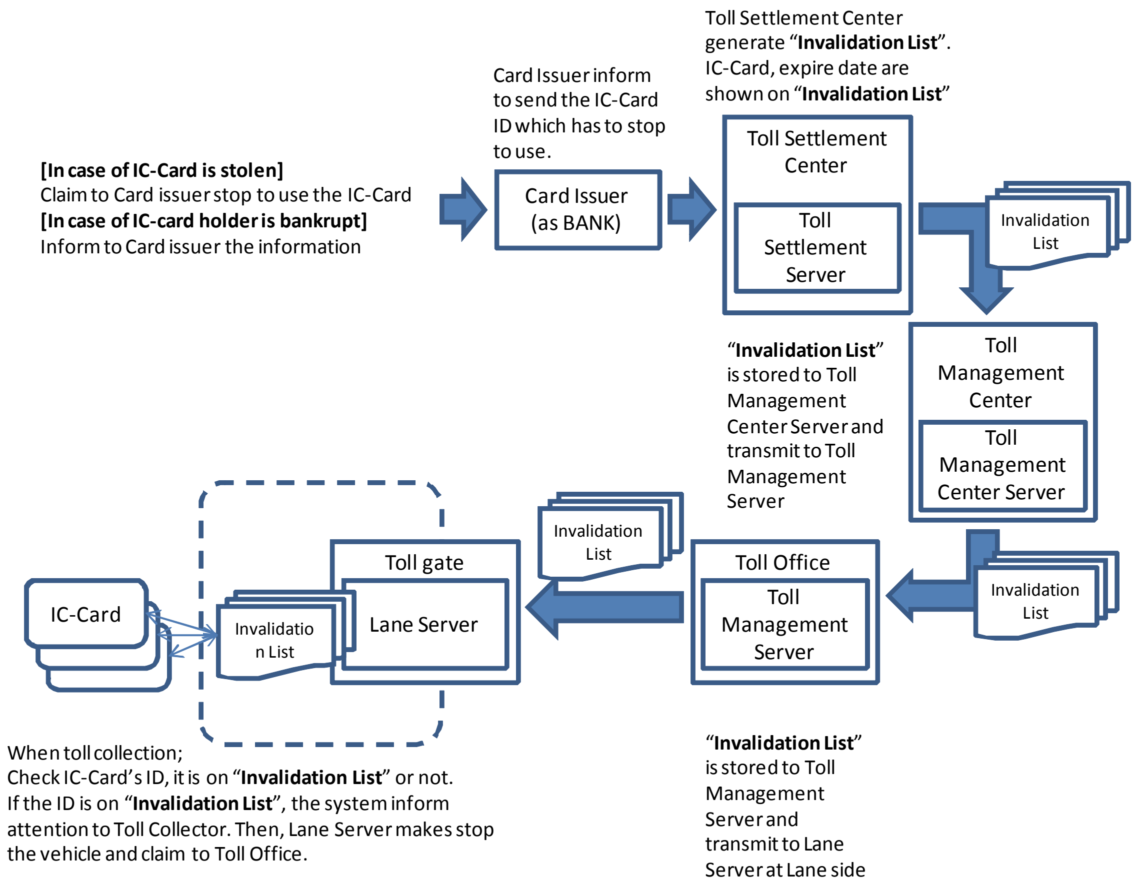
Source: The Study Team

9.2 Procedure of Toll Data Management

(1) Checking using "Invalidation list"

Invalidation list is for checking the card which shall be invalidated such as stolen and so on. If the invalidated card is used on toll, the fee is not collected from bank. Therefore, we have to consider the card shall not be capable of using for toll collection. The process is shown in the figure below.

Figure 9.2 Process of using Invalidation list



(2) Checking using "License number"

The toll fee amount of each car is depended on type of vehicle according to degree of Ministry of Finance standard; the vehicle class is recorded in OBU when set up OBU. If the OBU is moved to from car to different type of car, the ETC system charge the incorrect fee. For secure toll collection, we have to compare between the vehicle class and actual vehicle type using License number.

Therefore, Licence number shall be recorded in OBU and Vehicle Identification system (such as License Plate scanner) shall be installed on toll lane. Then the toll management system shall be check that the Licence number is the same or not due to comparison of between Licence number (by OBU) in Transaction data set and License number (by scan) in Toll collection data set; refer to Table 13.1 Data Set and Principal Data Elements for Toll

Management.

(3) Checking using "Termination sign"

In sometime, the communication between Roadside and Vehicle is not termination properly due to affected by the disorder outside and the being overheard. The system shall not be capable of settlement completely the error.

Therefore, Transaction data set include "Termination sign" which is for checking the communication is terminated properly or not. If the sign is not recorded, the meaning is the communication is not terminated properly. Refer to Table 13.1 Data Set and Principal Data Elements for Toll Management.

9.3 Required Documents/Forms

The required Documents/Forms are listed below. The data for these documents can output by CSV format. The item output by CSV is shown in the following tables.

- Daily Revenue Report
- Weekly Revenue Report
- Monthly Revenue Report
- Yearly Revenue Report
- Invalidation Report for IC-card
- Invalidation Report for OBU

Table 9.1 Item for Revenue Report

Data Elements	Type
Road Owner ID	INT*
Toll Office ID	INT*
Date of Toll Amount	TXT
Sum of Toll Amount	INT*
Number of Vehicle Passage	INT
Transaction Data Set	Set
Enforcement Status	TXT
Date/Time	Datetime

Table 9.2 Item for Invalidation Report for IC-card

Data Elements	Type
Issuer ID	INT*
Issue Terminal ID	INT
IC-card ID for Invalidation	INT
IC-card Owner ID	INT
Prepaid Balance	FLOAT
Date/Time of Issue	TXT
Date/Time of Expiry	TXT
Date/Time	Datetime

Table 9.3 Item for Invalidation Report for OBU

Data Elements	Type
Management Organization ID	INT
OBU ID for Invalidation	INT
OBU Owner ID	INT
License Plate Number	TXT
Vehicle Class	TXT
Date of Issue	TXT
Date of Expiry	TXT
Date/Time	Datetime

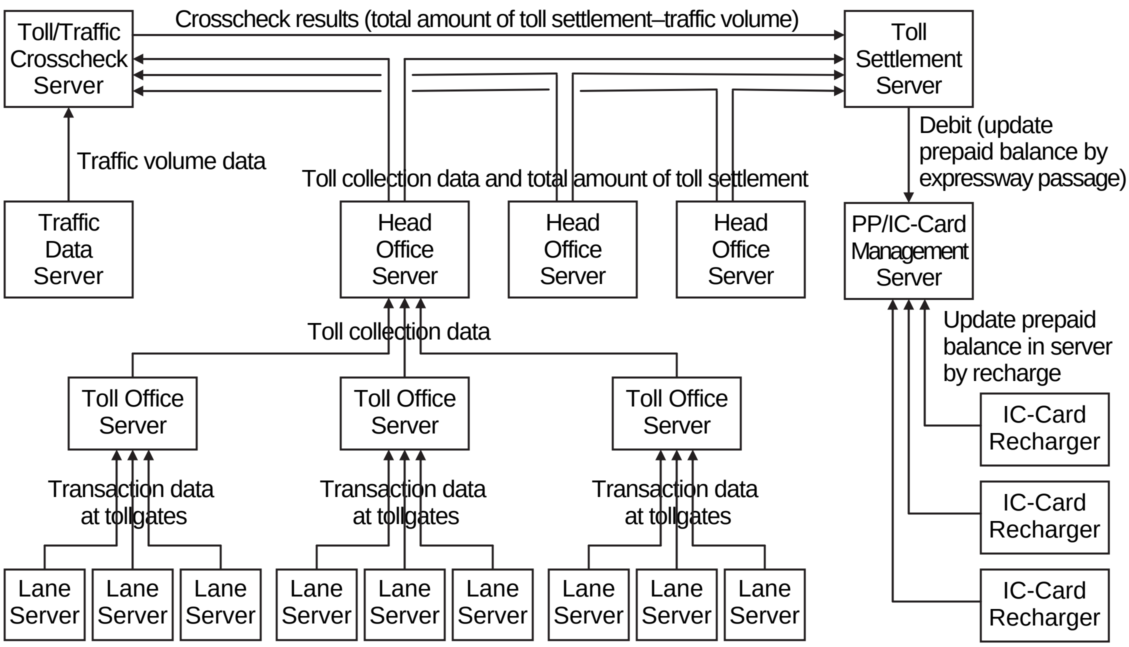
Note: INT* : Short integer

Source: The Study Team

9.4 Data Set for Toll Data Management

Major messages for toll management are to be exchanged as shown in the following figures.

Figure 9.3 Major Message Exchanges for Toll Management



Source: The Study Team

Data set and principal data elements for toll management are shown in the table below.

Table 9.1 Data Set and Principal Data Elements for Toll Management

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Toll Collection Data Set <G - Lane Server>	Road Owner ID	INT*	4	1	Every 10 minutes	6 months
	Toll Office ID	INT*	4	1		
	Date of Toll Amount	TXT	8	1		
	Sum of Toll Amount	INT*	12	1		
	Number of Vehicle Passage	INT	8	1		
	Transaction Data Set	Set	var	N		
	Enforcement Status	TXT	2			
	Date/Time	Datetime	≥14	1		
Hourly Toll Collection Data Set <G/C - Server>	Road Owner ID	INT*	4	1	Hourly	1 year
	Toll Office ID	INT*	4	1		
	Date/Hour of Record	TXT	10	1		
	Sum of Toll Amount	FLOAT	12	1		
	Number of Vehicle Passage	INT	8	1		
	Sum of Toll of Vehicle Class 1	FLOAT	12	1		
	Number of Vehicle of Class 1	INT	8	1		
	Sum of Toll of Vehicle Class 2	FLOAT	12	1		
	Number of Vehicle of Class 2	INT	8	1		
	Sum of Toll of Vehicle Class 3	FLOAT	12	1		
	Number of Vehicle of Class 3	INT	8	1		
	Sum of Toll of Vehicle Class 4	FLOAT	12	1		
	Number of Vehicle of Class 4	INT	8	1		
	Sum of Toll of Vehicle Class 5	FLOAT	12	1		
	Number of Vehicle of Class 5	INT	8	1		
	Sum of Toll of Vehicle Class 6	FLOAT	12	1		
	Number of Vehicle of Class 6	INT	8	1		
	Sum of Toll of Vehicle Class 7	FLOAT	12	1		
	Number of Vehicle of Class 7	INT	8	1		
	Sum of Toll of Vehicle Class 8	FLOAT	12	1		
	Number of Vehicle of Class 8	INT	8	1		
	Sum of Toll of Vehicle Class 9	FLOAT	12	1		
	Number of Vehicle of Class 9	INT	8	1		
	Sum of Toll of Vehicle Class 10	FLOAT	12	1		
	Number of Vehicle of Class 10	INT	8	1		
	Sum of Toll of Vehicle Class 11	FLOAT	12	1		
	Number of Vehicle of Class 11	INT	8	1		
	Sum of Toll of Vehicle Class 12	FLOAT	12	1		
	Number of Vehicle of Class 12	INT	8	1		
	Sum of Toll of Vehicle Class 13	FLOAT	12	1		
	Number of Vehicle of Class 13	INT	8	1		
	Sum of Toll of Vehicle Class 14	FLOAT	12	1		
	Number of Vehicle of Class 14	INT	8	1		
	Sum of Toll of Vehicle Class 15	FLOAT	12	1		
	Number of Vehicle of Class 15	INT	8	1		
	Sum of Toll of Vehicle Class 16	FLOAT	12	1		
	Number of Vehicle of Class 16	INT	8	1		
	Sum of Toll of Vehicle Class 17	FLOAT	12	1		
	Number of Vehicle of Class 17	INT	8	1		
	Sum of Toll of Vehicle Class 18	FLOAT	12	1		
	Number of Vehicle of Class 18	INT	8	1		
	Sum of Toll of Vehicle Class 19	FLOAT	12	1		
	Number of Vehicle of Class 19	INT	8	1		
	Sum of Toll of Vehicle Class 20	FLOAT	12	1		
	Number of Vehicle of Class 20	INT	8	1		
	Date/Time	Datetime	≥14	1		

Toll Revenue Data Set <G/C - Server>	Road Owner ID	INT*	4	1	Monthly	1 year
	Fiscal Month	TXT	6	1		
	Toll Revenue of The Month/Week	FLOAT	16	1		
	Number of Vehicle Passage	INT	8	1		
	Sum of Toll of Vehicle Class 1	FLOAT	12	1		
	Number of Vehicle of Class 1	INT	8	1		
	Sum of Toll of Vehicle Class 2	FLOAT	12	1		
	Number of Vehicle of Class 2	INT	8	1		
	Sum of Toll of Vehicle Class 3	FLOAT	12	1		
	Number of Vehicle of Class 3	INT	8	1		
	Sum of Toll of Vehicle Class 4	FLOAT	12	1		
	Number of Vehicle of Class 4	INT	8	1		
	Sum of Toll of Vehicle Class 5	FLOAT	12	1		
	Number of Vehicle of Class 5	INT	8	1		
	Sum of Toll of Vehicle Class 6	FLOAT	12	1		
	Number of Vehicle of Class 6	INT	8	1		
	Sum of Toll of Vehicle Class 7	FLOAT	12	1		
	Number of Vehicle of Class 7	INT	8	1		
	Sum of Toll of Vehicle Class 8	FLOAT	12	1		
	Number of Vehicle of Class 8	INT	8	1		
	Sum of Toll of Vehicle Class 9	FLOAT	12	1		
	Number of Vehicle of Class 9	INT	8	1		
	Sum of Toll of Vehicle Class 10	FLOAT	12	1		
	Number of Vehicle of Class 10	INT	8	1		
	Sum of Toll of Vehicle Class 11	FLOAT	12	1		
	Number of Vehicle of Class 11	INT	8	1		
	Sum of Toll of Vehicle Class 12	FLOAT	12	1		
	Number of Vehicle of Class 12	INT	8	1		
	Sum of Toll of Vehicle Class 13	FLOAT	12	1		
	Number of Vehicle of Class 13	INT	8	1		
	Sum of Toll of Vehicle Class 14	FLOAT	12	1		
	Number of Vehicle of Class 14	INT	8	1		
	Sum of Toll of Vehicle Class 15	FLOAT	x	1		
	Number of Vehicle of Class 15	INT	8	1		
	Sum of Toll of Vehicle Class 16	FLOAT	12	1		
	Number of Vehicle of Class 16	INT	8	1		
	Sum of Toll of Vehicle Class 17	FLOAT	12	1		
	Number of Vehicle of Class 17	INT	8	1		
	Sum of Toll of Vehicle Class 18	FLOAT	12	1		
	Number of Vehicle of Class 18	INT	8	1		
	Sum of Toll of Vehicle Class 19	FLOAT	12	1		
	Number of Vehicle of Class 19	INT	8	1		
	Sum of Toll of Vehicle Class 20	FLOAT	12	1		
	Number of Vehicle of Class 20	INT	8	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

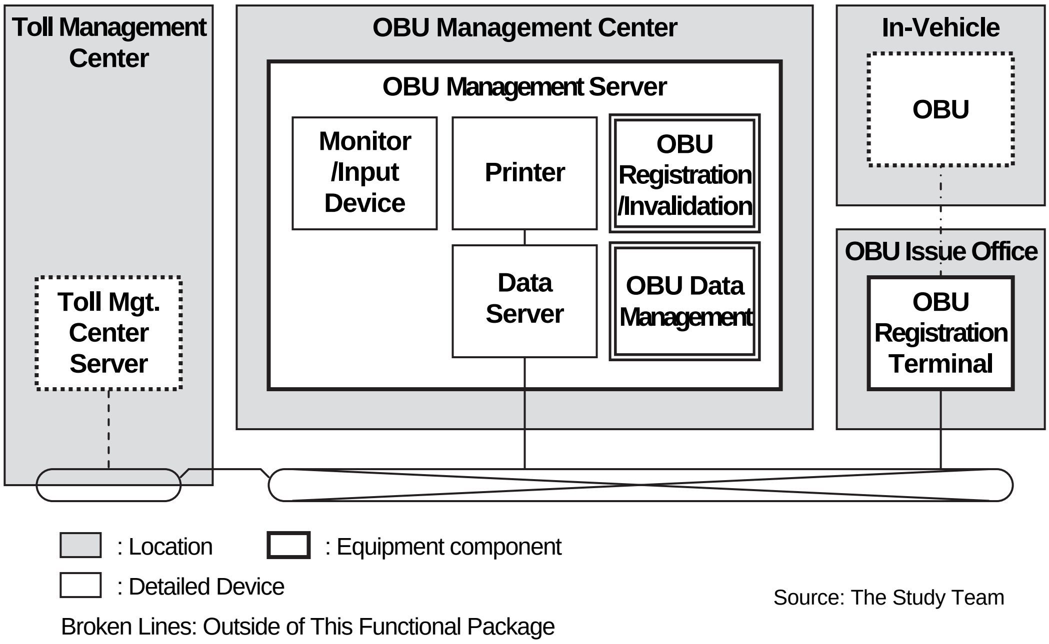
Source: The Study Team

10. OBU Management

10.1 Outline and System Architecture

This functional package allows to register on-board units by using equipment installed in OBU issue offices, and allows to generate/manage the registration list and the invalidation list of on-board units by using computers and software installed in the OBU registration center.

Figure 10.1 System Architecture for OBU Management



Source: The Study Team

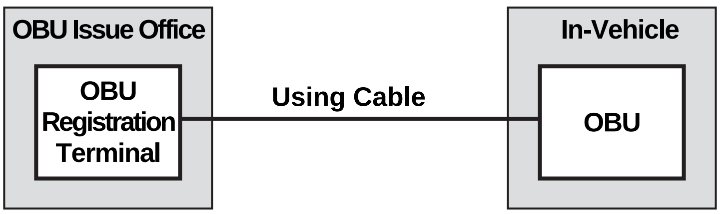
10.2 Procedure of OBU Management

There is some method for the set up. For example; a) connect cable, b) using the same as DSRC antenna, c) using IC-Card. The characteristic of each method as follows;

(1) Using cable

Cost: Cheapest (OBU shall be equipped the interface of cable connection)
Re-set up: Inconvenient (user should go to OBU Issue Office and bring the OBU)

Figure 10.2 Set up using Cable

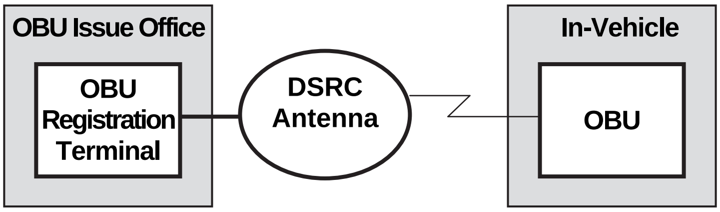


Source: The Study Team

(2) Using DSRC antenna

Cost: Expensive (DSRC antenna shall be installed on each OBU Issue Office)
Re-set up: Convenient (can be set up at OBU Issue Office and Tollgate)

Figure 10.3 Set up OBU using DSRC antenna

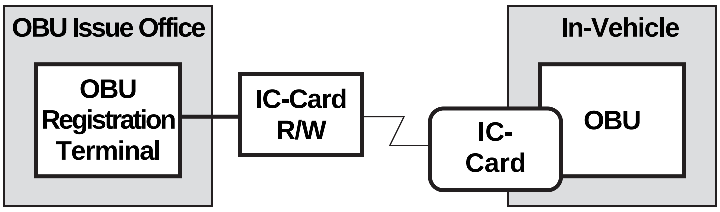


Source: The Study Team

(3) Using IC-Card

Cost: Cheaper (OBU shall be 2 piece type and IC-Card R/W shall be installed on each OBU Issue Office)
Re-set up: Convenient (can be set up at OBU Issue Office and Tollgate)

Figure 10.4 Set up OBU using IC-Card



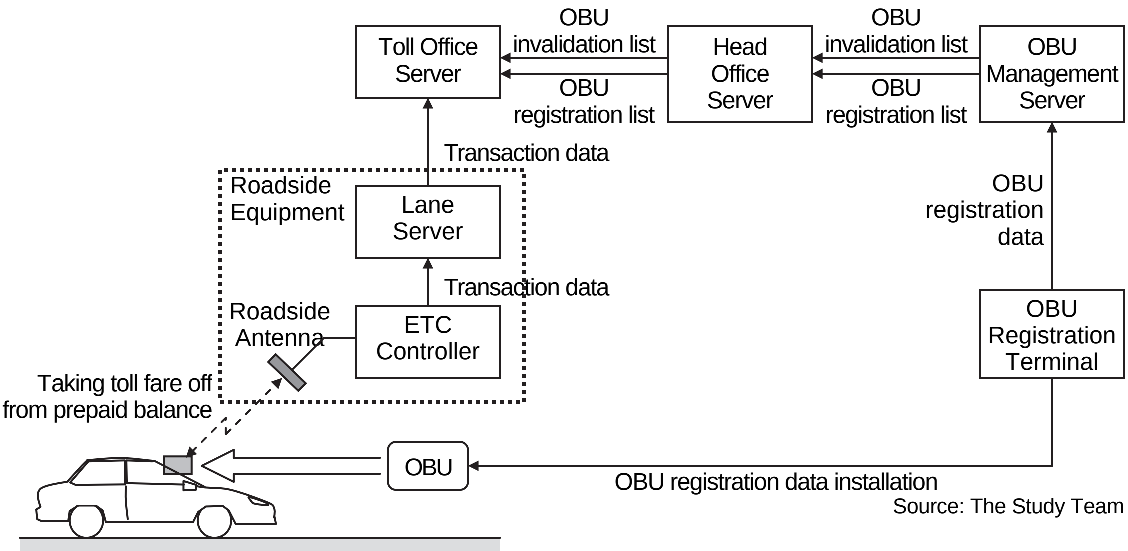
Source: The Study Team

10.3 Data Set for OBU Management

(1) OBU Registration/Invalidity

Major messages for OBU in the procedures of registration, toll collection and invalidity management are to be exchanged as shown in the following figures.

Figure 10.5 Major Message Exchanges of OBU



Source: The Study Team

The data set and principal data elements to be recorded in OBU are shown in the table below.

Table 10.1 Data Set and Principal Data Elements to be Recorded in OBU

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
OBU Registration Data Set <R - OBU>	Management Organization ID	INT	12	1	OBU registration	Permanent
	OBU ID	INT	12	1		
	OBU Owner ID	INT	18	1		
	License Plate Number	TXT	12	1		
	Vehicle Class	TXT	2	1		
	Date of Issue	TXT	8	1		
	Date of Expiry	TXT	8	1		
OBU Passage Data Set <R - OBU>	Toll Office ID	INT*	4	3	Each passage at tollgate	Latest
	Tollgate ID	INT*	4			
	Lane ID	INT*	4			
	IC-card ID	INT	12			
	Toll Amount	FLOAT	4			
	Prepaid Balance	INT	8			
	Date/Time	Datetime	≥14			
OBU Invalidation List Data Set <G - Server>	Management Organization ID	INT	12	1	Daily + Upon Demand	1 year
	OBU ID for Invalidation	INT	12	N		
	OBU Owner ID	INT	18			
	License Plate Number	TXT	12			
	Vehicle Class	TXT	2			
	Date of Issue	TXT	8			
	Date of Expiry	TXT	8			
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Inputed; G: Generated; C:Checked; R: Recorded

Source: The Study Team

PART 5: VEHICLE WEIGHING SYSTEM (FOR REFERENCE)

TABLE OF CONTENTS

1. Introduction

Service descriptions:

This service eliminates overloading of heavy trucks by automatic execution of vehicle weighing at interchanges. It restrains damage to the road structure and extends its durable lifetime. This service restrains congestion caused by heavy trucks and allows freight trans-port to improve safety by eliminating overloading. This service allows prompt action of the road operator at the occurrence of serious accidents caused by heavy trucks and hazardous-material trucks and appropriate vehicle operation by keeping track of the trucks on the expressway network.

Functional packages to be included in the system:

(20) Axle load measurement
(21) Measurement lane monitoring.

2. Use Case and General System Architecture

Use cases and general system architecture are illustrated for the following implementation packages of vehicle weighing:

(1) Vehicle weighing
(2) Center-to-center Data Exchange.

Relationships between the system and users/operators/other-systems are illustrated by the following use case diagrams in the design drawings:

Road traffic supervision

- Axle load measurement
- Axle load data management
- Overloading regulation assistance.

The general system architecture is sown using collaboration diagrams and message sequence diagrams titled as below in the design drawings:

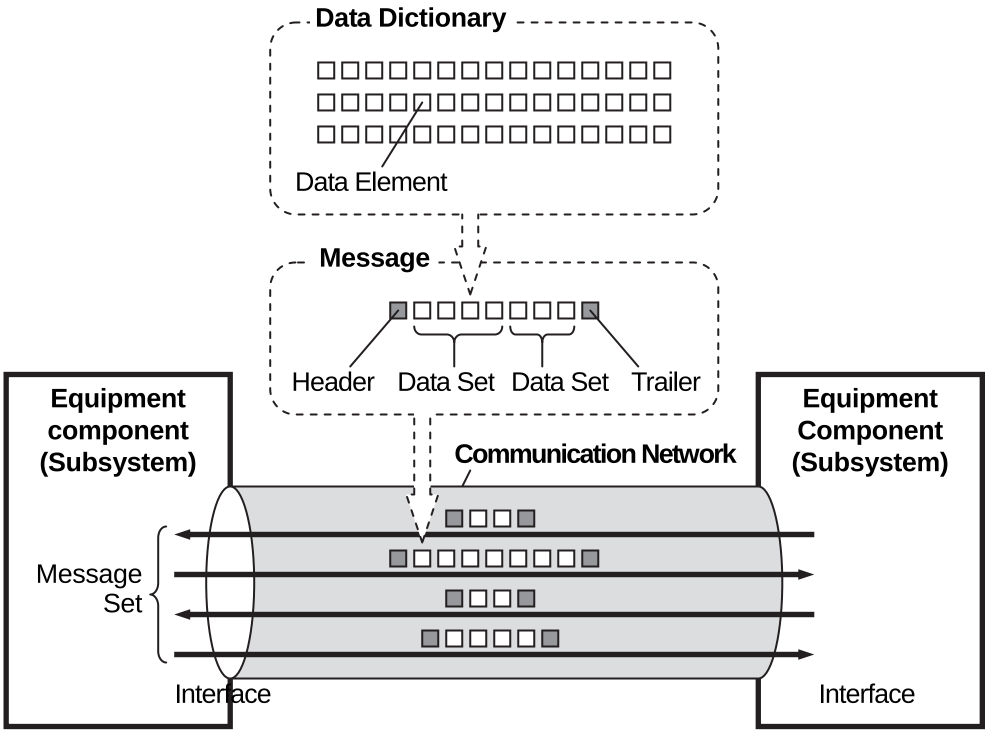
(1) Vehicle weighing by axle load scale
(2) Center-to-center data exchange for heavy truck control.

3. Message/Data Design

3.1 General

ITS consists of many pieces of equipment, which are illustrated as the equipment components in the diagrams of system architecture. The equipment components need to be connected with each other by communication network in order to exchange messages and data between them, to actualise the system and to provide intended services.

Figure 3.1 Conceptual Illustration of Message/Data Exchange



Source: The Study Team

3.2 Major Message List

The major message list for vehicle weighing system is shown in the following table.

Table 3.1 Major Message List of Vehicle Weighing System

Name of Message	A Pair of Equipment Components on Both Side of Interface through Which Message is Exchanged		Name of Include Data Sets
Over Loading Message	Heavy Truck Control Data Server	Traffic Event Data Server	Axle Load Measurement Data Set Over Loading Vehicle Data Set
License Plate Message	Vehicle Detector	Heavy Truck Control data Server	License Plate Recognition Data Set
Axle Load Measurement Data Set	Axle Load Scale	Heavy Truck Control data Server	Axle Load Measurement Data Set

Source: The Study Team

3.3 Primary Data Dictionary

Primary data dictionary for vehicle weighing system is shown in the table below.

Figure 3.2 Primary Data Dictionary for Vehicle Weighing System

	Major Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin	Definition
30	Axle Load Measurement Data Set <G -Axle Load Scale>	Road Section ID	INT*	4	1	When overloading data detected	6 months	An unique identifier of the road section where the axle load scale installed
		Axle Load Scale Location ID	INT*	4	1			An unique identifier of install location of axle load scale
		Lane ID	INT*	2	1			An unique identifier of the lane of axle load scale (Numbered from the median)
		Number of Axles	INT*	2	1			Number of axles (less than or equal to 10)
		Axle Load	INT*	2	10			Measurement data of load of an axle (unit: Ton)
		Maximum Axle Load	INT*	2	1			Maximum value of measured axle loads of a vehicle (unit: Ton)
		Axle Load Status	INT*	2	1			Status of the axle load scale: - 0: Normal - 1: Suspicious at overloading - 2: Overloaded
		Serial Number of Vehicle	INT	5	1			Daily serial number for a vehicle passing through the axle load scale. (For reference to other data set)
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
31	Axle Load License Plate Data Set <G -Image Processor>	Road Section ID	INT*	4	1	When overloading data detected	6 months	An unique identifier of the road section where the axle load scale installed
		Axle Load Scale Location ID	INT*	4	1			An unique identifier of install location of axle load scale
		Lane ID	INT*	2	1			An unique identifier of the lane of axle load scale (Numbered from the median)
		Roadside Equipment ID	INT*	4	1			An unique identifier of a license recognition device
		Captured License Plate Number	TXT	12	1			License plate number recognized by image processor
		Captured License Plate Image	IMG	var	1			The license plate image captured by CCTV camera
		Serial Number of Vehicle	INT	5	1			Daily serial number for a vehicle passing through the axle load scale. (For reference to other data set)
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set
32	Axle Load Management Data Set <G/C-Server>	Road Owner ID	INT*	4	1	Hourly	1 year	An unique identifier of a road owner
		Road Section ID	INT*	4	1			An unique identifier of the road section where the axle load scale installed
		Axle Load Scale Location ID	INT*	4	1			An unique identifier of install location of axle load scale
		Lane ID	INT*	2	1			An unique identifier of the lane of axle load scale (Numbered from the median)
		Date/Hour of Record	TXT	10	1			Day/month/year/hour of the record
		Number of Heavy Trucks	INT	5	1			Number of heavy trucks measured
		Number of Suspicious Trucks	INT	5	1			Number of heavy trucks suspicious at overloading
		Number of Overloaded Trucks	INT	5	1			Number of heavy trucks overloaded
		<u>Axle Load Measurement Data Set</u>	Set	var	N			Axle load measurement data set of vehicle passing through axle load scale
		Axle Load Status	INT*	2				Status of the axle load scale: - 0: Normal - 1: Suspicious at overloading - 2: Overloaded
		Serial Number of Vehicle	INT	5				Daily serial number for a vehicle passing through the axle load scale. (For reference to other data set)
		Date/Time	Datetime	≥14	1			Year/ month/day/hour/minutes/second of generating data set

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

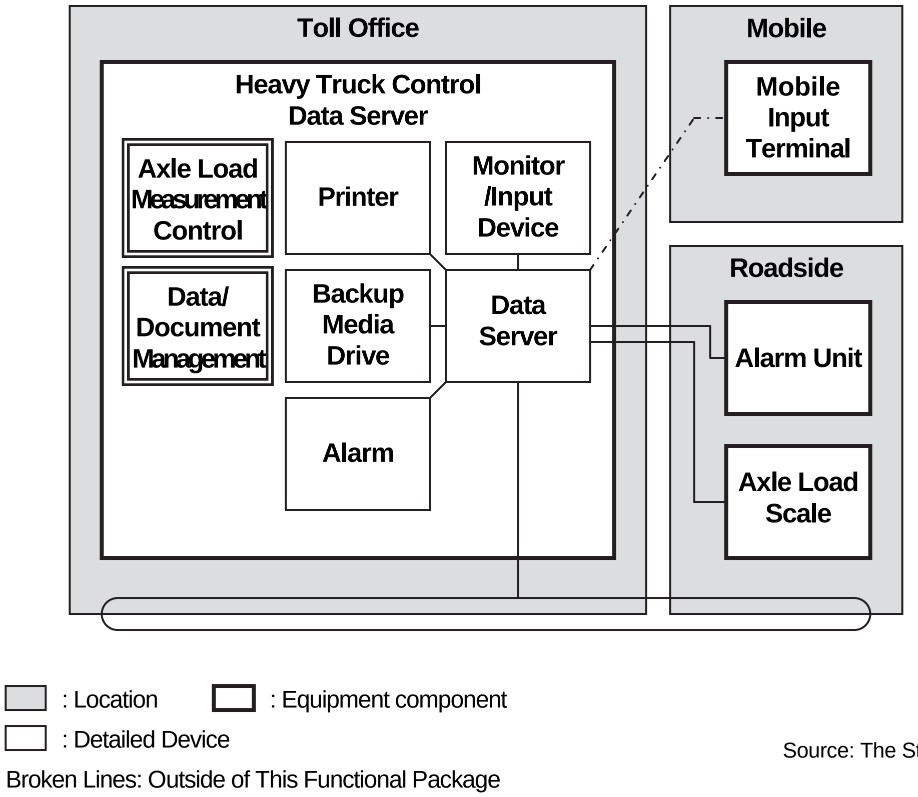
Source: The Study Team

4. Axle Load Measurement

4.1 Outline and System Architecture

This functional package allows the road operators to detect/regulate overloaded heavy trucks on the expressways by using axle load scale installed in the exit tollgate lane exclusive for large-size vehicles.

Figure 4.1 System Architecture for Axle Load Measurement



Source: The Study Team

4.2 Procedure of Axle Load Measurement

(1) General

Axle load measurement function is measuring and recording functions of the axle load of heavy trucks which drive low speed. The judgement is made whether the measured result exceed the limited load or not with combination of other functions.

(2) Objective Heavy Trucks to be Measured

The objective heavy trucks to be measured are all vehicles which pass the axle load measurement system zone to be located after passing entrance toll gate of expressway dedicated only for heavy trucks.

(3) Measuring Item and Measuring Range

Measuring item and measuring range is shown in the following table.

Table 4.1 Measuring Item and Measuring Range

No.	Measuring Item	Measuring range	Resolution
1	Axle load	1.0 – 20 ton	0.1 ton
2	Number of Axles	2 – 7 axles	
3	―	40 km/h	

Source: The Study Team

- Gross weight of the heavy truck is calculated by summation of each axle load
- Number of axles more than 7 is deemed as 7, and the load for more than 8th axle should be added to 7th axle load basically
- Although the driving speed of heavy truck is not measurement item, it is assumed that there will be a sign board showing max 20km/h. However since the location of axle load measurement system zone is after the entrance toll gate, the condition for measurable speed is 40km/h

4.3 Required Functions/Performance of Equipment

The allowable measurement error of the equipment component is considered within 10% for 95% of measured heavy trucks based on the condition shown in the previous measurement range, and also under the condition of installation of equipment component shown in the following item.

4.4 Location of Axle Load Scale

Axle load scale for the overloading regulation can be installed in the following three locations:

- Location alternative 1: Closely back from entrance tollgates
- Location alternative 2: Closely behind entrance tollgates
- Location alternative 3: Closely back from exit tollgates.

The location closely back from exit tollgates is recommended for axle load scale comparing advantages and disadvantages of three alternatives above as summarized in the table below.

Table 4.2 Comparison on Location Alternatives of Axle Load Scale

	Location Alternative 1	Location Alternative 2	Location Alternative 3
Securing of Conformance to Jurisdiction of Road Operator	Difficult	Capable	Capable
Measuring Accuracy by Controlling Vehicle Trail in a Tollgate Lane	Capable (within Tollgate Lane)	Capable (within Tollgate Lane)	Capable (within Tollgate Lane)
Necessity of Large Land Acquisition for Rejecting Overloaded Vehicles	Necessary	Necessary	Not Necessary
Installation into Every Tollgate for Preventing Avoidance/Unfairness	Difficult	Difficult	Possible
Effects of Rejecting Overloaded Vehicles from the Expressway	Average	Average	High
Grading	Not Suitable	Comparable	Recommended

Source: The Study Team

4.5 Axle Load Scale Arrangement at Tollgate

Arrangement criteria of axle load scale are defined responding to design traffic volume passes through the tollgate and according to the basic policy that heavy vehicles are to be processed in the tollgate lanes near roadside.

Table 4.3 Arrangement Criteria of Axle Load Scale

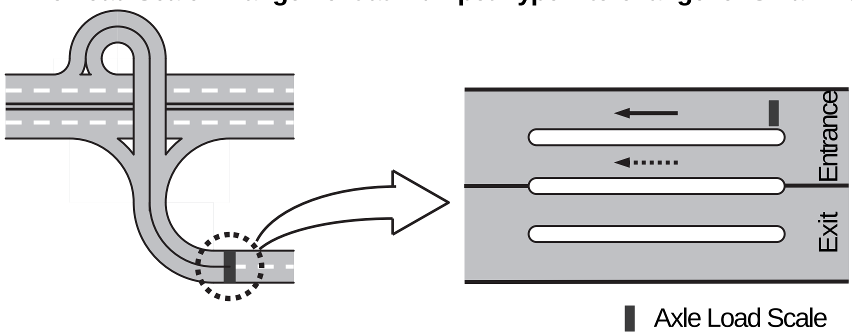
	Small Traffic Volume	Average Traffic Volume	Large Traffic Volume	
For Overloading Regulation	Axle Load Scale Arrangement Criteria 1	Axle Load Scale Arrangement Criteria 2	Axle Load Scale Arrangement Criteria 3	Axle Load Scale Arrangement Criteria 4

Source: The Study Team

(1) Axle Load Scale Arrangement Criteria 1

As the standard arrangement for the tollgate consists of two lanes in each direction at a trumpet-type interchange for small traffic volume, an axle load scale is to be installed on the roadside lane of entrance tollgate as shown in the figure below.

Figure 4.2 Axle Load Scale Arrangement at Trumpet-Type Interchange for Small Traffic Volume

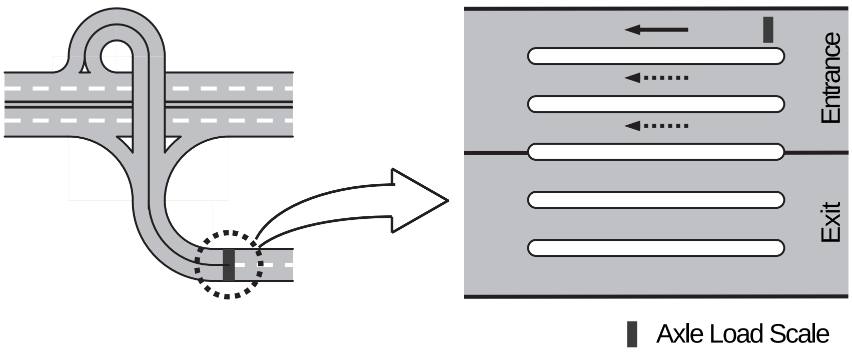


Source: The Study Team

(2) Axle Load Scale Arrangement Criteria 2

As the standard arrangement for the tollgate consists of three lanes in each direction at a trumpet-type interchange for middle traffic volume, an axle load scale is to be installed on the roadside lane of entrance tollgate as shown in the figure below. In the later stage, when overloaded trucks increase, axle load scale is to be installed additionally in other lane.

Figure 4.3 Axle Load Scale Arrangement at Trumpet-Type Interchange for Small Traffic Volume

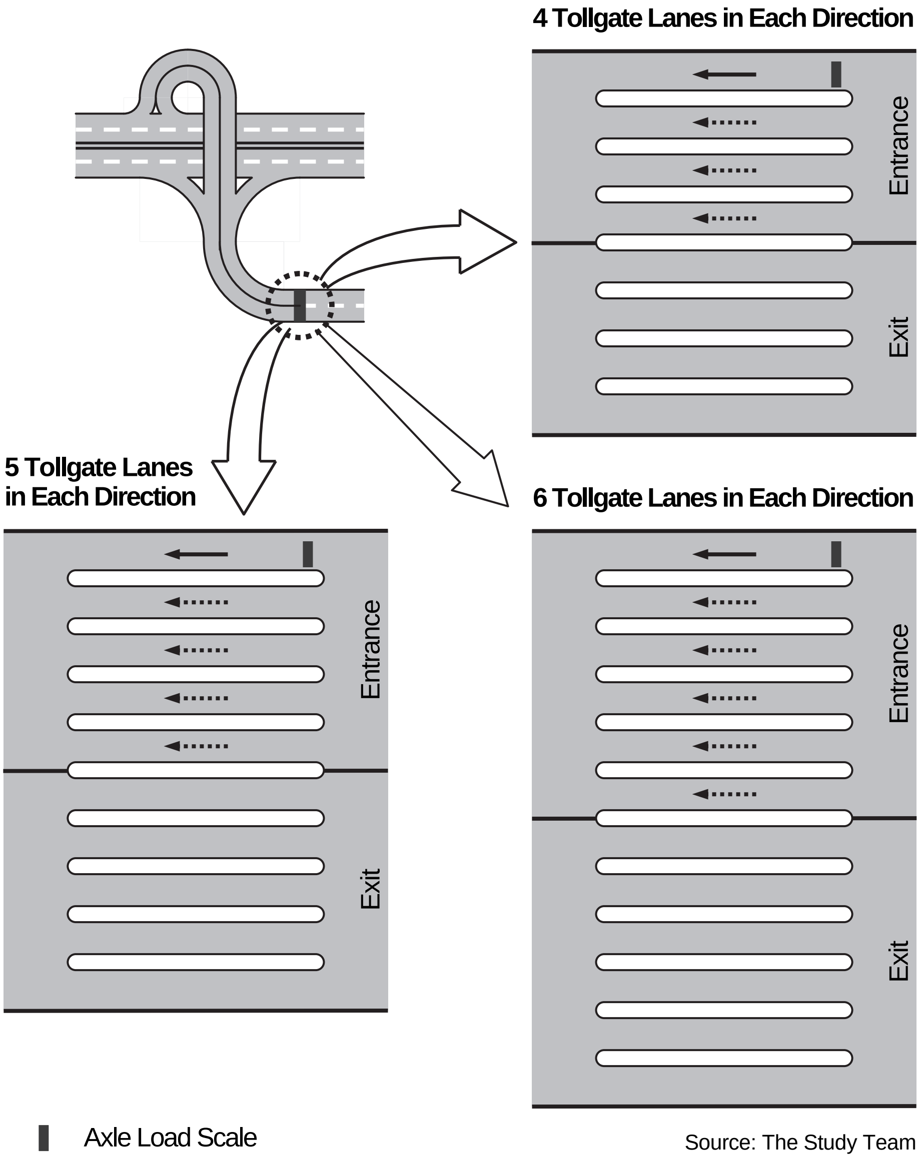


Source: The Study Team

(3) Axle Load Scale Arrangement Criteria 3

As the standard arrangement for the tollgate consists of more than four lanes in each direction at a trumpet-type interchange for large traffic volume, an axle load scale is to be installed on the roadside lane of entrance tollgate as shown in the figure below. In the later stage, when overloaded trucks increase, axle load scale is to be installed additionally in other lane.

Figure 4.4 Axle Load Scale Arrangement at Trumpet-Type Interchange for Small Traffic Volume

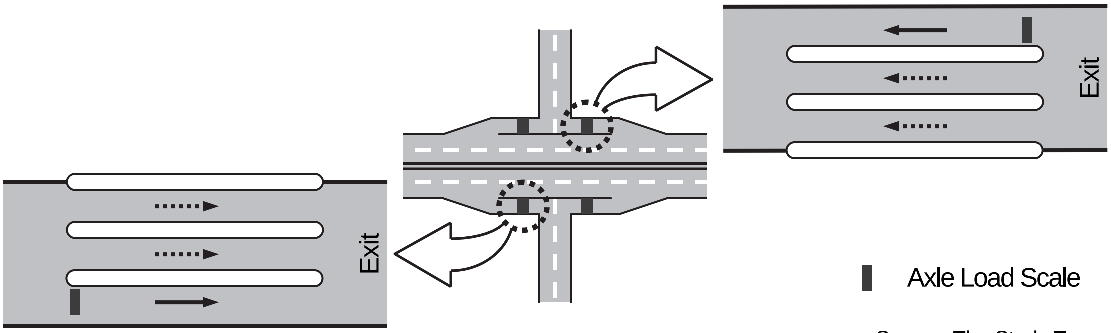


Source: The Study Team

(4) Axle Load Scale Arrangement Criteria 4

As the standard arrangement for the tollgate consists of three lanes in each direction at a diamond-type interchange for middle traffic volume, an axle load scale is to be installed on the roadside lane of entrance tollgate as shown in the figure below. In the later stage, when overloaded trucks increase, axle load scale is to be installed additionally in other lane.

Figure 4.5 Axle Load Scale Arrangement at Diamond-Type Interchange for Large Traffic Volume



Source: The Study Team

(5) Installation of Major Equipment Components

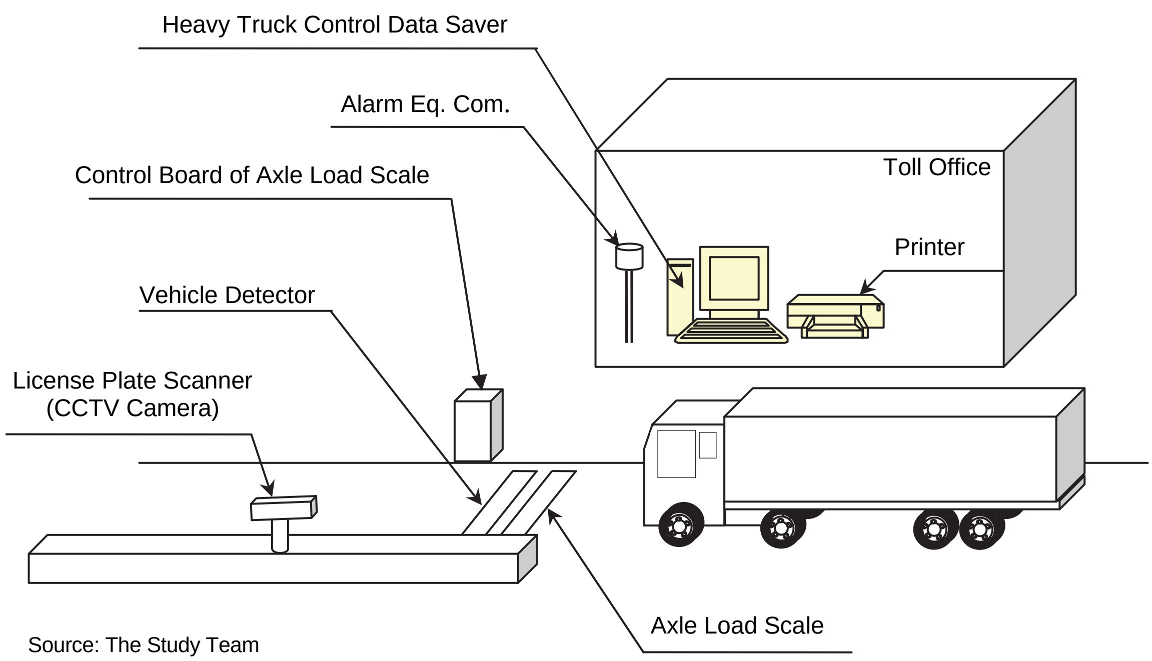
This functional package is implemented for toll office and related roadside only. For project implementation, specific location is required to be specified in detail.

The major equipment components are described in the following items;

- **Axle Load Sensor :**
  Measure the axle weight of vehicle
- **Control Board for Axle Load Scale :**
  Control the axle load scale, receive the measured data from the scale and transmit the data to the Heavy Truck Control Data Server
- **Heavy Truck Control Data Server :**
  It is the center item of axle load measurement for organize collection of the axle weight data, calculate the total weight of the vehicle, detect the overloading from calculated data, control alarm equipment when detect the overloading vehicle
- **Alarm Equipment :**
  Calling for attention when detect the overloading vehicle. It is should be installed in the tollbooth and the toll office
- **Vehicle Detector :**
  Detect the vehicle coming into the measurement lane
- **License Plate Scanner :**
  Recognize for the license plate information by image

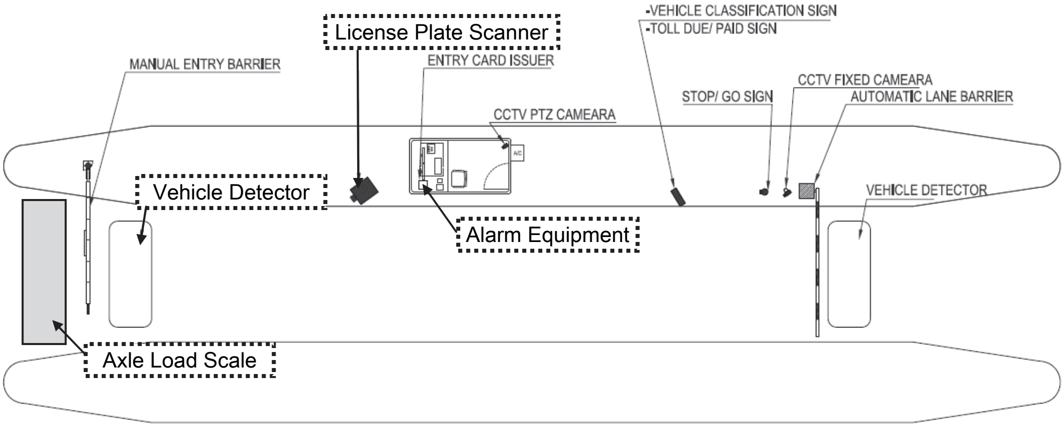
General equipment component location is shown in the following figure as a typical case.

Figure 4.6 Major Equipment Components Arrangement



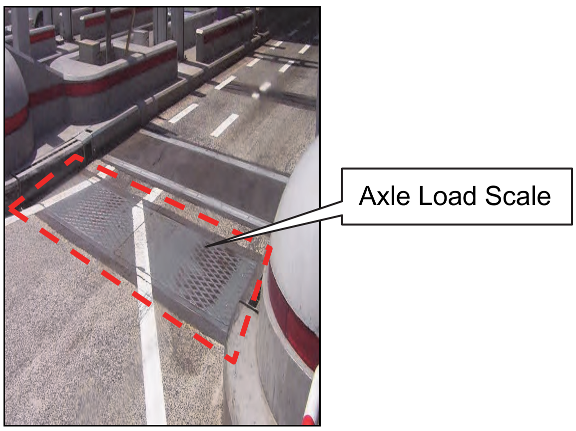
Source: The Study Team

Figure 4.7 Layout of relevant equipment for Axle Load measurement on Tollgate



Source: The Study Team

Figure 4.8 Installation example of Axle Load Scale at Tollgate



Source: NEXCO

Above these figure is conceptual ones, and it is not shown precise system or combination of equipment components. As for the software to be realized necessary functions, as mentioned above, it may be installed in another equipment component under the conditions that total necessary functions are covered by others.

(6) Installation Condition of Equipment Component

The equipment installation condition to be guaranteed for the previous error rate is shown below;

- Gradient Ratio: Cross and longitudinal slope ratio should be within 2%
- Road surface dent due to track: The road surface should be well maintained that there should not be observed apparent rolling or pitching of the heavy truck visually

4.6 Required Documents/Forms

The required Documents/Forms are listed below. The data for these documents can output by CSV format. The item output by CSV is shown in the following tables.

- Overloading Report for Each Vehicle
- Daily Report for Overloading
- Monthly Report for Overloading
- Yearly Report for Overloading

Table 4.4 Item for Overloading Report for Each Vehicle

Data Elements	Type
Road Section ID	INT*
Axle Load Scale Location ID	INT*
Lane ID	INT*
Number of Axles	INT*
Axle Load	INT*
Maximum Axle Load	INT*
Axle Load Status	INT*
Serial Number of Vehicle	INT
Date/Time	Datetime

Table 4.5 Item for Summary Report

Data Elements	Type
Road Owner ID	INT*
Road Section ID	INT*
Axle Load Scale Location ID	INT*
Lane ID	INT*
Date/Hour of Record	TXT
Number of Heavy Trucks	INT
Number of Suspicious Trucks	INT
Number of Overloaded Trucks	INT
Axle Load Measurement Data Set	Set
Axle Load Status	INT*
Serial Number of Vehicle	INT
Date/Time	Datetime

Note: INT* : Short integer

Source: The Study Team

4.7 Data Set for Axle Load Measurement

The measurement data is composed of the following items:

Table 4.6 Data Set List for Axle Load Measurement

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Axle Load Measurement Data Set <G -Axle Load Scale>	Road Section ID	INT*	4	1	When overloading data detected	6 months
	Axle Load Scale Location ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Number of Axles	INT*	2	1		
	Axle Load	INT*	2	10		
	Maximum Axle Load	INT*	2	1		
	Axle Load Status	INT*	2	1		
	Serial Number of Vehicle	INT	5	1		
	Date/Time	Datetime	≥14	1		
Axle Load License Plate Data Set <G -Image Processor>	Road Section ID	INT*	4	1	When overloading data detected	6 months
	Axle Load Scale Location ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Roadside Equipment ID	INT*	4	1		
	Captured License Plate Number	TXT	12	1		
	Captured License Plate Image	IMG	var	1		
	Serial Number of Vehicle	INT	5	1		
	Date/Time	Datetime	≥14	1		
Axle Load Management Data Set <G/C-Server>	Road Owner ID	INT*	4	1	Hourly	1 year
	Road Section ID	INT*	4	1		
	Axle Load Scale Location ID	INT*	4	1		
	Lane ID	INT*	2	1		
	Date/Hour of Record	TXT	10	1		
	Number of Heavy Trucks	INT	5	1		
	Number of Suspicious Trucks	INT	5	1		
	Number of Overloaded Trucks	INT	5	1		
	Axle Load Measurement Data Set	Set	var	N		
	Axle Load Status	INT*	2			
	Serial Number of Vehicle	INT	5			
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

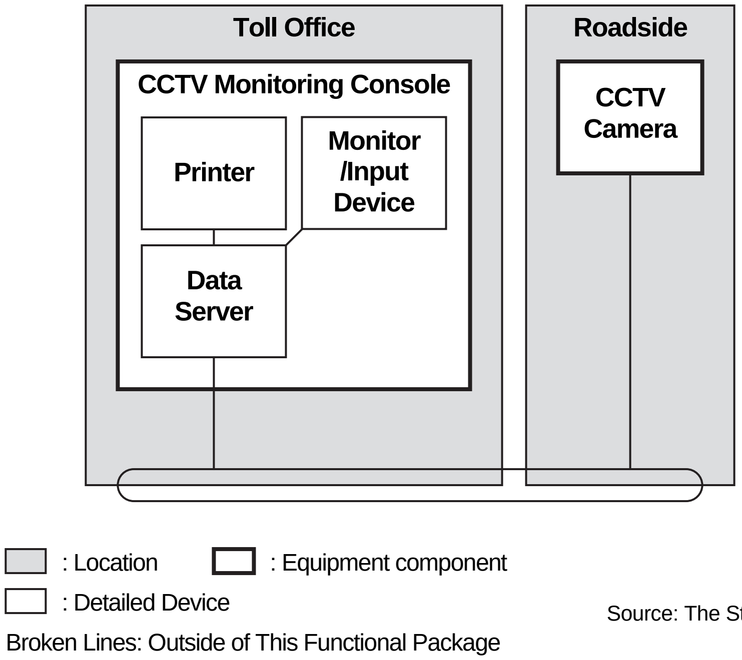
Source: The Study Team

5. Measurement Lane Monitoring

5.1 Outline and System Architecture

This functional package allows the road operators to store/retrieve data of the heavy trucks overloaded on the expressways by using computers and software installed in the road management office.

Figure 5.1 System Architecture for Measurement Lane Monitoring



Source: The Study Team

5.2 Conditions to be Monitored

CCTV camera is to give assistance for operator to monitor the following conditions:

- Vehicle coming into the measurement lane
- Class and appearance of the vehicle
- Activities of the driver and the operator
- Occurrence of trouble and response to it in the measurement lane
- Vehicle going out from the measurement lane

5.3 Data Set for Measurement Lane Monitoring

Table 5.1 Data Set List for Management Lane Monitoring

Data Set <Origin>	Data Elements	Type	Digit	Set	Update Cycle	Storage Period for Origin
Image Recognition Result Data Set <G - Image Processor>	Road Management Office ID	INT*	4	1	When an event occurs	Latest
	Roadside Equipment ID	INT*	4	1		
	Image Recognition Result Status	INT*	2	1		
	Video Image Address	TXT	60	1		
	Date/Time	Datetime	≥14	1		
Event Image Data Set <G - Server>	Road Management Office ID	INT*	4	1	When an event is checked	1 year
	Roadside Equipment ID	INT*	4	1		
	Place ID	INT*	4	1		
	Video Image ID	INT	8	1		
	Event Video Image	IMG	var	1		
	Traffic Event Data ID	INT	8	1		
	Date/Time	Datetime	≥14	1		
Transaction Data Set <R - Lane Server> (For Reference)	Toll Office ID	INT*	4	1	Each passage at tollgate	6 months
	Tollgate ID	INT	8	1		
	Lane ID	INT*	4	1		
	OBU ID	INT	12	1		
	Vehicle Class in OBU	INT*	2	1		
	License number in OBU	TXT	12	1		
	IC-card ID	INT	12	1		
	Toll Amount	INT	8	1		
	Prepaid Balance	FLOAT	8	1		
	Termination Status	INT*	2	1		
	Serial Number of Vehicle	INT	5	1		
	Date/Time	Datetime	≥14	1		

Note: INT* : Short integer; I: Input; G: Generated; C:Checked; R: Recorded

Source: The Study Team

PART 6: COMMUNICATION SYSTEM

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1. Introduction

1.1 Basic Policy of Communication Network

As for the Basic Policy for Communication Network for ITS, the following points are required.

(1) Securing of redundancy of backbone network

The backbone communication network shall be redundant by combination of ring network configuration so as not to disconnect due to incident or other reasons. If necessary, the back up by communication network carrier is also considered.

(2) Monitoring of fault or failure of the network

In case failure or fault occurs on the specific position of backbone communication network such as disconnection or malfunction, it shall be detected such failure or fault and its location by Regional Main Center or road management office with monitoring function of the network using hardware or software before switch over to the redundant equipment component or network. All such log shall be recorded for recovery of fault.

(3) Securing of QoS for directive communication in emergency case

In case severe incident occurs, it is supposed that communication traffic increases or specific system functions are utilized bursty. In addition, it should be considered that the communication network failure of the related part due to maintenance mistake. Even under such situation, Quality of Service (QoS) for important communication, such as directive of voice communication, shall be secured logically or physically.

1.2 Network Layers

The network for expressway ITS is recommended to composed of the following layers taking actual expressway construction conditions into consideration.

(1) National Layer Network

Communication network among the Regional Main Centers

(2) Integration Layer Network

Communication network among one Regional Main Center and its related road management offices

(3) Road Section Layer Network

Communication network among one road management office and its related terminal nodes

(4) Terminal Layer Network

Communication network among terminal node and roadside equipment components

1.3 Communication Traffic

The communication traffic for ITS operation will be voice, data and moving image, and details are shown below;

(1) Voice Communication

The Traffic for directive communication and administrative telephone

(2) Data and moving image

Moving image monitored by CCTV camera, data obtained by roadside equipment components such as weather sensor, and data to the VMS and controlling data for roadside equipment components

(3) Forecasted Communication Traffic

The major communication traffic for considering transmission capacity is moving image to be transmitted from roadside CCTV cameras to Road Management Center and Regional Main Center. The forecasted communication traffic for upstream and downstream is shown in the following table.

Table 1.1 Communication Traffic (Upstream)

No.	Communication Traffic Category	Traffic for Road Section Layer Network	Traffic for Integration Layer Network
1	Moving Images from CCTV Cameras	Approx. 256	128 Mbps (for 20 cameras)
2	Event Detector	Approx. 102 Mbps	Approx. 0.001Mbps (Note a)
3	Vehicle Detector	Approx. 102 Mbps	Approx. 0.5 Mbps
4	Voice Communication	Approx. 1.5 Mbps	Approx. 1.5Mbps
5	Weather Data	Approx. 0.0016 Mbps	None
	Total	Approx. 465 Mbps	Approx. 150Mbps

Note: a) This communication traffic is originated only upon the event is detected.
b) The above communication traffic does not include necessary header volume.

Source: The Study Team

Table 1.2 Communication Traffic (Downstream)

No.	Communication Traffic Category	Traffic for Road Section Layer Network	Traffic for Integration Layer Network
1	Voice Communication	Approx. 2Mbps	Approx.18 Mbps
2	VMS	Approx. 1.2Mbps (Note a)	Approx. 1.2 Mbps (Note a)
	Total	Approx. 4Mbps	Approx. 20 Mbps

Note: a) Multicast technology is applied.
b) The above communication traffic does not include necessary header volume.

The communication traffic calculation basis is shown below; Source: The Study Team

(a) One Road Management Office which covers 60 km expressway section is assumed to include 4 interchanges.

(b) One Regional Main Center assumed to cover approximately 2000 km expressway section including 35 Road Management Offices.

(c) Network Video Recorder (NVR) will be installed in Road Management Office for recording moving images obtained by CCTV camera including event detection and vehicle detection, and not to be installed in Terminal Node.

(d) Equipment for Image Recognition will be installed in Road Management Office and not to be installed in Roadside. Therefore moving image will be transmitted from roadside cameras to NVR located in Road Management Office.

(e) Communication traffic for moving image obtained by one CCTV Camera is assumed approximately 6.4Mbps.

(f) Communication traffic for event detection will be originated only when the event is detected for integration layer network. The approximate traffic for one event detector is assumed 0.001Mbps.

(g) Communication traffic for one vehicle detector will be approximately 5kbyte per 1 minute data for 1 vehicle detector for integration layer network. Therefore the data volume of approximately 0.04Mbps is assumed for one vehicle detector.

(h) In 60 km expressway section managed under one Road Management Office, approx. 40 CCTV cameras for through lane, 16 fixed type cameras for event detection, and 16 fixed type cameras for vehicle detection will be assumed to be installed. (In total approximately 72 moving images obtained by CCTV cameras are transmitted from roadside to Road Management Office.)

(i) In one Regional Main Center, one directive communication console and 10 ~~20~~ sets administrative telephone is assumed to be installed.

(j) Under one Road Management Office, 8 sets directive telephone and 20 sets administrative telephone is assumed to be installed.

(k) One weather station's data which includes data for temperature, wind speed, precipitation and visibility is assumed to be approx. 100 byte. Therefore communication traffic will be approximately 800 bps per station.

(l) Under one Road Management Office, approximately 16 sets VMS and 24 sets of CSS will be estimated to install. Traffic for one VMS and CSS will be approximately 150 Kbyte and 10Kbyte respectively.

(m) As for dissemination of Traffic Information/Control from Regional Main Center, it is assumed under the worst case. However the case of broadcasting is the same traffic of controlling one VMS since switch can make a copy of data if multicast technology is applied. Therefore the data traffic volume is approx. 150Kbyte.

1.4 Appropriate Transmission System for ITS

Basic concept is IP over G-Ethernet is to be applied due to the following reasons;

(1) Consistency with the basic policy of communication network for ITS

The G-Ethernet meets three requirements of the basic policy of communication network for ITS mentioned above.

(2) Connectivity with ITS related equipment components

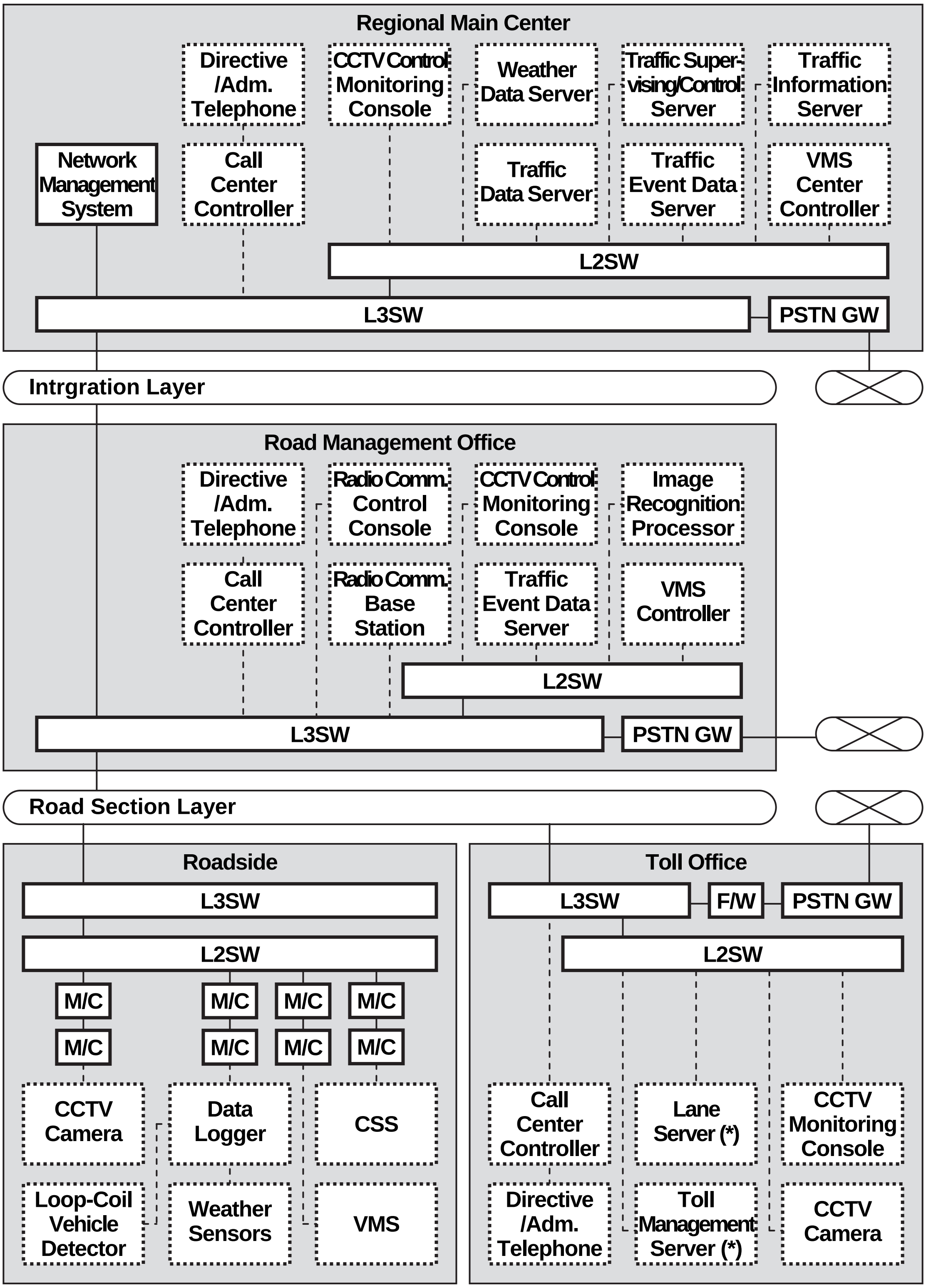
There are no equipment components or systems to be introduced under ITS related project, which is impossible to connect with G-Ethernet.

(3) Availability

Availability of equipment component or spare parts of G-Ethernet related products is widely available currently and this condition will not change in near future. Therefore, such kind of equipment component is expected to utilize longer period.

The Equipment Component of Communication Network for ITS is shown in the Figure 6.1 below;

Figure 1.1 Equipment Component of Communication Network



(*) : (For Reference)

Source: The Study Team

1.5 Basic Communication Equipment Component

The basic communication Equipment component for ITS is shown below;

(1) Layer 3 Switch (L3SW)

Layer 3 Switch (L3SW) is required for the connection between different LANs. In the ITS Integration Project, L3SW is applied for the connection between Northern Regional Main Center and Road Management Offices, and Road Management Office and Terminal Nodes.

(2) Layer 2 Switch (L2SW)

Layer 2 Switch (L2SW) is required for the connection within LAN. In the ITS Integration Project, L2SW is applied for the network under L3SW such as connection between Terminal Node and Roadside Equipment components.

(3) Media Converter (M/C)

Media Converter (M/C) is required where optical/electrical conversion is needed. However in between SWs, Small Form-Factor Pluggable (SFP) transceiver module is recommended to apply.

(4) SIP Server

SIP Server is required to control voice communication. The directive communication should be connected without calling loss.

(5) VoIP Gateway

VoIP Gateway is required to connect voice communication using administrative telephone to other offices and Public Switched Telephone Network (PSTN) and vice versa.

(6) Directive Communication Console

Directive Communication Console is needed for disseminating directive from Regional Main Center to others. It is required in operating room for Traffic Information/Control in Regional Main Center.

(7) Directive Telephone

Directive telephone is required for Regional Main Center, Road Management Offices and Toll Offices. The detailed number is shown later.

(8) Administrative Telephone

Administrative Telephone is required for Regional Main Center, Road Management Offices and Toll Offices. The detailed number is shown later.

(9) Optical Fiber Cable

Optical Fiber Cable is required for connecting network equipment components.

(10) Network Management System (NMS)

Network Management System (NMS) is required for monitoring network operating conditions including fault or failure detection.

(11) IPv4/IPv6 Translator

The IPv4/IPv6 Translator is required to translate the data transmission from IPv4 compatible equipment component to IPv6 only network and vice versa.

1.6 Applicable Protocol

As for the communication network for ITS, IP is recommended to apply as layer 3 for all transmitting data, moving image, and voice communication except for the communication between roadside equipment and data logger/controller. For layer 4, TCP is recommended to apply for data and moving image transmission, and UDP is recommended to apply for voice communication.

1.7 IP Version

IP version 6 is recommended to apply for National Layer and Integration Layer Network. At the project implementation time, most of the Roadside equipment is stall not fully compatible to IPv6. Therefore IPv4/IPv6 Translator is required in the network.

1.8 Network Configuration Overview for ITS Integration Project

The communication traffic necessary for expressway ITS, such as moving image, data and voice, is planed to transmit through the fiber optic transmission system using optical fiber cable basically.

In the target road sections of the project, the section between Noi Bai and Mai Dich through Thang Long Bridge is planned to construct as expressway in future, however this section is ordinary road with open system without access control currently. This section is a part of ring configuration road which is composed of this section, Ring Road 3, Ha Noi – Bac Ninh Expressway Section, and Noi Bai – Bac Ninh Expressway Section. In this ring configuration road, the communication network called Integration Layer which connects Northern Regional Main Center and individual Road Management Offices will be installed, and in the view point to secure redundancy of the important communication network called integration layer, the network route is planned to install along the ring road in order to secure communication route redundancy. However, considering current condition and near future expressway construction plan, the following alternatives are considered for the section between Road Management Office of RR3 and Road Management Office of Noi Bai – Bac Ninh.

(1) Until construction of expressway between Noi Bai and mai Dich, the network is developed using existing road section.

(2) Borrowing existing optical fiber cores for the mentioned section from telecommunications carrier

(3) Borrowing existing duct from telecommunications carrier and installing optical fiber cable under ITS Integration Project

(4) Utilization of communication services such as leased line, VPN or others provided by the telecommunications carrier

Among the options mentioned above, the most suitable option (1) is recommended based on the following points of view for this project;

- Reasonable initial cost is recommended
- Low operation and maintenance cost is recommended
- Redundancy can be secured
- Necessary transmission capacity is 1 Gbps considering the communication traffic for integration layer network shown above

In future, when expressway is constructed between Noi Bai and Mai Dich, it is recommended to install necessary duct and cables, and change over to the newly installed facilities.

The expressway construction project takes long period basically compared to the procurement of ITS equipment component, and there will be the case to make a communication plan for the expressway sections which includes partially uncompleted section. In such case, the fiber optic transmission system is recommended to apply for the expressway section to be completed, and for the section to be uncompleted, above options are recommended to compare. It is important to adopt the suitable combination of the communication systems taking actual expressway construction progress into consideration.

2. Communication System

2.1 General

The communication network for ITS Integration Project is planned to be developed on the basis of IP over Ethernet as mentioned above. The equipment component for communication network is planned to consist of L2SW, L3SW, Media Converter, IPv4/IPv6 translator and Optical Fiber Cable mainly. In addition, Network Management System (NMS) is planned to introduce to monitor the network.

The communication traffic for ITS is composed of moving image, data and voice. The quality of service for the traffic is required to secure based on the timing required under the expressway operation conditions or international standard such as ITU-T Recommendation Y1541. The delay sensitive communication traffic for ITS is voice. Therefore for voice communication, L3SW is applied.

2.2 Planned Network Equipment Component

In order to secure voice communication's quality, L3SW is applied up to Terminal Node which connects voice related equipment components.

AS for the transmission equipment, Small Form-Factor Pluggable (SFP) transceiver module is applied between L3SW and L3SW and L3SW and L2SW taking better maintenance condition compared to Media Converter into consideration. In between L2SW and the roadside equipment, Media Converter is applied since roadside equipment is not able to apply SFP module.

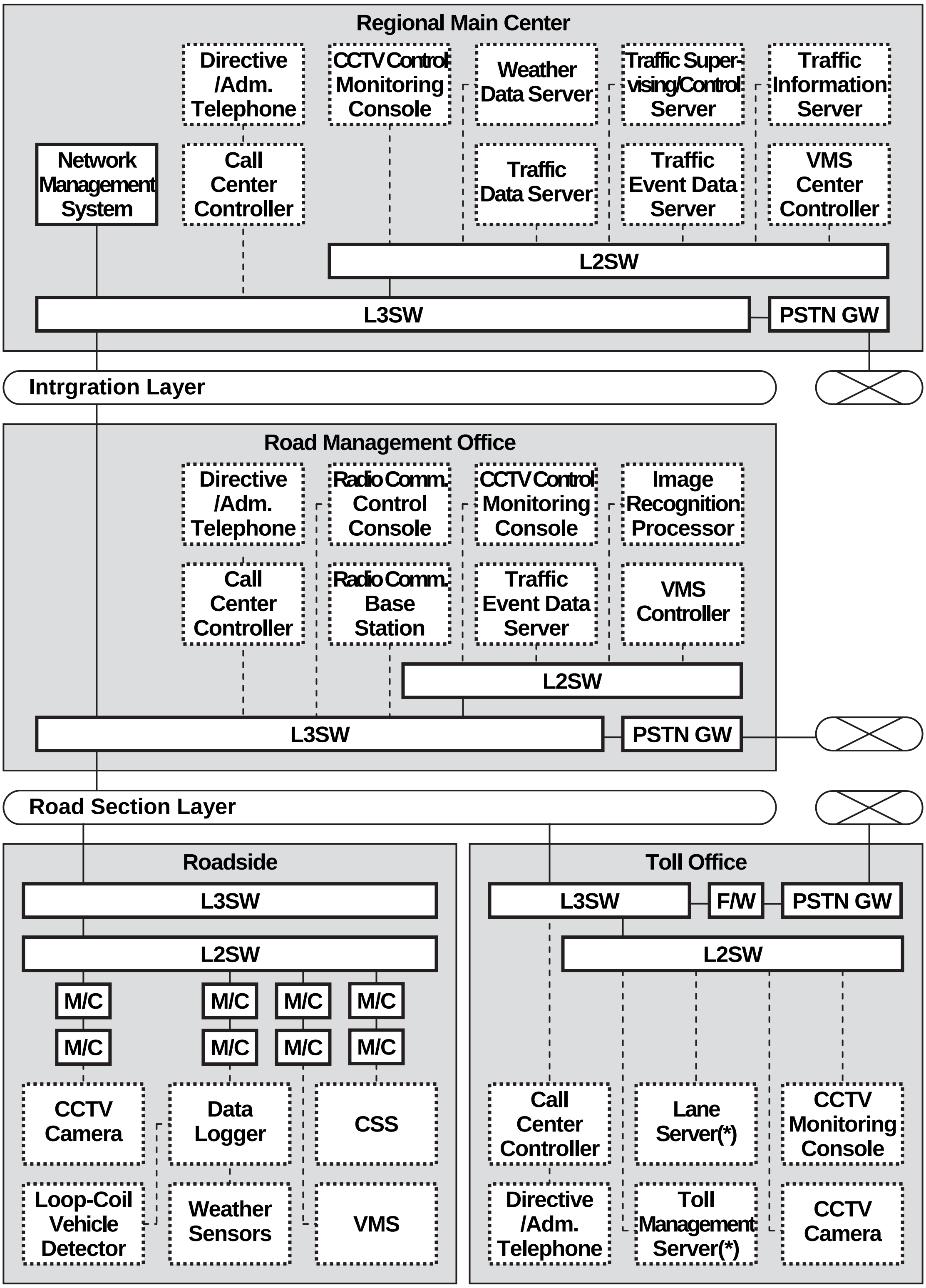
As it is recommended, IPv6 will be applied in future for Integration Network. Therefore IPv4/IPv6 translator is applied.

In addition, in order to monitor the network operating condition, Network Management System (NMS) is planned to install in order to detect the failure or fault of the network. The detail on NMS is described later

The planned equipment component of communication network is shown below.

2.3 System Architecture for Communication System

Figure 2.1 System Architecture for Communication System



(*) : (For Reference)

Source: The Study Team

2.4 Transmission Distance

The transmission distance of the optical fiber cable is limited based on the receivable optical signalling level, and it is different from the optical fiber characteristics and transmission equipment, however in the design of ITS Integration Project, the maximum transmission distance is planed up to 40 km. If the transmission distance exceeds 40 km, repeater is planned to install.

2.5 Number of Optical Fiber Cores

(1) Integration Layer Network

Although the communication traffic from one road management office to the regional main center is small compared to its transmittable capacity of one optical fiber cable as it is shown in the communication traffic mentioned above, 4 cores are recommended to connect between the Regional Main Center and the Road Management Office taking necessary construction years of the expressway into consideration. The breakdown of 4 cores is active 2 cores for upstream and downstream respectively, and another 2 cores for redundancy of the active cores. In addition to the above 4 cores, additional 4 cores are reserved for future necessity. Therefore in total 8 cores are recommended to connect between the Regional Main Center and the Road Management Office.

In this project, those 8 cores is planned to allocate and connect between Northern Regional Main Center and 7 Road Management Offices shown below;

- RMO (RMB) Ring Road No. 3
- RMO Phap Van – Cau Gie
- RMO Cau Gie – Ninh Binh
- RMO Ha Noi – Bac Giang
- RMO (RMB) Noi Bai – Ca Lo Bridge
- RMO (RMB) Ca Lo Bridge – Bac Ninh
- RMO (RMB) Lang – Hoa Lac

It is noted that Road Management Box (RMB) is planned to install roadside which is composed of L3SW, backup power supply facility such as batteries and auxiliaries such as surge protection devices. The RMB is required for the road sections where Hanoi DOT or Bac Ninh DOT manages. In the Box, traffic control system related servers are not installed. Such servers including software is planned to install Northern Regional Main Center until each DOT establish own traffic control center.

In addition to the above 8 cores, additional fiber cores are planned to include for near future necessity to connect the following Road Management Offices to Northern Regional Main Center;

- RMO Hanoi – Hai Phong
- RMO Noi Bai – Lao Cai
- RMO Hanoi – Tai Nguyen (New NH3)

As for the other future possibility to connect other Road Management Offices to Northern Regional Main Center, necessary cable installation space is considered. In the server room of NRMC, the space for future is considered approx. 2 times of this project equipment component volume. Therefore 2 times of cable termination space of this project should be considered to keep in NRMC for future.

If several road management offices can be connected at the same timing, necessary number of fiber cores can be reduced. However, as road construction work takes time generally, 8 cores are allocated for each road section at least.

Thereofre, in this project, 24-core fiber cable is applied for Integration Layer Network for the road section between Northern Regional Main Center and RMO Cau Gie – inh Binh through through Bac Ninh, RR3 and Phap Van including future connection possibility of RMO Hanoi – Hai Phong and another possibility. As for the road section between NRMC and Noi Bai, it is also considered to install 24-core fiber cable since RMO Noi Bai – Lao Cai and RMO New NH3 will be necessary near future in addition to RMO Noi Bai – Ca Lo Bridge.

(2) Road Section Layer Network

The 4 cores are planned to connect between L3SW to be installed in road management office and L3SW to be installed in terminal node basically. The breakdown of 4 cores is active 2 cores for upstream and downstream respectively, and another 2 cores for redundancy of the active cores.

In most cases, as ring configuration is applied for Road Section Layer Network, it will be required to utilize 4 cores for operation and redundancy, and 4 cores for future reservation.

Therefore in total 8 cores are recommended to allocate between L3SW in Road Management Office and L3SW in Terminal Nodes.

Between L3SW in Terminal Node and L2SW for Terminal Layer, it will not ring configuration but 2 active cores and 2 cores for redundancy is required. In addition considering 4 cores are reserved. Therefore 8 cores are required for this connection.

Therefore as Road Section layer Network, 16 cores are required.

(3) Terminal Layer Network

In Terminal Layer, there are mainly two methods to connect the equipment to the Terminal Node as follows;

1) Applying one wave into one optical fiber core and connecting two fiber cores between L2SW connected to Terminal Node and roadside equipment component
2) Applying more than two waves into one optical fiber core and commonly use fiber core between L2SW connected to Terminal Node and roadside equipment components

If we select alternative 2), we need to install multiplexer between one end of optical fiber core and L2SW connected to Terminal Node, and between another end of fiber core and roadside equipment. If additional roadside equipment will be installed in future, the additional multiplexer is required to procure only the product of the same company of the existing one, as different manufacturer's product does not compatible. Therefore we recommend the above alternative 1) connection method.

The number of equipment components to be connected to the roadside L2SW will be 16 sets. Therefore necessary number of optical fiber cores for terminal layer is 32 cores (16x2 cores).

2.6 Number of Optical Fiber Cables

The operation and maintenance of the communication system is recommended to outsource from the road operator to communication service company.

Based on the mentioned operation and maintenance conditions, the optical fiber core for integration layer and road section layer should not combined into one cable since the owner of the facility may be different. On the other hand, the cores for road section layer and terminal layer is recommended to combine as one cable since those cores are managed under one road management office. The necessary number of cables is planned on the basis of above condition.

The cables to be installed in the individual expressway section and number of fiber cores are shown in the table below;

The number of cores shown in the following table is rough target. During project implementation time, installation drawings should be approved taking, number of roadside equipment to be installed, and future spare cores into consideration.

Table 2.1 Number of Optical Fiber Cables and its Number of Cores

Expressway Section	Number of Optical Fiber Cores for Integration Layer Cable	Number of Optical Fiber Cores for Road Section Layer and Terminal Layer	Number of Optical Fiber Cable for the specified expressway section
Lang – Hoa Lac	Note	48(8+8+32)	2
RR3	8	48(8+8+32)	2
Phap Van – Cau Gie	Note	48(8+8+32)	2
Cau Gie – Ninh Binh	Note	48(8+8+32)	2
Ha Noi – Bac Giang	Note	To be installed By VTN	2
Noi Bai – Bac Ninh	Note	48(8+8+32)	2
Hanoi – Hai Phong	8	To be installed	
Noi Bai – Lao Cai	8	To be installed by VTN	
Ha Noi – Thai Nguyen	8	To be installed by VTN	
Others	Not designed yet	Not designed yet	

Note: The same cores to be installed in RR3 are also used for those expressway sections. However as a cable, it includes the cores for other expressway sections shown in the above table. Therefore the cable for integration layer network is 24-core optical fiber cable.

3. Network Management System

3.1 Outline of NMS

Operation condition of the communication network is to be monitored by introducing Network Management System (NMS). The outline of NMS is summarized in the following table.

Table 3.1 Outline of NMS

Network Layer	Location of NMS Display	Supervision Framework
Integration Layer	Communication Equipment Components Room in Regional Main Center	Round the Clock
Road section and Terminal Layer	Monitoring Room in Road Management Office	Monitoring Alert

The Network Management System to be located in a Road Management Office shall be capable to monitor Road Section and Terminal Layer Network under the Road Management Office. The NMS to be located in a Regional Main Center shall be capable to monitor Integration Layer Network under the Regional Main Center.

All network equipment components shall be capable to be monitored by at least one of the above Network Management Systems.

3.2 Functions of NMS

NMS is required to equip the following functions;

(1) Monitoring Alert and Notification Function

Function for detection of origination and recovery of various types of alert and monitoring L3SW, L2SW, roadside equipment is required. Recording function of alert log is necessary, and displaying/printing out function is also required whenever required. Notification function to the operating staff by buzzer or alert display on screen is also required.

(2) Resource Management Function

Function of monitoring operation condition of L3SW, L2SW, roadside equipment which is connected to the network is required. When system configuration is modified, the function of adding system, registration and modification of the equipment component should be also equipped. During replacement of the equipment component, it should be distinguished “Operating Condition” and “under installation”.

(3) Performance Monitoring Function

The function to monitor the communication traffic on the network is required.

(4) Testing Function

Testing function of Communication line and connecting conditions of communication equipment should be equipped.

(5) Switching Function to the Redundant Equipment Component

The switching function to the redundant equipment component should be equipped automatically basically when failure is detected, and it should be capable to distinguish operation conditions of equipment components such as “Normal” or “Trouble” for both in operation and redundant equipment components. If it is not switched over to the redundant equipment component, NMS should be equipped to switch it over manually on mandatory basis. If this function is realized by L3SW, it is acceptable.

3.3 Monitoring Target of NMS

Monitoring target of NMS is shown below;

(1) Switches (L3SW and L2SW)

(2) Roadside Equipment components which is able to allocate IP address

Necessary monitoring items are required to select to detect fault location and faulty conditions.

3.4 Installation Location of NMS

Alert terminal of the NMS is recommended to install in the traffic control room or adjacent area in the Regional Main Center and Road Management Office so as to share such information with traffic control operator on duty.

PART 7: DUCTS, STRUCTURES & OTHERS

TABLE OF CONTENTS

1. Communication Ducts Design

1.1 General

Communication Ducts design should be performed by selecting a rational and economical route as well as method of construction in consideration of various related facilities. Furthermore, "Communication Ducts" is the collective term for communication duct cable rack, cable chamber. etc.

- As duct design is mutually related to earthworks, pavement works, viaduct section works, tunnel section works, etc., its designing should be performed with sufficient understanding of such related regulations and this document.
- Communication ducts means the duct used for communication cables.

1) Installation Location of Ducts

Basically the ducts should be laid underground in earthwork area and should be supported by superstructure at the bridge.

In earthwork area, using the median is better than using the shoulder for easy construction, maintenance and economical considerations. So in case the median is wider than 2.0 m (possible to install chamber), the ducts should be laid in the median.
For other cases in earthwork area, they should be laid in the shoulder.

In case of bridge, the ducts should be set on the outer side of the bridge not in median for easy construction and maintenance. However, in case of Ha Noi Ring Road 3, the ducts must be set in the median due to structural difficulty for setting on the outer side and with regard for aesthetics.

2) Number of Ducts

The required number of ducts should be considered on the basis of one cable for one duct. The number of ducts is calculated that the number of proposed cables plus spare duct(s) for the cables to be installed in future and empty duct which is used only for emergency cable installation for damaged cable replacement. As for the spare duct(s), it is necessary to consider cable for national layer between regional main centers.

In addition, the duct for electric power supply cable is needed to consider. It should be 2 ducts in addition to the communication ducts.

Number of cables to be installed and proposed number of ducts in RR3, Ha Noi – Bac Ninh, and Noi Bai – Bac Ninh is shown in the following table.

Table 1.1 Proposed Number of Ducts and its Calculation Basis for RR3, Ha Noi – Bac Ninh and Noi Bai – Bac Ninh Expressway Section

Layer/Expressway Section	Number of Cable to be installed	Proposed Number of Ducts
Cable for Integration Layer	1	1
Cable for Road Section Layer including Terminal Layer	1	1
Spare ducts for future cable installation (Expressway Extension beyond Hoa Lac, Ha Long, and Ninh Binh including cable for National Layer)	3	3
Empty duct for emergency cable replacement	-	1
Electric Power Supply Cable	1 or 2	2
Total	6 or 7	8

Source: The Study Team

Number of cables to be installed and proposed number of ducts in Lang – Hoa Lac and Noi Bai – Viet Tri is shown in the following table.

Table 1.2 Proposed Number of Ducts and its Calculation Basis for Lang – Hoa Lac, Phap Van – Ninh Binh Expressway Section

Layer/Expressway Section	Number of Cable to be installed	Proposed Number of Ducts
Cable for Integration Layer	1	1
Cable for Road Section Layer including Terminal Layer	1	1
Spare ducts for future cable installation (Expressway Extension beyond Hoa Lac, Ha Long, and Ninh Binh including cable for National Layer)	3*	3*
Empty duct for emergency cable replacement	-	1
Electric Power Supply Cable	1 or 2	2
Total	6 or 7	8

Note: The expansion of Expressway which will be managed under Road Management Office under future project is assumed 3 offices in individual expressway route under the coverage of Northern Regional Main Center.

Source: The Study Team

3) Diameter of Duct

The maximum number of fiber cores required for this project will be 60 cores for Road Section and Terminal Layer Network. However considering future necessity, it should be considered that the cables with higher number of cores should be possible to install. Therefore it is recommended to consider 2 to 3 times of necessary number of cores. In general, available number of fiber cores depends on the manufacturer's cable design, however, widely available number of cores are 48, 72, 96, 144, etc.

The outer diameter of optical fiber cable with 144 cores is considered as 2 to 3 times of necessary number of fiber cores. The outer diameter of the cable with 144 cores for installing in duct is approximately 19mm. The inner diameter of the duct is needed to determine at least 1.7 times of outer diameter of cables. On the basis of this requirement, the inner diameter of duct should be 19 x 1.7 = 32.3 mm, therefore the duct of D40mm with 36 mm inner diameter is recommended to utilize for ITS Integration project

In general, diameter of ducts shall be considered and determined as follows;

4) General Provisions related to Communication Ducts Design

(1) Number of Cables in a Duct

- Communication main cable (optical fiber cable) shall be 1 cable for each duct
- Cables other than above shall be maximum 3 per 1 duct
- Control cables less than 60V and the cables which may affect the signal of the control cable shall not be installed together within same duct

(2) Number of Duct

When cables are to be installed into duct, cable jacket might be damaged due to friction heat, or cable might be damaged due to excessive pulling force. In order to avoid such cases, and taking necessary number of cables to be installed into account, required number of ducts should be considered.

The number of duct is composed of necessary number and spare number of ducts. The reference is made to the following table.

Table 1.3 Number of Ducts

Number	Breakdown	Criterion
Required	Initial stage	Initial number of ducts estimated/calculated based on the required number of cables to be installed.
	Future stage	For sections uneconomical to construct ducts in future, such required number to be estimated and included in the required number of duct.
Reserved for Emergency	Reserve	One duct is to be required for cable replacement for emergency case

(3) Necessary Diameter of Duct

Necessary diameter of a duct when cables are installed should be obtained by the following method

(a) One cable per duct

D≧d+15（In this case d≧30）
D≧1.7d（In this case d＜30）

Note 1: D is inner diameter of duct, d is outside diameter of cable

(b) Laying 2 cables within 1 duct

$D \geqq 1.5(d_1 + d_2)$

Note: D is inner diameter of duct, d_1, d_2 are outside diameters of cables.

(c) Laying 3 cables within 1 duct

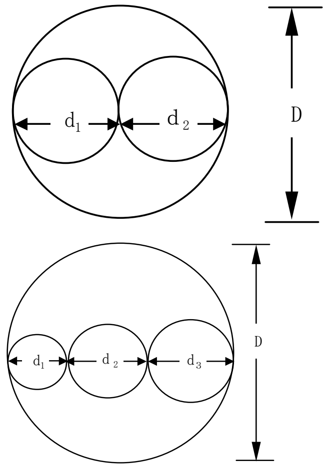
Select inner diameter 2.85 times that of maximum diameter of cable to be inserted and make its numerical value 2.85 times as much as possible.

In case $d_3 \geqq d_2 \geqq d_1$

$D > 2.85 \times d_3$

Note: D is inner diameter of duct, d_1, d_2 and d_3 are outside diameter of cables.

Diameter of cable and duct



(4) Linearity of Duct

Communication duct is recommended to install linearly as much as possible. When it is required to install curve section, radius of the duct run should be as large as possible. If the curved section is required to apply, it shall be minimum 2.5 m in a two cable chambers.

5) Cable Chamber Span

The Cable Chamber which is required for cable installation, jointing, and cable branch, is required to be located cable branch point such as interchange. In normal expressway section, at least one (1) cable chamber should be installed for maximum 333m span taking metal cable installation case into consideration.

1.2 Plan Arrangement

The planning of each project is discussed below.

(1) Ring Road 3

Ring Road 3 is viaduct in all target areas, so the ducts should be supported by superstructure. As mentioned above, they will be set in the median.

From the starting point of Thanh Tri Bridge (the ending point of Ring Road 3) to KM 1 + 120, the ducts should be set in the median sequentially from Ring Road 3.

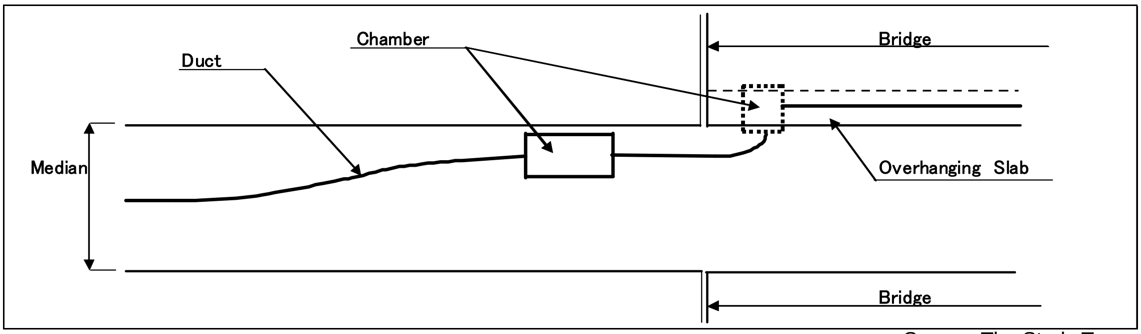
At the abutment (KM 1+120), the ducts will be shifted to the north side shoulder. From this point the ducts should be set in the shoulder in the earthwork area and be set on the outer side of bridges.

(2) Lang – Hoa Lac

The width of median is 20.0 m, so the ducts should be laid in the underground area of the median in the earthwork area.

Before the bridge, the ducts will be shifted to shoulder side smoothly and be set on the outer side of the bridge as shown in Figure 1.1.

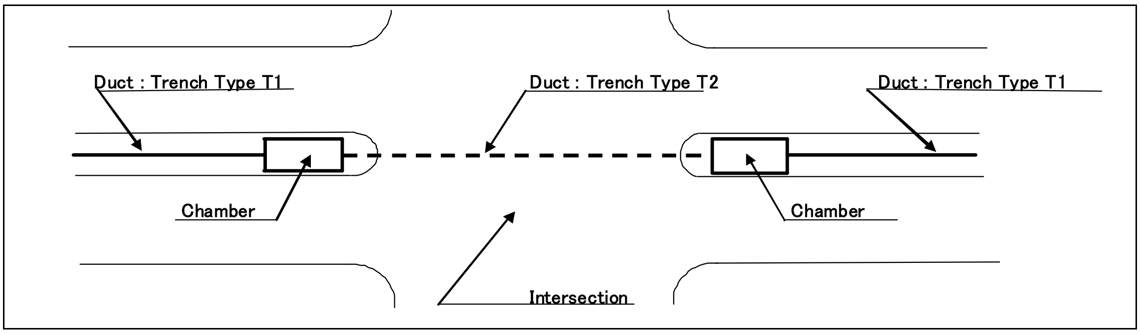
Figure 1.1 Lang-Hoa Lac Duct Arrangement



Source: The Study Team

At the intersection, the ducts cross the intersection from median to the opposite side median changing the Type of duct as shown in Figure 1.2. Type of duct will be explained in section 1.3.

Figure 1.2 Duct Arrangement at the Intersection



Source: The Study Team

(3) Phap Van – Cau Gie

Ducts and Chambers were already designed by CADPRO.
Some equipment that must be added was designed in this project.
Hence ducts and new chambers also were designed in this project.

(4) Cau Gie – Ninh Binh

Ducts and Chambers were already designed by CADPRO.
Some equipment that must be added was designed in this project.
Hence ducts and new chambers also were designed in this project.

(5) Ha Noi – Bac Ninh

The width of median is 3.0 m, so the ducts should be laid underground in the median in earthwork area.

Before the bridge, the ducts will be shifted to the shoulder side and be set on the outer side of the bridge.

(6) Noi Bai – Bac Ninh

There is no median in this area, so the ducts should be laid underground on the shoulder in the earthwork area. When there is widening to south according to the plan in the future, the ducts will be set on the north side shoulder to avoid being any obstruction against to the widening working.

In the bridge, the ducts will be set on the northern outer side of the bridge.

(7) Noi Bai – Viet Tri (for Reference)

The width of median is 1.5 m which is not sufficient for setting a chamber in it, so the ducts should be laid underground in the shoulder in the earthwork area.

North side shoulder will be used for setting ducts because of the connection to the Noi Bai-Bac Ninh project.

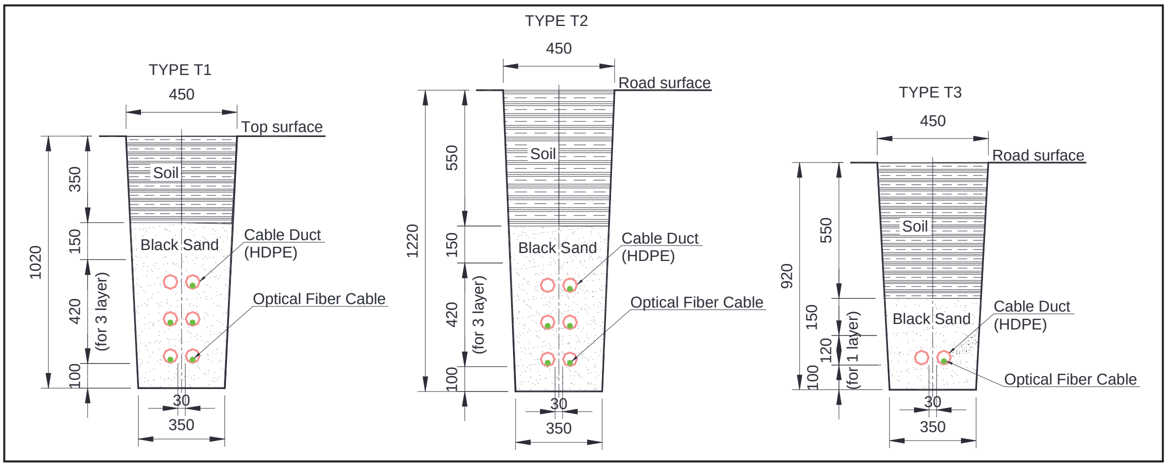
In the bridge, the ducts will be set on the northern outer side of the bridge.

1.3 Earthwork Sections

Ducts should be laid underground in the median or in the shoulder.

In case of using the median, trench type T1 is adopted if there is no effect by vehicle load. In case of using the shoulder, trench type T2 is adopted that does consider vehicle load. In the part connecting to CCTV or VMS, type T3 is adopted as shown in Figure 1.3.

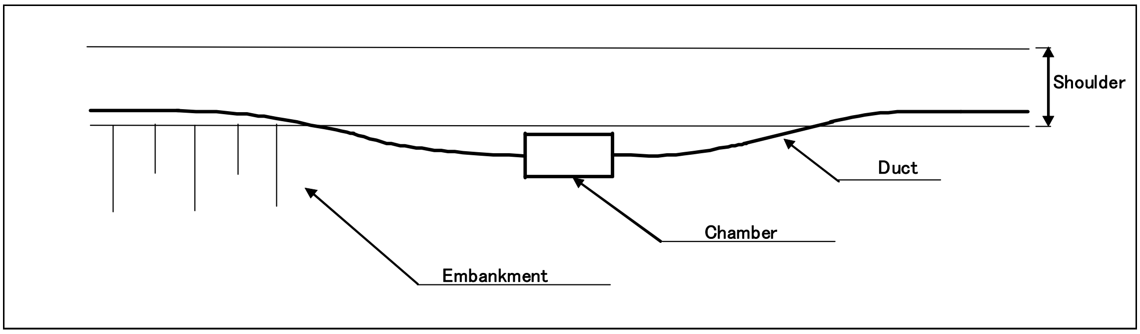
Figure 1.3 Earthwork Area Trench Types



Source: The Study Team

In the case of using the shoulder, the chamber should be set outside of the shoulder in consideration for driver safety. Hence, the ducts must be sifted smoothly to the chamber as shown in Figure 1.4.

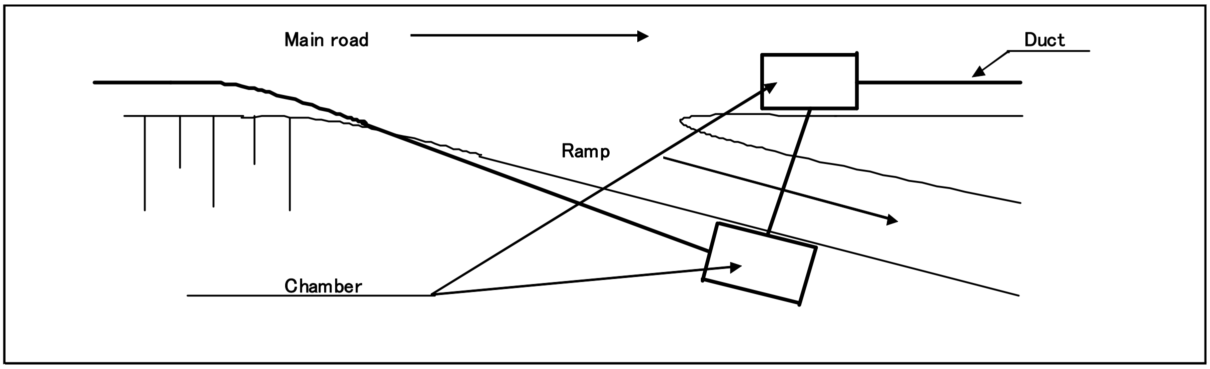
Figure 1.4 Shifting Ducts to a Chamber



Source: The Study Team

In the interchange, the ducts cross ramps, so it is desirable that the ducts cross the ramp along the shortest possible route because of easy and safe maintenance as shown in Figure 1.5.

Figure 1.5 Ducts at Interchanges with the shortest possible route



Source: The Study Team

1) General Provisions related to Communication Ducts Installation in earthwork section

Location of embedded ducts in earthwork sections should be where specified covering depth and linearity can be secured, difficulty of installation due to other existing underground utilities and structures is negligible and design is required to be performed in consideration of safety of duct, work efficiency, economical efficiency, etc.

(1) Ducts are recommended to be buried within the same cross section of earthwork of expressway during road construction time simultaneously. The duct is required to be installed at a depth and location to keep its strength, where it is not endangered during and after construction and considering the depth and location preventing damage from vehicle accident.

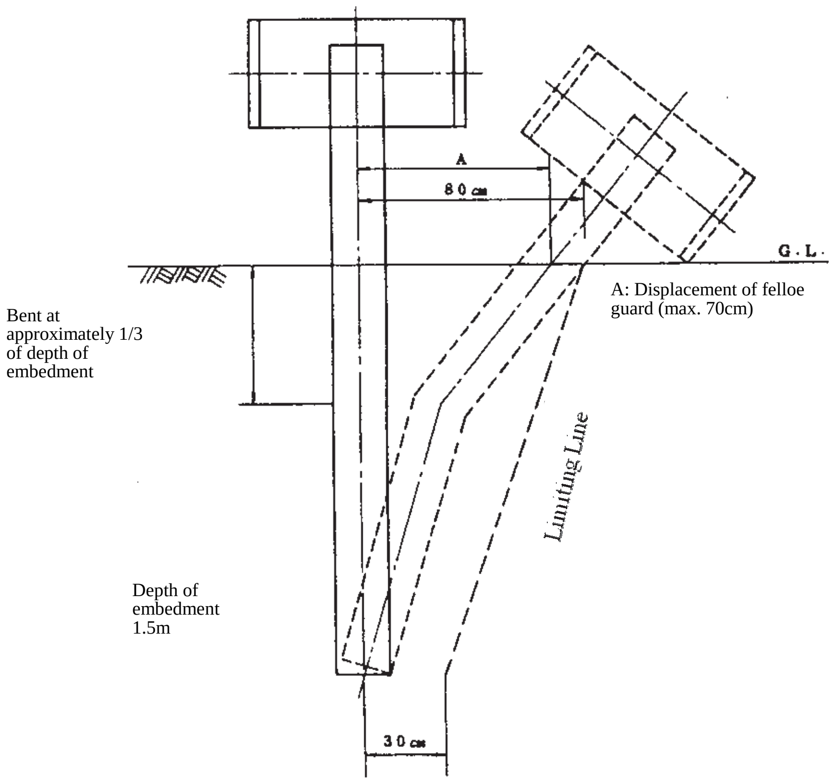
(2) In case duct is installed in road shoulder part, clearance from ancillary structures such as drainage, etc. shall be kept by standardized means of construction wherever possible.

(3) Location of installation of ducts should be considered to prevent damage accidents and alleviating burden caused by maintenance and improvement works at maintenance stage. In principle, the ducts should be installed in shoulder part of expressway road where the location will not affect the pavement, or be installed in the roadbed located at the bottom end of the slope of earthwork. As for the bridge and tunnel section, the ducts should be installed at shoulder part or center divider.

(4) To avoid danger caused by impact of drilling of guard-rail and impact of driving vehicles onto guard-rail posts, ducts should, in principle, be installed away from affection limit line as per following figure.

(5) Ducts crossing roads should be crossed at right angles to road center lines.

Deformed Guard-rail Post



1.4 Box Culverts and Crossing Pipes

There are many box culverts for vehicles crossing pipes everywhere.

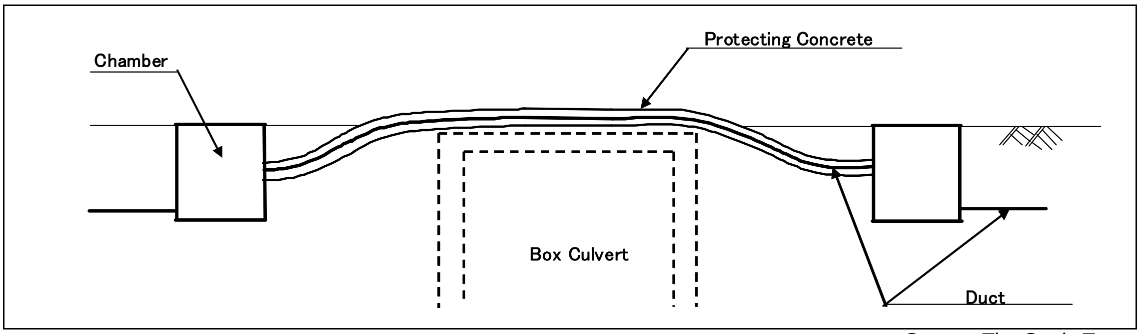
In case of crossing pipes the clearance between top of pipe and the bottom of ducts should be made so the ducts can cross over the pipes without any countermeasures.

In case of box culvert, the clearance between surface of culvert slab and the bottom of ducts depends on many factors for each box culvert. The clearance must be checked in the stage of Detail Design and Construction.

In case of small clearance, protecting concrete is adopted as a countermeasure.

Ducts in the median will cross over the box culvert as shown in Figure 1.6.

Figure 1.6 Protecting Concrete Countermeasure in case of small clearance

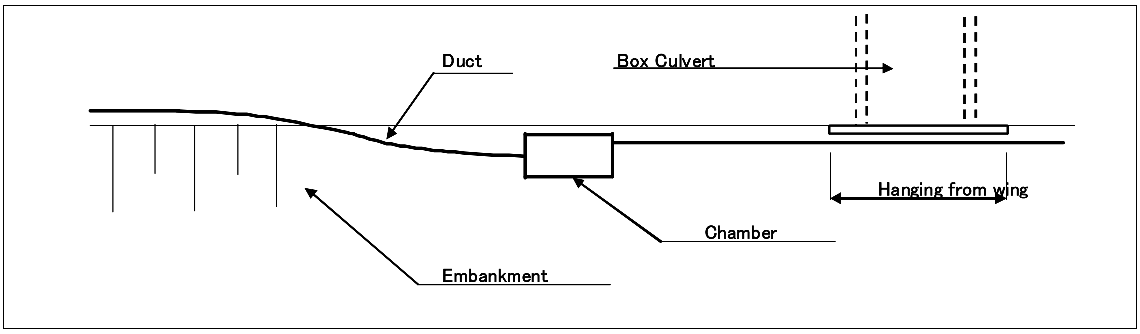


Source: The Study Team

Ducts in the shoulder will be shifted to outside of shoulder smoothly and cross the culvert using the wing of culvert the same as for bridge type A as shown in Figure 1.7. Bridge type A will be explained in section 1.5.

If there is space between the shoulder and the wing of box culvert, the ducts can cross over the box culvert using the space as shown in Figure 1.6.

Figure 1.7 Use of wing of culvert



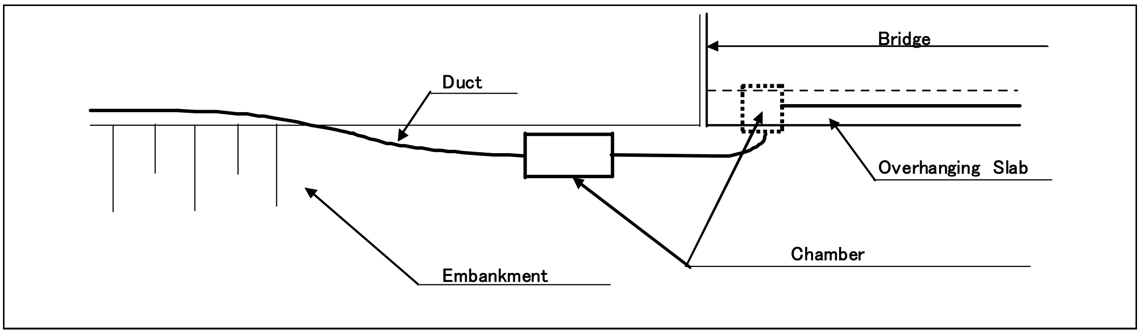
Source: The Study Team

1.5 Bridge Sections

From the chamber behind abutment, the ducts will access to the bridge as shown in Figure 1.8.

In case of using the median, the ducts should be shifted to the shoulder-side chamber behind abutment and then access to the bridge.

Figure 1.8 Access to Bridge from chamber behind abutment



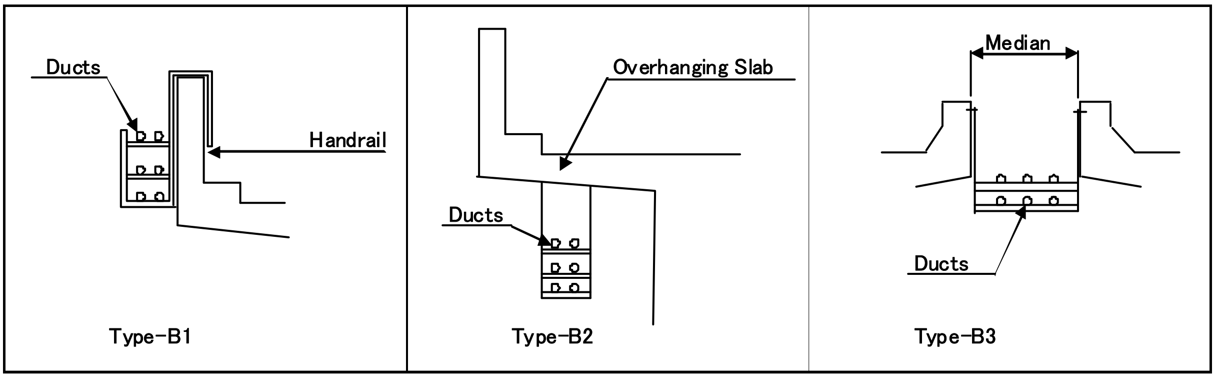
Source: The Study Team

There are three types of supporting methods for ducts on bridges as shown in Figure 1.9.

Basically Type-B should be adopted because of easy construction and maintenance as well as large track record. Type-A is adopted in case of an old bridge in order to protect the old concrete without using much anchoring.

Type-C is a special case, only adopted in Ha Noi Ring Road 3 because of the structural difficulty for setting on bridge outer side and with regard for aesthetics.

Figure 1.9 Types of supporting methods for ducts on bridges



Source: The Study Team

1) General Provisions related to Communication Ducts Installation in bridge section

(1) Location to install duct

Ducts to be installed on viaduct section or bridges are required to design proper location taking future cable installation work and maintenance/inspection work into account.

Duct material for bridge part should, in principle, be steel.

(a) Duct installation location should be selected considering easy cable installation work and maintenance /inspection work.

(b) For the protection of cables from fires from the lower part of bridge elevated segments or duct due to aging deterioration, embedded ducts should, in principle, be located as per the cases shown in Figure 1.10 or a case in Figure 1.11.

(c) Bridges on which wheel guard or wall type bridge railings were constructed in advance without installing duct for communication cables, the duct is required to be installed as attachment or suspension method.

(d) If duct is located the position to be embedded, the concrete will be casted in the form surrounding the duct. In order to protect duct deformation from heat of the concrete solidification or vibrator during casting of concrete, the duct type should be steel. On the other hand, if the duct is attached to the bridge or suspended from the bridge, the steel duct is also applied to protect from deterioration due to sunlight exposure or fire from lower part of brides. The duct installation location (5) in Figure 1.11 allows to be applied synthetic resin pipes.

Figure 1.10 Location of duct installation (1)

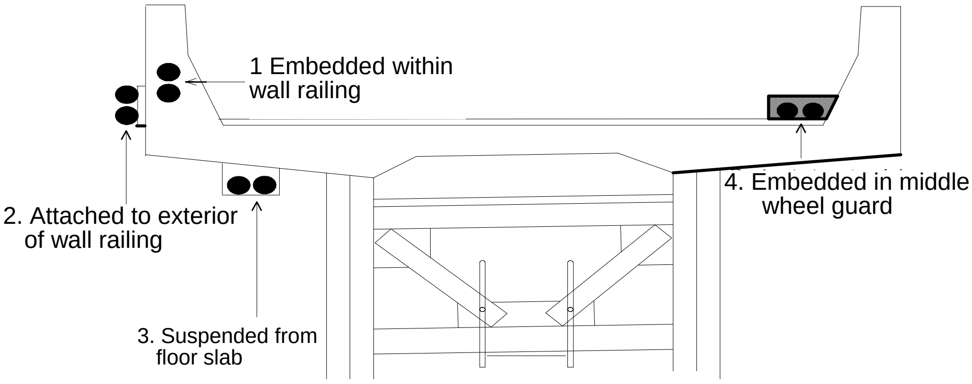
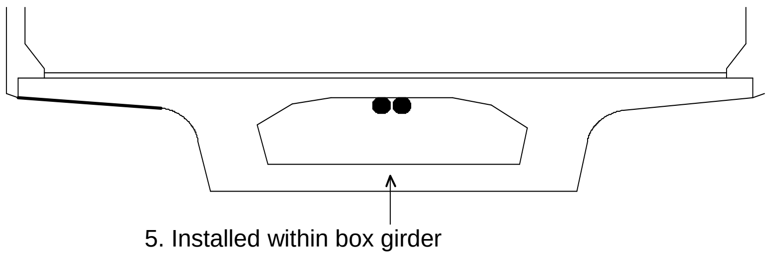


Figure 1.11 Location of duct installation (2)



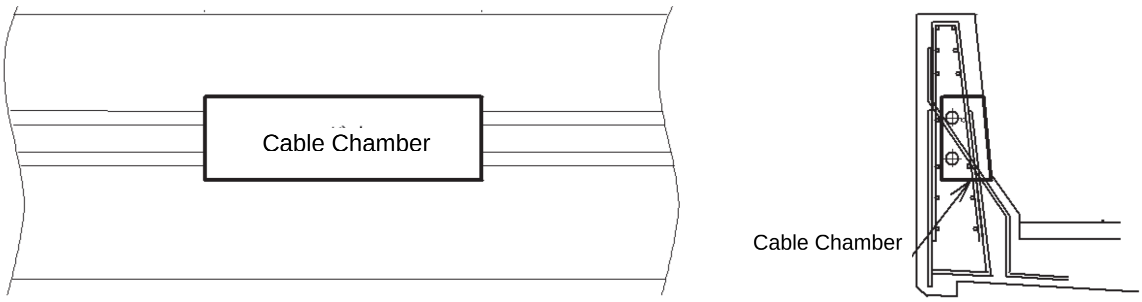
(2) Embedded duct

In case duct is embedded in wheel guard concrete or concrete wall railing, it should be designed taking into account several factors such as influence of structural strength of wall, workability of concrete encasement, and available space for other facility such as vehicle noise barriers to be installed in future in concrete wall railing.

(a) Embedded duct should be designed to prevent damage due to vibrator at time of casting of concrete (when vinyl duct is used in particular,) lack of concrete filling, and deviation of duct location.

(b) When embedding in wall railing, connections with other structures such as vehicle noise barriers should be considered in the design. As for sections at which noise barriers will initially not be installed, available space for noise barriers should be considered for future needs, and straightness of duct is required to be secured as much as possible.

Figure 1.12 Piping embedded in concrete wall railing



(3) Attached duct

Duct installed by attachment method should be executed so as not to impair the appearance of the structure, and it should be located for easy maintenance and inspection of duct and cables.

Supports for attachment should not only sufficiently support its own load and vibration with margin of safety but also expansion and contraction of duct will have to be taken into consideration.

(a) In order to avoid uncoupling of jointed duct due to duct extension or contraction, fixed support is required to install in specific intervals.

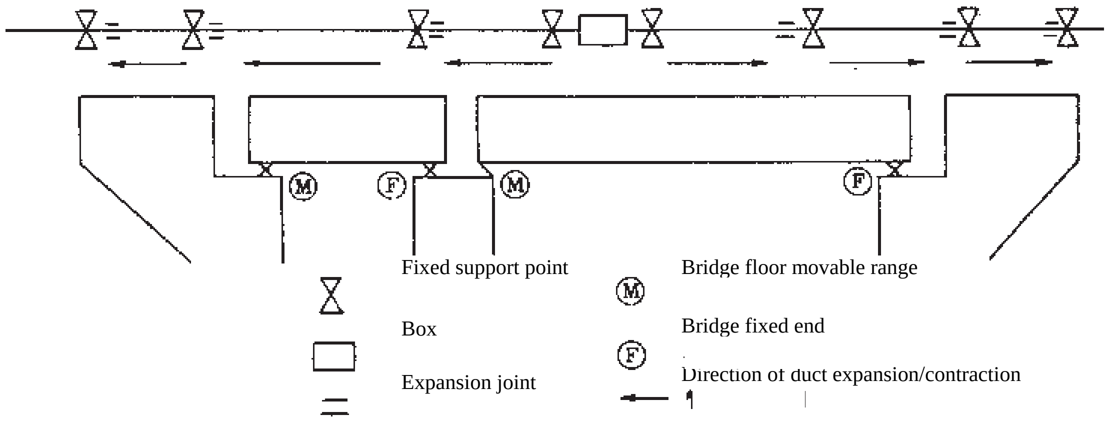
(b) The interval between supporting points to attach steel pipes is as per Table 9.18 and specific supporting point and supporting type should be determined taking following points into account;

- (i) Fixed support points (for expansion joint side only) should be fixed 1m from bridge floor separation point or abutment.
- (ii) When box which accommodates equipment component exists, fixed support should be installed 1m away from the box.
- (iii) When expansion joint is installed at bridge floor intermediate point, fixed support point is required 1m away from the intermediate expansion joint.
- (iV) General support points are required to be located between fixed support points within 4m intervals with equal distances as much as possible.

Table 1.4 Interval of supporting points in general

Supporting type	Supporting interval for steel pipe
General support	4m
Fixed support	50m

Figure 1.13 Supporting points in general



(c) When there is a possibility of fire below bridge elevated segment and attached ducts in the vicinity of abutment, required duct protection measures against fire is required to be taken in consideration of importance of cable. zones at which measures are to be taken are as follows:

(i) Barrier to prevent entry does not exist, places whereby entry is easy (excluding road crossings,) shortest height to duct is less than 5m and sections where risk of telecommunication cables being damamged by fire is high. (Figure 1.13)

(ii) Regardless of whether a barrier exists or not, shortest height to duct is less than 5m and slope is protected with grass. (Figure 1.14)

(iii) Places where duct is attached on wall of culvert (Figure 1.15). However, where slopes are of stone or concrete blocks, duct protection against fire is not required.

Figure 1.14 Places of side attachment of duct and less than 5m height

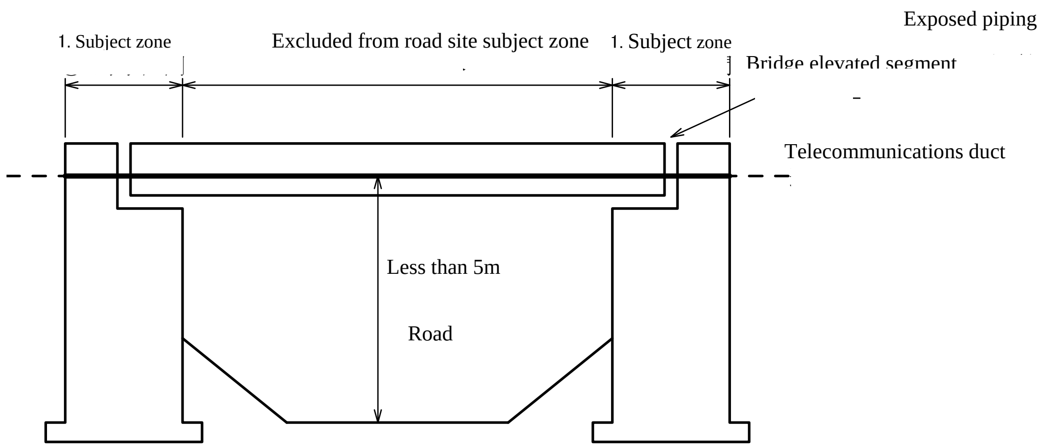


Figure 1.15 Less than 5m height to duct and where slope with grass space outside road site could be exposed to spreading fire

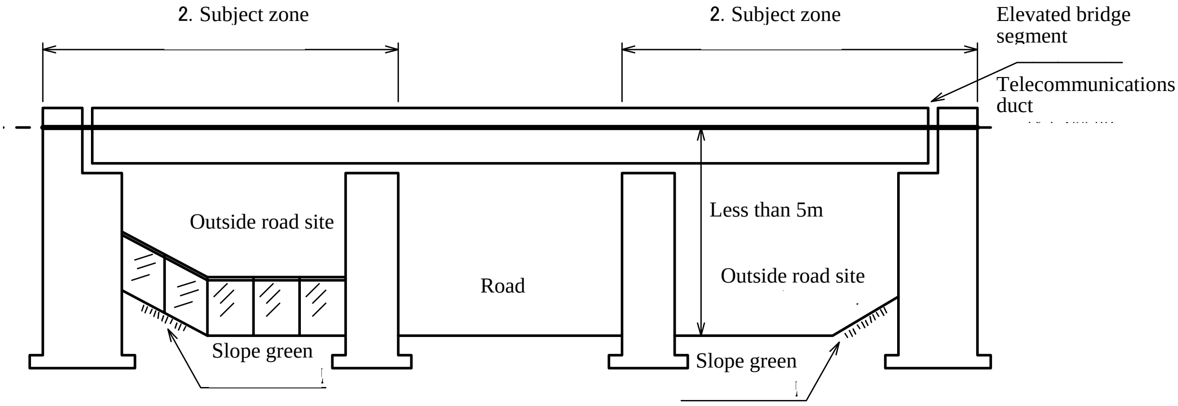
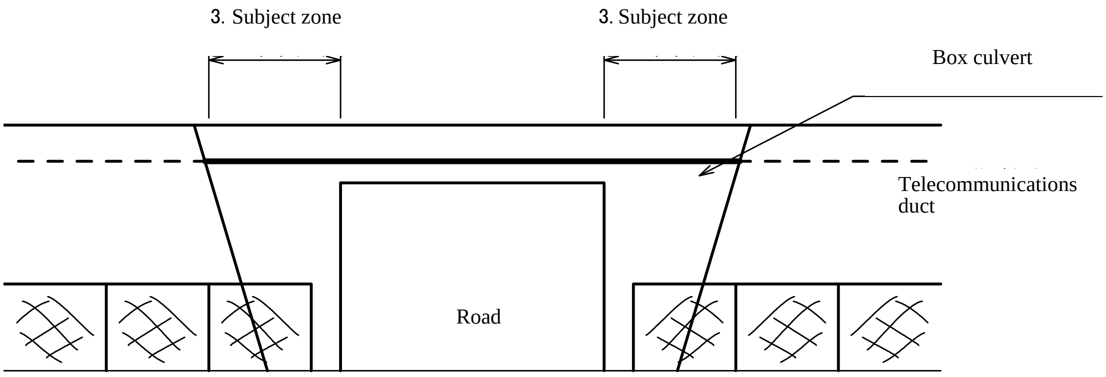


Figure 1.16 Box culvert where slope with grass could be exposed to spreading fire



(4) Expansion joint

Expansion joints are required to be installed at points of bridge floor separation and at abutment connections.

When no expansion joints are installed over a span exceeding 50m of steel pipe installation, an expansion joint is to be installed in the span next to the fixed support point.

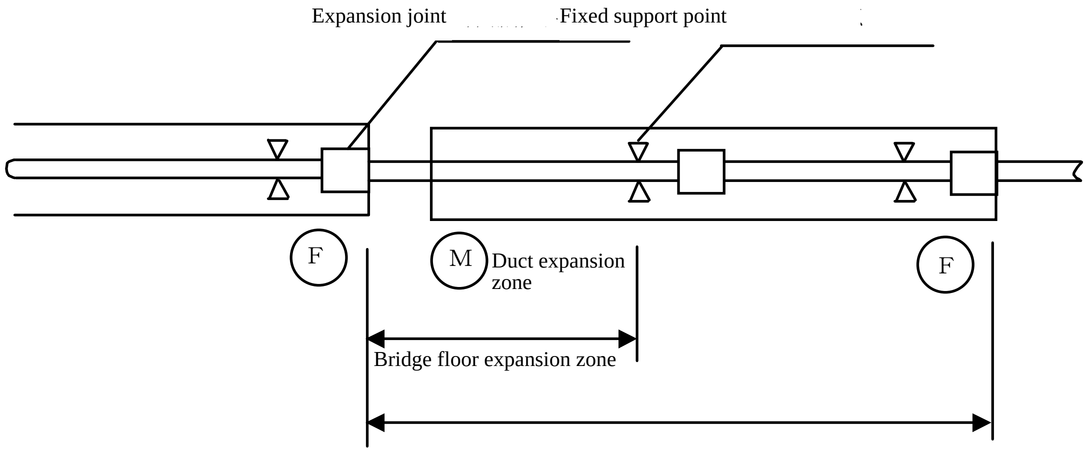
Appropriate and economical expansion joint is required to be selected taking into account the conditions such as movable length of expansion/contraction, and moveable direction of the joint.

In addition to the above, expansion/contraction due to thermal characteristics of steel pipe, and movable direction and length of expansion joint for road bridge is also need to be considered.

(a) For protection of pipe body and supports from pipe’s thermal stress, expansion joints are required to install at bridge elevated part for embedded duct and attached duct.

(b) Expansion joint of the bridge attached duct is to be applied at separation point of bridge floor and between abutment and bridge floor considering sufficient absorb length to cover total expansion/contraction for the section.

Figure 1.17 Expansion zone of attached duct section



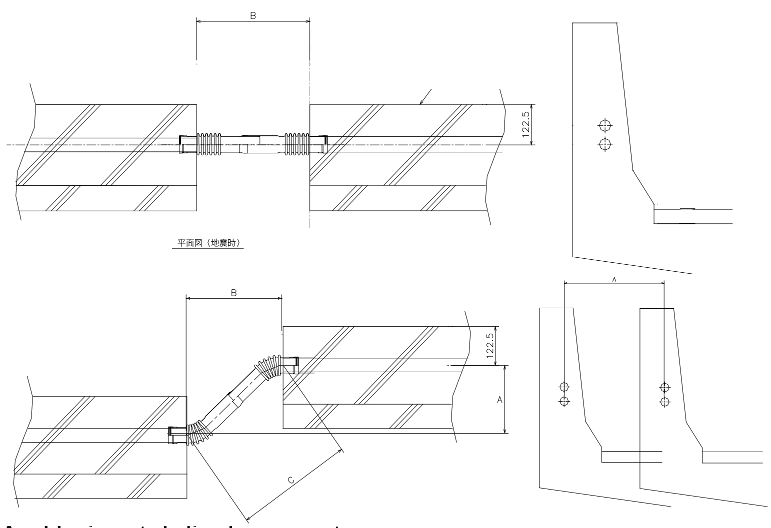
(c) Rust-proof expansion joints is needed to be used for attached ducts or corrosion protection applied at site.

(d) Expansion/contraction length of duct is required to consider the bridge expansion/ contraction basically. In the bridge expansion/contraction is considered following factors mainly:

(i) Expansion/contraction due to thermal characteristics of bridge
(ii) Displacement due to earthquake ground motion

The expansion joint is required to absorb the expansion/contraction due to above factors. The sample calculation method in item b) above is shown in Figure 1.17.

Figure 1.18 Horizontal displacement during an earthquake



A= Horizontal displacement
B=Normal expansion spacing width
C＝Maximum expansion/contraction (C＝ $\sqrt{A^2+B^2}$)

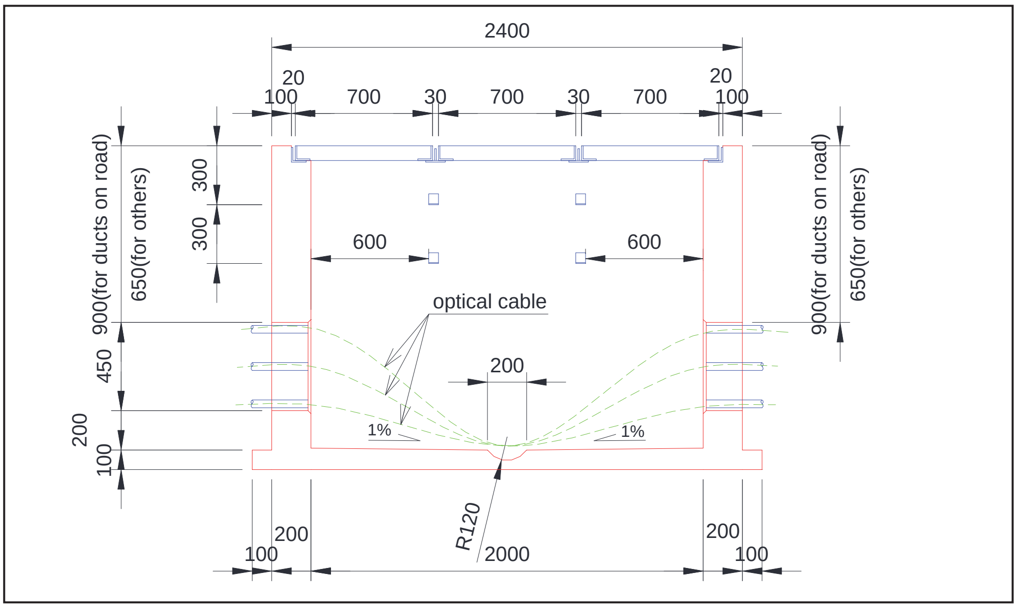
(5) Surplus length of cable to meet the expansion joint selected in accordance with above items is required to confirm in cable installation design.

1.6 Chamber

Of six main types of chamber shown in Figures 8.10 ~ 8.15, M1~M4 made by concrete are adopted in earthwork areas and M5~M6 made by steel are adopted on bridges.

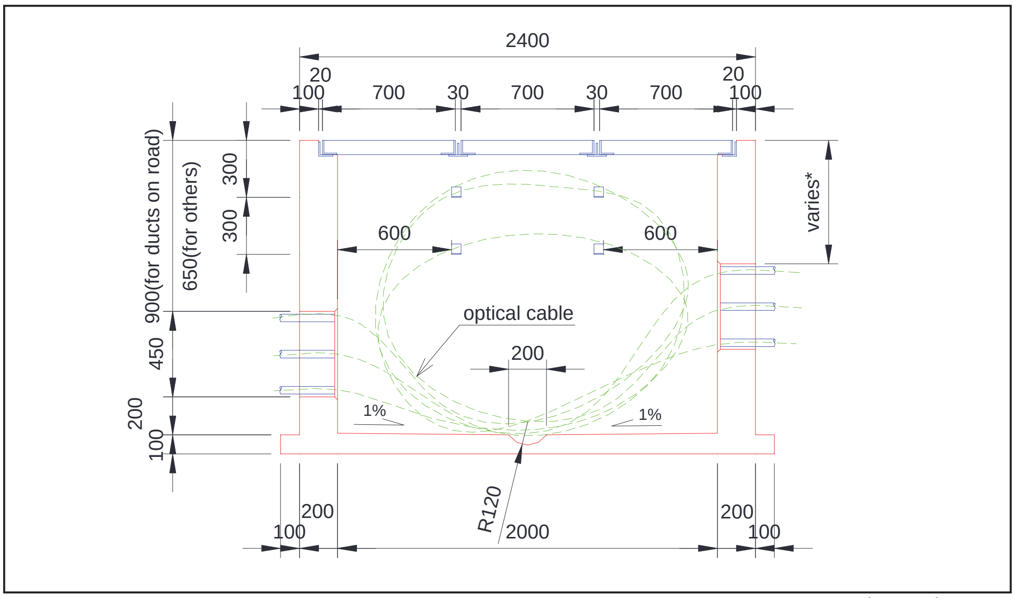
* M1 : This chamber handles cables and for keeping them slack.
Regular interval is approximately 333 m.
* M2 : This chamber connects the ducts in earthwork area to the bridge.
It is set behind abutment.
* M3 : This chamber is for installing and connecting cables.
Regular interval is approximately 2.0 km.
* M4 : This chamber is set at changing point of cable direction both horizontally and vertically. For example, Figures 1.5 and 1.6 are M4 type.
* M5 : This chamber is set at bridge section. It is for maintaining cables slack against expansion and contraction of bridge. Regular interval is approximately 100 m.
For bridges which its length is over 2.0km or M5 chamber which needs to connect to roadside equipment, a closure shall be installed in the chamber.

Figure 1.19 Main types of chambers M1



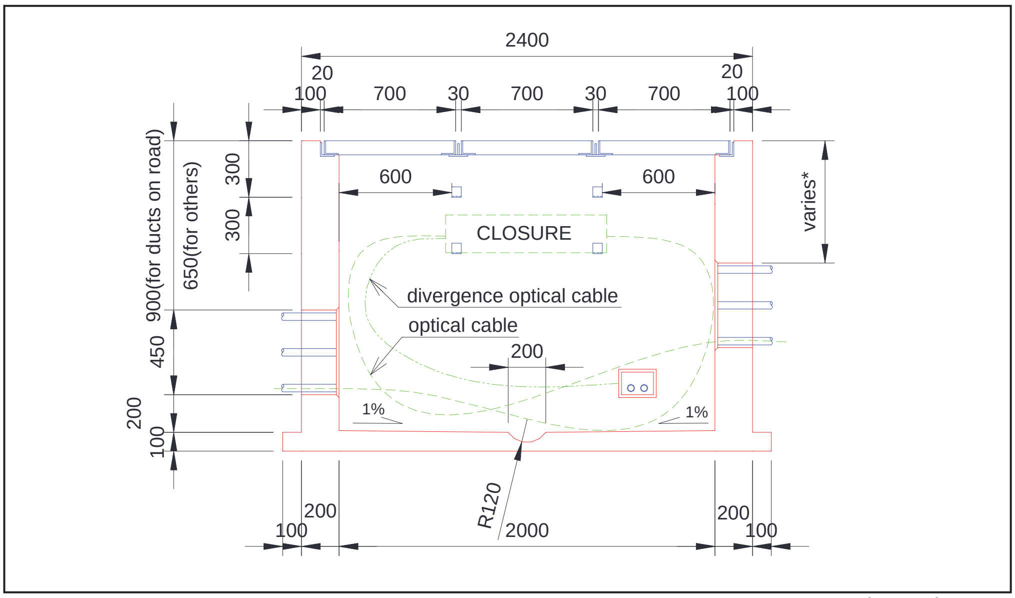
Source: The Study Team

Figure 1.20 Main types of chambers M2



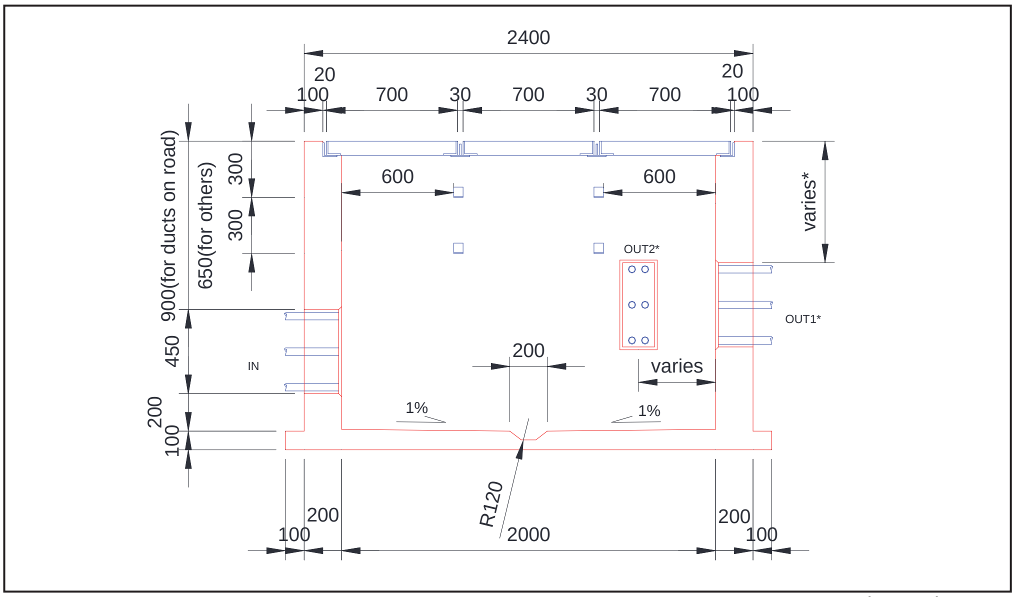
Source: The Study Team

Figure 1.21 Main types of chambers M3



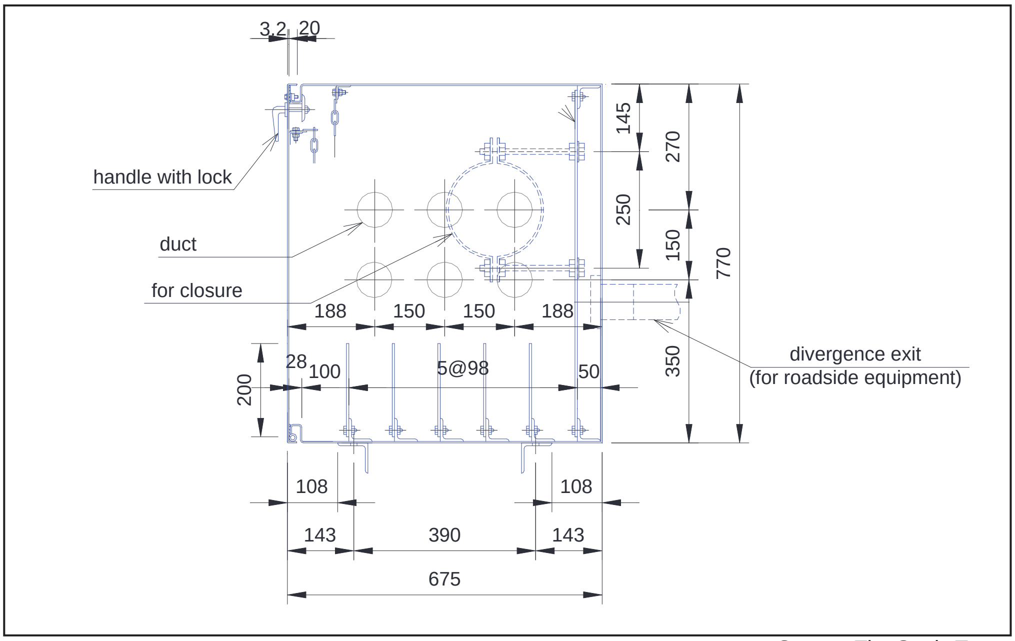
Source: The Study Team

Figure 1.22 Main types of chambers M4



Source: The Study Team

Figure 1.23 Main types of chambers M5



Source: The Study Team

1) General Provisions related to Cable Chamber

(1) General information

(a) Cable Chambers are required to be installed at locations/points where cables are connected or installed and where small radius bending is required.

(b) Size of a cable chamber is considered necessary factors of cable and cable joint accommodation capacity and cable installation work space.

(c) Strength of cable chamber is required to withstand cable pulling force, live load caused by earth pressure and traveling vehicles at time of construction and after commencement of service.

(2) Required Dimensions of MH/HH

The dimensions of Cable chambers are to be determined taking occupied space of cables and splicing points and cable installation working space into account.

(3) Locations of installment and span

(a) Cable chamber is to be installed where cables are joined, at road crossings, where small radius bends exist in roads, etc. Concerning its locations on viaduct section and within tunnels, location shall be considered taking other supporting facilities location into account. Moreover, they shall be installed at equal distances wherever possible.

(b) When connections are to be made with the room in building structures such as electric room, communication equipment component room, etc., the cable chamber should not be located close to the building foundation and installed exterior of the cat walk.

(c) Cable Chamber is not considered to be located those places where it will be expressway driving lane, unequal external pressure being applied, and the location where there is a possibility of ground subsidence, however when installation of such location is unavoidably required, sufficient protection should be made to cable chamber cover and its duct connection part.

(4) Number indication

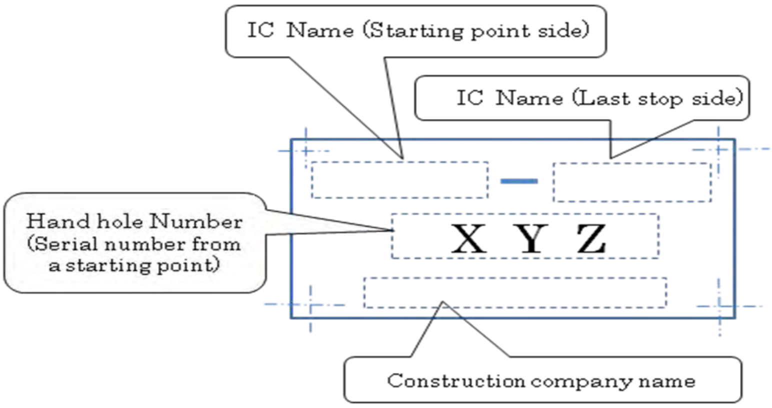
Name and number plate for cable chamber is required to be indicated inside of cable chamber.

(a) The name plate is required to include the nearest interchange names, serial numbers starting from one side interchange, and others as shown below.”

(b) In case cable chamber is to be added between existing cable chambers after completion of installation work, “supplementary number” to be added to serial number.

(c) Plant record for each cable chamber is required to prepare and periodically needed to update for operation and maintenance. The plant record includes the information of cable chamber number, connected ducts, installed cables, installed cable joint and other necessary information to manage cable facilities.

Figure 1.24 Cable Chamber Nameplate Example



2. Base Structure Design

2.1 General

Detail design of base structure shall be carried out considering the site conditions and final specifications of equipment at the construction stage.

At the basic design stage, each supporting structure must be designed individually In case of heavy equipment.

In case of non-heavy equipment, there is possibility to use existing pole for lighting system.

The size and steel thickness were designed based on the standards as follows:

(1) Specification for Bridges Design 22TCN-272-05 (Vietnam)
(2) Load and Effect-Design standard, TCVN2737:1995 (Vietnam)
(3) AASHTO LRFD Bridge Design Specification, 4^{th} edition 2007, etc.

2.2 Pole for CCTV

A single steel pole should be adopted in order to install each CCTV unit as shown in Figure 2.1 left.

The height of installing CCTV is about 8 m from ground level, so 9 m pole will be designed.

2.3 Pole for Changeable Speed Limit Sign (CSS)

In order to install Changeable Speed Limit Sign, two types of poles should be adopted as shown in Figure 2.1 center. One is for installing at the ends of a expressway, one is at middle of a expressway.

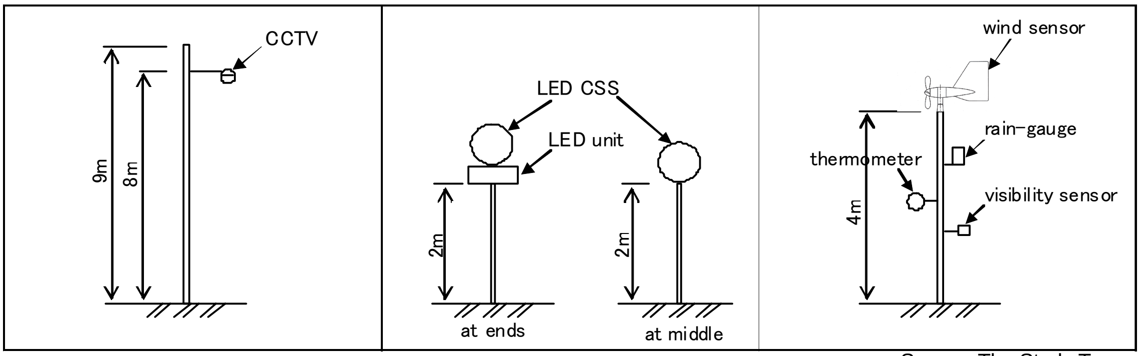
In detail design stage, the pole shape should be redesigned regarding to site condition, especially users ‘s visibility.

2.4 Pole for Weather Observation Equipment

In order to install 4 equipment units as listed below, a pole of D=200 mm, h=4.0 m should be adopted as shown in Figure 2.1 right.

* Rain-Gauge
* Wind Sensor
* Visibility Sensor
* Thermometer

Figure 2.1 Poles for small equipment



Source: The Study Team

2.5 Gantry for VMS

VMS is designed to set at an earthwork section and a bridge section. Because gantries for VMS are not included in dead loads when existing bridges have been designed, gantries for VMS set at a bridge section should be installed at ground level.

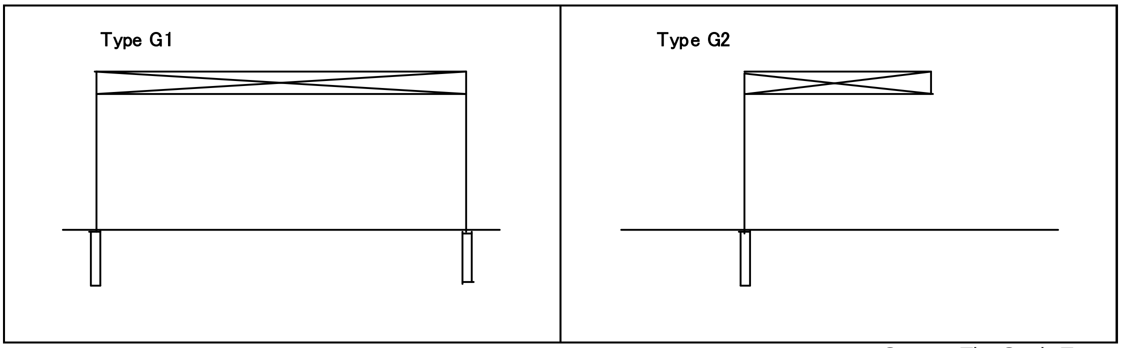
Two groups of gantries for VMS mentioned as above, are shown in Figures 2.2 and 2.3 respectively.

Table 2.1

Gantry for VMS set at Earthwork section	G1 : Standard frame type
	G2 : Cantilever type
Gantry for VMS set at Bridge section	G3 : Special type on bridge on Ha Noi Ring Road 3

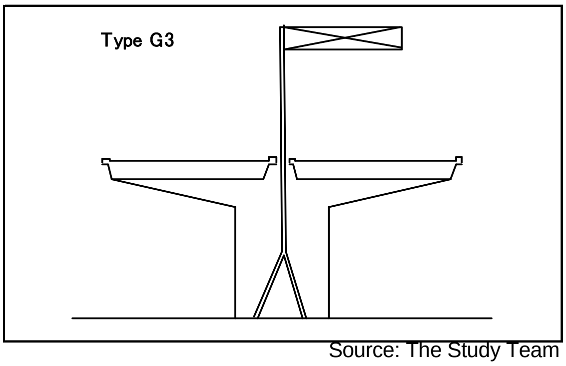
The pole of G3 must be widen near the ground to reduce the deflection that is caused by cantilever-beam and it's height.

Figure 2.2 Gantry for VMS in earthwork area



Source: The Study Team

Figure 2.3 Gantry for VMS on bridge



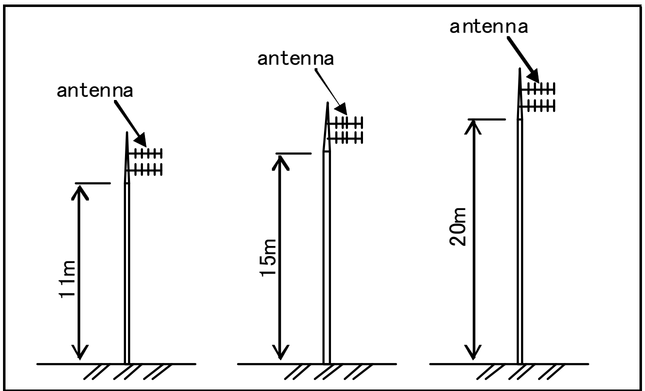
Source: The Study Team

2.6 Tower for Mobile Radio Communication

In order to install an antenna that will cover about 8 km area for Mobile Radio communication, a steel pipe tower should be adopted as shown in Figure 2.4.

The height of tower should be 11.0 m,15.0m, 20.0m. Tower height shall be designed depending on a radio disturbance surrounding antennas.

Figure 2.4 Tower for Mobile Radio communication



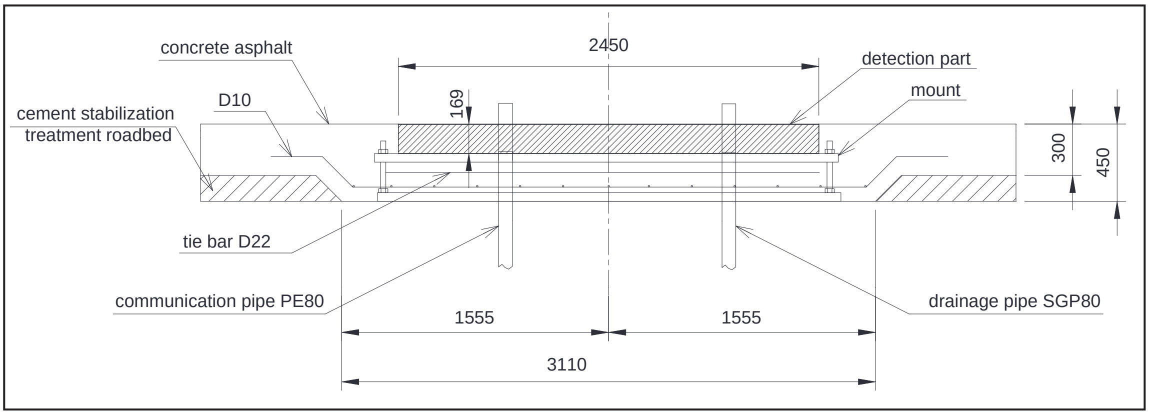
Source: The Study Team

2.7 Works for Axle Load Scale

When an axle load scale is installed at an existing road, asphalt surface shall be cut for the axle load scale. It is supposed that the equipment supplier shall handle even civil works to install the equipment.

An axle load scale equipment is shown as Figure 9.5 for reference.

Figure 2.5 Axle Load Scale Equipment (for reference)



Source: The Study Team

3. Building Plan

3.1 General

Floor areas of the buildings below are planned for estimating construction cost.

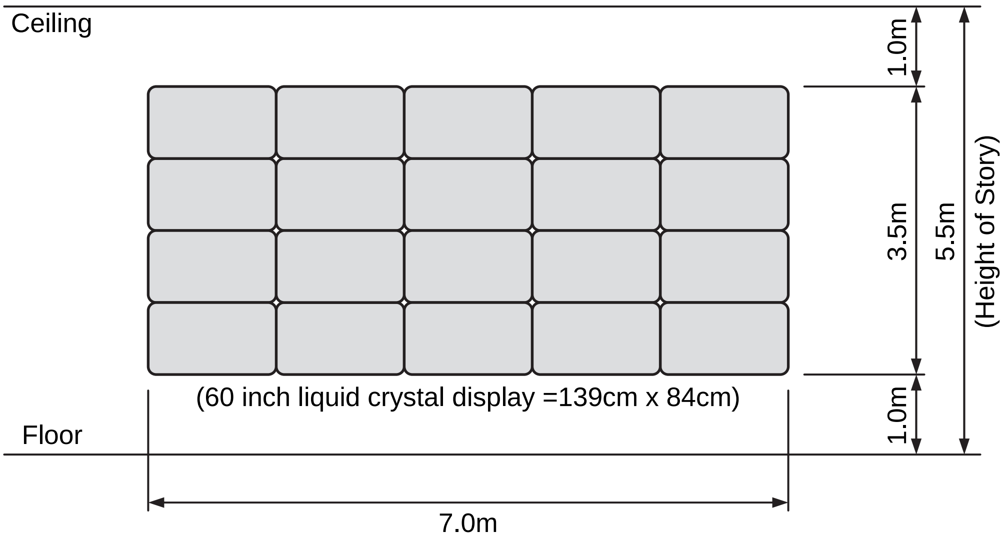
- Northern regional main center
- Road management office
- Toll office

3.2 Northern Regional Main Center

1) Main Monitor Screen

For indication of the map of the expressway network in the Northern Region, images sent from CCTV cameras, traffic data, information for VMS, the size of Main Monitor Screen is required to be 7.0 m wide by 3.5 m high. Responding to the size, the height of story of the Regional Main Center is to be 5.5 m at least as shown in the figure below.

Figure 3.1 Required Size of Main Monitor Screen and Height of Story



2) Console Terminals

Console terminals are needed for traffic control in the Regional Main Center. The console terminals are to be utilized for CCTV monitoring, weather data check, traffic event data input/check, VMS indication input/check, etc.

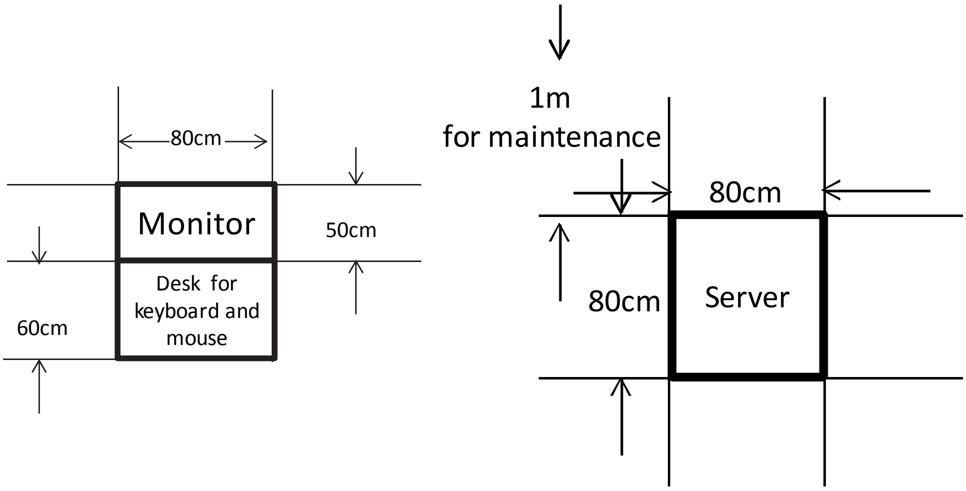
The size of a console terminal is shown in the following figure, and 7 terminals need to be installed at least.

3) Data Servers

Data servers are needed for traffic control in the Regional Main Center. The data servers are to be utilized for weather monitoring, traffic analysis, traffic event data management, VMS indication, etc.

The size of a data server is shown in the following figure, and 7 servers need to be installed at least.

Figure 3.2 Required Size of Console Terminal and Data Server



4) Number of Staffs for Traffic Control in Regional Main Center

The estimated numbers of staffs for traffic control in the Regional Main Center are shown in the table below.

The Regional Main Center is required to be operated 24 hours a day. For this reason, the operation staffs, the telephone clerks and the maintenance staffs for the equipment in the Regional Main Center are to be attended to the work by three shifts around the clock. In addition, a general director and the administration staffs are to be attended to the work day time. Totally less than 100 persons are needed to work at Main Center and 16 persons are to be attended to the night work.

Table 3.1 Estimated Number of Staffs for Traffic Control in Regional Main Center

Class	Number of person	Remarks
1) General Director	1 person	3turn/day(8hours x 3 = 24hours) = 3 groups, 1 group for holiday = 4 groups is needed for operation 24 hours a day
2) Center Operators	10 x 4 groups = 40 persons	
3) Telephone Clerks	3 x 4 groups = 12 persons	
4) System Maintenance Staffs	3 x 4 groups = 12 persons	
5) Administration Staffs	20 persons	
Total	85 persons (Less than 100)	

5) Area for Building of Regional Main Center

The area required for the building of the Regional Main Center is shown in the table below, which responds to the functions necessary for the Center, the number of staff and the space for console terminals and data servers.

Table 3.2 Area for Building of Regional Main Center

Floor	Partition	Area	Number of Resident Staffs	Maximum Number of Persons including Visitors
2F	1) Operating Room	180 m^2	13	13
	2) Server Room	90 m^2	3	3
	3) Visitor Room	90 m^2	-	* 30
	4) Police Officer Room	72 m^2	-	*** 6
	5) Meeting Room	72 m^2	-	** 12
	6) General Director Room	72 m^2	1	*** 6
	7) Toilet and Hallway	144 m^2	-	-
	Total area of 2F	**720 m^2**	**17**	**70**
1F	1) Machine Room	90 m^2	-	-
	2) Depository	90 m^2	-	-
	3) Office Room	180 ㎡	20	** 30
	4) Resting Room	72 m^2	16	16
	5) Mess Hall	132 m^2	-	** 22
	6) Toilet and Hallway	156 m^2	-	-
	Total area of 2F	**720 m^2**	**36**	**68**
BF	1) Depository	162 m^2	-	-
	2) Motorcycle Parking	468 m^2	-	-
	3) Toilet and Hallway	90 m^2	-	-
	Total area of BF	**720 m^2**	**-**	**-**
	Total area of Building	**2,160 m^2**	**53**	**138**

Note: * : 3 m^2/person, ** : 6 m^2/person, *** : 12 m^2/person,

(6) Land Area for Regional Main Center

The land area required for the Regional Main Center consists of building lot area, parking/ passage area and green area. Maximum numbers of motorcycles and passenger cars for calculating the parking/passage area are estimated for respective cases as shown in the table below.

Table 3.3 Land Area for Regional Main Center

Partition	Land Area	Remarks
1) Building Lot Area	720 m^2	
2) Parking/Passage Area	40 m^2 x 37 = 1,500 m^2	• Case-1: Maximum number of motorcycles 138 x 80% =110 • Case-2: Maximum number of passenger cars 138 x 50% / 2 =35 and 2 busses in addition.
3) Green Area	780 m^2	
Total	3,000 m^2	

7) Values for Main Center in the Project (Rough Draft)

(1) Land Area

- Total Area : $3000m^2$
- Building Lot Area : $720\ m^2$
- Parking/Passage Area : $40\ m^2$ x36=$1500\ m^2$ (Passenger Cars: 35, Busses: 2)
- Green Area : $780\ m^2$

(2) Floor Space

- Total Floor Space : $2160\ m^2$

(2F: $720m^2$)

- Operating Room : $180\ m^2$
- Server Room : $90\ m^2$
- Visitor Room : $90\ m^2$
- Police Officer Room : $72\ m^2$
- Meeting Room : $72\ m^2$
- General Director Room : $72\ m^2$
- Toilet, Hallway, etc. : $144\ m^2$

(1F: $720m^2$)

- Machine Room : $90\ m^2$
- Depository : $90\ m^2$
- Office Room : $180\ m^2$
- Resting Room : $72\ m^2$
- Mess Room : $132\ m^2$
- Toilet, Hallway, etc. : $156\ m^2$

(BF: $720m^2$)

- Depository : $162\ m^2$
- Motorcycle Parking : $468\ m^2$ (Motorcycles: 110)
- Toilet, Hallway, etc. : $90\ m^2$

(3) Staffing

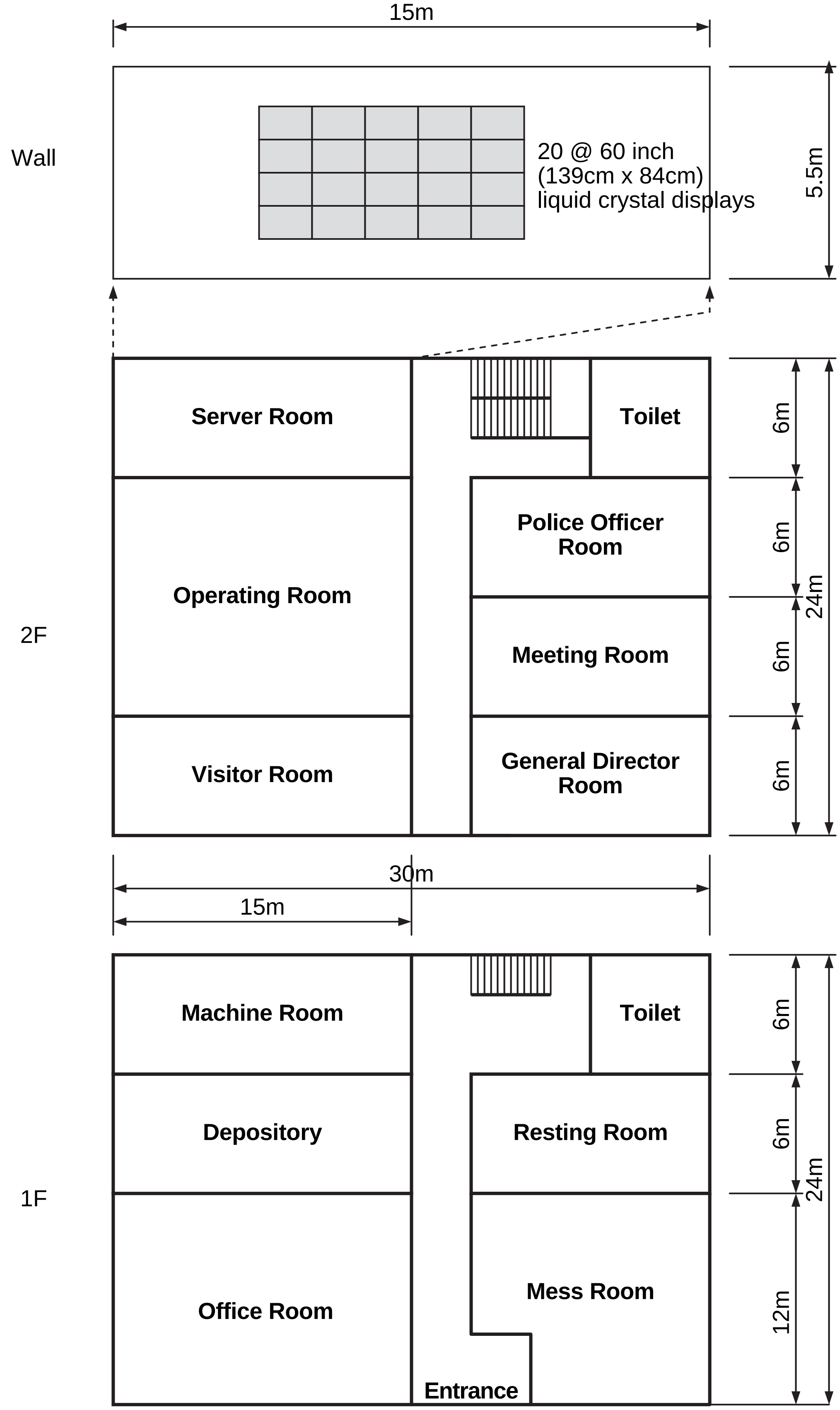
- Total number of staffs : Less than 100
- General Manager : 1
- Operators : $10 \times 4=40$
- Telephone clerks : $3 \times 4=12$
- Maintenance crews : $3 \times 4=12$
- Administration staffs : 20

(4) Electric power supply

- Less than 500kVA

8) Layout of Building

Figure 3.3 Layout of Building



3.3 Road Management Office

1) Number of Staffs in Road Management Office

The estimated number of staffs in the Road Management Office is shown in the following table.

Road Management Office is required to be operational 24 hours a day. Therefore, Operator, Maintenance Staff, Ambulance Station Staff, and Police are needed for the response to the incident.

Table 3.4 Number of Staffs in Road Management Office

Type of appointment	Number of person	Description
1) Manager	1 person	3turns/day(8hours x 3 = 24hours) = 3 groups, 1 group for holiday = 4 groups are needed for operation of 24 hours a day
2) Road/System Operators	3 x 4 groups = 12 persons	
3) Road/System Maintenance Staffs	6 x 4 groups = 24 persons	
4) Ambulance Staffs	4 x 4 group = 16 persons	
5) Police	2 for day time (1 for night time) x 4 groups = 6 persons	
6) Other Staffs	10 persons	
Total number of staff	Approx. 26 persons	

2) Required Space for Road Management Office

For the Road Management Office, in consideration of the number of staff, the required space is shown in the table below.

Table 3.5 Required Space for Road Management Office

Floor	Type of room	Space	Description
2nd	1) Operating Room	30 m^2	
	2) Manager Room **	36 m^2	
	3) Office Room **	60 m^2	
	4) Meeting Room **	36 m^2	
	5) Resting Room **	36 m^2	
	6) Toilet and Passageway **	72 m^2	
	Total area of 2nd floor **	**270 m^2**	
1st	1) Police Room **	36 m^2	
	2) Ambulance Room **	36 m^2	
	3) Machine Room **	36 m^2	
	4) Patrol Crew Room **	72 m^2	
	5) Depository **	36 m^2	
	6) Mess Hall **	54 m^2	
	7) Toilet and Passageway **	90 m^2	
	Total area of 1st floor **	**360 m^2**	
	Total area of Building **	**630 m^2**	

Note, ** : Only for reference.

(3) Land Area for Road Management Office of Lang – Hoa Lac Expressway

Required site area depends on required space of road management office building of Lang – Hoa Lac Expressway and Parking space. The required land area is shown in the table below.

Table 3.6 Land Area for Road Management Office of Lang – Hoa Lac Expressway

Type of area	Space	Description
1) Building site area	360 m^2	
2) Parking space	30 x 25 m = 750 m^2	for motorcycle：1.0 x (2.3+1.5)m =3.8 m^2/ motorcycle (100 motorcycles x 3.8 m^2= 380 m^2) for vehicles：2.3 x (5.0+3.0)m=18.4 m^2/vehicle (20 vehicles x 18.4 m^2 = 368 m^2) 380 + 368 = 748 m^2 = approx.750 m^2
3) Green space	890 m^2	
Total area	2,000 m^2	

3.4 Toll Office

1) Required Space for Toll Office

For the Toll Office, the required space is shown in the table below.

Table 3.7 Required Space for Toll Office

Floor	Type of room	Space	Description
2nd	1) Operating Room	20 m^2	For 2 Operators
	2) Meeting & Rest Room **	20 m^2	
	3) Passageway **	15 m^2	
	Total area of 2nd floor **	**55 m^2**	
1st	1) Office & Operating Room **	20 m^2	
	2) Machine Room **	10 m^2	
	3) Toilet **	10 m^2	
	4) Passageway **	15 m^2	
	Total area of 1st floor **	**55 m^2**	
	Total area of Building **	**110 m^2**	

Note, ** : Only for reference.

4. Electric Power Supply Plan/Design

4.1 General

1) Basic Concepts

Main design includes Main design includes Northern Regional Main Center, but the Project is also one of the basic designs for the electric power supply plan of electric power sources, etc.

The Regional Main Center and Road Management Offices, electric power supply equipment sets which are accompanied with construction equipment sets at toll collection booth are out of the scope of this design. When designing and making plan for electric power supply which includes electric power supply equipment sets and special electric equipment sets, it has to consider properly the local economic conditions including electric power supply systems of electric power supply companies in order to have a proper and save design.

Besides, it should be complied with all regulations and technical standards and other regulations relating to the safety of electrical works, especially “provisions for the electric supply of Electric of Vietnam Company EVN”. Different productions have to meet their own standards, respectively.

2) Electric Power Supply Plan

Procedure for the design of electric power supply plan in electric supply equipment sets is mentioned as follow:

(1) Investigation of electric transmission equipment sets

Capacity of the facilities, type of installation and effective voltage of individual equipment sets, determining the input data that takes electric elements into account, etc ... are classified according to each type of capacity. The classification of capacity has to be implemented properly.

(2) Estimate capacity for receiving electric power

Based on a survey of basic capacity of facilities which is calculated by electric demand of each facility to calculate the electric power distribution (ability to receive transformer).

(3) Calculate contracted electric equipment sets

To calculate electric equipment which is contracted with the electric power supply company, the maximum electric power demand has to be computed.

In general, the basis for calculating the contracted electric equipment has to comply with the "rules of the electric power supply" of the electric power companies.

In addition, to become an economical electric power contract, it has to meet activity regulations that are determined in consultation with the electric power companies.

(4) Decide measure of receiving electric power

When deciding measure of receiving power, it has to consider the current situation of the distribution network of electric power company in the vicinity of the receiving stations, the reliability of the power supply (power failure). Moreover, deciding measure of receiving electric power only after checking measures to deal with power outages through the electric power company which relates to the future plan of the electric power distribution network. When making a decision of measure for receiving electric power, it has to negotiate with the electric power company about issues on the design of receiving system, receiving voltage, transmission methods, etc. ... and it also has to negotiate with the electric power company on the issues of designing electric power distribution equipment.

(5) Design of the receiving power station

Based on the location of distribution station and location of the first column to make a plan for an arrangement of facilities to install optimally receiving power station.

(6) Decide measure of distributing electric power

Voltage fluctuation is very important to decide measure of distributing electric power. Moreover, proper measure of distributing electric power should be decided with a full consideration of economy and connecting measure as in electric power manufacture and backup electric power.

It should be noted, that when designing touching to the ground and breaking circuit, it has to consider fully different protectively measures such as overload etc.

(7) Selection of equipment sets

When selecting the electrical distribution equipment sets, it has to consider carefully the compatibility of each devices in term of many aspects such as economic,(fire fighting equipment, etc), various safety devices, required space, magnitude, safety, reliability, capability, function ...

(8) Design electric line

Requirements for designing electric line have to be reliable to provide electricity safely to the machines with a full compliance with relevant standards and regulations "electrical engineering standards", etc. It has to consider fully issues such as: circuit breaker, touching ground, voltage fluctuations, in tunnels, partial filling embankment, and after full consideration to the conditions outside of the bridge, etc. In addition, it should be designed with a centralized economy.

Generally, electrical distribution equipment sets have been described in the step of designing power supply with a specific plan, because in addition to the theme of this design for power distribution equipment sets which are accompanied with construction equipment sets as described above (works), the following streets are described below about the electric power supply to the terminals.

3) Basic Principle for Design

In order to provide electric power to road management facilities and traffic management facilities such as the Regional Main Center, Road Management Office, Toll Booth and roadside equipment, electric equipment shall be installed in accordance with legal regulations on related electric and fire protection. Since ITS equipment operates constantly, even in the event of power blackout in regards of the commercial power supplied by electric company, it is crucial for the Regional Main Center, Road Management Office and Toll Office to operate normally.

Therefore, in-house electric generator contactor (GC) will supply power in case of electric black-out, besides, the Constant Voltage and Constant Frequency Unit (CNCF) shall be installed to compensate instantaneous blackout in a few minutes which this GC secures regular voltage.

(1) Voltage classification

The voltage classification of power transmission line in Vietnam is shown in the Table 4.1.

In principle, the Regional Main Center, Road Management Office and Toll Office will receive power with commercial high voltage. In terms of transmission line, the higher the nominal voltage is, the safer it gets. However, because the transformer equipment sets are expensive, it is appropriate to select low voltage when possible for the facilities other than Main Center.

The Northern Regional Main Center will receive 20KV power as the result of the collaboration with electric company. The Road Management Office and Toll Office will use commercial high voltage because if the power for the Road Management Office and road lighting is added to ITS equipment load, the power will exceed 50kVA.

The voltage classification from 1~4 for commercial high voltage shall be supplied by each electric company through negotiations. In principal, the method in which ITS equipment sets installed on the road side receive power individually like general electrical light 1Φ2W-220V and general engine 3Φ4W-380/220V is the best solution in regards of cost effectiveness. In case of having no other choice but using the commercial high voltage as the result of negotiations with electric company, in principle, ITS equipment sets will receive commercial high voltage 6000V, the voltage will be dropped by pole-mounted transformer and transmitted.

Table 4.1 Input Voltage Classification

	Transmission Classification	Number of phase/line	Frequency	Nominal voltage
1	General Electrical Light	1Φ2W	50Hz	220V
	General Engine	3Φ4W	50Hz	380/220V
3	Commercial High Voltage 1	3Φ3W	50Hz	6000V
4	Commercial High Voltage 2	3Φ3W	50Hz	10KV
5	Commercial High Voltage 3	3Φ3W	50Hz	22KV
6	Commercial High Voltage 4	3Φ3W	50Hz	35KV
7	Commercial Special High Voltage 1	3Φ3W	50Hz	77KV
8	Commercial Special High Voltage 2	3Φ3W	50Hz	140KV

Note: The nominal voltage referred in this Table means the nominal voltage of power receiving terminal. Since the power transmission terminal voltages below No. 3 are transmitted with the voltage which is raised by 10% of the writing of value, terminal voltage can be raised by 10% of the nominal voltage because of load fluctuation in different time slot.

In principle, the receiving voltage of terminal equipment is 1Φ2W-2, in order control the voltage drop of the power line, those equipment sets with large capacity exceeding 2kVA have receiving voltage of 3Φ3W-380V.

(2) Blackout compensation

In order to avoid the stoppage of traffic control function and the paralysis of information collection, treatment and information provision even in the case of commercial power blackout, it is necessary to have blackout compensation. All the ITS equipment sets and air conditioners for these equipment installed in the Regional Main Center, the Road Management Office and Toll Office shall need blackout compensation.

Besides, the movement radio equipment sets installed in road side also need blackout compensation in order to avoid the stoppage of radio command function. The relay apparatus of transmitter installed in the roadside transmits direct current from the transmitter of the nearest Toll Office.

Table 4.2 Classification of Blackout Compensation

	Name of Equipment	In-house power generator	Permanent power supply	Direct current power equipment
1	Traffic control equipment	XX	XX	
2	Movement radio equipment	XX		XX
3	Transmission and switching equipment	XX		XX
4	Other key circuit	XX		
5	Others			
	Compensation time	24 Hour	20 Minute	24 Hour

4) Investigation Situations of Power Supply

The balance between gravity center of the load and leading distance decide receiving point. It’s necessary to investigate the positions of branch points from power Supply Company. If the main line equipment of installation position is defined and it is necessary to receive power in many positions, we will search whether it is possible in the transmission network of the power supply company or not and decide the economic power receiving position.

In the power receiving points in the Regional Main Center and the Road Management Office, regarding the system which receives power supply, when possible, we will make a research on (a) the number of times of accident blackout, blackout duration and its reasons; and (b) the number of times of operation blackout and blackout duration.

This can be used as a document to judge the necessity of standby power. It’s necessary for the power receiving point to stay in proximity to the load.

That’s why in case the transmission line from the power supply company is too long, it’s necessary to consider comprehensively in order to avoid the excessive construction expense.

(1) Power supply system

(a) Power receiving points: field surveys had been conducted; or branch point is the any point from power supplier because it is necessary to identify the distance for power line installation and center of additional loading charge.

(b) In the case of requirement for consideration of receiving mostly power supply locations for terminal equipment sets, power lines had been examined by taking into account of setting up one new transformer to assist in understanding economic conditions as well as verifying power supplying capacities of sub-transformers, and problems or shortcomings in distribution system of power supplier.

(2) The survey on power supply status

Necessary documents for negotiation or discussion on examining next back-up power supply of (a) and (b) within potential capacity relating to receiving system of power supplying.

Results of surveys and investigations to relevant stakeholders on electricity cut-off incidents including duration and number of times in Hanoi city: objective data and information had been obtained with the main answers as follows:

(a) Causes and duration of electricity cut-off and times of electricity cut-off incidents.

- Times of electricity cut-off incidents: around once or twice per month
- Duration of continuous electricity cut-off: around two to three hours
- Causes:
  - + Cable failures due to mice
  - + Cable failures due to vehicles

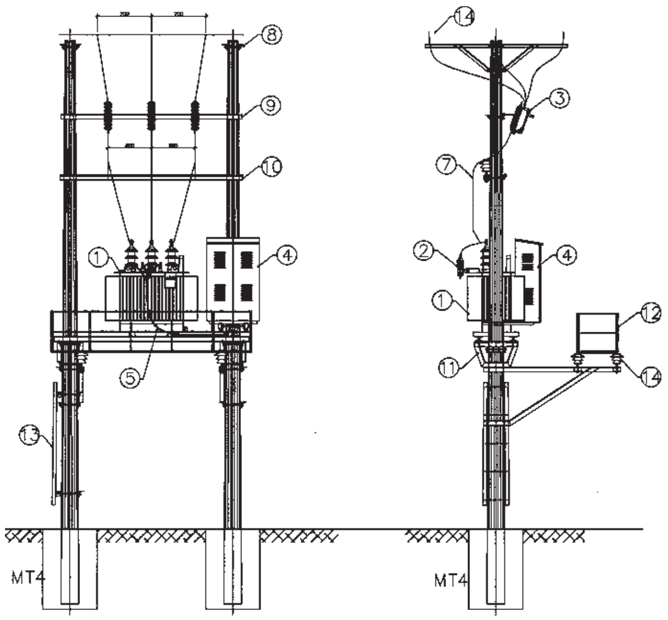
(b) Duration of continuous electricity cut-off and times of electricity cut-off incidents

- Times of electricity cut-off incidents: plan of electricity cut-off (annual plan, 6 month-plan, 12 month-plan)
- Duration of continuous electricity cut-off: around 8 to 24 hours

Approximately estimation the cost to constribute for construction cost in case of installation new electricity transformer sub-stations to receive power supplying for proper sources of power using.

Moreover, in order to make comparison of transformer capacity and installation type, it is common that two transformers are installed on columns and record physical relations of equipment piers that consist of 6 types: 400KVA, 560KVA, 630KVA.

The place of the sub-station in each section is shown in the following tables.



※ About the result of cost estimation, refer to different page.

Table 4.3 Power Supply of Cau Gie – Ninh Binh

No	Drawing No – 01 (KM 213 +600 – KM 214 + 800)	
1	**Substation**	
	Name of Substation:	***TBA chiếu sáng 1***
	Class Voltage:	***35kV***
	Capacity:	***400kVA***
	Address of Substation:	
2	**Substation**	
	Name of Substation:	***TBA chiếu sáng 2***
	Class Voltage:	***35kV***
	Capacity:	***400kVA***
	Address of Substation:	
3	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	*Drawing No – 03 (KM 211 + 000 – KM 212 + 400)*	
4	**No Substation**	
5	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	Drawing No – 04 (KM 212 + *800* – KM 216 + 000)	
6	**Substation**	
	Name of Substation:	***TBA chiếu sáng 3***
	Class Voltage:	***35kV***
	Capacity:	***50kVA***
	Address of Substation:	
No	Drawing No – 05 (KM 216 + 000 – KM 218 + 500)	
7	**No Substation**	
8	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	Drawing No – 06 (KM 218 + 500 – KM 220 + 000)	
9	**Substation**	
	Name of Substation:	***TBA chiếu sáng 4***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	
No	*Drawing No – 07 (KM 220 + 000 – KM 222 + 000)*	
10	**No Substation**	
11	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	*Drawing No – 08 (KM 222 + 000– KM 225 + 00)*	

12	**Substation**	
	Name of Substation:	***TBA Chiếu sáng 5***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	
	Line low Voltage 0.4kV	***Near the line low Voltage***
No	*Drawing No – 09 (KM 225 + 00– KM 226 + 500)*	
13	**Substation**	
	Name of Substation:	***TBA Số 8***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	
14	**Substation**	
	Name of Substation:	***TBA Số 9***
	Class Voltage:	***35kV***
	Capacity:	***400 kVA***
	Address of Substation:	
15	**Substation**	
	Name of Substation:	***TBA Số 10***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	
16	**Substation**	
	Name of Substation:	***TBA Số 11***
	Class Voltage:	***10kV***
	Capacity:	***50 kVA***
	Address of Substation:	
No	*Drawing No – 11 (KM 229 + 500– KM 231 + 900)*	
17	**Substation**	
	Name of Substation:	***TBA Số 12***
	Class Voltage:	***35kV***
	Capacity:	***400 kVA***
	Address of Substation:	
No	*Drawing No – 12 (KM 231 + 900– KM 234+ 900)*	
18	**Line low Voltage 0.4kV**	**Km 154 – Km155** ***Near the line low Voltage***
19	**Substation**	
	Name of Substation:	***CS số 13***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 13 (KM 234 + 900– KM 238 + 000)*	
20	**Substation**	
	Name of Substation:	***CS số 14***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 14 (KM 238 + 000– KM 241 + 000)*	
21	**Substation**	
	Name of Substation:	***CS số 15***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 14 (KM 238 + 000– KM 241 + 000)*	
22	**Substation**	
	Name of Substation:	***CS số 16***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	

No	*Drawing No – 15 (KM 241 + 000– KM 243 + 000)*	
23	**Substation**	
	Name of Substation:	***CS Cầu Phù Đổng***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 16 (KM 243 + 000– KM 245 + 800)*	
24	**No Substation**	
No	*Drawing No – 17 (KM 245 + 800– KM 248 + 500)*	
25	**Substation**	
	Name of Substation:	***CS số 17***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	
No	*Drawing No – 18 (KM 248 + 500– KM 251 + 000)*	
26	**Substation**	
	Name of Substation:	***CS Cầu Phù Đổng***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 19 (KM 251 + 000– KM 253 + 650)*	
27	**Substation**	
	Name of Substation:	***CS số 18***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 20 (KM 253 + 650– KM 255 + 500)*	
28	**Substation**	
	Name of Substation:	***CS số 19***
	Class Voltage:	***35kV***
	Capacity:	***400 kVA***
	Address of Substation:	
No	*Drawing No – 21 (KM 255 + 500– KM 257 + 500)*	
29	**Substation**	
	Name of Substation:	***CS số 20***
	Class Voltage:	***35kV***
	Capacity:	***400 kVA***
	Address of Substation:	
No	*Drawing No – 22 (KM 257 + 500– KM 259 + 000)*	
30	**Substation**	
	Name of Substation:	***CS số 21***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	
No	*Drawing No – 23 (KM 259 + 000– KM 260 + 000)*	
31	**Substation**	
	Name of Substation:	***CS số 22***
	Class Voltage:	***35kV***
	Capacity:	***250 kVA***
	Address of Substation:	

Table 4.4 Power Supply of Hanoi – Bac Ninh

No	*Drawing No – 01 (KM 137 +250 – KM 138 + 750)*	
1	**Substation**	
	Name of Substation:	***TBA Võ Cường 1***
	Class Voltage:	***35kV***
	Capacity:	***400kVA***
	Address of Substation:	***Võ Cường – Bắc Ninh (Km 137)***
2	**Substation**	
	Name of Substation:	***TBA Võ Cường 2***
	Class Voltage:	***35kV***
	Capacity:	***400kVA***
	Address of Substation	***Võ Cường – Bắc Ninh (Km 138 + 100)***
3	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	*Drawing No – 02 (KM 138 + 750 – KM 141 + 750)*	
4	**No Substation**	
5	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	Drawing No – 03 (KM 141 + 750 – KM 143 + 250)	
6	**Substation**	
	Name of Substation:	***TBA Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 142 – QL1***
No	Drawing No – 04 (KM 143 + 250 – KM 144 + 750)	
7	**No Substation**	
8	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	Drawing No – 05 (KM 144 + 750 – KM 146 + 250)	
9	**Substation**	
	Name of Substation:	***TBA Số 5 Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 145 – QL1 (KCN Tiên Sơn)***
10	**Substation**	
	Name of Substation:	***TBA Số 6 Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 146 – QL1 (KCN Tiên Sơn)***
No	*Drawing No – 06 (KM 146 + 250 – KM 147 + 750)*	
11	**No Substation**	
12	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	*Drawing No – 07 (KM 147 + 750– KM 149 + 00)*	
13	**Substation**	
	Name of Substation:	***TBA Số 7 Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 148 – QL1***
	Line low Voltage 0.4kV	***Near the line low Voltage***
No	*Drawing No – 08 (KM 149 + 00– KM 150 + 250)*	
14	**Substation**	
	Name of Substation:	***TBA Số 8 Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 149 – QL1***
15	**Substation**	
	Name of Substation:	***TBA Từ Sơn***
	Class Voltage:	***35kV***
	Capacity:	***400 kVA***
	Address of Substation:	***Từ Sơn – Bắc Ninh***

16	**Substation**	
	Name of Substation:	***TBA Số 9 Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 150 – QL1 (Bắc Ninh)***
No	*Drawing No – 09 (KM 150 + 250– KM 151 + 750)*	
17	**Substation**	
	Name of Substation:	***TBA Số 10 Chiếu sáng Quốc Lộ 1***
	Class Voltage:	***10kV***
	Capacity:	***50 kVA***
	Address of Substation:	***Km 151 – Từ Sơn – Bắc Ninh***
No	*Drawing No – 10 (KM 151 + 750– KM 153 + 250)*	
18	**Substation**	
	Name of Substation:	**TBA Chiếu sáng Vạn Điểm**
	Class Voltage:	**35kV**
	Capacity:	**100kVA**
	Address of Substation:	**Vạn Điểm – Thường Tín – Hà Nội (Km 204)**
19	**Line low Voltage**	**Near 500m**
No	*Drawing No – 12 (KM 205 + 000 – KM 207 + 800)*	
20	**Substation**	
	Name of Substation:	**TBA Dân Sinh**
	Class Voltage:	**35kV**
	Capacity:	**400kVA**
	Address of Substation:	**Thường Tín – Hà Nội (Km 205 + 200)**
21	**Line low Voltage**	**Near 500m**
No	*Drawing No – 13 (KM 207 + 800 – KM 210 + 600)*	
22	**Substation**	
	Name of Substation:	**TBA CS nút Đại Xuyên**
	Class Voltage:	**35kV**
	Capacity:	**50kVA**
	Address of Substation:	**Đại Xuyên (Km 209+300)**
23	**Line low Voltage**	Near 500m
No	*Drawing No – 14 (KM 210 + 600 – KM 211 + 00)*	
24	**Line low Voltage**	Near 500m
25	**Substation**	No

Table 4.5 Power Supply of Noi Bai –BacNinh

No	***Drawing No – 01 (KM 1- 593 – KM 0 - 100)***	
1	**Substation**	
	Name of Substation:	***HươngGia 2***
	Class Voltage:	***22kV***
	Capacity:	***400 kVA***
	Address of Substation:	***HươngGia – PhúCường – SócSơn – TP.HàNội (near Km 0 – 895)***
No	*Drawing No – 02 (KM 0 - 100 – KM 1 + 200)*	
2	**Substation**	***No Substation***
3	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	Drawing No – 03 (KM *1 + 200*– KM *4 + 200*)	
4	**Substation**	
	Name of Substation:	***Phú Minh 5***
	Class Voltage:	***22kV***
	Capacity:	***400 kVA***
	Address of Substation:	***Phú Minh – SócSơn – TP.HàNội*(Km 3 + 150)**
5	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	Drawing No – 04 (KM *4 + 200* – KM *7 + 300*)	
6	**Substation**	
	Name of Substation:	***Chiếusángcầu B1.3***
	Class Voltage:	***6(22) kV***
	Capacity:	***31.5 kVA***
	Address of Substation:	***CầuPhú Minh – SócSơn – TP.HàNội (Km 5+970)***

No	Drawing No – 05 (KM *7 + 300*– KM *8 + 800*)	
7	**No Substation**	
8	**Line low Voltage 0.4kV**	***Near the line low Voltage***
No	*Drawing No – 06 (KM 8 + 800– KM 10+ 300)*	
9	**Substation**	
	Name of Substation:	***Chiếusángcầu B1A5***
	Class Voltage:	***35kV***
	Capacity:	***31.5 kVA***
	Address of Substation:	***PhùLỗ - SócSơn – TP.HàNội*(Km 9 + 225)**
No	*Drawing No – 07 (KM 10+ 300– KM 13+ 300)*	
10	**Substation**	
	Name of Substation:	***ĐôngXuân***
	Class Voltage:	***22kV***
	Capacity:	***400 kVA***
	Address of Substation:	***ĐôngXuân - SócSơn – TP.HàNội (Km 11)***
11	**Line low Voltage 0.4kV**	*Near the line low Voltage (Km 12)*
No	*Drawing No – 08 (KM 13+ 300– KM 16+ 300)*	
12	**Substation**	
	Name of Substation:	***Kim Thượng 1***
	Class Voltage:	***22kV***
	Capacity:	***250 kVA***
	Address of Substation:	***Kim Thượng - SócSơn – TP.HàNội (Km 14 +)***
13	**Substation**	
	Name of Substation:	***Kim Chung 2***
	Class Voltage:	***6(22) kV***
	Capacity:	***250 kVA***
	Address of Substation:	***Kim Chung - SócSơn – TP.HàNội (Km 15 +457)***
No	*Drawing No – 09 (KM 16+ 300– KM 19 + 300)*	
14	**Substation**	
	Name of Substation:	***TrạmBơm***
	Class Voltage:	***35kV***
	Capacity:	***50 kVA***
	Address of Substation:	***(Km 19)***
No	*Drawing No – 10 (KM 19 + 300– KM 20 + 800)*	
15	**Substation**	
	Name of Substation:	***TBA Chiếusáng***
	Class Voltage:	***35kV***
	Capacity:	***400kVA***
	Address of Substation:	***(Km 19 + 800)***
	Line low Voltage 0.4kV	***Near the line low Voltage (near 200m)***
No	*Drawing No – 11 (KM 20 + 800 – KM 23 + 800)*	
16	***No Substation***	
17	**Line low Voltage 0.4kV**	***Near the line low Voltage (near 500m)***
No	*Drawing No – 12 (KM 23 + 800– KM 26 + 800)*	
18	**Substation**	
	Name of Substation:	***TBA LâmSản – BắcNinh***
	Class Voltage:	***35kV***
	Capacity:	***630kVA***
	Address of Substation:	***BắcNinh (Km 25 + 750)***
19	Line low Voltage 0.4kV	***Near the line low Voltage (Km 26)***
No	*Drawing No – 13 (KM 26 + 800– KM 29 + 800)*	
20	**Substation**	
	Name of Substation:	***KCN PhongKhê***
	Class Voltage:	***35kV***
	Capacity:	***630kVA***
	Address of Substation:	***PhongKhê – BắcNinh (Km 28 + 200)***
No	*Drawing No – 14 (KM 29 + 800– KM 31+ 200)*	

21	**Substation**	
	Name of Substation:	***TBA Cầu***
	Class Voltage:	***35kV***
	Capacity:	***250kVA***
	Address of Substation:	***TừSơn – BắcNinh (Km 29 + 991)***
22	**Substation**	
	Name of Substation:	***TBA TừSơn***
	Class Voltage:	***35kV***
	Capacity:	***400kVA***
	Address of Substation:	***TừSơn – BắcNinh (Km 31)***
23	**Line low Voltage 0.4kV**	***Near the line low Voltage***

Table 4.6 Power Supply of Phap Van –CauGie

No	*Drawing No – 01 (KM 181 +570 – KM 184 + 200)*	
1	**Substation**	
	Name of Substation:	***TBA Công ty 248***
	Class Voltage:	***22kV***
	Capacity:	***180 kVA***
	Address of Substation:	***Hoàng Mai – TP.HàNội (near Km 182)***
2	**Substation**	
	Name of Substation:	**TBA dânsinh**
	Class Voltage:	**22kV**
	Capacity:	**400kVA**
	Address of Substation:	**(Km 183 + 500)**
No	*Drawing No – 02 (KM 184 + 200 – KM 187 + 000)*	
3	**Substation**	
	Name of Substation:	**TBA chiếusáng QL 1A**
	Class Voltage:	**22kV**
	Capacity:	**100kVA**
	Address of Substation:	**ThanhTrì – HàNội (Km 185)**
4	Line low Voltage: Near 500m	
No	*Drawing No – 03 (Km 187 + 000 – KM 188 + 500)*	
5	**Substation**	
	Name of Substation:	**TBA dânsinh**
	Class Voltage:	**22kV**
	Capacity:	**630kVA**
	Address of Substation:	**ThanhTrì – HàNội (Km 188)**
No	*Drawing No – 04 (KM 188 + 500 – KM 191 + 200)*	
6	**Substation**	
	Name of Substation:	**TBA dânsinh**
	Class Voltage:	**22kV**
	Capacity:	**630kVA**
	Address of Substation:	**ThanhTrì – HàNội (Km 191)**
7	**Line low Voltage:**	**Near 400m**
No	*Drawing No – 05 (KM 191 + 200– KM 192 + 500)*	
8	**Substation**	
	Name of Substation:	**TBA XãLiênPhương**
	Class Voltage:	**35kV**
	Capacity:	**30kVA**
	Address of Substation:	**LiênPhương – ThanhTrì _ HàNội (Km 192 + 200)**
No	*Drawing No – 06 (KM 192 + 500 – KM 194 +000)*	
9	**No Substation**	
10	**Line High Voltage**	Km 206 - 208
No	*Drawing No – 07 (194 +000 – KM 196 + 800)*	
11	**Substation**	
12	**Line low Voltage**	Near 500m
No	*Drawing No – 08 (KM 196 + 800 – KM 198 + 200)*	

13	**Substation**	
	Name of Substation:	**TBA dânsinh**
	Class Voltage:	**35kV**
	Capacity:	**400kVA**
	Address of Substation:	**(Km 197 + 400)**
No	*Drawing No – 09 (KM 198 + 200 – KM 200 + 800)*	
14	**Substation**	
	Name of Substation:	**TBA ĐènĐườngTôHiệu**
	Class Voltage:	**35kV**
	Capacity:	**100kVA**
	Address of Substation:	**TôHiệu – ThườngTín – HàNội (Km 199 + 300)**
15	**Line low Voltage**	**Near 500m**
No	*Drawing No – 10 (KM 200 + 800 – KM 203 + 600)*	
16	**Substation**	
	Name of Substation:	**TBA Dânsinh**
	Class Voltage:	**35kV**
	Capacity:	**400kVA**
	Address of Substation:	**Km 201 + 500**
17	**Line low Voltage**	**Near 300m**
No	*Drawing No – 11 (KM 203 + 600 – KM 205 + 000)*	
18	**Substation**	
	Name of Substation:	**TBA Chiếusáng VạnĐiểm**
	Class Voltage:	**35kV**
	Capacity:	**100kVA**
	Address of Substation:	**VạnĐiểm – ThườngTín – HàNội (Km 204)**
19	**Line low Voltage**	**Near 500m**
No	*Drawing No – 12 (KM 205 + 000 – KM 207 + 800)*	
20	**Substation**	
	Name of Substation:	**TBA DânSinh**
	Class Voltage:	**35kV**
	Capacity:	**400kVA**
	Address of Substation:	**ThườngTín – HàNội (Km 205 + 200)**
21	**Line low Voltage**	**Near 500m**
No	*Drawing No – 13 (KM 207 + 800 – KM 210 + 600)*	
22	**Substation**	
	Name of Substation:	**TBA CS nút Đại Xuyên**
	Class Voltage:	**35kV**
	Capacity:	**50kVA**
	Address of Substation:	**Đại Xuyên (Km 209+300)**
23	**Line low Voltage**	Near 500m
No	*Drawing No – 14 (KM 210 + 600 – KM 211 + 00)*	
24	**Line low Voltage**	Near 500m
25	**Substation**	No

5) Responsibility Demarcation Point

During the negotiations with power Supply Company, It's necessary to decide the property demarcation point in order to define the responsibility demarcation point in terms of management and property classification. In principle, if Road Company installs switchgear on the first supporting pole within its premise, the primary connection point of this switchgear shall be considered to be the property demarcation point and the responsibility demarcation point.

6) Power Receiving Capacity

The power receiving capacity is defined by the following formula

$$Pr = \Sigma\left[\frac{P}{Pf\times(\eta\times\frac{1}{100})}\times\frac{Df}{100}\right]\times\frac{1}{F}$$

Here, Pr: Power receiving capacity (KVA)
P: The installation capacity of each load class (KW)
Pf: Power factor for each load class =0.9
η : Efficiency of each load class (%)
Df : Demand factor of each load class (%)
F: Diversity factor

Generally, the functional part of ITS equipment operates by direct circuit, after go through AC-DC stabilization power circuit, it supplies the CPU with 90%. Other load efficiencies are shown in Table 4.7.

Table 4.7 Load efficiency (η)

	Name of equipment	Efficiency %		Name of equipment	Efficiency %
1	ITS equipment overall	90	3	Electric light in buildings	70
2	Street lighting	90	4	Engine in buildings	90

Demand factor is the ratio of maximum load capacity to average power capacity. In case of receiving power of commercial high voltage for many type of equipment of the Regional Main Center, the Road Management Office and Toll Office, it is essential to avoid the problem of power summation which is multiplied by each demand factor shown in Table 4.4.

Table 4.8 Demand factor (Df)

	Name of equipment	Demand factor %		Name of equipment	Demand factor %
1	CCTV	100	6	GC	50
2	VMS	60	7	CVCF	50
3	Transmission switch	50	8	Electric light in buildings	50
4	Traffic control equipment	50	9	Air conditioners in buildings	60
5	ETC	100	10	Other engines	50

7) Voltage Drop

Generally, the allowable voltage fluctuation range of terminal equipment is within ±10%

of rated voltage. Therefore, in case the supply voltage to electrical equipment falls below minimum allowable voltage by the voltage drop, the solution of cutting the voltage drop shall be implemented.

The power supply company shall take the voltage drop of transmission lines into consideration and transmit with a certain extra voltage. In Vietnam, the voltage which equals to nominal voltage shown in Table 11.1 plus 10% is the transmission voltage from substation. That means the nominal voltage at the power receiving point in customer's side is increased by 10%. In other words, this results in the fluctuation between ±5%. Therefore, it is nece ssary to keep the voltage drop of transmission line on load side under 5%.

Regarding the calculation of voltage drop of transmission line, in case many loads are connected in series, power is transmitted in dendritic structure. The project will calculate the voltage drop of each transmission network and sum up all the calculation values as the voltage drop value.

4.2 Northern Regional Main Center

1) Power Reception Place

The Electrical Receiving Station should be near urban centers, this warrants the convenient connection to the electric sources (provided by the Power Supply Company), and principally be within the area (Campus) where the electricity is consumed.

The Electrical Receiving Station is placed as close as possible the power supply. The consultation of the Power Supply Company is very necessary in order to find the most reasonable location which minimizes the construction cost and creates favorable condition for the maintenance.

It should be noted that the adjustment of the ground protection equipment (such as circuit breaker), the installation position of the Metering Out Fit transformer (MOF), the specifications and location position of the switch at the receiving electricity point, should be carried out with the consultation of the Power Supply Company in term of the scope of lightning arresters.

The construction of the Regional Main Center requires an exclusive and detailed design. This design should be tested and delivered to the power source which will supply electricity for its equipment for the purpose of checking. This power source should be specified in the settings of the control centers.

The results of a field survey showing that there is a 35 KV Substation (owned by the Northern Transport/Control Center) located at 19+ 800 Kilometer-posts (KP) has planned to construct an electrical grid (35,000V). The substation that is about 20 Kilometer-posts (KP) far from that grid has been built and be chosen as an Electrical Receiving Station.

The format of power reception place is indoor type. The space of power reception place varies by case, but the area should be planned in terms of distance between powers switchboards, carrying in and out space, etc. Since the distance of major parts such as transformer, power switchboard shall secure the necessary space for equipment maintenance and inspection as well as the effective space in terms of fire safety, the distance shall be higher than the values shown in the Table 4.5. Besides, regarding the necessary passage for maintenance and inspection, the width shall be more than 0.8m and the clearance shall be more than 1.8m.

In the future, in order to change power switchboards and transformers, it is preferable to secure a passage from equipment sets such as power switchboards to the carrying in and out door.

Table 4.9 The minimum distance between equipment sets such as power switchboard

	Overall area or operation surface	Rear surface or inspection surface	Interval between rows
High voltage power switchboard	1.0m	0.6m	1.2m
Low voltage power switchboard	1.0m	0.6m	1.2m
Transformer	0.6m	0.6m	1.2m

Note: The interval between rows is referred to in case there are more than two rows of equipment sets.

2) Electrical System

In principal, the electrical system complies with the system shown in Table 4.6. In this case, the electrical system of the building and terminal load equipment shall be fully examined in order to decide the appropriate circuit. In case of transmission to equipment sets in the IC premise and on the road, the efficient system is 3Φ4W-380V/220V.

Table 4.10 Electrical system of Main Center

Load category	Electrical system	Remarks
ITS equipment	3Φ3W-380V	.
House engine	3Φ3W-380V	Electric appliances such as air conditioners, etc
House electric light	3Φ4W-380V/220V	The electric light socket in the building and measurement facilities.
Road lighting	3Φ4W-380V/220V	To control the lighting-up of power switchboard
Equipment sets on the road	3Φ4W-380V/220V	Full-time transmission

The power to ITS equipment in the Regional Main Center is supplied through the constant voltage and constant frequency unit (CVCF) or direct current power supply system. Besides, the power to ETC equipment sets of mentioned IC is supplied through the constant voltage and constant frequency unit (CVCF).

The power for lighting the Interchange and plaza complies with standard of 3Φ4W for sodium vapour lamp and mercury vapour lamp, but in case of lighting equipment sets for smaller scale,there should be consideration for using 3Φ3W 380V in terms of economic efficiency.

3) Main Current Mode

The terminal load voltage is 3Φ380V for engines and 1Φ220V for lamps and sockets. 220V and 380 V, which is $\sqrt{3}$ times of 220V, are simultaneous output, and 3Φ4W 380V-220V of three-phase four-wire type as to be shown in Figure 4.1 utilizing the neutral phase (N phase) of secondary voltage of transformer. The house generator output is also 3Φ4W380V-220V, in the event of commercial power blackout, the house generator is switched on automatically in order to secure electricity failure.

The main current mode of power switchboard is shown in Figure 4.1. Because the mobile generator can be used in case of periodical inspection for power switchboard, it is preferable to set up the secondary maintenance switchboard in advance.

Figure 4.1 Secondary voltage of transformer.

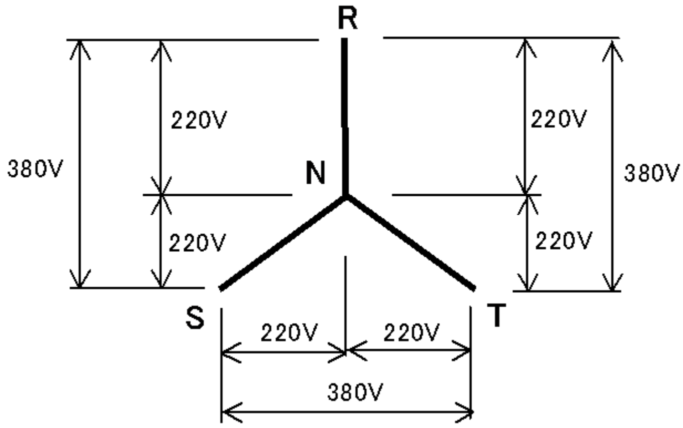
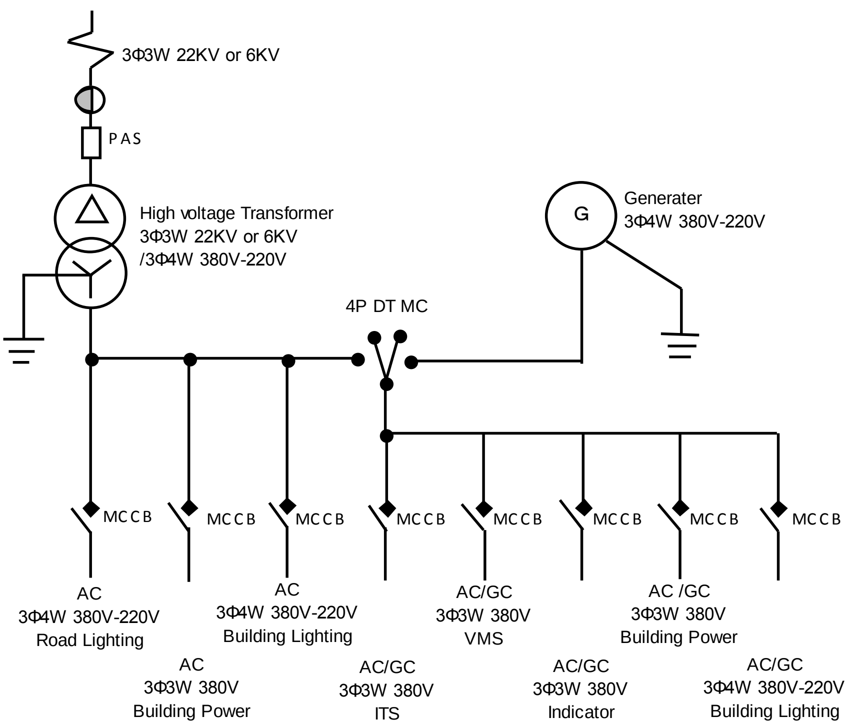


Figure 4.2 Power distribution Wiring Diagram



4) House Generator Facilities

House generator facilities are the equipment sets which generate power by house generator and supply power to electric appliances in event of commercial power blackout, they are not operated in parallel with commercial power.

(1) Generator electrical system

Generator electrical system is similar to secondary voltage of transformer, i.e. 3Φ4W380V - 220V.

(2) Load of generator

Load of generator complies with Table 4.7, but it shall be kept below the minimum necessary.

Table 4.11 Load of Generator

Type of load	Content	Amount of load
Road Lighting etc	Road Lighting	-
	VMS	100%
	Internal lighting signboard	100%
	External lighting signboard	-
ITS Equipment		100%
ETC Equipment		100%
ITS Equipment on the main route		-
Building Power	CVCF, direct current	100%
	Weight scale	100%
	Water supply pump and sewage pump	100%
	Generator auxiliary components	100%
Building Lighting	Electric lamp, socket	60%
	Toll gate 1	100%
	Lamps in equipment room	50%
	Air-conditioning system in equipment room	100%

(3) Generator and engines

The generator is horizontal synchronous generator with constant rating, the engine is diesel one with air start-up mode. The consecutive operation standard of the two equipment sets is more than 24 hours. The excitation system of generator is brushless system or static excitation system, the cooling system is air cooling self ventilation.

(4) Volume of fuel tank

The Regional Main Center and the Road Management Office is the stronghold in terms of fire safety. Therefore, it is necessary to install a fuel tank which is sufficient for consecutive 3 days (72 hours) operation.

The fuel is a heavy oil or light oil. Because the fuel tank installation shall conform to legal regulations such as fire prevention ordinance, the registry and approval from competent fire department are required.

Therefore, it is preferable to examine thoroughly in advance and negotiate with competent fire department in terms of installation place and building structure, etc.

The fuel consumption of engine and tank volume is obtained by the following formula:

i) Fuel consumption of the engine

$Q = b \times Le\ /\ \varphi$

Q : Engine fuel oil consumption (ℓ/h)

b : Engine fuel oil consumption rate (kg/p.s×h) 0.231 ~ 0.299 kg/p.sh

Le : Engine power output (ps)

φ : Fuel oil specific gravity (A heavy oil: 0,84kg/ ℓ, light oil: 0,83kg/ ℓ)

ii) Fuel tank volume

$V = Q \cdot H$

V : Fuel tank volume (ℓ)

H : Consecutive operation time (h)

5) Grounding

It is necessary to equip grounding for the purpose of electrification prevention and insulation protection for electric appliances against the abnormal voltage occurred in lightning surge and system. In principal, grounding types are shown in Table 4.8.

However, grounding type D for communication device and light electrical appliances shall be separated from other equipment and implemented by dedicated grounding.

Table 4.12 Types of grounding

Grounding Type	Target Equipment
Type A	Lightning arrester, high voltage equipment sets
Type B	The secondary voltage of transformer in Y-connection; anyphase among 3 phases in other cases
Type C	Equipment sets above low voltage 300V
Type D	Equipment sets below low voltage 300V

4.3 Road Management Office

Since ITS equipment is not a single reception system, it is designed from a temporary power switchboard among ITS devices in the Road Management Office.

4.4 Toll Office

Since ITS equipment is not a single reception system, it is designed from a temporary power switchboard among ITS devices in Toll Office.

4.5 Roadside Equipment

1) General Information

(1) Single power reception and collective power reception

The power reception system of equipment sets on the road has two types: separate reception from distribution line of Power Company, and collective reception in interchange and toll barrier and distribution from reception equipment. In case of extracting the consideration on the comparison between the two modes in terms of lead-in expenses for the interval PhapVan ~ Cau Gie, the approximate expenses for 40 places are shown in the Table 4.9. In other words, single power reception is comparatively cheaper.

Table 4.13 Comparison of the reception system (40 places per)

Phân loại	Hệ nhận điện đơn Đơn vị: 1,000 USD		Hệ thống nhận điện tập trung Đơn vị: 1,000 USD	
Chi phí dây dẫn	600m	6	37,625m	868
Chi phí Quản lý	480m	108		0
Chi phí đường vào	40	165		0
HH	80	240	160	120
Bảng chuyển mạch đường vào		0	1	375
Tổng		519		1,363

Note 1: Collective reception means the distribution from reception equipment sets of IC, TB.
Note 2: Wiring expense includes the expense of cable connection, etc

Therefore, in principal, the equipment sets on the road are single reception system. Because the interchange and toll barrier, which are receiving high voltage, enjoy stable power due to the power generation compensation by house generator in event of electricity failure, in principal, the VMS and measurement facilities in its vicinity are distributed from high voltage reception equipment sets.

In case equipment sets on the road are located in several neighbourhood places, there is possibility that the collective reception system is cheaper than single reception system for each equipment. In such case, in principal, the power is received in gravity center of load electrical energy and distributed through distribution switchboard to each electrical appliance.

If there are no distribution lines of Power Company in the vicinity of equipment sets on the road, the expense for Power Company to lay long aerial distribution line can be a huge amount of money. Especially in case of distribution lines across mountains and valleys, there is a method in which the underground cables are laid to road side to connect with the distribution lines of Power Company in its vicinity. By receiving the rough quotation mount of instruction from Power Company, the cheaper method can be taken into consideration.

In case of power reception via bridge or overhead lines, the power line can be led in by mounting metal clasps outside the bridge railing on the road shoulder. But it is necessary to be able to confirm the power meter from outside the premise. In such cases, there are two solutions: (1) installing the trespassing prevention net around the power meter; (2) confirming the power meter from inside the bridge railing on the road shoulder, reading the meter on the roadside then contacting the power company. The latter has cheaper construction expense so it is necessary to negotiate with Power Company.

(2) Communication line and separation

In order to prevent electrical hazard to communication device end user and noise to communication device, the communication line and power line shall not be put in the same duct line.

In principal, the shared use of cable chamber between communication line and power line shall be avoided and equip cable chamber for each line. But in case sharing the same cable chamber is inevitable such as the lead-in part of equipment, the required separation distance shown in Table 4.10 shall be secured.

Table 4.14 Required Separation distance from Communication line

Voltage power line (V)	Required separation distance
V ≦ AC300v	More than 6(12) cm
AC300v ＜ V ＜ AC600v	More than 15(30) cm
AC600v ≦ V	More than 30cm

Note 1. Power line voltage (V) is the voltage to ground.
Note 2. ( ) Is not visible location in the wall and easily.

(3) High voltage demand area premise and collective power reception prohibition

In order to prevent electrical hazard to communication device end user and noise to communication device, the communication line and power line shall not be put in the same duct line.

Regarding areas receiving high voltage power such as interchange and toll barrier, it is necessary to designate and approve the House electric facilities including the area from power reception equipment sets to the furthest power distribution load equipment. If the individual power line is led in from the power company to this area, this will probably lead to “chaotic electrical hazard” where some aspect could be taken under control whistle other aspect still remains. Therefore, do not receive any other power within the high voltage power reception area.

The intervals continuously which are lined up with load terminals such as main road lighting system, in case of adding new load equipment, will be relevant to this issue. Therefore, it is necessary to consider distributing power by setting up a new branch circuit in power reception device for the purpose of road lighting or dividing the area for private use into new power reception place and separating it from area for private use.

(4) Grounding

It is necessary to equip grounding for the purpose of electrification prevention and insulation protection for electric appliances against the abnormal voltage occurred in lightning surge and system. Grounding types are classified in Table 4.8. However, class D grounding type for communication device and light electrical appliances shall be separated from other equipment and implemented by dedicated grounding.

Table 4.15 Types of grounding

Grounding Type	Target Equipment
Type A	Lightning arrester, high voltage equipment sets
Type B	The secondary voltage of transformer in Y-connection; and N phase; any phase among 3 phases in other cases
Type C	Low voltage equipment (above 300V)
Type D	Low voltage equipment (below 300V)

In case peripheral sensors such as ETC equipment sets are multiply connected, it is necessary to secure the voltage to ground of equipment sets as electric potential and to implement collective grounding.

The grounding for transmission – exchange equipment sets and their direct current apparatus conforms to Type A in Table 4.11.

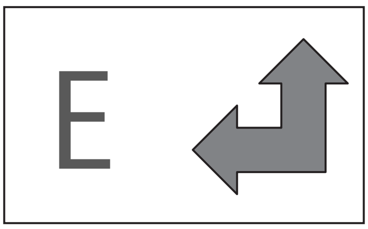
Mobile wireless aerial line tower requires lightning rod and grounding resistance value is below 10Ω. Besides, lightning protection conducting wire is twisted copper wire of 38mm2. The grounding place shall be indicated by signboard for underground grounding, in which information such as grounding type, resistance value and date of construction are written down and can hardly be removed.

(5) Signs for cable and underground cable

The “Sign for Cable” shall be sticked inside the cable chamber for cables for power distribution work and in connection terminal vicinity of equipment so that it can not be removed easily. Information of cable type, use application, date of construction is mentioned in the Sign for cable.

In case the cable is laid underground, the sign for underground cable shall be put on the ground to indicate the underground location. The signs for underground cable shall be put on the ground every 50m above the cable and right in place where the cable changes its direction, and right after the cable chamber. Besides, the sign for power line is “E”, the sign for communication line is “C”, these letters are engraved with the arrows indicating the underground cable directions.

Figure 4.3 Cable embedded marker Sign for underground cable



2) Low Voltage Power Reception

In case equipment sets on the road are single power reception system with low voltage, they conform to Table 4.12. Generally, equipment sets on the road are 1Φ2W 220V. If the distance from power reception place to the load is long, in order to reduce the voltage depression, it is possible for 1Φ3W 380V-220V power reception system, but only if terminal equipment is one – phase load, the input voltage is 380V and do not use N phase (neutral phase).

In case several equipment sets are collective power reception system with low voltage, it is possible for 1Φ3W 380V-220V or 3Φ4W 380V-220V, the phase in use will vary with each load, and it is necessary to reduce the N phase current to the utmost.

Table 4.16 Type of Power

Type	Target Load
1Φ2W 220V	In case of small load and short distance
1Φ3W 380V-220V	In case of small load and long distance
3Φ4W 380V-220V	In case of big load

The lead-in power pole shall be built in the lower part of embankment slope or in the higher part of earth cut slope with lead-in metal clasp, and equipped with power distribution switchboard, power meter box, grounding, branch line, etc. In general, the power meter can be read from the roadside.

3) High Voltage Power Reception

In case of power reception system of high voltage above 6000V, two lead-in power poles shall be built and equipped with the mount for high voltage transformer. The inspection place shall be built in the lower part of transformer mount. In principal, the secondary voltage of transformer is the voltage shown in Table 11.12. The power meter is attached with secondary low voltage and it can be read from roadside. If the voltage of power reception increases, the protection relay will cost more. Therefore, it is lowest voltage.

4) The Receiving Power Ability and Maximum Power Demand

Maximum Power Demand is the basis factor for determining the company’s power contract. This contract should include the total power demand and the power distribution to all the devices used by the company, and is based on formal written statements.

The determination of the Receiving Power Ability is to calculate the power demand of devices at different level of operation, in other word, is to estimate the power demand from the Maximum Power Demand. This will be used to specify the capacity and electrical contract of the electrical receiving devices.

In this design, the calculation has been done to determine the power demand, types of Roadside equipment and the Northern Regional Center Main equipment.

The smallest necessary electric power of each section was estimated to a base in the power consumption of equipment installed in the roadside. The power consumption of each section is shown in the following tables.

Table 4.17 Power Consumption of Mai Dich – Thanh Tri

Ring Road 3			
Classification	Qty.	Power(KVA)	Total(KVA)
PTZ Camera	23	0.12	2.76
Fixed Camera	14	0.07	0.98
VMS Type-A	6	4.22	25.32
VMS Type-B	2	2.82	5.64
VMS Type-C	12	0.22	2.64
Vehicle Detector:(by Image)	18	0.07	1.26
Processing	18	0.30	5.40
Vehicle Detector:(by Loop)	2	0.22	0.44
Processing	2	1.00	2.00
CSS	15	0.14	2.10
Weather Sensor	1	0.30	0.30
touch&go/manual toll collection	2	50.00	100.00
etc toll collection	2	10.70	21.40
axle load scale	2	1.00	2.00
switch/transmission equipment			0.00
Mobile Radio Communication	3	1.50	4.50
Grand Total(KVA)			176.74

Table 4.18 Power Consumption of Ha Noi – Bac Ninh

HaNoi-BacNinh			
Classification	Qty.	Power(KVA)	Total(KVA)
PTZ Camera	31	0.12	3.72
Fixed Camera	26	0.07	1.82
VMS Type-A	9	4.22	37.98
VMS Type-B	10	2.82	28.20
VMS Type-C	0	0.22	0.00
Vehicle Detector:(by Image)	10	0.07	0.70
Processing	10	0.30	3.00
Vehicle Detector:(by Loop)	2	0.22	0.44
Processing	2	1.00	2.00
CSS	10	0.14	1.40
Weather Sensor	1	0.30	0.30
touch&go/manual toll collection	2	50.00	100.00
etc toll collection	2	10.70	21.40
axle load scale	2	1.00	2.00
switch/transmission equipment		0.00	0.00
Mobile Radio Communication	3	1.50	4.50
Grand Total(KVA)			207.46

Table 4.19 Power Consumption of Noi Bai – Bac Ninh

NoiBai-BacNinh			
Classification	Qty.	Power(KVA)	Total(KVA)
PTZ Camera	50	0.12	6.00
Fixed Camera	12	0.07	0.84
VMS Type-A	8	4.22	33.76
VMS Type-B	6	2.82	16.92
VMS Type-C	0	0.22	0.00
Vehicle Detector:(by Image)	8	0.07	0.56
Processing	8	0.30	2.40
Vehicle Detector:(by Loop)	2	0.22	0.44
Processing	2	1.00	2.00
CSS	18	0.14	2.52
Weather Sensor	0	0.30	0.00
touch&go/manual toll collection	2	50.00	100.00
etc toll collection	2	10.70	21.40
axle load scale	2	1.00	2.00
switch/transmission equipment		0.00	0.00

Mobile RadioCommunication	2	1.50	3.00
Grand Total(KVA)			191.84

Table 4.20 Power Consumption of Phap Van – Cau Gie

PhapVan-CauGie			
Classification	Qty.	Power(KVA)	Total(KVA)
PTZ Camera	16	0.12	1.92
Fixed Camera	0	0.07	0.00
VMS Type-A	4	4.22	16.88
VMS Type-B	4	2.82	11.28
VMS Type-C	0	0.22	0.00
Vehicle Detector:(by Image)	6	0.07	0.42
Processing	6	0.30	1.80
Vehicle Detector:(by Loop)	2	0.22	0.44
Processing	2	1.00	2.00
CSS	16	0.14	2.24
Weather Sensor	0	0.30	0.00
touch&go/manual toll collection		50.00	0.00
etc toll collection		10.70	0.00
axle load scale		1.00	0.00
switch/transmission equipment		0.00	0.00
Mobile RadioCommunication	2	1.50	3.00
Grand Total(KVA)			39.98

Table 4.21 Power Consumption of Cau Gie – Ninh Binh

CauGie-NinhBinh			
Classification	Qty.	Power(KVA)	Total(KVA)
PTZ Camera	0	0.12	0.00
Fixed Camera	0	0.07	0.00
VMS Type-A	6	4.22	25.32
VMS Type-B	4	2.82	11.28
VMS Type-C	0	0.22	0.00
Vehicle Detector:(by Image)	6	0.07	0.42
Processing	6	0.30	1.80
Vehicle Detector:(by Loop)	0	0.22	0.00
Processing	0	1.00	0.00
CSS	20	0.14	2.80
Weather Sensor	1	0.30	0.30
touch&go/manual toll collection		50.00	0.00
etc toll collection		10.70	0.00
axle load scale		1.00	0.00
switch/transmission equipment		0.00	0.00
Mobile Radio Communication	3	1.50	4.50
Grand Total(KVA)			46.42

Table 4.22 Power Consumption of Regional Main Center

Regional Main Center			
Classification	Qty.	Power(KVA)	Total(KVA)
60 inches display	12	0.172	2.06
32 inch display	20	0.084	1.68
26 inch display	62	0.02	1.24
Server	14	0.0024	0.03
Lighting	0	0.00	38.00
Air conditioning	0	0.00	350.00
PTZ Camera	2	0.12	0.24
Fixed Camera	3	0.14	0.42
VMS Type-A	2	4.22	8.44
VMS Type-B	1	2.82	2.82
VMS Type-C	0	0.22	0.00
Vehicle Detector:(by Image)	1	0.07	0.07
Processing	1	0.30	0.30

Vehicle Detector:(by Loop)	1	0.22	0.22
Processing	1	1.00	1.00
CSS	2	0.14	0.28
Grand Total(KVA)			406.81

And the total load capacity of roadside equipment and the toll equipment that load capacity of the equipment was estimated to a base is shown in the tables below.

Table 4.23 Load Capacity of Roadside Equipment sets

	PTZ Camera	Fixed Camera	VMS Type-A	VMS Type-B	VMS Type-C	Vehicle Detector (by Image)	Vehicle Detector (by Loop)	CSS	Weather Sensor
Main Unit	100	50	4,200	2,800	300	350	1,000	120	50
M/C-Switch	20	20	20	20	20	20	20	20	20
Sub-total	120	70	4,220	2,820	320	370	1,020	140	70
Total (approx.)	200	100	4,300	2,900	400	400	1,100	200	100
Quantity	158	65	34	34	12	54	10	89	4
Total	31,600	6,500	146,200	98,600	4,800	21,600	11,000	17,800	400

Total Consumed Power per Month (KW)	243,720

Table 4.24 Load Capacity of Toll Equipment sets

	DSRC Antenna	Vehicle Detector	License Plate Scanner	Entry Card Issuer	IC Card Reader Writer	Lane Server	Vehicle Classification Sign	Toll Due Paid Sign	STOP GO Sign	PTZ Camera	Fixed Camera	Automatic Barrier
Main Unit	1,000	50	1,000	1,000	100	1,000	300	300	100	100	50	500
M/C-Switch												
Sub-total	1,000	50	1,000	1,000	100	1,000	300	300	100	100	50	500
Total (approx.)	1,000	100	1,000	1,000	100	1,000	300	300	100	100	100	500
Quantity	30	188	94	44	120	94	94	94	94	94	94	94
Total	30,000	18,800	94,000	44,000	12,000	94,000	28,200	28,200	9,400	9,400	9,400	47,000

Total Consumed Power per Month (KW)	305,568

5. Road Operation Vehicles

5.1 General

Road Operation Vehicles below are planned for traffic Management.

- Patrol Vehicle
- Towing Vehicle

5.2 Requirements and Numbers of Vehicle

1) Requirements

(1) Patrol Vehicle

Patrol vehicle will be used to patrol on the expressway to locate damage, to implement countermeasures such as expressway closure or lane closure, and to undertake emergency action such as removing obstacle on the expressway. As such, the vehicle shall have high driving performance, short stopping distance, high safety features, large loading capacity, and environmentally friendly features.

The image of vehicle is shown below.

Figure 5.1 Image of Patrol Vehicle

(2) Towing Vehicle

Towing vehicle has equipment moving a vehicle disturbing the road traffic such as an accident vehicle and a broken-down vehicle. And the towing vehicle used to tow those vehicles on an expressway. As such, the vehicle shall have high driving performance, short stopping distance, high safety features, large loading capacity, and environmentally friendly features.

The image of vehicle is shown below.

Figure 5.2 Image of Towing Vehicle

2) Numbers of Vehicle

A patrol vehicle and the towing vehicle are arranged in Road Management Office of each section or the parking space along the expressway for operation and maintenance in the expressway.

The number of an arranged vehicle is shown in the following table.

Table 5.1 Number of Vehicle for Each Section

Vehicle Type	MaiDich–ThanhTri	Lang–HoaLac	PhapVan–CauGie	CauGie–NinhBinh	HaNoi–BachGiang	HaNoi–CaLoBrg.	CaLoBrg.–BacNinh
Patrol Vehicle	1	1		1		1	1
Towing Vehicle	1	1		1		1	1