MINISTRY OF TRANSPORT
VIETNAM

STUDY FOR
ITS INTEGRATION PROJECT
IN NORTHERN AREA OF VIETNAM

MAIN 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.
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Summary

➢ 1. Background and Necessity

The number of vehicle ownership has been growing at an annual rate of nearly 10% in Vietnam and further growth is expected in the future. In such a situation, 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. 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.

On the other hand, the increase in traffic accidents has become a major problem in Vietnam. On the HCMC – Trung Luong Expressway 40 km in the South of Vietnam, 113 occurrences of traffic accidents have been reported during 18 months from its commencement in February 2010, and accident rate has become a high value at 1.8 affairs/km/year.

In Vietnam, 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 has been obstructing the timely 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 to install ETC for non-stop processing at the tollgates.

On the other hand, in Vietnam, expressway network being constructed by sections funded by different donors, it has become an important issue how integrate the operation of such sectioned expressway network. It is required to set up cooperative management system over many different operators. For the purpose, 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.

Facing Necessity of ITS Intergraton Project

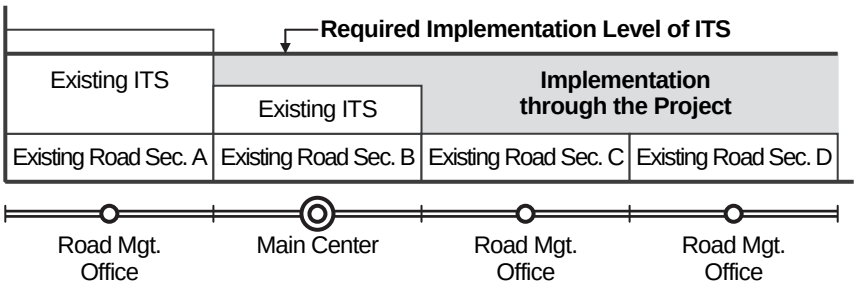
ITS is actualized by data exchange among various centers and devices on the communication

network and, for this reason, unhappy situations caused by section-by-section implementation of ITS need to be resolved. It is necessary accordingly to promote ITS implementation in a standardized and integrated manner based on the following three concepts:

- Connectivity: To be capable of securing connection of the communication network between the different systems (installed in the different expressway sections)
- Interoperability: To be capable of sharing the data among the different systems (operated by the different road operators)
- Compatibility: To be capable of sharing the interchangeable devices among the different systems (provided by the different suppliers).

The needs for implementing the Project are to implement ITS to secure the required level of implementation covering the target road network, to build up the Northern Regional Main Center necessary for achieving the integrated expressway operation, 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: The Study Team

➢ 2. Objectives of Study

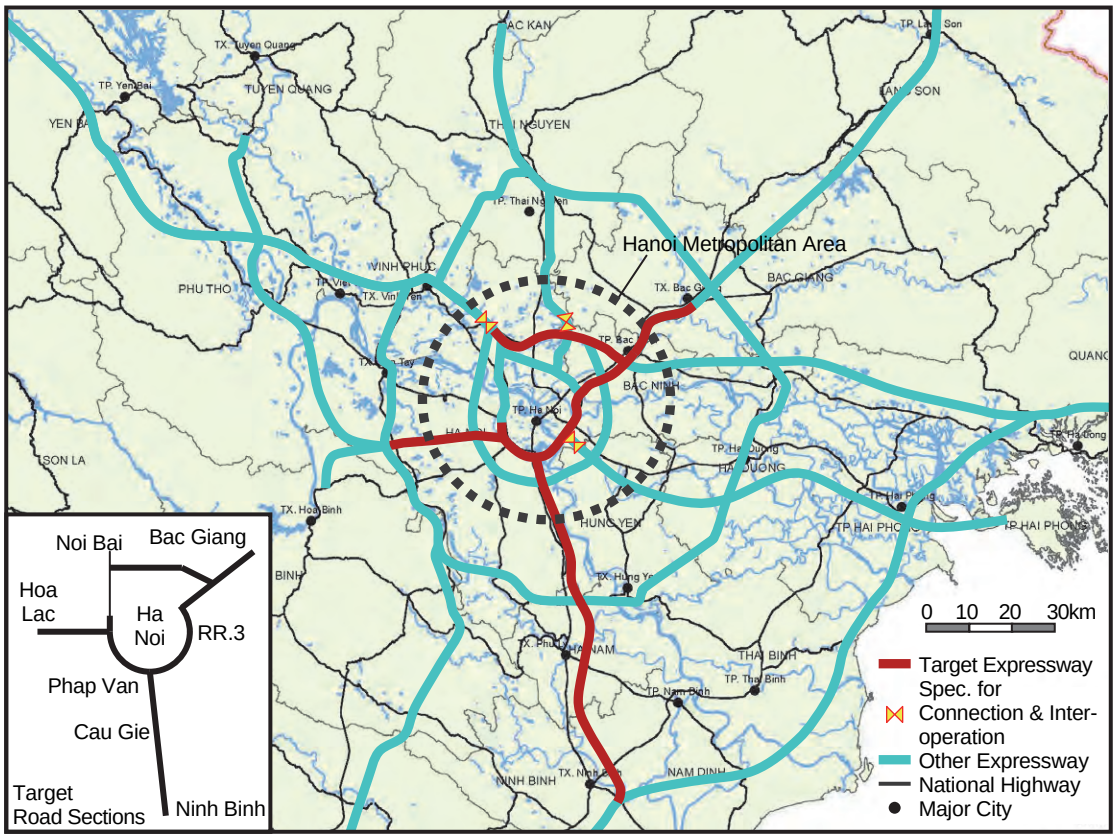
The Study is intended to make a finding of facts, to compile acquired information and to perform the research for making inspection of the ITS Integration Project in Northern Area of Vietnam, which is to be implemented by Japanese ODA Loan aiming to introduce ITS for integrating road traffic information and achieving a smooth traffic in the target area, keeping pace with a rapid construction of expressway network, to promote its economic development and to enhance international competitiveness.

➢ 3. Study Scope

1) Study Area

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

Figure 3.1 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 Discussed

The scope of the Study embraces to discuss and evaluate the ITS Integration Project focused on the following four systems according to the ITS user services shown in the ITS Master Plan:

- System for road traffic information/control
- System for non-stop toll collection
- System for heavy truck control
- Communication system.

3) Study Outputs

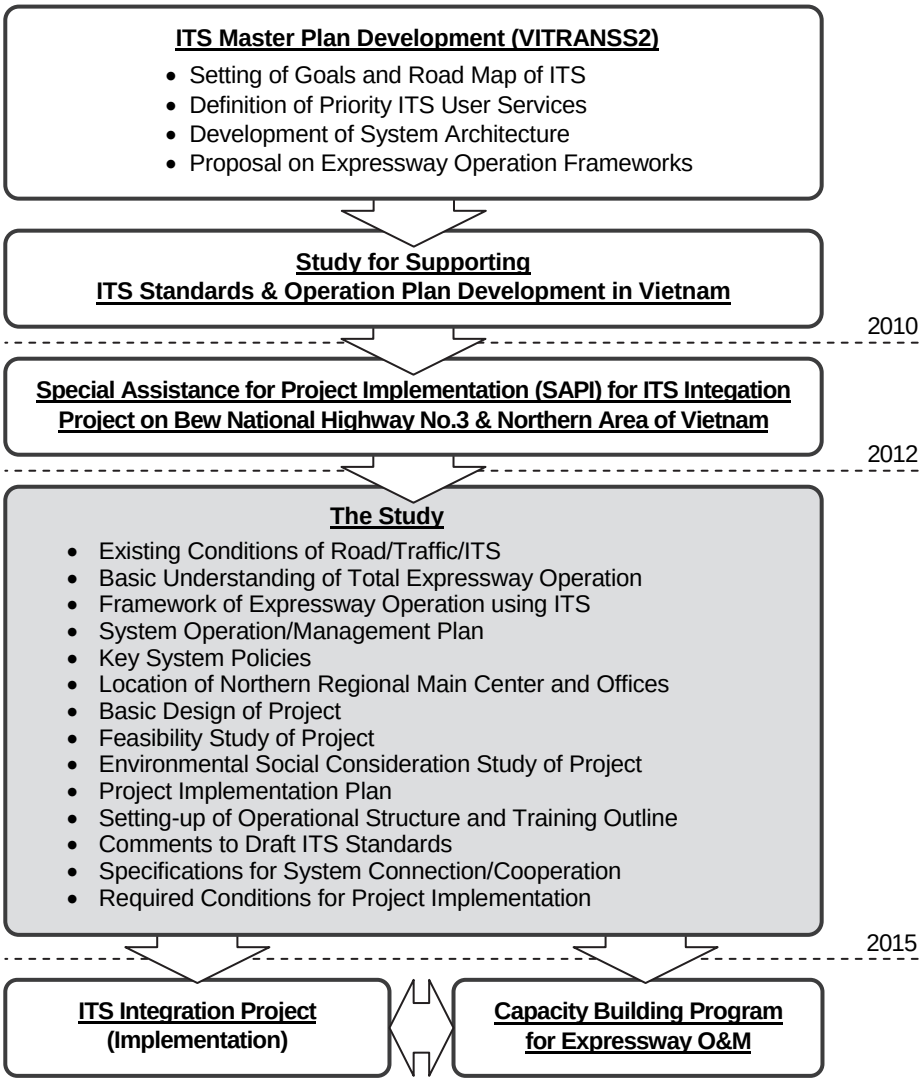
The following items are to be developed in the Study:

- Feasibility Study Report of ITS Integration Project
- Project Basic Design (including Report, Drawings and Specifications)
- Project Implementation Plan
- System Operation/Management Plan
- Specifications for Securing System Connection/Cooperation.

➢ 4. Context of Study

The flowchart from the development of the ITS Master Plan up to implementation of the ITS Integration Project is shown in the figure below. The Study, in which five outputs are to be prepared, is the keystone in the flowchart.

Figure 4.1 Context of Study



Source: The Study Team

➢ 5. Framework of Expressway Operation using ITS

The following various frameworks needed for expressway operation were discussed and recommended one was itemized for each:

- Total Framework of Expressway Operation
- Framework for Service Level Control
- Framework for Traffic Information/Control
- Framework for 113 Call & Police Car Dispatch
- Framework for 115 Call & Ambulance Dispatch

- Framework for Incident Notification to Road Operator
- Framework for Traffic Restriction & Incident Clearance
- Framework for Road/Traffic Monitoring
- Framework for Traffic Event Data Management
- Framework for Traffic Information Dissemination
- Framework for Toll Collection/Management
- Framework for Toll Settlement
- Framework for IC-card Issuance/Operation
- Framework for OBU Registration/Management
- Framework for Toll Enforcement
- Framework for Overloading Regulation
- Framework for Integrated Data Management
- Framework for Communication Network Management
- Framework for Radio Frequency Allocation
- Framework for System Maintenance

➢ 6. System Operation/Management Plan

Operation and management of the system was discussed and the following results were reasoned out from the discussion (see Appendix-1):

- Frameworks for expressway operation
- Role sharing for system operation
- Event trace diagrams (for the System Operation/Maintenance Plan)
- Screen transition diagram (for the System Operation/Maintenance Manual)
- Basic policy on training system operation/management

➢ 7. Key System Policies

The following key policies of ITS were discussed from the perspective of appropriateness for applying to expressway operation:

- CCTV camera arrangement
- Event Detection by Image
- Vehicle detector arrangement
- Integrated/Prioritized Information Dissemination for Traffic Control
- Road-to-vehicle communication method for ETC
- Method of Checking Prepaid Balance
- Contact-less IC-Card type
- Axle load scale arrangement
- Integration of roadside equipment control
- Transmission method.

➢ 8. Recommended Traffic Information/Control System

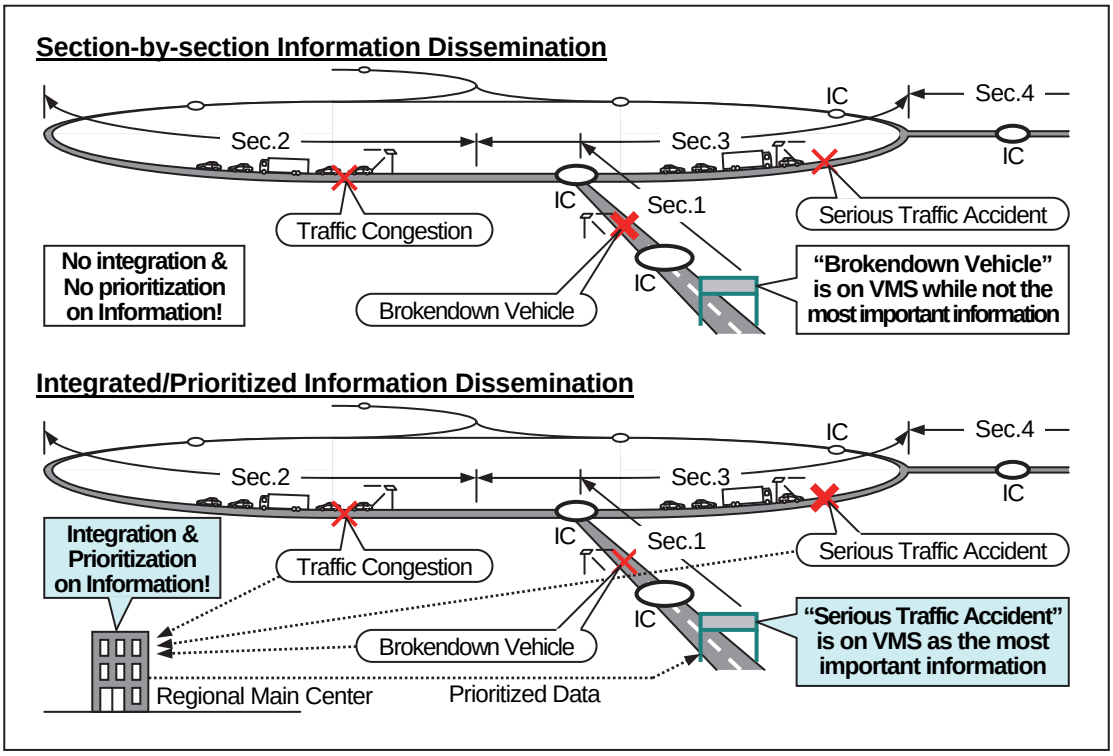
1) Integrated/Prioritized Information Dissemination for Traffic Control

There can be the following two typical information dissemination policies for traffic control:

- Section-by-section information dissemination
- Integrated/prioritized information dissemination (actualized by empirical-based prioritization using traffic event data).

Outline and comparison of them are shown in the figure and table below.

Figure 8.1 Typical Information Dissemination Policies for Traffic Control



Source: The Study Team

Table 8.1 Comparison of Typical Information Dissemination Policies

	Section-by-section Information Dissemination	Integrated/Prioritized Information Dissemination
Monitoring of the entire expressway network	Capable	Capable
Concurrent/respective controls of many VMSs on the entire expressway network	Not capable	Capable
Information prioritization for the drivers at respective locations on the expressway network	Not capable	Capable
Minimization of the duration of traffic restriction and the toll revenue losses	Not effective	Effective
Reduction of manpower and operation costs for traffic information/control	Not effective	Effective
Grading	Inadequate	**Recommended**

Source: The Study Team

From the results of comparison above, "integrated/prioritized information dissemination" is recommended as the system policy. This policy is consistent with the basic stance, of both the Decision No. 140/QD-TTg and the ITS Master Plan, that the traffic control over the entire

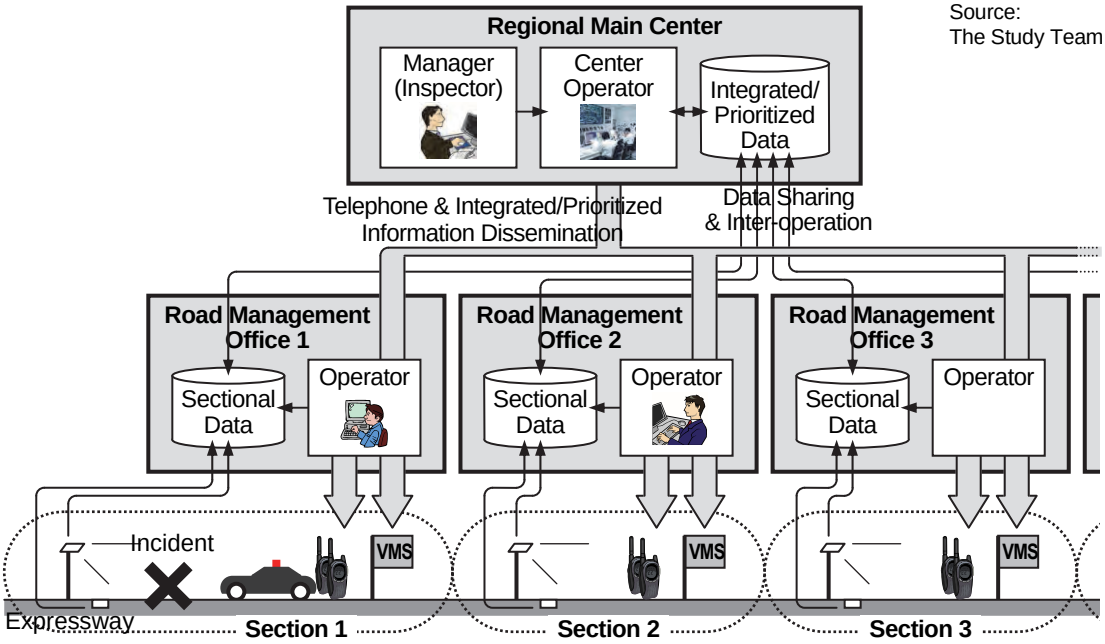
expressway network is to be performed integrally at the three Regional Main Centers.

2) Role-sharing/Cooperation between Regional Main Center and Road Mgt. Offices

Role-sharing/cooperation, in the normal state and in the event of serious incident, between the Regional Main Center and the Road Management Office is shown in the figure below.

Figure 8.2 Role-sharing/Cooperation between Regional Main Center and Road Mgt. Offices

Source:
The Study Team



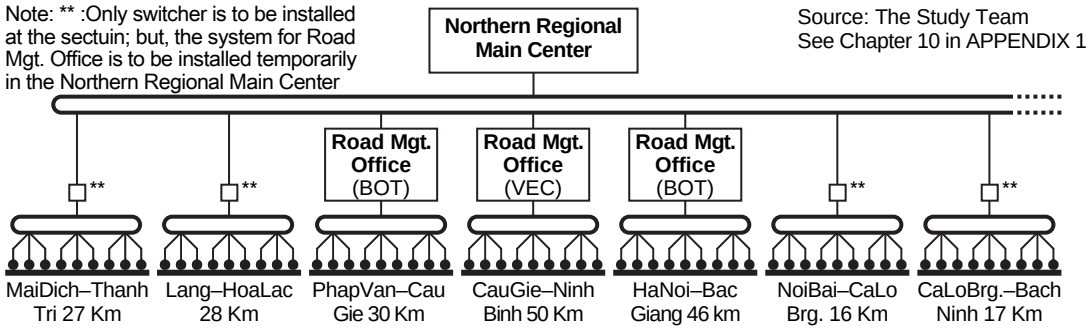
	Normal State	Roles in the Event of Serious Incident
Regional Main Cnter (Expressway Management Agency)	• Regulation on hardware/software in compliance with the ITS Standards	• Ditto
	• Monitoring of the entire expressway network in the Regional Main Center	• Ditto
	• Exchange monitored information/data of traffic conditions/events	• Ditto
		• Guidance and/or direct system control to the road management offices for integrated/ prioritized information dissemination in the event of serious incident
		• Decision to enforce a serious traffic restriction, such as closure, considering the integration over many expressway sections.
	• Integrated management on the data from traffic information/control, toll collection/ management and heavy truck control	• Ditto
	• Development of inspection/budget plan of expressway improvement/maintenance.	• Ditto
Road Management Office (Road Operator)	• Acquisition of information through the special call number or sensors of ITS • Traffic event data input at the road management office or roadside and sharing them with the Regional Main Center and other organizations • Traffic information/control of an expressway section • Dispatch of a patrol crew to the incident site • Identification of the situation/gravity of an incident • Enforcement/removal of a traffic restriction • Incident handling/clearance works.	

➢ 9. Basic Design of Project

1) Structure of Centers/Offices in the Project

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 off the Northern Regional Main Center is to be constructed in the Project as well.

Figure 9.1 Northern Regional Main Center and Road Management Offices



The systems are to be installed in the respective road sections in the Project as shown in the tables below. (see Appendix-2, -3 and -4 for the specific contents)

Table 9.1 Systems for Each Section in the Project

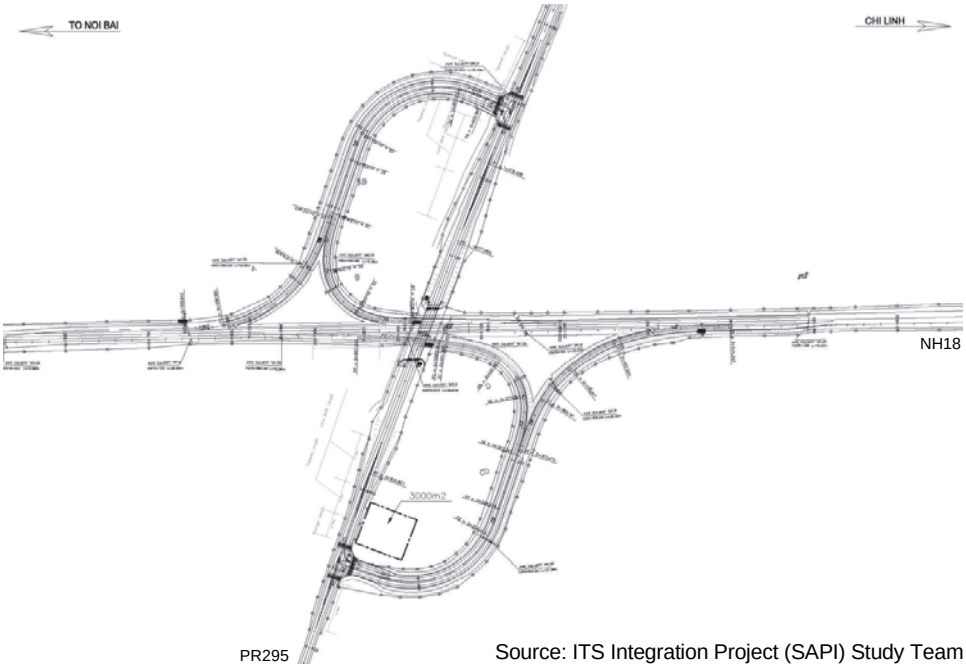
Systems to be Installed	MaiDich–ThanhTri	Lang–HoaLac	PhapVan–CauGie	CauGie–NinhBinh	HaNoi–BacGiang	NoiBai–CaLoBrg.	CaLoBrg.–BacNinh
Traffic Information/Control	XX	XX	XX	XX	XX	XX	XX
Toll Collection/Management	**		***	***	***		**
Vehicle Weighing	**		***	***	***		**
Communication System	XX	XX	XX	XX	XX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

Note: ** : Road section where tollgates are removed responding to application of the road maintenance fund.
***: Road section where the system is implemented by other funds.
Source: The Study Team

2) Northern Regional Main Center

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.

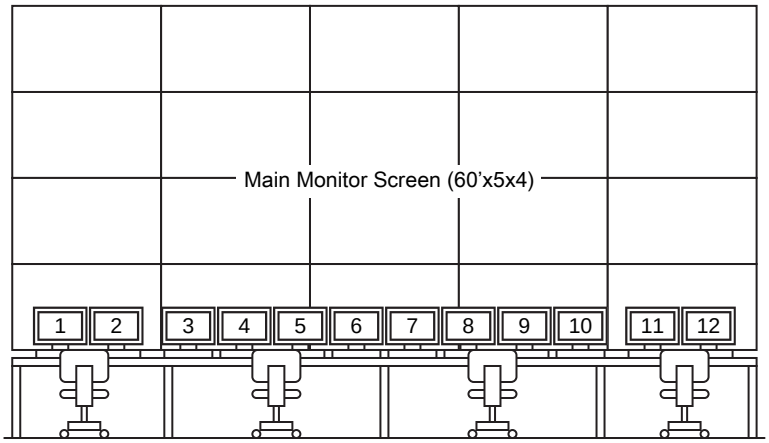
Figure 9.2 Location of Northern regional Main Center



Source: ITS Integration Project (SAPI) Study Team

For actualising the respective functions, pieces of the center equipment are to be installed in the Regional Main Center as shown in the figure below. The data from detectors and 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 taking appropriate action in the event of serious incident.

Figure 9.3 Equipment Overview in Regional Main Center

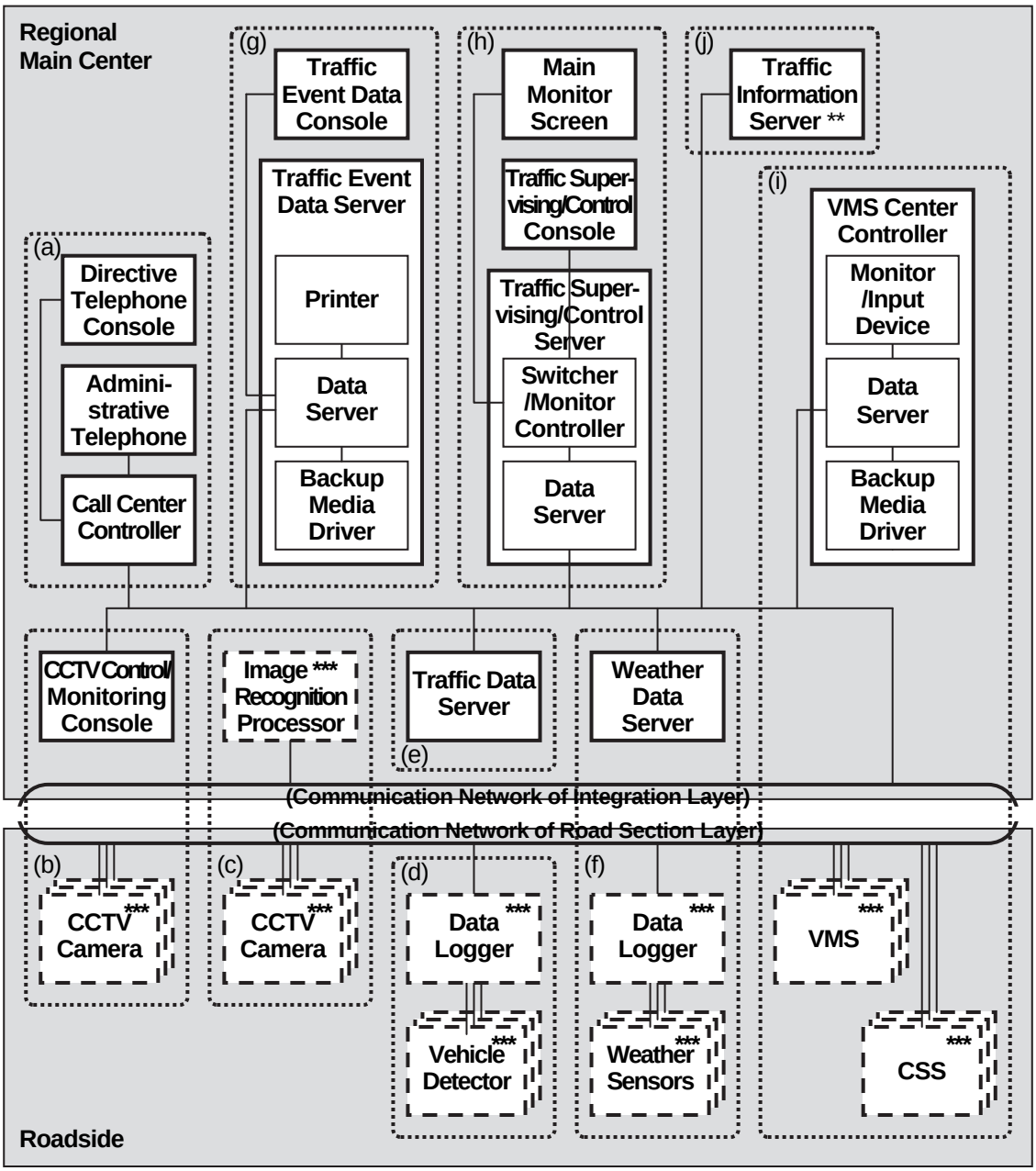


1. Traffic Data Monitor/Input Device
2. Weather Data Monitor/input Device
3. Directive Telephone Console
4. CCTV Control/Monitoring Console
5. Traffic Event Data Console
6. Traffic Supervising/Control Console
7. Directive Telephone Console
8. CCTV Control/Monitoring Console
9. Traffic Event Data Console
10. Traffic Supervising/Control Console
11. VMS Center Controller Monitor/Input Device
12. Traffic Information Monitor/Input Device

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

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

Figure 9.4 System Architecture for Northern Regional Main Center



Note, ⬚ : 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.

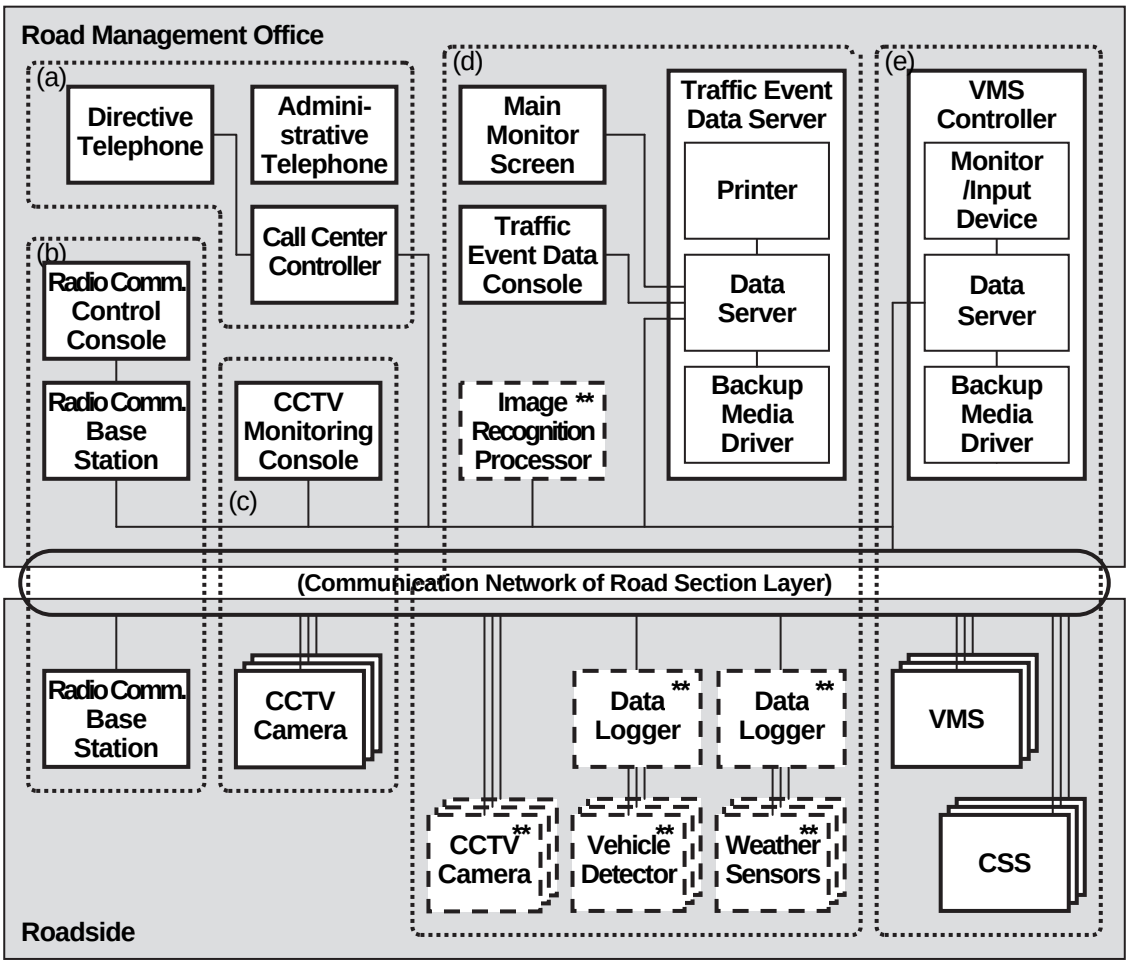
Source: The Study Team

3) Road Management Office

Center equipment necessary for expressway operation is to be installed in the road management office. CCTV cameras are to be controlled and the traffic event data are to be input in the office for handling/clearing incidents. Prioritisation of the data is to be done in the Regional Main Center and guidance based on it is to be sent to the operator in the road management office to input data for iVMS/CSS indication. Additionally, the direct VMS/CSS control from the Regional Main Center is to be accepted as well for responding to the serious incidents.

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

Figure 9.5 System Architecture for Road Management Office



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

Source: The Study Team

Table 9.2 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 Data 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			

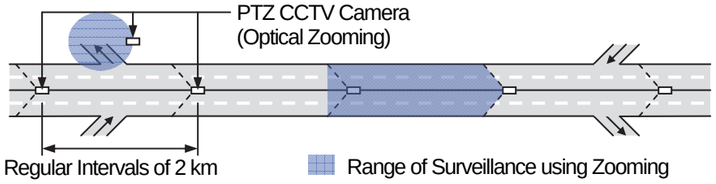
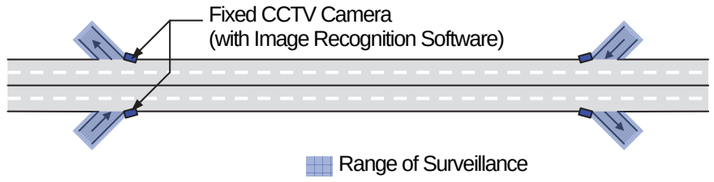
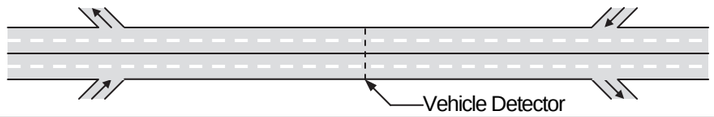
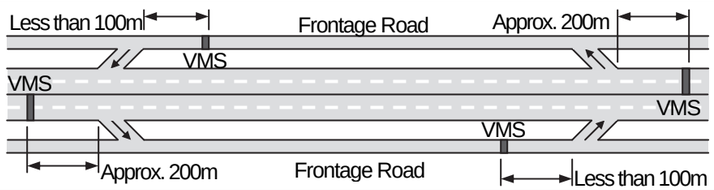
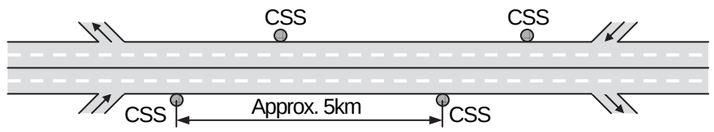
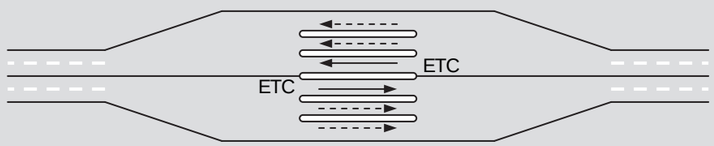
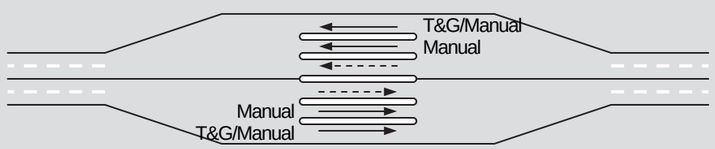
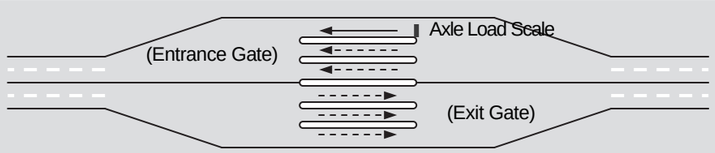
Source: The Study Team

4) Roadside Equipment

Roadside equipment components are to be installed in the Project as shown in the following table:

- CCTV camera (for monitoring and for event detection)
- Vehicle detector
- VMS (Variable Message Sign)
- CSS (Changeable Speed Limit Sign)

Table 9.3 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 Excluding items installed in other project designed by Cadpro	-- Excluding items installed in other project designed by Cadpro	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 Excluding items installed in other project designed by Cadpro	-- Excluding items installed in other project designed by Cadpro	2 sets	--	--

Source: The Study Team

5) Needed Harmonization to Existing Conditions and Requests of MOT

(1) Proposed Equipment Components to be substituted with Existing System

In the 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

In the discussions, all parts of 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, such parts of Traffic Information/Control System for the two BOT sections are to be excluded in principle from the Project Scope and from the final discussions in the Study; 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 for the BOT sections that the following parts of Traffic Information/Control System are to be installed in the Project:

- 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 including the components to be installed in a space 30 m^2 in the Road Management Office.

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 beginning sections of the Study, 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 a type of ETC system appropriate for this country is to be selected eventually through the market competition process.

For the reasons above, MOT is requesting to exclude the Toll Collection/Management System from the Project Scope and from the discussions in the Study. It is needed to secure

harmonization to such conditions.

(4) Vehicle Weighing System

In the beginning sections of the Study, 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 this system is in the same condition as that of the Toll Collection/Management System.

For this reason, MOT is requesting to exclude the Vehicle Weighing System from the Project Scope and from the discussions in the Study. It is needed to secure harmonization to such conditions.

6) Project Cost

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

- Unit prices 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 for which quotations were received from two or more companies, the Study Team decided a unit price from the viewpoint of experience of the companies.
- The Study Team conducted assessments of prices according to the local conditions.
- 10% of equipment cost including the cost for installation, test and inspection was added to the original equipment cost as the cost for spare parts for two years.
- The result of cost estimation was summarized for each Functional Package and for each expressway/section.
- The common cost such as "design and construction management" were calculated independently for each section.
- The costs of "Guideline and manual preparation" and "Initial operation training" were calculated as the common cost.
- Price Escalation for Foreign Currency 2.0%, Price Escalation for Local currency 4.9% and 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 9.4 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/Managment	--	--	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

7) Propriety of Estimated Project Cost

The allocation of the Project cost only of traffic information/control system and communication system for each section of the target road network and its unit cost (per kilometer) is shown in the table below. Where the Project cost, that is to say ITS implementation cost, comprises the equipment/matrial cost and the installation cost including the procurement cost and the testing/inspection cost.

Table 9.5 Allocation of Project Cost to Each Section

Section	Total ITS Implementation Cost		Road Length (km)	Unit Cost (per km)	
	Million JPY	Billion VND		Million JPY	Billion VND
Northern Regional Main Center	942.2	169.2	--	--	--
Mai Dich–Thanh Tri (Ring Road 3)	814.7	146.3	27	30.2	5.4
Lang–Hoa Lac	750.4	134.7	28	26.8	4.8
Phap Van–Cau Gie	354.1	63.6	30	11.8	2.1
Cau Gie–Ninh Binh	363.6	65.3	50	7.3	1.3
Ha Noi–Bac Giang	522.1	93.7	46	11.3	2.0
Noi Bai–Ca Lo Bridge	497.5	89.3	16	31.1	5.6
Ca Lo Bridge–Bac Ninh	510.2	91.6	17	30.0	5.4

Source: The Study Team

Additionally, a comparison is to be made, using the ITS implementation cost per unit road length, between the Project cost above and the costs of two other expressway sections: Da Nang – Quang Ngai and Ha Noi – Hai Phong. However, it should be noted the ITS implementation cost of the Project in the table below excludes the costs for constructing the buildings, the electronic toll collection system and vehicle weighing system.

Table 9.6 Comparison of ITS Implementation Cost per Unit Road Length

Name of Project/Section	Total ITS Implementation Cost		Road Length (km)	Unit Cost (per km)	
	Million JPY	Billion VND		Million JPY	Billion VND
The Project	4,553.64	817.53	214.00	21.28	3.82
Da Nang – Quang Ngai	3,331.30	598.08	139.00	23.97	4.30
Hanoi - Hai Phong	3,678.12	660.35	105.84	34.75	6.24

Source: The Study Team

From the comparison results above, it is confirmed that the estimated unit cost of the Project is lower than or in the same level as that of the two sections. Accordingly, the ITS proposed for the Project and the estimated Project cost above are to be considered reasonable.

8) Required Cost for Technology of "Integrated/Prioritized Information Dissemination"

For the implementation of ITS Integration Project, the technology of "integrated/prioritized information dissemination", which is the core part of the traffic information/control, has been established only in Japan. Accordingly this part of the Project needs to be provided by the supplier which has the track records of this technology in Japan.

However, as shown in the table below, the implementation cost of this technology has amounted to 852.6 million JPY, which has taken account for only 17.9% of the Total Project cost at 4,754.7 million JPY. The advantages of this technology aforementioned, which are extremely useful for the traffic control of expressway network, can be realized by such limited amount of implementation cost.

In addition, other large parts of the Project can be provided by any suppliers in the world including the local companies in Vietnam.

Table 9.7 Breakdown of Project Cost

Item	Project Cost	
	Value in JPY (Million JPY)	Value in VND (Billion VND)
Part of System for "Integrated/Prioritized Information Dissemination"	852.6	153.1
Other Part of System including all Roadside Equipment Components	2,417.4	434.0
Communication Duct, Building and Others	1,484.8	266.6
Total	4,754.7	853.6

Source: the Study Team

➢ 10. Feasibility Study of Project

ITS to be implemented in the Project is to aid in a part of expressway operation. Its effects are to be provided by using it together with the road structure, accordingly, and are to be included in the effects which are already estimated or will be estimated for the road construction.

Furthermore, it is impossible to estimate most part of the effects of ITS even in the case they can be separated from the effects of road construction. Because, while the effects of ITS are to be brought through the response to traffic accidents or congestions, it is impossible to estimate where or how many traffic accidents or congestions occurs before opening of the expressway.

The economic analysis of the Project is made for the following two effects:

- Estimation of some of individual effects of ITS implementation which are separable from that of road construction and possible to quantification
- Cost reduction effects by system integration compared to without integration.

1) Quantified Effects

The quantified ITS implementation effects, the cost ratio of ITS implementation to road construction and the cost reduction effects by system integration are shown using the indicators -1 to -7 in the table in the following page.

From the results of these typical effects of ITS introduction from economic and financial aspects, it is examined that the ITS integration is to be achieved coverring the 7 sections as the Project Scope: Mai Dich – Thanh Tri (Ring Road 3), 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.

Especially, the effect of cost reduction by system integration for the 10 expressways with a total length of 673 km is estimated as 1,979 billion VND, which is equivalent to the difference in system implementation cost between the cases of integration by “stepwise method” and by “immediate metod”.

- Stepwise Method: One-way Integration in the stage of the ITS Integration Project, and then Two-way Integration in the later stage.
- Immediate Method: Two-way Integration in the stage of the ITS Integration Project immediately.

The reduced cost, approximately estimated based on the values calculated in the Study, reaches an amount far larger than the implementation cost of the ITS Integration Project. And in addition to this amount, the cost due to the payment of technical disclosure fee is possibly be reduced.

Hence, the Immediate Method (i.e. immediate implementation of the Two-way Integration in the ITS Integration Project) is recommended to eliminate the unnecessary costs and to minimize the ITS implementation cost.

Table 10.1 Quantified Effects for Targeted Expressways

	Without ITS	With ITS (by integrated system implementation by immediate method)
Operation Length km	Zero	214
Indicator-1: Estimated Number of Accidents to be Identified by CCTV Camera for Operation Length in km	Zero	214
Indicator-2: Estimated Reduction of Fatalities in Accidents on Expressway for Unit Length in the Case Assumed Rate of Number of Accidents per 10^9 Vehicle-km = 600 (Unit : fatalities/year/km)		
(Number of Fatalities in 2020)	1,378	689
(Number of Fatalities in 2030)	2,136	1,068
Reduction per Unit Length in Year 2020	--	3.22
Reduction per Unit Length in Year 2030	--	4.99
Indicator-3: Effect of Reduction of Passing Time at Tollgates for Operation Length in km (Unit : hours/day)		
(in 2020)	5,096	3,066
(in 2030)	7,899	4,752
Reduction in Year 2020	--	2,030
Reduction in Year 2030	--	3,147
Indicator-4: Effect of CO2 Emission Reduction for Operation Length in km (Unit : ton-CO2 per day)		
(in 2020)	3,977.9	3,966.3
(in 2030)	5,820.8	5,803.8
Reduction in Year 2020	--	11.6
(For reference) Reduction in Year 2030	--	17.0
Indicator-5: Effect of Fuel Consumption Reduction for Operation Length in km (Unit : Kilo Litter per day)		
(in 2020)	1,405.7	1,401.4
(in 2030)	2,062.9	2,056.6
Reduction in Year 2020	--	4.3
(For reference) Reduction in Year 2030	--	6.3
Indicator-6: Cost Ratio of ITS Implementation to Road Construction	--	2.11%
Indicator-7: Cost reduction by Integrated System Implementation (Unit : billion VND)	--	1,979

Source: Estimated by the Study Team

Note: The effects in terms of "per original distance km" have been estimated by multiplying the effects per one km by the total distance km.
The objective expressway sections are:
Targeted Espressways including Seven (7) Sections of Mai Dich – Thanh Tri (Ring Road No.3), Lang – Hoa Lac, Phap Van – Cau Gie, Cau Gie – Ninh Binh, Ha Noi – Bac Giang, Noi Bai – Ca Lo Bridge and Ca Lo Bridge – Bac Ninh.

2) Preliminary Estimation of EIRR

The preliminary estimation of EIRR is calculated at 12.33% for the period from 2017 to 2060.

However, the effects of the road construction oliginally include the part which cannot be realized witout traffic information; that is the effects of ITS implementation. Accordingly, it can be said that the value 12.33% is corresponding to the part, in the effects of road construction, which will be lost in the case ITS is not installed. In addition, it is difficult to quantify the functions of ITS and it is impossible to separate/estimate the effects of ITS implementation with higher accuracy.

➢11. Project implementation plan

1) Project Implementation Organizations

For the efficient and economical implementation of the Project with the least technical difficulties in integrating the ITS for all expressway sections in the northern area (including those sections not covered by the Project) at the least additional costs and time, the Project should be implemented by the following organizations:

- DRVN (Directorate for Roads of Vietnam) responsible for the overall Project implementation (ITS design, construction or installation and integration) for all expressway sections proposed and the proposed Northern Regional Main Center (as the "Executing Agency" under the JICA loan agreement),
- MOT (Ministry of Transport) responsible for administration and execution of the Project implementation budget (as the "Line Agency"),
- PMU3 directly under DRVN responsible for day-to-day operation and management of the Project including management of the Consultant and the Contractors (as the "Implementing Agency").

The proposed institutional arrangements for implementing the ITS Integration Project, including the Northern Regional Main Center and the 7 expressway sections and for the ITS O&M, are summarized in the table below.

Table 11.1 Institutional Arrangement for Project Implementation

	Proposed Implementation Org.	Existing Contract Type of O&M	Org. of Road Owner	Org. of Road Operator	Remarks
Northern Regional Main Center	DRVN	--	VEA	VEA	
Mai Dich– Thanh Tri	DRVN	Service Contract	HPC	O&M-Company	Existing ITS by JICA Grant is to be transferred from VEC-O&M*
Lang – Hoa Lac	DRVN	Service Contract	HPC	O&M-Company	
Phap Van – Cau Gie	DRVN	Concession Contract	DRVN/BOT	BOT Company	Existing ITS by JICA Grant is to be transferred from VEC-O&M*
Cau Gie – Ninh Binh	DRVN (VEC)	Service Contract	VEC	VEC-O&M	ITS is partially installed already
Ha Noi – Bac Giang	DRVN	Concession Contract	DRVN/BOT	BOT Company	
Noi Bai – Ca Lo Bridge	DRVN	Service Contract	Bac Ninh Prov.	O&M-Company	
Ca Lo Bridge – Bac Ninh	DRVN	Service Contract	HPC	O&M-Company	

Note, *: VEC currently owns the existing ITS in the sections of Mai Dich – Thanh Tri and Phap Van – CauGie and VEC-O&M (VEC's subsidiary company) currently operates and maintains the existing ITS in the said 2 sections.

Source: The Study Team

The following concerns exist in the case the Project is implemented by other entities or other schemes:

- ITS integration will not progress efficiently and effectively.

- BOT investors will refuse to implement the ITS installation, because ITS work is not included in their BOT work.
- If ITS installation begins only after completion of the NRMC by DRVN/VEA, several expressway sections must operate without ITS for a long period.
- Effectiveness of the NRMC cannot be fully verified without ITS installation in multiple expressway sections.

2) Packages for Implementing Project

The Project is proposed to be implemented in the following three packages:

Package-1: The systems for traffic information/control and communication, and supply of the O&M vehicles (on a Design and Build basis).

Package-2: The communication ducts and the power supply system (on a Build only basis).

Package-3: The NRMC buildings and the associated works (on a Build only basis).

The functional packages and other items included in each package for implementing the Project are shown in the table below.

Table 11.2 Functional Packages and Other Items in Package for Implementing Project

Functional Packages and Other Items		Package-1	Package-2	Package-3
Traffic Information /Control System	(1) Voice Communication	XX		
	(2) CCTV Monitoring	XX		
	(3) Event Detection (by Image)	XX		
	(4) Vehicle Detection	XX		
	(5) Traffic Analysis	XX		
	(6) Weather Monitoring	XX		
	(7) Traffic Event Data Management	XX		
	(8) Traffic Supervision	XX		
	(9) VMS Indication	XX		
	(10) Mobile Radio Communication	XX		
	(11) Traffic Information	XX		
	(12) Integrated Data Management	XX		
Automated Toll Collection /Management 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			
Vehicle Weighing System	(20) Axle Load Measurement			
	(21) Measurement Lane Monitoring			
Other Items	Communication System	XX		
	Communication Ducts		XX	
	Buildings			XX
	Power Supply		XX	
	O&M Vehicles	XX		

Note: Greyed out area is "For Reference".

Source: ITS Integration Project (SAPI) Study Team

3) Project Implementation Schedule

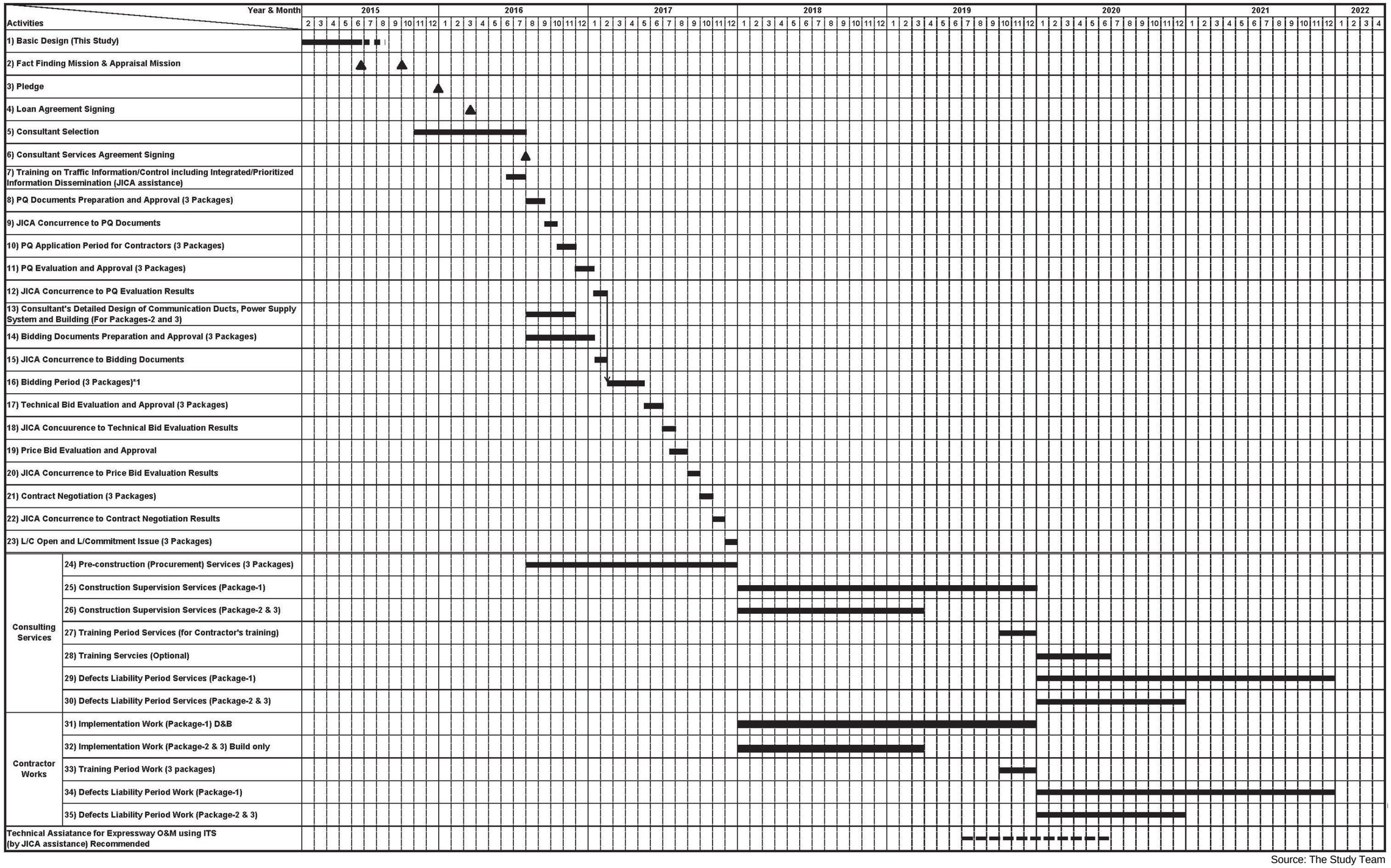
The following activities are to be completed in advance of the Project implementation as shown in the figure later.

- Appraisal mission
- Loan agreement sign
- Consultant selection
- Training of the relevant personnel on traffic information/control including integrated/ prioritized Information Dissemination before PQ documents preparation
- PQ and Bidding Documents preparation and PQ/Bid evaluation management
- Detailed designs of communication ducts, power supply system and NRMC building and associated works
- Design and PQ/bidding documents endorsement
- PQ process for contractors/bidders selection
- Bidding process for Contractors selection.

For Package-1, the bidding period for the Contractors should be 3 months or more to allow the bidders' preparation of their bidding designs and cost estimates based on their bidding designs, and the Project implementation period for the Contractors' design and build/ installation is to be around 2 years. Additionally, a longer Defect Liability/Notification Period of 2 years is recommended for successful integration of ITS during this period.

For Packages-2 and 3, the bidding period may be 2 months because the Bidders will be give the detailed designs of the Employer before bidding. The construction period may be 15 months or so, as the work volume is not large and the works must be completed well in advance of the cable and equipment installation in the completed ducts and buildings. The Defects Liability/Notification Period may be 1 year for these 2 packages as per the JICA standard.

Figure 11.1 Proposed Project Implementation Schedule



Source: The Study Team

4) Important Points on Procurement

The following important points should be observed when procuring the Contractors and the Consultant for the Project:

- The procurement activities for this JICA ODA loan-finance project should be performed, managed/administered in strict accordance with the JICA procurement guidelines and procedures;
- The JICA Standard PQ Documents and Bidding Documents must be used for PQ and bidding;
- Package-1 of the Project should be implemented on a Design and Build (D&B), lump sum price basis, while Package-2 and Package-3 should be a construction only, unit price basis based on the detailed designs to be prepared by the Employer (DRVN);
- The bidding period of package-1 should be 3 months or more to allow a sufficient time for the bidders to prepare their designs for bidding purpose and estimate their bid prices based on the bidding designs;
- Modifications of the contract conditions and/or requirements during the procurement process must be made in a proper manner through a proper variation process (the successful bidder should not be forced to accept the modifications);
- The Standard General Conditions contained in the JICA Standard Bidding Documents might need to be reinforced and/or improved to suit this particular ITS integration project, because the JICA Standard Bidding Documents are not specifically written for ITS projects; and
- The Consultant for pre-construction and construction supervision services should be employed before commencement of the process for prequalification of the contractors so that the Consultant can prepare the prequalification documents as an integral part of the procurement-related documents.

➢ 12 Specifications for System Connection/Cooperation

The Northern Regional Main Center is to be installed by the ITS Integration Project; however, a number of ITS equipment components and communication networks are to be installed separately by other projects of the expressways with their Road Management Offices. Such separated ITS installation can mess up the connectivity of network and of the interoperability of data between the systems in the respective sections and in the Northern Regional Main Center. For avoiding such potential problems, the Study provides the Specifications for System Connection/Cooperation and the following discussion results (see Appendix-5):

- Procedure of system integration with other expressway projects
- Target connecting interfaces with adjoining sections
- Specifications for respective system functions & data dictionary.

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- Records of Working Groups & Workshop
- Relevant Legal Documents & Srandards in Vietnam

1. Introduction

1.1 Background

The number of vehicle ownership has been growing at an annual rate of nearly 10% in Vietnam and further growth is expected in the future. In such a situation, 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. 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.

On the other hand, the increase in traffic accidents has become a major problem in Vietnam. On the HCMC – Trung Luong Expressway 40 km in the South of Vietnam, 113 occurrences of traffic accidents have been reported during 18 months from its commencement in February 2010, and accident rate has become a high value at 1.8 affairs/km/year.

It is estimated that the inexperience in high speed driving is a cause of such high rate of traffic accident and it should be expected that it decreases gradually keeping pace with ripeness in high speed driving. In any case, it is necessary to take a measure against such undesired condition. In particular, prompt response to an accident is extremely important, because the potentiality of serious injuries and fatalities is generally high in the traffic accidents on expressways. To deal with this problem, introduction of ITS is now under discussion and a significant effect is expected to be achieved by ITS introduction for quick identification and notification of accident occurrence or its situation.

In addition, insufficiency in the road network development makes it difficult to find a detour in the event of a traffic accident in Vietnam. For this reason, a high effect is expected in rapid notification of accident occurrence using ITS for finding appropriate detours in good time.

Use of expressway has begun only recently in Vietnam and occurrences of significant traffic congestions have not been reported. However, it is estimated that congestion will take place at the occurrence of traffic accident and at the section around the exit gates to ordinary roads in step with the increase in daily use of expressway. It is expected to secure smooth traffic by taking advantage of ITS to support the selection of appropriate entrance/exit gate, to provide the latest information of traffic restriction and to utilize the collected traffic data.

At the same time, the barrier tollgates have been installed at many places on arterial roads in Vietnam and these are operated by flat tariff system. However, by contrast, application of distance proportional tariff system is being planned for the expressways under construction and many tollgates are being built at their entrances and exits. A significant effect is expected to be provided by system introduction of ETC (Electronic Toll Collection) for non-stop processing and increase of tollgate capacity, because the tollgates are prone to interrupt a smooth traffic and a superior route selectivity. Accordingly, when introducing ETC, it becomes important requirement for it to be capable of processing both tariff systems simultaneously for securing a smooth and sustainable road operation.

In Vietnam, 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 has been obstructing the timely 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 to install ETC for non-stop processing at the tollgates.

On the other hand, in Vietnam, expressway network being constructed by sections funded by different donors, it has become an important issue how integrate the operation of such sectioned expressway network. It is required to set up cooperative management system over many different operators. For the purpose, 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 Study

The Study is intended to make a finding of facts, to compile acquired information and to perform the research for making inspection of the ITS Integration Project in Northern Area of Vietnam, which is to be implemented by Japanese ODA Loan aiming to introduce ITS for integrating road traffic information and achieving a smooth traffic in the target area, keeping pace with a rapid construction of expressway network, to promote its economic development and to enhance international competitiveness.

1.3 Study Outputs

The following items are to be developed in the Study:

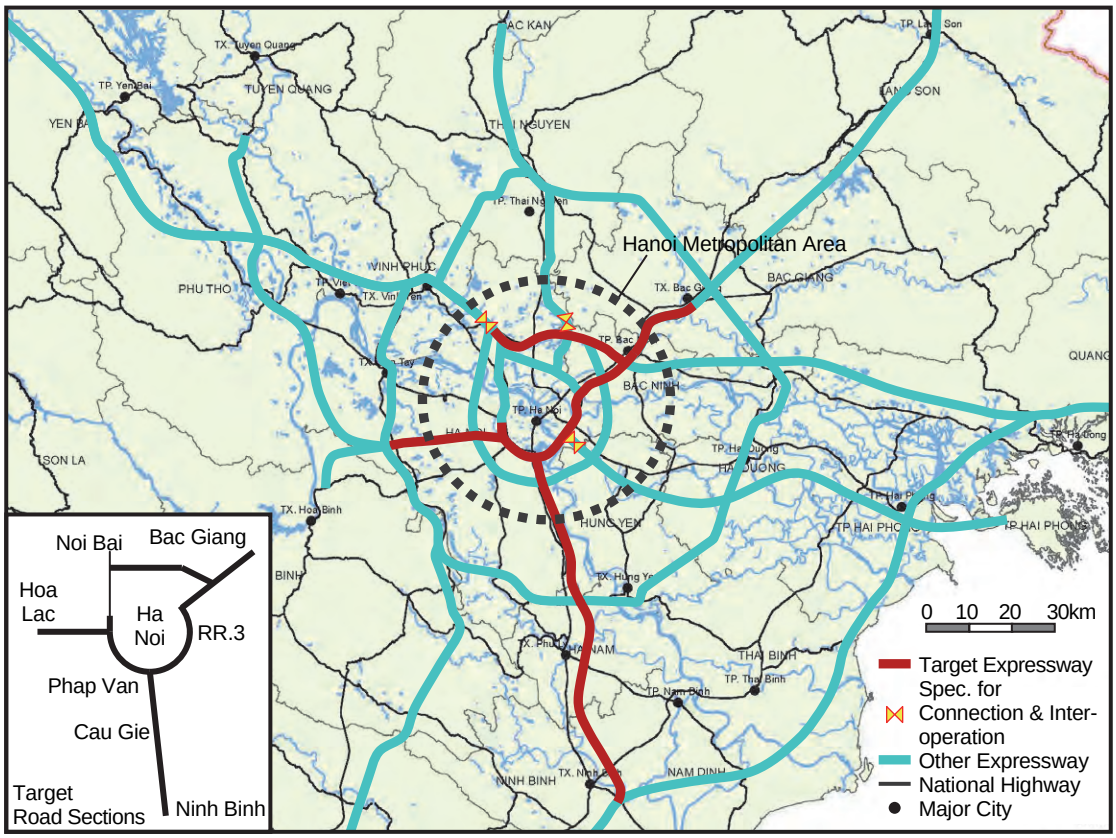
- Feasibility Study Report of ITS Integration Project
- Project Basic Design (including Report, Drawings and Specifications)
- Project Implementation Plan
- System Operation/Management Plan
- Specifications for Securing System Cooperation.

1.4 Study Scope

1) Study Area

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

Figure 1.1 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 Discussed

The scope of the Study embraces to discuss and evaluate the ITS Integration Project focused on the following four systems according to the ITS user services shown in the ITS Master Plan:

- System for road traffic information/control
- System for non-stop toll collection
- System for heavy truck control
- Communication system.

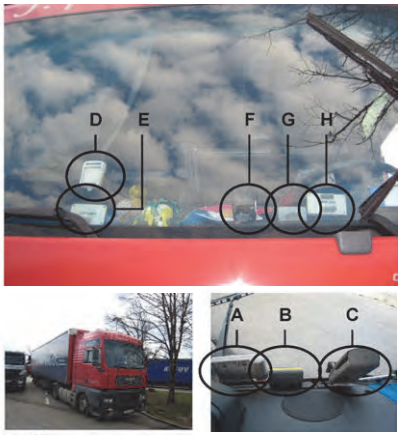
1.5 Facing Necessity of ITS Integration Project

1) Integration of ITS on Target Road Network

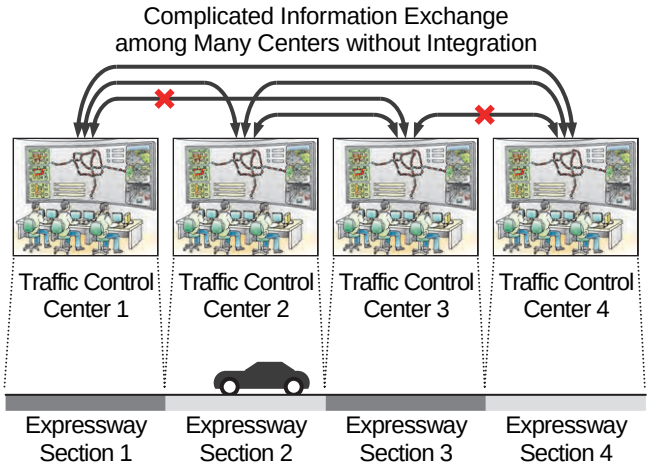
ITS is actualized by data exchange among various centers and devices on the communication network; however, an unhappy situation shown in the figure below can be caused by ongoing section-by-section ITS implementation without standards. Standardization and integration based on the following three concepts are necessary for reducing cost of ITS implementation accordingly:

- Connectivity: To be capable of securing connection of the communication network between the different systems (installed in the different expressway sections)
- Interoperability: To be capable of sharing the data among the different systems (operated by the different road operators)
- Compatibility: To be capable of sharing the interchangeable devices among the different systems (provided by the different suppliers).

Figure 1.2 Unhappy Situation of ITS without Standard or Integration



Many OBUs in a Vehicle

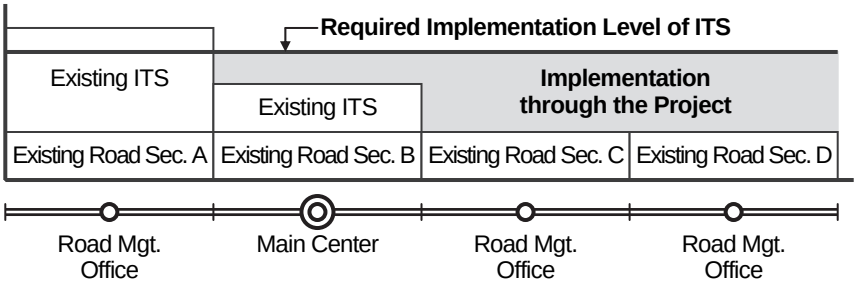


Source: ITS Integration Project (SAPI) Study

2) Securing of Required Implementation Levels of ITS

The needs for implementing the Project are to implement ITS to secure the required level of implementation covering the target road network, to build up the Northern Regional Main Center necessary for achieving the integrated expressway operation, 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 1.3 Securing of Required Implementation Levels of ITS through the Project



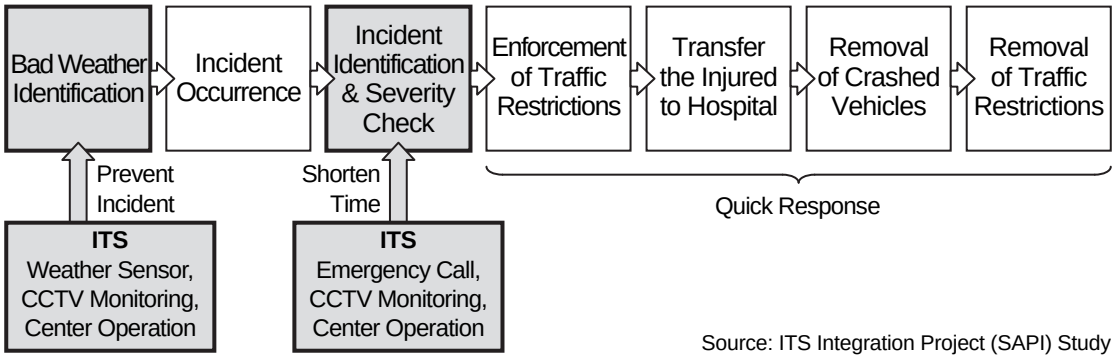
Source: The Study Team

1.6 Goals Proposed for Integration of Expressway Network

1) Improvement in Quick Response to Incident Occurrence

A serious incident carries off a number of human lives and paralyzes the functions of the expressway network for several hours. It is a keen issue for expressway operation to realize the quick response to incident occurrence. The project will establish measures for the quick response using ITS.

Figure 1.4 Quick Response to Incident Occurrence using ITS

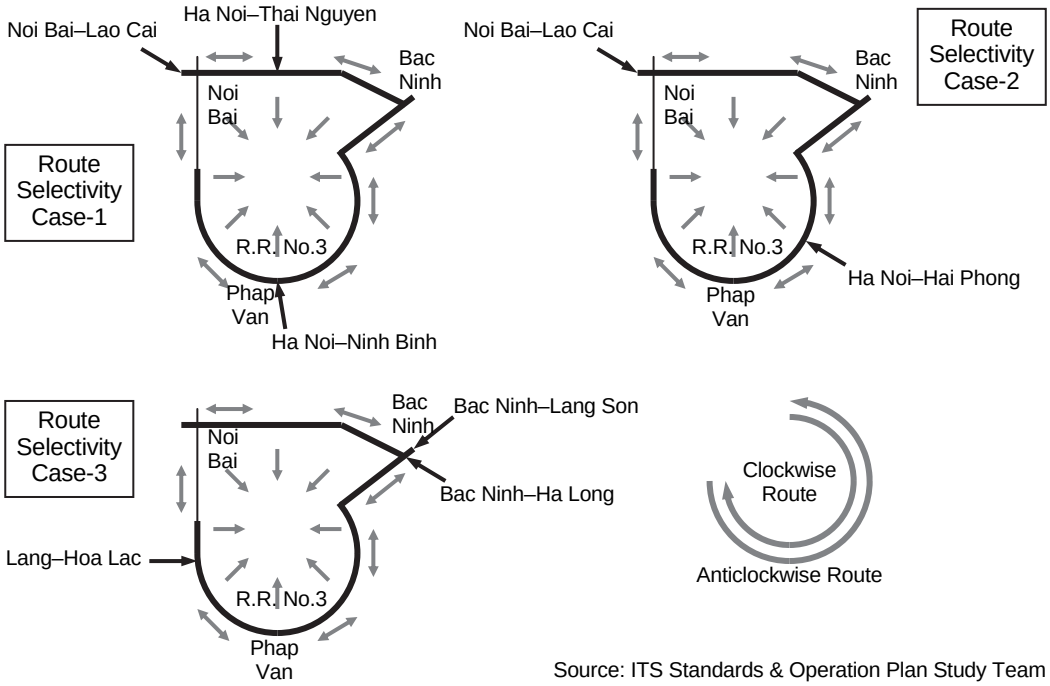


Source: ITS Integration Project (SAPI) Study

2) Increase in Route Selectivity by Introducing ITS

It is useful for traffic information/control and smooth traffic to install roadside equipment along the ring-shaped road network shown in the figures below. The installed equipment allows to disseminate information on incident occurrences or traffic congestion to the through traffic and the traffic flows into Ha Noi City from the radial roads. By this means, it becomes possible for drivers to select a clockwise or anticlockwise driving route or an exit interchange appropriately and to avoid obstructions.

Figure 1.5 Route Selectivity on Ring-shaped Road Network Equipped by ITS



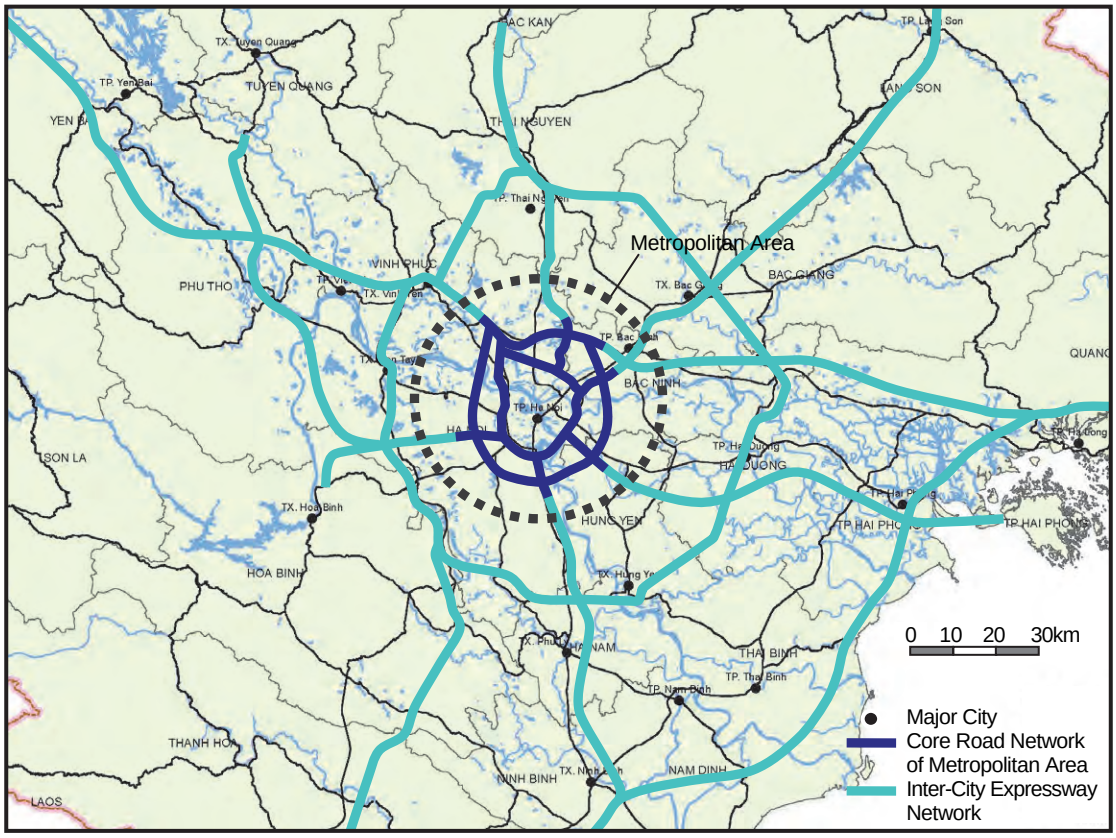
Source: ITS Standards & Operation Plan Study Team

Furthermore, by introducing ETC into the tollgates located on the ramps of entrance/exit interchanges along the ring-shaped motorway and on the through lanes of radial roads, bottlenecks of the road network can be eliminated and traffic flow will get smooth.

3) Smooth Transport by Integrated Traffic Information/Control

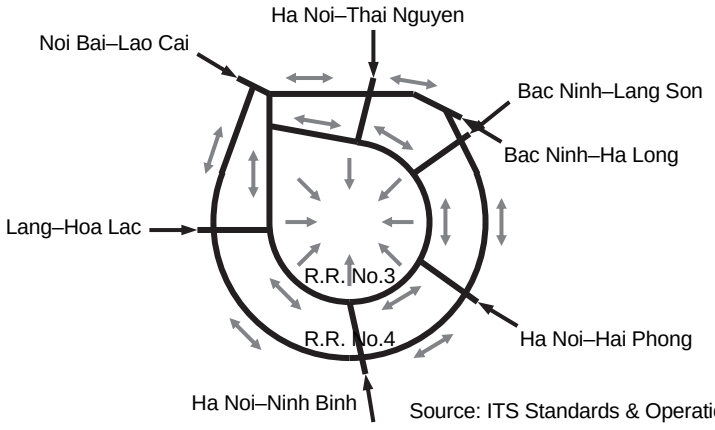
Through the expressways in radial directions around Ha Noi, a large volume of traffic will flow into the Metropolitan Area. That is to say, the Core Road Network of Metropolitan Area is required to receive the large inflow traffic volume and arrange it in appropriate directions for performing smooth transport.

Figure 1.6 Core Road Network of Metropolitan Area



Source: ITS Standards & Operation Plan Study Team

Figure 1.7 Route Selection over Core Road Network



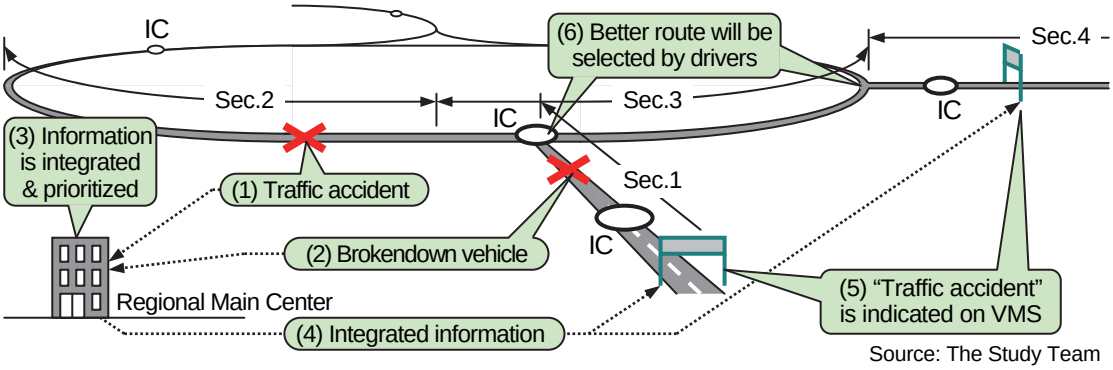
Source: ITS Standards & Operation Plan Study Team

Through installation of roadside equipment of traffic information/control system along the Core Road Network and other expressways, drivers can utilize the two ring roads in combination responding to incident occurrences and the traffic congestion can be dispersed.

For performing smooth transport, the Core Road Network is to function as a unit. Accordingly, ITS needs to be designed and installed totally over the Core Road Network and to be operated in an integrated form. And after the operation takes root, the installed system of ITS can be transferred to the road operators of respective sections.

For example, incident information is to be provided from the Regional Main Center to the drivers over the whole expressway network with a total prioritization.

Figure 1.8 Integrated Incident Information with Prioritization



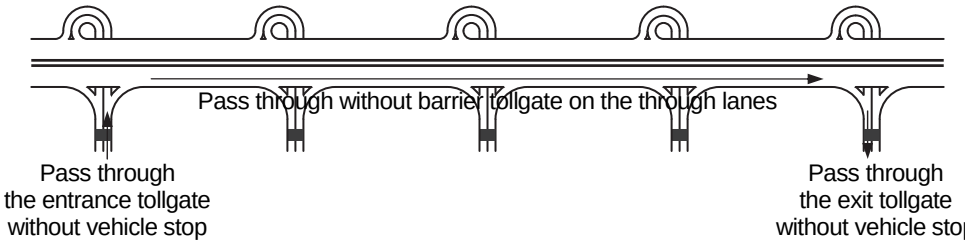
Source: The Study Team

4) Smooth Traffic by Integrated Non-stop Toll Collection

Application of a closed system to the expressways is defined by TCVN 5729/2007: Expressway Standard for Design in Vietnam, and introduction of the system of distance proportional tariff has been decided. It is suitable for securing fairness among the road users corresponding to driving distances on the inter-city expressway network to introduce ETC based on the distance proportional tariff.

On the other hand, for dispersing concentrated traffic into a reasonable volume of traffic over the wider road network in the metropolitan area, it is effective to adopt the flat tariff. From this perspective, a combined toll rate system can be proposed as an ideal model for the future in Ha Noi Metropolitan Area. This system consists of the flat tariff system for the urban expressways and the distance proportional tariff system for the inter-city expressways, and the two systems are separated by barrier tollgates located right outside of a ring road, such as the Ring Road No.4, on the radial expressway.

Figure 1.9 Non-stop Toll Collection based on Distance Proportional Tariff



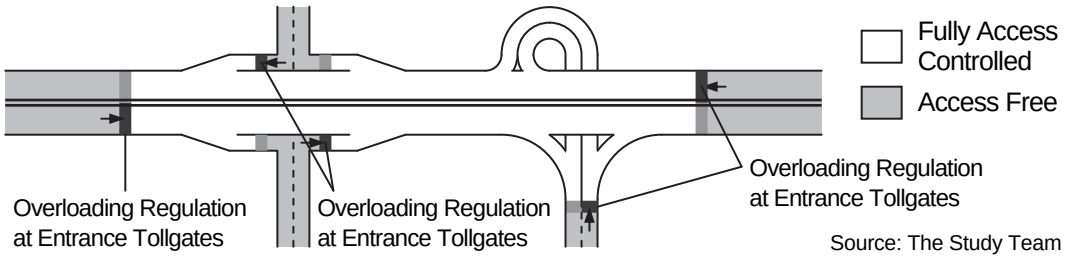
Source: The Study Team

5) Sustainable Expressway System by Integrated Heavy Truck Control

By the introduction the closed system defined by TCVN 5729/2007: Expressway Standard for Design in Vietnam, the through lanes of an expressway is completely enclosed by tollgates as shown in the figure below. The incoming and outgoing vehicles of expressway are both fully controlled by the tollgates. Judgment of allowing a vehicle to enter the expressway or not is to be conducted at entrance tollgates and toll collection is to be conducted at exit tollgates.

It is enormously effective accordingly to install the facilities of overloading regulation at the entrance tollgates in an integrated arrangement for sweeping off the overloaded heavy trucks from the through lanes and for establishing a sustainable expressway system unaffected from the damages by overloading.

Figure 1.10 Overloading Regulation at Entrance Tollgates



Source: The Study Team

6) Setting Up of Cooperative Management System for Total Road Network

The major highways and the expressways in the Northern Region mentioned in "Decision 1734/QĐ-TTg: Approving the Vietnam Expressway Network Development Master Plan toward 2020 and a vision beyond 2020" is shown in the following table.

Excluding Ring Road No. 5 which length remains undefined by the end of 2nd Stage of ITS Master plan, the total length of inter-city expressway network in the Northern Region of Vietnam will be around 1000 km. However, it is assumed that the expressway operation is to be shared by many different BOT investors as well as VEC. Setting up of a cooperative management system is required for achieving an appropriate operation, which covers the expressway network in the Northern Region of Vietnam.

Table 1.1 Major Highways and Expressways in Northern Region

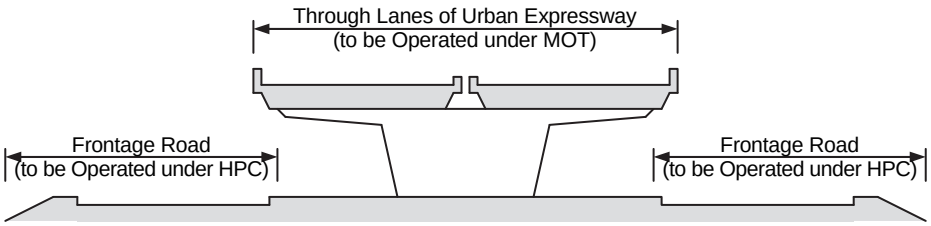
Road Section	Length	Composition	Parallel Road
Ring Road 3	56 km	Through lanes** + Frontage Road***	--
Ring Road 4	125 km	Through lanes** + Frontage Road***	--
Ring Road 5	320 km	Expressway**	--
Lang–Hoa Lac–Hoa Binh	56 km	Through lanes** + Frontage Road***	--
Phap Van–Cau Gie–Ninh Binh	83 km	Expressway**	NH 1 ****
Ha Noi–Hai Phong	105 km	Expressway**	NH 5 ****
Ha Noi–Bac Ninh–Bac Giang–Lang Son	130 km	Expressway**	NH 1 ****
Noi Bai–Bac Ninh–Ha Long–Mong Cai	294 km	Expressway**	NH 18 ****
Ha Noi–Thai Nguyen–Bac kan	90 km	Expressway**	NH 3 ****
Ha Noi–Viet Tri–Lao Cai	264 km	Expressway**	NH 2 ****
Ninh Binh–Hai Phong–Quang Ninh	160 km	Expressway**	NH 10 ****

Note: **: Recommended to be operated under the Expressway Management Org. in MOT, ***: Recommended to be operated under the Ha Noi People's Committee, ****: To be operated under DRVN, NH: National highway.

Source: The Study Team

The figure below illustrates the proposal for Ring Roads No.3 and No.4 whereby the frontage roads are to be operated under Ha Noi City as urban arteries and the through lanes are to be operated under the Expressway Management Organization in MOT as urban expressways.

Figure 1.11 Cooperative Operation for Ring Roads No. 3 and No. 4



Source: ITS Integration Project (SAPI) Study

1.7 Related Laws and National Plans/Strategies

The followings are enumerated as the related national plans/strategies for the Study:

- Decision No. 60/2013/QD-TTg: Defining Functions, Tasks, Powers and Organizational Structure of DRVN under MOT
- Decision No. 400/QD-TCDBVN: Defining Functions, Tasks, Powers and Organizational Structure of VEA under DRVN
- Decree No. 32/2014/ND-CP: on Management, Operation and Maintenance of Expressway Works
- Circular No. 90/2014/TT-BGTVT: Guideline some Contents on Management, Operation and Maintenance of Expressway Works
- Decision No.1327/QD-TTg: The Master Plan on Development of Road Transportation in Vietnam up to 2020 with a Vision towards 3030
- Decision No.1734/QĐ-TTg: The Vietnam Expressway Network Development Master Plan toward 2020 and a vision beyond 2020
- Decision No.140/QD-TTg: Detailed Planning on the Eastern North-South Expressway
- ITS Master Plan in “the Comprehensive Study on the Sustainable Development of Transportation System in Vietnam (VITRANSS2)”
- Decision No.05/2011/QD-TTg: The Master Plan on Transport Development in the Northern Region up to 2020 with a Vision towards 3030
- Decision No.1259/QD-TTg: General Planning on Construction of Hanoi up to 2030 with a Vision toward 2050
- Decision No. 1248/QĐ-BGTVT: Formulation of the Project on ITS Center for Expressway Network in Northern Area of Vietnam
- Document/letter No. 1503xx/DRVN's Report: Report on Implementation Situation of the Project for Investment and Construction of ITS Center in Northern Area
- Decision No. 713/QĐ-TCĐBVN: by DRVN: On Establishing a Working Group for Cooperation with JICA Experts during the Period of Developing ITS Standards and the Study for Finalizing the Project of Investment and Construction of ITS Main Center
- Decision No.3569/VPCP-KTN: Coordination in Construction of Fiber Optic Cable Network for Expressway System

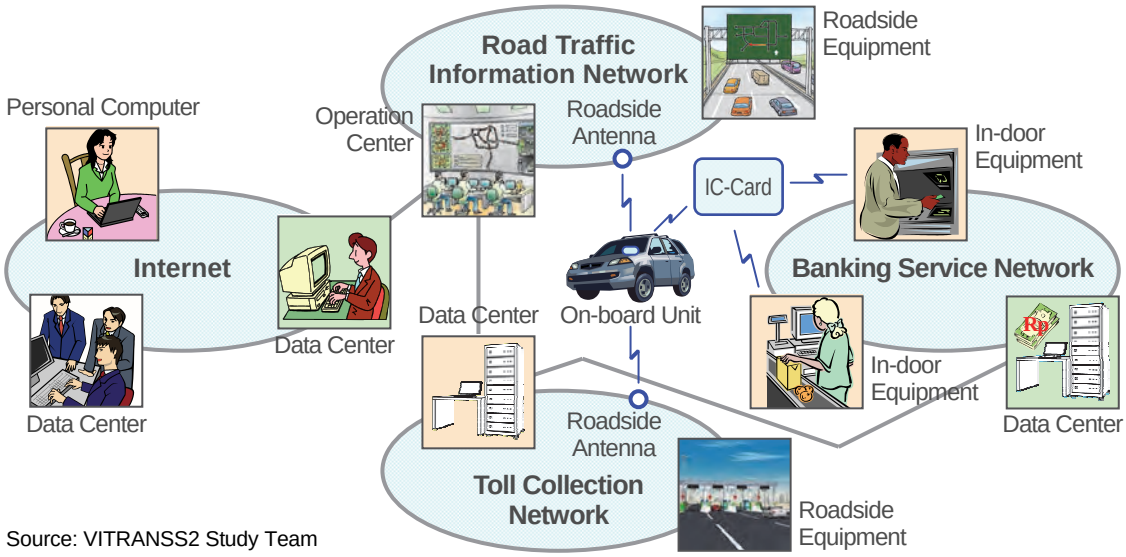
- No. 23/2008/QH12: Law on Road Traffic
- No.10/2010/TT-BGTVT (CIRCULAR/MOT): Providing for Road Administration and Maintenance
- No.11/2010/ND-CP (DECREE): Prescript the Management and Protection of Road Infrastructure Facilities
- No.07/2010/TT-BGTVT (CIRCULAR/MOT): Regulations on the Loading Capacity, Limit of Roads; Circulation of Oversized, Overloaded Vehicles & Caterpillars; Transportation of Extra-long & Extra-heavy Cargoes; and Cargoes Loading Limits of Road Vehicles in Road Traffic
- No. 90/2004/TT-BTC (CIRCULAR/MOF): Guidance Collection, Remittance, Management and Road Usage Fee
- No. 36/2009/TT-BTTTT(CIRCULAR/MOIC): Stipulating specifications and exploiting conditions of short range Radio Frequency Devices of conditional use
- National Standards TCVN5729/Draft Revision: Expressway-Specifications for Design
- National Standards QCVN 33:2011/BTTTT: Installation Standards for Telecommunications Cable (Outside Plant)
- 34/2010/ND-CP (DECREE): Government Stipulating on Penalization due to Administrative Violations on the Field of Road Traffic
- 06/2009/TT-BCA(C11)(CIRCULAR/MOPS): Standard of Vietnamese License Plate Number.

2. Approach for System Integration of ITS

2.1 General

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

Figure 2.1 Conceptual Illustration of ITS



Source: VITRANSS2 Study Team

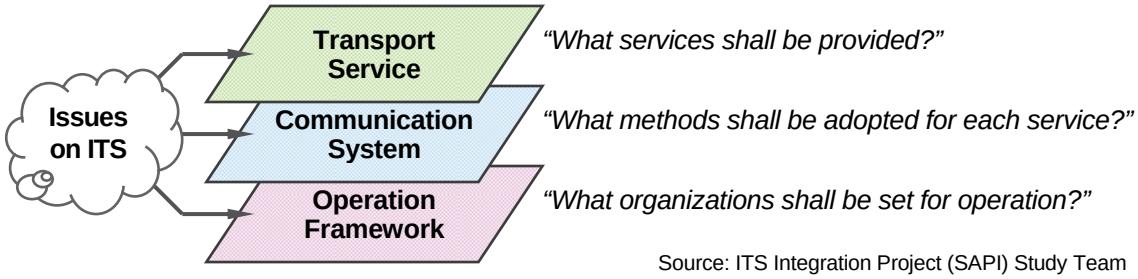
In this chapter, the following approaches are adopted for discussing the system integration of ITS in the Study:

- Three viewpoints for discussing ITS
- Context and discussion items of the Study
- Concept of stepwise introduction of ITS
- Understanding based on system architecture
- Stepwise system implementation by package
- System integration with other expressway projects.

2.2 Three Viewpoints for Discussing ITS

In the Study, issues on ITS introduction were discussed from the following three points of view: transport service, communication system and operation framework.

Figure 2.2 Viewpoints for Discussing Issues on ITS Introduction

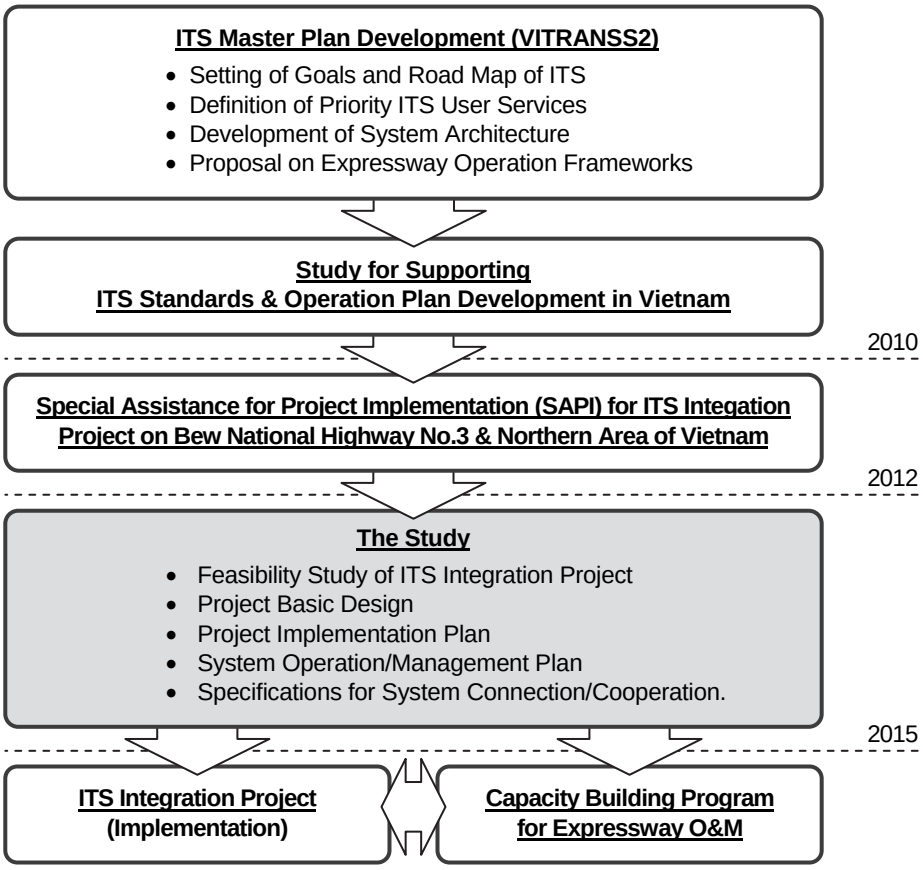


Source: ITS Integration Project (SAPI) Study Team

2.3 Context & Discussion Items of the Study

The flowchart from the development of the ITS Master Plan up to implementation of the ITS Integration Project is shown in the figure below. The Study, in which five outputs are to be prepared, is the keystone in the flowchart.

Figure 2.3 Context of the Study



Source: The Study Team

The items below are to be discussed, from the corresponding viewpoints, in the Study.

Table 2.1 Discussion Items in the Study and Corresponding Viewpoints

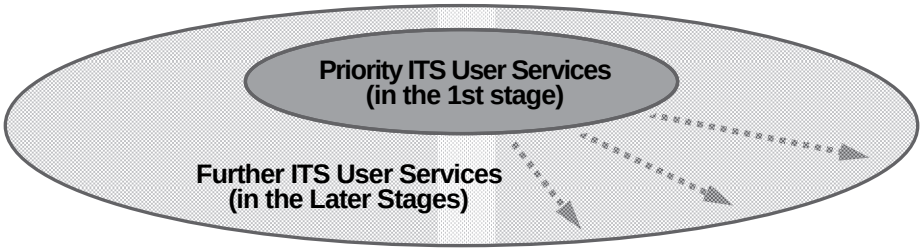
Discussion Items	Viewpoint of Transport Service	Viewpoint of Communication System	Viewpoint of Operation Framework
Existing Conditions of Road/Traffic/ITS	●	●	●
Basic Understanding of Total Expressway Operation	●		●
Framework of Expressway Operation using ITS			●
System Operation/Management Plan	●	●	●
Key System Policies		●	
Location of Northern Regional Main Center and Offices		●	●
Basic Design of the Project		●	
Feasibility Study of Project	●	●	●
Environmental Social Consideration Study of Project	●	●	●
Project Implementation Plan	●	●	●
Setting-up of Operational Structure and Training Outline	●	●	●
Comments to Draft ITS Standards		●	
Specifications for System Connection/Cooperation		●	
Required Conditions for Project Implementation		●	●

Source: The Study Team

2.4 Concept of Stepwise Introduction of ITS

The ITS Integration Project is to be implemented for initiation of the Priority ITS User Services focusing on the expressway operation and aiming to extend them to the further services in the later stages based on the policy shown in the ITS Master Plan.

Figure 2.4 Initiation and Extension of ITS User Services

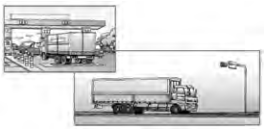


Source: ITS Integration Project (SAPI) Study Team

The Priority ITS User Services are the following three:

- Traffic information/control
- Non-stop toll collection
- Heavy truck control.

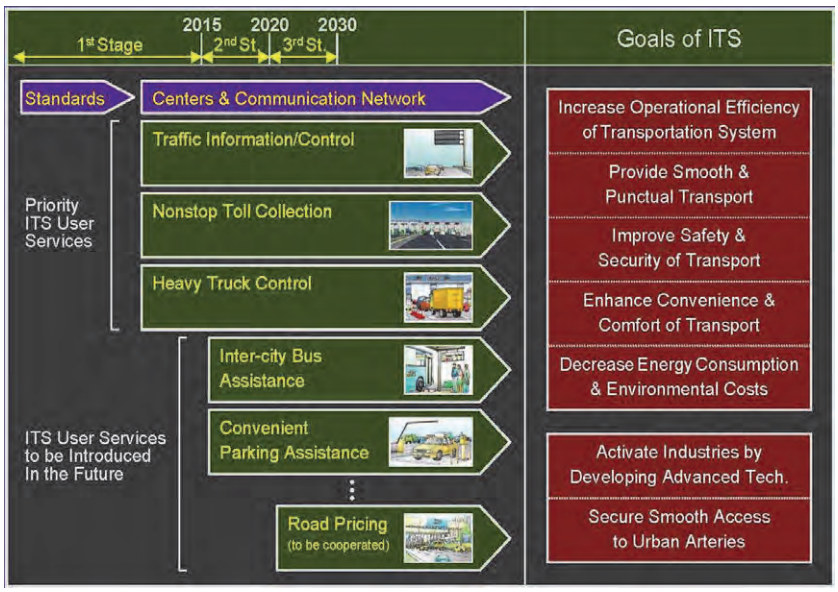
Table 2.2 Definition of Three Priority ITS User Services

Traffic Information/Control 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.	
Non-stop Toll Collection 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.	
Heavy Truck Control 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.	

Source: ITS Integration Project (SAPI) Study Team

In the ITS Master Plan, the road map has been proposed over the time period divided into three stages, including the three Priority ITS User Services, as shown in the following figure.

Figure 2.5 Road Map of ITS Introduction



Source: VITRANSS2 Study Team

The service contents, which are assigned the highest priority to be introduced in the 1st stage, are defined, being included in the three Priority ITS User Services, as shown in the schedule below. The ITS Integration Project is to be focused on these prioritised service contents.

Figure 2.6 ITS User Service Introduction Schedule (in ITS Master Plan)

	1st Stage 2015	2nd Stage 2020	3rd Stage 2030
Traffic Information /Control	• Incident notification assistance and information • Traffic congestion information related to incidents • Weather information • Traffic control assistance responding to occurrences of incidents • Center-to-center data exchange for traffic information and control	• Traffic congestion information • Travel-time information • Traffic control assistance	• Incident information by monitoring continuously along the roads
Non-stop Toll Collection	• Non-stop toll collection at toll island • Center-to-center data exchange for non-stop toll collection		• Non-stop toll collection on free-flow at ETC exclusive interchange
Heavy Truck Control	• Overloading regulation by automatic vehicle weighing • Center-to-center data exchange for overloading regulation	• Heavy/hazardous material truck tracking • Center-to-center data exchange for truck tracking	
Inter-city Bus Assistance		• Bus tracking information provision • Center-to-center data exchange for bus tracking	
Convenient Parking Assistance		• Parking information provision • Center-to-center data exchange for convenient parking assistance	• Parking fee collection at highway-oasis • Integrated fee collection for park&bus-ride • Center-to-center data exchange for park& bus-ride fee collection
Road Pricing			• Cooperation with road pricing in urban areas

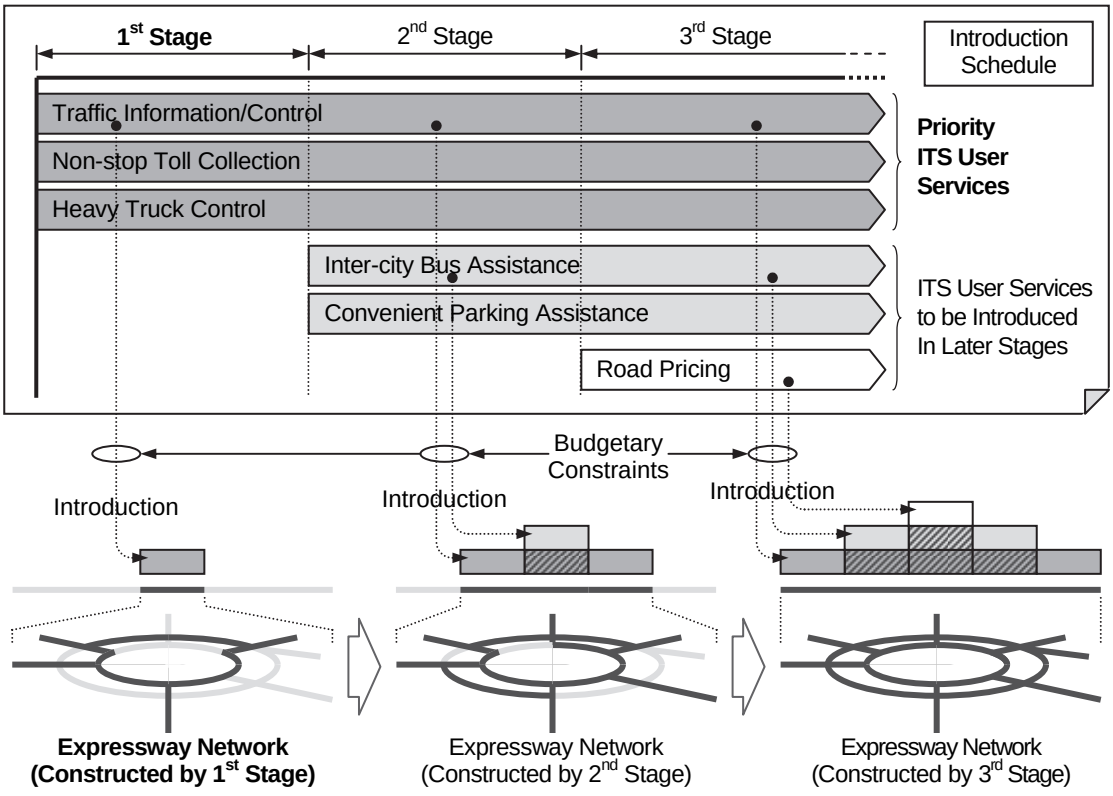
Source: ITS Integration Project (SAPI) Study Team

ITS user services are to be introduced stepwise keeping pace with progress of road network construction and changes in volume/quality of road traffic and user needs. The system of ITS as well is to be implemented stepwise responding to the conditions of existing road network and already installed system. For launching of the stepwise implementation through the ITS Integration Project in the 1st stage, various issues are to be discussed in the system planning in consideration of the following fundamental requirements:

- To meet changes in needs responding to economics or traffic
- To harmonize with progress of the expressway network construction
- To meet budgetary constraints
- To respond to technological improvement.

The detailed concept of stepwise introduction of ITS is to be illustrated in the figure below.

Figure 2.7 Detailed Concept of Stepwise Introduction of ITS



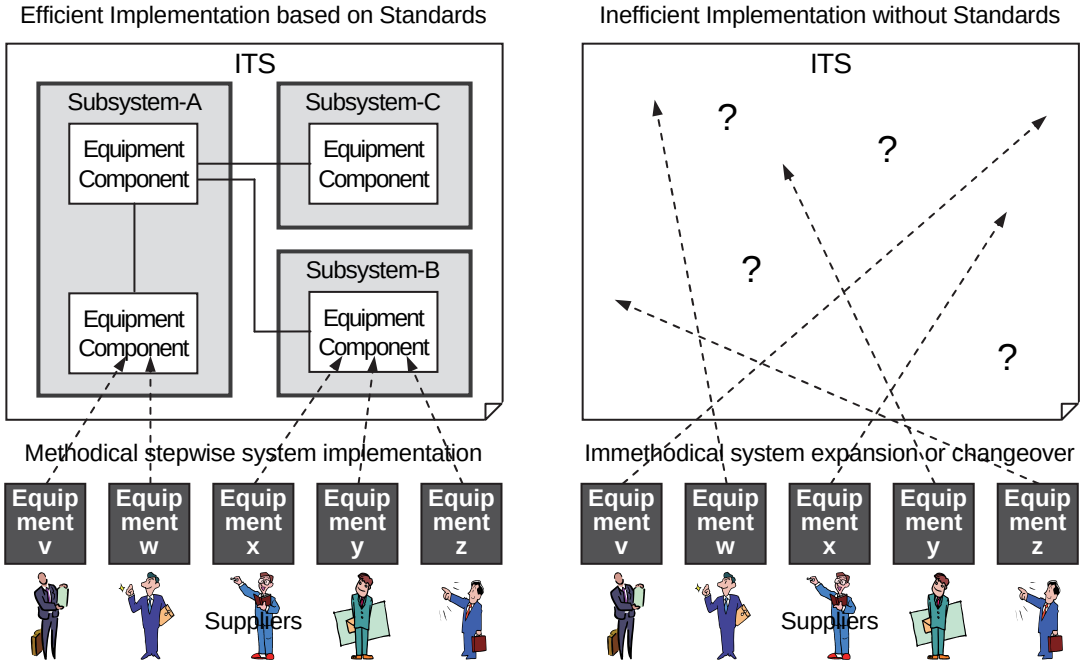
Source: ITS Integration Project (SAPI) Study

2.5 Understanding based on System Architecture

1) Efficiency and Outline of System Architecture

Through the ITS Master Plan Study and the Study of ITS Standards & Operation Plan, ITS has been illustrated using the system architecture consists of simple graphical symbols and texts in order to share understanding of system configuration of ITS among all persons in charge. When an unknown device is substituted for a subsystem in the system architecture by the supplier in actual implementation, appropriateness of the substitution can be verified easily and clearly in reference to the system architecture. Inheriting this method, system planning of ITS was performed in the Study aiming for what should be implemented in the Project.

Figure 2.8 Efficient ITS Implementation by Sharing Understanding



Source: ITS Integration Project (SAPI) Study Team

In the Study, the following diagrams prepared in the ITS Master Plan Study and the Study of ITS Standards & Operation Plan have been used as the system architecture. Notation of these diagrams is to conform to UML (Unified Modelling Language), which is adopted for the reference model architecture for the ITS sector shown in ISO/CD 14813.

Collaboration Diagram

This diagram indicates a system by the combination of subsystems and interfaces for sharing basic understanding of the system.

Message Sequence Diagram

This diagram indicates a sequence of exchanging messages and their data elements for making discussions on interoperability of the data.

Total System Architecture of ITS

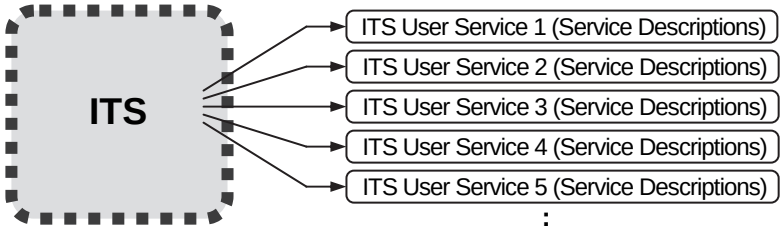
This diagram indicates an integration of collaboration diagrams for sharing understanding of the total structure of ITS and location of each subsystem in the center or on roadside.

2) Concept of Breakdown into Packages

Definition of User Needs through ITS User Services

User needs and total picture of ITS are clarified by defining and describing ITS user services.

Figure 2.9 Description of ITS User services

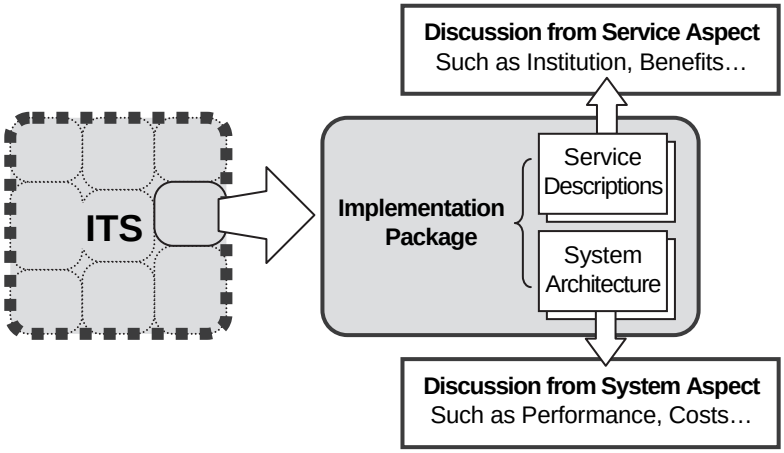


Source: ITS Integration Project (SAPI) Study Team

Definition of Implementation Package Connecting a Service to a System Architecture

Implementation packages are to be defined for stepwise implementation combining a system architecture apparently to service descriptions brokendown from the ITS user service in order to discuss ITS on a common ground from the aspects both of service and system.

Figure 2.10 Definition of Implementation Package

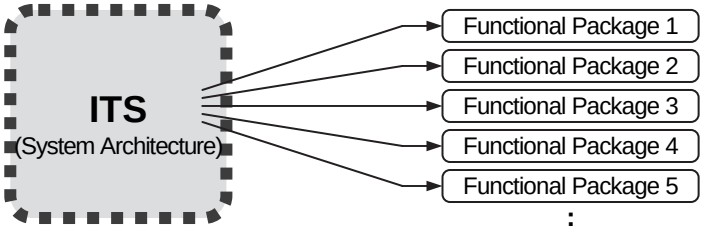


Source: ITS Integration Project (SAPI) Study Team

Detailing of a System Architecture by Implementation Packages

The system architecture is to be detailed being segmented into packages focused on the functions of ITS.

Figure 2.11 Detailing System Architecture through Implementation Packages

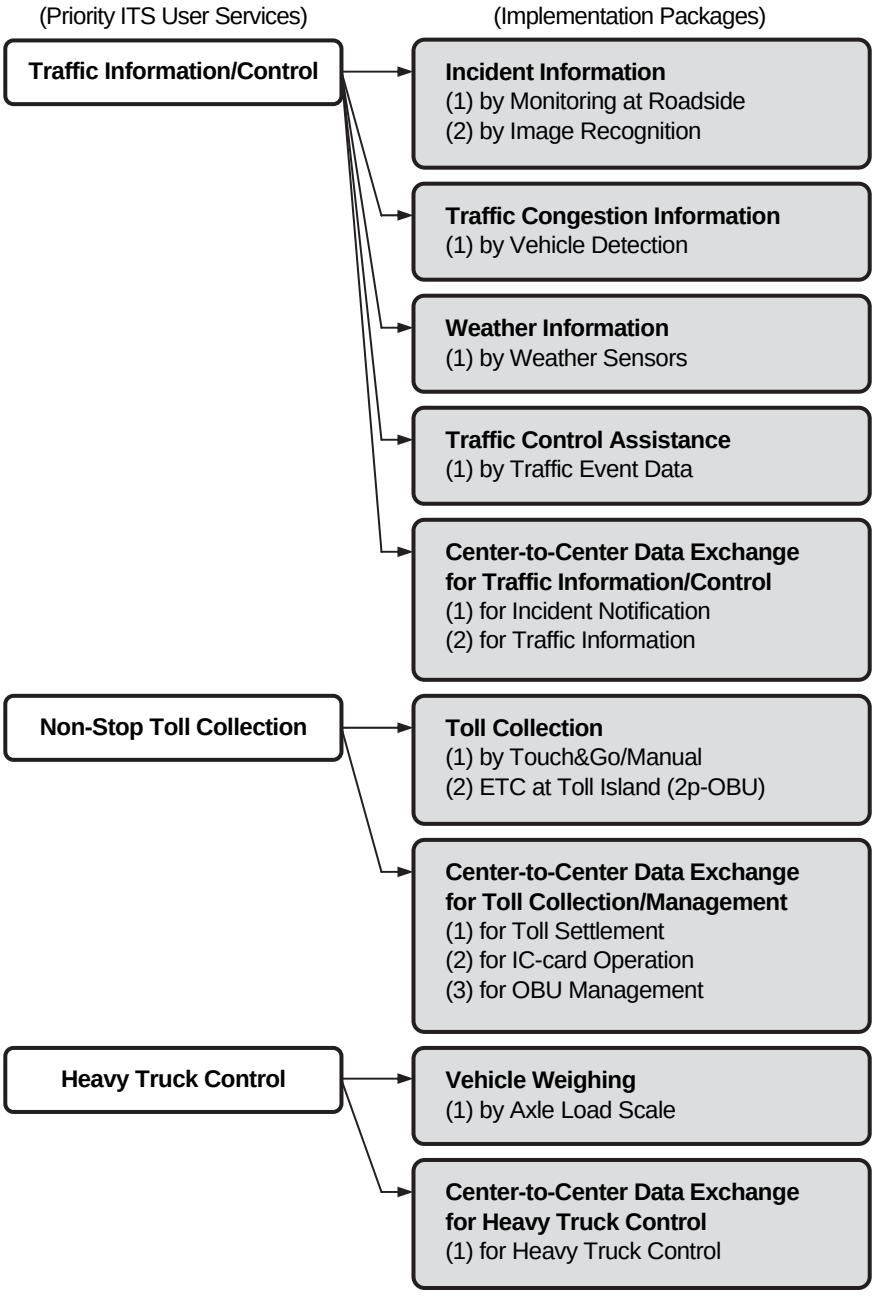


Source: ITS Integration Project (SAPI) Study Team

3) Implementation Packages

Implementation packages are to be prepared for discussing the policy of ITS introduction. In the Study, the system to be implemented in the Project is assumed to be composed of the implementation packages shown in the figure below for providing the three priority ITS user services to the road users and operators. Center-to-center data exchange is the implementation package necessary for all of the three services. Each implementation package can be actualized by one or more implementation methods.

Figure 2.12 Implementation Packages for Priority ITS User Services

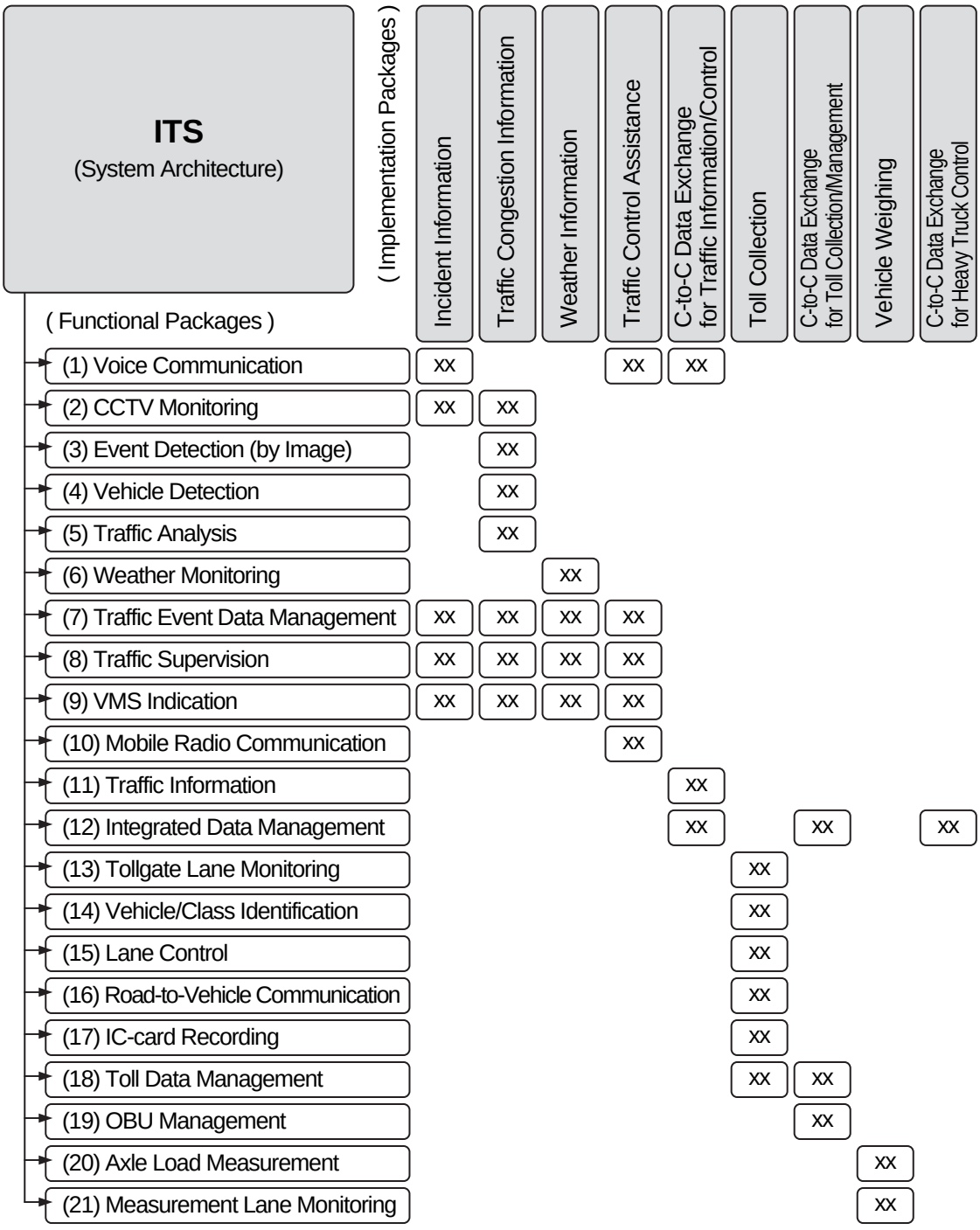


Source: ITS Integration Project (SAPI) Study Team

4) Functional Packages

As is evident from the foregoing table, the system architecture and the implementation packages of ITS are assumed to be composed of functional packages in the Study. 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. Correspondences between the functional packages and the implementation packages aforementioned are shown in the figure below.

Figure 2.13 Functional Packages corresponded to Implementation Packages



Source: ITS Integration Project (SAPI) Study Team

Design specifications are to be developed corresponding to the 21 functional packages and communication system, which are outlined in the following.

(1) Voice Communication

This functional package 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.

(2) CCTV Monitoring

This functional package allows the 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.

(3) Event Detection (by Image)

This functional package allows the 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.

(4) Vehicle Detection

This functional package allows the road operators to measure actual traffic volume and heavy vehicle ratio with identifing the velocity and the license plate number of each vehicle on the expressway for utilizing them to develop road improvement/operation plans and to regulate traffic, by using cameras and vehicle detectors installed at important points on the through lanes.

(5) Traffic Analysis

This functional package allows the 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.

(6) Weather Monitoring

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 frequently affect traffic safety.

(7) Traffic Event Data Management

This functional package allows the 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.

(8) Traffic Supervision

This functional package allows the 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.

(9) VMS Indication

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 locations short of entrances, exits, tollgates, junctions and tunnels.

(10) Mobile Radio Communication

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.

(11) Traffic Information

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

(12) Integrated Data Management

This functional package allows the 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.

(13) Tollgate 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 such as a tollgate lane of the expressway.

(14) Vehicle/Class Identification

This functional package allows the 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.

(15) Lane Control

This functional package allows the 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.

(16) Road-to-Vehicle Communication

This functional package allows the 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.

(17) IC-Card Recording

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

(18) Toll Management

This functional package allows the 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.

(19) 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.

(20) Axle Load Measurement

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 exclusively for large-size vehicles.

(21) Measurement Lane Monitoring

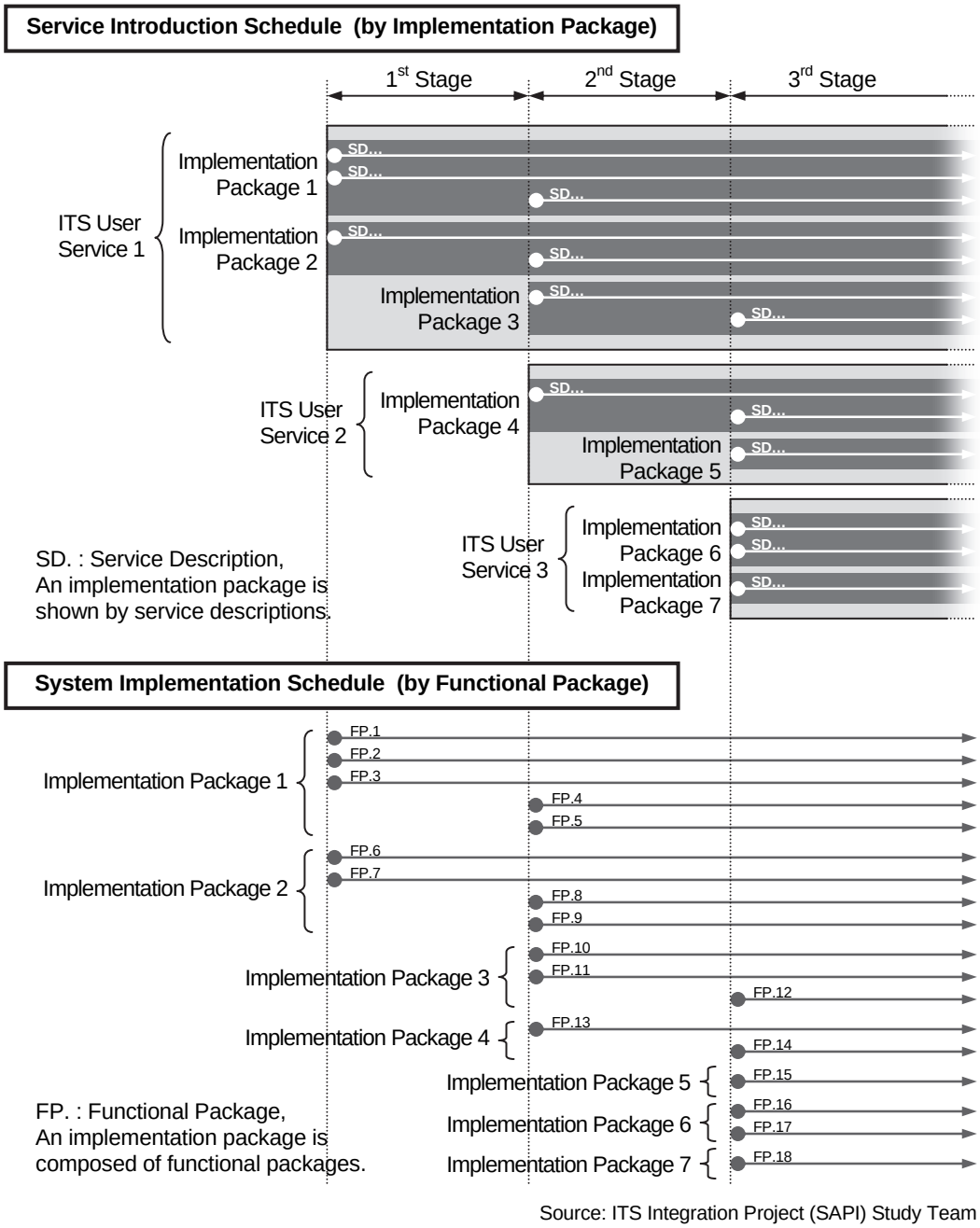
This functional package allows the road operators to monitor current conditions of vehicle passage and operations by workers by using cameras installed in a separated lane for axle load measurement of the expressway.

2.6 Stepwise System Implementation by Package

It is to be proposed in the Study to implement ITS by package for responding to the smaller scale of progress road network construction and changes in user needs. The implementation packages aforementioned are defined for this purpose. A part of ITS user service can be realized by an implementation package and the implementation package is to be composed a set of functional packages. The system of ITS is to be implemented by functional package.

Consequently, the ITS user service introduction schedule is actualized through the stepwise implementation by functional package as shown in the figure below.

Figure 2.14 Stepwise Implementation by Package



Source: ITS Integration Project (SAPI) Study Team

(1) Traffic Information/Control System

In the Study, it is assumed that stepwise system implementation for traffic information/control is to be launched in the Project based on the functional packages as shown in the figure below.

Figure 2.15 Stepwise System Implementation Schedule for Traffic Information/Control

Functional Package	1st Stage In the Project	2nd – 3rd Stage
(1) Voice Communication	• Terminal installation in the Regional Main Center, road management offices and toll offices	
(2) CCTV Monitoring	• Camera installation at 2km intervals continuously along through lanes	• Camera installation at shorter intervals continuously along through lanes • Concurrent use of camera with event detection and vehicle detection
(3) Event Detection (by Image)	• Camera installation on several ramps for trial use	• Camera installation on ramps for practical use • Camera installation around incident-prone sections on through lanes for practical use
(4) Vehicle Detection	• Detector installation at midway between a pair of interchanges on the through lanes	• Detector installation at shorter intervals continuously along through lanes • Detector installation at small intervals around congestion-prone sections on through lanes
(5) Traffic Analysis	• Estimation of traffic volume, occupancy and average travel speed	• Estimation of queue length and travel time including utilization of probe vehicles
(6) Weather Monitoring	• Sensor installation in all road management office and toll office at intervals of 20 to 40 km	• Sensor installation at shorter intervals
(7) Traffic Event Management	• Traffic control assistance based on traffic event data responding to occurrence of incidents	• Traffic control assistance based on traffic event data responding to occurrence of incidents and traffic congestion
(8) Traffic Supervision	• Traffic supervision using multi purpose large monitor screens in the Regional Main Center	
(9) VMS Indication	• VMS installation in front of entrance/exit gates and at barrier tollgates • CSS installation at 5km intervals along through lanes	• VMS installation midway between a pair of interchanges on the through lanes • CSS installation at shorter intervals along through lanes • SGM installation in front of junctions
(10) Mobile Radio Communication	• Installation for voice communication between patrol crews and road management office	
(11) Traffic Information	• Installation for providing traffic information to radio broadcasting, the Internet and mobile phones	
(12) Integrated Data Management	• System installation in in the Regional Main Center	

Source: ITS Integration Project (SAPI) Study Team

(2) Automated Toll Collection/Management System

It is assumed that stepwise system implementation for toll collection/management is to be launched in the Project based on the functional packages as shown in the figure below.

Figure 2.16 Stepwise System Implementation Schedule for Toll Collection/Management

Functional Package	1st Stage In the Project	2nd – 3rd Stage
(13) Tollgate Lane Monitoring	• Camera installation on all tollgate lanes for ETC, Touch&Go and manual	
(14) Vehicle/Class Identification	• System installation for post facto toll enforcement based on current vehicle classification	• System installation for immediate toll enforcement based on revised vehicle classification
(15) Lane Control	• System installation on all tollgate lanes for ETC, Touch&Go and manual	
(16) Road-to-Vehicle Communication	• DSRC system installation at toll islands for trial use	• DSRC system installation at toll islands for practical use • GPS/DSRC/SGM system installation for toll collection on free flow
(17) IC-card Recording	• System installation at tollgate for Touch&Go • System installation in toll offices, road management offices and a bank for prepayment	• System installation in banks and other places for prepayment
(18) Toll Data Management	• System installation in toll offices and road owner's offices	
(19) OBU Management	• System installation in the OBU management center	

Source: ITS Integration Project (SAPI) Study Team

(3) Vehicle Weighing System

It is assumed that stepwise system implementation for vehicle weighing is to be launched in the Project based on the functional packages as shown in the table below.

Figure 2.17 Stepwise System Implementation Schedule for Vehicle Weighing

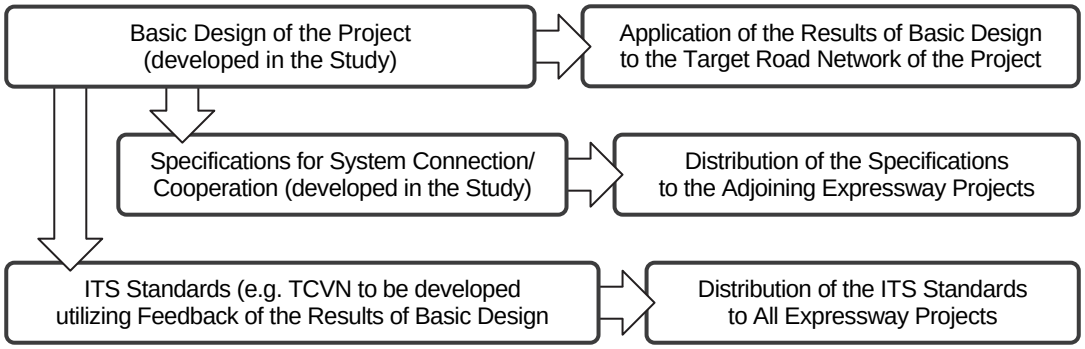
Functional Package	1st Stage In the Project	2nd – 3rd Stage
(20) Axle Load Measurement	• Axle load scale installation on a Touch&Go/Manual lanes at each entrance tollgates	• Axle load scale installation on more lanes at each entrance tollgates • Weigh bridge installation at appropriate place on through lanes
(21) Measurement Lane Monitoring	• System installation at entrance tollgates	

Source: ITS Integration Project (SAPI) Study Team

2.7 System Integration with Other Expressway Projects

Through the system planning and the Basic Design in the Study, integration and cooperation of the system is to be discussed for securing harmonization among the target road network of the Project and the adjoining expressway sections. The ITS Standards is under development utilizing feedback of the results of the Basic Design and will be distributed to all expressway projects.

Figure 2.18 Procedure for System Integration including All Expressway Projects



Source: ITS Integration Project (SAPI) Study Team

(1) Outputs from the Basic Design in the Study are:

- To show the equipment components by showing the system architecture
- To show the specifications of equipment components and communication system
- To show the specifications of protocols, messages and data dictionary for the interfaces between equipment components.

(2) Activities in the Project Supervision are:

- To find the equipment components in the system proposed by the Contractor by making reference to the system architecture of the Basic Design
- To check the compliance of the equipment components and communication system proposed by the Contractor to the specifications of the Basic Design
- To check the compliance of the protocols, messages and data dictionary proposed by the Contractor to the specifications of the Basic Design.

(3) Outputs from the Project Implementation are:

- To revise/detail the system architecture based on the equipment components implemented
- To revise/detail the specifications based on the equipment components and communication system implemented
- To revise/detail the protocols, messages and data dictionary based on the equipment components implemented.

The ITS Standards can be revised based on the outputs of (3) after the Project Implementation.

3. Existing Conditions of Road/Traffic/ITS

3.1 General

The following items are surveyed as the existing conditions of the study area and the social system in Vietnam:

- Road network
- Road traffic
- Communication network and power supply
- ITS implementation and pre-existing study results
- Legal affairs relevant to ITS

Especially road traffic data are acquired focusing on the effectiveness of traffic information for route selection on the ring shaped road of the target road network of the Project. Detailed data are shown in Appendix-5.

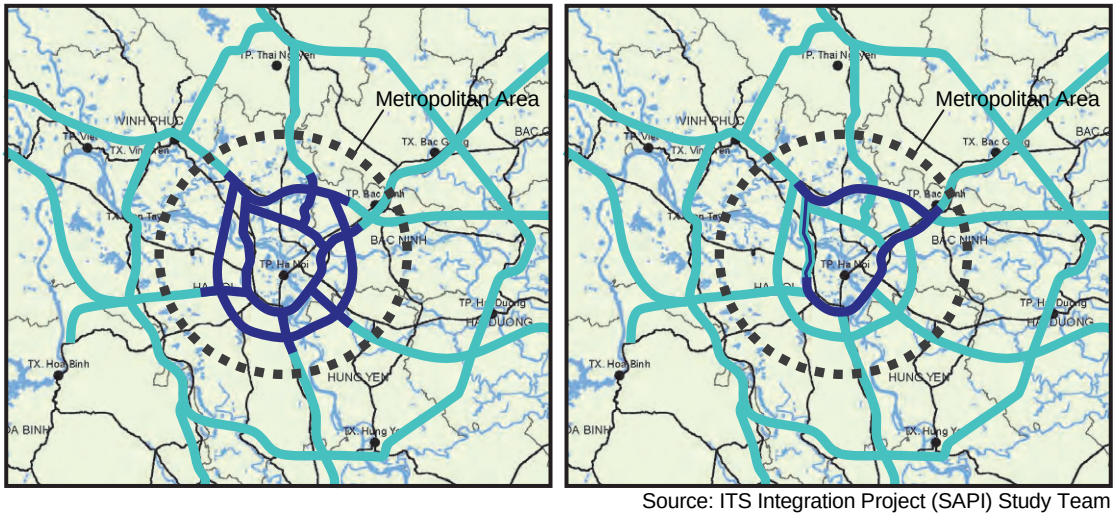
3.2 Road Network

1) Road Network and Interchanges

As mentioned in the concept of the Project in Section 1.6, combined use of the Ring Roads No.3 and No.4 is useful for securing route selectivity in case of incident occurrence and dispersing concentrated traffic. That will bring the effectiveness of traffic information/control using ITS into clear view in the future.

Figure 3.1 Ring Roads around Ha Noi

(Planned Ring Roads No.3 and No.4) (Existing Ring-shaped Road Network)



Source: ITS Integration Project (SAPI) Study Team

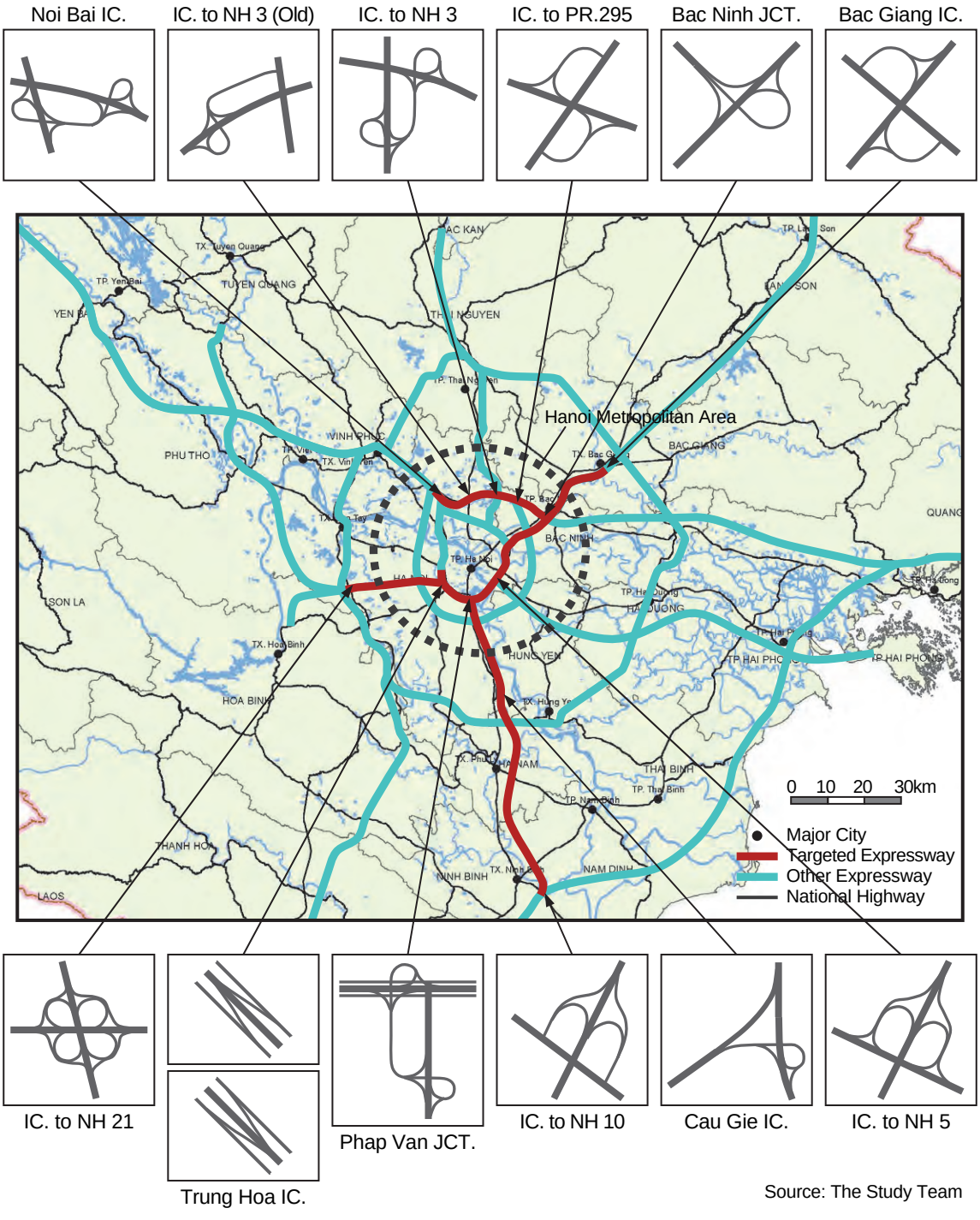
Instead of these two incomplete ring roads in the present situation, the existing ring-shaped road network shown in the right part of the figure above provides the route selectivity in the core part of the road network around Ha Noi. And the following radial expressways/highways are bundled by the ring-shaped road network:

- Lang – Hoa Lac Highway

- Phap Van – Cau Gie – Ninh Binh Expressway
- Ha Noi – Hai Phong Expressway
- Ha Noi – Bac giang – Lang Son Highway
- Ha Noi – Thai Nguyen Highway
- Noi Bai – Viet Tri – Lao Cai Expressway.

The major interchanges/junctions on the target road network of the Project is shown in the figure below. The names of interchanges/junctions are defined using the names of places or connected roads.

Figure 3.2 Road Network and Interchanges



Source: The Study Team

2) Outline of Road Sections

In this section, outline of the target expressways surveyed in the Study are shown in the table.

The outline illustrates the characteristics of respective expressways, especially as the number of lanes of expressways of Lang – Hoa Lac and the type of road structure of Mai Dich – Thanh Tri, which will be much reflected to the scale of construction cost per kilo-meter.

Table 3.1 Outline of Road Sections (1)

Expressway	**Mai Dich - Thanh Tri (Ring Road 3)**	**Lang - Hoa Lac**
Length	27 km	28 km
Design Speed	100 (km/h)	120 (km/h)
Number of Lane	-Number of Through Lanes: 4 -Number of Emergency Stop Lanes: 2	- Number of Through Lanes: 6 (with median strip) - Number of Emergency Stop Lanes: 2 - Frontage Road Lanes: 6
Major River to Pass	- Dau Bridge (To Lich River) - Thanh Tri Bridge (Red River) - Phu Dong Bridge (Duong River)	- Phu Do Bridge (Nhue River) - Day River Bridge (Day River) - Tich River Bridge (Tich River)
Characteristics of Road Structure	- Section: Mai Dich - Linh Dam: Elevated - Section: Linh Dam - Thanh Tri Bridge: Embankment	Embankment
Access Control	Full Access Control	Full Access Control
Expected Function	Expected to alleviate the existing traffic congestion and to support the future urban development outside the built-up area.	Linking Hanoi area to Hoa Lac area, where regional development related to High-tech Park, Industry Park and National University is expected in future.
Expressway	**Phap Van – Cau Gie**	**Cau Gie – Ninh Binh**
Length	30 km	50 km
Design Speed	from 60-100 upgrade to 120 km/h	120 km/h
Number of Lane	- Number of Through Lanes: 4 (or 6)	- Number of Through Lanes: 4 (or 6)
Major River to Pass	- Van Dien Bridge (To Lich River) - Tu Khoai Bridge (To Lich River) - Ha Thai Bridge (To Lich River)	About 14 bridges in total: - Duy Tien River - Chau Giang River; Day River)
Characteristics of Road Structure	Embankment	Embankment
Access Control	Full Access Control	Full Access Control
Expected Function	Expected to reduce transport cost and travel times for the movement of passengers and cargo between North to South (share traffic volume with the arterial NH.1A)	Expected to reduce transport cost and travel times for the movement of passengers and cargo between North to South (share traffic volume with the arterial NH.1A)

Source: Compiled by the Study Team

Table 3.2 Outline of Road Sections (2)

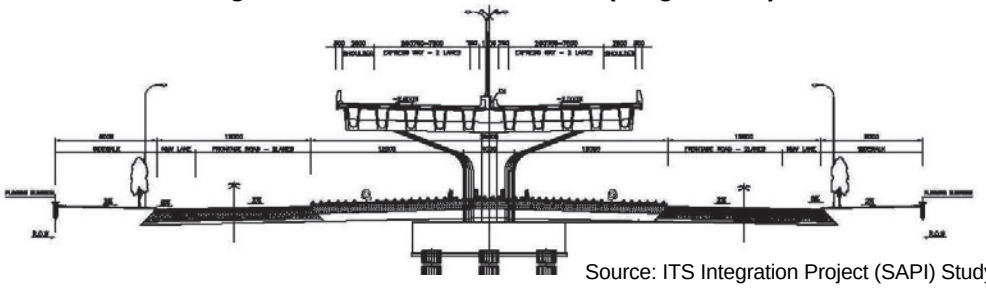
Expressway	**Ha Noi – Bac Giang**	**Noi Bai – Ca Lo Bridge**
Length	46 km	16 km
Design Speed	80 (km/h)	120 (km/h)
Number of Lane	- Number of Through Lanes: 4	- Number of Through Lanes: 4 - Number of Emergency Stop Lanes: 2
Major River to Pass		- Do Lo No.1 Bridge (Ca Lo River) - Do Lo No.2 Bridge (Ca Lo River) - Ca Lo Bridge (Ca Lo River)
Characteristics of Road Structure	Almost Embankment	Embankment
Access Control	Full Access Control	Full Access Control
Major Function	Expected to alleviate the existing traffic congestion and to support regional development and cargo transportation to Lang Son border with China.	Expected to alleviate the existing traffic congestion and to support regional development and cargo transport related to Noi Bai Airport and Cai Lan Port.
Expressway	**Ca Lo Bridge – Bac Ninh**	
Length	17 km	
Design Speed	120 (km/h)	
Number of Lane	- Number of Through Lanes: 4 - Number of Emergency Stop Lanes: 2	
Major River to Pass	- Ca Lo Bridge (Ca Lo River) - Phong Khe Bridge (Ca Lo River)	
Characteristics of Road Structure	Embankment	
Access Control	Full Access Control	
Expected Function	Expected to alleviate the existing traffic congestion and to support regional development and cargo transport related to Noi Bai Airport and Cai Lan Port.	

Source: Compiled by the Study Team

3) Typical Cross Sections

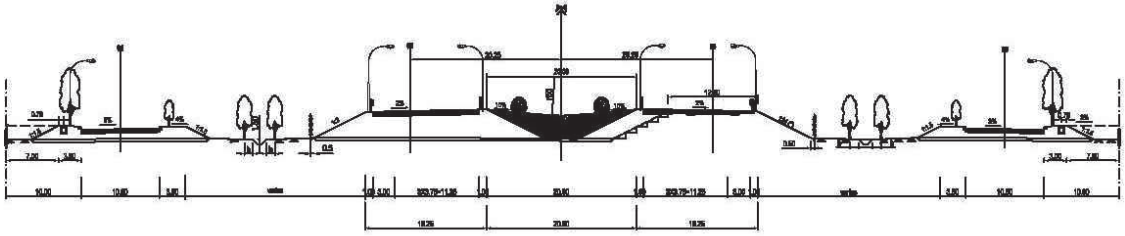
Typical cross section of each road section on the target road network is shown in the following figures. The most part of the Ring Road No.3 consists of viaducts and bridges and the other road sections are constructed mainly by earth work.

Figure 3.3 Mai Dich – Linh Dam (Ring Road 3)



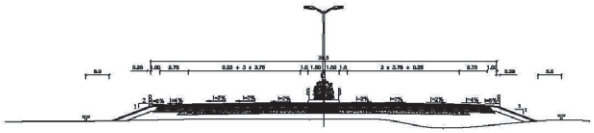
Source: ITS Integration Project (SAPI) Study Team

Figure 3.4 Lang – Hoa Lac



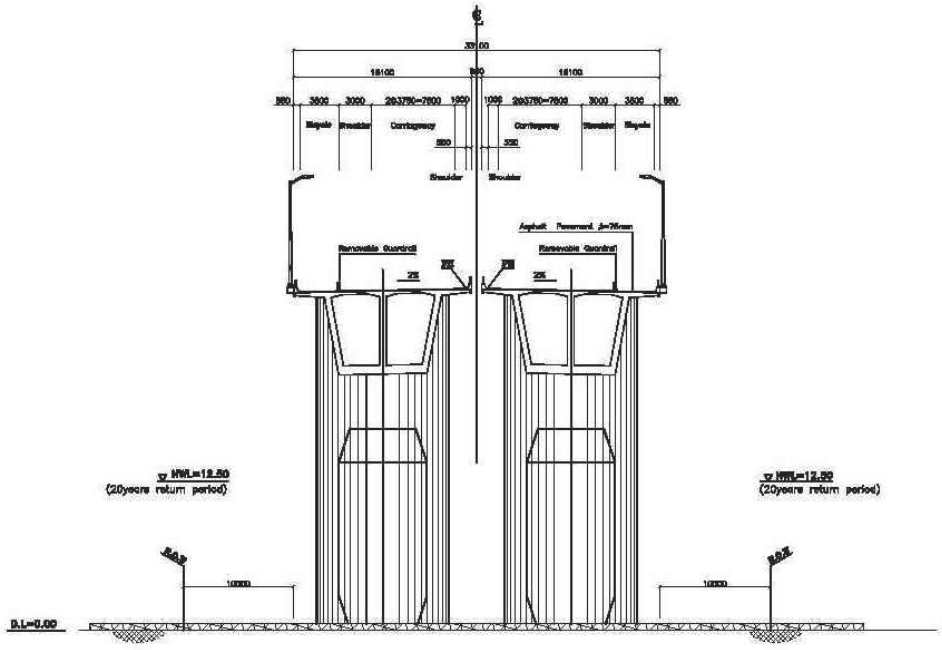
Source: ITS Integration Project (SAPI) Study Team

Figure 3.5 Phap Van – Cau Gie – Ninh Binh



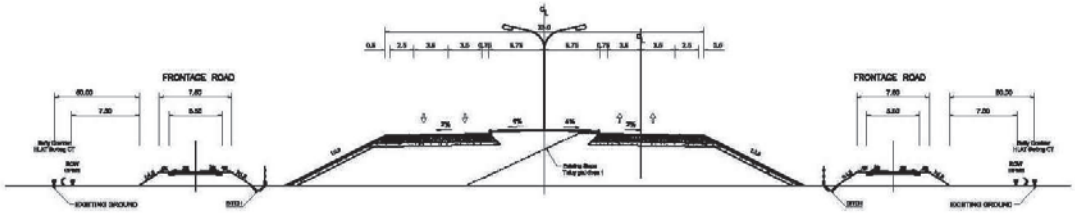
Source: ITS Integration Project (SAPI) Study Team

Figure 3.6 Thanh Tri Bridge (Ring Road 3)



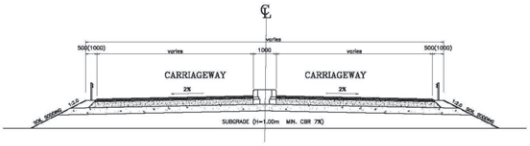
Source: ITS Integration Project (SAPI) Study Team

Figure 3.7 Ha Noi – Bac Ninh



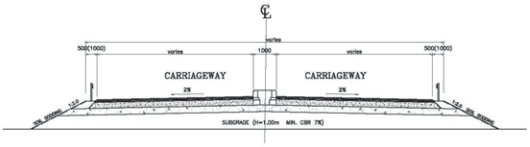
Source: ITS Integration Project (SAPI) Study Team

Figure 3.8 Noi Bai – Ca Lo Bridge



Source: ITS Integration Project (SAPI) Study Team

Figure 3.9 Ca Lo Bridge – Viet Tri



Source: ITS Integration Project (SAPI) Study Team

4) Present Conditions on Road Network

Present conditions on the target road network are shown in the pictures below. Tollgates are located on the Ha Noi–Cau Gie Expressway, the National Highway No.1 and the 3rd ring Road. In addition, installation of CCTV cameras by traffic police has begun on the Ha Noi–Cau Gie Expressway as well as installation of VMS on the Lang–Hoa Lac Expressway and the 3rd Ring Road.

Figure 3.10 Present Conditions on Target Road Network (1)

VMS on Ring Road 3 at Mai Dich

TL of Ring Road 3 at Mai Dich

Viaduct on Ring Road 3 at Trung Hoa

Signs on Lang–Hoa Lac

Interchange on Lang–Hoa Lac

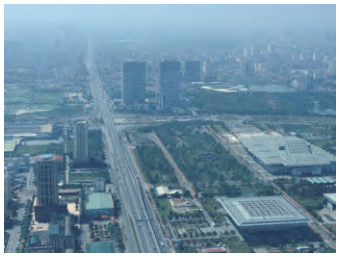
TL of Lang–Hoa Lac

Note: TL: Through lanes.

Source: The Study Team

Figure 3.11 Present Conditions on Target Road Network (2)


Overview of Ring Road 3


Overview of Ring Road 3


TL on Thanh Tri Bridge


Phap Van Junction


Signs on Phap Van–Cau Gie


TL of Phap Van–Cau Gie


VMS on Phap Van–Cau Gie


Mgt. Office at Vuc Vong


TL of Cau Gie–Ninh Binh


Tollgate at Liem Tuyen


TL of Ha Noi–Bac Ninh


Junction Ha Noi–Bac Ninh to NH3


VMS on Ha Noi–Bac Ninh


Bac Ninh Junction


TL of Bac Ninh–Bac Giang


Ca Lo Bridge


TL of Noi Bai–Ca Lo Bridge


Noi Bai Interchange

Source: The Study Team

3.3 Road Traffic

In Vietnam, use of expressway has begun only recently and occurrences of significant congestions have not been reported, while traffic volume has been increasing. In addition, a negative influence upon the use of expressway by collecting toll seems still large in this country. For example, it is reported that the traffic volume on the HCMC – Trung Luong Expressway, which was 32,000～35,000 vehicles/day in the period of free toll, decreased dramatically to 18,000 vehicles/day when toll collection was started.

The summary of estimated traffic demand in the table below shows the traffic volume per lane of each section of the target road network of the Project estimated in consideration of the influence of toll mentioned above. As the results of estimates for the years 2015 and 2020 in this table, the value of the traffic volume per lane is not excess of 2,000 pcu/lane in any section and the possibility of occurred congestion is not so high. However, in order to respond to the occurrence of congestion in the future, it is extremely important to collect the data of traffic using ITS.

Table 3.3 Summary of Estimated Traffic Demand by Road Section

		Traffic Volume per Day				Traffic Volume per Peak Hour (pcu)	Traffic Volume per Lane (pcu/lane)
		Psgr.Car (Vehicles)	Bus (Vehicles)	Truck (Vehicles)	Total (pcu)		
Mai Dich -	2015	15,633	6,733	12,950	58,367	7,588	1,138
Thanh Tri	2020	25,317	9,550	16,500	82,192	10,685	1,603
Lang -	2015	15,675	2,000	10,325	41,325	5,372	537
Hoa Lac	2020	12,550	1,550	8,275	32,975	4,287	429
Phap Van	2015	9,400	15,800	9,300	67,500	8,775	878
- Cau Gie	2020	15,100	19,700	11,450	87,250	11,343	1,134
Cau Gie -	2015	11,200	18,900	11,600	81,650	10,615	1,061
Ninh Binh	2020	24,550	33,300	21,300	150,400	19,552	1,955
Ha Noi -	2015	12,450	4,450	9,825	43,225	5,619	562
Bac Ninh	2020	15,900	5,125	12,750	54,213	7,048	705
Noi Bai -	2015	5,267	900	6,133	19,783	2,572	386
Bac Ninh	2020	8,467	1,433	9,100	30,250	3,933	590
Noi Bai -	2015	3,767	500	900	6,817	886	89
Viet Tri	2020	7,533	633	1,833	12,783	1,662	166

Source: ITS Integration Project (SAPI) Study Team

Furthermore, in the Study, a survey of traffic condition was performed focused on the ring-shaped part of the target road network. The survey was carried out in the way to record data of vehicle position/speed (probe data) using the smart-phone with the function of GPS. The results are shown in the following table and figures and the details are shown in Appendix-1.

As evidenced obviously by the Table 3.4, the necessary time for a longer distance of the clockwise route is shorter than the necessary time for a shorter distance of the anti-clockwise route. At the same time, it can be observed the values of average speed of the clockwise route are between 60 and 70 km/h (excluding the result in a.m. of the Weekday 2), whereas the values of average speed of the anti-clockwise route are between 35 and 40 km/h.

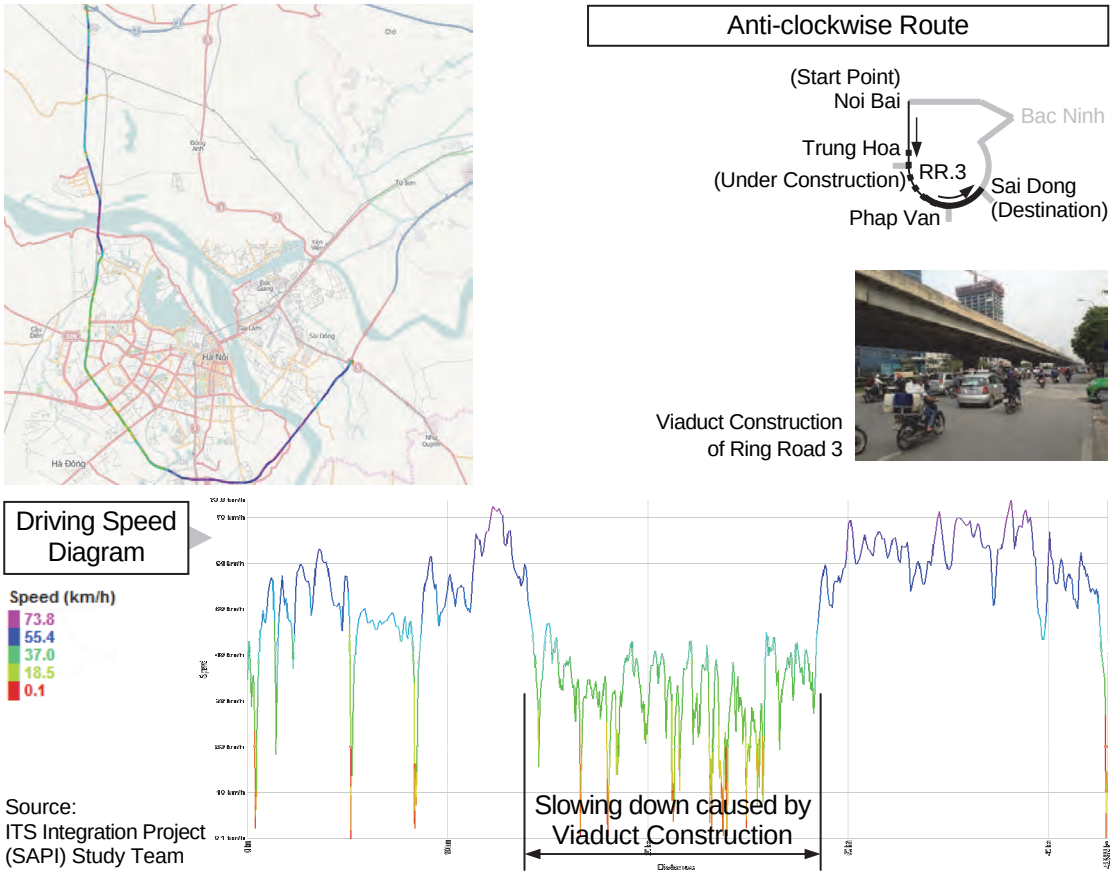
Table 3.4 Summary of Traffic Conditions on Ring-shaped Road Network

		Anti-clockwise Route (Noi Bai→Trung Hoa→Sai Dong)			Clockwise Route (Noi Bai→Bac Ninh→Phap Van)		
		Drive Distance (km)	Duration Time (min)	Average Speed (km/h)	Drive Distance (km)	Duration Time (min)	Average Speed (km/h)
Weekday 1	am	44	69	38.6	65	60	63.3
	pm		85	30.5		67	58.4
Weekday 2	am		70	37.4		106	36.8
	pm		78	33.7		58	66.7
Holiday	am		61	43.3		52	74.5
	pm		67	38.6		55	70.4

Source: ITS Integration Project (SAPI) Study Team

The prime reason of such traffic condition mentioned above is a slow speed in the section under viaduct construction on the Ring Road No. 3, which is shown by the driving speed diagram in Figure 3.12. Currently, in this section, the vehicles need to run on the existing frontage road and running speed has been significantly reduced. This condition takes place in common around the exit gates of expressways in the big cities. This fact suggest that there is a high possibility, also in Vietnam, of the occurrence of traffic congestion around the exit gates of expressways in the future.

Figure 3.12 Traffic Condition of Noi Bai→Trung Hoa→Sai Dong in the Morinig on Weekday 2



The land in the northeastern area of Ha Noi is mostly in use of agriculture and the number of trips generated in this area is not so large. Hence, the sections of Ha Noi – Bac Ninh and Noi Bai – Bac Ninh have very few traffic as shown in the picture below.

Figure 3.13 Existing Condition of Traffic in Northeastern Area of Ha Noi

(Ha Noi – Bac Ninh Section) (Noi Bai – Bac Ninh Section)

Source: ITS Integration Project (SAPI) Study Team

In contrast to this, the southwestern area of Ha Noi are in the midst of developing the new center of metropolis and a large number of high-rise buildings for offices and apartment, large-scale commercial establishment and hotels are being constructed. As a consequence, it has become daily routine that the trips generated this area cause crowdedness. Especially along the Ring Road No.3, the construction of the viaducts causes heavy congestion around intersections.

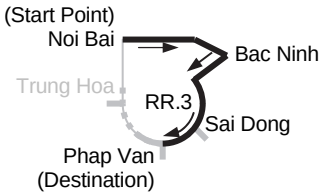
Figure 3.14 Existing Condition of Traffic in Southwestern Section of Ring Road 3

Source: ITS Integration Project (SAPI) Study Team

On the other hand, the situation described above has changed completely in the morning of the Weekday 2 when a serious traffic accident has occurred in the vicinity of the Phu Dong Bridge. The average speed of clockwise route falls to 36.8 km/h and the necessary time for going the destination is 106 minutes, which is nearly twice of the necessary time at the other dates. At the site of the accident, heavy truck overturned and blocked more than one lane as shown in the Figure 3.16. It is judged that reduction of average speed is obviously due to the congestion caused by the traffic accident.

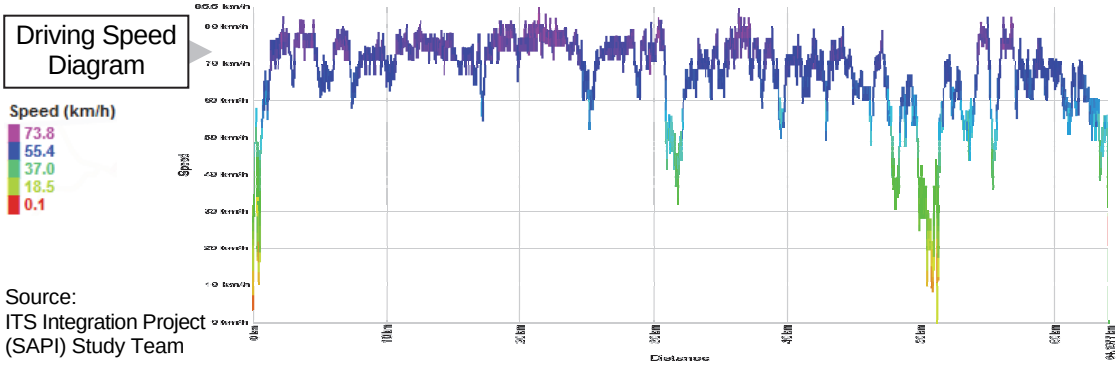
Figure 3.15 Traffic Condition of Noi Bai→Bac Ninh→Phap Van in the Morinig on Weekday 1

Clockwise Route



Start Point Destination

Driving Speed Diagram



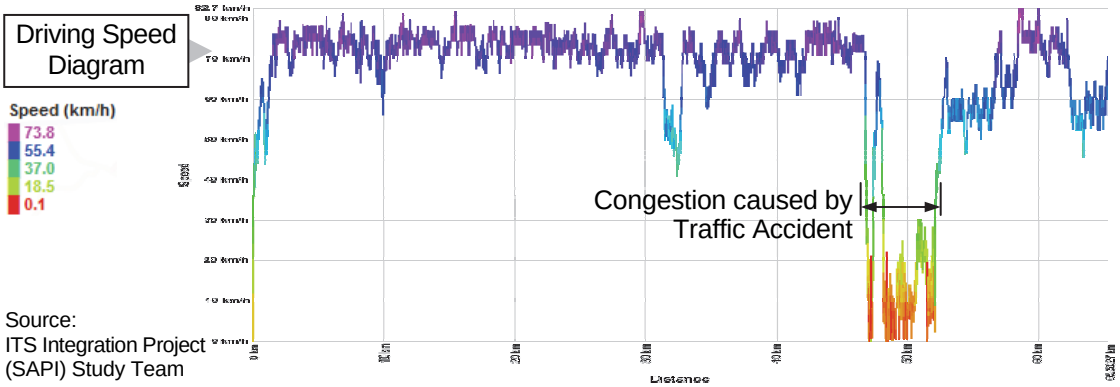
Source:
ITS Integration Project (SAPI) Study Team

Figure 3.16 Traffic Condition of Noi Bai→Bac Ninh→Phap Van in the Morinig on Weekday 2

Clockwise Route

A serious traffic accident happened near Phu Dong Bridge on the route of Vehicle 3: at 48.8km distance from the starting point.

Driving Speed Diagram



Source:
ITS Integration Project (SAPI) Study Team

Not only on the date of the survey foregoing, but frequently occur single-vehicle accidents in Vietnam. It is conceivable that such kind of accidents are caused by the following reasons:

- Inexperience in high-speed driving
- Poor maintenance of the vehicle
- Overloading on the truck.

Moreover, the number of occurrence of the traffic accident in each expressway section is shown in the following tables.

Table 3.5 Traffic Accident Information Expressway Cau Gie – Ninh Binh

Years	Traffic Volume	Number of Accidents							
		In terms of Accident Types					In terms of severity		
		Total	Car Broken	Vehicles crashing	Lost of Steering Control	Others	With injured	With fatal	Serious (need road/ lane closing)
2012 (Half Year)	2,245,966	525	180	21	-	324	-	2	0
2013	5,188,087	432	185	24	-	223	-	1	0
2014	6,110,163	795	385	22	-	388	8	7	0
2015 (First Quarter)	2,043,776	199	99	4	-	96	0	0	0

Source: The Study Team

Table 3.6 Traffic Accident Information Expressway Noi Bai – Lao Cai

Years	Traffic Volume	Number of Accidents							
		In terms of Accident Types					In terms of severity		
		Total	Car Broken	Vehicles crashing	Lost of Steering Control	Others	With injured	With fatal	Serious (need road/ lane closing)
2014 (Last Quarter)	846,931	379	141	11	-	227	6	1	0
2015 (First Quarter)	1,288,137	396	163	31	-	202	4	2	0

Source: The Study Team

Table 3.7 Traffic Accident Information Expressway Ho Chi Minh City – Trung Luong

Years	Traffic Volume	Number of Accidents							
		In terms of Accident Types					In terms of severity		
		Total	Car Broken	Vehicles crashing	Lost of Steering Control	Others	With injured	With fatal	Serious (need road/ lane closing)
2012	19,282	3,343	3,262	52	-	29	56	5	-
2013	22,199	4,300	4,236	42	-	22	45	7	-
2014	24,622	3,617	3,542	61	-	14	34	12	-
2015 (First Quarter)	28,983	708	694	12	-	2	-	-	-

Source: The Study Team

Vehicles crashing more than 20 occur every year in the Cau Gie – Ninh Binh section, and cases becoming fatal increase. The Noi Bai – Lao Cai section just opened in 2014, and there is small traffic volume, but the number of accident occurrence becomes more. And a lot of car broken occur though the Ho Chi Minh City – Trung Luong section of the southern area has less traffic volume than the northern area.

A traffic accident causes congestion in general and it is considerable that an ambulance is involved in the traffic congestion and is delayed in arrival at the accident site. Shortage of tow-cars frequently requires the supports of construction vehicles in Vietnam. The construction vehicles in the picture below was going to the accident site by reverse driving.

Figure 3.17 Traffic Accident on Thanh Tri Bridge

Source: ITS Integration Project (SAPI) Study Team

In Vietnam where the road network and detour has not been improved sufficiently, it is difficult to escape from the influence of a traffic accident while driving a vehicle like the case above. With such being the situation, it is extremely important to respond promptly to the accident and it is expected, for this reason, that significant effects on identifying quickly the accident occurrence/situation and disseminating the accident information can be achieved by ITS introduction. In addition, it goes without saying that the prompt response will contribute to reduce the number of fatalities caused by the traffic accidents.

Figure 3.18 Existing Condition of Vehicle Queueing at Tollgate

Source: ITS Integration Project (SAPI) Study Team

Congestion at the tollgates on the expressways around Ha Noi is not so serious. A reason of such condition is the small traffic volume on the expressways and another reason is the monthly tickets used by many drivers, which allow non-stop passage at the tollgates.

A large number of the heavy trucks carrying marine containers move up and down on the expressways mainly from Hai Phong to the inland areas passing by Ha Noi. It is reported that the heavy trucks commit overloading at high rates. Overloading regulation is to be considered as an urgent issue, because overloaded heavy trucks frequently cause traffic accidents by lowering in breaking force and traffic congestion by shortage of accelerating ability .

Figure 3.19 Heavy Trucks transporting Marine Containers on Expressways

Source: ITS Integration Project (SAPI) Study Team

3.4 Communication Network

1) Communication Network Installation Work for ITS in Expressway and its O&M

On the existing expressways, communication ducts have not been installed in many sections. The communication ducts are often installed by telecommunication companies; however, it appears that the communication ducts is not get proper and sufficient maintenance.

In the case of the sections on the existing bridges, it is frequently seen that communication ducts have been attached using brackets to the hand rails as shown in the figure below.

Figure 3.20 Existing Condition of Communication Ducts

Source: ITS Integration Project (SAPI) Study Team

According to the official letter of the Government of Viet Nam dated May 22, 2012 with Ref. No. 3569/VPCP-KTN, the Government of Vietnam agreed with the policy that MOT should

cooperate with VNPT to install communication infrastructures (optical fiber cable and auxiliaries and services) and partial use to support the ITS in the expressways which MOT is investing to construct in Vietnam.

On the basis of the above policy, Vietnam Telecoms National (VTN) which is the subsidiary of VNPT installs the optical fiber cable including its duct facility for the following expressway sections:

- National Highway No.1 Hanoi – Bac Giang
- National Highway No.1 Bac Giang – Lang Son
- Noi Bai – Lao Cai
- Da Nang – Quang Ngai
- Long Thanh – Dau Giay
- Ben Luc – Long Thanh.

As for the following, expressway sections, the optical fiber cable was installed already:

- Hanoi – Thai Nguyen
- HCMC – Trung Luong.

VTN installs main optical fiber cable only. The cable connection from main cable to the roadside equipment component and installation of necessary switches are demarcated as the contractor's work of ITS equipment installation. The demarcation of maintenance work is also the same point of the installation work basically. (i.e. VTN will maintain only main optical fiber cable.) The cost for road operator to use optical fiver cable installed by VTN is free of charge.

According to VTN, the optical fiber cable for ITS and the optical fiber cable for VNPT will be installed separately. In addition, the cable for ITS is the one complies with ITU-T Recommendation G 652.D taking necessary communication traffic for ITS into consideration. The G 652.D is not applicable for Dense Wavelength Division Multiplexing (DWDM) technology. Therefore the transmission method for ITS project is not required to consider the possibility of utilization of DWDM technology.

2) Communication Network of Phap Van –Cau Gie Expressway Section

The communication network between Phap Van and Cau Gie was installed in the JICA Grant Aid Project titled "The Project for Development of Traffic Control System for the Expressway in Hanoi" which was completed in May 2014.

In the project, the roadside equipment components were installed in the Ring Road No.3 between Phap Van and the National Highway No. 5 interchange, and the expressway section between Phap Van and Cau Gie. Since those equipment components are required to connect to the traffic control center located in Vuc Vong, the communication network was installed to connect all those roadside equipment components and related control equipment component in Vuc Vong center.

(1) Installed Communication Network Equipment

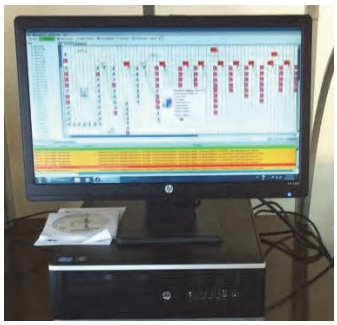
The transmission method of this communication network is IP over G-Ethernet. Therefore the network is composed of switches, optical fiber cable and media convertors. The applied

version of IP is version 4 for this network, however taking future necessity into consideration; the IPv4/IPv6 translator is also introduced.

The network is composed of 2 layers. The upper layer is composed of L3SWs located in Vuc Vong center and road side including connecting optical fiber cable for those switches. The lower layer network is connecting among roadside L3SWs, roadside L2SWs and the roadside equipment components such as CCTV cameras and VMSs including connecting optical fiber cable for those equipment components. The redundancy is equipped for the upper layer network only .

The network management system (NMS), which monitors roadside equipment components and detect the failure of the equipment components, is installed for this network and monitored from the Vuc Vong center.

Figure 3.21 Network Management System



Source: The Study Team

(2) Communication Ducts

The optical fiber cable and power supply cable is installed in the different duct which is installed in the medium strip along the above road section. The inner diameter of duct is 35mm, and 3 ducts are installed. The cable chamber which is required to install the cable into the duct is used for both optical fiber cable and power supply cable. Cable chamber interval is 1000m for optical fiber cable and 150m for power supply cable.

3) Communication Network of Cau Gie – Ninh Binh Expressway Section

The communication network for Cau Gie – Ninh Binh Expressway is designed CadPro and completed to install before Phap Van – Cau Gie Expressway section.

The roadside equipment components are composed of monitoring camera, vehicle detection camera, and changeable speed limit sign. The communication network which connects those equipment components to the equipment in Vuc Vong center is also installed.

(1) Installed Communication Network Equipment

The communication method applied in this communication network is IP over 10G Ethernet for backbone network and the IP version is 4.

In this expressway section, there is special telephone number when the expressway user needs to contact road operator. The telephone call is incoming to the telephone at Vuc Vong center, and the operator is able to receive it 24 hours a day and 365 days a year. The operator records when he receives the call and inform it to the patrol crew.

(2) Communication Ducts

The ducts for optical fiber cable for Cau Gie – Ninh Binh Expressway is 28 mm in inner diameter and 10 ducts are installed. The power cable is installed in another duct around interchanges. As for the electric power to the roadside equipment whose location is relatively far from the interchange is supplied from the equipped solar panel and battery.

3.5 ITS Facilities

The following items were surveyed for the preparation of the Study.

- Traffic information (by Voice of Vietnam)
- VMS
- ETC

Introduction and operation situations of ITS were confirmed in the objective area of the Study.

1) Phap Van – Cau Gie

A traffic control system was introduced into this section by the Grant Aid of Japan. The equipment installed in the roadside had CCTV camera, event detector, vehicle detector, VMS, and a traffic control system was installed as a center in a room of Road Management Office of Buc Bong. And VEC O&M does this road maintenance and operation of the system.

Figure 3.22 Present Conditions on Traffic Control System in Phap Van – Cau Gie

Source: The Study Team

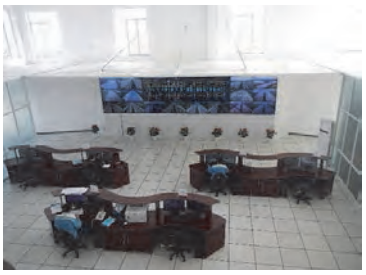
2) Cau Gie – Ninh Binh

A traffic monitoring system was introduced into this section by a local company. The equipment installed in the roadside are CCTV camera, vehicle detector, and VMS. A traffic

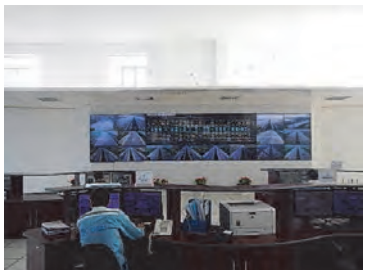
monitoring system was installed as a center in a room of Road Management Office of Buc Bong. This section starts the toll with the manual.

Figure 3.23 Present Conditions on Traffic Control System in Cau Gie – Ninh Binh

Traffic Monitoring Room



Traffic Monitoring System



Multi-Screen

Vehicle Detector

Toll Booth

Toll Collection by Manual

Source: The Study Team

3.6 Progress/Issues of ITS Standards Development

The ITS Standards: TCVN is now under development in Vietnam. The Drafts of TCVN are being prepared and discussed in the organization consists of 8 Sub-Groups under DOST/ MOT as shown in the table below.

Table 3.8 List of Sub-groups for Developing Draft TCVN

		Item of TCVN	Name of Leader	Draft
Leader			Mr.Nguyen Tuan Anh (MOT/DOST)	--
Sub-group	1	ITS System Architecture	Mr.Nguyen Dinh Khoa (ITST)	N.Y.
	2	Traffic Monitoring & Control on Expressways	Mr.Pham Hong Quang (CadPro)	U.D.
	3	Traffic Database and Message System on Expressways	Mr.Van Van Trung (MOT/ITC)	N.Y.
	4	CCTV Camera System on Expressways	Mr.Chu Quang Trung (MOT/ITC)	N.Y.
	5	VMS on Expressways	Mr.Nguyen Anh Tuan (ITST)	U.D.
	6	Communication System on Expressways	Mr.Le Thanh Tung (MOT/ITC)	N.Y.
	7	ETC System on Expressways	Mr.Pham Duc Long (ITD)	U.D.
	8	Management Office/Center on Expressways	Mr.Ta Tuan Anh (CadPro)	U.D.

Note, N.Y.: Not yet, U.D.: Under drafting.

Source: The Study Team

For the reason that the discussion of TCVN has begun separately in each Sub-group without sharing a total concept, various issues have become evident for the Drafts prepared by the Sub-groups.

It is proposed to implement the ITS Integration Project urgently to establish the effective ITS Standards by providing the experimental proof for securing the actual connectivity of interfaces and inter-operability of data based on a unified system architecture which provides the common basis to be shared for discussion on ITS.

4. Basic Understanding of Total Expressway Operation

4.1 General

The discussion in the Study is focusing on the three priority ITS user services and that aims to focus on the expressway operation by using ITS. Basic understanding of total expressway operation is to be prepared in the beginning of the discussion accordingly.

In this chapter, the following items are to be discussed as basic understanding of the total expressway operation.

- Minimal Service Requirements for Expressway Operation
- Access Control of Expressway Network
- Toll Rate System for Expressway Network
- Outline of Expressway Operation

4.2 Minimal Service Requirements for Expressway Operation

1) Schemes for Road Operation/Maintenance

The ownership of road facilities is in a public road owner or a road investor; however it is necessary for them to share the roles of road operation/maintenance with road operators. In the Study, the schemes based on service contract and concession contract are proposed to be adopted for the respective road sections.

Table 4.1 Shemes for Road Operation/Maintenance

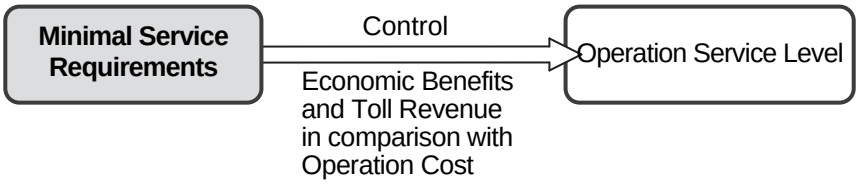
	(a) Service Contract	(b) Lease Contract	(c) Concession Contract
Roles of Public Road Owner or Investor	- Ownership of road facilities - Responsibility for providing O/M services, all capital investments, tariff setting and toll collection.	- Ownership of road facilities - Responsibility for new/replacement investments, establishing performance stds., monitoring conformity and tariff setting.	- Ownership of road facilities - Responsibility for establishing performance stds., monitoring conformity and tariff setting.
Roles of Road Operator	- Responsibility for providing O/M services only in working level by fee payment from public org.	- Responsibility for providing O/M services, toll collection and making a specified lease payment to Public Road Owner or Investor - Responsibility for working capital funds and rehabilitation costs.	- Responsibility for providing O/M services and toll collection based on the concession contract - Responsibility for all capital investment including working capital funds and rehabilitation costs.
Toll Revenue Risk	Public	Private	Private
Applied Sections in the Project	- Mai Dich–Thanh Tri (HPC/O&M-Company) - Lang–Hoa Lac (HPC/O&M-Company) - Cau Gie–Ninh Binh (VEC/VEC-O&M) - Noi Bai–Ca Lo Bridge (HPC/O&M-Company) - Ca Lo Bridge–Bac Ninh (Bac Ninh/O&M-Company)	--	- Phap Van–Cau Gie (DRVN/BOT) - Ha Noi–Bac Giang (DRVN/BOT).

Source: The Study Team

2) Minimal Service Requirements for the Expressways

In order to enhance a road operator's motivation, minimal service levels required for the expressway operation shall be defined as a standard. The Minimal Service Requirements allow to control the operation service levels provided by a road operator as shown in the figure below. The operator's achievement in expressway operation is to be evaluated in reference to the Minimal Service Requirements.

Figure 4.1 Minimal Service Requirements for Controlling Operation Service Level



Source: ITS Integration Project (SAPI) Study Team

The following benefits to be provided through expressway operation shall be specified in the Minimal Service Requirements:

- Accessibility
- Mobility
- Safety & response to incident
- Environmental protection.

These benefits of expressway operation can be specified as shown in the table in the following page with reference to the ITS Master Plan. In the Study, these are defined as the Minimal Service Requirements for the discussion on ITS operation, which is to be included in the expressway operation.

In the table, the Minimal Service Requirements are described with correspondence to the services of road operation/maintenance (→See Table 4.9 and Figure 5.7) indicated by the following symbols (a) to (e):

(a) : Road structure/facility management
(b) : Toll collection/management →Non-stop toll collection (as a priority ITS user service)
(c) : Traffic information/control →Traffic information/control (as a priority ITS user service)
(d) : Heavy truck control →Heavy truck control (as a priority ITS user service)
(e) : Communication system management.

As shown above, the services (b) to (d) are corresponding also to the three priority ITS user services aforementioned in Table 1.1.

Table 4.2 Minimal Service Requirements for Expressway Operation

Accessibility	• Establishment of appropriate access control system to expressway network: - Rejection of vehicles above the dimensional limits to reduce damage to road structure →(a) - Rejection of impermissible type of vehicles including motor bikes →(b) - Rejection of overloading heavy trucks to reduce damage to road structure →(d) - Rejection of vehicles without payment adequate for regulated toll rate →(b) • Establishment of fair and reliable toll collection system based on the latest toll rate regulation for expressway network: - Availability for any drivers who intend to use expressway network rightfully →(b) - Reliability of automated toll collection: Error ratio by frequency less than 0.0001% on checking sufficiency of prepaid balance with reference to the vehicle class defined by the regulation →(b) • Provision of sufficient vehicle processing capacity at the tollgate by non-stop and one-stop toll collection responding to traffic volume: - Non-stop toll collection at average service-time less than 4.5 sec/vehicle →(b) - One-stop toll collection at average service-time less than 9.0 sec/vehicle →(b). • Connectivity of communication network in conformity with the Standards. →(e) • Inter-operability of information/data in conformity with the Standards. →(e)
Mobility	• Establishment of road management offices equipped with adequate system for monitoring traffic, patrol crews for restoring road functions and enforcing/releasing traffic restrictions and vehicles for road operation including tow car, police car and ambulance →(a), (c), (e) • Provision of smooth traffic flow by dispatching routine patrol using operation vehicles: more than 4 times a day →(a), (c) • Provision of smooth traffic flow through traffic information/control: responding to locations of the vehicle on the road network and traffic volume →(c) • Maximum speed: 120 km/hr →(c) • Lowest speed to be secured: 50 km/hr (to be not less than maximum speed –70 km/hr, otherwise coming-in traffic shall be restricted) →(c) • Average travel speed: more than 60 km/hr →(c) • Traffic surveillance and information dissemination with update intervals: 5 minutes →(c).
Safety & Response to Incident	• Establishment of adequate organization to keep road structure/facility well-maintained to secure safety for road traffic →(a), (c) • Establishment of appropriate framework to address incidents including traffic accidents notified by emergency calls (including 113 and 115) →(c), (e) • Securing of means for emergency call with a delay time less than 10 minutes from the incident occurrence even in mountainous areas →(c) • Provision of traffic safety by dispatching road operation vehicles to an incident site with a delayed time less than 1 hour from the reception of emergency call →(c) • Enforcement of adequate traffic restrictions responding to the incident occurrences and the traffic conditions →(c) • Information dissemination of incident with a delay time less than 1 hour →(c), (e).
Environmental Protection	• Promotion of installation and dissemination of non-stop toll collection →(b) • Keeping smooth traffic flow by enhancing traffic information/control →(c).

Note: (a), (b), (c), (d), (e) are to be referred to Table 4.9.

Source: ITS Integration Project (SAPI) Study Team

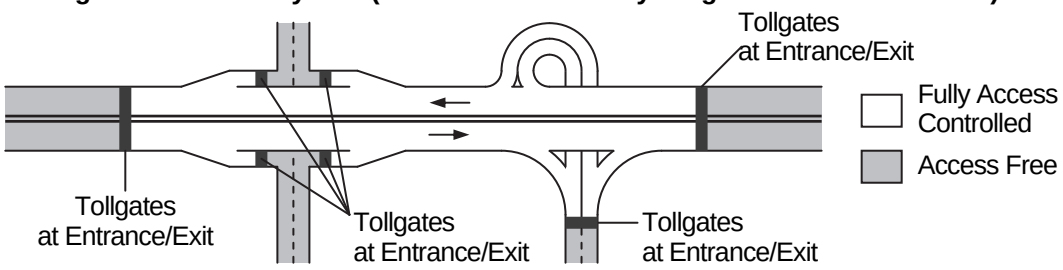
4.3 Access Control of Expressway Network

1) Typical Access Control

(1) Closed System

In this system, a road section concerned is to be separated from all other road sections by tollgates at entrances and exits as shown in the figure below. The vehicle access to the road section is fully controlled and no vehicle can come into or go out from the section without check at the tollgate. Unlawful passages, such as toll-cheating, overloading and reverse driving, can be completely rejected from the road section accordingly. If necessary, motorbikes also can be rejected from the road section. However, in the case overloading regulation is enforced in front of the entrance tollgates, large land acquisition is necessary for preparing discharge ramps for overloading vehicles.

Figure 4.2 Closed System (Full Access Control by Tollgates at Entrances/Exits)



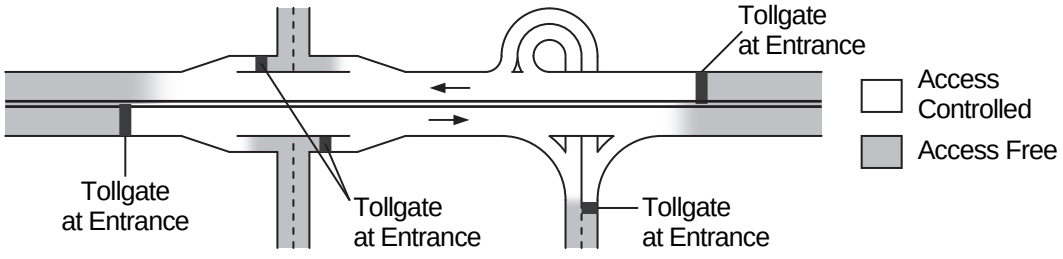
Source: ITS Integration Project (SAPI) Study Team

(2) Open System

In this system, tollgates are to be installed at entrances or exit or on the through lanes of a road section.

In the case tollgates are installed at the entrance as shown in the figure below, the vehicle access to the road section is controlled at the entrance tollgates and unlawful passages, such as toll-cheating and overloading, can be rejected. However, imprudent vehicles can come into the road section by reverse driving from the exit. And in the case overloading regulation is enforced in front of the entrance tollgates, large land acquisition is necessary as in the case of closed system.

Figure 4.3 Open System (Access Control by Tollgates at Entrances)

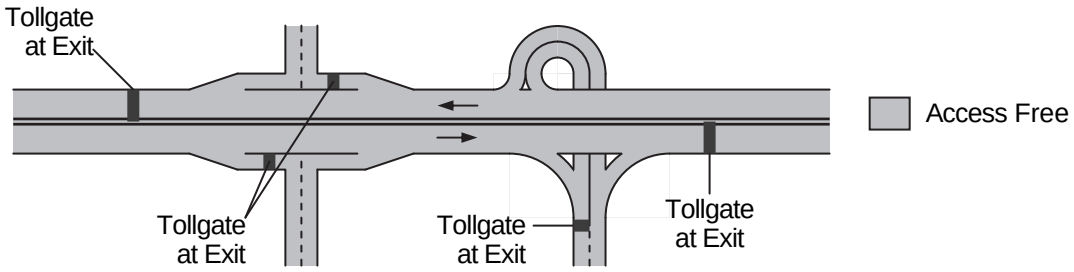


Source: ITS Integration Project (SAPI) Study Team

In the case tollgates are installed at the exit or on the through lanes, all vehicles including imprudent vehicles with overloading can come into and drive on the road section concerned to the exit tollgate. There is no traffic lane where access is controlled in this system and,

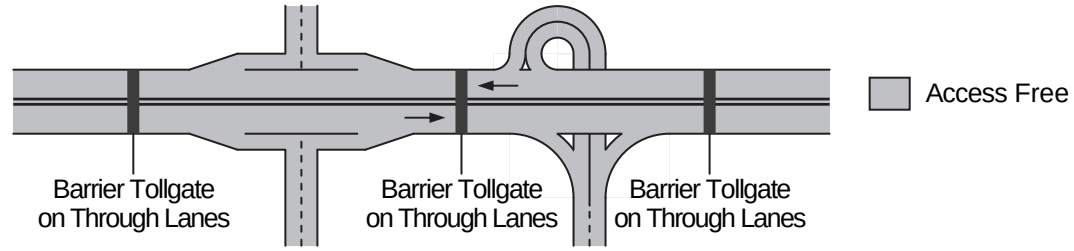
even if necessary, motorbikes also cannot be controlled and rejected from the road section.

Figure 4.4 Open System (Access Control by Tollgates at Exits)



Source: ITS Integration Project (SAPI) Study Team

Figure 4.5 Open System (Access Control by Barrier Tollgate on Through Lanes)



Source: ITS Integration Project (SAPI) Study Team

Under present circumstances in Vietnam, the open system by the barrier tollgates on through lanes is popularly practiced.

Table 4.3 Comparison on Typical Access Control

	Closed System	Open System		
		Entrance Tollgate	Exit Tollgate	Barrier Tollgate
Access to Road Section	Fully Controlled	Controlled	Free	Free
Rejection of Toll-cheating	Capable	Capable	Capable	Capable
Rejection of Overloading	Capable	Capable	Incapable	Incapable
Rejection of Motorbike	Capable	Capable	Incapable	Incapable
Rejection of Reverse Driving	Capable	Incapable	Capable	Capable
Experiences in Vietnam	None (Only Planned)	Many (Generally for Short Section)	Many (Generally for Short Section)	Many (Generally for Short Section)

Source: ITS Integration Project (SAPI) Study Team

2) Access Control of Expressway Network

The types of access control is strongly related with the types of toll rate system, Accordingly, appropriate type of access control for the expressway network in Vietnam will be selected based on the discussion on toll rate system in the following chapter in consideration of the feature of traffic on the inter-city road network and the arteries in urban areas.

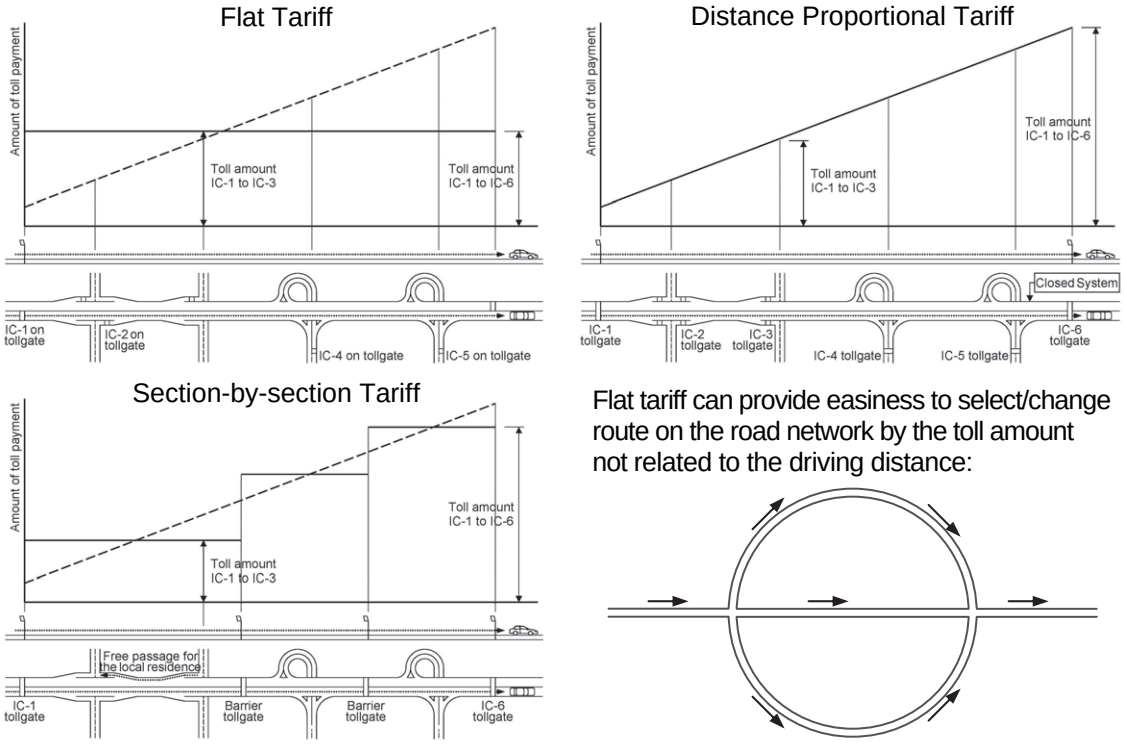
4.4 Toll Rate System for Expressway Network

Toll rate is an important budgetary constraint on the road operation/maintenance as well as construction. At the same time, it affects the arrangement of the tollgates and the roadside equipment. The following two toll rate system policies are adopted in the Study.

1) Typical Toll Rate System

Toll rate is an important precondition that should give a budgetary constraint on the road operation/maintenance as well as construction. At the same time, that affects the arrangement of the tollgates and the roadside equipment. Three typical toll rate systems below are to be taken up in the discussion.

Figure 4.6 Three Typical Toll Rate Systems



Source: VITRANSS2 Study Team

Table 4.4 Comparison on Typical Toll Rate Systems

	Distance Proportional Tariff	Flat Tariff	Section-by-section Tariff
Total number of Tollgates	Large	Average	Average
Evenness of Alternative Driving Route	Not secured	Secured	Not secured
Free Passage for Local Residents	Not available	Not available	Available
Applicability to Inter-city Expressways	Suitable	Not Suitable	Suitable
Need to stop on Through Lanes for Driver	Few times	Few times	Many times
Suitability for Access Control	Close	Open	Open
Fairness for Driving Distance	Secured	Not secured	Secured
Possibility of collectng Sufficient Toll	Possible	Difficult	Difficult
Applicability to Urban Expressways	Not Suitable	Suitable	Average

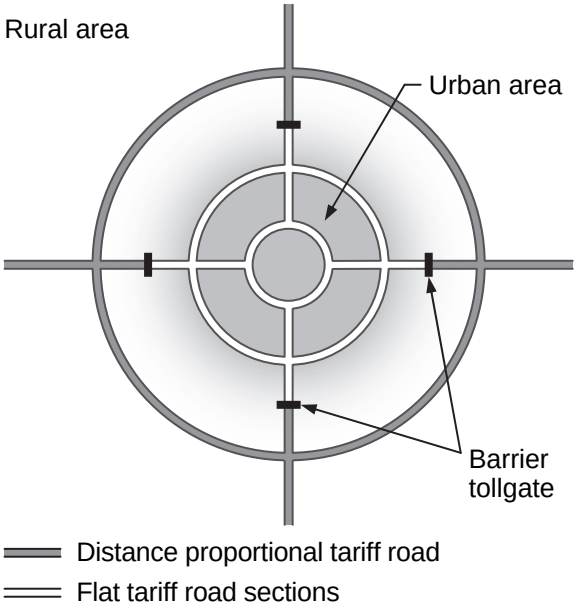
Source: VITRANSS2 Study Team

2) Toll Rate System for Metropolitan Area

Distance proportional tariff is suitable for the inter-city road network in the rural area. However, in the near future, it will become main issue in urban areas in Vietnam to disperse concentrated traffic. Flat tariff will provide good effect for this purpose. On that account, a combined toll rate system shown in the figure is recommended for metropolitan areas. In many Asian countries which is characterized by huge metropolises and less-populated countryside, this combined system is already applied to major cities such as Tokyo and Jakarta.

Both the distance proportional tariff system and the flat tariff system will be discussed in the Study, accordingly.

Figure 4.7 Combined Toll Rate System for Metropolitan Area



Source: VITRANSS2 Study Team

3) Toll Rate System for Expressway Network

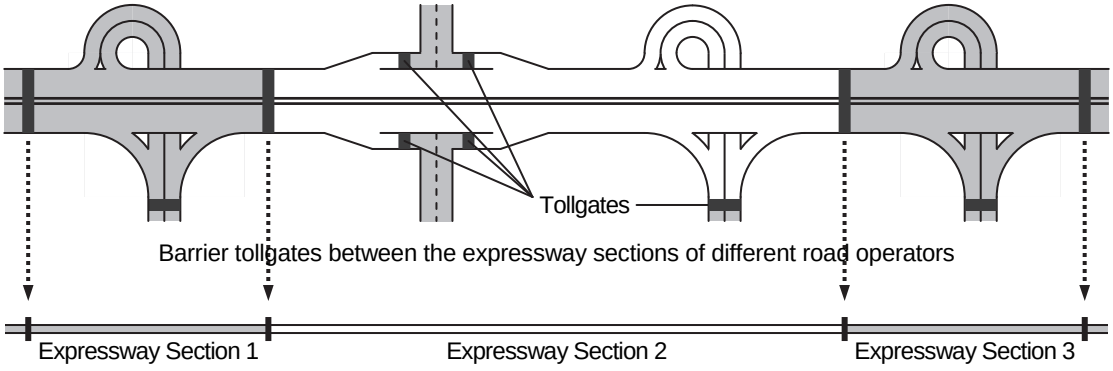
Distance proportional tariff, which provides road users with fairness for driving distance, is suitable for a wide inter-city expressway network. However, the inter-city expressway network is composed of many sections operated by different road operators in Vietnam. Such network has a difficulty in calculating toll amount to be paid by a road user who drives continuously through different expressway sections. Because a toll rate system is usually defined only for each road section and toll revenue cannot be shared clearly among relevant road operators.

There are the following two alternative methods to address this problem.

(1) Separation of Expressway Sections by Barrier Tollgates

In this method, the road sections operated by different road operators are to be separated by barrier tollgates in order to easily calculate toll amount to be paid by a road user who drives continuously through these sections and to share toll revenue clearly among the operators.

Figure 4.8 Separation of Expressway Sections by Barrier Tollgate



Source: ITS Integration Project (SAPI) Study Team

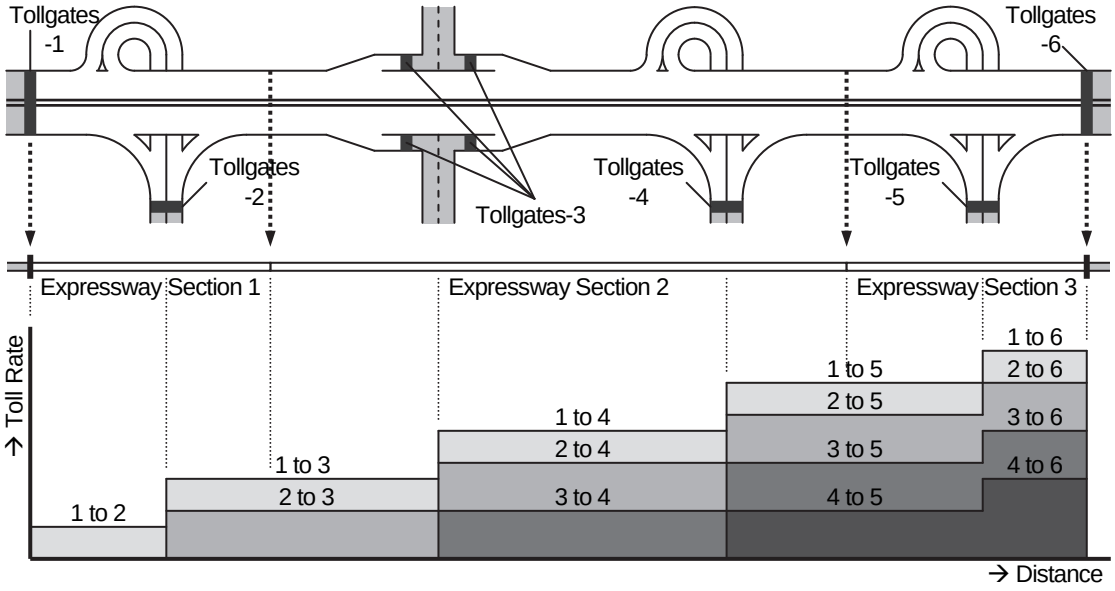
(2) Toll Rate Table for Whole Inter-city Expressway Network

A method using a toll rate table for the whole expressway network is recommended for inter-city expressway network as a premise for discussion in the Study.

In this method, a toll rate table, in which toll amounts are defined respectively for all pairs of tollgates on the whole expressway network, shall be prepared in advance. The table make it easy to calculate toll amount to be paid by a road user who drives through different sections continuously and make it clear to share toll revenue among the different road operators. And the cost for constructing barrier tollgate can be cut by use of the table.

For this method, the toll rate table shall be revised and maintained when a new expressway section comes into service. A specific organization is to be in charge of the revision and maintenance of the table. The figure below shows an example of this method applied to an expressway network consists of three adjacent sections.

Figure 4.9 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: ITS Integration Project (SAPI) Study Team

4) Toll Levels

Specific toll amount for the expressway network is to be defined considering the following factors:

- Costs of construction and operation/maintenance of each expressway section
- Benefits that road users can obtain by using each expressway section

- Harmonization with the tariff rates of the existing national highways and the existing inter-city buses/railways
- Financial independence/profitability of the road operator of each expressway section.

At the current stage in Vietnam, toll amount for ordinary vehicles is fixed for 10,000 VND as the flat tariff to be applied to a travel distance more than 70 km between two tollgates, which is defined by the Circular No.90/2004/TT-BTC of MOF. In addition, for the expressway network in the next stage, distance proportional tariff, which amount is around 1,000 VND/km, has been discussed among MOT, MOF and MPI.

5) Vehicle Classification

Vehicle Classification in VIETNAM

In Vietnam, vehicle classification for national highway is defined in the Circular No.90/2004/TT-BTC of MOF and vehicle classification and toll rate of epxressway is defined in the Circular No.14/2012/TT-BTC of MOF as shown below. The discussion in the Study is based on them.

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 can be enforced automatically by using license plate scanners based on license plate system.

Table 4.5 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
MOD Vehicle	6	Military vehicles in the missions	0
Police Vehicle	7	Public security vehicles in the missions	0

Note, MOD: Ministry of Defence

Source: ITS Standards & Operation Plan Study Team

Vehicle Classification in INDONESIA

In Indonesia, vehicle classification by the number of axles is adopted for the toll rate system focusing on the damage by the trucks to the road structure. This classification can be enforced with simple sensors.

Table 4.6 Vehicle Classification in INDONESIA

Vehicle Class	Definition
Class I	Sedan, Jeep, Pickup truck, Small truck and Bus
Class II	Truck with 2 axles
Class III	Truck with 3 axles
Class IV	Truck with 4 axles
Class V	Truck with 5 or more axles

Source: VITRANSS2 Study Team

Vehicle Classification in MALAYSIA

In Malaysia, vehicle classification by the number of axles is adopted for the toll rate system focusing on the damage by the vehicles to the road structure. In addition, lower toll rates are prepared for the highly public buses and the taxis. This classification can be enforced with simple sensors.

Table 4.7 Vehicle Classification in MALAYSIA

Vehicle Class	Definition
Class 0	Motorcycles, bicycles or vehicles with 2 or less wheels
Class 1	Vehicles with 2 axles and 3 or 4 wheels excluding taxis
Class 2	Vehicles with 2 axles and 5 or 6 wheels excluding buses
Class 3	Vehicles with 3 or more axles
Class 4	Taxis
Class 5	Buses

Source: VITRANSS2 Study Team

Vehicle Classification in JAPAN

In Japan, vehicle classification for the toll rate system is by the combination of the number of axles, the vehicle weight and the vehicle dimensions focusing on the damage by the vehicles to the road structure and on occupancy on the road. This classification can be enforced using many kinds of sensors including treadles and vehicle detectors, and by using a license plate scanner based on the license plate system.

Table 4.8 Vehicle Classification in JAPAN

Vehicle Class	Definition
Light Vehicle	Light vehicle /Motorcycle
Ordinary Vehicle	Small size vehicle (excluding light vehicle and motorcycle) /Sedan /Light tractor with trailer (which has an axle)
Medium Vehicle	Small bus with 11 to 29 seats and a weight less than 8 tons /Truck with a weight less than 8 ton and axles of 3 or less /Light tractor with trailer (which has 2 or more axles) /Tractor with trailer (which has an axle)
Large Vehicle	Bus with 30 or more seats or a weight more than 8 tons, and a length less than 9 m /Truck with a weight of 8 to 25 tons and axles of 3 or less /Tractor with trailer (which has 2 or more axles) /Large tractor with trailer (which has an axle)
Extra Large Vehicle	Bus with 30 or more seats, a weight more than 8 tons, and a length more than 9 m /Truck with axles of 4 or more /Large tractor with trailer (which has 2 or more axles) /Large construction vehicle

Source: VITRANSS2 Study Team

Vehicle Classification assumed for Study

For discussion in the Study, it is assumed that the vehicle classification is based on the Circular No.90/2004/TT-BTC of MOF.

However, it needs to be brought into view that new vehicle classification has been discussed among MOT, MOF and MPI for the expressway network in the next stage. The new vehicle classification is to be realized by using simple sensors, such as a license plate scanners and an axle load scale, for cutting costs. For example, the vehicle classification responding to the vehicle weight can be realized only by counting the number of axles without equipment for vehicle weight measurement.

4.5 Outline of Expressway Operation

1) Services of Road Operation/Maintenance

Based on the minimal service requirements, the operator is to provide the services shown in the table below. It is assumed as a premise for discussion in the Study that ITS is to be applied to a part of the road operation, which includes road structure/facility management, toll collection/management, traffic information/control and communication system management.

Table 4.9 Services of Road Operation/Maintenance

Operation	Maintenance
(a) Road Structure/Facility Management Cleaning-up, green space management, disaster recovery, energy and water supply and checkups of structure and facility in order to secure safety and comfort in road use.	Maintenance for restoring structure and facility to their original state of function and performance. - Pavement - Bridge - Tunnel - Semi-underground structure - Architectural structure - Mechanical equipment - Electrical equipment.
(b) Toll Collection/Management Toll collection from the road users and its management.	
(c) Traffic Information/Control (d) Heavy Truck Control Routine patrol, regulation against illegal vehicles and traffic control for safe/comfortable drive and smooth traffic flow.	
(e) Communication System Management Fiber optic cable network system operation and management	**Applicable Scope of ITS**

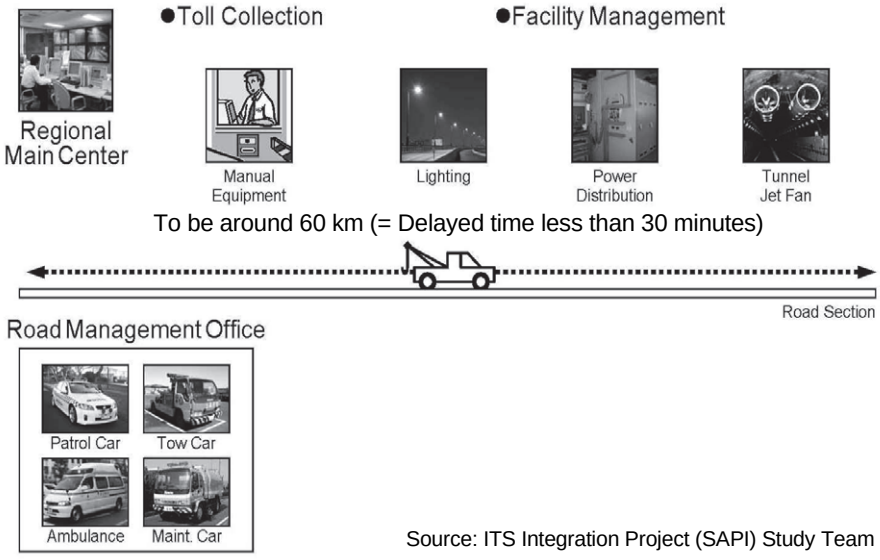
Source: ITS Integration Project (SAPI) Study Team

A single organization can be in charge both of construction and operation/maintenance of the road section; however, some parts of the work can be transferred to the other organization under contract.

2) Facilities and Offices for Road Operation

The services of road operation are actualized through many kinds of facilities and vehicles as shown below.

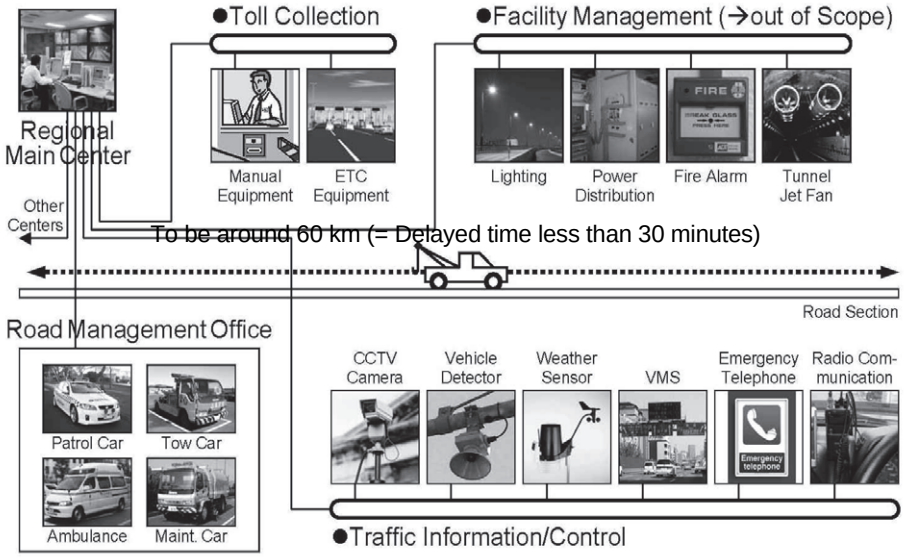
Figure 4.10 Illustration of Basic Road Operation



Source: ITS Integration Project (SAPI) Study Team

On the other hand, advanced method of road operation, which allows proper judgment and prompt action, is based on ITS and is supported by data exchange through a communication network.

Figure 4.11 Illustration of Advanced Road Operation Using ITS



Source: ITS Integration Project (SAPI) Study Team

A border of the road management office jurisdiction is to be located at a location of the interchanges arranged at 15 km intervals on the expressway network. And according to the minimal service requirements, the travel speed of a vehicle is more than 50 km/h and less than 120 km/h on the one-way lanes. And according to the Decree No. 32/2014/ND-CP, the operation vehicle needs to be dispatched and arrive at an incident site within less than 30 minutes from the reception of emergency call.

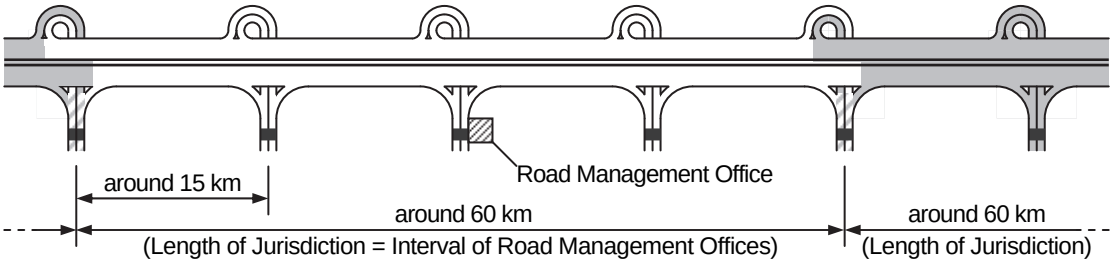
3) Location/Structure Outline of Offices

On the conditions above, it is required that the maximum interval of the road management offices on the expressway network is less than 85 km as calculated below.

Maximum interval of road management offices = 85 km = (120+50) / 2 x 0.5 x 2

In the Study, the interval of the road management offices is assumed as 60 km considering disproportionate location of the road management office within the length of its jurisdiction.

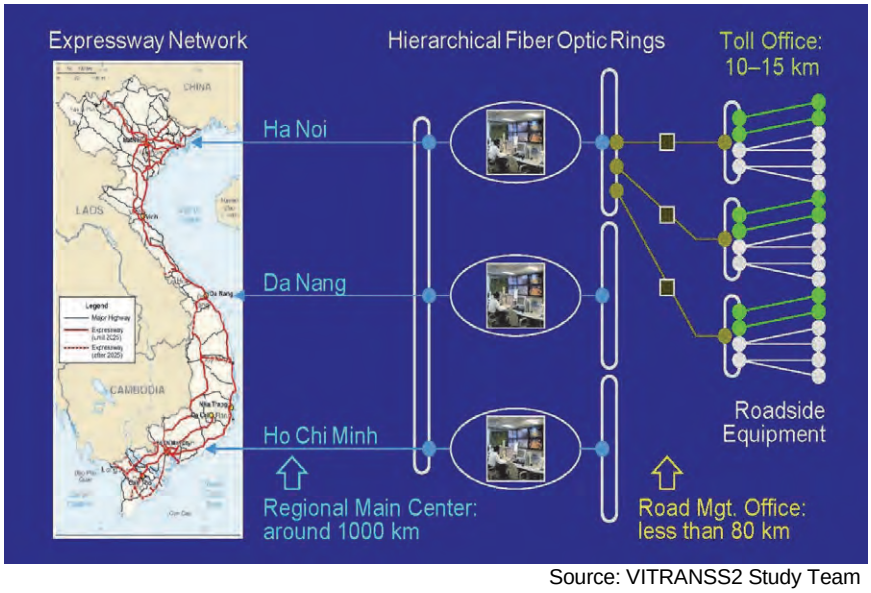
Figure 4.12 Maximum Interval of Road Management Offices



Source: The Study Team

The location/structure outline of the offices for expressway operation is illustrated in the ITS Master Plan as shown in the figure below. The regional main centers are to be located in Ha Noi, Da Nang and Ho Chi Minh.

Figure 4.13 Structure Outline of Offices for Expressway Operation



Source: VITRANSS2 Study Team

Table 4.10 Function/Location of Offices

Classification	Functions/Locations
Regional Main Center	This center is to perform the functions of integration of road management offices, traffic regulation, traffic control and traffic information and is to be located in the major cities such as Ha Noi, Da Nang and HCMC.
Road Management Office	This office is to perform the functions of patrol for surveying current road/traffic conditions and integration of communication nodes in a jurisdiction and is to be installed one or more in an expressway section.
Toll Office	This office is to be installed at the tollgate, which has two or more toll booths, and perform the function of toll collection. A communication node, which integrates pieces of roadside equipment for ITS, is to be installed usually in a toll office.

Source: ITS Integration Project (SAPI) Study Team

5. Framework of Expressway Operation using ITS

5.1 General

In this chapter, the following various frameworks needed for expressway operation are to be discussed and recommended one is to be itemized for each:

- Total Framework of Expressway Operation
- Framework for Service Level Control
- Framework for Traffic Information/Control
- Framework for 113 Call & Police Car Dispatch
- Framework for 115 Call & Ambulance Dispatch
- Framework for Incident Notification to Road Operator
- Framework for Traffic Restriction & Incident Clearance
- Framework for Road/Traffic Monitoring
- Framework for Traffic Event Data Management
- Framework for Traffic Information Dissemination
- Framework for Toll Collection/Management
- Framework for Toll Settlement
- Framework for IC-card Issuance/Operation
- Framework for OBU Registration/Management
- Framework for Toll Enforcement
- Framework for Overloading Regulation
- Framework for Integrated Data Management
- Framework for Communication Network Management
- Framework for Radio Frequency Allocation
- Framework for System Maintenance

The discussion is to be performed only on the frameworks closely related with ITS operation in order to clarify the preconditions necessary for the system analysis of ITS but not to define all frameworks of expressway operation.

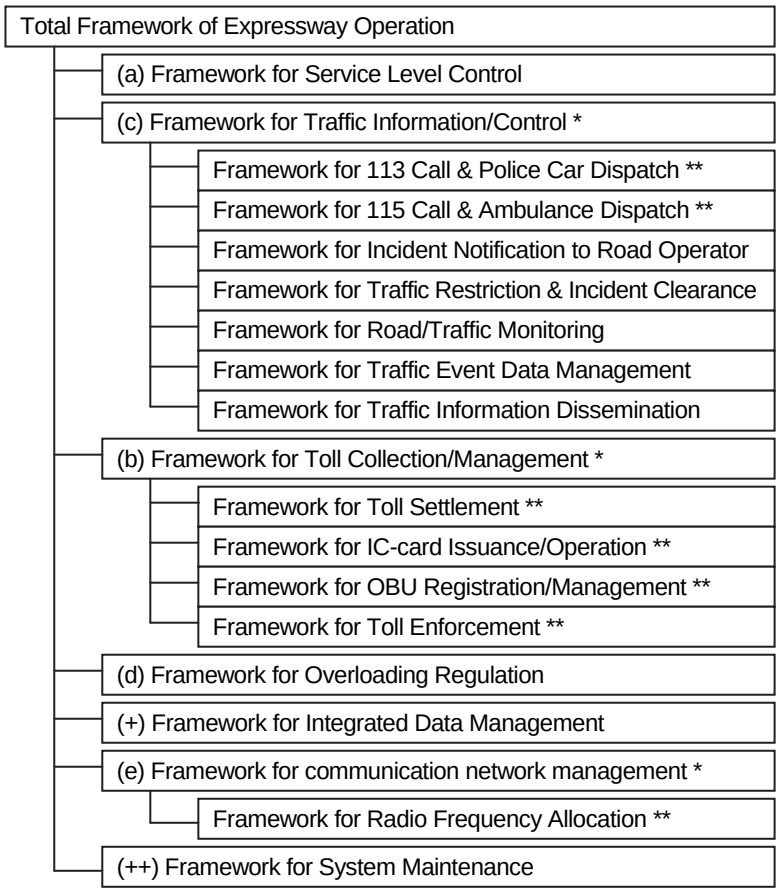
These frameworks totally cover the following five fields, which are the services of the road operation/maintenance aforementioned, and the services of (b), (c), (d) and (e) are to be supported by ITS:

(a) Road structure/facility management
(b) Toll collection/management
(c) Traffic information/control
(d) Heavy truck control
(e) Communication system management.

} To be supported by ITS

The relationship between these five fields and the frameworks listed first above is illustrated in the following figure. The “total framework of expressway operation” at the top of the figures is described in the following section to show the whole picture of expressway operation using ITS and the description includes other frameworks conceptually. The proposed frameworks of these five fileds are discussed in this chapter.

Figure 5.1 Composition of Frameworks



Note:
* : Key Framework
** : Framework included mainly in organization other than road operator
\+ : Integration of data for (b), (c) and (d)
++ : Maintenance covering (b), (c), (d) and (e)

Source: ITS Integration Project (SAPI) Study Team

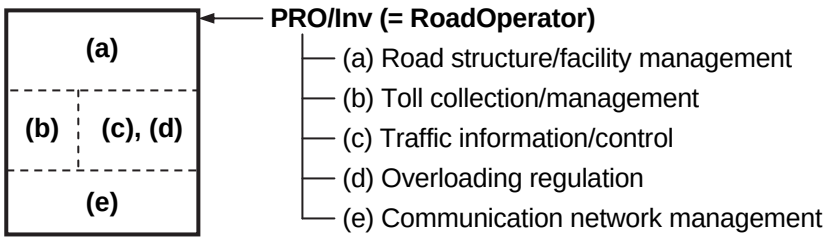
5.2 Total Framework of Expressway Operation

For clarifying appropriate division in the total framework of expressway operation as a major premise of discussion in the Study, a comparison among the types of total frameworks is made below. The Public Road Owner or Investor (PRO/Inv) in the following can be corresponded to the definition in the the Decree No.32/2014/ND-CP.

1) Type FW-1: Operations Performed by PRO/Inv (= Road Operator)

In this framework, the road owner/operator is required to perform many different parts of expressway operation by deploying skilled manpower. All parts of operation need to be financed solely by toll revenue.

Figure 5.2 Burden Sharing in Framework FW-1



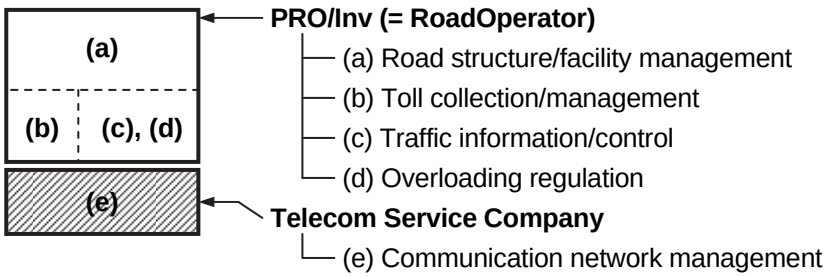
	Cost	Revenue
PRO/Inv (= RoadOperator)	- All implementation/O&M cost	- Toll revenue

Source: The Study Team

2) FW-2: Operations Shared by PRO/Inv (=Road Operator) and Telecom Service Company

In this framework, operation of communication network system is transferred to a telecom service company; however, the PRO/Inv is still required to perform many different parts of the expressway operation by deploying skilled manpower. Communication service revenue can be obtained in addition to toll revenue.

Figure 5.4 Burden Sharing in Framework FW-3



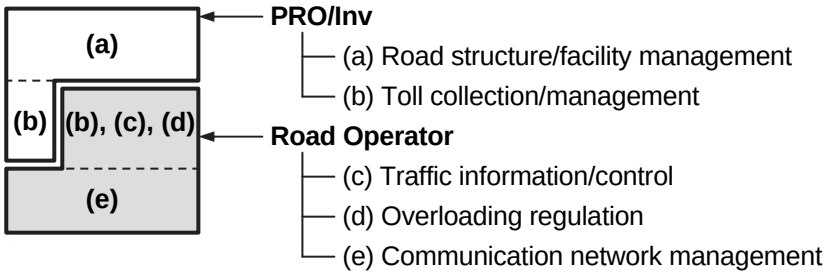
	Cost	Revenue
PRO/Inv (= RoadOperator)	- Implementation/O&M cost of (a), (b), (c), (d)	- Toll revenue - Payment by the telecom service company
Telecom Service Company	- Implementation/O&M cost of (e) - Payment to the road owner/operator	- Communication service revenue

Source: The Study Team

3) Type FW-3: Operations Shared by PRO/Inv and Road Operator

In this framework, the PRO/Inv can concentrate on managing toll revenue for paying implementation/maintenance cost of road structure and facilities, while the road operator can concentrate on proper expressway operation and communication network management. All parts of operation need to be financed solely by toll revenue.

Figure 5.5 Burden Sharing in Framework FW-4



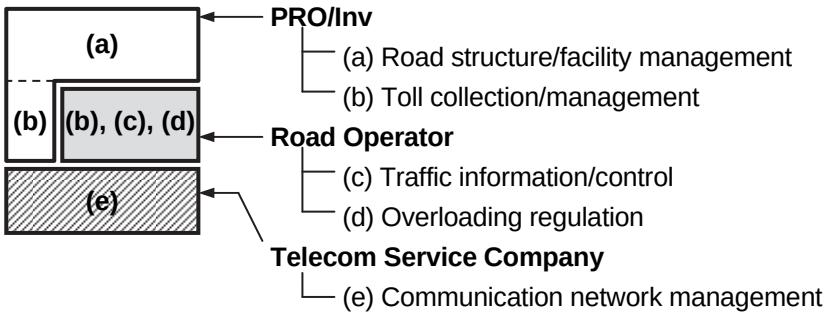
	Cost	Revenue
PRO/Inv	- Implementation/O&M cost of (a), (b) - Payment to the road operator	- Toll revenue
Road Operator	- Implementation/O&M cost of (b), (c), (d), (e)	- Payment by the road owner

Source: The Study Team

4) Type FW-4: Operations Shared by PRO/Inv, Road Operator and Telecom Service Company

In this framework, the PRO/Inv can concentrate on managing toll revenue for paying implementation/maintenance cost of road structure and facilities, while the road operator can focus only on proper expressway operation by transferring communication network management to a dedicated telecom service company. Communication service revenue can be obtained in addition to toll revenue.

Figure 5.6 Burden Sharing in Framework FW-5



	Cost	Revenue
PRO/Inv	- Implementation/O&M cost of (a), (b) - Payment to the road operator	- Toll revenue - Payment by the telecom service company
Road Operator	- Implementation/O&M cost of (b), (c), (d)	- Payment by the road owner
Telecom Service Company	- Implementation/O&M cost of (e) - Payment to the road owner	- Communication service revenue

Source: The Study Team

5) Selection of a Type of Expressway Operation Framework

Type FW-5 is selected as the recommended type and Type FW-4 is regarded as the reasonable type for the discussion on ITS operation in the Study based on the comparison of advantages and disadvantages of the types of framework aforementioned, which is shown in the table below.

Table 5.1 Advantage/Disadvantages on Types of Framework

Type	Advantage	Disadvantage	Grading
FW-1**	-	- Many different parts of expressway operation need to be done only by the PRO/Inv - All parts of operation need to be financed solely by the toll revenue.	Available for peculiar need
FW-2**	- Communication network management can be transferred to and integrated by a dedicated telecom service company - Communication service revenue can be obtained.	- Many different parts of expressway operation need to be done by the PRO/Inv. - Dedicated telecom service company (existing or newly-organized) needs to be prepared.	Available for peculiar need
FW-3**	- The road owner can concentrate on implementation/maintenance of road structure/facility in harmony with toll revenue - The road operator can concentrate on proper expressway operation and communication network management	- All parts of operation need to be financed solely by the toll revenue.	Available for peculiar need
FW-4**	- The road owner can concentrate on implementation/maintenance of road structure/facility in harmony with toll revenue - The road operator can focus only on proper expressway operation and the expertise and scale effects of covering many expressway sections can provide cost cutting - Communication network management can be transferred to and integrated by a dedicated telecom service company - Communication service revenue can be obtained.	- Dedicated telecom service company (existing or newly-organized) needs to be prepared.	Recommended

** : Subcontract can be brought into the framework Source: ITS Integration Project (SAPI) Study Team

However, it should be noted that communication service in the Types FW-3 and FW-5 requires introduction of a large-capacity transmission method capable of allocating a wide bandwidth for each basic service, such as DWDM, which is being adopted by a number of telecom service companies.

7) Recommended Total Framework for Expressway Operation

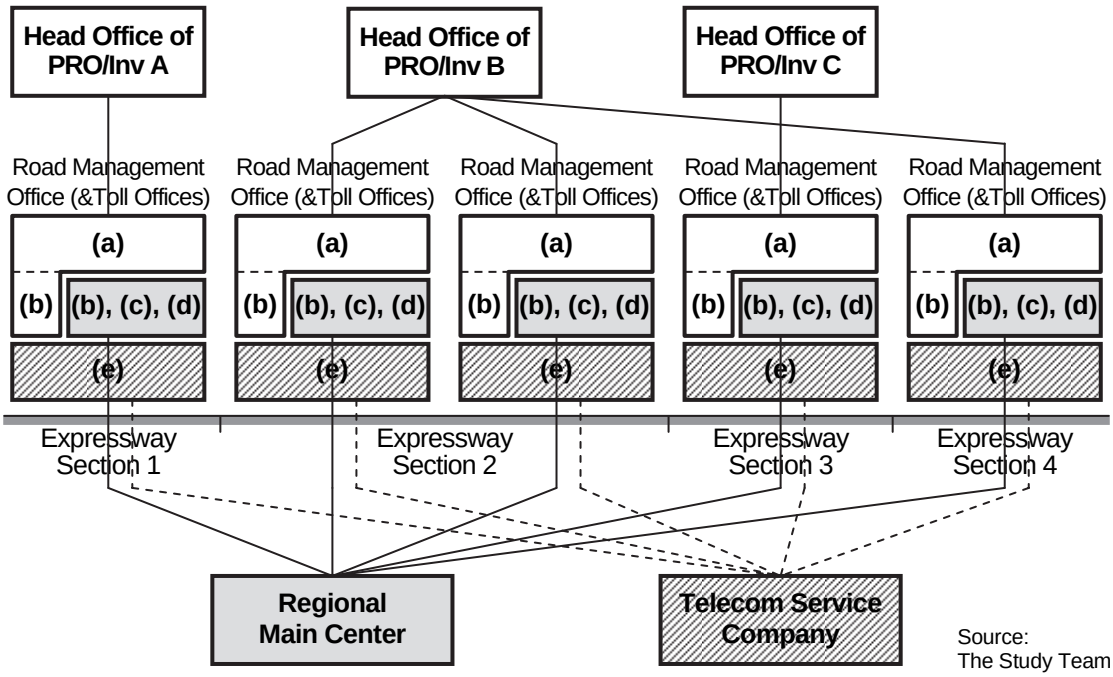
An expressway network will be constructed/operated by section; however, the operation needs to be integrated by field. Road structure/facility management and toll collection/management are to be integrated by the head offices of PRO/Invs. Proper expressway operation and communication network management are to be integrated by the Regional Main Center in the total framework Type FW-5 (or Type FW-4).

- Head office of road owner
  - (a) Road structure/facility management
  - (b) Toll collection/management
- Regional Main Center
  - (c) Traffic information/control
  - (d) Overloading regulation
- Regional Main Center
  - (e) Communication network management

Based on this condition, an example of the proposed total framework is shown in the figure below, where three PRO/Invs are involved:

- PRO/Inv A: has an expressway section
- PRO/Inv B: has many expressway sections
- PRO/Inv C: has an expressway section.

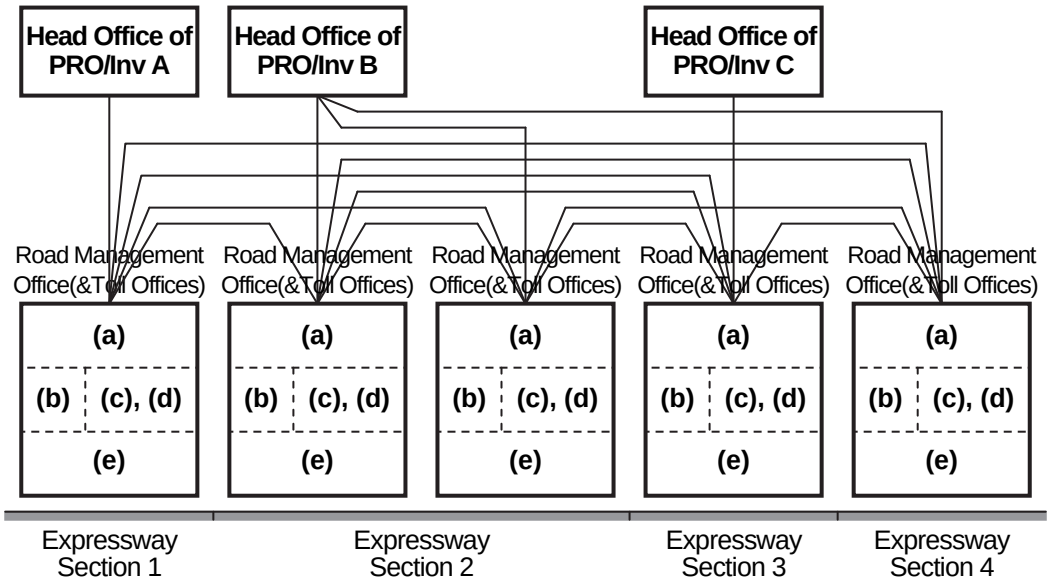
Figure 5.7 Total Framework based on Type FW-5 Integrated by Regional Main Center



In this framework, some roles of the road operator are to be consolidated to and conducted in the Regional Main Center as shown above. The system needs to be built up in considration of the cooperation among the centers/offices of different purposes and covering the required fields.

If the Regional Main Center is not established, such complicated framework without integrateion as shown in the figure below will be developed responding only to the road construction by section, which provides unclear sharing of responsibility on the data/information exchange.

Figure 5.8 Undesirable Complecated Framework without Integrateion

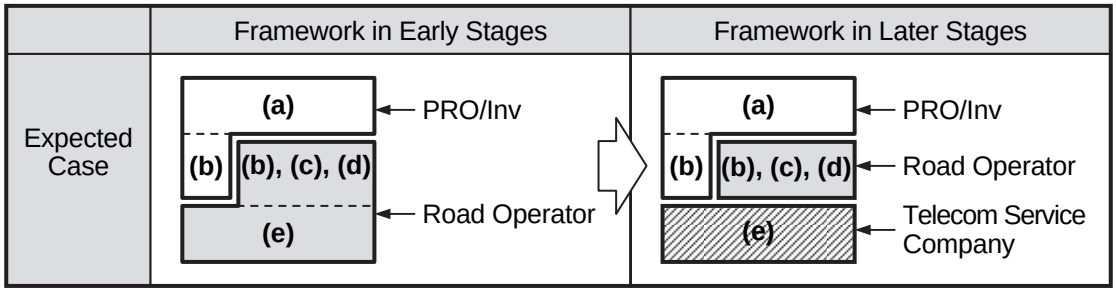


Source: The Study Team

8) Expected Shift on Total Framework

The role sharing among organizations cannot be minutely established in the early stage of ITS installation. However, in later stages, it will be broken down into some parts appropriately for covering extensive expressway network. Total frame work can shift accordingly as shown in the figure below.

Figure 5.9 Expected Shift on Total Framework



Source: The Study Team

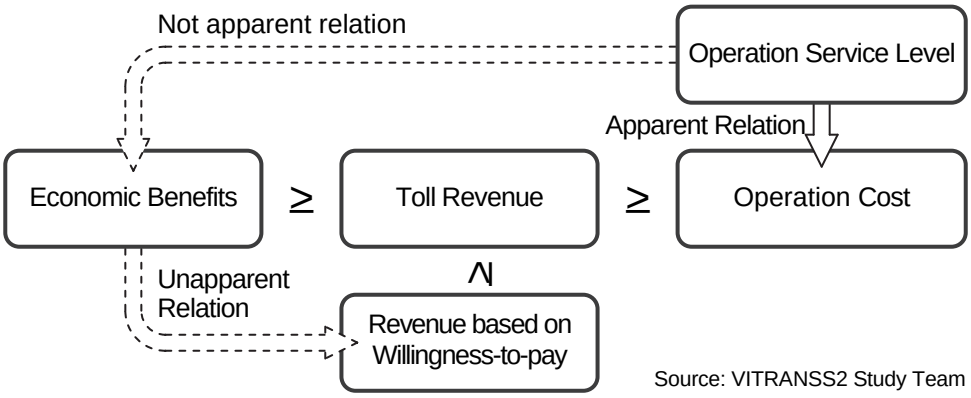
The concept described in this section conforms totally to the policy shown in the Decree No.32/2014/ND-CP. And additionally, it is proposed by Decision No.3569/VPCP-KTN that Vietnam Posts & Telecommunications (VNPT) is in the position of the telecom service company in the figure.

5.3 Framework for Service Level Control

1) Necessity of Service Level Control

Unfortunately, any improvement in expressway operation service causes an increase in costs and a decrease in profits apparently for a road operator. And in addition, it is not easy for the road operator to raise the toll rate. Because, the expressway users will not accept the raise, even if additional benefits are made available for them. That is to say the correlation between the increase in operation service level and the increasing amount of economic benefits or user's willingness to pay is not apparent. On this account, road operators tend to be reluctant to improve their operation services in many countries.

Figure 5.10 Relation between Operation Service Level and Toll Revenue



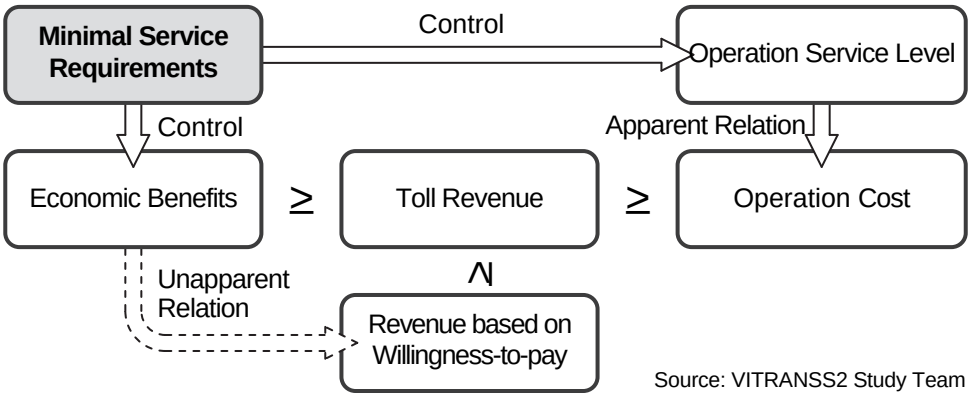
Source: VITRANSS2 Study Team

Accordingly, for the purpose of motivating the road operators, the minimal service levels required for the proper expressway operation shall be defined as a standard.

2) Recommended Framework for Service Level Control

The Minimal Service Requirements so defined will be useful to control the operation service levels provided by the road operators as shown in the figure below. A set of specific Minimal Service Requirements is shown in Chapter 4.

Figure 5.11 Minimal Service Requirements for Controlling Operation Service Level

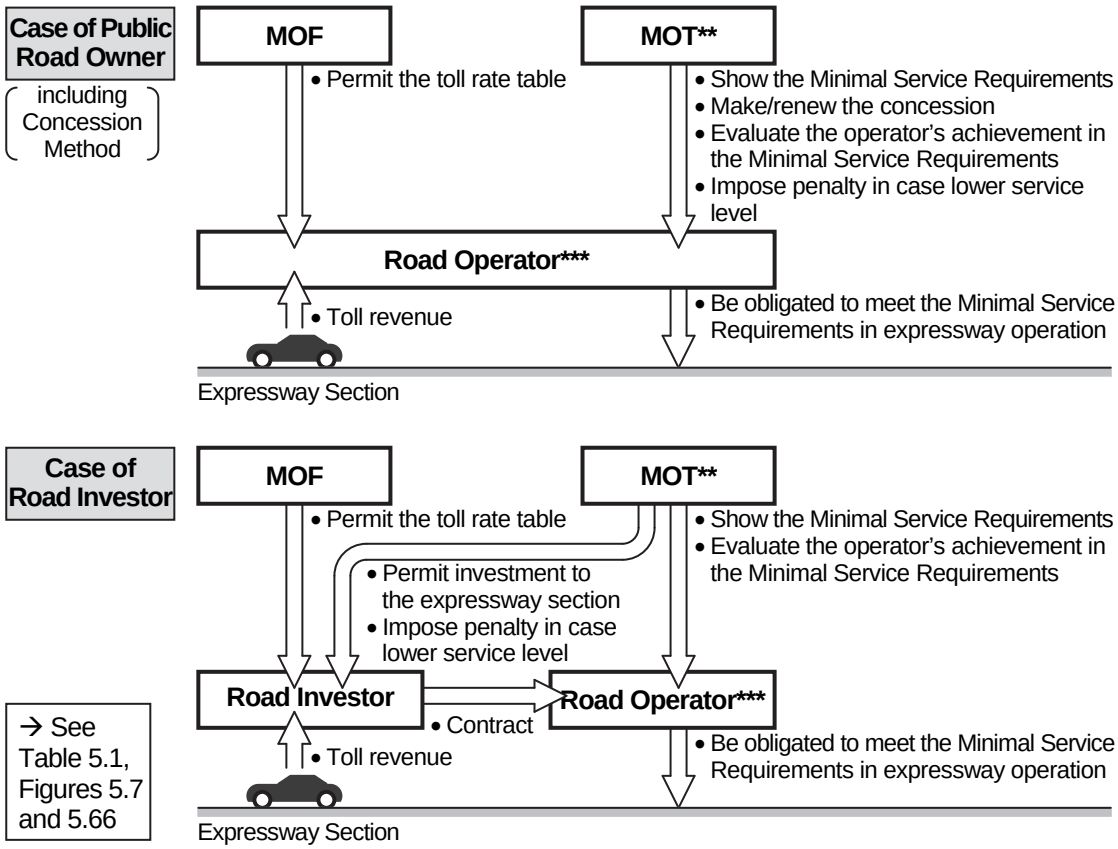


Source: VITRANSS2 Study Team

A framework shown in the following figure is proposed for proper control of the operation service levels of expressways. In the framework, a set of Minimal Service Requirements shall be

shown by MOT to the road owner (or the road investor) and the road operator in the process of making a concession of expressway operation. The road operator is to be obliged to meet the Minimal Service Requirements. And, on the occasion when the concession is renewed, specific amounts of the raises in the toll rate and in the operation fee to the road operator are to be permitted by MOF based on an evaluation by MOT of the degree of the road operator's achievement in reference to the preset requirements.

Figure 5.12 Recommended Framework for Service Level Control



Note, ** : Corresponding to the expressway management agency in the Decree No.32/2014/ND-CP, *** : Corresponding to the assigned unit for expressway O&M in the Decree No.32/2014/ND-CP.

Source: The Study Team

For example, VEC is one of the road owner and VEC Expressway O&M Company is one of the road operator.

In Vietnam, O&M concession is to be applied to the contract between MOT and the road operator for trial. This type of contract will achieve the following role sharing.

Roles of MOT (Public Organization):

- Ownership of road facilities
- Responsibility for establishing performance standard and monitoring.

Roles of the Road Operator (Private Organization):

- Responsibility for providing service including O&M and collecting toll based on the concession contract
- Responsibility for all capital investment as well as for working capital.

5.4 Framework for Traffic Information/Control

5.4.1 Key Framework

1) Required Actions for Traffic Control

The framework for traffic control needs to achieve the following actions on the expressway network:

- Police Car Dispatch
- Ambulance Dispatch
- Incident Notification to Road Operator
- Traffic Restriction
- Road/Traffic Monitoring
- Traffic Event Data Management
- Traffic Information Dissemination

As shown in the beginning of this chapter, detailed frameworks required respectively for the actions above will be specified in the following sections.

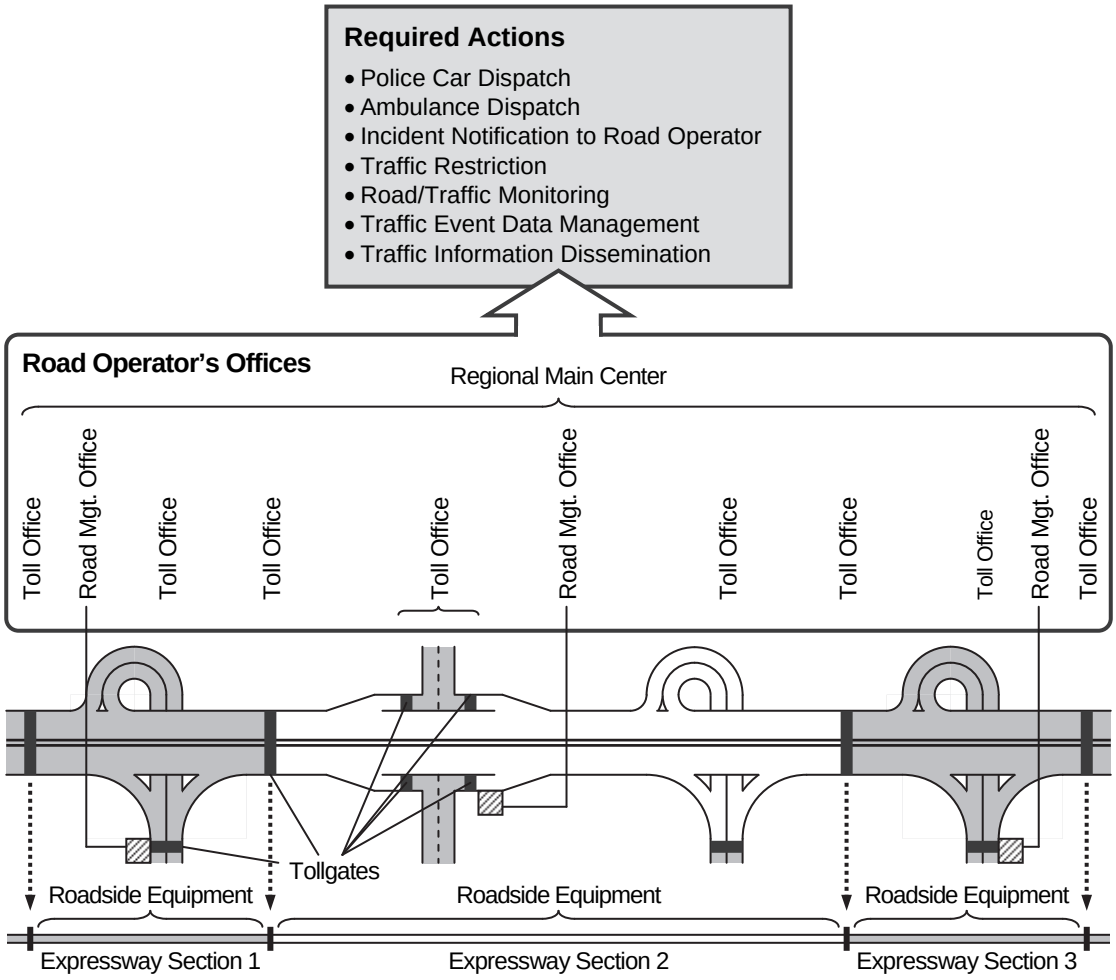
2) Road Operator's Offices Required for Expressway Operation

The framework for traffic control on the expressway network involves the following centers/ offices of the road operator:

- **Toll Office and Roadside Equipment:** The toll office is to be established near the tollgate which include two or more tollbooths, and functions as toll collection. In most of the cases, communication node which transmits data from roadside equipment components of ITS is installed in the toll office.
- **Road Management Office:** The road management office manages patrol needed to comprehend the latest road/traffic conditions and controls communication node of own management section, and at least one office will be established for each expressway section. This office is to be the base for dispatching a patrol team for surveying current traffic conditions on the expressway.
- **Regional Main Center:** The Regional Main Center controls road management offices, and functions for traffic monitoring, traffic control and provision of traffic information dissemination. The Centers are to be set up in principle city such as Ha Noi, Da Nang, and Ho Chi Minh for integrating the management offices.

Additionally, in Vietnam, the traffic control of the expressway network will be shared by many different road operators; however, the framework for traffic control needs to be integrated into a single hierarchical structure for the whole expressway network.

Figure 5.13 Required Actions and Road Operator's Offices for Traffic Control

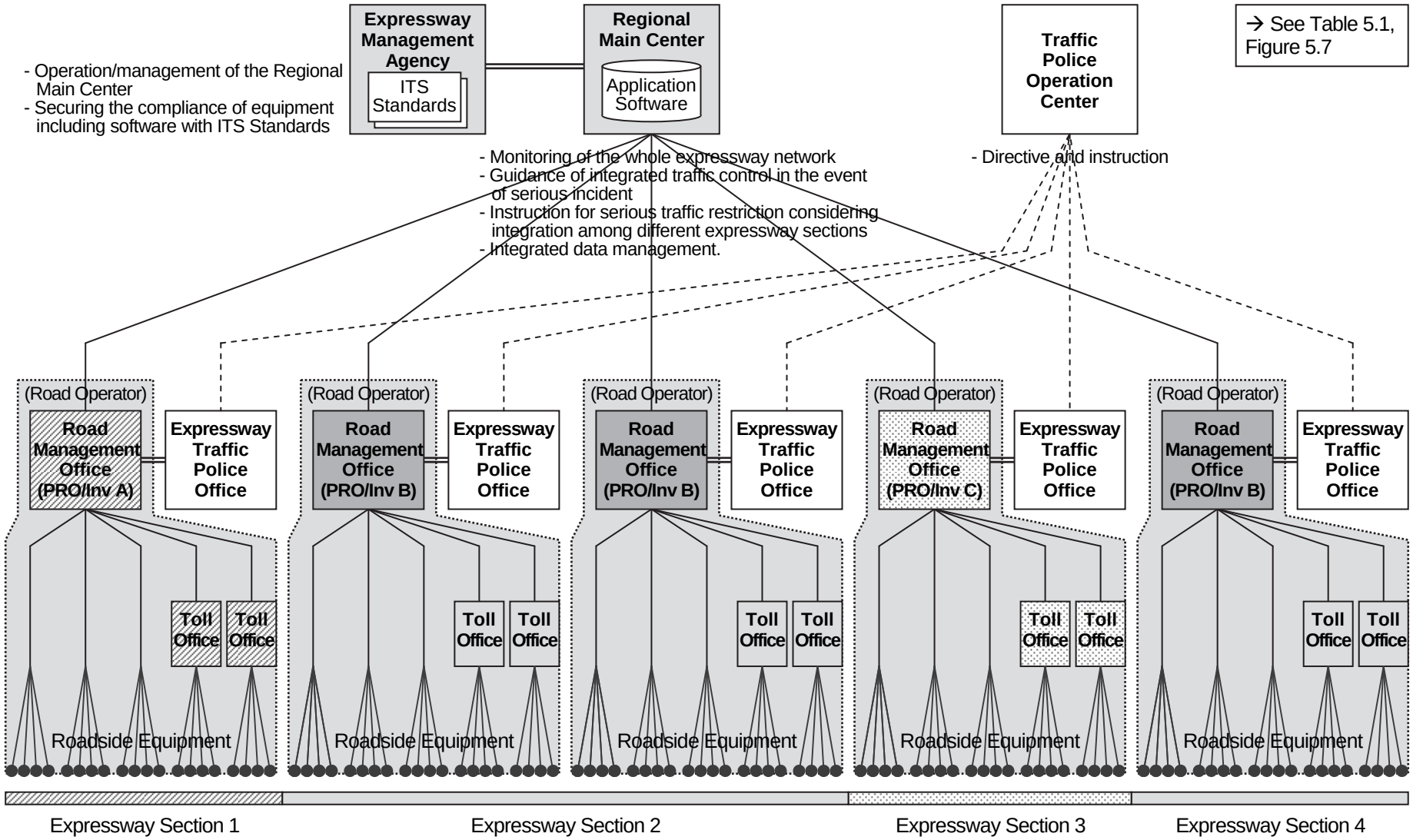


Source: ITS Integration Project (SAPI) Study Team

3) Recommended Framework for Traffic Control on Expressway Network

The framework for traffic control in the following figure is to be defined as a premise for discussion in the Study, which is based on the total framework of Type FW-5 mentioned in the previous section for the total framework for expressway operation. This framework shows that the expressway traffic police offices are to be organized corresponding to the expressway sections that are under the jurisdictions of the respective road management offices. The Standards on ITS is to be managed by the Expressway Management Agency in MOT and the application software in the Regional Main Center is to be for shared use by the road operators.

Figure 5.14 Recommended Framework for Traffic Control of Expressway Network



Source: The Study Team

5.4.2 Framework for 113 Call & Police Car Dispatch

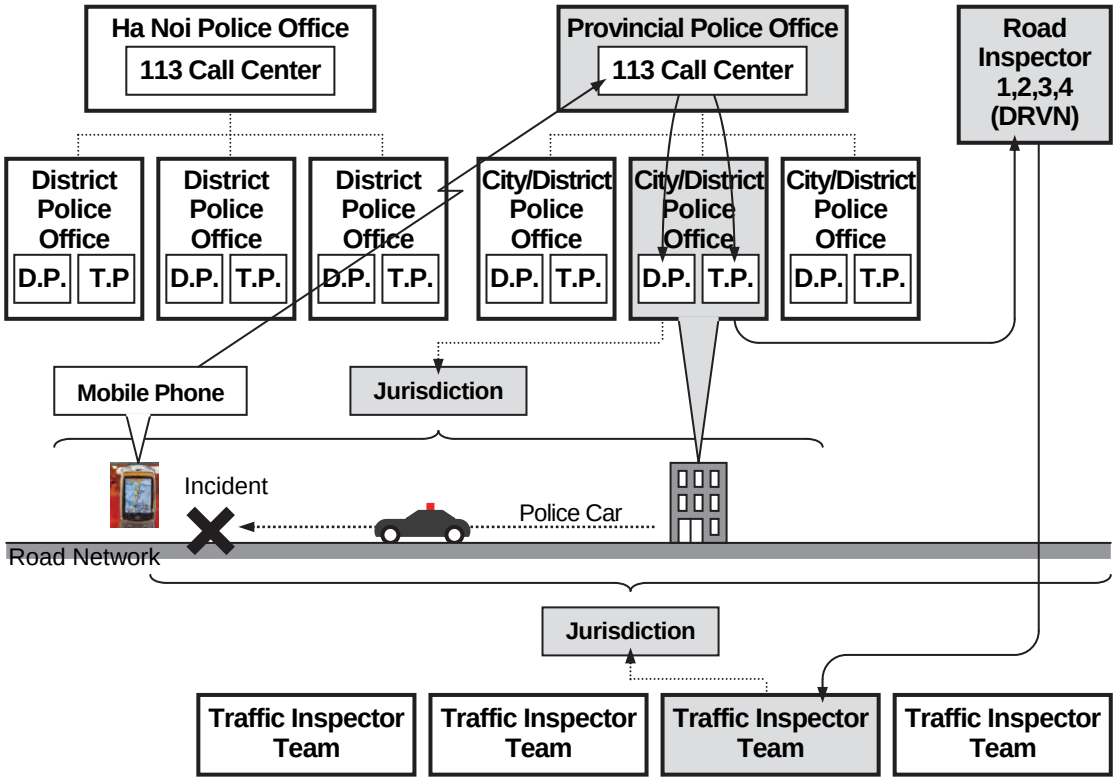
1) Existing Framework for Police Car Dispatch on National Highways

As for the regulations related to the Framework for Police Car Dispatch, the following regulations are to be applied;

- No. 23/2008/QH12: Law on Road Traffic
- MOPS Decision No. 18/2007/QĐ-BCA (C11): 113 Force and Traffic Police

When traffic incident occurs and someone calls 113, the calls are connected to the Urgent Reaction Center in the nearest police office of a Central Governed City or a Province. No area code is necessary for 113 call. When an operator in the center receives phone call, he/she analyses the information and contacts to the responsible parties. In the case of traffic accident without injured persons, the traffic police in a district or city police office is responsible, but in the case with injured persons, the detective police is to be included in the parties. The same framework is built up in each Central Governed City and Province. Additionally, in the case of traffic accident with infrastructure damages, the police office needs to contact to the traffic inspector under DRVN.

Figure 5.15 Existing Framework for Police Car Dispatch on National Highways



Note: Police office of centralized governed cities: Ha Noi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho
D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities
Traffic Inspector to be dispatched from their office in Ha Noi, Vinh, Da Nang or Ho Chi Minh under DRVN for traffic accidents with infrastructure damages.

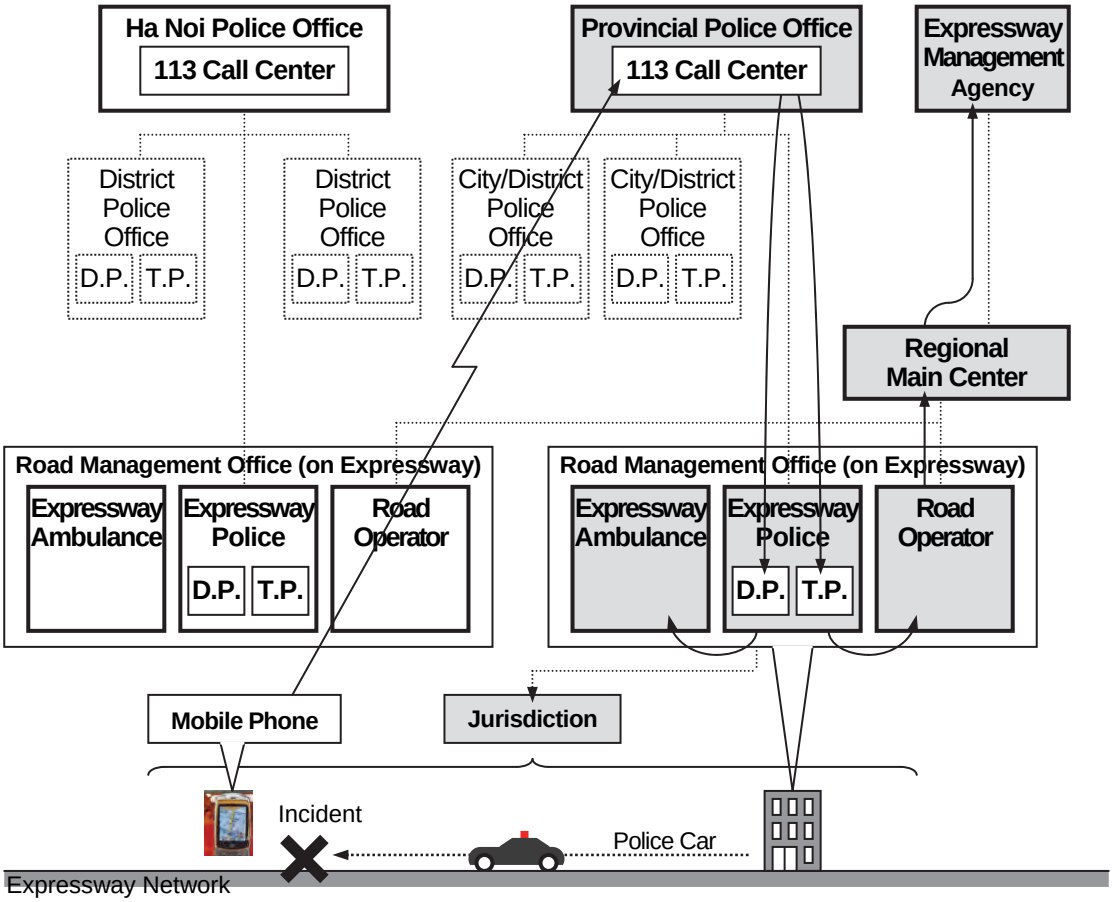
Source: ITS Integration Project (SAPI) Study Team

Currently, there are 2 expressways in Vietnam: the Lang – Hoa Lac Expressway, called Thang Long Avenue, and the Ho Chi Minh – Trung Luong Expressway. Both expressway section has its own managing unit related to the traffic police organization. The Ha Noi Traffic Police Office manages the Lang – Hoa Lac Expressway, which is located inside of Ha Noi City. On the other hand, the traffic police department under the Ministry of Public Security manages the Ho Chi Minh – Trung Luong Expressway, which passes throughh 3 provinces.

2) Recommended Framework for Police Car Dispatch on Expressway Network

A team of "Expressway Police" is proposed to be assigned to each road management office with teams of the road operator and the ambulance service with an identical jurisdiction. It is recommended as a premise for discussion in the Study that the three teams in the framework are to cooperate with each other in responding to 113 calls in case of traffic accidents.

Figure 5.16 Recommended Framework for Police Car Dispatch on Expressway Network



Note: Police office of centralized governed cities: Ha Noi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho
D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities
Crew of road operator under the Expressway Management Office is to be dispatched for traffic accidents with infrastructure damages.

Source: The Study Team

5.4.3 Framework for 115 Call & Ambulance Dispatch

1) Existing Framework for Ambulance Dispatch

Ambulance services (first aid) belong to Ministry of Health. According to the Decision No. 01/2008/QD-BYT dated January 21, 2008, which stipulates the regulation of first aid, active recuperation and detoxification, the provinces and cities under central management must have their ambulance service centers. The provinces, where such center is out of reach for certain reasons, must have ambulance team belonging to provincial general hospital. Districts and townships must have first aid teams outside the hospitals.

The people can call the emergency number 115 to ask for the fist aid service which will be provided at a very small fee. After receiving a call for first aid service, the permanent staff will verify the accuracy of information, locate the address and dispatch an ambulance car, which is deployed nearest to the incident site. An ambulance crews consist of a doctor, a nurse and a driver. The ambulance crews provide the first aid treatment for injured people and bring them to the nearest hospital. The ambulance dispatch decision is made by the 115 call receiver. The ambulance driver decides the route to reach the incident site based on his own experience. The service is available 24 hours a day, everyday.

The 115 calls are routed through the telecommunication operator's network to the nearest ambulance station. No area code is required. If the caller needs to call ambulance from the specific province, the area code must be added before 115.

For example, Ha Noi City has a 115 center and there are 4 ambulance stations with several ambulances in each. The photographs below show the ambulance service center in Ha Noi for receiving of 115 calls and dispatching ambulance team. There are 4 telephone lines and two operators in this center. The operators are permanent staffs who are responsible to receive information and dispatche an ambulance.

Figure 5.17 Center for Receiving of 115 Calls and Ambulance Dispatch

Source: VITRANSS 2 Study Team

According to the interview survey at the 115 center of Ha Noi City, the average time from receiving the call to dispatch ambulance is about 2 minutes in daytime and about 3 minutes in night time; however, it should depend on the availability of ambulances and traffic. Normally, the average time for an ambulance to reach the incident site is about 10 to 15 minutes after receiving the call. It is also mentioned in the decision above that the 115 center shall be indicated on the area administrative/transport maps and GPS if practicable.

The ambulance service is available not only in Ha Noi but also in Hai Phong, Da Nang, Hue

and HCMC. However, the ambulance system is started under a new decision, accordingly this service is not available in certain cities and provinces. Because the number of the first aid facilities including the ambulance cars is limited, it is reported that the service met only 10% of demand even in Ha Noi and HCMC at its outset. In future, when the provincial 115 center will be organized, all calls for the first aid can be connected to the provincial 115 center, and the center will assign a district first aid team to provide the service.

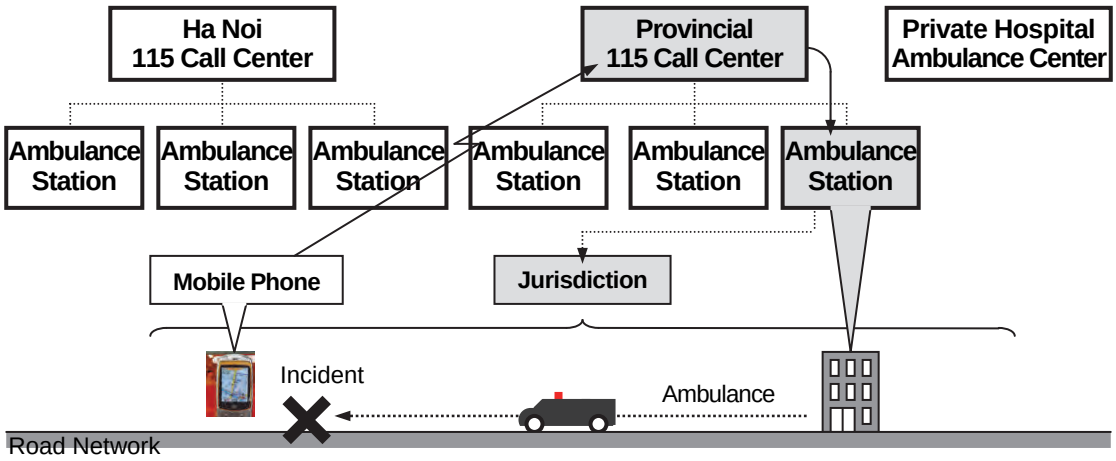
In rural areas, this emergency service is supported by the provincial and district hospital. The current situation of hospitals in Vietnam is as described below.

- A large number of public and private hospitals are in Ha Noi and HCMC; however only public hospitals are in rural area
- Even the provincial hospitals do not have medical equipment supported by advanced technologies such as CT scan and MRI
- Users of the ambulance service, except the resident appointed to the hospital, need to pay fees responding to the travel distance.
- Some hospitals provide their services by their own ambulance cars.

As for the expressway section between Cau Gie and Ninh Binh, VEC made an agreement with the local government about ambulance operation. In this section, two ambulances will be stationed at the related road management office.

When the 115 call center in a Centralized Governed City or a Province receives a call, an ambulance is to be dispatched to the incident site to bring injured persons. Some of private hospitals have their own ambulance centers and can dispatch ambulances as well. However, in both case, little information is exchanged between the ambulance team and the road operator.

Figure 5.18 Existing Framework for Ambulance Dispatch



Note: Ambulance center of centralized governed cities: Ha Noi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho

Source: ITS Integration Project (SAPI) Study Team

2) Recommended Framework for Ambulance Dispatch on Expressway Network

The information on ambulance dispatch to an incident site needs to be shared among the ambulance stations and the related road management offices and toll offices for the mutual

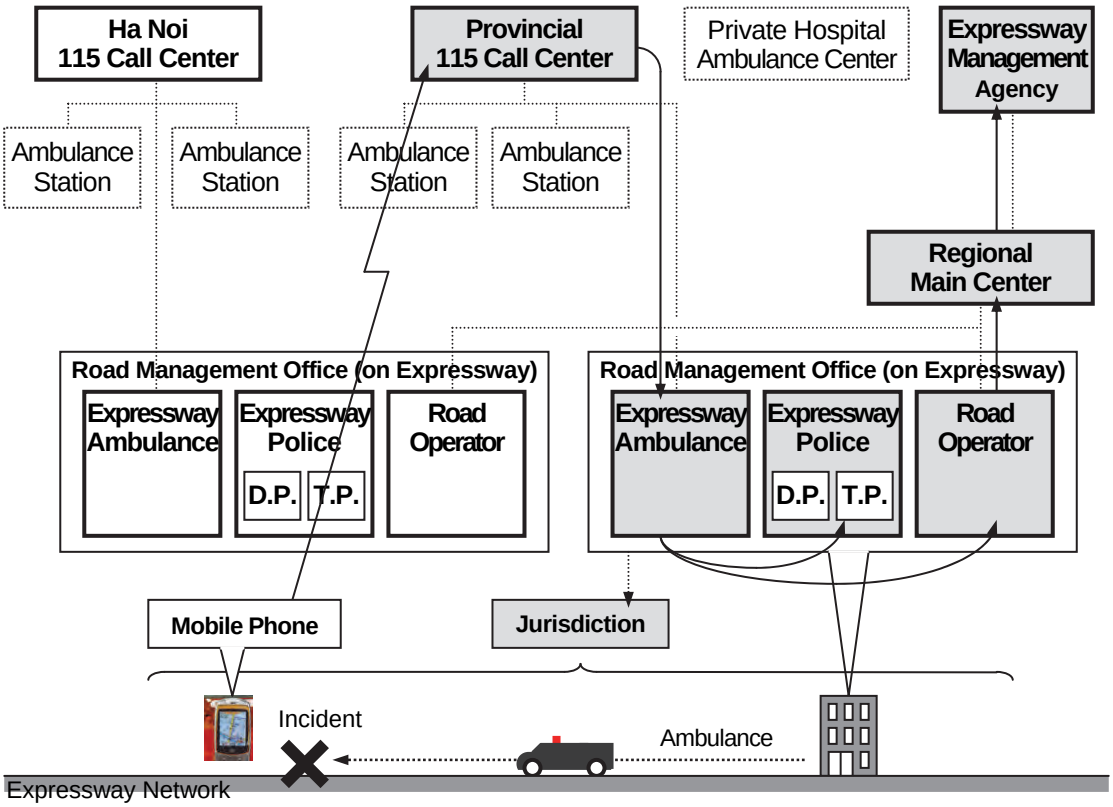
cooperation. The following data are to be shared among them for making necessary decision:

- List of contact telephone numbers of ambulance stations
- List of contact telephone numbers of road management offices
- Map of expressway network including locations of entrances and exits.

The data is to be updated when a new ambulance station, a new road management office or a new expressway section is installed.

A team of "Expressway Ambulance" is proposed to be assigned to each road management office with teams of the road operator and the police with an identical jurisdiction. It is recommended as a premise for discussion in the Study that the three teams in the framework are to cooperate with each other in responding to 115 calls in case of traffic accidents.

Figure 5.19 Recommended Framework for Ambulance Dispatch on Expressway Network

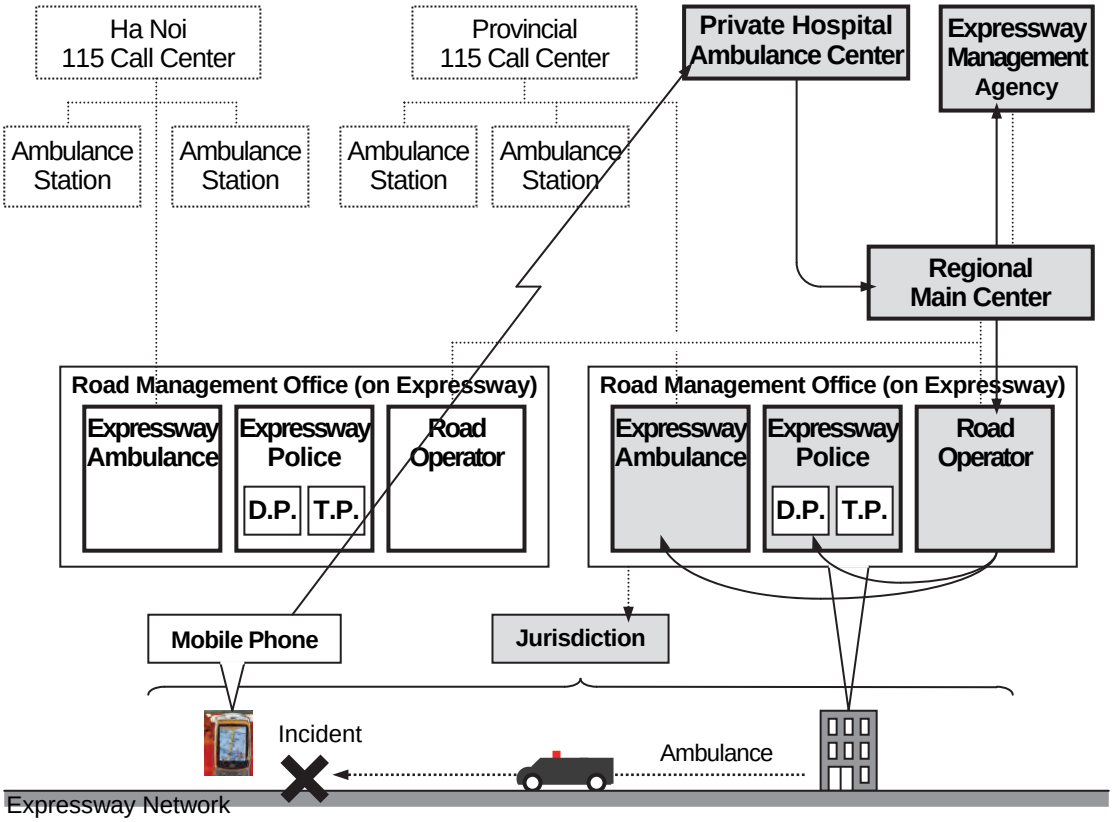


Note: Ambulance center of centralized governed cities: Ha Noi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho
D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities
Crew of road operator under the Expressway Management Office is to be dispatched for traffic accidents with infrastructure damages.

Source: The Study Team

Even when an ambulance request comes to some specific private hospital, response to the request needs to be performed rapidly in the relationship with the road operator and the police. It is recommended to establish a framework that the hospital can provide necessary information to the road operator through the Regional Main Center as shown in the following figure.

Figure 5.20 Additional Framework for Ambulance Dispatch on Expressway Network



Note: D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities
Crew of road operator under the Road Management Office is to be dispatched for traffic accidents with infrastructure damages.

Source: The Study Team

5.4.4 Framework for Incident Notification to Road Operator

1) Conditions of Incident Notification on Existing Roads

As for the regulations related to the Framework for Incident Notification, the followings are to be applied:

- No. 23/2008/QH12: Law on Road Traffic
- MOPS Decision No. 1922/2006/QĐ-BCA (C11): Duties, Powers and Operation of Road Traffic Police's Inspection and Control
- MOT Draft Circular No. /2010/TT – BGTVT: Functions, duties, powers and organization of Directorate of Road for Vietnam's Inspector

As for the incident notification, there seems to be no clear framework for notification to the road operator for the present. The relationship between the informantion sender, which includes the witnesses and the source of incident, and the information addressee is shown in the table below.

Table 5.2 Relationship between Witness and Addressee on Incident Notification

Information Sender	Relationship	Information Addressee
Traffic Police Ward Police		113: Urgent Reaction Center
		District Police Office
		Procuracy, Inspection Police, Forensic Doctor
Ambulance related staff		115: Ambulance Station
Traffic Inspector		Road Operator (including Traffic Inspector)
Collaborator on Traffic Information Collection (VOV)		VOV Broadcasting Center
CCTV Camera (VOV)		
Witness of Incident except for the above		

Note: The arrow line means possible addressees and not conclusive ones.

Source: ITS Integration Project (SAPI) Study Team

In general, if a traffic accident happens and any witness information comes into the police-related organization, the organization should analyze the information and remain responsible for accessing, protecting and examining the accident site conditions and for controlling traffic to avoid congestion. In case of a serious accident with fatalities, a procurator, an inspection police and a forensic doctor should be involved.

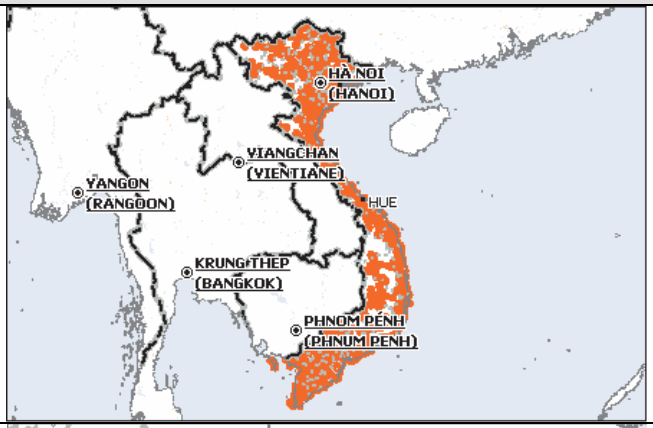
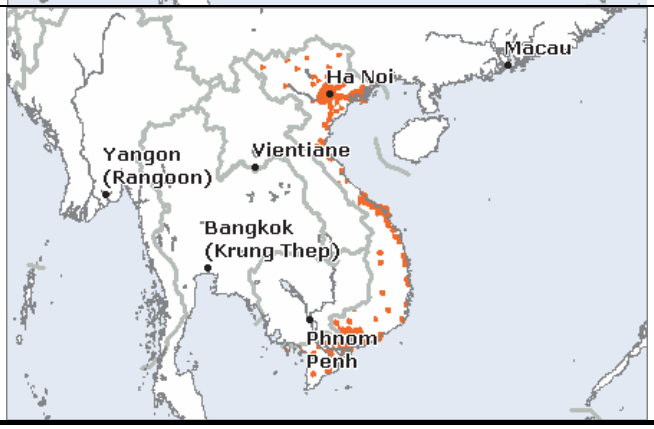
As for the relation between 115 and 113, there is almost no mechanism for sharing the incident information each other. If a 115 center is the first organization to receive a call from someone about a traffic accident, an ambulance will be dispatched to the accident site and carry the injuries to the hospital without notifying any 113 centers. If a 113 center is the first organization to receive the call about an accident, the center dispatches its own first aid team to the accident site for rescuing the victims, blocking the traffic and protecting the accident site. If the traffic police is unable to come to the accident site immediately, the district police has the right to protect the accident site and settle the case.

If a traffic inspector finds a traffic accident, he notifies it to the traffic police first for the on-site investigation and then informs it to the related road operator for clearing the road.

2) Existing Conditions of Coverage/Diffusion of Mobile Phones

For consideration of the availability of mobile phones for the use on expressways, the Study Team collected data on the coverage of mobile phone of GSM system. The table below shows the coverage and the market shre of mobile phones of of the respective telecom companies.

Table 5.3 Coverage & Market Share of Mobile Phones

	Coverage in Vietnam	Share %
Viettel GSM900		34%
Mobifone GSM900		41%
VINAPHONE GSM900		20%

Legend: High, Variable Source: GSM Coverage Website

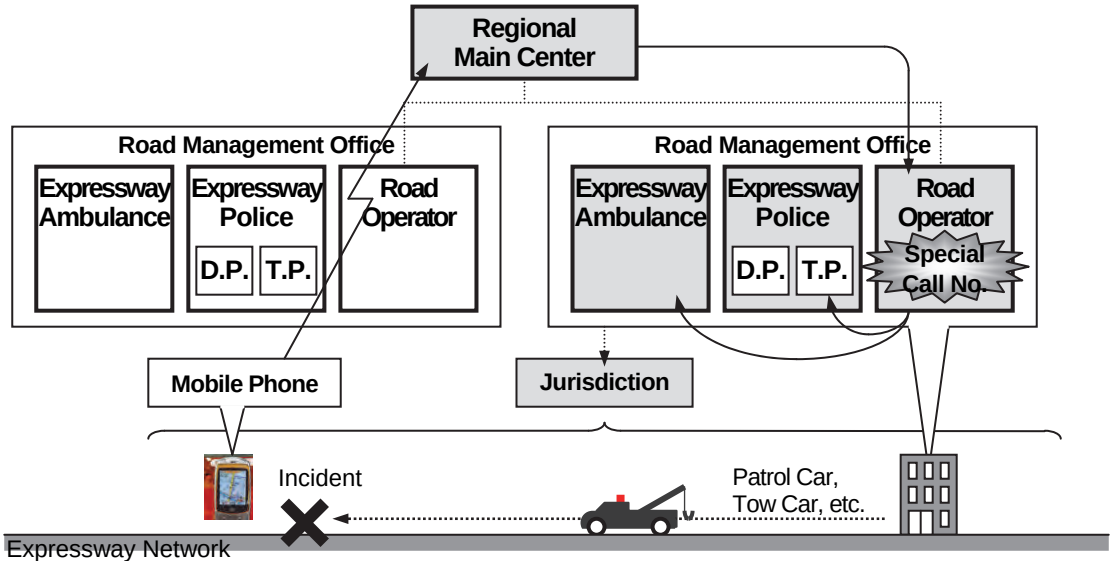
3) Expected Procedures of Incident Notification on Expressway Network

Two types of telephone systems can be used for emergency call to the road operator at an incident occurrence, which outlines, advantages and issues are shown in the following. As a conclusion, mobile phones are recommended in the Study as a primary tool for emergency call.

(1) Case-1: Emergency Call using Mobile Phone

Advantages: - Lower implementation cost for the road operator
Issues: - Necessity to imrove the service coverage over the expressway network
- Necessity to set up a special telephone number to call the Regional Main Center
- Difficulty to precisely identify the location of incident site.

Figure 5.21 Incident Notification by Mobile Phones

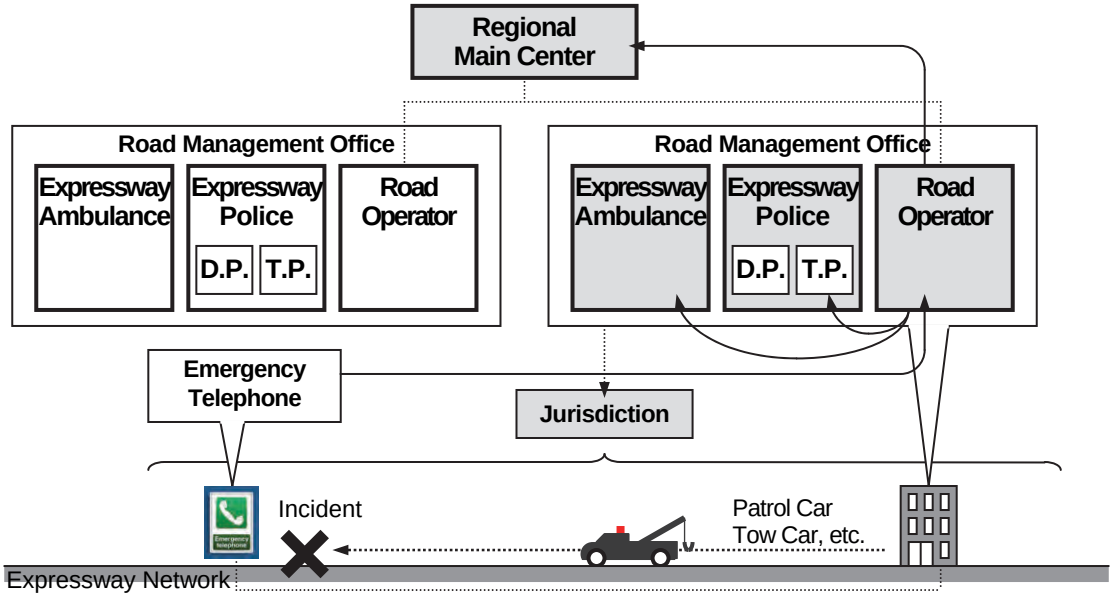


Source: The Study Team

(2) Case-2: Emergency Call using Roadside Telephone (Complementary Use)

Advantages: - Suitability for complementary use in areas outside of the coverage of mobile phone service such as mountainous area or a tunnel section
- Accompanied function of identifying the location of incident site
Issues: - Higher implementation cost for the road operator.

Figure 5.22 Incident Notification by Emergency Telephone



Source: ITS Integration Project (SAPI) Study Team

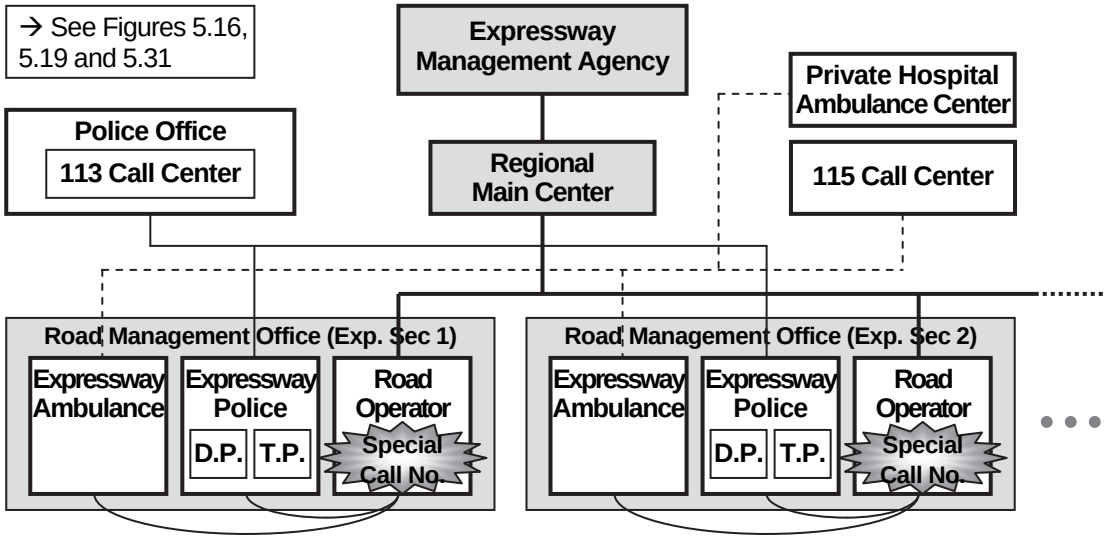
4) Recommended Framework for Incident Notification on Expressway Network

In case of the incident on the expressway, primary information from the incident site is usually provided by the witness or injured person himself through 113 or 115 call. The incident information should be transferred thereafter to the related road operator immediately and precisely so as to settle the matter with related organizations: the Expressway Police the Traffic Inspector and the Expressway Ambulance. Even though the incident information is incoming directly to the Road Management Office, the information is to be reported to the Regional Main Center is required so as to transfer it to the other related Road Management Offices. Therefore the following Framework for Incident Notification is recommended based on the discussions above.

The framework below is to be prepared for the road operator to receive the notification at the occurrence of incident on the expressway network:

- Main part is to be formed by the Expressway Management Agency in MOT, the Regional Main Center and the road management offices
- A special call number is to be prepared for each expressway section to receive incident notification in accordance with the Decree No.32/2014/ND-CP
- The road management offices are to cooperate with the Police offices including 113 Call Center
- The road management offices are to cooperate with the Ambulance Centers
- A team consists of the expressway police, the expressway ambulance and the road operator is to be assigned to each road management office.

Figure 5.23 Recommended Framework for Incident Notification on Expressway Network



Note: D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities

Source: The Study Team

5.4.5 Framework for Traffic Restriction & Incident Clearance

1) Existing Framework for Traffic Restriction

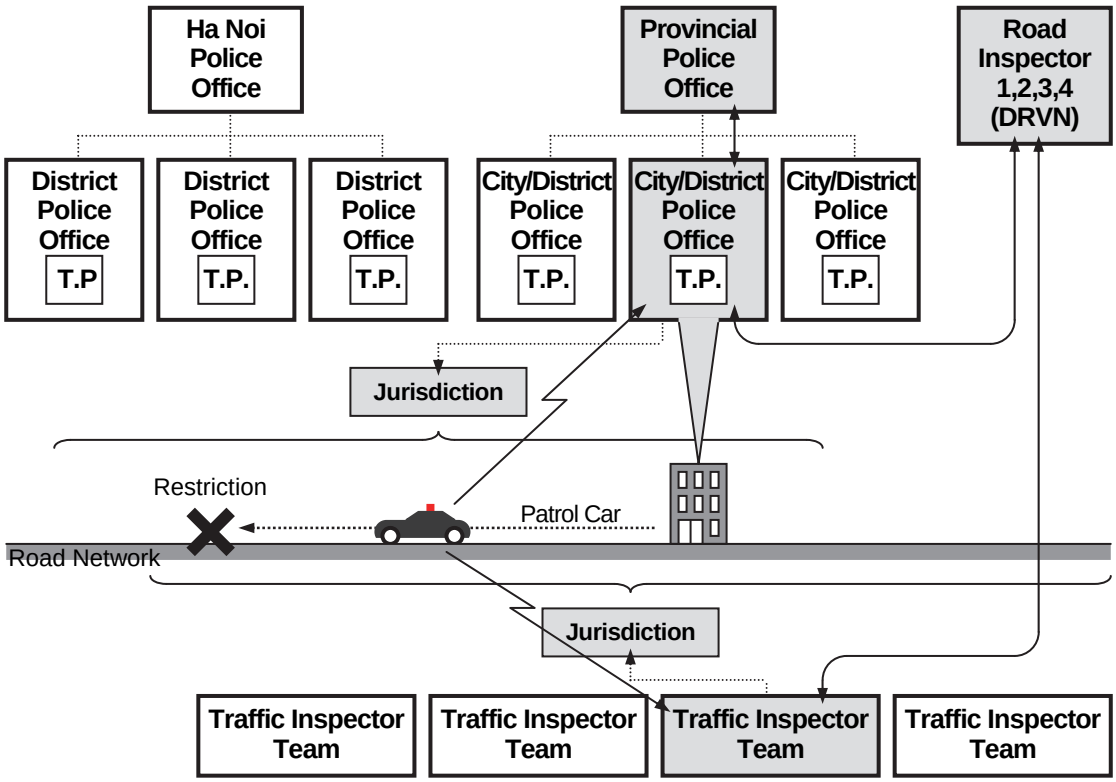
The following regulations are to be applied to the Framework for Traffic Restriction:

- No. 23/2008/QH12: Law on Road Traffic
- MOPS Decision No. 18/2007/QĐ-BCA (C11): 113 Force and Traffic Police

These regulations include the clauses describing the traffic restrictions to be imposed at the occurrence of traffic accident. The accident site needs to be protected in order to rescue the injuries quickly, to bring them to the hospital and to preserve their belongings and goods of the vehicles involved in the accident. The police who receive the accident notification have a responsibility to manage the traffic in a proper manner.

In case of bad weather, such as heavy rain or dense fog, an appropriate restriction need to be applied to the traffic on the relevant road sections. However, there exists no specific regulation on the procedure to enforce traffic restrictions for bad weather. Only in case a typhoon is forecast to approach to Vietnam, measures such as a road closure can be enforced by the General Committee of Storm and Flood Defend based on relevant information from the National Center for Hydro-meteorological Forecasting.

Figure 5.24 Existing Framework for Traffic Restriction



Note: Police office of centralized governed cities: Ha Noi, Ho Chi Minh City, Hai Phong, Da Nang, Can Tho
D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities
Traffic Inspector under DRVN to be dispatched for traffic accidents with infrastructure damages.

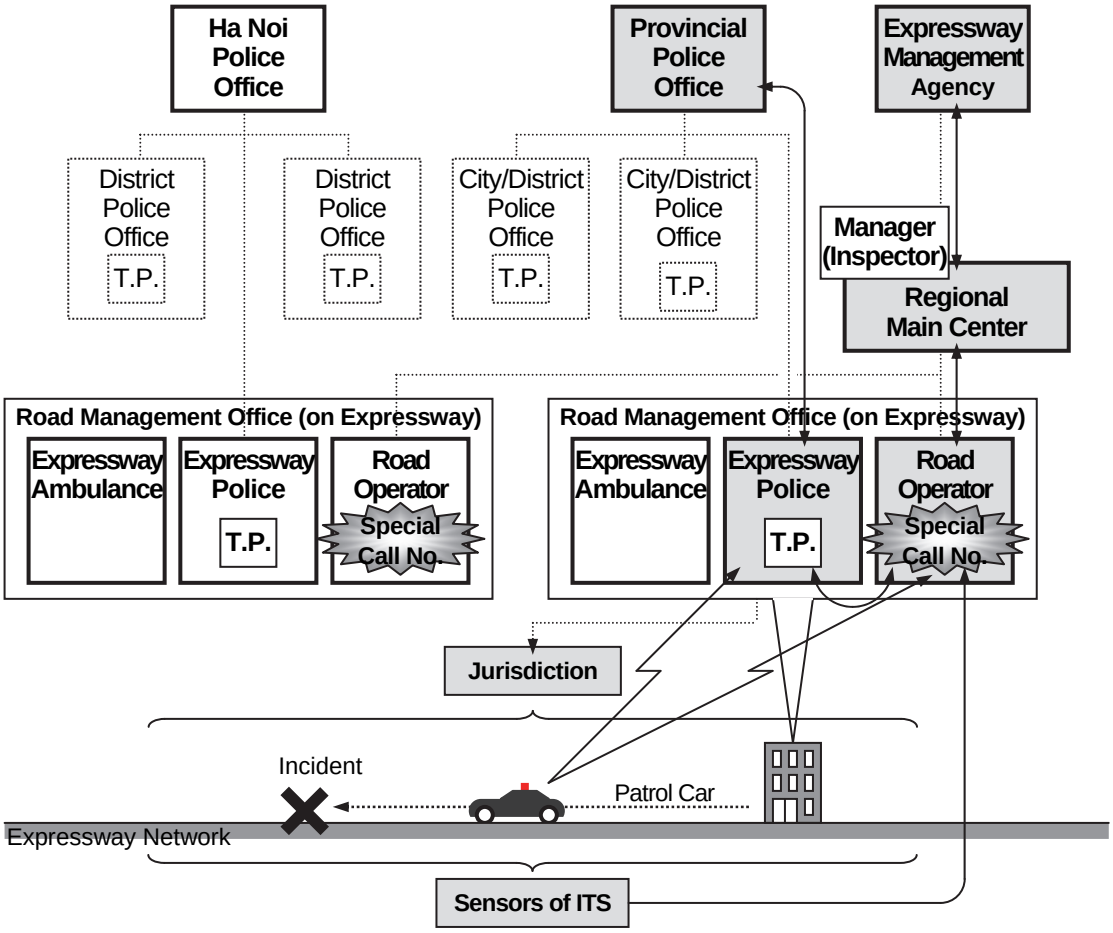
Source: ITS Integration Project (SAPI) Study Team

The decision to enforce a traffic restriction on a national highway is to be made by the traffic police officers or the traffic inspectors under DRVN as shown in the figure foregoing. In many cases, information needed for a decision-making is to be acquired only by the patrol; however, the procedure and the criteria for decision-making are not clear.

2) Recommended Framework for Traffic Restriction on Expressway Network

It is recommended as a premise for discussion in the Study that the road operators, who make decisions to enforce the traffic restrictions on the expressway as well as the police, are to be organized under the Expressway Management Agency. In addition, the information needed for deciding the application of traffic restriction is to be acquired through the calls to the special numbers or the sensors of ITS.

Figure 5.25 Recommended Framework for Traffic Restriction on Expressway Network



Note: D.P. : Detective police to be dispatched for traffic accidents with injuries/fatalities
T.P. : Traffic police to be dispatched for traffic accidents without injuries/fatalities.

Source: The Study Team

A traffic restriction is to be enfoced by disseminatng specific information, which consists of a traffic restriction and causal traffic events such as incident, traffic congestion, bad weather and construction work. The definitions of the “traffic events”, the “traffic restrictions” and the ultimate decision maker for each kind of traffic restriction are shown in the tables in Section 7.5.

5.4.6 Framework for Road/Traffic Monitoring

1) Conditions of Road/Traffic Monitoring on Existing Roads

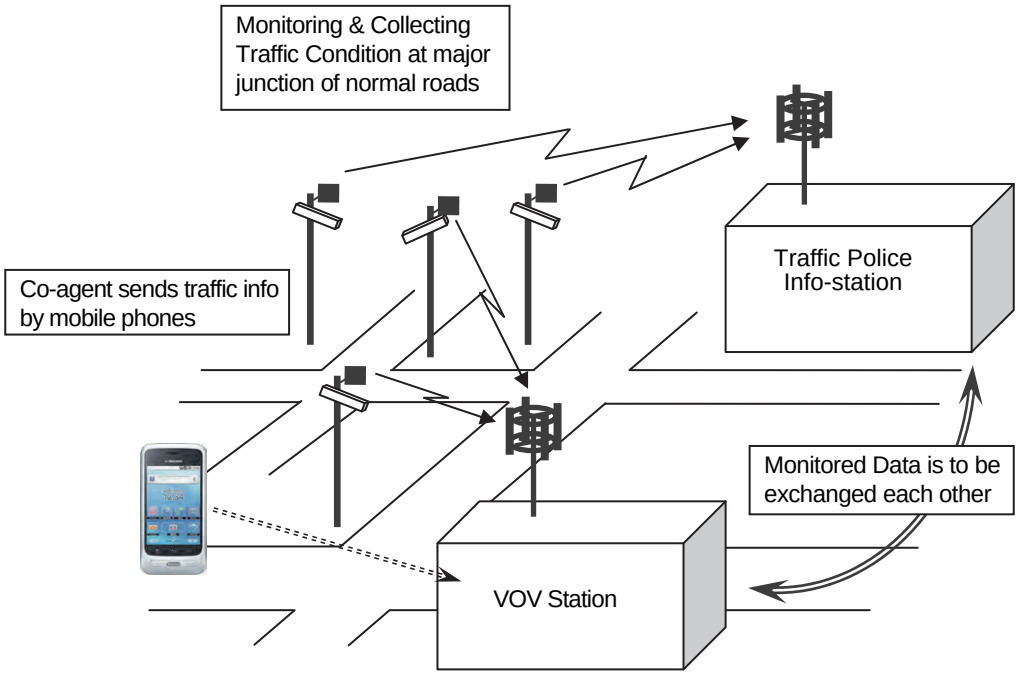
As for the monitoring of road/traffic on the existing roads, there seems to be no clear framework exists pertaining to the road operators. Currently, in Ha Noi area, the road/traffic monitoring is undertaken mainly by VOV and the traffic police, and they exchange the obtained data each other.

The road/traffic monitoring by VOV is being implemented in Ha Noi and HCM Cities currently, but it will be extended to the entire NH1 (National Highway No.1). Although major parts of the road/traffic information is being collected through CCTV camera, important information is provided by the drivers on the roads and by the VOV reporters and coagents as well. The collected information is mainly on traffic congestion, heavy traffic, and construction activities. There is no weather sensor being monitored by VOV; however, the weather information can be received from the Weather Forecast Center.

VOV installed 66 CCTV cameras in/around the major intersections in the urban area of Ha Noi city, and the captured video images are transmitted to the VOV Center through wireless communication. The cameras can be controlled remotely from the VOV Center. The collected images are provided also to the traffic police for their use.

On the other hand, the traffic police have installed more than 100 CCTV cameras at the major intersections in the area inside the Ring Road 3 in Ha Noi for monitoring traffic. The Hanoi Traffic Police has a plan to install additional CCTV cameras. The captured video images are transmitted to the traffic police center through optical fiber cable. In this system, the images are being used for visual; however, judgment processing technology has not been utilized. The images are being provided to VOV also.

Figure 5.26 Existing Framework for Road/Traffic Monitoring



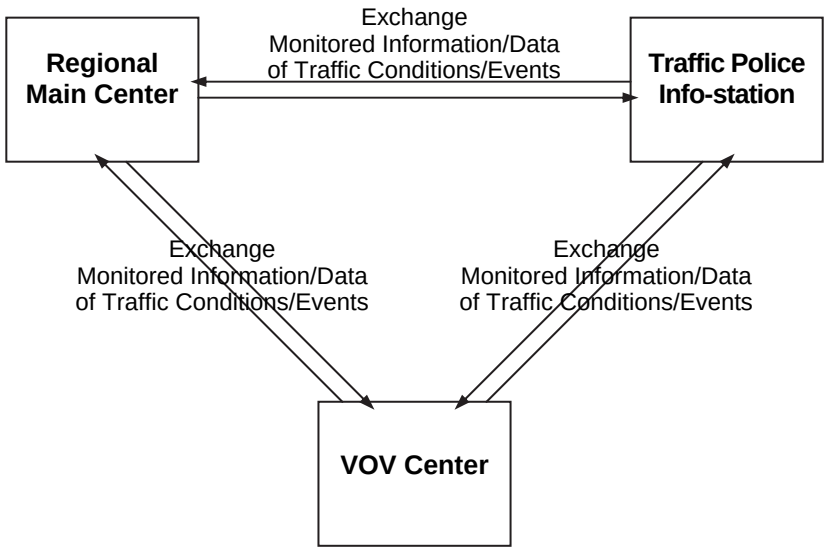
Source: ITS Integration Project (SAPI) Study Team

2) Recommended Framework for Road/Traffic Monitoring on Expressway Network

The road/traffic conditions are to be monitored continuously by operators in the Regional Main Center. Incident occurrences and other traffic events are to be monitored/identified in the Regional Main Center. These acquireded information/data are to be transferred to the traffic police center and the VOV Center.

On the other hand, the information/data of traffic conditions/events on the national highways or arteries around the exits of expressways are to be exchanged among the Regional Main Center, the traffic police canter and the VOV Center as shown in the framework below.

Figure 5.27 Recommended Framework for Road/Traffic Monitoring on Expressway Network



Source: ITS Integration Project (SAPI) Study Team

5.4.7 Framework for Traffic Event Data Management

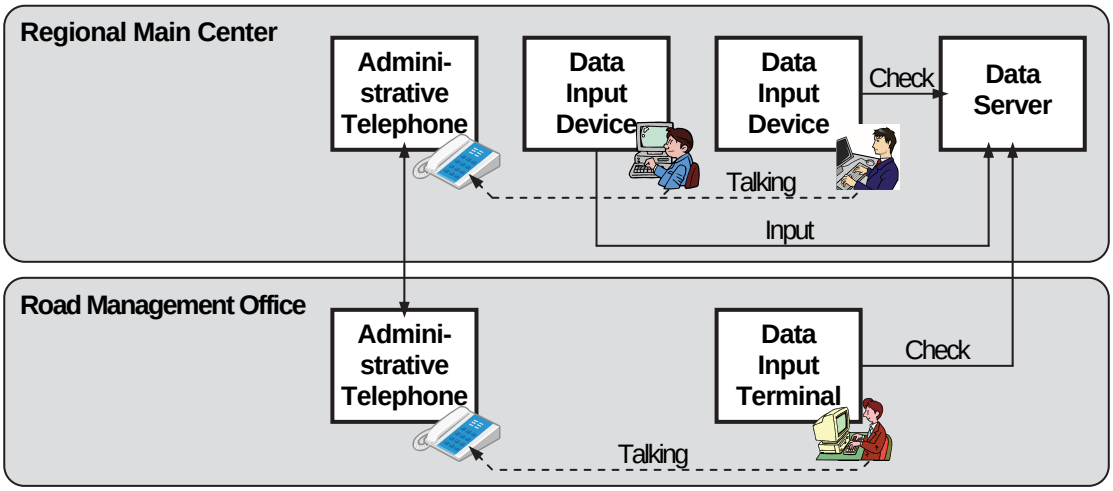
1) Expected Procedures of Traffic Event Data Management

The following three procedures, with details shown in the following figures, are to be allowed for inputting traffic event data:

- Input by an operator in the Regional Main Center
- Input by an operator in the road management office
- Input by patrol personnel on site through a mobile data input terminal.

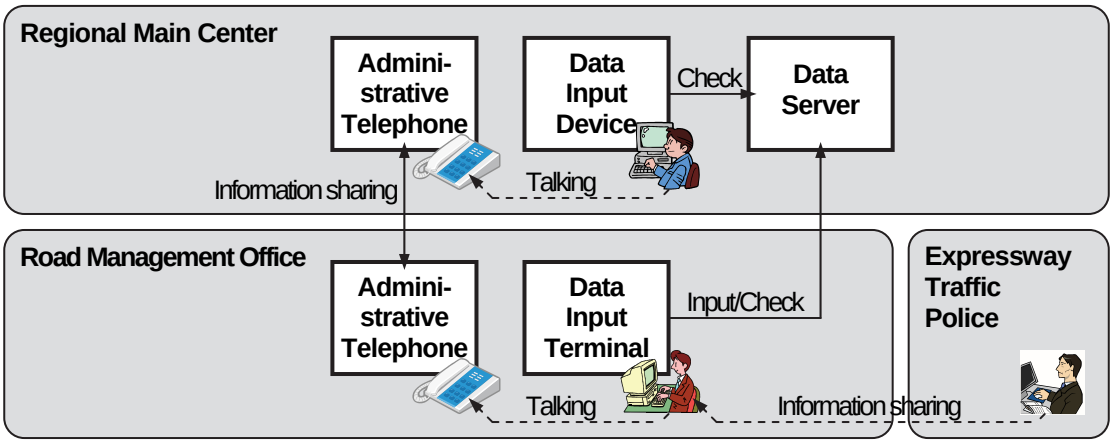
In all procesures above, it is required to receive the approvals of the responsible persons in the Regional Main Center and the road management office. Through this doubled approval process, appropriate traffic event data can be generated even in the case that the operating body of the Regional Main Center which is in charge of traffic information/control is different from that of the road management office, which is in charge of patrol for current traffic condition surveillance. Data input without the approval by the Regional Main Center or that by the road management office is to be given the status “non-approved”, and is not to be used for traffic information/Control.

Figure 5.28 Traffic Event Data Input by “Staff in the Regional Main Center”



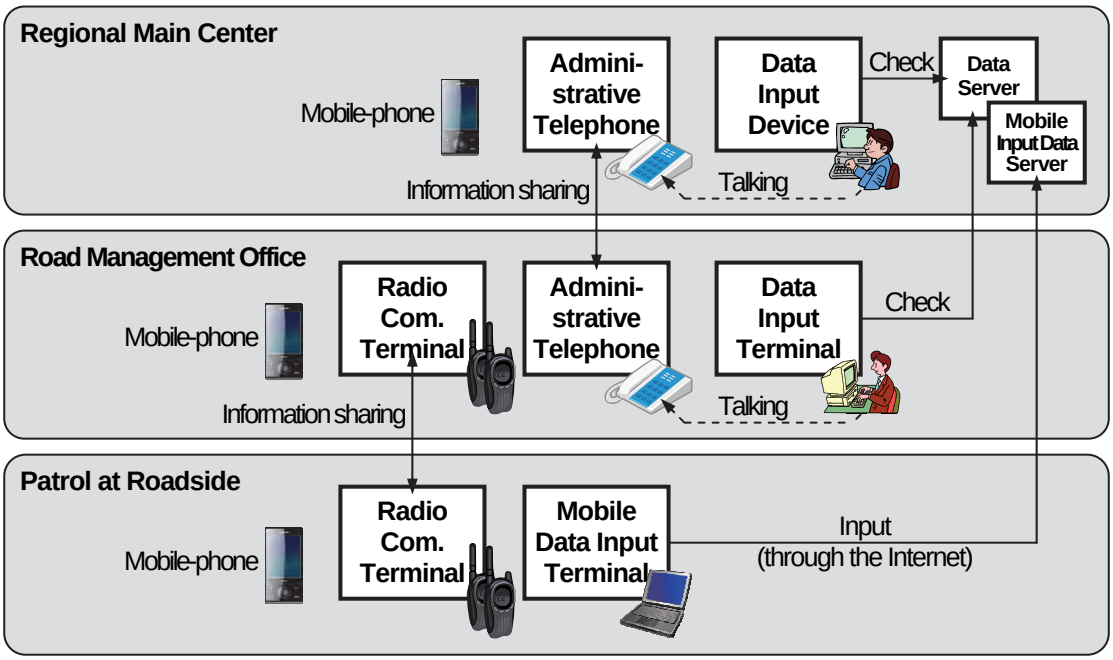
Source: ITS Standards & Operation Plan Study Team

Figure 5.29 Traffic Event Data Input by “Staff in Road Management Office”



Source: ITS Standards & Operation Plan Study Team

Figure 5.30 Traffic Event Data Input by "Patrol Staff at Roadside"

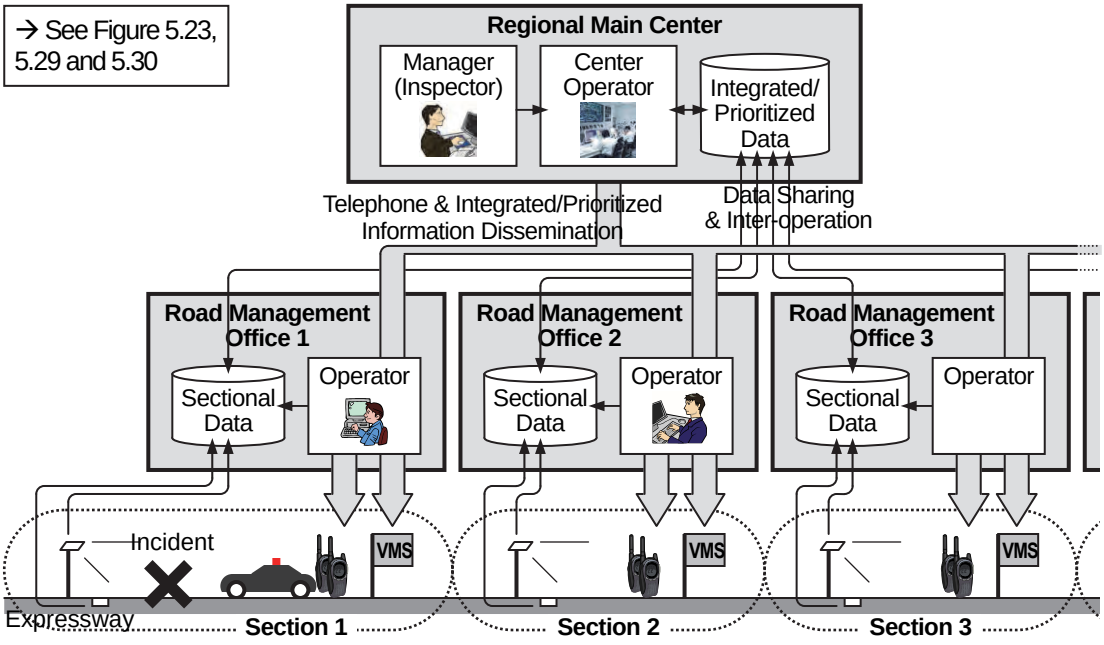


Source: ITS Standards & Operation Plan Study Team

2) Recommended Framework for Traffic Event Data Management on Expressway Network

When a traffic event is identified, its data can be input directly at a road management office or at roadside as well as at the Regional Main Center. The validity of the data needs to be checked at both the Regional Main Center and the road management office. Especially in case of the expressway closure, the check is to be accomplished by getting permission by the inspector under the Expressway Management Agency assigned to the Regional Main Center.

Figure 5.31 Recommended Framework for Traffic Event Data Management



Source: The Study Team

5.4.8 Framework for Traffic Information Dissemination

1) Conditions of Traffic Information Dissemination

In order to reduce the situations of traffic congestion and accident in cities nationwide, the General Director of VOV (Voice of Vietnam) has issued a decision to set up the "Traffic VOV". In the short term, the channel broadcasts the program 18 hours a day (from 6:00 to 24:00) in Ha Noi area to provide information on traffic condition around the capital city. The trial broadcasting started on 18th May 2009 and the official broadcasting on 21st June 2009.

The main contents of the Traffic VOV are the traffic information and the guidance to the drivers as well as the road authorities. The live broadcasting of the traffic information and guidance is limited to rush hours from Monday to Friday weekly: the durations of 6:30–8:30, 11:00–12:00 and 16:30–19:00 (the total duration is more than 30% of the daily total broadcasting hours). On Sunday, the live broadcasting is from 17:00 to 18:00. The remaining broadcasting hours are used for providing traffic-related information such as transport culture, urban transport, transport means and information related to politics, economic, culture, social, sport, music and advertisements. Road users can have access to the traffic information via a radio, SMS, or direct call to the Information Center. The hot line numbers of the Traffic VOV are (04) - 6.272.9191, 6.282.9191 and 6.292.9191.

General news on traffic issue, on-time announcement of traffic situation, as well as weather condition en-routes, warnings of accident possibility and guidance of optimal routes for the drivers, will be broadcasted by voice lively to the listeners based on the actual on-site information. With such broadcasting, the Traffic VOV has been satisfying most of the drivers about traffic information made available to them during their trips. The traffic monitoring center and the sound recording room are shown in the figure below.

Figure 5.32 Traffic Monitoring Center and Sound Recording Room

Source: VITRANSS 2 Study Team

At present, Ha Noi City has installed many cameras at major intersections to provide traffic information to the Traffic Signal Controlling Center as needed to manage and control traffic for reducing congestion and accident. Ha Noi Public Security has assigned the Department of Traffic Police to undertake this role in combination with VOV.

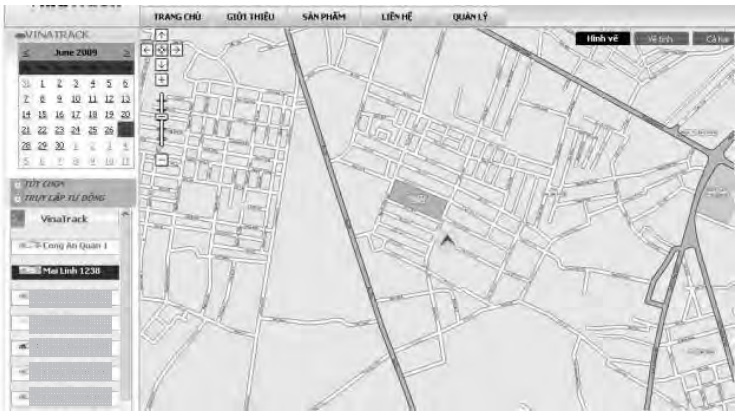
According to the VOV's plans, 100 cameras installed at 60 stations in the center of Ha Noi are to be transmitted to the National Voice Broadcasting Center and to be utilized for continuous

recording of traffic situation.

Moreover, as discussed previous section, some bus and taxi companies have already installed the GPS monitoring system in their operation centers for monitoring the locations of their vehicles. The figure below shows a sample of GPS trucking application software for Vina Track.

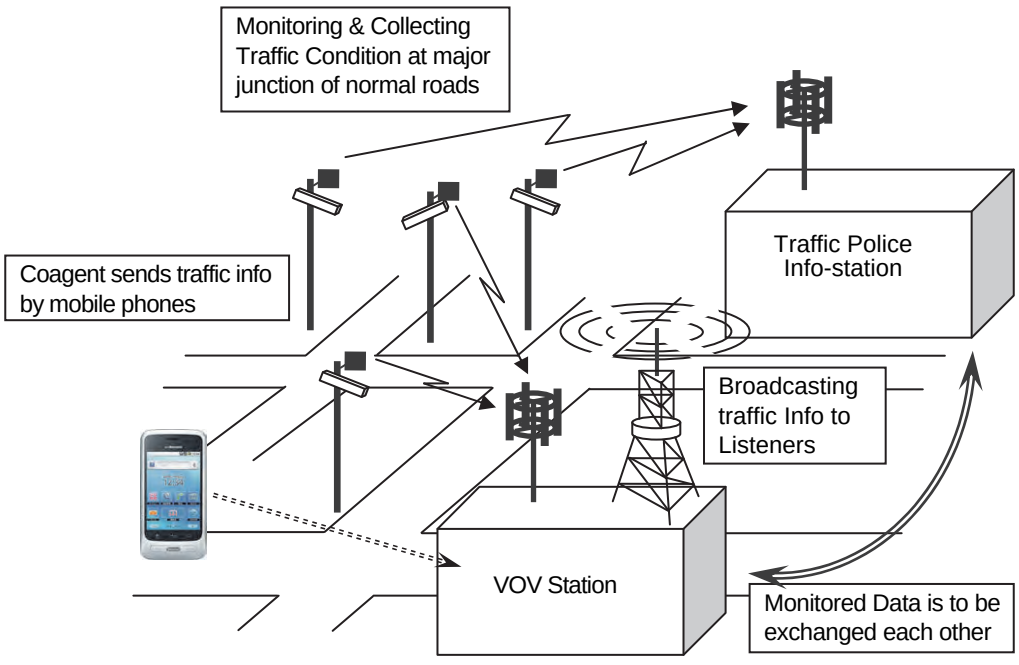
If the data based on the actual traffic conditions becomes available, more reliable and organized traffic information can be provided by using these systems in future.

Figure 5.33 Sample of GPS Tracking Application Software



Source: Vinatrack JSC

Figure 5.34 Existing Framework for Traffic Information Dissemination

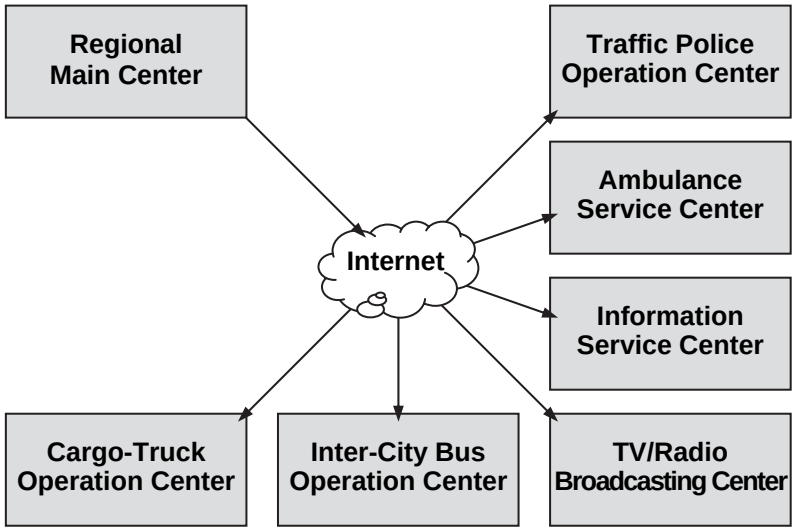


Source: ITS Integration Project (SAPI) Study Team

2) Recommended Framework for Traffic Information Dissemination

Traffic Information, which consists of the standardised messages and data elements, is to be disseminated from the Regional Main Center to the concerned organizations through the Internet as shown in the figure below.

Figure 5.35 Recommended Framework for Traffic Information Dissemination



Source: ITS Standards & Operation Plan Study Team

5.5 Framework for Toll Collection/Management

5.5.1 Key Framework

1) Conditions of Toll Management on Existing Roads

In Vietnam, there are 63 toll booths which are installed in 2008. The list of these tool booths are shown in the table below. The following figure shows the location of toll booths in 2004. Since 2003, 5 booths have been already implemented as a non-stop toll collection by infrared method. There are also other one-stop toll booths which are applied "barcode receipts".

Table 5.4 Toll Booths along National Highway Network as of 2008

No.	Name of Road	Name of Tollbooth	Station (Km)	Operator	Province	State Management Agency	No. of Lane	Toll Collection Method	Moving to One stop collection	Combination with free flow
Toll booths under VRA management										
1	NR 1	Hoang Mai	391	RRMU IV	Nghe An	VRA	4	One Stop	completed	
2	NR 1	My Thuan	2027	RRMU VII	Tien Giang	VRA	8	One Stop	completed	
3	NR 6	Chuong My	31	RRMU II	Ha Noi	VRA	4	One Stop	completed	
4	NR 14	No. 4	731	RRMU V	Dac Lac	VRA	6	One Stop	completed	
5	NR 14	No. 2	957	RRMU VII	Binh Phuoc	VRA	6	One Stop	completed	
6	NR 1	Luong Met	97	RRMU II	Lang Son	VRA	6	Two Stop	under construction	
7	NR 1	Phu Bai	840	RRMU IV	Th.Th. Hue	VRA	6	Two Stop	under construction	under appraisal
8	NR 1	North Hai Van tunnel	892	RRMU IV	Th.Th. Hue	VRA	3	Two Stop	under construction	under appraisal
9	NR 1	Sourth Hai Van tunnel	902	RRMU V	Da Nang	VRA	3	Two Stop	under construction	under appraisal
10	NR 2	Viet Tri	54	RRMU II	Vinh Yen	VRA	4	Two Stop	under construction	
11	NR 3	Soc Son	30	RRMU II	Ha Noi	VRA	4	Two Stop	under construction	
12	NR 10	Tien Cuu	41	RRMU II	Hai Phong	VRA	6	Two Stop	under construction	
13	NR 18	Pha Lai	21	RRMU II	Hai Duong	VRA	4	Two Stop	under construction	
14	NR 21	My Loc	137	Nam Dinh DOT	Nam Dinh	VRA	4	Two Stop	under construction	
15	NR 1	Ninh An	1408	RRMU V	Khanh Hoa	VRA	6	Two Stop	under bidding	
16	NR 18	Uong Bi	58	Quang Ninh DOT	Quang Ninh	VRA	4	Two Stop	under bidding	
17	NR 20	Dinh Quan	52	RRMU VII	Dong Nai	VRA	4	Two Stop	under bidding	
18	NR 32	Trung Ha	63	Phu tho DOT	Phu Tho	VRA	4	Two Stop	under bidding	
19	NR 38	Cau Ho	10	RRMU II	Bac Ninh	VRA	4	Two Stop	under bidding	
20	NR 1	Gianh	625	RRMU IV	Quang Binh	VRA	6	Two Stop	project approved	
21	NR 18	Ba Che	198	Quang Ninh DOT	Quang Ninh	VRA	2	Two Stop	designed appraised cost estimation is under appraisal	
22	NR 1	Cam Thinh	1517	RRMU V	Khanh Hoa	VRA	6	Two Stop	prooject documents is under revision	
23	NR 7	Yen Thanh	18	RRMU IV	Nghe An	VRA	4	Two Stop	prooject documents is under revision	
24	NR 8	Hong Linh	2	RRMU IV	Ha Tinh	VRA	4	Two Stop	prooject documents is under revision	
25	NR 80	Lo Te	65	RRMU VII	Kien Giang	VRA	4	Two Stop	prooject documents is under revision	
26	NR 14	Buon Ho	681	RRMU V	Dac Lac	VRA	4	Two Stop	under appraisal	
27	NR 19	Nhon Tan	30	RRMU V	Binh Dinh	VRA	4	Two Stop	under appraisal	
28	NR 26	Madrak	62	RRMU V	Dac Lac	VRA	4	Two Stop	under appraisal	
29	NR 37	Cau Binh	17	RRMU II	Hai Duong	VRA	6	Two Stop	wating for MOT opinion on utilizationi of Da Bac equipment	
30	NR 14	No. 3	871	RRMU V	Dac Nong	VRA	4	Two Stop	waiting for moving to other location	
31	NR 19	Chu A	120	RRMU V	Gia Lai	VRA	4	Two Stop	waiting for moving to other location	
32	NR 20	Duc Trong	203	RRMU VII	Lam Dong	VRA	4	Two Stop	waiting for moving to other location	
33	NR 22A	Suoi Sau (Go Dau)	30	RRMU VII	Tay Ninh	VRA	6	Two Stop	waiting for moving to other location	
34	NR 1	Ban Thach (Da Rang)	1333	RRMU V	Phu Yen	VRA	4	Two Stop	wating for authorization of toll collection to other body	
35	NR 18	Bai Chay	114	Quang Ninh DOT	Quang Ninh		8	Two Stop	wating for authorization of toll collection to other body	
36	Thang Long - Noi Bai	Noi Bai	10	RRMU II	Ha Noi	VRA	8	Two Stop	wating for authorization of toll collection to other body	under appraisal
37	NR 51	No. 1	11	RRMU VII	Dong Nai	VRA	8	Two Stop	wating for authorization of toll collection to other body	
Toll booths under BOT project or under authorized toll collection companies										
38	LHL	Km15	15	RRMU II	Ha Noi	VINACONEX	4	Two Stop		
39	NR 1	Lien Chieu	917	Da Nang DOT	Da Nang	Da Nang PC	4	Two Stop		
40	NR 1	Phu Dong	159	RRMU II	Ha Noi	VEC	8	Two Stop		
41	NR 1	Nam Cau Gie	226	Hai Chau Group	Ha Nam	VEC	6	Two Stop		
42	NR 1	An Suong-An Lac	1910	ASAL BOT	Ho Chi Minh	ASAL BOT	12		completed	Completed
43	NR 1	Song Phan	1725	RRMU VII	Binh Thuan	CC1 BOT	6	Two Stop	designed appraised	
44	NR 1	Tao Xuyen	318	Thanh Hoa Bypass BOT	Thanh Hoa	Cienco1 BOT	4	Two Stop	under construction	
45	NR 1	Ben Thuy	468	Vinh Bypass BOT	Nghe An	Cienco4 BOT	4	One Stop	completed	
46	NR 1	Hoa Cam-Hoa Phuoc		HCHP BOT	Da Nang	Cienco5 BOT	6	One Stop	under completion	
47	NR 1	Tam Ky	965	Hiep Phuoc BOT	Quang Nam	Hiep Phuoc BOT	4	Two Stop		
48	NR 1	Deo Ngang Tunnel	592	Deo Ngang BOT	Ha Tinh	Song Da BOT	6	Two Stop	under documents revision/waiting for handover	
49	NR 1	Dong Ha	770	RRMU IV	Quang Tri	Truong Thinh BOT	6	Two Stop		
50	NR 1	Cau Rac	539	RRMU IV	Ha Tinh	BOT...	6	Two Stop		
51	NR 1	Quan Hau	671	RRMU IV	Quang Binh	BOT...	6	Two Stop		
52	NR 1K	T1-T2		NR 1K - BOT	Ho Chi Minh	NR1K BOT	6	Two Stop		
53	NR 2	T1-T2		Noi Bai - Vinh Yen BOT	Vinh Yen	Associated BOT	3	One Stop	completed	
54	NR 2	T2		Noi Bai - Vinh Yen BOT	Vinh Yen	Associated BOT	3	One Stop	completed	
55	NR 5	Km 18	18	Dai Duong Co.	Hung Yen	VIDIFI	8	Two Stop	under project preparation	
56	NR 5	Quan Toan	83	Dai Duong Co.	Hai Phong	VIDIFI	8	Two Stop	under project preparation	
57	NR 10	Tan De	98	Tasco BOT	Thai Binh	TASCO	6	Two Stop	under appraisal	
58	NR 13	Thu Dau Mot	20	BECAMEX	Binh Duong	Binh Duong PC	6	Combination 1-stop&2stop		
59	NR 21	Do Quan	150	Nam Dinh DOT	Nam Dinh	Nam Dinh PC	4	Two Stop		
60	NR 37	Nong Tien	136	Company Ltd.	Tuyen Quang	Tuyen Quang DOT	4	Two Stop		
61	NR 39	Trieu Duong	44	Thai Binh DOT	Thai Binh	Thai Binh DOT	4	Two Stop		
62	NR 50	Cau Ong Thin	11	CIENCO 5- BOT	Ho Chi Minh	Cienco 5 - BOT	6	Two Stop		
63	NR 51	Co May	70	Hai Chau-BOT	B.Ria V.Tau	Hai Chau	8	Two Stop		

Source: VITRANSS 2 Study Team

(1) MOT's Response for the Modernization Plan

In the official Letter No. 2740/GTVT-KHCN to VRA dated May 10, 2005 regarding "Modernization of tollbooth network along national highways", MOT stated below opinion:

- Semi-automatic toll collection: Barcode technology is applied for one-stop collection.
- Automatic toll collection: Data communication by WL technology will be applied for non-stop collection. The prepaid account will be deducted after every passing time of vehicle through toll booth with speed approximately 30 km/h.
- To explain on selected technology among Microwaves and Infrared, the combination of both technologies is recommendable.
- For the toll Station have less 6 lanes will applied one-stop technology only
- For the toll Station have 6 lane or more will applied none-stop technology in 2 middle lanes, the other lanes will applied one-stop technology"

Figure 5.36 Photos of One-Stop Toll Collection

Upper: Hanoi Highway
Middle: Binh Bridge
Lower: NR13 by BECAMEX

Source: Oriental Consultants Co.,Ltd

Figure 5.37 Tollgate Lanes and Monitor Screen at Binh Bridge in Hai Phong Province

Source: Oriental Consultants Co.,Ltd.

Figure 5.38 Tollgate Lanes and OBU with IC-card at Ha Noi Highway in HCMC

Source: VITRANSS 2 Study Team

ETC (Electronic Toll Collection) systems have been installed in the following tollgates described later.

- Binh Bridge Toll Plaza in Hai Phong Province (ETC installed in 2 lanes in 2006)
- Ha Noi Highway Toll Plaza in HCMC (ETC installed in 2 lanes in 2007)
- Kinh Duong Vuong Toll Plaza in HCMC (ETC installed in 2 lanes in 2007)
- Binh Duong Boulevard Toll Plaza in Binh Duong Province (ETC installed in 4 lanes in 2007 and additional 4 lanes in 2008)

These systems adopted IR (Infrared Ray) communication for the data exchange between roadside and the vehicle.

(2) Notices for the ETC lane for Gau Gie–Ninh Binh Expressway

There is a notice, 41/TB-BGTVT, on conclusions by vice minister, Mr. Ngo Thinh Duc, on implementation of package 10.1 under Gie–Ninh Binh expressway construction project and technology standard for ITS for Expressway System in Vietnam on 10th February, 2009. It said that the concept of installation for ETC booth as below.

For toll plaza with 6 gates or more (3 gates for each way), pilot application of 1 gate for ETC could be considered, for toll plaza with 2 gates for each way, pilot application of 1 gate for mixed and closed type between Touch & Go and ETC could be considered.

After this notice, another notice has issued as Reviewing Result of Basic Design for Expressway of Cau Gie–Ninh Binh, 347/TB-BGTVT on 6th August, 2009 as below.

As for toll collection systems, vice minister has basically agreed with planned number of lanes, toll collection method, which is “ETC at middle lane” + “semi-automatic (one-stop) collection” + “manual collection”, and the most outside lane is for super length and super weight vehicles.

2-pieces OBU is recommended and 1-piece OBU introduction should be considered for appropriate roads

IC card should be used for automatic and semi-automatic toll collection systems. Communication method between OBU and roadside equipments should be DRSC 5.8 GHz. Toll collection method should allow toll clearance among tollgates through banks.

2) Existing Framework for Toll Management

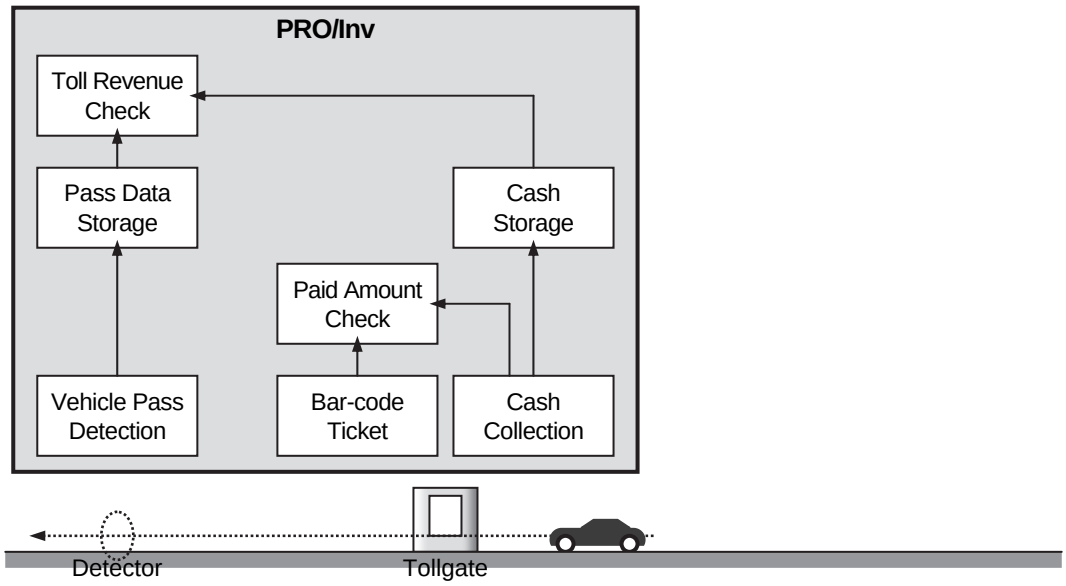
There exist three types of framework for toll management in Vietnam:

- Managed by the Government (as a road owner)
- Managed by a road owner
- Managed by a toll collection company.

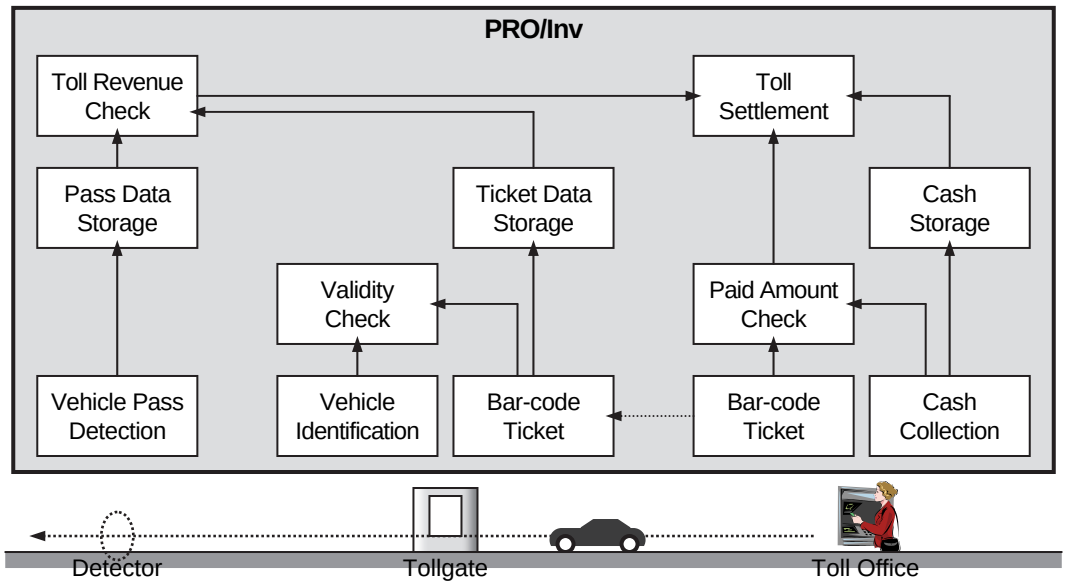
The first type of framework can be included in the second type and these two types are applied to toll collection by cash and bar-code ticket as shown in the following two figures. There can be many different types of framework for toll management; however, the process to check the toll revenue needs to be executed by the road owner in the all frameworks.

Figure 5.39 Existing Framework for Toll Management by Road Owner

Pay by Cash



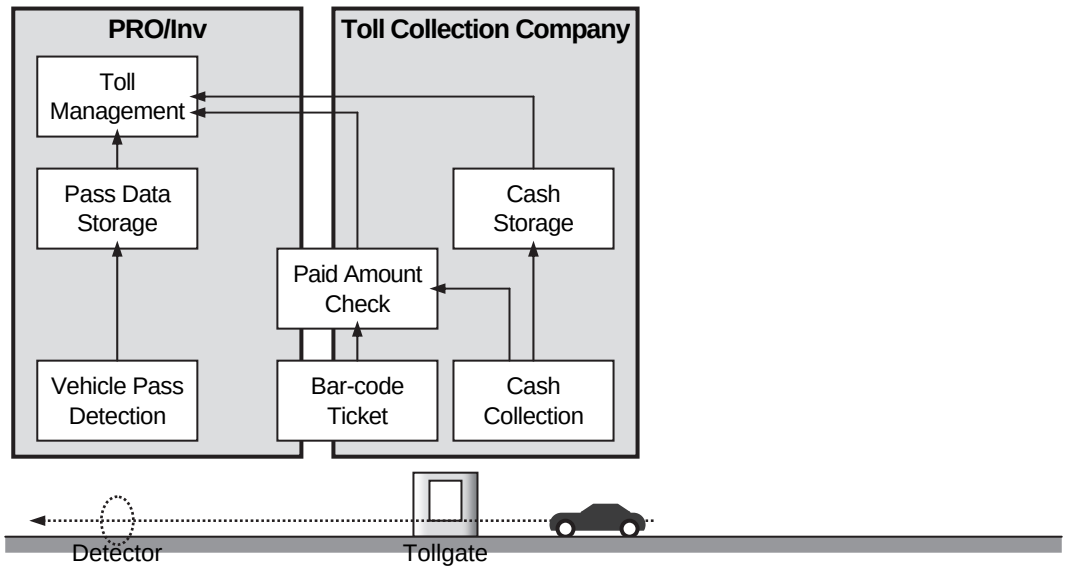
Pay by Bar-code Ticket



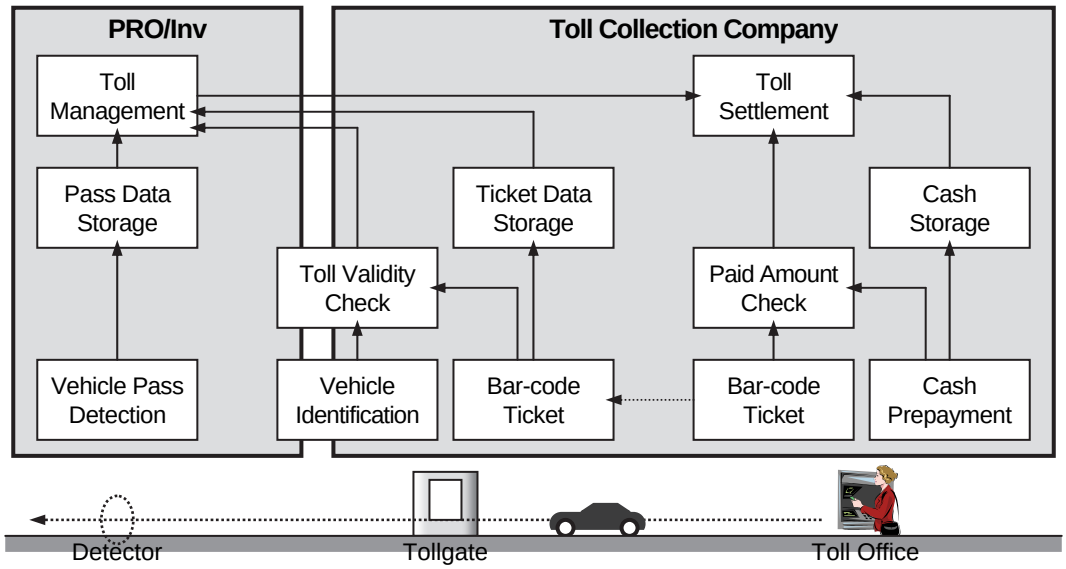
Source: The Study Team

Figure 5.40 Existing Framework for Toll Management by Toll Collection Company

Pay by Cash



Pay by Bar-code Ticket



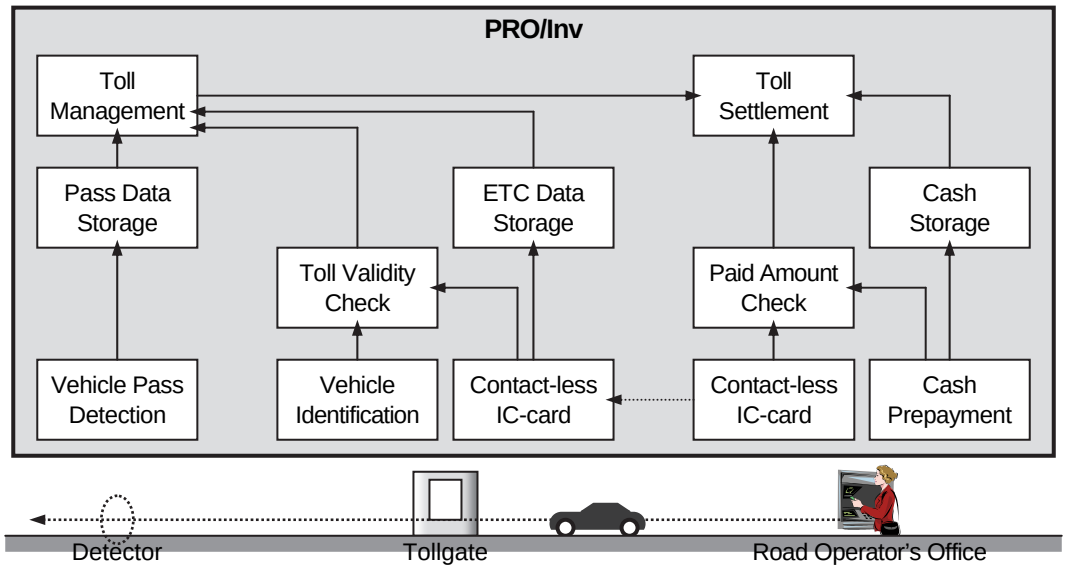
Source: The Study Team

3) Applicable Framework for Toll Management using ETC

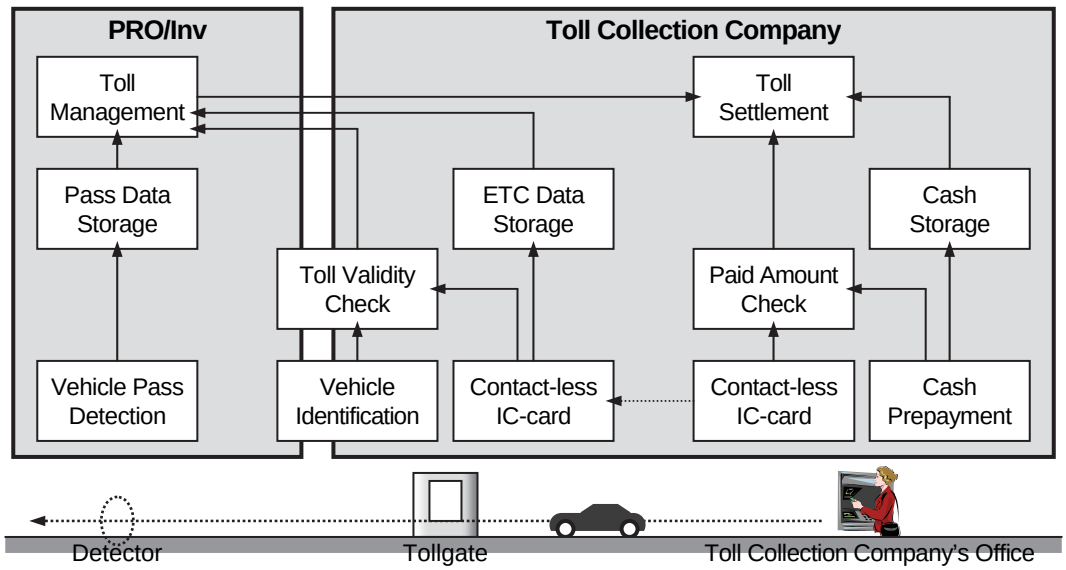
The traditional type of framework composed by the road owner and the toll collection company can be applied also to toll management using ETC as shown in the following figure. In this figure, only the bar-code ticket as a tool for checking paid amount in the previous figures is replaced to a contact-less IC-card.

Figure 5.41 Applicable Framework for Toll Management using ETC (1)

ETC Framework -0a



ETC Framework 0b



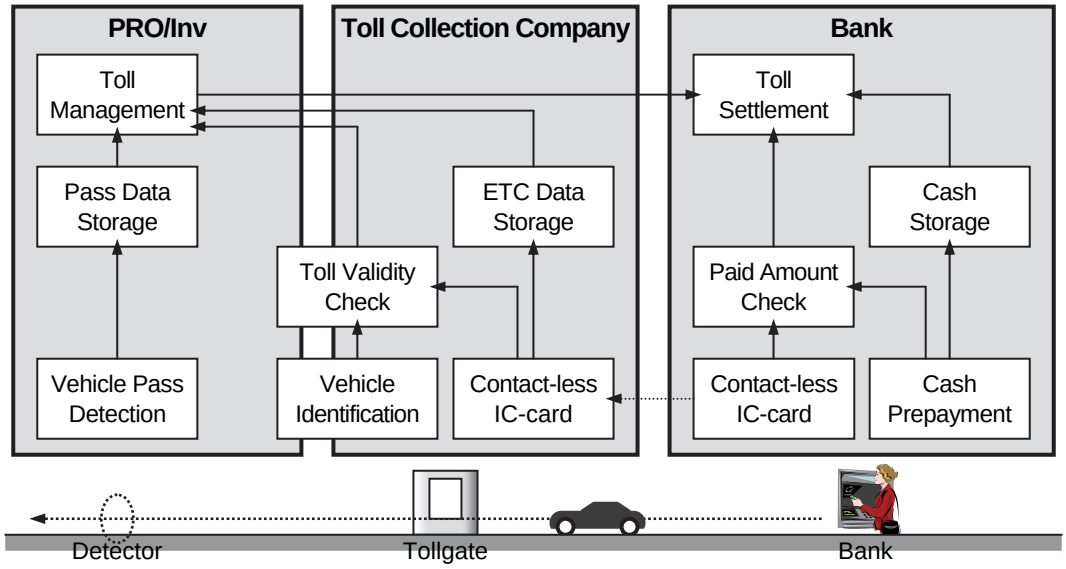
Source: The Study Team

In addition, it is useful for road users that a contact-less IC-card is disseminated and available at ATMs in every branch office of a bank for recharging the prepaid balance recorded in it. For such benefit the processes of cash storage and toll settlement can be transferred to a bank as shown in the following figures. Accordingly, the "ETC Framework-1a" and "ETC Framework-1b" is recommended in the Study.

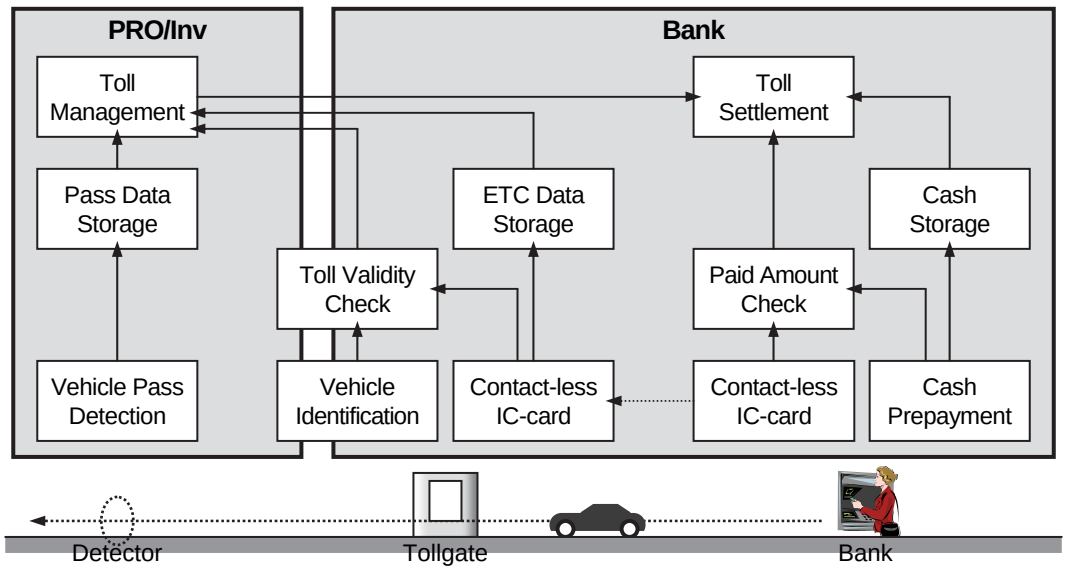
It is not a common framework for ETC in the world that the processes at the tollgate including vehicle identification and validity check are executed directly by a bank. Because, these processes need to be performed by a method with high reliability both for the road owner and the road user. Appropriate level of participation by a bank is to be determined by the Government of Vietnam.

Figure 5.42 Applicable Framework for Toll Management using ETC (2)

ETC Framework -1a



ETC Framework -1b



Source: The Study Team

The discussion above is summarized in the Table 5.8, with evaluation viewpoints: initial investment burden on PRO/Inv, liability of illegal-use of IC-cards and interoperability in card payment. Trough those comparison, Framework -1a is recommended as the suitable frame.

Table 5.5 Role Sharing on Toll Collection/Management

	Framework -0a,0b	Framework -1a	Framework -1b	Framework -2
Owner of Roadside Equipment	PRO/Inv, TCC	PRO/Inv, TCC	Bank	Bank
Owner of IC-card ***	PRO/Inv, TCC	Bank	Bank	Bank
Cash Prepayment	PRO/Inv, TCC	Bank	Bank	Bank
Toll Collection (ETC)	PRO/Inv, TCC	PRO/Inv	Bank	Bank
Toll Validity Check	PRO/Inv	PRO/Inv	PRO/Inv	Bank
Toll Management	PRO/Inv	PRO/Inv	PRO/Inv	Bank
Toll Settlement	PRO/Inv	Bank	Bank	Bank
Initial investment by PRO/Inv	low (expensive)	middle (moderate)	high (cheap)	highest (cheapest)
Liability of illegal-use of the IC-cards ***	PRO/Inv, TCC	Bank	Bank	Bank
Interoperability in card payment ****	Legally impossible	Legally possible	Legally possible	Legally possible
Grade	Not Suitable	Recommended (→ See Figure 5.45)	Not Suitable	Not Suitable

Note: TCC: Toll Collection Company, ***: See Figures 5.50 and 5.51.

**** : As per SBV's Decision 20/2007/QD-NHNN, If the card is illegally used after the card-issuing organization's confirmation, the card-issuing organization is wholly liable for any loss and shall compensate for any loss caused by the illegal use of the card.

***** : SBV Letter 408/NHNN-TT dated 21, January, 2015: Only bank and credit organization under bank can provide and realize payment by prepaid balance service.

4) Road Owner's Offices Required for Toll Management

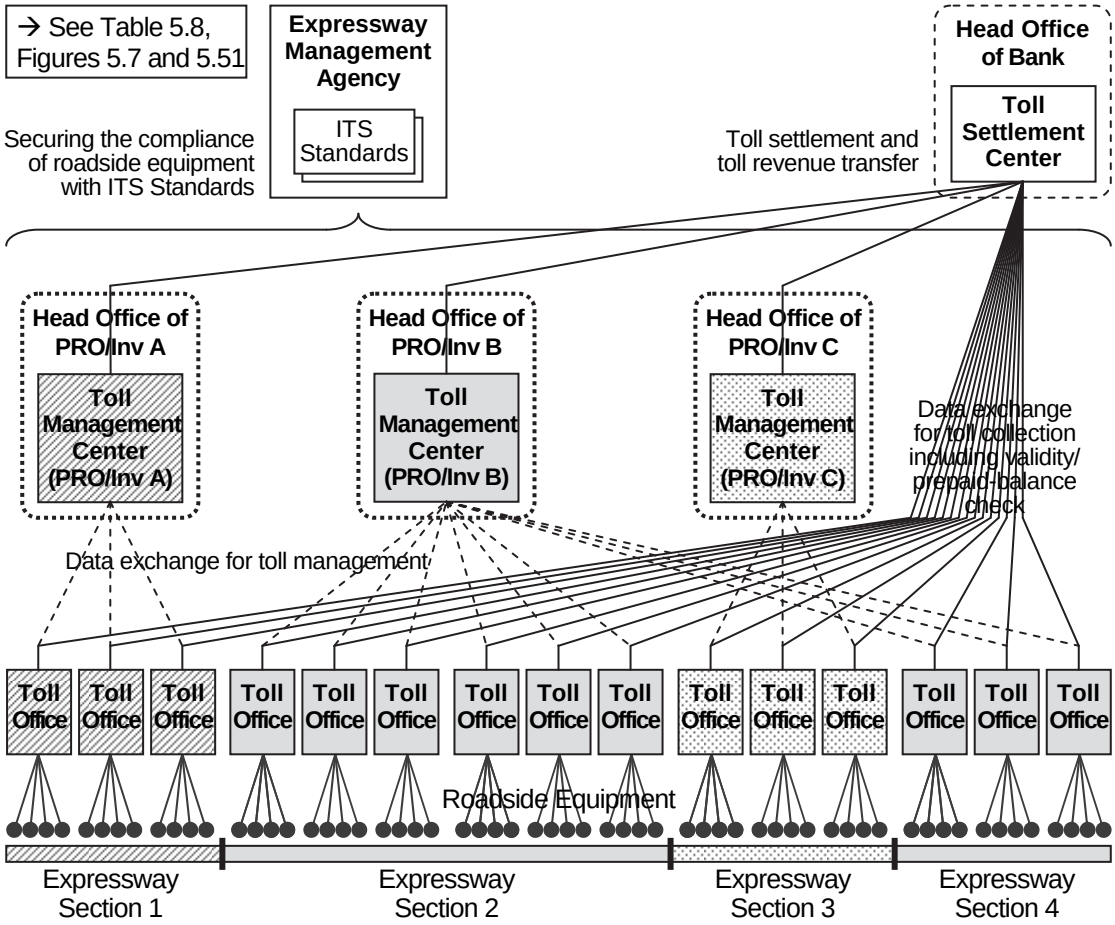
The expressway network in Vietnam will be shared among many different road owners; hence, the framework for toll management needs to be integrated based on separation for each operator.

- **Expressway Sections:** Road sections are shared among the road owners, and the road sections of different road owners are to be separated by barrier tollgates.
- **Toll Office:** Toll Office is to be established near the tollgate which include two or more tollbooths, and functions as toll collection.
- **Road Owner's Head Office:** Road Owner's Head Office means headquarters of road management offices and staffs under its organization, and includes a toll management center which manages toll offices. This office is to manage toll rate and toll revenue.

5) Recommended Framework for Toll Management of Expressway Network

The framework for toll management in the following figure, which includes many different road owners and a bank, is to be defined as a premise for discussion in the Study. The Standards on hardware/software is to be managed by the Expressway Management Agency in MOT and the application software is to distributed under license from the Regional Main Center.

Figure 5.43 Recommended Framework for Toll Management of Expressway Network



Note: ▌: Barrier tollgates between the expressway sections of different road operators

Source: The Study Team

5.5.2 Framework for Toll Settlement

1) Recommended Payment Method

For introducing automated toll collection systems such as ETC and Touch&Go, toll settlement will be conducted by using contact-less IC-cards for prepayment. Comparison of various payment methods for toll collection is shown in the table below.

Table 5.6 Comparison of Various Payment Methods for ETC and Touch&Go

	Prepayment	Payment on Credit	Payment by Direct Debit
Outline	Toll fare is offset from the prepaid balance when OBU passes the tollgate. Deposit for prepayment ↓ OBU passes the tollgate ↓ Toll fare is offset from the prepaid balance	Toll fare is claimed later on to user's bank account by the credit company. Deposit in bank account ↓ Open a credit ↓ OBU passes the tollgate ↓ Passage data is sent to the credit company ↓ Toll fare is claimed later on by credit company	Toll fare is deducted later on from user's bank account by direct debit. Deposit in bank account ↓ OBU passes the tollgate ↓ Passage data is sent to the credit company ↓ Toll fare is deducted later on by direct debit
Available User	Unlimited	Limited to Credit Card Holder	Limited to Bank Account Holder
Suitability to Pay Small Amount	Good	Average	Average
Exclusive Means for Payment	Necessary	Not Necessary	Not Necessary
Good Quality Telecom.	Necessary	Indispensable	Indispensable
Familiarity in Vietnam	High	Not High	High
Grading	Recommended	Not Suitable	Average

Source: ITS Standards & Operation Plan Study Team

A single IC-card needs to be shared by many different road owners, and issue/recharge of the IC-card needs to be used conveniently in the city as well as the roadside. Adequate data exchange needs to be conducted for toll settlement between the toll management center of the road owner and the toll settlement center in the bank.

2) Expected Toll Settlement Frameworks

The following frameworks are compared for executing the toll settlement:

- Toll Settlement Framework -0 : unshared IC-cards issued by road owners
- Toll Settlement Framework -1': shared IC-cards issued by a bank
- Toll Settlement Framework -1 : of shared IC-cards issued by banks
- Toll Settlement Framework -2 : operated all by a bank.

Toll settlement among different road owners is to be operated a bank or an organization permitted by the State Bank (as the case of Decision No.5190/NHNN-TT). The following discussion on above four is premised on the distance proportional tariff system for toll rate.

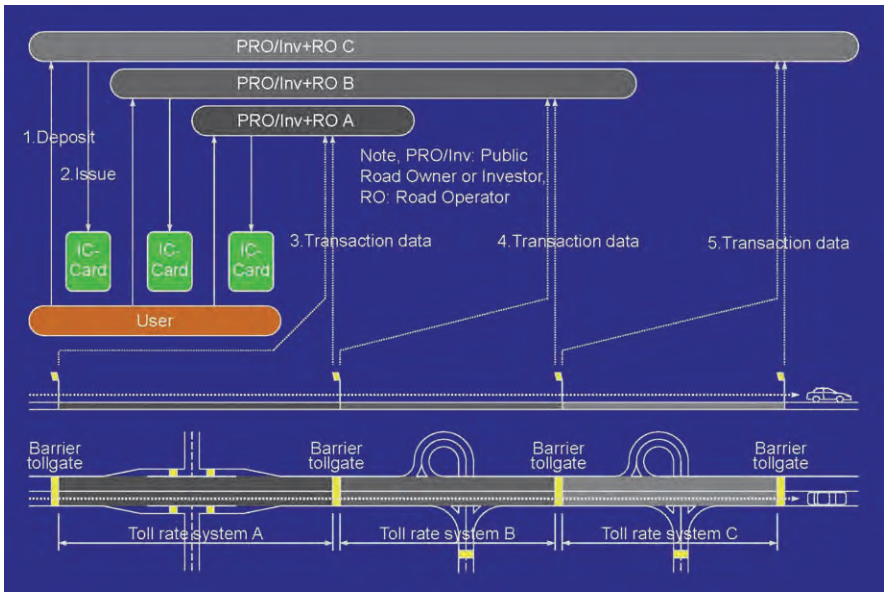
(1) Toll Settlement Framework -0 : Unshared IC-cards Issued by Road Owners

This framework for toll settlement is based on many kinds of unshared IC-cards issued by

different road owners and has the following problems:

- Users need to prepare many IC-cards for passing continuously through the expressway sections shared by different road owners.
- Users can receive issue/recharge service of the IC-cards only at the roadside of the expressways.
- Road owners need to prepare all the equipment for IC-card issue/recharge and car parks for convenience of the users who intend to use the issue/recharge service.
- Measures against congestion are necessary for access roads to car parks for IC-card issue/recharge service.
- Diffusion of OBU and IC-card tends to be slow.

Figure 5.44 Toll Settlement Framework-0 : Unshared IC-cards Issued by Road Owners



Source: The Study Team

(2) Toll Settlement Framework -1 : Shared IC-card Issued by Banks

To resolve the problems, a staged implementation of framework is to be defined as a premise for discussion in the Study. Issue/recharge service for IC-cards is provided by a single bank in the 1st stage and by several different banks in later stages. These frameworks for toll settlement are based on utilization of a single kind of IC-card shared by different road owners. The staged implementation of framework achieves the following advantages:

<in the 1st stage>

- Users can use a single IC-card through the whole expressway sections.
- Users can receive issue/recharge service of the IC-card at many places in urban area using the equipment prepared by the bank.
- Road owners need not prepare the equipment for IC-card issue service and the relevant car parks.
- OBU and IC-card tends to be diffused rapidly.

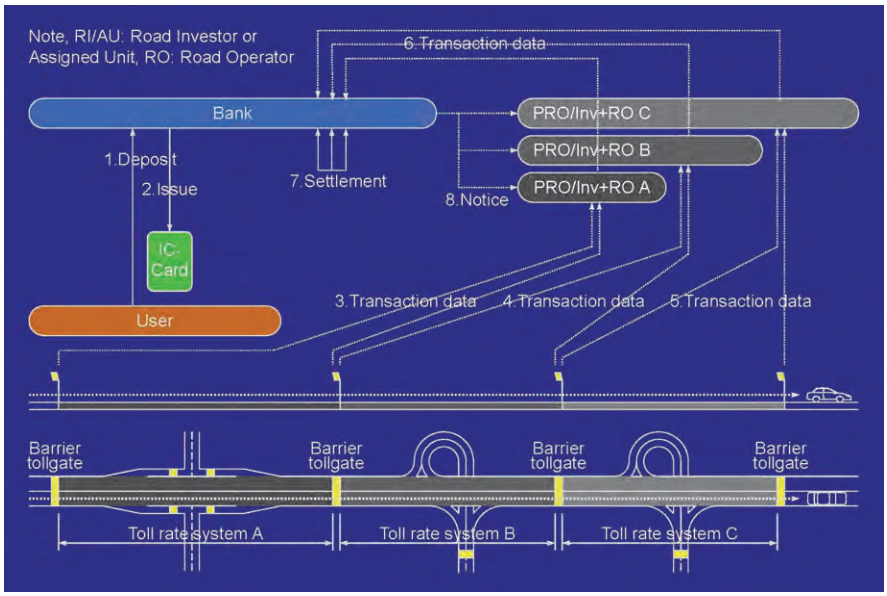
<in later stages>

- Users can receive the IC-card issue/recharge service more conveniently.

- Driver needs not stop the vehicle many times on the expressway to get the IC-card issue/recharge service.
- Congestion to access the IC-card issue/recharge service can be removed.

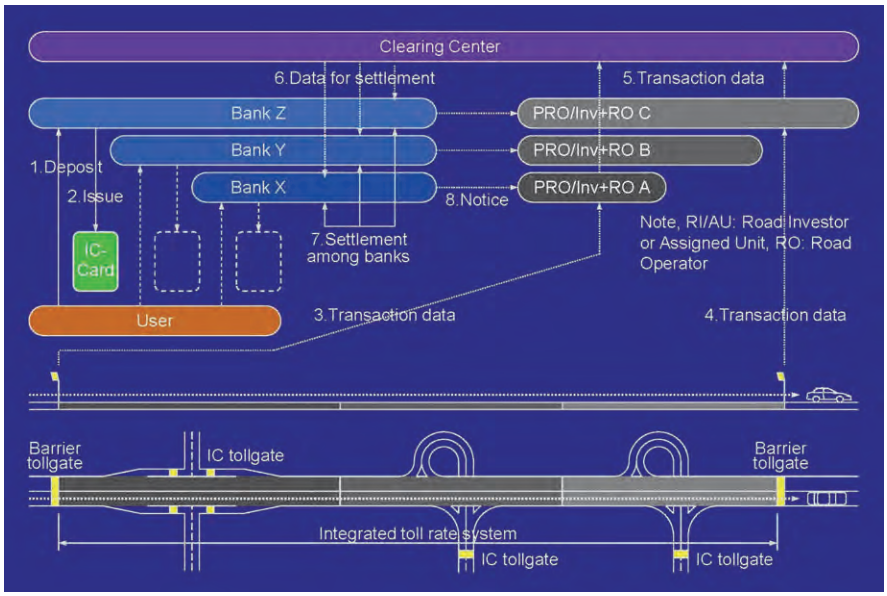
However, for integrating the road owners and the banks, a clearing center needs to be discussed to establish it in a later stage.

Figure 5.45 Toll Settlement Framework-1' : Shared IC-card Issued by a Bank (in 1st Stage)



Source: The Study Team

Figure 5.46 Toll Settlement Framework-1 : Shared IC-card Issued by Banks (in Later Stages)



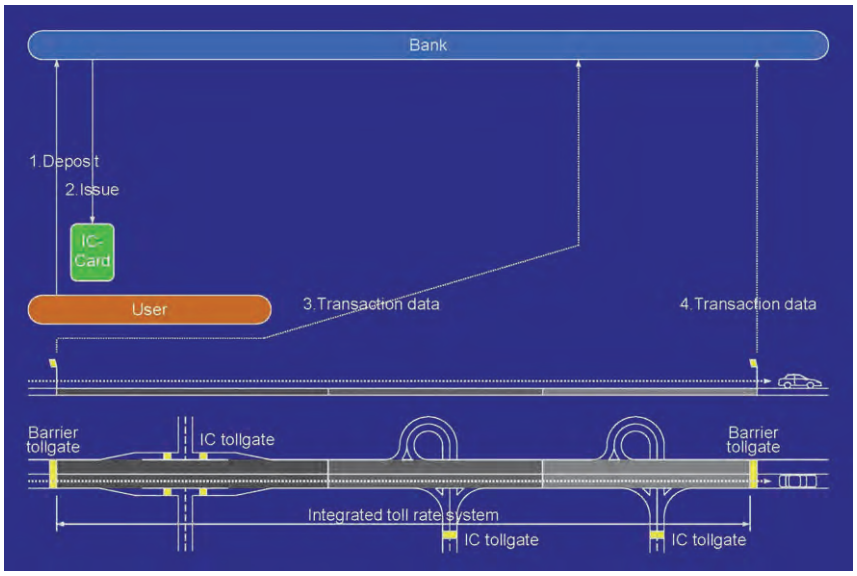
Source: The Study Team

(3) Toll Settlement Framework -2 : Operated All by a Bank

In this framework, all processes including passage data collection and toll settlement are operated by a single bank and advantages on the toll settlement can be achieved as well as Framework-1. However, it is difficult to control/secure the reliability of this framework, because

a single organization occupies processing of both passage data collection and toll settlement for many expressway sections without any benefit and duty on the road operation. For this reason, this framework is not suitable.

Figure 5.47 Toll Settlement Framework-2 : Operated All by a Bank



Source: VITRANSS2 Study Team

3) Recommended Toll Settlement Framework for Expressway Network

The Framework-1 is recommended as a premise for discussion in the Study based on the comparison on toll settlement frameworks summarized below.

Table 5.7 Selection of Toll Settlement Framework

	Framework-0	Framework -1'	Framework -1	Framework -2
IC-card Issue Organization	Road operators	A bank	Banks	A bank
Cost-cutting on IC-card Operation for Road Operator	Incapable	Capable	Capable	Capable
Tollgate-to-center Cash Delivery by Road Operator	Necessary	Not necessary	Not necessary	Not necessary
Number of IC-cards Necessary for a User	2 or more	1	1	1
Clearing Center	Not necessary	Not necessary	Necessary	Not necessary
Convenience of IC-card Recharge for the User	Average	High	Very high	High
Control/Securing of Reliability of the Framework	Average	Average	Average	Difficult
Grading	Not suitable	Useful in 1st Stage	Recommended	Not suitable

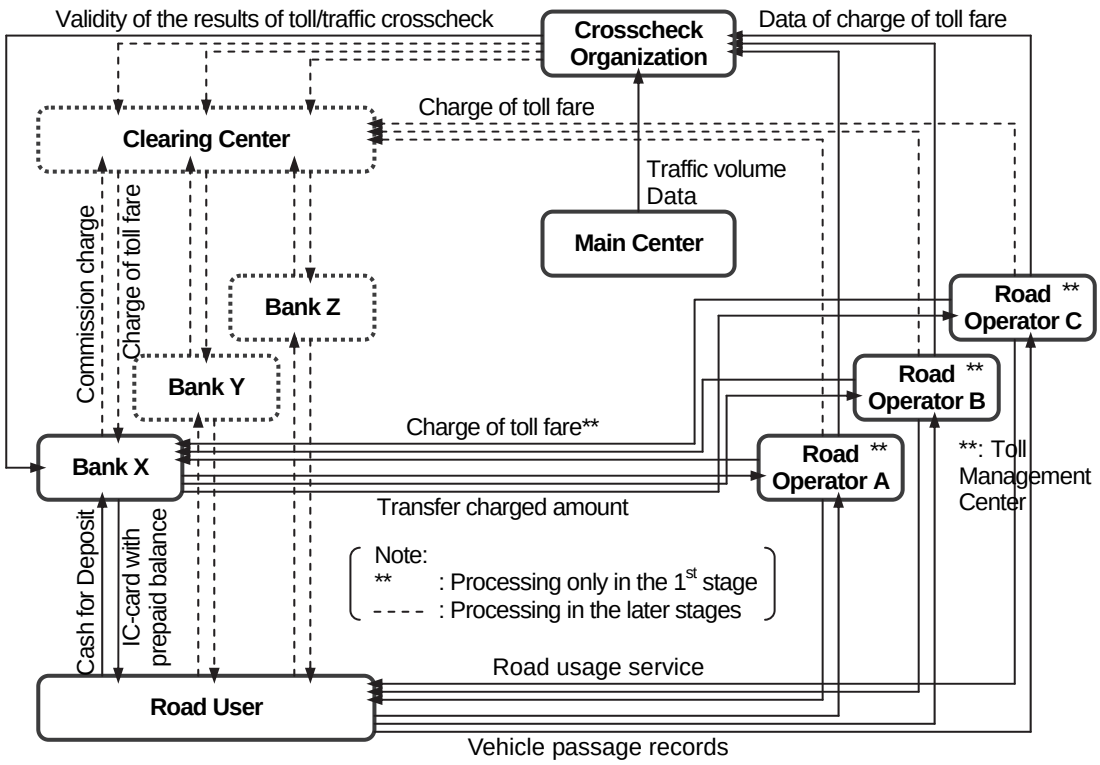
Note: →See Table 5.8, Figures 5.44, 5.45, 5.46 and 5.47

Source: ITS Standards & Operation Plan Study Team

The toll settlement framework shown in the following figure is to be built up by the staged implementation of Framework-1' and Framework-1. The toll fare is directly reported by a bank

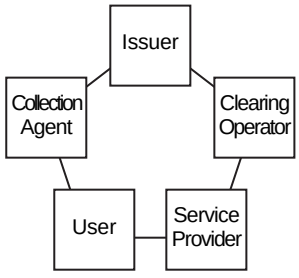
in the 1st stage; however, a clearing center needs to be set up in the later stage to allocate charged amount of toll fare to two or more banks. Additionally, a crosscheck organization needs to be set up to check the charged amounts by road owners against traffic volumes.

Figure 5.48 Recommended Toll Settlement Framework for Expressway Network



Source: ITS Standards & Operation Plan Study Team

Table 5.8 Correspondence to the Basic Conceptual Model in ISO 14904

ISO 14904: "EFC Interface Specification for Clearing between Operators"			Case of Toll Settlement Framework-1
 Basic Conceptual Model for EFC	Issuer	The entity responsible for the payment system and responsible for issuing the payment means (IC-card) to the User.	Bank
	Collection Agent	The entity responsible for selling, reloading or delivering the payment means to the User.	Bank
	Clearing Operator	The entity that collects and possibly aggregates transactions from one or more Service Providers for delivery to the Issuers. The Clearing Operator can also handle the apportionment between the Service Providers.	Clearing-house
	Service Provider	The entity that accepts the User's payment means and in return provides the service to the User.	Road Owners
	User	The entity that uses services provided by the Service Provider according to the terms of the Contract expressed by the payment means. The user receives and reloads the electronic payment means through the Collection Agent.	Road Users

Note: EFC: Electronic fee collection.

Source: ITS Standards & Operation Plan Study Team

5.5.3 Framework for IC-card Issuance/Operation

1) Existing Conditions of Bank IC-card Issuance/Operation

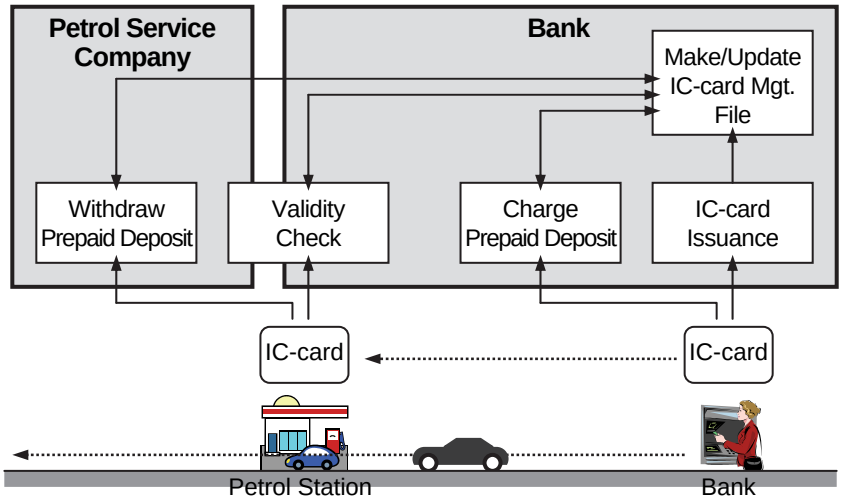
According to the Decision No: 20/2007/QD-NHNN, which is ”Promulgating the regulation on issuance, payment, use of bank cards and provision of bank card operation support services (May 15, 2007. "Bank card" is a tool issued by a card-issuing organization for conducting card transactions under the conditions and terms agreed upon by the involved parties.

Pre-paid card is a card permitting its holder to conduct card transactions within the value limit loaded on the card corresponding to the amount of money already prepaid by its holder to the card-issuing organization. Pre-paid cards include bearer pre-paid card and non-bearer pre-paid card (anonymous prepaid cards).

After this decision, there are decision of the governor of the state bank of Vietnam No.32/ 2007/QD-NHNN (July 3, 2007) which shows the “Balance Limit of bearer pre-paid cards” regulated, it is regulated to be not in excess of 5,000,000 VND.

A kind of prepaid IC-card issued by bank is can be applied to the payment of petrol as shown in the figure below.

Figure 5.49 Existing Framework for IC-card Issuance/Operation



Source: ITS Integration Project (SAPI) Study Team

2) Applicable Framework of IC-card Issuance/Operation for ETC

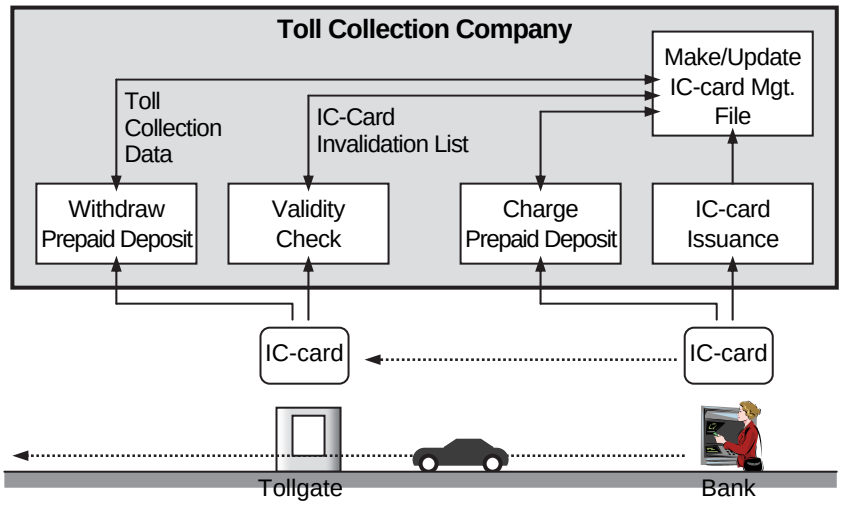
The bank issues the contact-less IC-card as with VietinBank. It can be used for toll payment at the Touch &go tollgates. However, this card cannot be used at the ETC tollgates; because, only 1-piece type OBUs are existing currently in Vietnam.

The card is available at every branch office of the bank nationwide or at toll office located near the tollgates where the bank equips Touch&go tollgate. The person who has the bank account is available to obtain the card. In the form of application of the card, there are options on type of pre-paid or post-paid, recharge options such as internet banking, request through mobile phone, or process at ATM. The card is able to issue on the basis of the options selected in the application form.

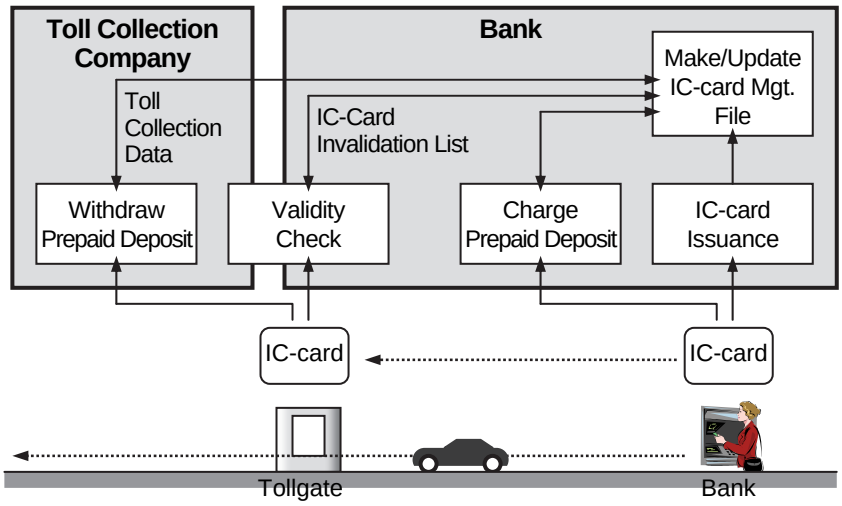
2-piece type OBU will be introduced In near future and it will become possible to use IC-card with OBU for passing through the ETC tollgate. In such stage, the frameworks shown below are applicable to IC-card issuance/operation for ETC.

Figure 5.50 Applicable Framework of IC-card Issuance/Operation for ETC

IC-card Framework -0



IC-card Framework -1



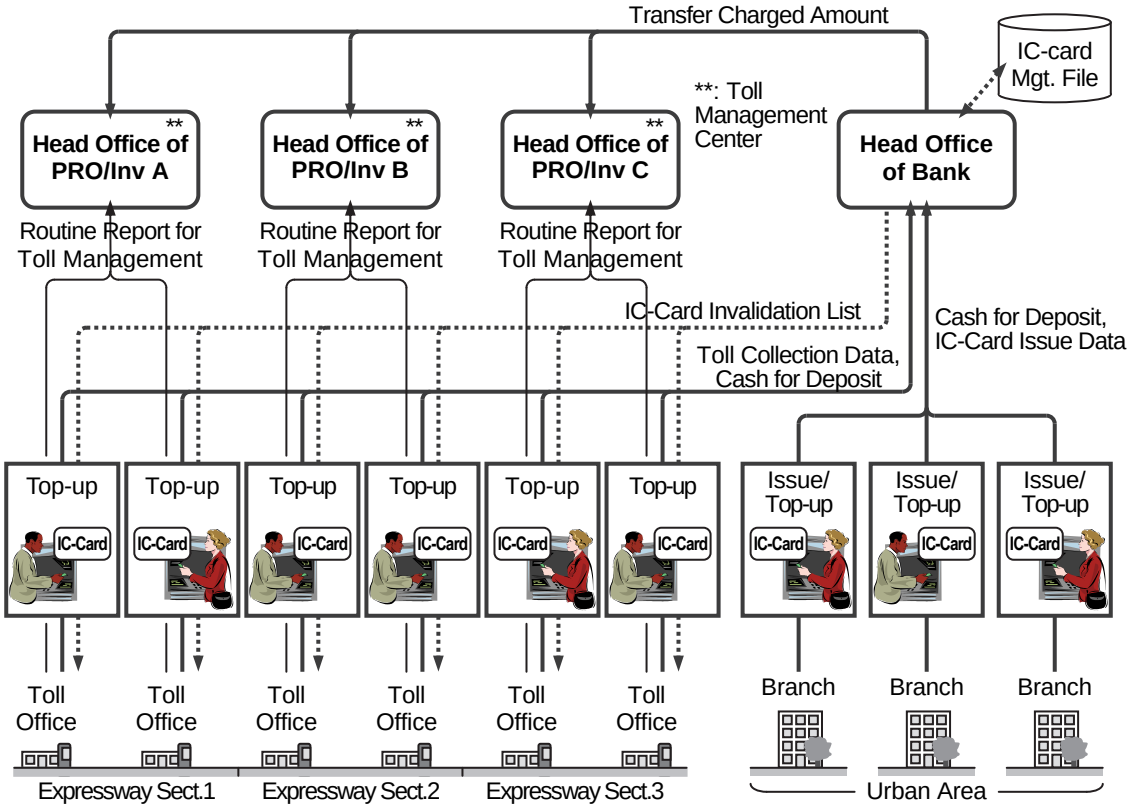
Source: ITS Integration Project (SAPI) Study Team

For a harmonization with the framework for ETC, the “IC-card Framework-1” is recommended and to be discussed and illustrated in more detail in the following.

2) Recommended Framework for IC-card Issuance/Operation

The framework for IC-card issuance/operation both of Touch&Go and ETC shown below is to be defined as a premise for discussion in the Study.

Figure 5.51 Recommended Framework for IC-Card Issuance/Operation



Source: The Study Team

For creating the framework, IC-card issuers/rechargers need to be installed in the branches of the bank in urban area and the toll offices along the expressway. Cash for deposit and IC-card Issue data are to be received by the issuers/rechargers and to be accumulated in the head office of the bank. The head office of the bank receives charge of toll fare from the road owners and transfers the charged amounts to the road operator's bank account. Additionally, The head office of the bank generates an IC-card invalidation list and sends it to the road operators as well.

5.5.4 Framework for OBU Registration/Management

1) Existing Framework for Vehicle Registration

(1) Vehicle Registration System

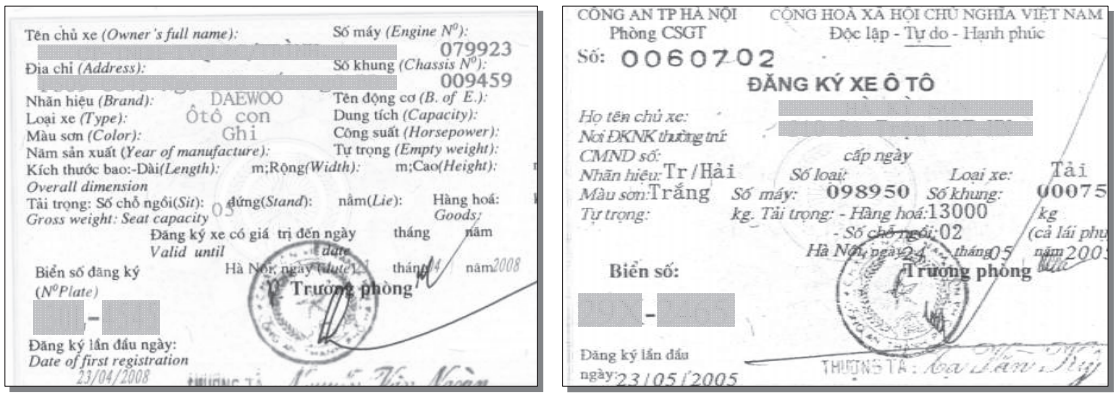
Vehicle registration and issue of vehicle number plate is conducted by the Ministry of Public Security under the Circular 01/2002/TT-BCA and Circular No 12/2008/TT-BCA-C11, and Circular No 34/2003/TT-BTC of the Ministry of Finance for registration fee. The provincial land road police division is in charged for vehicle registration of normal passenger, private firm and government agency, and the land/railway road police department is in charged for diplomatic vehicle registration.

The procedure for vehicle registration is required to submit following documents in order to issue registration certificate. (Normally, it is required within 5 working days in Hanoi, 7 working days in HCMC)

- Owner's Identification Document
- Registration Form
- Vehicle's ownership transfer document
- Receipt of Registration Fee
- Documents showing the vehicle's original: imported as whole vehicle, domestic assembled vehicle, converted vehicles, etc. (included inspection certificate for domestic assembled vehicles)

In the registration certificate, name of owner, address, vehicle type (color), engine number, chassis number, number plate are described (the registration certificate for truck is also required to indicate the loading capacity (kg)). The figure below shows the sample of registration certification form.

Figure 5.52 Registration Certification (Left: Passenger Car, Right: Truck)



Source: VITRANSS 2 Study Team

According to the vehicle classification under the Circular No60/2004/TT-BTC of Ministry of Finance, there are 7 types as below.

- Type 1: Motorbikes, motorbikes with 3 wheel and similar types
- Type 2: Lambretta, rudimentary trucks, tractors
- Type 3: Cars of under 12 seats, trucks of a tonnage of under 2 tons and mass transit buses

- Type 4: Cars of between 12 and 30 seats, trucks of a tonnage of between 2 tons and under 4 tons
- Type 5: Cars of 31 seats or more; trucks of a tonnage of between 4 and under 10 tons
- Type 6: Trucks of a tonnage of between 10 and under 18 tons and 20 ft-container lorries
- Type 7: Trucks of a tonnage of 18 tons or over and 40 ft-container lorries

(2) License Plate System

The vehicle number plate is issued same as vehicle registration, by the Ministry of Public and Security under Circular No 06/2009/TT-BCB (C11). The regulation of Number plate is as follows.

(a) Vehicles for Non-business Administrative Offices or Government Agencies
- Background of Plate: Blue
- Characters & number: White
- Region code: followed by Table 5.12
- Series no: Use 1 of 5 symbols below: A, B, C, D, E

(b) Vehicles for All Economic Sectors and Individuals
- Background of Plate : White
- Characters & number: Black
- Region code: followed by Table 5.12
- Series no: Use 1 of 5 symbols below: F, H, K, L, M, N, P, R, S, T, U, V, X, Y, Z (and some symbols for special cases

(c) Vehicles for Diplomatic Organizations, Consulates, Individuals of Foreigner
- Background of Plate: White
- Characters & number: Black
- Series no: “NG” in red

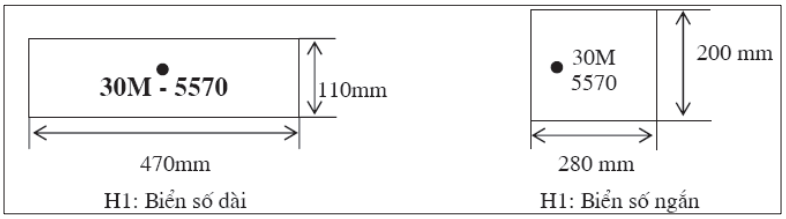
(d) Vehicles for International Organizations, Individuals of Foreigner:
- Background of Plate: White
- Characters & number: Black
- Series no: “QT” in red

(e) Vehicles for Representative Office, Representative Organizations, Individuals of Foreigner and Student learning abroad
- Background of Plate: White
- Characters & number: Black
- Series no: “NN” in red

The material of plate should be made by metal. And there are two type of size at one for front, the other is in behind of vehicle in the following figure.

- Type 1 Short Plate: Height 200 mm, Length 280 mm,
- Type 2 Long Plate: Height 110 mm, Length 470 mm

Figure 5.53 Size and Dimension of Number Plate



Source: VITRANSS 2 Study Team

Table 5.9 Region Code List of Number Plate

TT	TÊN ĐỊA PHƯƠNG	KÝ HIỆU	TT	TÊN ĐỊA PHƯƠNG	KÝ HIỆU
1	Cao Bằng	11	34	Cần Thơ	65
2	Lạng Sơn	12	35	Đồng Tháp	66
3	Quảng Ninh	14	36	An Giang	67
4	Hải Phòng	15-16	37	Kiên Giang	68
5	Thái Bình	17	38	Cà Mau	69
6	Nam Định	18	39	Tây Ninh	70
7	Phú Thọ	19	40	Bến Tre	71
8	Thái Nguyên	20	41	Bà Rịa-Vũng Tàu	72
9	Yên Bái	21	42	Quảng Bình	73
10	Tuyên Quang	22	43	Quảng Trị	74
11	Hà Giang	23	44	Thừa Thiên Huế	75
12	Lào Cai	24	45	Quảng Ngãi	76
13	Lai Châu	25	46	Bình Định	77
14	Sơn La	26	47	Phú Yên	78
15	Điện Biên	27	48	Khánh Hòa	79
16	Hòa Bình	28	49	Cục CSGT ĐB-ĐS	80
17	Hà Nội	29-32	50	Gia Lai	81
18	Hà Tây	33	51	Kon Tum	82
19	Hải Dương	34	52	Sóc Trăng	83
20	Ninh Bình	35	53	Trà Vinh	84
21	Thanh Hóa	36	54	Ninh Thuận	85
22	Nghệ An	37	55	Bình Thuận	86
23	Hà Tĩnh	38	56	Vĩnh Phúc	88
24	TP.Đà Nẵng	43	57	Hưng Yên	89
25	Đắk Lắk	47	58	Hà Nam	90
26	Đắk Nông	48	59	Quảng Nam	92
27	Lâm Đồng	49	60	Bình Phước	93
28	TP.Hồ Chí Minh	50-59	61	Bạc Liêu	94
29	Đồng Nai	60	62	Hậu Giang	95
30	Bình Dương	61	63	Bắc Cạn	97
31	Long An	62	64	Bắc Giang	98
32	Tiền Giang	63	65	Bắc Ninh	99
33	Vĩnh Long	64			

Source: VITRANSS 2 Study Team

Figure 5.54 Example of Number Plate

Upper: Individuals

Lower Left: Government Agencies

Lower Right: Foreign

Source: VITRANSS 2 Study Team

Number plate for temporally registered vehicle is made by paper with the same design of above categories.

(3) Vehicle Inspection System

MOT has a responsibility for vehicle inspection as the function of vehicle technical safety environmental protection (VTSEP) since 1995. MOT assigned this inspection to the Vietnam Register (VR) and VA is the agency for conducting vehicle inspection with local TUPWS and DOT. Law and regulation for vehicle inspection are as follows.

- Decision No. 4105/2001/QĐ-BGTVT (December 04, 2001): Regulations on periodical inspection in terms of technical safety and environment protection for Motor Vehicles.
- Decision No. 39/2007/QD-BGTVT (August 22, 2007): Amending and Supplementing of Decision No. 4105/2001/QD-BGTVT: The Regulation on Periodical Inspection of Technical Safety and Environmental Protection of Motor Vehicles
- Decision 4134/2001/QD-BGTVT: Technical Standards for inspection based on 22TCN/224-2001: Technical safety and Environmental protection of land road motor vehicles dated 2001
- Decision 065/QD-DK (14 March 2006): Vietnam Register guiding the inspection on technical safety and environmental protection of land road motor vehicles.

Inspection is divided into the “Initial Inspection” conducted just after purchasing and “Periodical Inspection”.

Initial Inspection

Following documents are required for issuing certification record of motor vehicle inspection.

- Original copy of “Registration Certificate” or the registration application receipt note, or copy of valid registration certificate certified by the lending Bank, or the valid confirmation note of leasing company
- Original copy of import certificate or original copy note of notification on inspection exemption for imported vehicle, or vehicle quality certificate manufacturer (domestic produced, assembled or converted vehicles)
- License for transportation business (for the case that the vehicle is registered for transportation business.)

Routine Inspection

Following documents are required for routine inspection.

- Certification record of periodical motor vehicle inspection
- Vehicle Registration Certificate
- Business Registration Certificate (for the case that the vehicle is registered for transportation business.)

The Table 6.2.2 shows the inspection item and its frequency. Items are regulated by Decision No.4134/QD-BGTVT, and there are 55 items for general passenger vehicle and 75 items for motor cycle. That table shows also the main items to be inspected.

Table 5.10 Vehicle Inspection Item and Frequency

Type of Vehicle	Period (month)	
	Initial	Periodic
Truck (cargo)		
• Brand-new imported vehicle; domestic manufactured or assembled vehicle	24	12
• Modified/repaired vehicle	12	06
Small car (including working car) up to 9 seats incl. driver		
• Brand-new imported vehicle; domestic manufactured or assembled vehicle		
(i) for transportation business	24	12
(ii) not for transportation business	30	18
• Modified/repaired vehicle		
(i) for transportation business	18	06
(ii) not for transportation business	24	12
Passenger car with more than 9 seats including driver		
• Brand-new imported vehicle; domestic manufactured or assembled vehicle		
(i) for transportation business	18	06
(ii) not for transportation business	24	12
• Modified/repaired vehicle		
(i) for transportation business	12	06
(ii) not for transportation business	18	12
Motorized three-wheelers vehicle		
• Brand-new imported vehicle; domestic manufactured or assembled vehicle		
(i) for transportation business	24	12
(ii) not for transportation business	30	24
• Modified/repaired vehicle		
(i) for transportation business	18	06
(ii) not for transportation business	24	12
All the vehicle after manufacture date more than 7 years		06
All passenger cars from 15 years and truck from 20 years since from manufacture date should have inspection every 3 months at the Inspection Center, where the inspection record of that car is recorded. All required items should be checked up as stipulated in Standards. If the inspection result meets the Standard, the Inspection Certificate will be issued with 3 month effectuation. If the inspection result doesn't meet the Standard, the vehicle should be repaired/ improved for re-inspection. If the second inspection result doesn't meet its standard again, such vehicle can't have further repairing for joining the traffic.		
1. General Observation - Number plate, outside details - Number of engine and body - Form, general layout, size limit - Body, cap - Coach, boot - Drag hook - Drag disk and bolt - Container lock - Windscreens and door screen - Windscreen wiper, water spray - Mirrors - Driver seat, rear seats - Fire protection equipment 2. Engine and other systems for vehicle operation 3. Power train 4. Tire	5. Suspension system 6. Steering system - Flywheel - Steering column - Driving rod and arm - Coupling - Center shaft - Angle travel of flywheel - Power steering - Strike slip of guide wheels 7. Break system 8. Lighting and signalling system - Front lamps - Signalling lamps - Horn 9. Environment Standards: follows the current regulations of MOT.	

Source: VITRANSS 2 Study Team

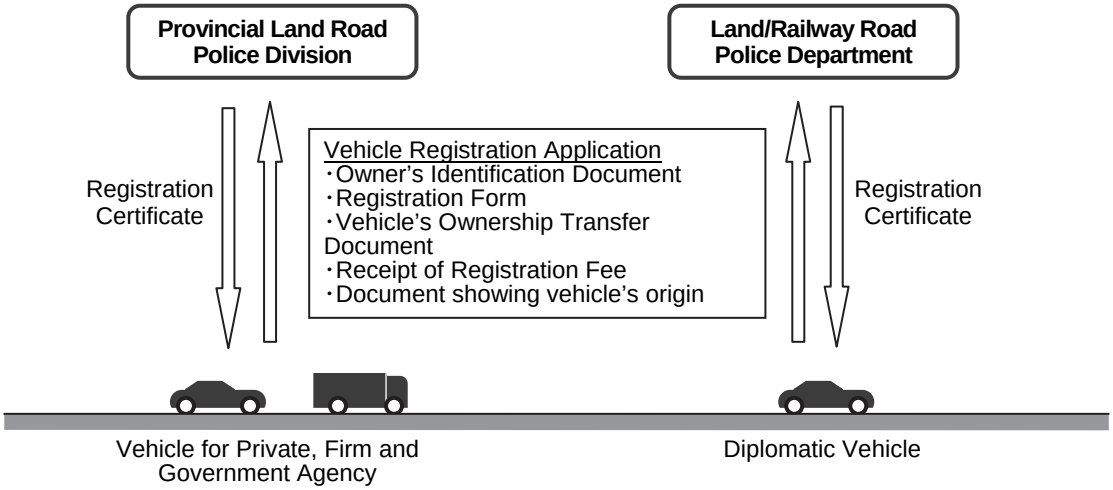
The sample shows the vehicle registration and inspection results. These registered information can be used for toll fare system based on different vehicle type if these data had been input in on board unit for ETC.

Figure 5.55 Sample of Vehicle Registration and Inspection Results

Source: VITRANSS 2 Study Team

The following figure shows the vehicle registration system. There are two different procedures are existing on the basis of the vehicle ownership. Except for the diplomatic vehicle, the same procedure is taken.

Figure 5.56 Existing Framework for Vehicle Registration



Source: ITS Integration Project (SAPI) Study Team

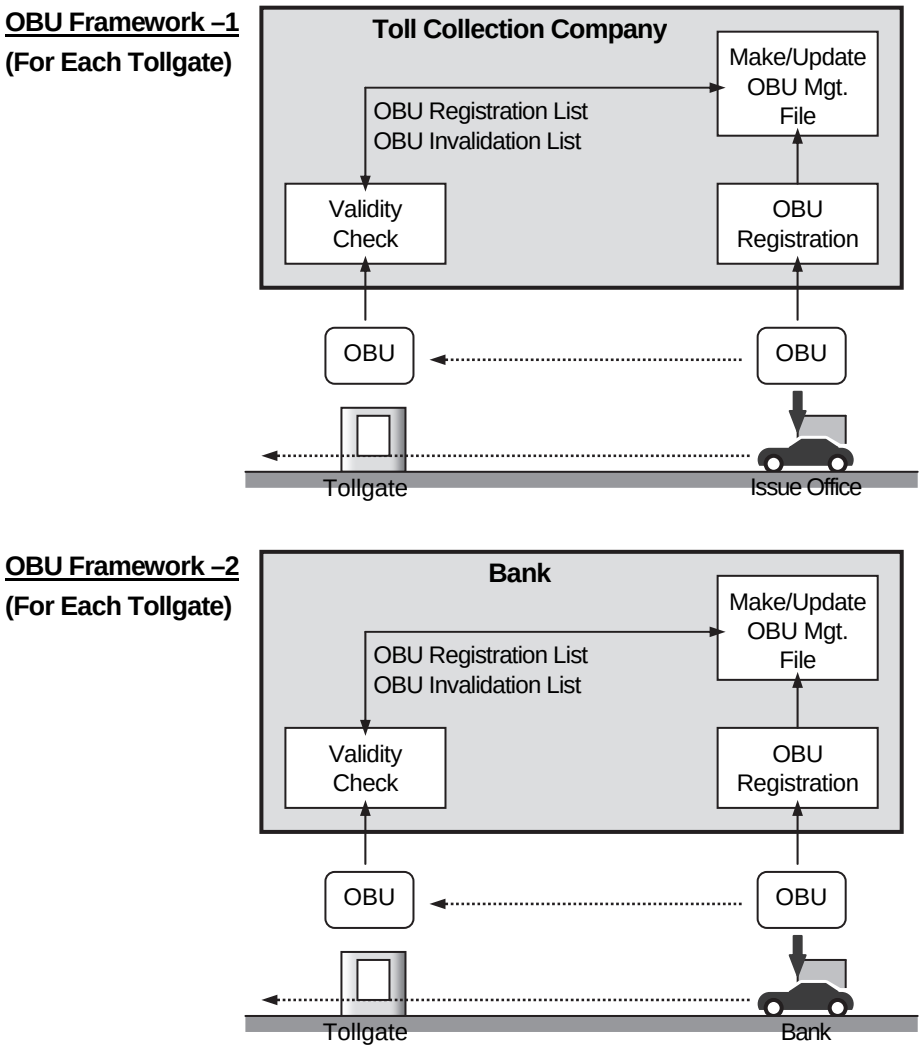
2) Existing Framework for OBU Registration/Management

The OBU is sold by VietinBank. The OBU is available at every branch office of VietinBank nationwide or at toll office located near the tollgates where VietinBank equips ETC.

The procedure to obtain the OBU is simple. Necessary documents are copies of ID card/ passport and automobile registration certificate. If the customer belongs to some organization, certificate of registry and business registration form is required additionally.

Currently 1-piece type OBU is available, and two kinds of payment methods :pre-paid and pre-payment by direct debit are available on the basis of the contract conditions. The OBU is registered and managed by two types of existing framework for each tollgate as shown below.

Figure 5.57 Existing Framework for OBU Registration/Management

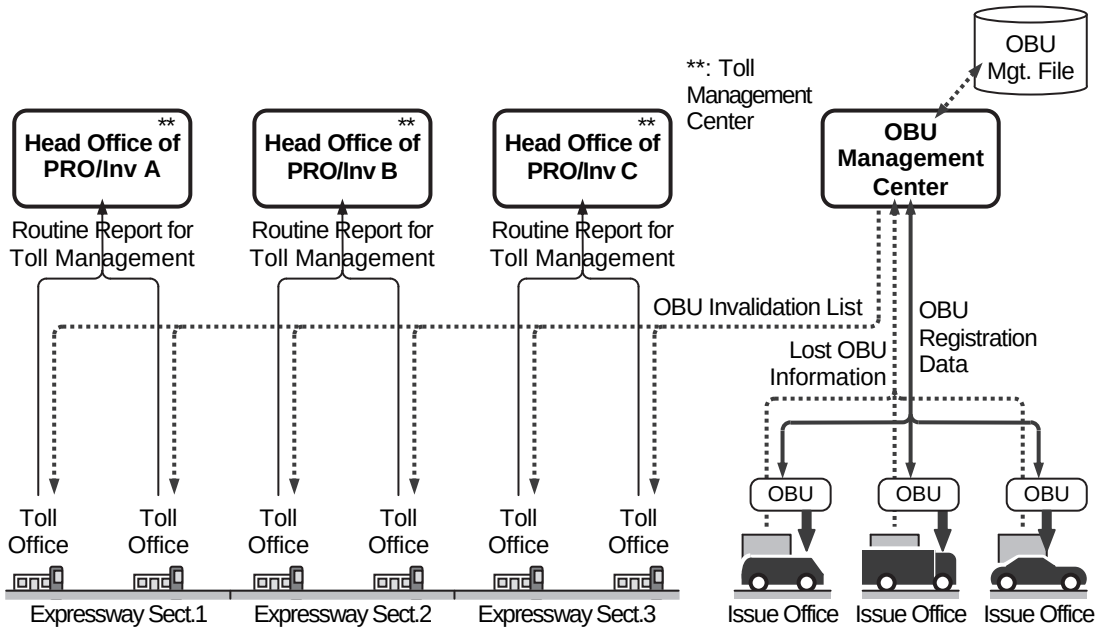


Source: ITS Integration Project (SAPI) Study Team

3) Recommended Framework for OBU Registration/Management

The framework below needs to be prepared for OBU registration/management, in which an OBU management center is operated by a unified organization for many different road owners.

Figure 5.58 Recommended Framework for OBU Registration/Management



Source: The Study Team

For creating the framework, OBU management center needs to be set up to integrate offices for OBU issuance. The lost OBU information is compiled into an OBU invalidation list at the OBU management center and the list is to be distributed to toll offices as well.

The information required for OBU registration is quite similar to the one for car registration certificates. From the viewpoint of information management, it would be ideal if they are managed in same data-base. However, the life cycle of OBU is not same as one of vehicle, the timing of OBU registration may be differ from the one of vehicles. Therefore, the OBU registration work does not have to be performed at the same time of the vehicle registration. It is possible any entities performing registration to manage the work without difficulty.

Regarding the OBU management, its major task is invalidation list management which is a quite new for the existing vehicle registration and requires an emergency action. In contrast, banks usually manage the invalidation list for their bank cards, they are already familiar with the work.

In addition to the above, it is important to consider the user-convenience for promoting the use of OBU. The number of car registration offices in Vietnam is approximately 100 in Vietnam, while the major banks in Vietnam have over 400 branches each.

Table 5.11 Role Sharing on OBU Registration and Management

	VR (Vietnam Register)	Bank
OBU Registration Capability of existing organization	High	High
OBU Management Capability of existing organization	Low	High
User Convenience Accessibility	Middle	High
Grade	Not Suitable	Suitable

5.5.5 Framework for Toll Enforcement

1) Existing Conditions of Enforcement on Road Traffic

(1) Penalty for Illegal Parking

This is regulated in Decree No.146/2007/ND-CP, which has warning notice, monetary penalty and supplementary sanctions (expropriating the permit, license, certificate forever or for a certain period; to confiscate exhibits, means which were used for such violations), for administrative violation. Followings are fine rate for penalty of illegal stopping and/or parking.

Table 5.12 Fine Rates for Illegal Stopping/Parking

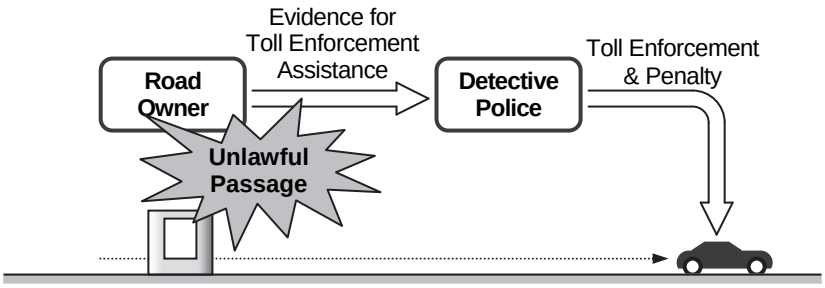
Fine Rate	100,000–200,000 VND	200,000–600,000 VND	600,000–1,000,000 VND
Case	• stopping, parking the vehicle without giving signals to operators of other means en route; • stopping, parking vehicles on the carriageway of non-urban roads, which have with broad roadsides; temporary stopping, parking the vehicle not closely to roadside on the right along to running direction where the roadsides are narrow or not available; stopping, parking the vehicle in inappropriate places on the road where car stops and/or are available; parking the vehicle on the slope without chocking the wheels. • stopping, parking the vehicle at the sports: on the left side of one-way road, on winding road sections and near slope heads where visibility is restricted; on bridges, under flyovers, in parallel with other stopping or parking vehicles; at cross-sections; at bus stops; on road wide enough only for one lane; covering the road signboards; • steeping down from the car when stopping the car; opening car door or leaving the door open without safety conditions. • illegal stopping, parking vehicles urban road; on the electric railways • If all above violations cause accidents but not at serious level supplementary penalty would be given, i.e. expropriating driving licenses for 90 days, at serious level – timeless revoking driving licenses.	• illegal stopping, parking vehicles on the road bed and roadside • If above violations cause accidents but not at serious level supplementary penalty would be given, i.e. expropriating driving licenses for 90 days, at serious level – timeless revoking driving licenses.	• Stopping, parking vehicles causing traffic congestions . • stopping, parking vehicles, opening car doors causing accident (If violations cause accidents but not at serious level supplementary penalty would be given, i.e. expropriating driving licenses for 90 days, at serious level – timeless revoking driving licenses)

Source: VITRANSS 2 Study Team

(2) Penalty for Unlawful Passage at Tollgate

Penalty for unlawful passage at tollgate is to be processed by detective police as shown in the following figure.

Figure 5.59 Existing Framework for Toll Enforcement



Source: ITS Standards & Operation Plan Study Team

2) Typical Policy of Toll Enforcement

Policies of toll enforcement can be broadly classified into the two types below. Policy 1 is adopted in many Asian countries, and Policy 2 is adopted in many European/American countries. In the Study, toll enforcement shall be discussed based on Policy 1 regarding common penalty systems in Vietnam.

Policy 1: Enforcement giving greater importance to fairness among the users

- Introduction of a relatively small penalty system aiming at a fixed deterrent effect
- Introduction of a highly reliable system intending a high exposure ratio for unlawful passages.

Policy 2: Enforcement giving greater importance to save manpower and cost

- Introduction of a heavy penalty system aiming at a large deterrent effect
- Introduction of a simple system intending a fixed exposure ratio for unlawful passages.

3) Conceivable Conditions of Toll Enforcement

(1) Legal Preconditions

It is assumed that the following legal definitions are prepared in advance of introducing ETC to complete the framework of toll enforcement:

- Legal Toll Payer: The IC-card owner shall be assumed as the legal toll payer when the intention to use the road service becomes apparent when IC-card is put in OBU. In the case of vehicle passage without IC-card put in OBU, the vehicle owner shall be assumed as the legal toll payer, because he has the obligation to put IC-card in OBU.
- Back Tax: Back tax shall be introduced for deterring mistakes and failures (e.g. 3-fold the regular toll amount).
- Penalty: Penalty shall be introduced for deterring unlawful passages (e.g. 3 million VND penalty charge for a violation).

(2) Assumed Cases of Unlawful Passage

Procedure of toll enforcement assistance is to be prepared for the following assumed cases:

- Mistake: Passage not turning on OBU, not putting IC-card into OBU, or not preparing enough prepaid balance of IC-card
- Failure: Passage under function failure of OBU or IC-card

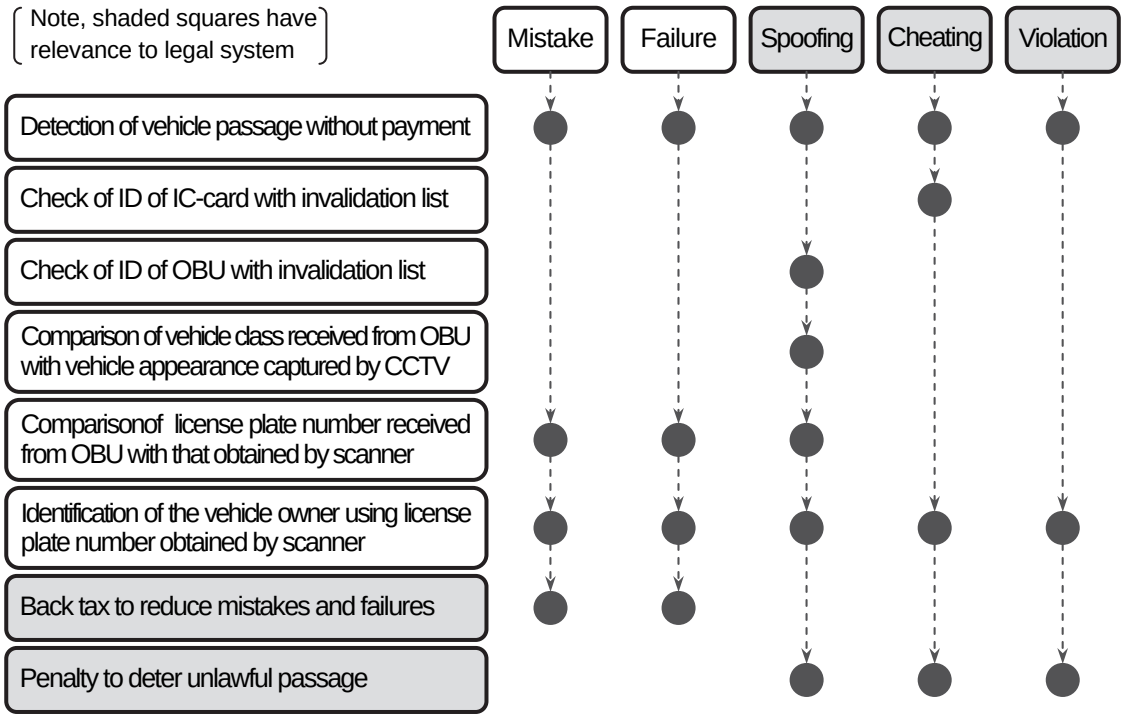
- Spoofing: Unlawful passage re-installing OBU to other vehicle or tampering with the vehicle class data in OBU
- Cheating: Unlawful passage tampering with the prepaid balance data or the bank account data in IC-card
- Violation: Unlawful passage without making available toll payment methods.

(3) Procedure of Toll Enforcement Assistance for ETC

In the case of ETC, some kinds of spoofing can be detected automatically by sensors; however, it is difficult to distinguish cheating and violation from mistake or failure without manpower. The following contorl measures including legal ones shall be taken for toll enforcement.

- Detection of vehicle passage without payment
- Check of ID of IC-card and OBU with invalidation list
- Comparison of vehicle class received from OBU with vehicle appearance captured by CCTV
- Comparison of license plate number received from OBU with that obtained by scanner
- Identification of the vehicle owner using license plate number obtained by scanner
- Back tax to reduce mistakes and failures
- Penalty to deter unlawful passage

Figure 5.60 Procedure of Toll Enforcement Assistance for ETC

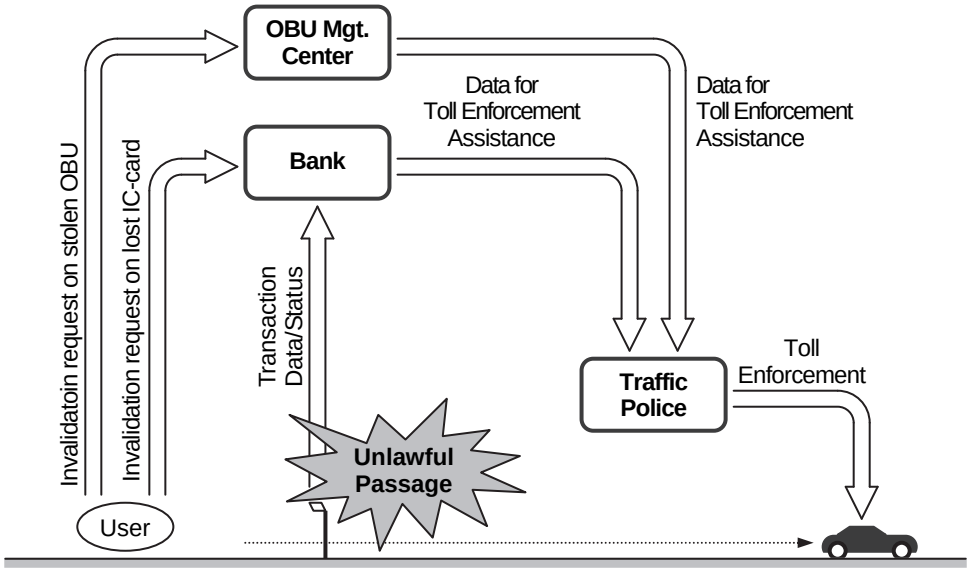


Source: ITS Standards & Operation Plan Study Team

4) Recommended Framework for Toll Enforcement (including Invalidation)

The recommended framework for toll enforcement and invalidation is shown in the figure below. In the framework, invalidation of IC-card or OBU is to be claimed by the user and the enforcement process is to be performed in cooperation between the road owner and the detective police through the bank and OBU management center.

Figure 5.61 Recommended Framework for Tol Enforcement (including Invalidation)



Source: The Study Team

5.6 Framework for Overloading Regulation

1) Existing Conditions of Overloading Regulation

According to the Study on "Vietnam Road Safety Phase 2 and Load Control (CONSIA)" shows that all trucks tend to carry overload. The data shows that

- On National Highway Route 3, the rate of overloaded trucked varies from 28% to 90%.
- On Notational Highway Route 5 (surveyed in May 2006), 30% overloaded trucks with overloaded rate of 200% in terms of weight.

(1) Law and Regulation for Vehicle Weight Control

There are law and regulations for vehicle weight control as below.

- Circular, No.07/2010/TT-BGTVT, dated 11/02/2010, Regulation on loading and limit size of vehicles on the road, issues on over-loading or over-size vehicles, issues on special or over-loaded/over-sized goods loaded on vehicles in the highway network
- Decree, No.146/2007/NĐ-CP, dated 14/09/2007
- Decision, No.20/2008/QĐ-BGTVT, dated 02/10/2008
- Circular, No.21/2001/TT-BGTVT, dated 10/12/2001
- Decision, No.05/2007/QĐ-BGTVT, dated 02/02/2007 (replaced Decision, No 42/2005/QĐ-BGTVT, dated 16/9/2005)

The Decree No.146/2007/NĐ-CP specifies the types of violation, penalty and procedures against violators.

(2) Historical and Current Enforcement Method

In 2003, Prime Minister gave the decision to establish 27 vehicle weight stations on national highways (according to decision No 455/TTg dated 04/09/2003), this is static weight stations and some portable weight equipments. At the each weight station included 3 forces, such as (i) Traffic Inspectors (staffs of Ministry of Transport), (ii) Traffic Polices and (iii) Military Inspectors. After some years, the traffic polices and military inspectors were no longer work in the weight stations. Then, all of 27 vehicle weight stations had been stopped their works since October, 2003. Table 5.15 shows the location of 27 weight stations.

The Vietnam Government issued in the document No 1882/TTg-CN, dated 03/12/2007, that the pilot project will be conducted by modernize and restore of 2 weight stations in Dong Nai Province & Quang Ninh Province.

(3) Pilot Project for Weight Control (Weigh-in-Motion) at Dau Giay

According to Invitation Letter of VRA, No 38/CĐBVN-KHCN & HTQT, the general requirements of pilot project for weight control at Dau Giay are as follows;

- Ability to control load on each lane separately
- The vehicle must be tested at WIM System before the inspection at static weight system.
- The system must have CCTV System to record images, number plate, time, images of staff in the operation static weight system.
- The system must connect to the data system of VRA

- This pilot project has been started since March, 2009 at Dau Giay on national highway route No 1, and planning another implementation at national highway rout 13. The purpose of this project aims to find the suitable procedure and technical requirements for modern weigh control and to apply to develop 27 weigh station described above.

Table 5.13 List of 27 Weight Stations on National Highway

	Station Name	Location
1	Pho Huong Station	Km57, QL3, Thai Nguyen
2	Bac Ninh Station	Km138+70057, QL1, Bac Ninh Town
3	QUANG NINH Station	Km103+800, QL18, Hoanh Bo
4	Vinh Phuc Station	Km47, QL2, Vinh Phuc
5	Ky son station	Km63, QL6, Hoa Binh
6	Quan Toan Station	Km87, QL5, Hai Phong
7	Phu thuy Station	Km15, QL5, Gai Lam, Ha noi
8	Phu Ly Station	Km231, QL1, Ha Nam Town
9	Hong Linh Station	Km481, QL1, Ha Tinh
10	Nam Gianh Station	Km657, QL1, South of Pha Gianh (Quang Binh)
11	Cam lo Station	Km15, QL9, Quang Tri
12	Que Son Station	Km965+500, QL1, Quang Nam
13	Ba To Station	Km18+250, QL24, Quang Ngai
14	Tru A Station	Km159+750, QL19, Gia Lai

	Station Name	Location
15	Ba Di Station	Km1214+500, QL1, Binh Dinh
16	Phu Yen Station	Km1537+500, QL1, TX Tuy Hoa
17	Madrak Station	Km62+900, QL26, Dac Lac
18	Kien Duc Station	Km871+089, QL14, Dac Nong
19	Ca Du Station	Km1551, QL1, Ninh Thuan
20	Chon Thanh Station	Km68+800, QL13, Binh Phuoc
21	Suoi Sau Station	Km31, QL22, Tay Ninh
22	Dau Giay Station	Km1846+700, QL1, Dong Nai
23	Binh Phuoc Station	Km1888+600, QL1, Tp.HCMC
24	Ben Luc Station	Km1934, QL1, Long an
25	My thuan Station	Km2028, QL1, Vinh Long
26	Hau Giang Station	Km2068, QL1, Can tho
27	My Tu Station	Km2126, QL1, Soc Trang

Source: VITRANSS 2 Study Team

It is operated by 4 officers who belong to different organization (i.e. VRA-RRMU, PDOT-Traffic Inspector, Military Control and Provincial Traffic Police) based on the agreement with MOT and People's Committee. The technical requirements of this system which has "Static Weigh System" and "Weigh-in-Motion (WIM) System" are described in table below. The procedure of this system which is installed in Gau Diay is following steps. The photo of WIM and static weigh system is shown below.

- A vehicles go to the WIM System, it will activity and measure parameters such as: weight, the distance of axle, Number plate, image of vehicle, parameters are calculated and transmitted to the control center at Static Weight System.
- If the vehicle is overloaded, the system with lamps and will display alerts for the stations. Overloaded Vehicles need go to the Static Weight System to check again.
- If the vehicle is not overloaded, passing to the system without stop.
- When vehicle is overload for second check at Static Weight System: If overload, staff will penalty and require drivers remove of goods.
- All data, pictures, will be displayed on the monitor in Control center, restored, processed

Table 5.14 Technical Requirements of Static Weight System and WIM System

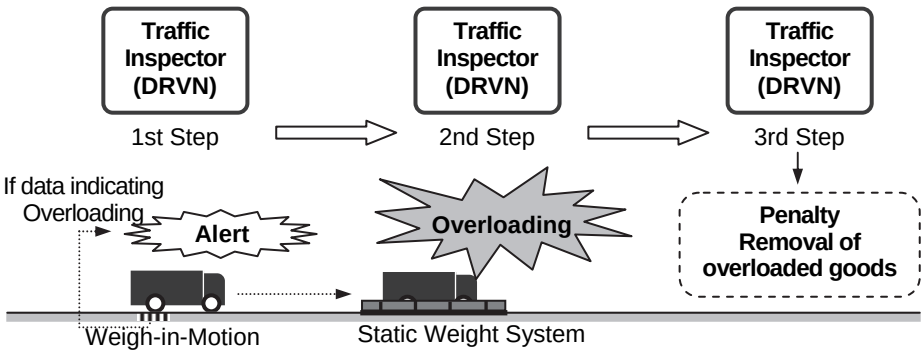
System	Static Weight System	Weigh-in-Motion (WIM) System
Technical Requirements	- Measure the load of each vehicle axles - Maximum load allowed: Not more than 30 tons - Accuracy: 3 tons - Software can record all information and calculate the weight of the vehicle. - Allows setting up and changing the threshold for the overloaded: axles, group of axles and vehicle. - Entry and store data of vehicle in the inspection processing. - Statistics and general data, data connection between WIM and static weight system - The system must register with the measurement quality of Vietnam	- Measure the load of each vehicle axles - Maximum load of axle allowed: Not more than 20 tons - Speed of vehicle through WIM System: Not more than 50 km/h - Determine the speed run, the distance of axles, No. axles and total weight of vehicle - Allows setting up and changing the threshold for the overloaded: axles, group of axles and vehicle. - Automatically detect overloaded by axle weight and the total weight of the vehicle - System controls traffic alerts overloaded vehicles go to the static weight system - System statistics the volume and classification of vehicles go through the station - Data connection between WIM and static weight system - Accuracy: Not more than 10% for the weight of axle, 3% for speed, 0.2m for the distance of axle

Source: VITRANSS 2 Study Team

Figure 5.62 WIM System (Left) /Static Weigh System (Right) /Static Weighbridge (Below)

Source: VITRANSS 2 Study Team

Figure 5.63 Existing Procedure for Overloading Regulation

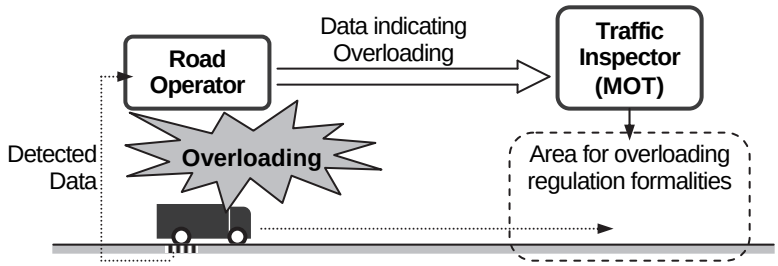


Source: ITS Integration Project (SAPI) Study Team

2) Recommended Framework for Overloading Regulation on Expressway Network

It is defined by the Decree 34/2010/ND-CP that actual procedure to enforce overloading regulation is a task to be conducted by the traffic inspectors. The role of road operator is to handover the inspector the information on the overloaded vehicle and the data from vehicle weighing system which indicates the fact of overloading.

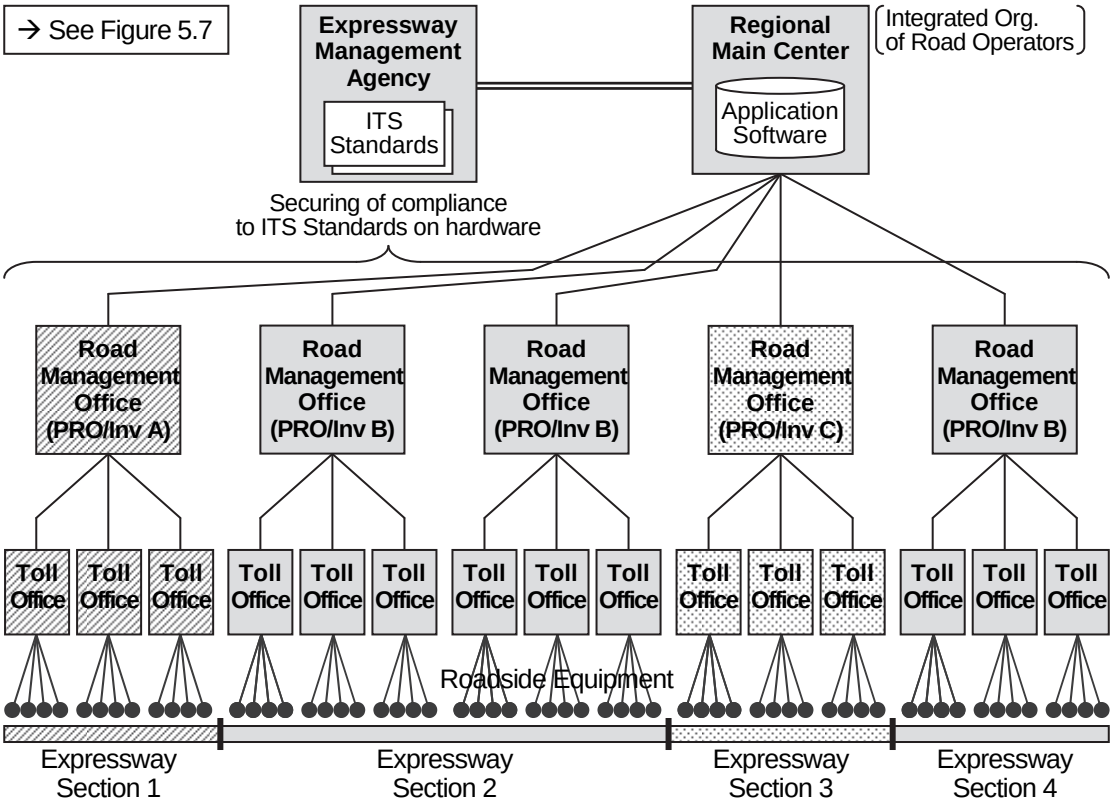
Figure 5.64 Recommended Procedure for Overloading Regulation on Expressway Network



Source: ITS Standards & Operation Plan Study Team

The framework for overloading regulation shown in the figure below is to be defined as a premise for discussion in the Study. This framework includes many different road owners, who own the expressway section and the vehicle weighing system, and the Regional Main Center. The Standards on hardware is to be managed by the Expressway Management Agency in MOT The application software is to be managed in the Regional Main Center and the part for roadside operation is to be distributed under license to each road owner.

Figure 5.65 Recommended Framework for Overloading Regulation on Expressway Network



Note: ▌: Barrier tollgates between the expressway sections of different road operators

Source: The Study Team

5.7 Framework for Integrated Data Management

1) Necessities of Integrated Data Management for Operation of Expressway Network

Integrated data management system of expressway network is necessary and important for the expressway operation and maintenance by the following reasons:

- Utilization of 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
- Validity check on toll revenue data in comparison with traffic data.

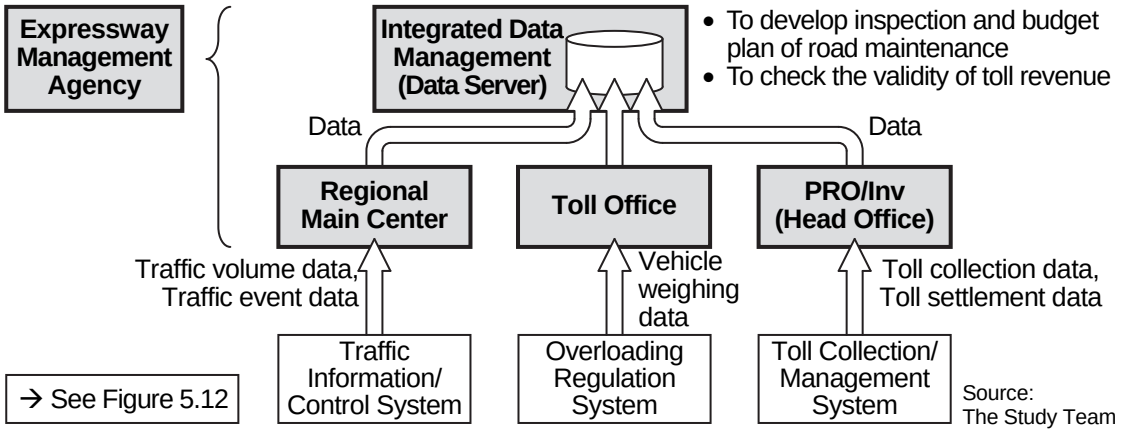
For establishing a sustainable system for maintenance of expressway network, it is necessary to develop the inspection and budget plan for road maintenance. For this purpose, measured data, such as the traffic volume and large vehicle ratio detected by traffic information/control system and the axle load measured by vehicle weighing system, are to be acquired and analysed for estimating the damage to the pavement or the bridges.

For establishing a sustainable concession system for expressway operation, it is necessary to secure appropriate and reliable apportionment of toll revenue among the road operators by prevention of unfair billings to the bank: the prepayment service center. For this purpose, the validity of toll revenue data of the road owners are to be checked in comparison with traffic data in the Regional Main Center.

2) Recommended Framework for Integrated Data Management

The framework shown below needs to be prepared for integrated data management. Traffic data, axle load data and toll revenue data are to be acquired and stored at the same place, and to be utilized for developing plans of inspection and budget for road maintenance and checking the validity of required toll revenue.

Figure 5.66 Recommended Framework for Integrated Data Management



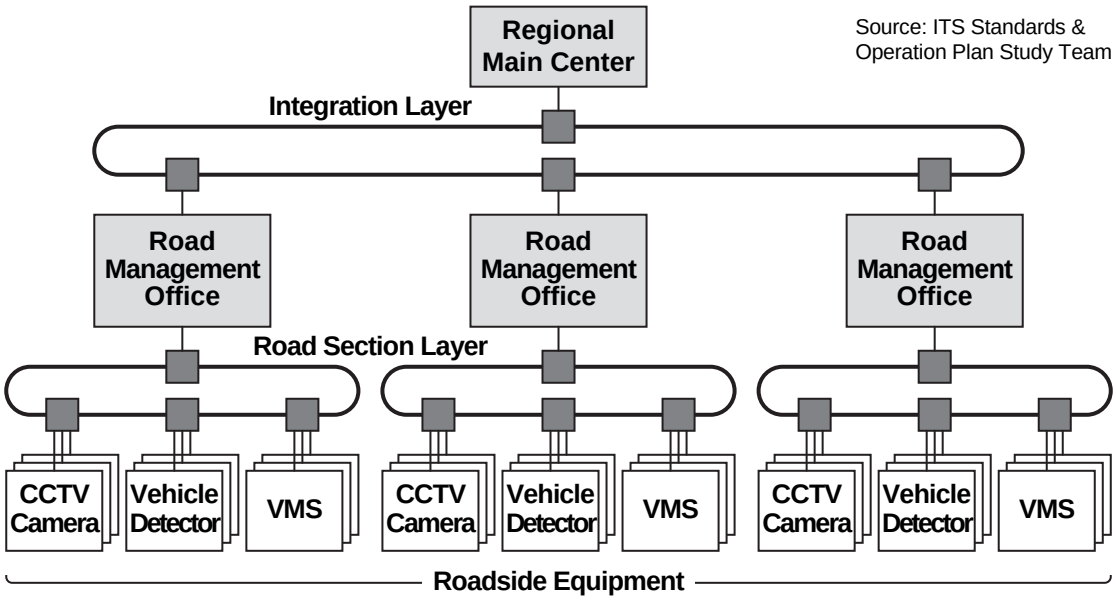
5.8 Framework for Communication Network Management

5.8.1 Key Framework

1) Hierarchical Network Structure for Road Operation

For road operation, a hierarchical communication network needs to be established. The reason is that fiber optic rings of road section layer for connecting a road management office and pieces of roadside equipment need to be installed section by section keeping pace with the road construction; however an integration layer is necessary for connecting the Regional Main Center and road management offices for total road operation.

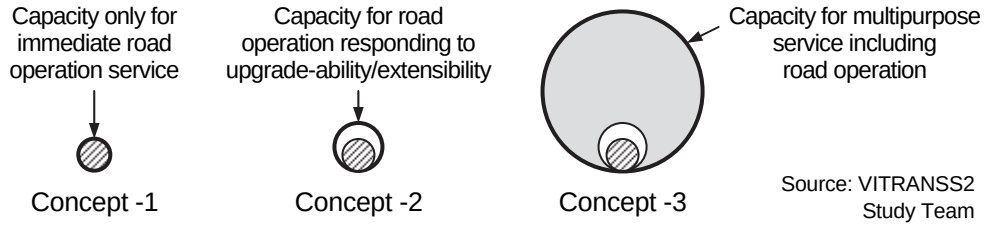
Figure 5.67 Hierarchical Network Structure



In addition, transmission capacity is an important factor for discussing communication network management, which is to respond to the scope of services provided through it. Three typical concepts are proposed for setting target transmission capacity of the communication network:

- Concept -1: Capacity only for immediate road operation service
- Concept -2: Capacity for road operation service with upgrade-ability/extensibility
- Concept -3: Capacity for multi-purpose service including road operation.

Figure 5.68 Concepts of Target Transmission Capacity of Communication Network

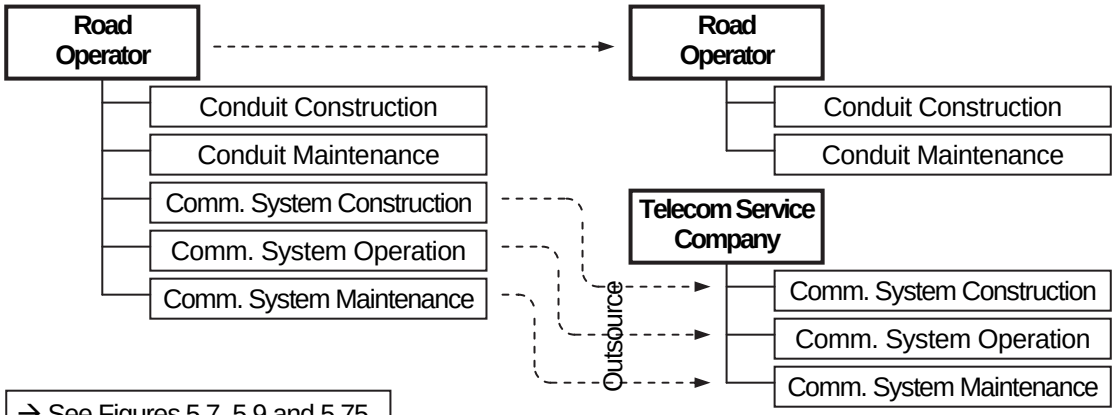


2) Applicable Framework for Communication Network Management

Several applicable frameworks for communication network management are compared in

the table below, considering role/cost sharing among organizations and revenue increase for the road operator. From a viewpoint of role sharing, the system transfer & use of telecom service is to be selected as a suitable framework for communication network management for the expressways in Vietnam.

Figure 5.69 Role Sharing on Communication Network Management



Source: ITS Integration Project (SAPI) Study Team

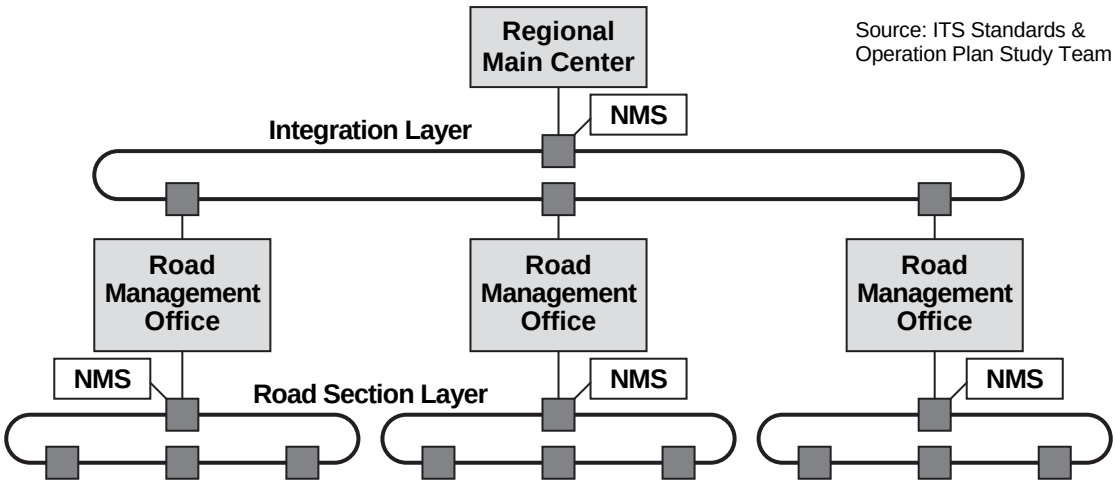
Table 5.15 Comparison on Frameworks for Communication Network Management

	Ownership & O/M	O/M Contract	Comm. System Lease Contract
Target Transmission Capacity	Concept-2	Concept-2	Concept-2
Owner of Duct	Road operator	Road operator	Road operator
Owner of Comm. System	Road operator	Road operator	Road operator
O/M of Comm. System	Road operator	Subcontractor	Road operator, Telecom service co.
Comm. System Engineer Employed by Road Operator	Necessary	Not necessary	Necessary
Cost for Road Operator	Construction cost, O/M cost	Construction cost, O/M service fee	Construction cost, Maintenance cost
Revenue for Road Operator	None	None	Lease charge paid by telecom service co.
Grade	Not Suitable	Not Suitable	Not Suitable
	System Transfer & Use of Telecom Service	Conduit Lease Contract	Use All of Telecom Service
Target Transmission Capacity	Concept-3	Concept-3	Concept-3
Owner of Duct	Road operator	Road operator	Telecom service co
Owner of Comm. System	Telecom service co	Telecom service co	Telecom service co
O/M of Comm. System	Telecom service co	Telecom service co	Telecom service co
Comm. System Engineer Employed by Road Operator	Not necessary	Not necessary	Not necessary
Cost for Road Operator	Construction cost, Conduit maintenance cost, Telecom service fee	Conduit construction cost, Conduit maintenance cost, Telecom service fee	Telecom service fee
Revenue for Road Operator	Transfer charge paid by telecom service co.	Lease charge paid by telecom service co.	None
Grade	Recommended (→ See Figure 5.7)	Average	Not Suitable

2) Typical Methods for Maintenance on Expressway Network

The network needs to be managed by using NMS (Network Management System). However, since there is no compatibility among NMSs supplied by different suppliers. An adequate organization needs to be set up to manage the hierarchical communication network for road operation.

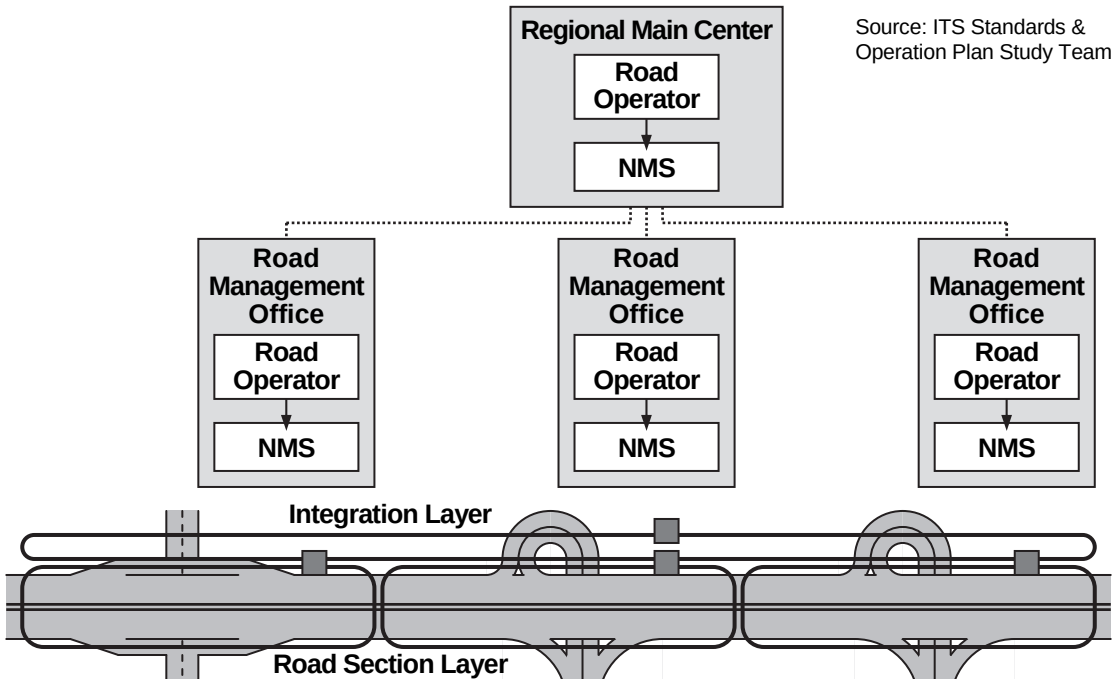
Figure 5.70 Communication Network Management



(1) Method-1: Management Respectively by the Road Operators

Communication network consists of roadside layer and integration layer, and both layers are to be managed by the respective road operators.

Figure 5.71 Management by the Respective Road Operators

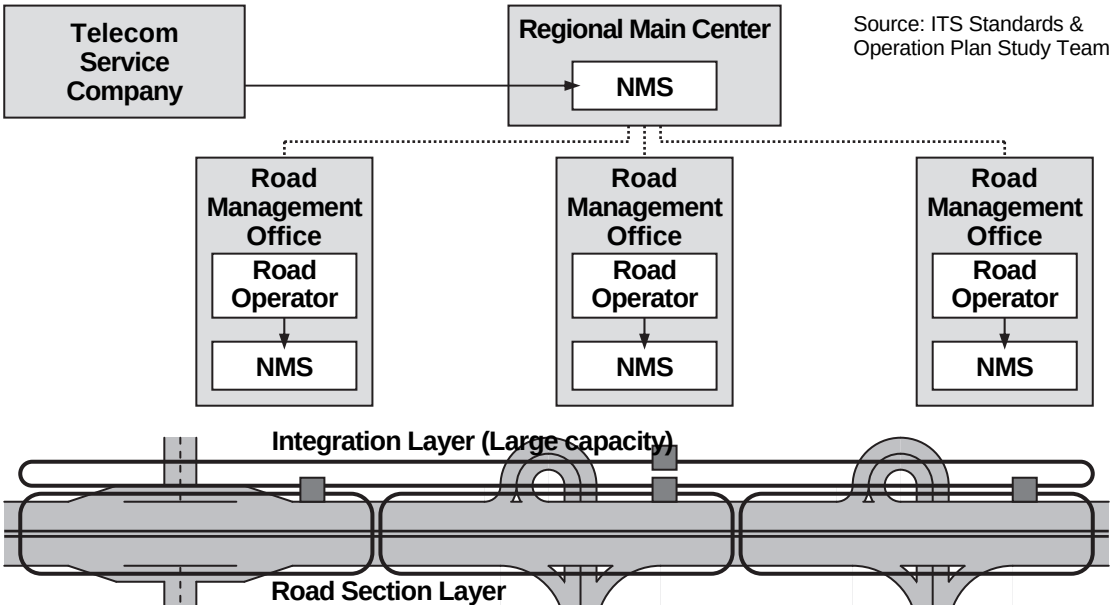


Note: Roadside layer: for connecting a road management office and pieces of roadside equipment, Integration layer: for connecting the Regional Main Center and road management offices, NMS: Network Management System.

(2) Method-2: Management by the Road Operators with Integration by a Telecom Service Company

Communication network consists of roadside layer managed by the respective road operators and integration layer managed by a telecom service company.

Figure 5.72 Management by the Road Operators with Integration by a telecom service Company

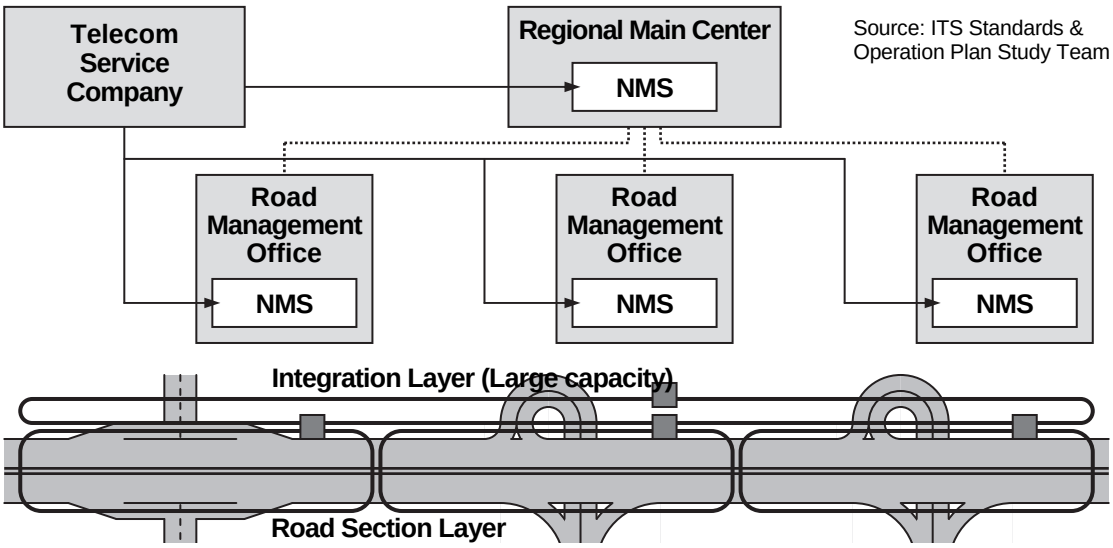


Note: Roadside layer: for connecting a road management office and pieces of roadside equipment, Integration layer: for connecting the Regional Main Center and road management offices, NMS: Network Management System.

(3) Method-3: Operation Totally by a Telecom Service Company

Communication network consists of roadside layer and integration layer, and both layers are to be managed totally by a telecom service company.

Figure 5.73 Operation Totally by a Telecom Service Company

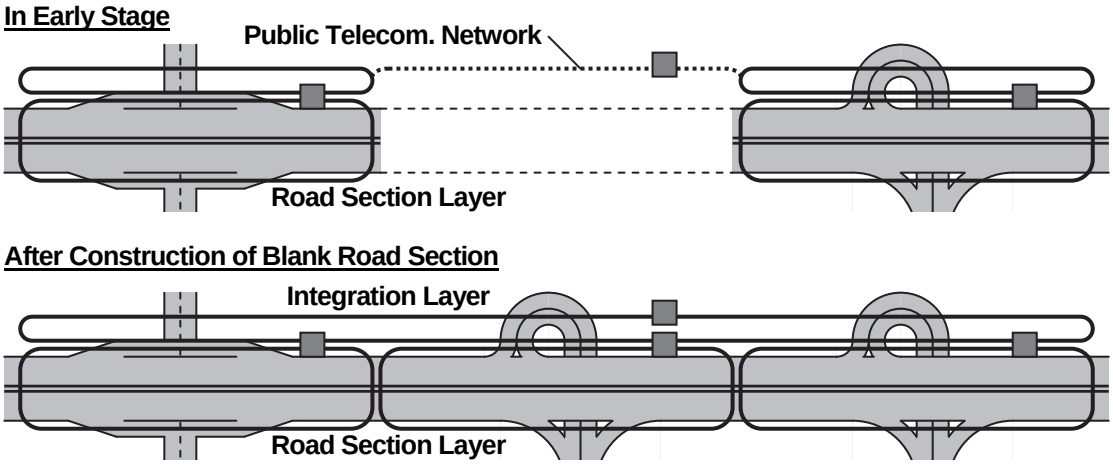


Note: Roadside layer: for connecting a road management office and pieces of roadside equipment, Integration layer: for connecting the Regional Main Center and road management offices, NMS: Network Management System.

(4) Additional Case: Operation during Construction of Communication Network

In addition, a fiber optic cable network is to be installed by road sections. For any blank sections, a public telecommunication network is to be used as a complement in early stage as shown below; later, the fiber optic cable is to be installed to form linked loops after construction of the blank road section.

Figure 5.74 Stepwise Installation of Fiber Optic Cable

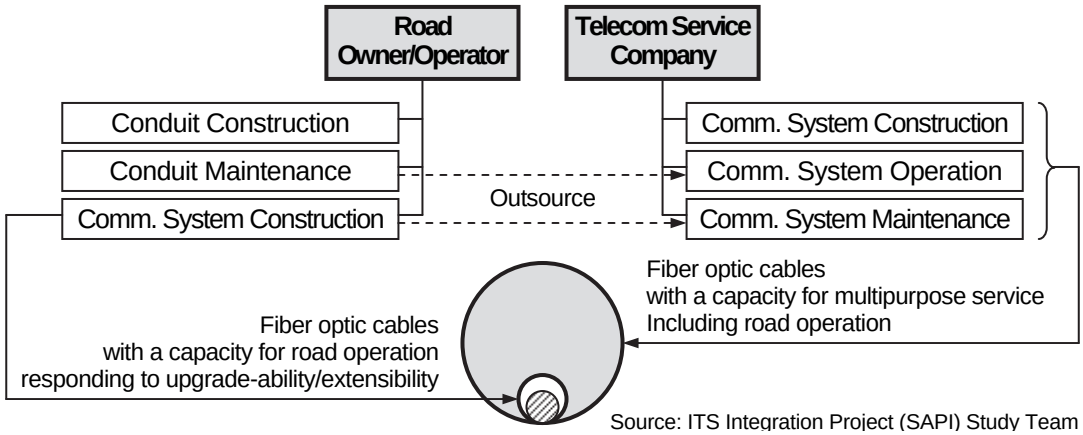


Source: ITS Standards & Operation Plan Study Team

3) Recommended Framework for Communication Network Management

The framework below is recommended communication network management from the results of comparison shown in Table 5.17. There are several different functions in the operation and maintenance of communication Network, such as resource management, network performance monitoring or fault detection. Those functions are realized by using Network Management System (NMS). It is recommended for road owners/operators to outsource the communication network management to a telecom service company, because telecom service companies have higher skills. Introduction of communication system/equipment also is to be outsourced to the telecom service companies in the future, as proposed in the Decision No.3569/VPCP-KTN VNPT, because they can select appropriate system, which will not be the hindrance of the operation and maintenance.

Figure 5.75 Recommended Framework for Communication Network Management



Source: ITS Integration Project (SAPI) Study Team

5.8.2 Framework for Radio Frequency Allocation

1) Necessities of Radio Frequency Allocation

In ITS, radio communication is to be used for exchanging information between patrol crews and road-to-vehicle data for ETC. However, for utilizing radio communication, it is necessary to allocate a specific radio frequency bandwidth for the intended purpose, to clear away usage for the other purpose and to prevent interference.

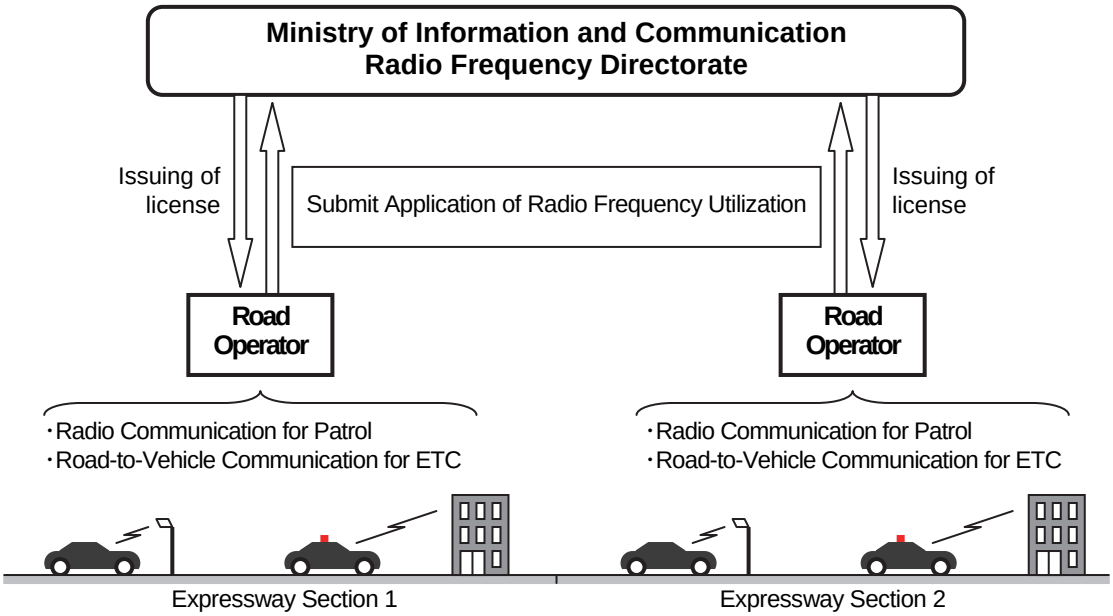
In the Draft ITS Standards prepared in the Study, the radio frequency bands and channels shown below are assumed to be allocated to communication for patrols and ETC. Toward that end, formalities for radio frequency allocation need to be conducted at the Radio Frequency Directorate in MIC (Ministry of Information and Communication) in advance.

- Radio communication for patrols: UHF band (3 channels, available VHF band as well)
- RF-Tag for ETC: UHF band (more than 2 channels at 865 MHz)
- DSRC for ETC: Microwave band (more than 2 channels at 5.8 GHz)

2) Framework for Radio Frequency Allocation

Upon the utilization of radio frequency, there is a band necessary to obtain the license. The necessity of the license should be checked to Radio Frequency Directorate, if the frequency to be used is required to be licensed, the road operator in road management office should submit the application to Radio Frequency Directorate, and before installing the radio transmitter, the license shall be obtained. The information required for application of the license is name of applicant, objective of utilization, frequency band, location of transmitter, output power and other information required by Radio Frequency Directorate. The application should be submitted in accordance with Decree No. 24/2004/ND-CP, dated January 14, 2004. The necessary period from submit the application up to obtaining the license will be approximately 20 days. The maximum effective period of the license will be 5 years and it should be extended if it is necessary.

Figure 5.76 Framework for Radio Frequency Allocation



Source: ITS Integration Project (SAPI) Study Team

5.9 Framework for System Maintenance

1) Necessities of System Maintenance on Expressway Network

Once commencement of ITS operation, equipment components in the Regional Main Center, in road management offices, in roadside, and communication network related equipment components should be operated 24 hours a day 365 days in a year continuously. Should there be found failure or fault, the downtime shall be minimized.

In order to realize such operation conditions, the appropriate organization, capable technical staff, necessary spares and tools are required to be ready for maintenance. In addition, required budget should be allocated for the maintenance works.

The maintenance quality for the equipment component to be introduced should be the same level among the different expressway sections. The equipment components to be installed in the specific road management section is supposed to be maintained by the road operator in charge of that expressway section, and those equipment components should be maintained properly by each road operator.

As for communication network, it is composed of integration layer which connects between the Regional Main Center and the road management offices, and both road section and the terminal layers which connects between road management office and roadside equipment components.

Since it is supposed to be different management organization for the integration layer and the road section layer respectively, each network should be maintained properly by each maintenance organization in charge.

Should there be made improper maintenance, the following concern may arise:

- Delay of response to the incident (In the worst case, injured person will not be rescued)
- Due to no dissemination of the proper information with VMS, delay of arrival of the destination of the expressway users and economic loss induced by this.

So as not to become such situations, it is essentially required to ensure to establish necessary organization and to assign skillful staff including outsourcing possibility. It is noted that the required budget allocation for the maintenance is also essentially required.

2) Recommended Framework for System Maintenance on Expressway Network

The following equipment components are to be maintained for expressway operation:

(1) The equipment components related to ITS to be installed in the Regional Main Center and road management offices
(2) The equipment components related to ITS to be installed at Roadside
(3) The communication network related to ITS

In the foregoing discussion on the total framework of expressway operation, the following points are recommended for the operation of equipment components (1) and (2) above;

- Toll collection/management is recommended to be operated by the Road Owner
- Traffic information/control and overloading regulation is recommended to be operated

by the road operator

Taking the conditions above into consideration, In addition, equipment components included in functional packages are recommended to be maintained by the same organization respectively.

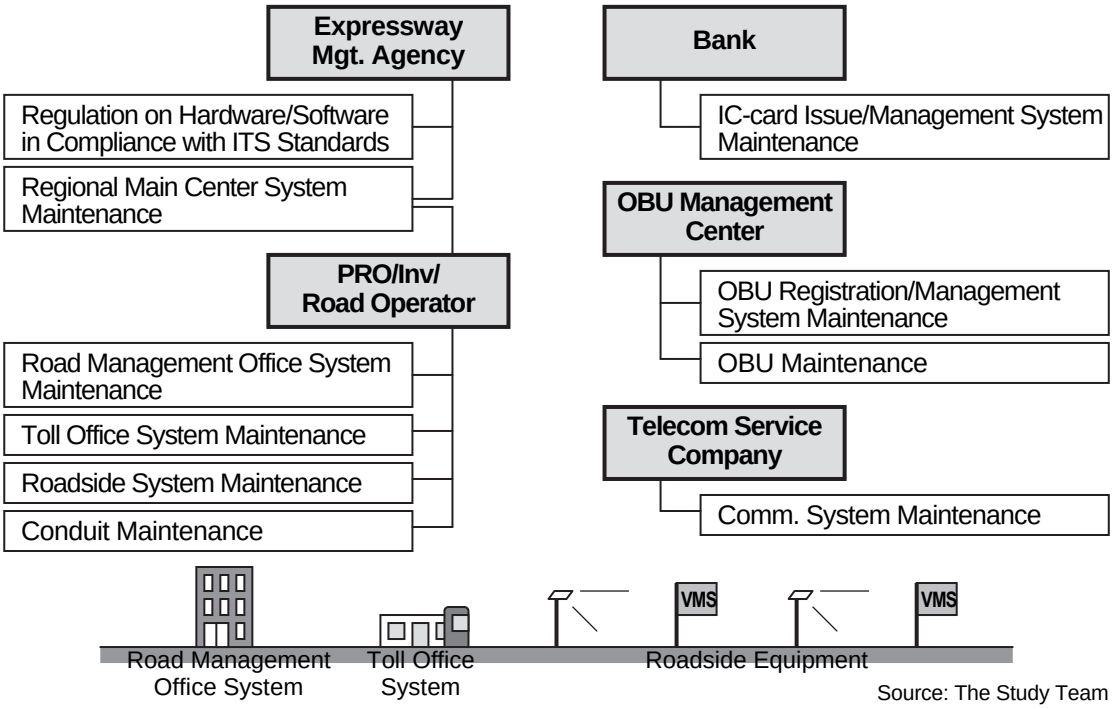
On the other hand, the equipment components of communication system is to be owned/ operated/maintained by the telecom service company in the future. As for the ducts, road operator is recommended to be owned.

After commencement of operation of communication network, it should be maintained 24 hours a day and 365days in a year. The fault occurrence and other monitoring should be made by the Network Management System and whenever required, the faulty parts shall be replaced with the spare parts. The communication network service provider provides such operation and maintenance services and deeply understands the technical know-how. Although the contract with the communication network service provider will be required, it is a merit for road operator to concentrate its own duty.

It is noted that in order to function whole system without failure or fault, each equipment component should function correctly as it is required. In order to identify the faulty parts promptly, maintenance demarcation shall be physically clarified among the parties concerned, and this condition shall be clearly shown in the contract document related to maintenance.

As shown below, the system maintenace is to be shared by the Expressway Management Agency, road owners, road operators, banks, the OBU management center and telecom service companies. The maintenance of the equipment components in the Regional Main Center requires cooperation between the Expressway Management Agency and the road owners/operators, because many system functions are actualized by the cooperation among the equipment components in the Regional Main Center and at roadside.

Figure 5.77 Recommended Framework for System Maintenance on Expressway Network



Source: The Study Team

5.10 Listing of Recommended Frameworks

Discussed frameworks and conditions in building recommended frameworks for expressway operation using ITS are shown in the listing table below.

Table 5.16 Listing of Recommended Frameworks

Discussed Frameworks	Conditions in Building Recommended Frameworks
Total Framework of Expressway Operation	Concept has been established in MOT based on the recommended frameworks shown in Table 5.1, Figures 5.7 and 5.9, which are described in the Decree No.32/2014/ND-CP.
Framework for Service Level Control	Consensus for project implementation is built in MOT based on the recommended framework shown in Figure 5.12.
Framework for Traffic Control	Consensus for project implementation is built in MOT based on the recommended framework shown in Figure 5.14.
Framework for Police Car Dispatch	Recommended framework shown in Figure 5.16 has been built for the existing expressway.
Framework for Ambulance Dispatch	Recommended framework shown in Figure 5.19 has been built for the existing expressway.
Framework for Incident Notification to Road Operator	Recommended framework shown in Figure 5.23 is to be built* for the existing expressway, and the special call number is under discussion in MOT.
Framework for Traffic Restriction	Recommended framework shown in Figure 5.25 has been built for the existing expressway, and the special call number is under discussion in MOT.
Framework for Road/Traffic Monitoring	Recommended framework shown in Figure 5.27 is to be evolved simply from the existing framework.
Framework for Traffic Event Data Management	Consensus for project implementation is built in MOT based on the recommended framework shown in Figure 5.31.
Framework for Traffic Information Dissemination	Recommended framework shown in Figure 5.35 is to be evolved simply from the existing framework.
Framework for Toll Management	Consensus for project implementation is built in MOT based on the recommended framework shown in Table 5.8 and Figure 5.43.
Framework for Toll Settlement	Recommended framework shown in Table 5.10, Figures 5.45 and 5.46 is to be evolved from the framework for existing tollgates.
Framework for IC-card Issuance/Operation	A bank for IC-card issuance/operation is to be selected* to build the recommended framework shown in Figure 5.51.
Framework for OBU Registration/Management	A Center for OBU Registration/Management is to be set up* to build the recommended framework shown in Figure 5.58.
Framework for Toll Enforcement	Recommended framework shown in Figure 5.61 to be evolved from the existing framework by setting up of a bank* and a Center*.
Framework for Overloading Regulation	Consensus for project implementation is built in MOT based on the recommended framework shown in Figure 5.65.
Framework for Integrated Data Management	Consensus for project implementation is built in MOT based on the recommended framework shown in Figure 5.66.
Framework for Communication Network Management	Consensus for project implementation is built in MOT based on the recommended framework shown in Table 5.17 and Figure 5.75.
Framework for Radio Frequency Allocation	Recommended framework shown in Figure 5.76 is included in the existing framework.
Framework for System Maintenance	Consensus for project implementation is built in MOT based on the recommended framework shown in Figure 5.77.

Note: * : Mentioned in Chapter 15 as the required conditions for project implementation

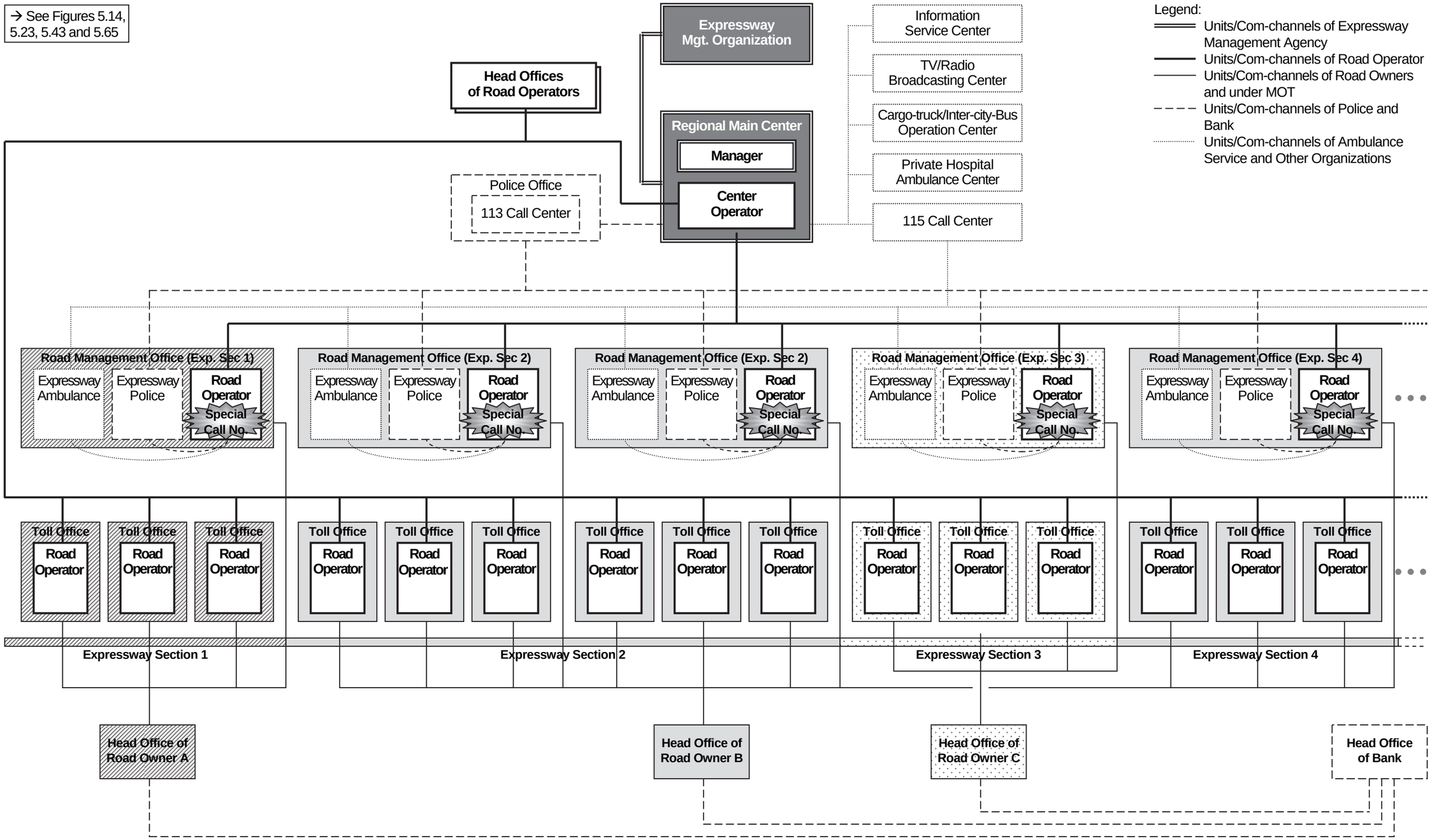
Source: The Study Team

5.11 Organization of Road Owner/Operator

The discussion results foregoing can be integrated as the organization of road owner/operator as shown in the figure in the following page.

In this figure, the organization of the road operator is indicated by using heavy solid lines, the organizations and relationships of the road owners and under MOT are indicated by thin lines and other organizations and relations are indicated by dotted lines.

Figure 5.78 Organization of Road Owner/Operator and Relationships with Other Organizations



Source: ITS Integration Project (SAPI) Study Team

6. System Operation/Management Plan

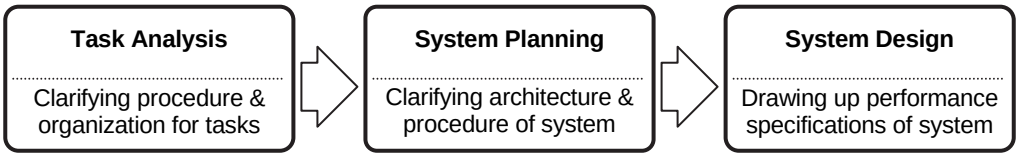
6.1 General

Operation and management of the system was discussed in this chapter and the following results were reasoned out from the discussion (see Appendix-2):

- Frameworks for expressway operation
- Role sharing for system operation
- Event trace diagrams (for the System Operation/Maintenance Plan)
- Screen transition diagram (for the System Operation/Maintenance Manual)
- Basic policy on training system operation/management

Procedures and organizations for expressway operation were clarified by using task analysis, and based on its results, an appropriate architecture and procedure for implementing tasks were defined and performance specifications of the system were to be drawn up as outputs.

Figure 6.1 Procedure of Discussion based on Task Analysis

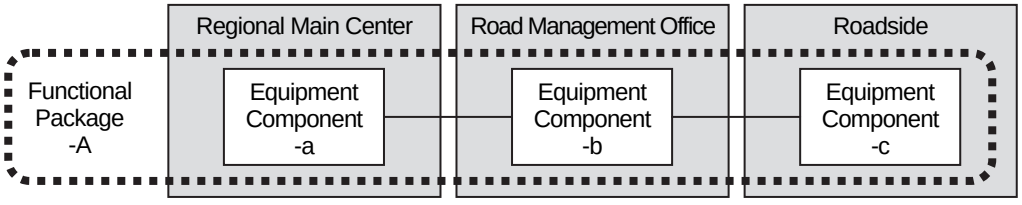


Source: The Study Team

6.2 Role Sharing

ITS consists of many Functional Packages. Each Functional Package consists of several equipment components which are installed separately in different locations as illustrated by the figure below. However, the components in the centers and the at roadside are operated respectively by the different organizations. For discussing the system operation, accordingly, the roles of respective organizations are to be detailed responding to the Functional packages and the installed places such as centers and offices.

Figure 6.2 Functional Package Consists of Equipment Components in Different Locations



Source: ITS Integration Project (SAPI) Study Team

In the following, discussing the frameworks responding to each Functional Package, the roles of the organizations below are to be clarified in the form of matrix table:

- Expressway Management Agency
- Public Road Owner or Investor
- Road Operator
- Telecommunication service company
- Other organizations (such as OBU management organization and bank).

6.2.1 Roles of Expressway Management Agency

The Expressway Management Agency is set up as the expressway management organization in MOT in 1st April 2011, is transferred to DRVN in 26th April 2012 and will be change into the Expressway Management Agency.

From the discussion on frameworks foregoing, roles of the Expressway Management Agency are to be sort out as shown below.

Table 5.1 Roles of Expressway Management Agency

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

Note, XX: Ownership, all capital investments and operation/maintenance services, S: Establishing performance standards and monitoring conformity.

Source: The Study Team

6.2.2 Roles of Public Road Owner or Investor (for Service Contract)

From the discussion on frameworks foregoing, roles of the Public Road Owner or Investor are sorted out as shown below for the service contract. Where, the Public Road Owners or Investor has been assigned respectively to the following sections in the Project Scope:

- VEC: Cau Gie–Ninh Binh
- HPC: Mai Dich–Thanh Tri (Ring Road 3), Lang–Hoa Lac and Noi Bai–Ca Lo Bridge
- Bac Ninh Province: Ca Lo Bridge–Bac Ninh.

Table 5.2 Roles of Public Road Owner or Investor

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

Note, XX: Owner ship, all capital investments, operation/maintenance services, tariff setting and toll collection.

Source: The Study Team

6.2.3 Roles of Public Road Owner (for Concession Contract)

From the discussion on frameworks foregoing, roles of the Public Road Owner or Investor are sorted out as shown below for the concession contract. Where, the Public Road Owners or Investor has been assigned respectively to the following sections in the Project Scope:

- DRVN: Phap Van–Cau Gie and Ha Noi–Bac Giang

Table 5.2 Roles of Public Road Owner or Investor

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

Note, XX: Ownership and tariff setting.

Source: The Study Team

6.2.4 Roles of Road Operator (for Service Contract)

From the discussion on frameworks foregoing, roles of the Road Operator are sorted out as shown below for the service contract. Where, the Public Road Owners or Investor has been assigned respectively to the following sections in the Project Scope:

- VEC-O&M: Cau Gie–Ninh Binh
- O&M Company under HPC: Mai Dich–Thanh Tri (Ring Road 3), Lang–Hoa Lac and Noi Bai–Ca Lo Bridge
- O&M Company under Bac Ninh Province: Ca Lo Bridge–Bac Ninh.

Table 5.3 Roles of Road Operator

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

Note, XX: Operation/maintenance services.

Source: The Study Team

6.2.5 Roles of Road Operator (for Concession Contract)

From the discussion on frameworks foregoing, roles of the Road Operator are sorted out as shown below for the concession contract. Where, the Public Road Owners or Investor has been assigned respectively to the following sections in the Project Scope:

- BOT under DRVN: Phap Van–Cau Gie and Ha Noi–Bac Giang

Table 5.3 Roles of Road Operator

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

Note, XX: All capital investments excluding initial capital investments for existing road section, operation/maintenance services and toll collection.

Source: The Study Team

6.2.6 Roles of Telecommunication Service Company

Introduction and O&M of communication system is to be outsourced to the telecom service companies for manpower saving in the later stage after the ITS Integration Project, that is proposed by the Decision No.3569/ VPCP-KTN VNPT.

From the discussion on frameworks foregoing, roles of the telecommunication service company are to be sorted out as shown below.

Table 5.4 Roles of Telecommunication Service Company

Items		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				
Functional Packages											
1	Voice Communication	XX		XX	XX			XX			
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			XX					XX	XX	
11	Traffic Information										
12	Integrated Data Management										
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										
20	Axle Load Measurement										
21	Measurement Lane Monitoring										
Communication System		XX		XX	XX			XX			
Communication Ducts											
Base Structures											
Electric Power Supply											

Note, XX: Operation/maintenance services, fee collection, working capital funds, rehabilitation costs, establishing performance standards and monitoring conformity.

Source: The Study Team

6.2.7 Roles of Other Organizations

IC-card recording, which is included prepayment strongly related to toll settlement among several different road owners, is to be operated a bank or an organization permitted by the State Bank (as the case of Decision No.5190/NHNN-TT). OBU Management is to be carried out independently by the Vietnam Register using the deposit and service charge for OBU.

From the discussion on frameworks foregoing, roles of the OBU management organization and the bank are to be sorted out as shown below.

Table 5.5 Roles of Other Organizations

Items		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				
Functional Packages											
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										
13	Tollgate Lane Monitoring										
14	Vehicle/Class Identification										
15	Lane Control										
16	Road-to-Vehicle Communication									Bank	
17	IC-card Recording									B	B
18	Toll Data Management										
19	OBU Management						O		O		O
20	Axle Load Measurement						OBU Management Organization				
21	Measurement Lane Monitoring										
Communication System											
Communication Ducts											
Base Structures											
Electric Power Supply											

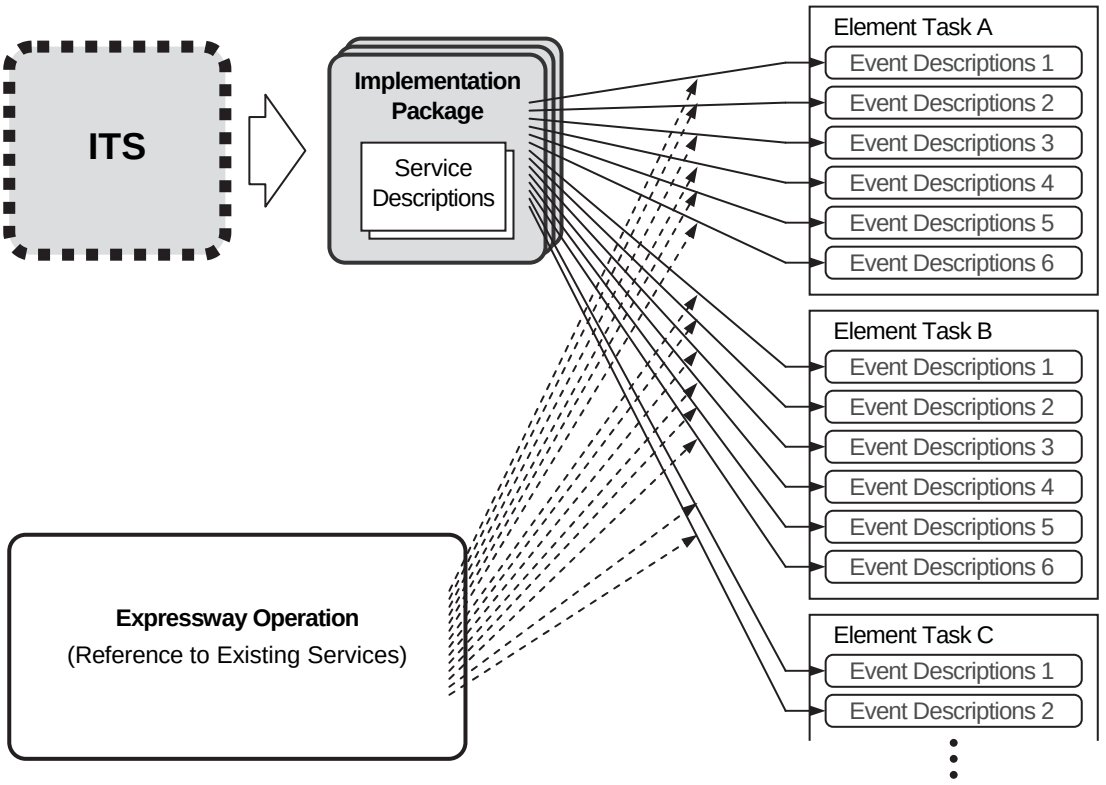
Note, B: Ownership, all capital investments, operation/maintenance services, establishing performance standards and monitoring conformity, O: Ownership, all capital investments, and operation/maintenance services.

Source: The Study Team

6.3 Event Trace Diagrams of Tasks for Expressway Operation

Applying the method of task analysis to examples of road operation in Vietnam and abroad, element tasks of expressway operation are to be picked out for actualizing service descriptions of the implementation packages. In addition, events included in an element task are to be organized in time sequence as an event tracing diagram.

Figure 6.3 Picking-out of Element Tasks and Events



Source: ITS Integration Project (SAPI) Study Team

The tasks for expressway operation are listed in the table below. In the Study, the discussion results on these tasks are shown by using the event trace diagrams in Appendix-2.

Table 6.6 Task List of Event Trace Diagrams

Name of System	No.	Task Procedures
Traffic Information/Control System	4.2	Routine Patrol
	4.3	Traffic Condition Monitoring
	4.4	Incident Reporting by Mobile Phone (113 Call)
	4.5	Incident Reporting by Mobile Phone (115 Call)
	4.6	Incident Reporting by Mobile Phone (to Private Hospital)
	4.7	Incident Reporting by Mobile Phone (to Regional Main Center)
	4.8	Incident Reporting from Patrol
	4.9	Incident Identification by Camera
	4.10	Ascertainment of Incident Situation
	4.11	Heavy Rain Identification
	4.12	High Wind Identification
	4.13	Dense Fog Identification
	4.14	High Temperature Identification
	4.15	Flood Identification
	4.16	Stopped Vehicle Identification
	4.17	Reverse Driving Identification
	4.18	Left Obstacle Reporting
	4.19	Vandalism Identification
	4.20	Road Damage Identification
	4.21	Construction Work Information Handling
	4.22	Road Traffic Supervision
	4.23	Decision of Traffic Restriction
	4.24	Entrance Closure
	4.25	Closure
	4.26	Exit Closure
	4.27	Lane Closure
	4.28	Speed Restriction
	4.29	Incident Handling
	4.30	Incident Clearance Reporting
	4.31	Restriction Removal
	4.32	Restriction Removal Reporting
	4.33	Traffic Event Management in Regional Main Center
	4.34	Traffic Event Management in Road Management Office
	4.35	Traffic Event Management by Patrol Crew
	4.36	Traffic Information by VMS
	4.37	Traffic Information by Internet
	4.38	Traffic Information by Broadcast
	4.39	Traffic Information Cancellation
	4.40	Traffic Data Management
	4.41	Integrated Data Management
	4.42	Routine Data Check in Regional Main Centre

Source: ITS Integration Project (SAPI) Study Team

Table 6.7 Task List of Event Trace Diagrams (2)

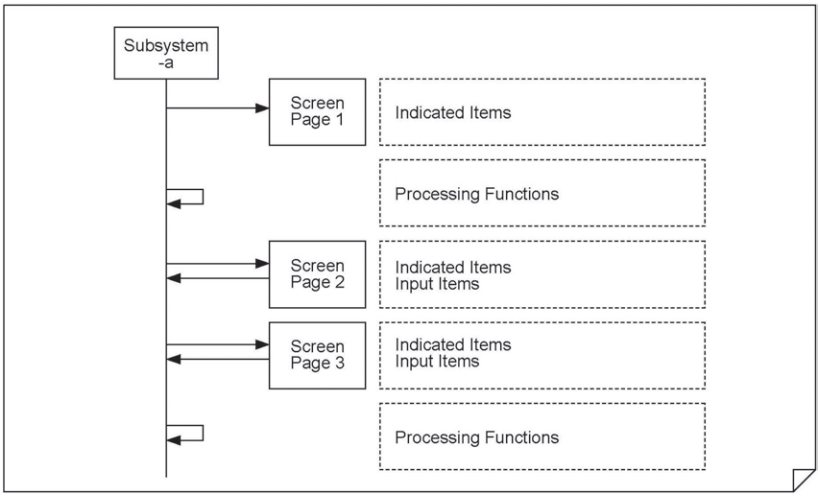
Name of System	No.	Task Procedures
Automated Toll Collection /Management System	4.43	Toll Collection by Manual
	4.44	Toll Collection by Touch & Go
	4.45	Toll Collection by ETC
	4.46	Handling of Balance Shortage Vehicle
	4.47	Toll Data Management
	4.48	Toll Settlement
	4.49	IC-card Issuance/Management
	4.50	Recharge of Prepaid Balance
	4.51	IC-card Data Management
	4.52	IC-card Negative List Management
	4.53	OBU Registration/Management
	4.54	OBU Negative List Management
	4.55	Toll Enforcement Assistance
Vehicle Weighing System	4.56	Axle Load Measurement
	4.57	Axle Load Data Management
	4.58	Overloading Regulation

Source: ITS Integration Project (SAPI) Study Team

6.4 Screen Transition Diagram

The screen transition diagram shows required function of processing and input/output in the form of time series as below. In this study, the screen transition diagrams shall be prepared and software components are to be discussed based on them.

Figure 6.4 Screen Transition Diagrams



Note: This diagram shows function of processing and input/output required for the software component in the form of time series. This need to be consistent with event tracing diagrams and message sequence diagrams.

Source: ITS Integration Project (SAPI) Study Team

7. Key System Policies

7.1 General

In this chapter, the following key policies of ITS are discussed from the perspective of appropriateness for applying to expressway operation:

- CCTV camera arrangement
- Event Detection by Image
- Vehicle detector arrangement
- Integrated/Prioritized Information Dissemination for Traffic Control
- Road-to-vehicle communication method for ETC
- Method of Checking Prepaid Balance
- Contact-less IC-Card type
- Axle load scale arrangement
- Integration of roadside equipment control
- Transmission method.

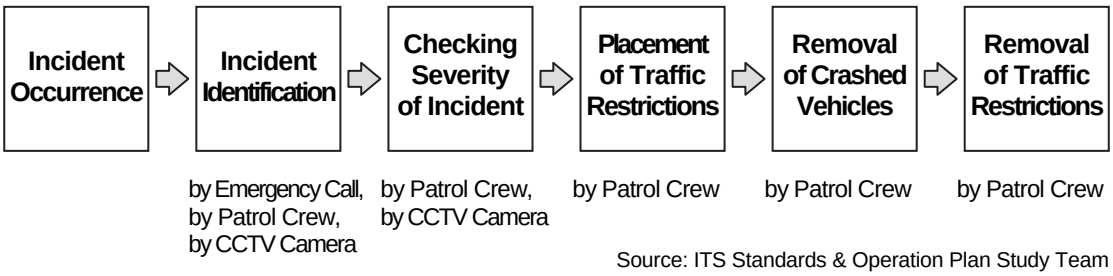
7.2 CCTV Camera Arrangement

1) Procedure to Address Incidents

CCTV camera can be used for various purposes on the expressway; however, the cameras need to be installed in different locations/conditions corresponding to the intended purpose. In this study, discussion focuses on the use of CCTV cameras for monitoring.

For example, the general procedure to address incidents is shown in the figure below.

Figure 7.1 General Procedure to Address Incidents



Source: ITS Standards & Operation Plan Study Team

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

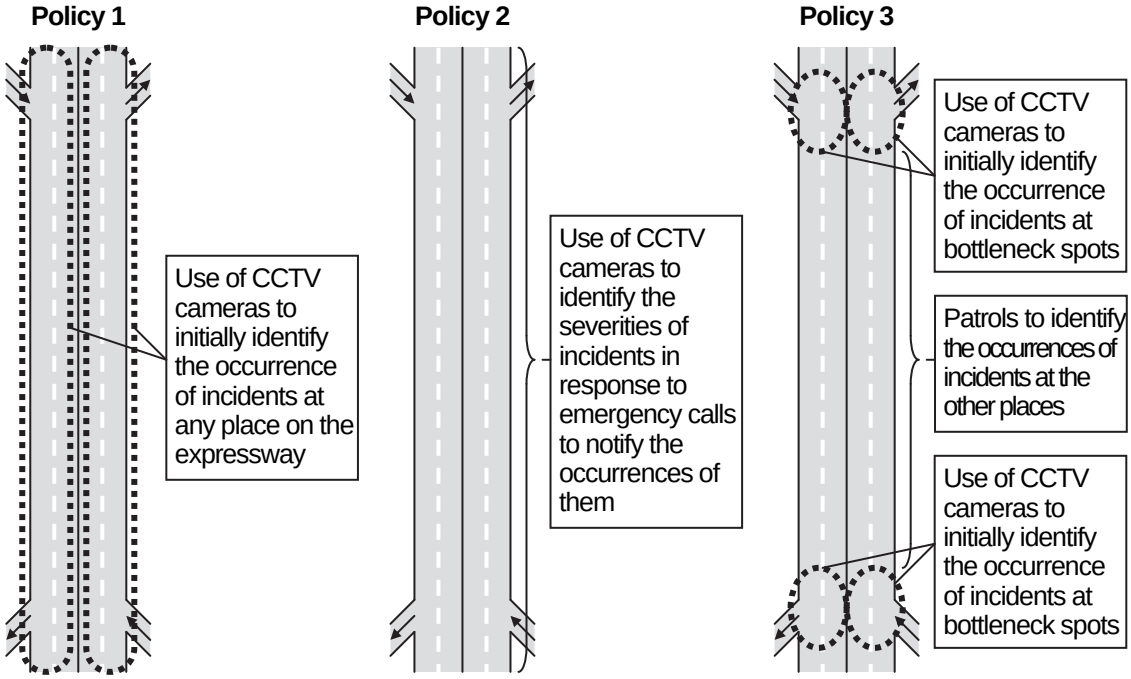
For this reason, effectiveness of CCTV camera is discussed in the following focusing on incident identification and checking of current situations.

2) Installation/Operation Policies of CCTV Camera

The following policies are considered for installation/operation of CCTV camera to provide incident information:

- **Policy 1:** Use of CCTV cameras to initially identify the occurrences of incidents at any place on the expressway without patrol or burdensome manual operation of panning/ zooming.
- **Policy 2:** Use of CCTV cameras, with manual operation of panning/zooming, to identify the severities of incidents at any place on the expressway in response to emergency calls to notify the occurrences of them.
- **Policy 3:** Use of CCTV cameras to initially identify the occurrences of incidents at bottleneck spots on the expressway where traffic can be stuck easily by the events without patrol or burdensome manual operation of panning/zooming in combination with patrols to identify the occurrences of incidents at the other places on the expressway.

Figure 7.2 Installation/Operation Policies of CCTV Camera



Source: ITS Standards & Operation Plan Study Team

3) Required Arrangement of CCTV Camera

Required arrangement of CCTV camera for each installation/operation policy is based on the following calculation elements.

Horizontal resolution: A man with normal eyesight can recognize a slit of 1.5 mm width of a Landolt Ring from a distance of 5 m. Hence, the required value of horizontal resolution is calculated by the following formula:

$$HR = \frac{0.75B}{1.5} \quad \frac{5}{d}$$

Where B: the width of monitoring screen (which is assumed as 406.4 mm for 20-inch display widely diffused or as 1016.0 mm for 50-inch display), 0.75: the aspect ratio of the monitoring screen (which needs to correspond with the aspect ratio of image sensor), d: the distance from the operator to the screen (which is assumed as 3 m).

Maximum range of surveillance: For a vehicle 1.5 m wide to be recognized by the operator, the vehicle needs to be displayed clearly on the screen using more than 4 lines (as large as 4.8 mm). Hence, the minimum size of a vehicle image on a 20-inch display in the Operator's Center is calculated by the following formula:

$$V' = 4 \frac{B}{HR}$$

The CCTV camera will provide the fine image of moving vehicles by using a wide-angle lens with a sufficient depth of field. For meeting this requirement, the maximum range of surveillance is calculated by the following formula:

$$L = f \frac{V}{V'} \frac{B}{0.95b}$$

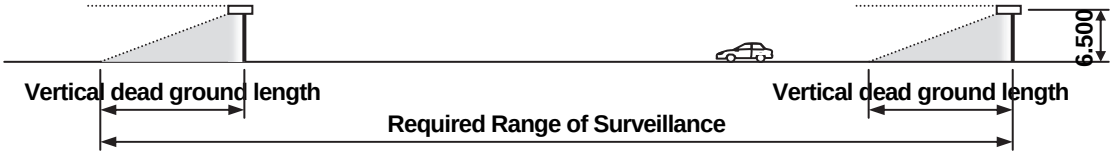
Where b: the size of image sensor (which is assumed as 6.5 mm for 1/2-inch image sensor), 0.95: over-scanning ratio, V: the width of an actual vehicle (which can be assumed as 1500 mm), V': the width of the displayed image of vehicle, and f: the focal length of lens of the CCTV camera (which is assumed as 3.8 mm to 8.0 mm).

Vertical dead ground length: On the same condition, the length of vertical dead ground is calculated by the following formula:

$$L = f \frac{H}{0.95h}$$

Where H: the height of camera installation (which is assumed as 6.5 m), and h: the vertical length of image sensor (which is assumed as 4.85 mm for 1/2-inch image sensor).

Table 7.1 Calculation Results of Maximum Range of Surveillance



Size of Monitoring Screen	Required Horizontal Resolution	Focal Length of Lens	Maximum Range of Surveillance	Vertical dead ground length
20 inches	339 lines	3.8 mm	78.2 m	5.3 m
		8.0 mm	164.5 m	11.2 m
		76.0 mm **	1563.1 m	--
		160.0 mm ***	3290.7 m	--
50 inches	847 lines	3.8 mm	195.4 m	5.3 m
		8.0 mm	411.3 m	11.2 m
		76.0 mm **	3907.7 m	--
		160.0 mm ***	8226.7 m	--
100 inches	847 lines	3.8 mm	390.8 m	5.3 m
		8.0 mm	833.7 m	11.2 m
		76.0 mm **	7815.4 m	--
		160.0 mm ***	16453.4 m	--

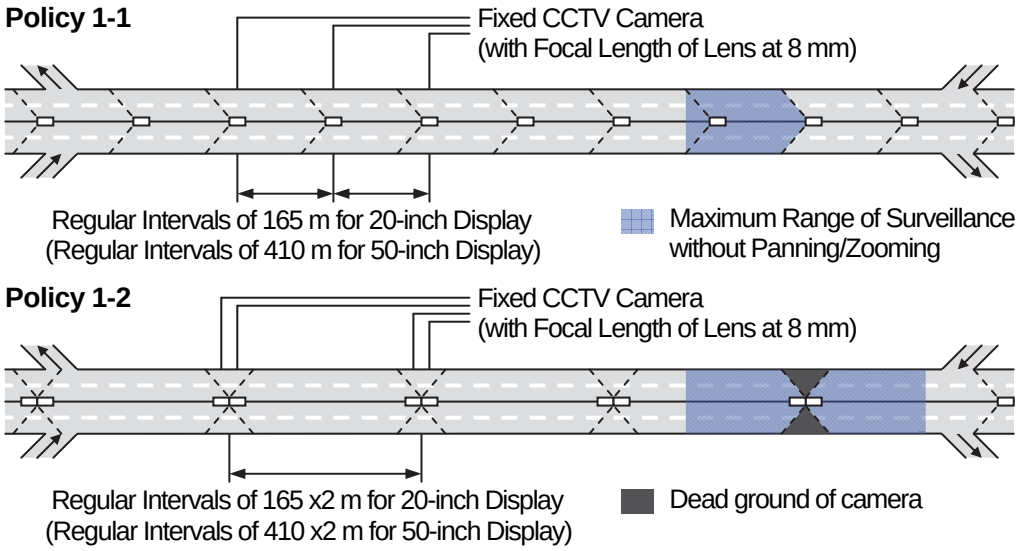
Note: ** : Focal length under 20 times zooming of 3.8 mm, *** : Focal length under 20 times zooming of 8.0 mm.

Source: ITS Standards & Operation Plan Study Team

(1) CCTV Camera Arrangement for Policy 1

In the case of Policy 1, CCTV cameras need to be installed continuously along the expressway for initially identifying the occurrences of incidents without manual panning/zooming of camera. Hence, if the expressway is monitored using 20-inch display and its alignment is assumed as completely straight, CCTV cameras with focal lengths of lenses at 8 mm need to be installed at regular intervals of 165 m. Even if 50-inch display is used, CCTV cameras need to be installed at regular intervals less than 410 m.

Figure 7.3 Installation at a Small Intervals Continuously along the Expressway



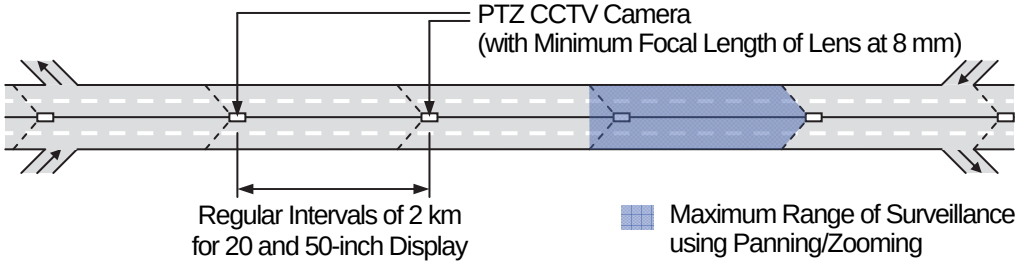
Source: ITS Integration Project (SAPI) Study Team

Difference between Policy1-1 and Policy 1-2 is only the direction of camera installation. In the case of Policy 1-2, a pair of cameras can be fixed on a single post for reducing installation cost; however, there exist dead ground behind of the cameras.

(2) CCTV Camera Arrangement for Policy 2

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

Figure 7.4 Installation Continuously along the Expressway



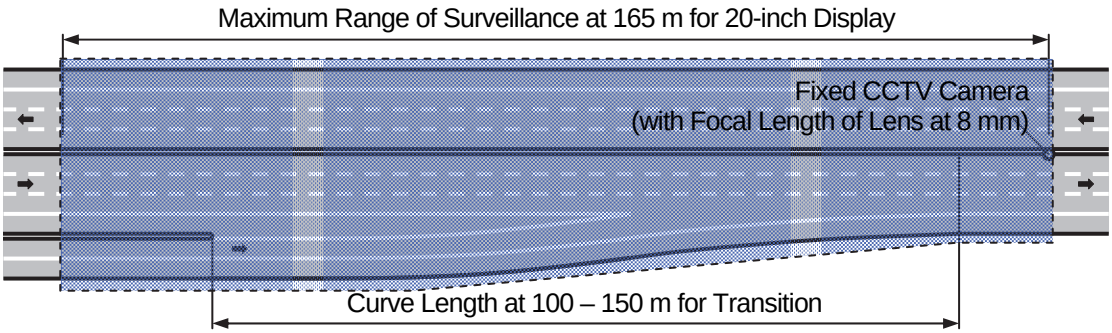
Source: ITS Standards & Operation Plan Study Team

(3) CCTV Camera Arrangement for Policy 3

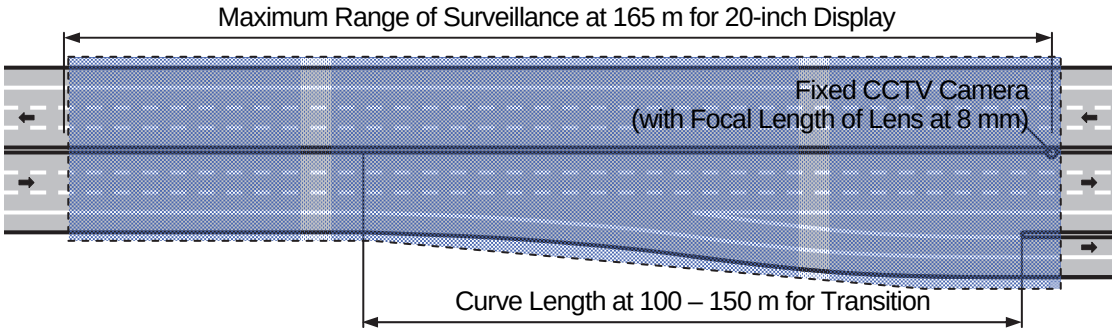
In the case of Policy 3, CCTV cameras need to be installed at bottleneck spots on the expressway and utilized for initially identifying the occurrences of incidents without manual panning/zooming of camera. As shown in the foregoing table, the maximum length of surveillance by the CCTV camera with focal lengths of lenses at 8 mm is around 165 m; hence, CCTV cameras are to be installed respectively for a merging point and a diverging point covering the transition curve lengths as shown in the following figure.

Figure 7.5 Installation at Bottleneck Spots on the Expressway

For Surveillance around Merging Point



For Surveillance around Diverging Point



Source: ITS Standards & Operation Plan Study Team

4) Comparison of Installation/Operation Policies

Advantages/disadvantages of the three installation/operation policies of CCTV camera are summarized in the table in the following page.

As shown in the table, Policy 1 requires very high cost of system implementation and is not suitable. Policy 3 allows reduction of implementation cost; however, the disadvantage of this policy is that no functions are prepared for occurrences of incidents at the places other than bottleneck spots.

Policy 2 has difficulty of identification in heavy rain or in darkness of the night, but is effective at identifying severities of incidents at any place on the expressway and at optimizing dispatch of patrol crew to be insufficient for estimated incident frequency rate. Hence, according to this comparison, Policy 2 is recommended for providing incident information.

Table 7.2 Comparison of Installation/Operation Policies of CCTV Camera

		Policy 1				Policy 2	Policy 3
		1-1	1-1w	1-2	1-2w		
Initial identification of the occurrences of incidents by CCTV cameras without patrol	At any place on the expressway	Capable	Capable	Capable	Capable	Impractical	Incapable
	At bottleneck spots on the expressway	Capable	Capable	Capable	Capable	Impractical	Capable
Identification of the severity of incidents by CCTV cameras in response to notification of the occurrences of incidents by emergency calls	At any place on the expressway	Capable	Capable	Capable	Capable	Capable	Incapable
	At bottleneck spots on the expressway	Capable	Capable	Capable	Capable	Capable	Capable
Applicability of image recognition for reducing human errors		Applicable	Applicable	Applicable	Applicable	Inapplicable	Applicable
Dead ground of cameras		None	None	Exist	Exist	None	None
Required number of monitoring displays in each road management office *		*** 40				**** 8	**** 5
Required cost of system implementation for 1000 km length of the expressway network (Unit: Million USD)	Roadside equipment including camera	*** 17.81				**** 4.10	**** 1.96
	Center equipment including displays **	*** 1.82				**** 0.32	**** 0.18
	Total	19.63				4.42	2.14
Actual Discussion in On-going Expressway Project in Vietnam		None	None	None	Phap Van – Cau Gie – Nonh Binh	HCMC – Trung Luong	HCMC – Long Thanh – Dau Giay
Grading		Not suitable	Not suitable	Not suitable	Not suitable	Recommended	Average

Note: * : It is assumed that five cameras can be monitored by a display by switching 5 times, ** : A Regional Main Center and 12.5 road management offices are to be constructed per 1000km, *** : Minimum cost by using 50-inch displays, **** : Minimum cost by using 20-inch displays.

Source: ITS Standards & Operation Plan Study Team

7.3 Event Detection by Image

1) Purpose and Outline of Event Detection

Event detection is realized by using the technology of image recognition. For the first step of this technology, moving objects, such as vehicles, are recognized by analysing the difference between a pair of serial frames in a video movie captured by CCTV camera. After that, changes in moving speed of the objects are recognized.

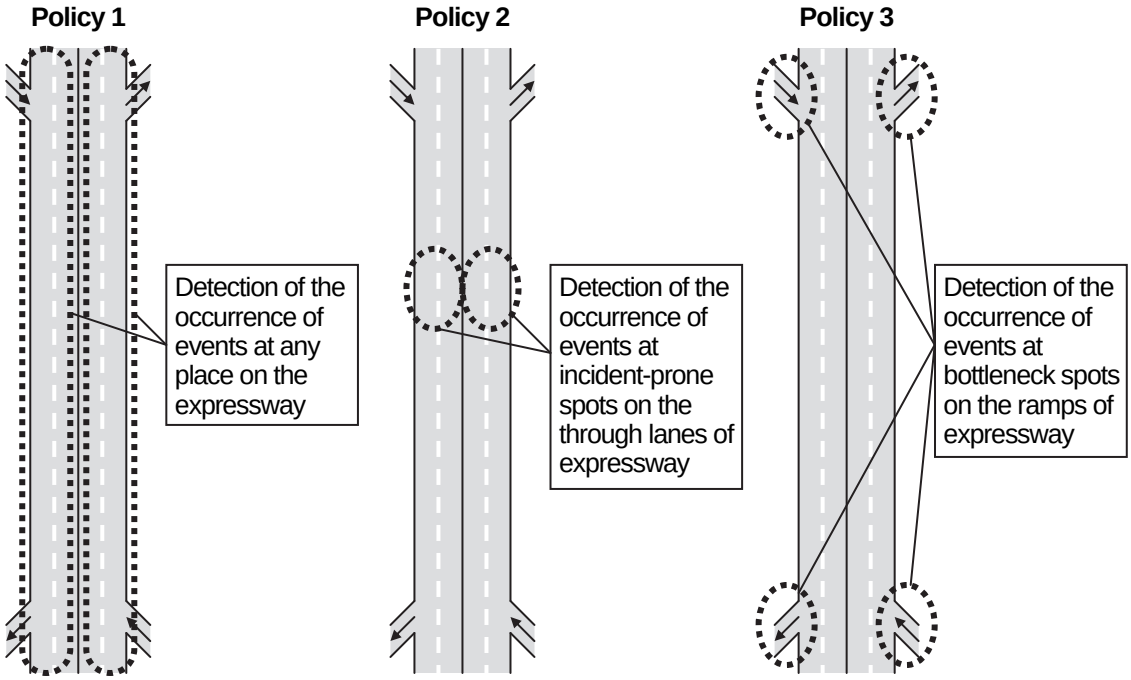
Event detection system recognize the Incidents, broken-down vehicles and traffic congestions usually only by the change in moving speed and give an alarm to the operators. Accordingly, even if a vehicle stops on the expressway only for taking a rest, the system will raise an alarm. In such a condition, it is very difficult for the operators to recognize which is the true alarm. This is the point of concern for introducing event detection to the expressways in Vietnam.

2) Installation Policies of Event Detection

The following installation policies are to be considered for event detection:

- **Policy 1:** Automatic detection and alarm at the occurrences of incidents at any place on the expressway
- **Policy 2:** Automatic detection and alarm at the occurrences of incidents at incident-prone spots on the through lanes of expressway
- **Policy 3:** Automatic detection and alarm at the occurrences of incidents at bottleneck spots on the ramps of expressway.

Figure 7.6 Installation Policies of Event Detection



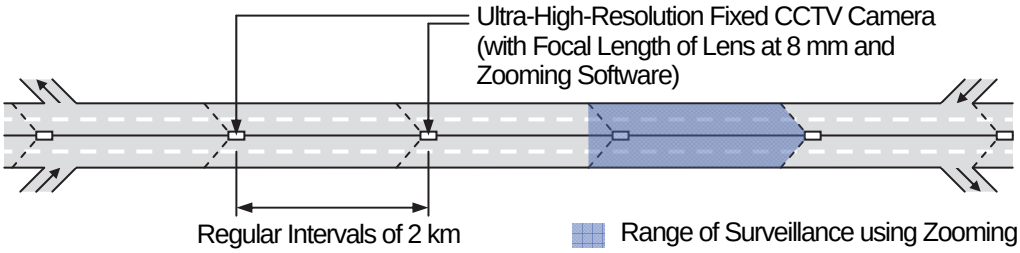
Source: ITS Integration Project (SAPI) Study Team

3) Required Arrangement of CCTV Camera

(1) CCTV Camera Arrangement for Policy 1

In the case of Policy 1, Fixed CCTV Cameras equipped with ultra-high-resolution image sensor and zooming software both for monitoring and image recognition need to be installed continuously along the expressway.

Figure 7.7 Ultra-High-Resolution Fixed CCTV Camera Installation for Event Detection



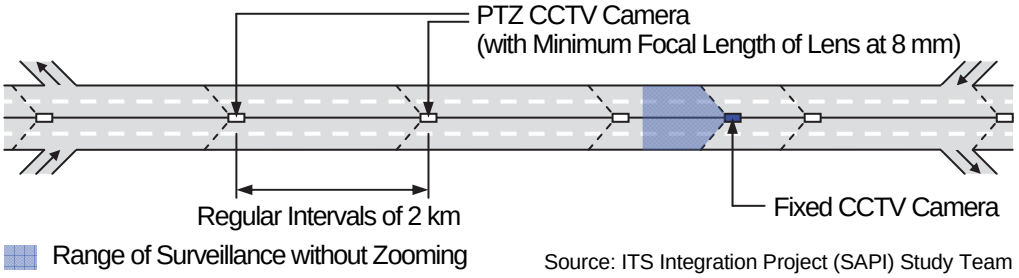
Required Resolution: RR =GRx(2000/165)^2,
where GR is general resolution.

Source: ITS Integration Project (SAPI) Study Team

(2) CCTV Camera Arrangement for Policy 2

In the case of Policy 2, fixed CCTV cameras for event detection need to be installed on the through lane additionally to the PTZ CCTV Cameras for monitoring.

Figure 7.8 Additional Fixed CCTV Camera Installation for Event Detection

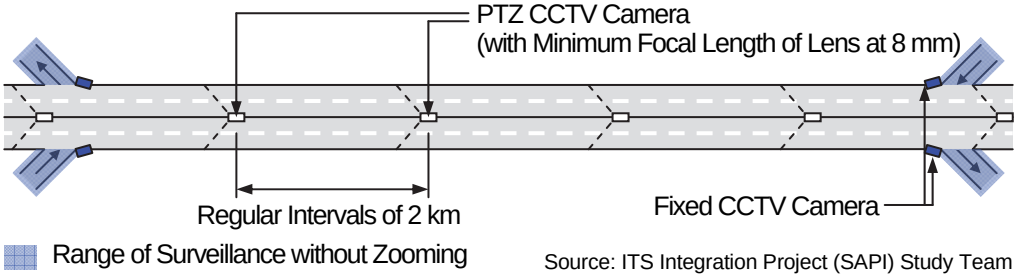


Source: ITS Integration Project (SAPI) Study Team

(3) CCTV Camera Arrangement for Policy 3

In the case of Policy 3, fixed CCTV cameras for event detection need to be installed on the ramps additionally to the PTZ CCTV cameras for monitoring.

Figure 7.9 Additional Fixed CCTV Camera Installation for Event Detection on Ramp



Source: ITS Integration Project (SAPI) Study Team

Policy 3 is recommended for event detection, because Policy 1 requires too much cost per 1000 km as shown in the comparison table below and congestion-prone spots for Policy 2 cannot be reasoned out from the data by actual observation.

Table 7.3 Comparison of CCTV Camera Arrangement Policies for Event Detection

		Policy 1	Policy 2	Policy 3
Reliability in bad weather conditions (e.g. heavy rain, heating of pavement, darkness in the night)		Low (in large distance)	High	High
Reliability in the condition many drivers take a rest on the through lanes of expressway		Low	Low	High
Urgency from the viewpoint of eliminating obstacles for vehicle passage		Not urgent	Urgent	Urgent
Required cost of system implementation for 1000 km length of the expressway network (Unit: Million USD)	Roadside Equipment including Camera	18.0	3.9	
	Software for Image Recognition including Zooming	270.0	2.1	
	Total	288.0	6.0	
Cost for Maintenance		Low	Average	Low
Grading		Not Suitable	Not Suitable	Recommended

Source: ITS Standards & Operation Plan Study Team

4) Upgrading to Next-generation System based on CCTV Camera for Multi-purpose

As mentioned foregoing in previous chapter and this chapter, CCTV camera is to be used for the following three purpose:

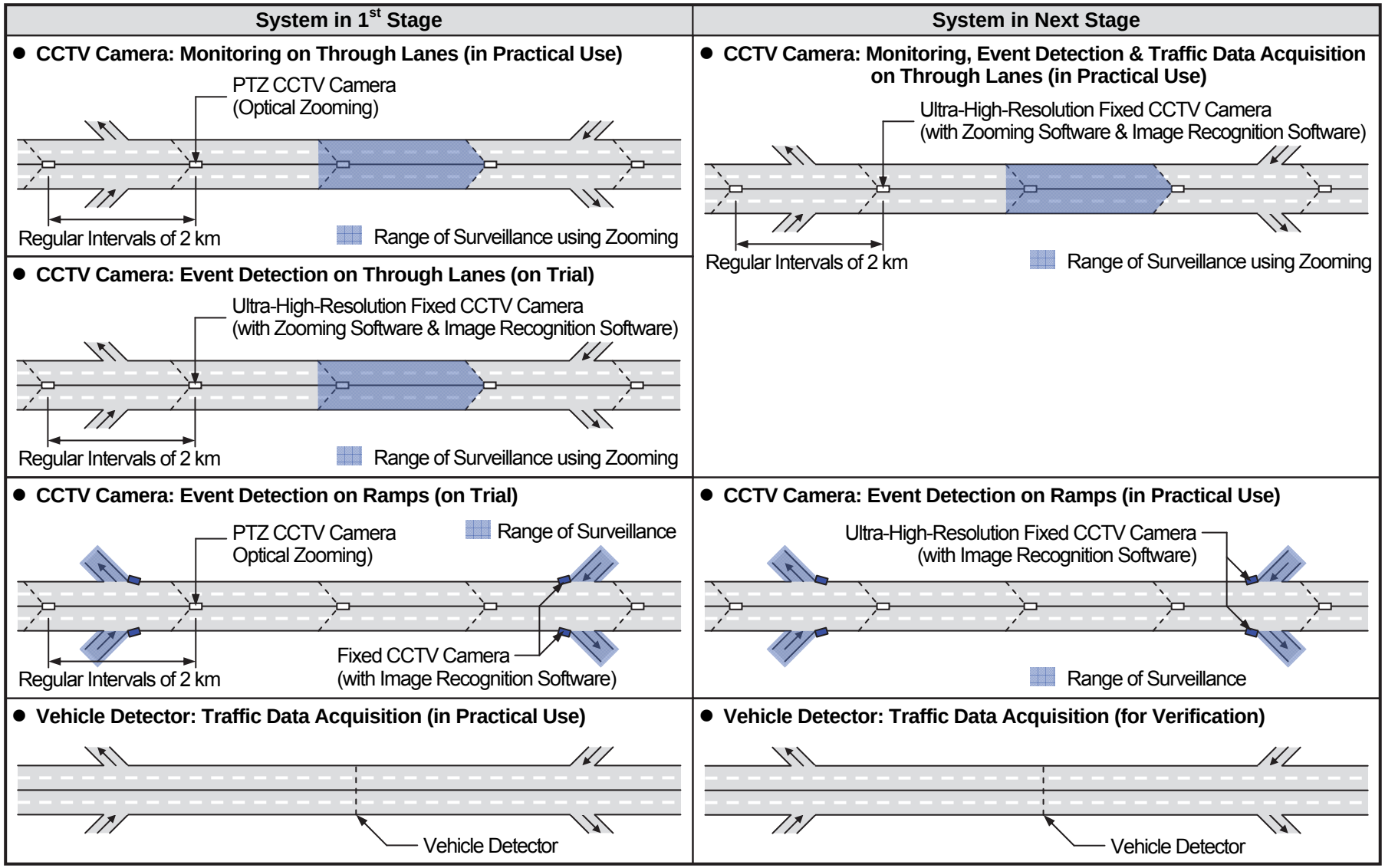
- Monitoring on the through lanes
- Event detection on through lanes
- Event detection on ramps

However, at the present moment, the resolution of IP-based CCTV camera is not sufficient for taking a view of 2 km range, which is the interval of installation of the camera. In addition there exists a disturbance against the technology of image recognition caused by many vehicles stop on the expressway only for taking a rest. Accordingly, the following types of camera need to be installed for each purpose in the 1st stage:

- Monitoring on the through lanes →PTZ CCTV camera
- Event detection on through lanes →Ultra-high-resolution fixed CCTV camera (on trial)
- Event detection on ramps →Fixed CCTV camera (on trial)

Toward the next stage, an upgrading to next-generation system can be proposed. These three purpose and traffic data acquisition will be accomplished by a single kind of ultra-high-resolution CCTV camera as shown in the table in the following page.

Figure 7.10 Upgrading to Next-generation System based on CCTV Camera for Multi-purpose



Source: ITS Integration Project (SAPI) Study Team

7.4 Vehicle Detector Arrangement

1) Objectives of Installing Vehicle Detector

Vehicle detector can be used for several different purposes on the expressway; however, the detectors need to be installed in different location and condition corresponding to the intended purpose.

In this study, discussion focuses on the usage of vehicle detectors for the following objectives:

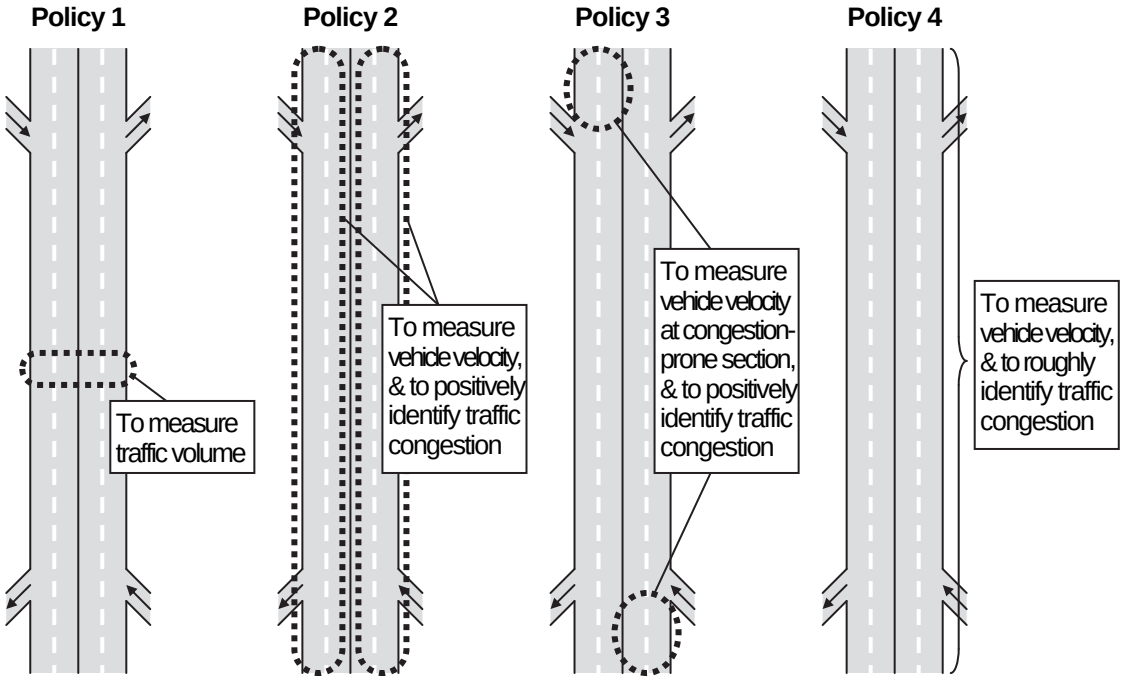
- Measurement of traffic volume
- Measurement of vehicle velocity
- Identification of traffic congestion
- Measurement of values of large vehicles.

2) Installation/Operation Policies of Vehicle Detector

The following operation/arrangement policies of vehicle detector for expressway operation are considered:

- **Policy 1:** To measure traffic volume on a section between a pair of interchanges on the expressway
- **Policy 2:** To measure vehicle velocity at any section on the expressway and to positively identify traffic congestion
- **Policy 3:** To measure vehicle velocity at congestion-prone sections on the expressway and to positively identify traffic congestion
- **Policy 4:** To measure vehicle velocity throughout the expressway and to roughly identify traffic congestion

Figure 7.11 Vehicle Detector Installation/Operation Policies



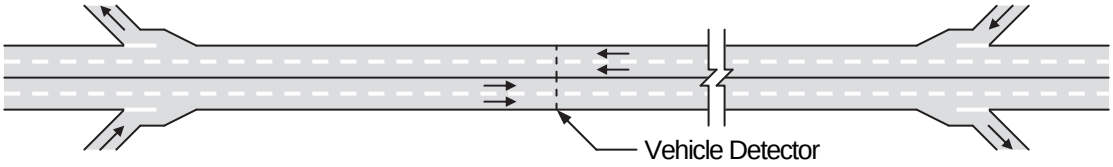
Source: ITS Standards & Operation Plan Study Team

2) Arrangement of Vehicle Detectors

(1) Vehicle Detector Arrangement for Policy 1

In the case of Policy 1, 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 7.12 Installation at Midway between a Pair of Interchanges

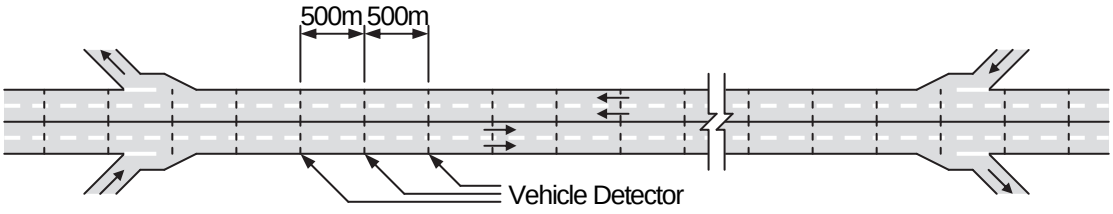


Source: ITS Standards & Operation Plan Study Team

(2) Vehicle Detector Arrangement for Policy 2

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

Figure 7.13 Installation at a Small Intervals Continuously along the Expressway

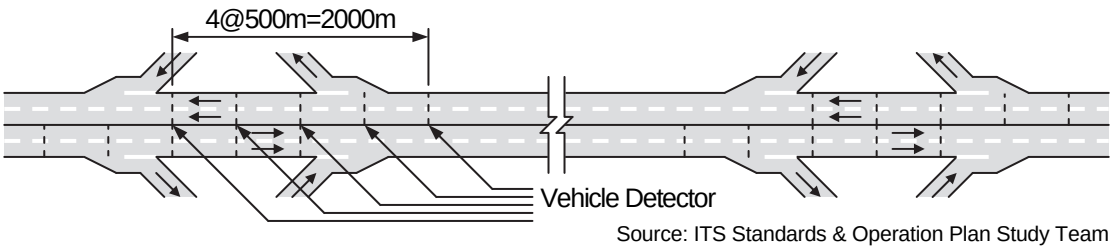


Source: ITS Standards & Operation Plan Study Team

(3) Vehicle Detector Arrangement for Policy 3

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

Figure 7.14 Installation at Congestion-prone Sections on the Expressway

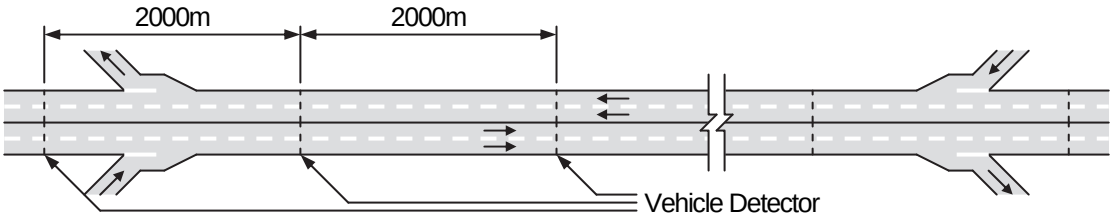


Source: ITS Standards & Operation Plan Study Team

(4) Vehicle Detector Arrangement for Policy 4

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

Figure 7.15 Installation Continuously along the Expressway



Source: ITS Standards & Operation Plan 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 7.4 Comparison 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 cost of system implementation for 1000km length of the expressway network (Unit: Million USD)		Roadside equipment	0.8 **	120 **	3.8 **	30 **
		Center equipment	0.2	0.2	0.2	0.2
		Total	1.0	120.2	4.0	30.2
Actual Discussion in On-going Expressway Project in Vietnam			Many	None	Cau Gie – Ninh Binh	HCMC – Long Thanh – Dau Giay, HCMC – Trung Luong
Grading			Recommended	Not suitable	Useful for Congest-prone Section	Not suitable

Note: QL: Minimum detectable queue length, **: In the case of using image recognition type

Source: ITS Standards & Operation Plan Study Team

Policy 2 requires very high cost of system implementation and is not suitable. Policy 4 is also costly and can be applicable only to the road sections with large traffic over the length of them. As shown in the table above, Policy 3 is useful for congestion-prone sections on the expressway; however, this also requires rather high cost.

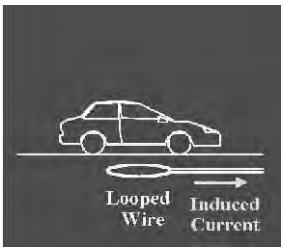
From the viewpoint that the next-generation system will be established using the technology of ultra-high-resolution CCTV camera for multi-purpose, Policy 1, which achieves measurement of traffic volume at low cost and can be applicable to any road sections, is recommended as the result of the Study.

4) Comparison of Vehicle Detectors

The following three types of vehicle detectors are compared:

- **Loop-coil Type:** Loop-coil 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 bridges with a slab densely reinforced because of difficulty to secure a sufficient distance from steel structures to the loop-coil.
- **Ultrasonic Type:** Ultrasonic 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, in this method, it is difficult to distinguish the vehicles from the other objects on the road.
- **Image Recognition Type:** Image recognition 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 than for visual inspection. Number of detected vehicles also can be counted in the system.

Table 7.5 Comparison on Types of Vehicle Detectors

	a) Loop-coil type	b) Ultrasonic type	c) Image Recognition type
Outline			
Detection of Vehicle Class	Capable	Incapable	Capable
Installation	Buried at a sufficient distance from steels	Fixed on the structure securing road clearance	Fixed on a stable structure securing sight path
Unsuitable Location	Bridges with a slab densely reinforced	None	None
Implementation Cost	Low	Average	High
Applicability to Traffic Changing Lanes	Incapable	Incapable	Capable
Secondary Use for Visual Check	Incapable	Incapable	Capable
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	Useful for Verification	Not Suitable	Recommended

Source: ITS Standards & Operation Plan Study Team

7.5 Integrated/Prioritized Information Dissemination for Traffic Control

1) Necessity of Integrated Traffic Information/Control for Event of Serious Incident

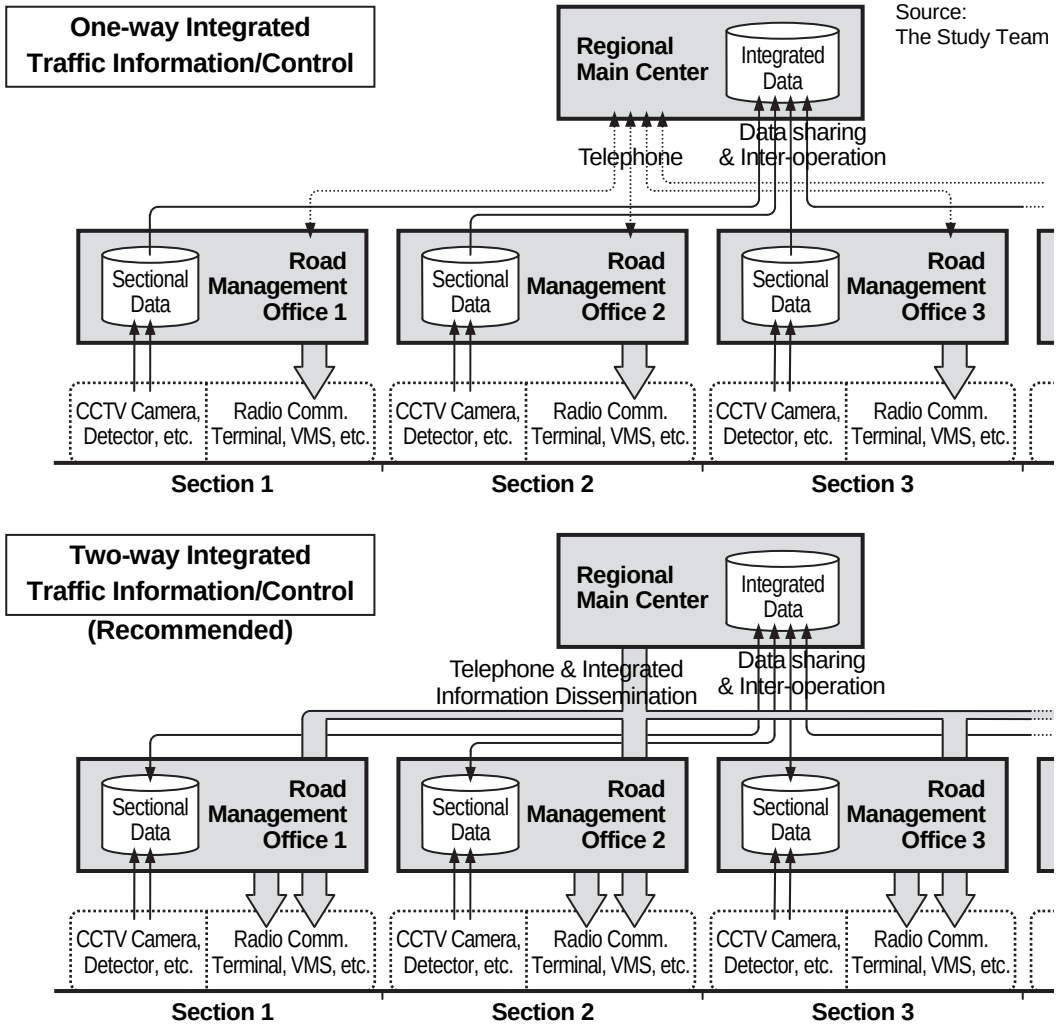
According to the Circular No. 90/2014/TT-BGTVT and the Decree No.32/2014/ND-CP, traffic information/control is to be executed by the operators in the respective Road Management Offices and its results and data are to be reported to the Regional Main Center in the normal state. However, in the events of serious incidents/accidents/disasters, the operator in the Regional Main Center is required to manage and supervise the traffic information/control, and this can be executed in the integrated way covering the expressway network.

There can be two types of the integrated traffic information/control:

- One-way integrated traffic information/control: Integration is to be established only on monitoring traffic
- Two-way integrated traffic information/control: Integration is to be established both on monitoring traffic and on disseminating information.

For controlling traffic on the expressway network, integration is necessary obviously on the dissemination of information. Accordingly, the two-way integration is recommended.

Figure 7.16 Two Types of Integrated Traffic Information/Control



The conceptual image of the Regional Main Center for two-way integrated traffic information/ control is shown in the figure below. A streamlined traffic control can be realized including the road/traffic monitoring by cameras and detectors, the processing of collected information and the dissemination of processed information through VMS and other devices. The traffic spread over the whole expressway network is to be managed/supervised based on the data concentrated at the Regional Main Center.

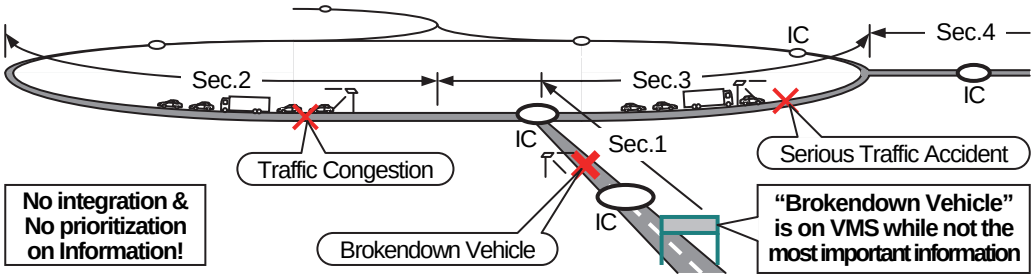
Figure 7.17 Conceptual Image of Two-way-integrated Traffic Information/Control

2) Problems of Section-by-section Information Dissemination

In Vietnam, expressway network is being constructed by sections funded by different donors and is going to be managed by sections by different operators. Such sectioned manner is prone to bring the following potential problems onto the traffic information dissemination:

- Wasteful use of VMSs occupied by fixed information such as slogans
- Spotty control of VMSs without consideration of the conditions of other road sections
- Losses in the cost for controlling respective VMSs by large manpower

Figure 7.18 A Problem of Section-by-section Information Dissemination



3) Technology of "Integrated/Prioritized Information Dissemination" in Japan

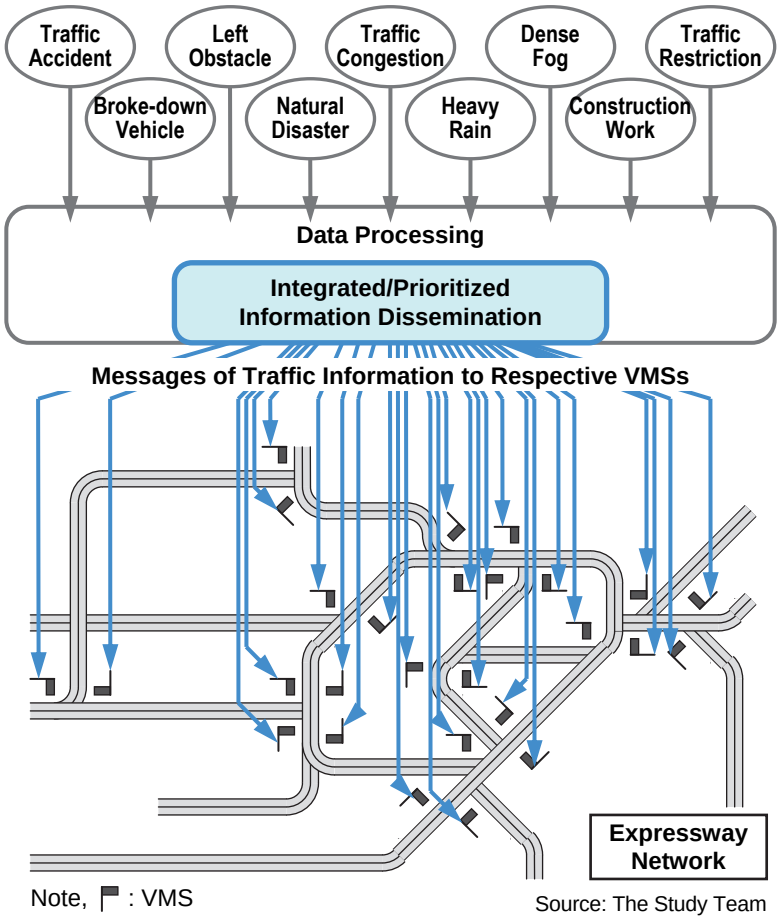
An advanced system of the two-way integrated traffic information/control has been in practical use in Japan. That is actualized by a core technology of "integrated/prioritized information dissemination", which has been developed through the application to the nationwide expressway network about 8000 km composed of the various sections managed by different road operators (e.g. NEXCO East, NEXCO Central, NEXCO West and SHUTOKO).

An empirical-based continuous improvement, to be mentioned later, have been made on the prioritization criteria for this technology throughout its track record more than 40 years. Through the improvement, its functions below have been established.

(1) Function-1: Concurrent Control of a Large Number of VMSs

Using this technology, a large number of VMSs are controlled concurrently to indicate the messages of traffic information the most suitable for their respective locations on the expressway network.

Figure 7.19 Concurrent Control of a Large Number of VMSs



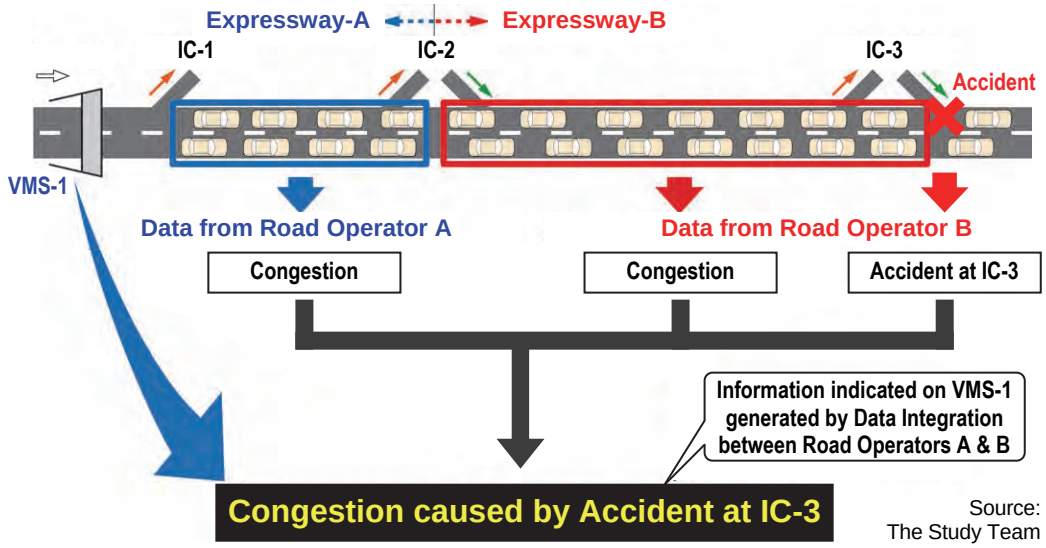
Note, : VMS

Source: The Study Team

(2) Function-2: Integration of Traffic Data/Information

Acquired data of traffic information are integrated and correlated each other, beyond the border between the sections operated by the different road operators, responding to their locations, the timings of occurrences and other related information.

Figure 7.20 Integration of Traffic Data/Information

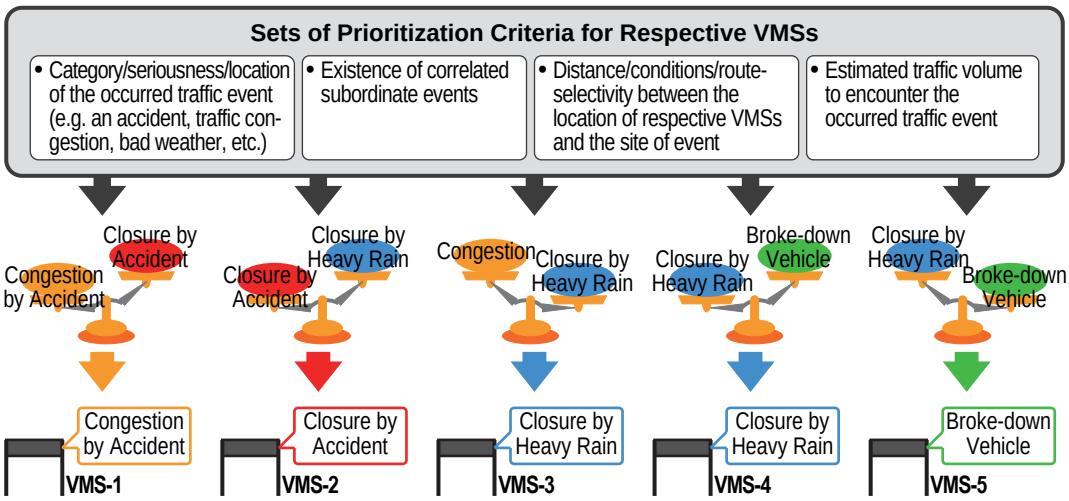


Source: The Study Team

(3) Function-3: Information Prioritization for Respective VMSs

Organized messages of traffic information are prioritized according to the locations/seriousness of the occurred traffic events, the distance/conditions/route-selectivity between the locations of respective VMSs and the sites of events on the expressway network and other factors.

Figure 7.21 Information Prioritization for Respective VMSs



Source: The Study Team

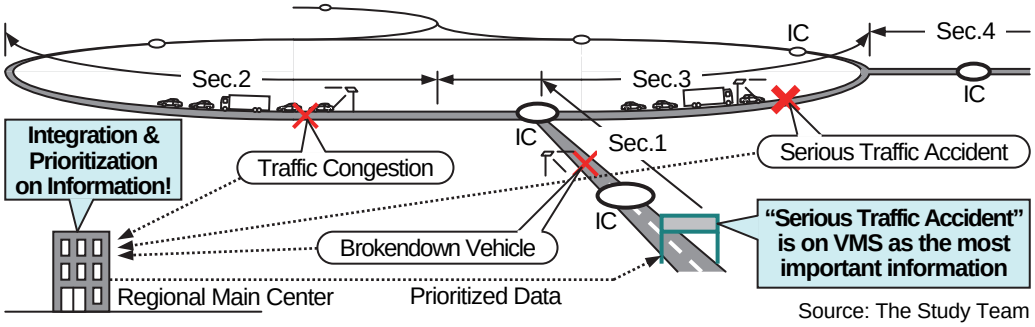
4) Continuous Improvement needed for Empirical-based Prioritization

An empirical-based continuous improvement is needed on the technology of integrated/ prioritized information dissemination for fitting it to the road/traffic conditions of expressway network in Vietnam. The function of prioritization is to be improved through the revisions on the coefficient values of prioritization criteria responding to the users' requests more than 10 years after its installation. Through such improvement, the empirical-based prioritization will be established to prioritize traffic information properly and to indicate the prioritized messages on the respective VMSs optimally for the drivers en route. And finally the optimal traffic control will be implemented throughout the expressway network without delay.

5) Recommendation of Integrated/Prioritized Information Dissemination

A large number of VMSs spread over the expressway network can be controlled, optimally responding to their locations on the expressway network and to the location of occurred traffic events, by the integrated/prioritized information dissemination, which is to be recommended in consideration of the advantages shown below.

Figure 7.22 An Outcome of Integrated/Prioritized Information Dissemination



Source: The Study Team

(1) Concurrent/Homogeneous Control of a Large Number of VMSs

Integrated/prioritized information dissemination allows a concurrent control of a large number of VMSs by a few skillful operators. Hereby, potential errors/delays/unevenness by unskilled operators are to be eliminated. A homogeneous control of VMSs is to be established regardless of the difference in the operators of respective expressway sections.

(2) Optimal Information Provision for Respective Locations of VMSs/Drivers

Integrated/prioritized information dissemination allows a large number of VMSs to indicate optimal messages for their respective locations, which can be assumed as the locations of drivers en routes, and the drivers can select their optimal routes on the expressway network.

(3) Minimization of Duration of Placing Traffic Restriction and Toll Revenue Losses

Integrated/prioritized information allows the operator to implement a timely/appropriate traffic restrictions in case of an incident and to prevent the possible secondary incidents. Hereby, prompt incident clearance and minimization of the duration of traffic restriction can be achieved.

(4) Reduction of Operating Manpower/Cost needed for VMS Indication

Integrated/prioritized information dissemination allows a large number of VMSs to be managed by a few skilful operators, and accordingly the operation costs can be significantly reduced.

Table 7.6 Comparison of Typical Two Information Dissemination Policies

	Section-by-section Information Dissemination	Integrated/Prioritized Information Dissemination
Monitoring of Entire Expressway Network	Capable	Capable
Concurrent/Homogeneous Control of a Large Number of VMSs	Not capable	Capable
Optimal Information Provision for Respective Locations of VMSs/Drivers	Not capable	Capable
Minimization of Duration of Placing Traffic Restriction and Toll Revenue Losses	Not effective	Effective
Reduction of Operating Manpower/Cost needed for VMS Indication	Not effective	Effective
Grading	Inadequate	Recommended

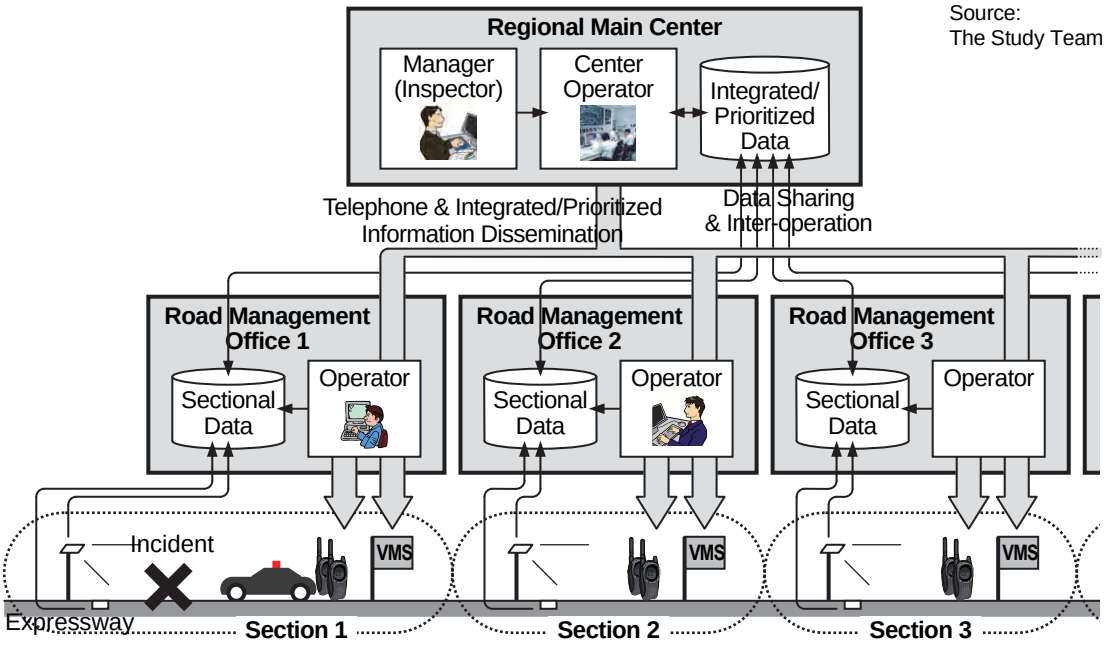
Source: The Study Team

The integrated/prioritized information dissemination is recommended as the system policy from the comparison of typical two information dissemination policies shown in the foregoing table.

6) Role-sharing/Cooperation between Regional Main Center and Road Mgt. Offices

Role-sharing/cooperation, in the normal state and in the event of serious incident, between the Regional Main Center and the Road Management Office in Vietnam is shown below.

Figure 7.23 Role-sharing/Cooperation between Regional Main Center and Road Mgt. Offices



	Normal State	Roles in the Event of Serious Incident
Regional Main Cnter (Expressway Management Agency)	• Regulation on hardware/software in compliance with the ITS Standards	• Ditto
	• Monitoring of the entire expressway network under the Regional Main Center	• Ditto
	• Exchange of monitored information/data of traffic conditions/events	• Ditto
		• Guidance and/or direct system control to the road management offices for integrated/ prioritized information dissemination in the event of serious incident
		• Decision to enforce a serious traffic restriction, such as closure, considering the integration over many expressway sections.
	• Integrated management on the data from traffic information/control, toll collection/ management and heavy truck control	• Ditto
	• Development of inspection/budget plan of expressway improvement/maintenance.	• Ditto
Road Management Office (Road Operator)	• Acquisition of information through the special call number or sensors of ITS • Traffic event data input at the road management office or roadside and sharing them with the Regional Main Center and other organizations • Traffic information/control of an expressway section • Dispatch of a patrol crew to the incident site • Identification of the situation/gravity of an incident • Enforcement/removal of a traffic restriction • Incident handling/clearance works.	

7) Specific Definition of Required Data for Integrated/Prioritized Information

Integrated/prioritized information dissemination, actualized by the empirical-based prioritization on the traffic event data, allows a large number of VMSs to be controlled responding optimally to their locations on the expressway network considering the following factors:

- Category/seriousness/location of the occurred traffic event (e.g. an accident, a construction work, bad weather, traffic congestion and traffic restrictions)
- Existence of correlated subordinate events
- Distance/conditions/route-selectivity between the location of respective VMSs and the site of event
- Estimated traffic volume to encounter the occurred traffic event.

The prioritizations are to be set for the occurred traffic event and the locations of respective VMSs based on the latest data. The generated information is to be provided through the radio broadcasts and the Internet as well.

The definitions of the traffic events are listed in the following table with the traffic restrictions to be corresponded.

Table 7.7 Definition of Traffic Events and Traffic Restrictions to be Correlated

Category	Traffic Event		Definition	Traffic Restrictions/Events 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 HR1 mm/h**	X	X	X	X	X	X	X	X	X				
		2	Heavy rain more than HR2 mm/h**	X	X	X	X	X	X	X					X	
		3	Heavy rain more than HR3 mm/h**	X	X	X	X	X	X	X						X
	High Wind	1	High wind more than HW1 m/sec** on average	X	X	X	X	X	X	X	X	X				
		2	High wind more than HW2 m/sec** on average	X	X	X	X	X	X	X					X	
		3	High wind more than HW3 m/sec** on average	X	X	X	X	X	X	X						X
	Dense Fog	1	Dense fog with visibility less than DF1 m**	X	X	X	X	X	X	X	X	X				
		2	Dense fog with visibility less than DF2 m**	X	X	X	X	X	X	X					X	
		3	Dense fog with visibility less than DF3 m**	X	X	X	X	X	X	X						X
	High Temperature		High temperature more than HT1 degrees C**													
Traffic Congestion	Congestion on Trough Lanes	1	VS continuously slower than V1 km/h** on av. with VQ longer than 4 km													
		2	VS continuously slower than V1 km/h** on av. with VQ longer than 2 km													
		3	VS continuously slower than V1 km/h** on av. with VQ longer than 1 km													
	Crowdedness on Trough Lanes		VS slower than V1 km/h** on av. with no or short VQ													
	Congestion at Exit	1	VS continuously slower than V1 km/h** on av. with VQ longer than 4 km at exit													
		2	VS continuously slower than V1 km/h** on av. with VQ longer than 2 km at exit													
		3	VS continuously slower than V1 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, ** : Specific values are to be defined, *** : Excluding vehicles.

8) Definition of Traffic Restrictions

A traffic restriction is to be enforced by using specific information, which consists of a traffic restriction and causal traffic events such as incident, traffic congestion, bad weather and construction work. The ultimate decision maker for each kind of traffic restriction can be defined as shown in the tables below.

The traffic restrictions responding to the traffic events are to be applied to the expressway network with reference to the existing system for the national highways. For our recommendation, the traffic restrictions responding to the incidents caused by the vehicles are to be enforced under the decisions of the traffic police and those responding to the other kind of incidents, bad weather and construction work are to be decided by the Expressway Management Agency.

Table 7.8 Recommended Traffic Restriction System for Expressway Network

Category	Traffic Event	Information Source	Traffic Restriction				Ultimate Decision Maker
			W	SL.	LC.	C.	
Special Event	Special Event	Submitted Materials	XX	XX	XX	XX	TP (MOT**)
Incident	Traffic Accident	Camera, Tel, Patrol	XX	XX	XX	XX	TP (MOT**)
	Tunnel Fire	Camera, Tel, Patrol	XX	XX	XX	XX	TP (MOT**)
	Reverse Driving	Camera, Tel, Patrol	XX	XX			TP
	Broken-down Vehicle	Camera, Tel, Patrol	XX	XX	XX	XX	TP (MOT**)
	Left Obstacle	Camera, Tel, Patrol	XX	XX	XX	XX	RO (MOT**)
	Natural Disaster	Camera, Tel, Patrol	XX	XX	XX	XX	RO (MOT**)
	Vandalism	Camera, Tel, Patrol	XX	XX	XX	XX	RO (MOT**)
Construction Work	Construction Work	Submitted Materials	XX	XX	XX	XX	RO (MOT**)
Bad Weather	Heavy Rain	WFC, Sensor, Patrol	XX	XX		XX	RO (MOT**)
	High Wind	WFC, Sensor, Patrol	XX	XX		XX	RO (MOT**)
	Dense Fog	WFC, Sensor, Patrol	XX	XX		XX	RO (MOT**)
Traffic Congestion	Traffic Congestion	Camera, Tel, Patrol	XX			XX	RO (MOT**)

Note: Tel: Telephone call, WFC: Weather forecasting, W: Warning, SL: Speed limitation, LC: Lane closure, C: Closure, exit closure or entry closure, TP: Traffic police, RO: Road operator, **: Speed limitation, lane closure and closure are to be enforced upon receiving the permission of the Expressway Management Agency.

Table 7.9 Existing Traffic Restriction System for National Highways

Category	Traffic Event	Information Source	Traffic Restriction				Ultimate Decision Maker
			W	SL.	LC.	RC.	
Special Event	Special Event	Submitted Materials	XX	XX	XX	XX	TP (DRVN**)
Incident	Traffic Accident	Tel, Patrol	XX		XX	XX	TP (DRVN**)
	Tunnel Fire	Tel, Patrol	XX			XX	TP (DRVN**)
	Reverse Driving	Tel, Patrol	XX				TP
	Broken-down Vehicle	Tel, Patrol	XX		XX	XX	TP (DRVN**)
	Left Obstacle	Tel, Patrol	XX		XX	XX	DRVN
	Natural Disaster	Tel, Patrol	XX		XX	XX	DRVN
	Vandalism	Tel, Patrol	XX			XX	DRVN
Construction Work	Construction Work	Submitted Materials	XX	XX	XX	XX	DRVN
Bad Weather	Heavy Rain	WFC, Patrol	XX			XX	DRVN
	High Wind	WFC, Patrol	XX				DRVN
	Dense Fog	WFC, Patrol	XX				DRVN
Traffic Congestion	Traffic Congestion	Tel, Patrol	XX				

Note: Tel: Telephone call, WFC: Weather forecasting, W: Warning, SL: Speed limitation, LC: Lane closure, RC: Road closure, TP: Traffic police, **: Road closure is to be enforced upon receiving the permission of DRVN.

7.6 Road-to-vehicle Communication Method for ETC

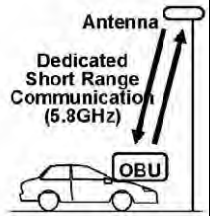
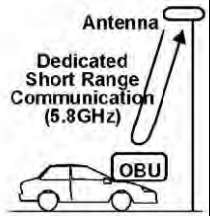
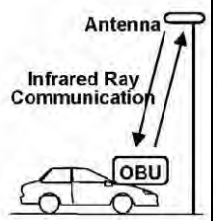
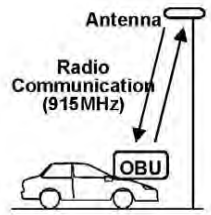
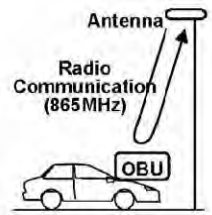
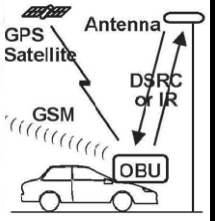
The advantage/disadvantages of the following six alternative road-to-vehicle communication methods for ETC are compared in the table on the next page.

- Active-DSRC
- Passive-DSRC
- DSRC/IR
- IR
- RF-Tag (Active)
- RF-Tag (Passive)
- GPS/GSM/IR,

Note:
DSRC: Dedicated Short Range Communication,
IR: Infrared ray, GPS: Global Positioning System,
GSM: Global System for Mobile Communications

According to the comparison, it is concluded that Active-DSRC, which has the largest number of advantages, is recommended, and Passive-DSRC is competitive mainly from the view point of equipment cost. RF-Tag (Passive) is to be followed up. The most appropriate road-to-vehicle communication for ETC will be selected from among these three methods through trial use.

Table 7.10 Comparison of Alternative Road-to-Vehicle Communication Methods for ETC

	Active-DSRC	Passive-DSRC	DSRC/IR	IR	RF-Tag (Active)	RF-Tag (Passive)	GPS/GSM
Outline							
Actual Use in Toll Collection	Many experiences	Many experiences	Many experiences	Many experiences	Many experiences	Many experiences	No experience
Sharing System among Different Operators/Suppliers	Many experiences	Many experiences	A few experiences	No experience	No experience	Few experience	No experience
Applicability to Distance Proportional Tariff	Applicable (Many experiences)	Not applicable (Few experiences)	Applicable (Many experiences)	Applicable (A few experiences)	Applicable (A few experiences)	Not applicable (Few experiences)	No experience
Applicability to ERP	Applicable	Applicable	Not applicable	Not applicable	Applicable	Applicable	Applicable
Recommendation in On-going Project in Vietnam	HCMC–Long Thanh –Dau Giay	HCMC–Trung Luong, Can Tho Bridge	None	None	Not Applicable (Conflict with GSM)	Cau Gie–Ninh Binh	None
Accuracy of Data Communication	High (99.9999%)	No regulation	Lowering by Sunlight	Lowering by Sunlight	Relatively low (Fear of double charge)	Lowering (To the order of 60%)	No regulation
Vehicle Deceleration	Not necessary	Not necessary	Not necessary	Necessary	Not necessary	Not necessary	Not necessary
2-pice Type OBU (Prepaid-Balance-in-Card)	Many experiences	For trial	Many experiences	Many experiences	Not capable	Not capable	No experience
Combined Use with Touch&Go	Capable	For trial	Capable	Capable	Capable	Capable	Not capable
Extensibility to Further IC-card Business	Possible	Not possible	Possible	Possible	Not possible	Not possible	Not possible
Required Cost of OBU	Average	Low (1-piece type)	Average	Average	Low (1-piece type)	Very low (1-piece type)	High (1-piece type)
Required Cost of Roadside Equipment	Low	Average	High	Average	Average	Average	Very low
International Standard	Established	Established	Established	Patented	Established	Established	None
Grading (The Number of Advantages)	Recommended (12)	Competitive (7)	Not suitable (7)	Not suitable (5)	Not suitable (6)	Competitive (7)	Not suitable (3)

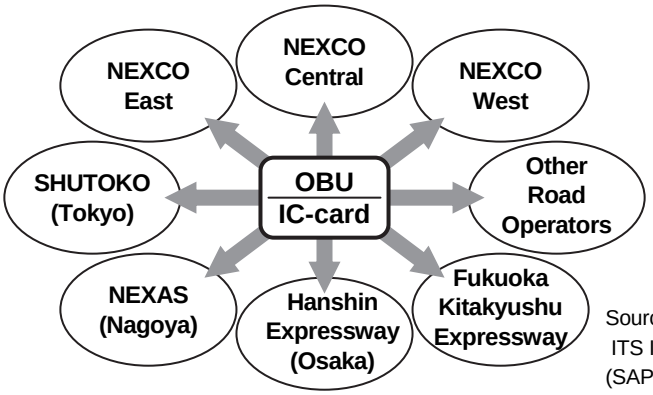
Note: ERP: ERP by multi-lane free-flow, OBU: OBU includes Tag, Underlined words: Fatal disadvantage

Source: ITS Standards & Operation Plan Study Team

1) Shared Use of System among Different Road Operators

Shared use of a single system among different road operator is necessary for convenience for road users. For example, an OBU for Active-DSRC and an IC-card is shared among all road operators in Japan as shown below. However, IR, Active RF-Tag and GPS/GSM has no experience and Passive RF-Tag has few experiences in shared use among road operators.

Figure 7.24 Shared Use of System among Different Road Operators in Japan



Source:
ITS Integration Project (SAPI) Study Team

2) Shared Suppliers in Actual Road Operation

Present situation of shared suppliers of each road-to-vehicle communication method for ETC is mentioned below.

- **Active-DSRC in Japan:** In the case of Active-DSRC in Japan, even though OBUs are manufactured by six suppliers and the roadside antennas are manufactured by eight suppliers, OBUs manufactured by different suppliers are shared on the whole road network. In addition, the road network includes the sections operated by more than five different road operators.
- **Passive-DSRC in France:** In the case of Passive-DSRC in France, OBUs and the roadside antennas are manufactured totally by five suppliers, and OBUs manufactured by three different suppliers are shared on the specific road sections. However, OBUs manufactured by the other two suppliers are not shared and need to be used separately.
- **DSRC/IR in Korea:** In the case of DSRC/IR in Korea, two roadside antennas for DSRC and IR are installed together on the same toll island, and the antenna for use is selected by the OBU installed in the vehicle. OBUs of DSRC are manufactured by three suppliers, and OBUs manufactured by different suppliers are shared on the same road.
- **IR in Malaysia:** In the case of IR in Malaysia, OBUs and the roadside antennas are manufactured by only one supplier who holds the patent for IR system. There is no sharing and no competition of OBU among the suppliers.
- **Active RF-Tag in USA:** In the case of RF-Tag (Active, 915 MHz) in USA, primary track records of ETC installation are monopolistic as shown in the following table. The system in each state is manufactured exclusively by a single supplier that has some advantage in the target state. There is no sharing and no competition of OBU among the different suppliers. The track records of Active RF-Tag in USA is shown in the table below.

Table 7.11 Track Records of Active RF-Tag for Toll Collection in USA

Installed System	Installed Location	Supplier
EZ-Pass	Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Virginia	Kapsch
Fast Lane	Massachusetts	Kapsch
I-Pass	Illinois	TransCore
Smart Tag	Virginia	TransCore
Sun Pass	Florida	TransCore
K-Tag	Kansas	TransCore
Pike Pass	Oklahoma	TransCore
EZ TAG	Texas	TransCore
PAL PASS	South Carolina	SIRIT
FASTRAK	California	SIRIT

Source: ITS Integration Project (SAPI) Study Team

- **Passive RF-Tag in Taiwan:** In the case of RF-Tag in Taiwan, Tag, roadside, and system are supplied by one vendor. Due to its system feature, it is required to compare tag ID and vehicle number. Its accuracy of data-communication is unstable. Reportedly, it can be lowered to the order of 60%, depending on a condition. As a result, approximately 120,000 transactions per day are subject to manual inspection for increasing the claiming rate up to sufficient percentage.
- **GPS/GSM/IR in Germany:** In the case of GPS/GSM/IR in Germany, vehicle passage at the tollgate is tracked by using GPS and the roadside antenna of IR. OBUs and the roadside antennas are manufactured by two suppliers; however, there is no sharing of OBU among the different suppliers.

3) Applicability to Distance Proportional Tariff System

Hereunder, applicability to the distance proportional tariff system is to be clarified especially on the three alternative methods of the road-to-vehicle communication for ETC: Active-DSRC, Passive-DSRC and RF-Tag (Passive). The comparison rsults on these three methods are shown in the table below.

Table 7.12 Comparison on Applicability to Distance Proportional Tariff System

	Active-DSRC	Passive-DSRC	RF-Tag (Passive)
Track Records in Distance Proportional Tariff	Many	Few	Few
Track Records in Blance in IC-card	Many	For trial	None
Needed Time for checking Negative List	Less than 1 Sec	Less than 1 Sec	Less than 1 Sec
Negative List Check before Vehicle Passage	Capable	Capable	Capable
Applicability to Section-by-section Tariff	Good	Good	Good
Needed Time for checking Balance	Less than 1 Sec	More than 15 Sec	More than 15 Sec
Balance Check before Vehicle Passage	Capable	Not capable	Not capable
Applicablity to Distance Proportional Tariff	Good	Not good	Not good
Collection of Adequate Amount of Toll	Possible	Difficult	Difficult

Source: The Study Team

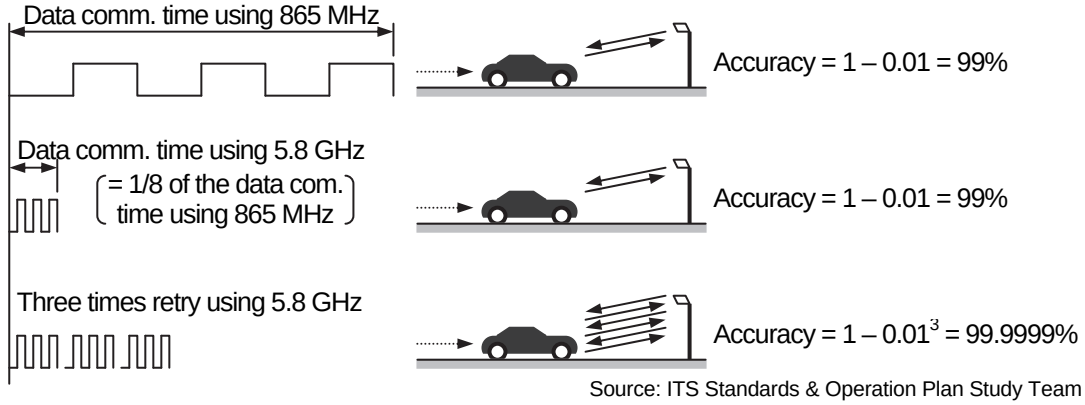
From the comparison results, only Active-DSRC can achieve the distance proportional tariff system with checking balance before vehicle passage.

4) Accuracy of Data Communication

Accuracy Improvement by Retry of Data Communication

Accuracy of radio communication is around 99% in either cases of 5.8 GHz for DSRC or 865 MHz for RF-Tag. However, in the former case, a certain amount of data communication can be completed within one-eighth time of what required in the latter case. Based on this principle, the message exchange using 5.8 GHz radio frequency band can be retried three times within the duration for using 865 MHz, and this three times retry of message exchange achieves an accuracy of 99.9999%, which is defined as the general specification of Active-DSRC in Japan.

Figure 7.25 Accuracy Improvement by Retry of Data Communication



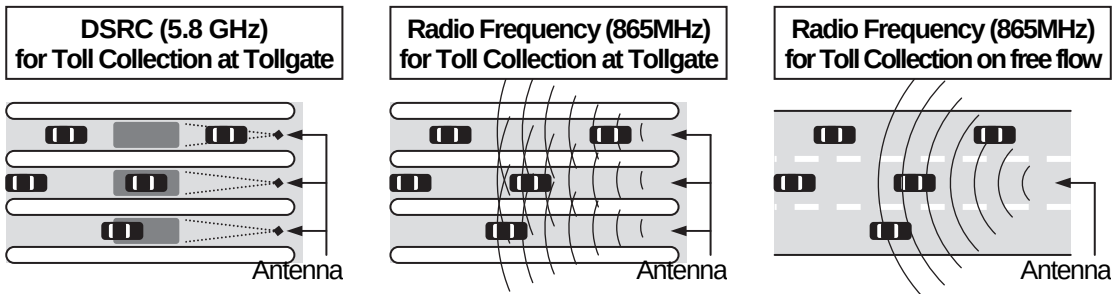
Source: ITS Standards & Operation Plan Study Team

A high accuracy of data communication is necessary for ETC, which deals with payment data; however, there is no specification on the accuracy of road-to-vehicle communication other than the case of Active-DSRC.

Additional Features Due to Diffraction of Radio Wave

Additional features on accuracy of communication due to diffraction of the radio waves of 5.8 GHz and 865 MHz, which may cause double toll charge, are shown the figure below.

Figure 7.26 Additional Features of DSRC (5.8GHz) and Radio Frequency (865 MHz)



- High accuracy of road-to-vehicle communication
- Ease in identifying unlawful passage by focused radio wave
- Reliable system at reasonable cost aiming at a high exposure rate for unlawful passage
- Necessity of a fixed deterrent effect by a small penalty system for unlawful passages.**

- Relatively low accuracy of road-to-vehicle communication
- Fear of double toll charge caused by diffraction of radio wave
- Difficulty in identifying unlawful passage by diffused radio wave
- Complicated system with difficulties in finding a solution to technical problems and enforcement.

- Relatively low accuracy of road-to-vehicle communication
- Difficulty in identifying unlawful passage by diffused radio wave
- Simple system at low cost aiming at a fixed exposure rate for unlawful passage
- Necessity of a large deterrent effect by a heavy penalty system for unlawful passages.**

Note: ** : See Section 6.13.

Source: ITS Standards & Operation Plan Study Team

5) Vehicle Deceleration

The capacity of each road-to-vehicle communication method for ETC is shown below. The methods with sufficient capacity for transmitting data volume allow the vehicles to pass through the tollgate without deceleration.

- Active-DSRC: 1.0 – 4.0 Mbps both for downlink and uplink
- Passive-DSRC: 1.0 Mbps for downlink and 0.25 Mbps for uplink
- IR: 0.5 Mbps for downlink and 0.125 Mbps uplink
- RF-Tag: 0.5 Mbps both for downlink and uplink.

Large communication capacity allows ERP (Electronic Road Pricing) on multi-lane free-flow as well.

6) 2-piece Type OBU (Prepaid-Balance-in-Card)

2-piece type OBU is adopted in many Asian countries, such as Active-DSRC in Japan, DSRC/ IR in Korea and IR in Malaysia and Vietnam. 2-piece type OBU is suitable to ETC based on prepayment, because it allows prepaid-balance-in-card, which brings the following features as mentioned in Section 7.7.

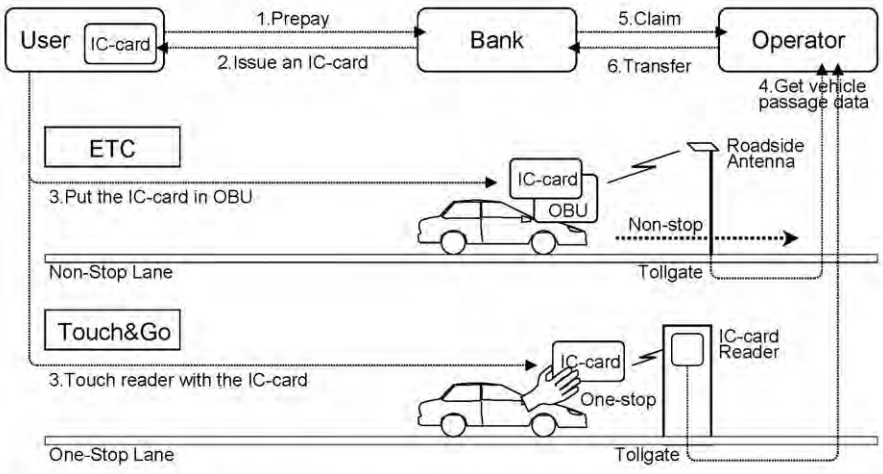
- Free from the difficulty in prepaid balance distribution to all tollgate lanes
- Free from the problem due to update interval of prepaid balance
- Free from the problems caused by low-quality telecommunication.

The 2-piece type OBU create a chance of further IC-card business proposed later; however, Active RF-Tag and Passive RF-Tag does not utilize IC-cards and brings no chance for the IC-card business.

7) Combined Use with Touch&Go

A single IC-card shall be shared for ETC as well as Touch&Go for the convenience of road users and road operators.

Figure 7.27 ETC Combined Use with Touch&Go



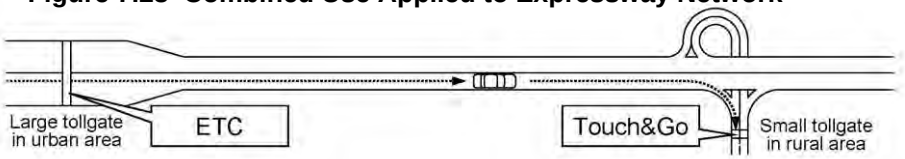
Source: VITRANSS2 Study Team

ETC combined use with Touch&Go provides the following advantages:

- Flexible operation by combined use of the toll collection methods: incoming by ETC and

outgoing by Touch&Go, or incoming by Touch&Go and outgoing by ETC as well.

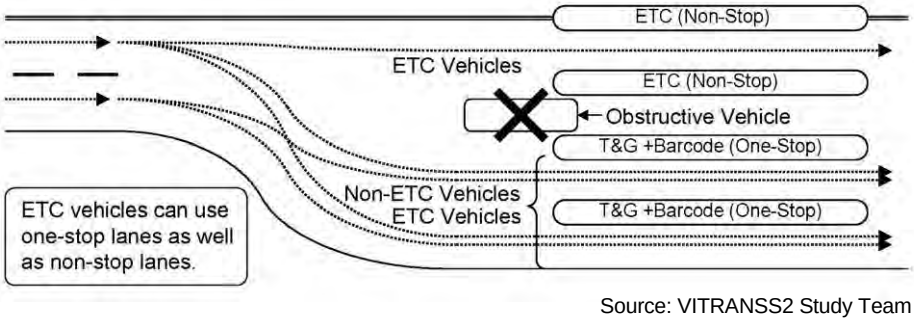
Figure 7.28 Combined Use Applied to Expressway Network



Source: VITRANSS2 Study Team

- Cost-cutting by excluding ETC installation at small tollgates in rural areas, and capability of stepwise ETC installation beginning with large tollgates in urban areas.
- Flexible tollgate lane operation that prevents mix-ups caused by inexperienced ETC vehicle drivers and/or accidents at ETC lanes.

Figure 7.29 Flexible Tollgate Lane Operation



Source: VITRANSS2 Study Team

ETC exclusive operation and ETC/manual mixed operation can be applied to an ETC lane operation at tollgate. The ETC exclusive operation is recommended by the comparison below.

Table 7.13 Comparison on Methods of ETC Lane Operation at Tollgate

	ETC Exclusive Operation	ETC/Manual Mixed Operation
Outline	Only the vehicles equipped with OBU can pass exclusively through ETC lanes at the tollgate. A human collector needs to deal with wrong tollgate lane selection by vehicles without OBU.	The vehicles without OBU can pass through ETC lanes at the tollgate as well as the vehicles equipped with OBU. A human collector needs to attend for toll collection of the vehicles without OBU.
Capacity	Vehicle processing design capacity: 800 vehicles/lane/hr.	Vehicle processing design capacity: 450–600 vehicles/lane/hr.
Advantages	- Attainment of large vehicle processing capacity in the ETC lane, - Large effects to relieve congestion at the tollgates, - Swift diffusion of OBU motivated by smooth passing through the ETC lane.	- Reduction of the possibility of congestion on the manual lanes caused by low diffusion rate of OBU in the early stage of ETC introduction.
Problems	- Possibility of congestion on the manual lanes caused by low diffusion rate of OBU in the early stage of ETC introduction.	- Lowering of vehicle processing capacity of the ETC lane due to longer processing time for the vehicles without OBU, - Small effect on relieving congestion at the tollgate, - Slow diffusion of OBU affected by delay in passing through the ETC lane.
Grading	Recommended	Not Suitable

Source: VITRANSS2 Study Team

8) Extensibility to Further IC-card Business

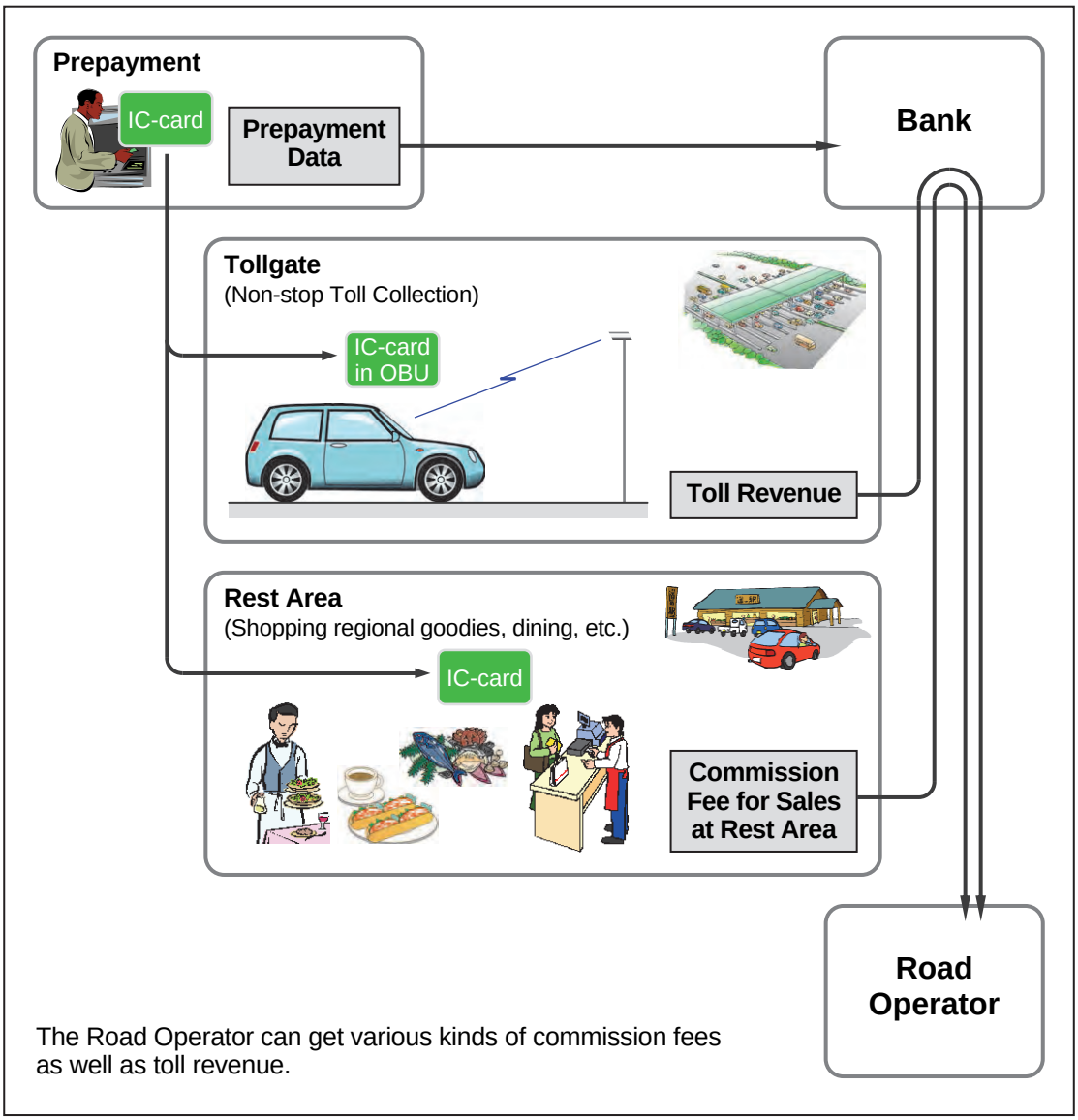
ETC using 2-piece type OBU create a chance of IC-card business as shown in the figure below. The IC-cards (easily out from OBUs) can be used conveniently for shopping regional goodies, drinking beverage, dining, entertainment and other services at rest areas.

Under this proposed IC-card business scheme, the following advantages can be offered to the ETC users, to promote the businesses in rest areas:

- Present of bonus points to the IC-card users upon shopping, dining or other services by IC-cards at rest areas (the bonus points will attract repeater customers)
- Provision of timely sales advertisement information, via mobile/smart phones, from the businesses in rest areas to the ETC-user drivers, immediately after the vehicles enter an entrance gate.

Rise in business revenue at rest areas will result in increase of commission fee for sales at rest areas.

Figure 7.30 Prposed IC-card Business around Expressways



Source: The Study Team

9) Required Cost of Roadside Equipment

GPS/GSM is based on the vehicle location estimated by using GPS and requires only a small number of roadside antennas for enforcement and correction; hence, in the case of GPS/GSM, required cost of roadside equipment is very low. On the contrary, DSRC/IR needs combined roadside antenna for two types of road-to-vehicle communication and requires high cost.

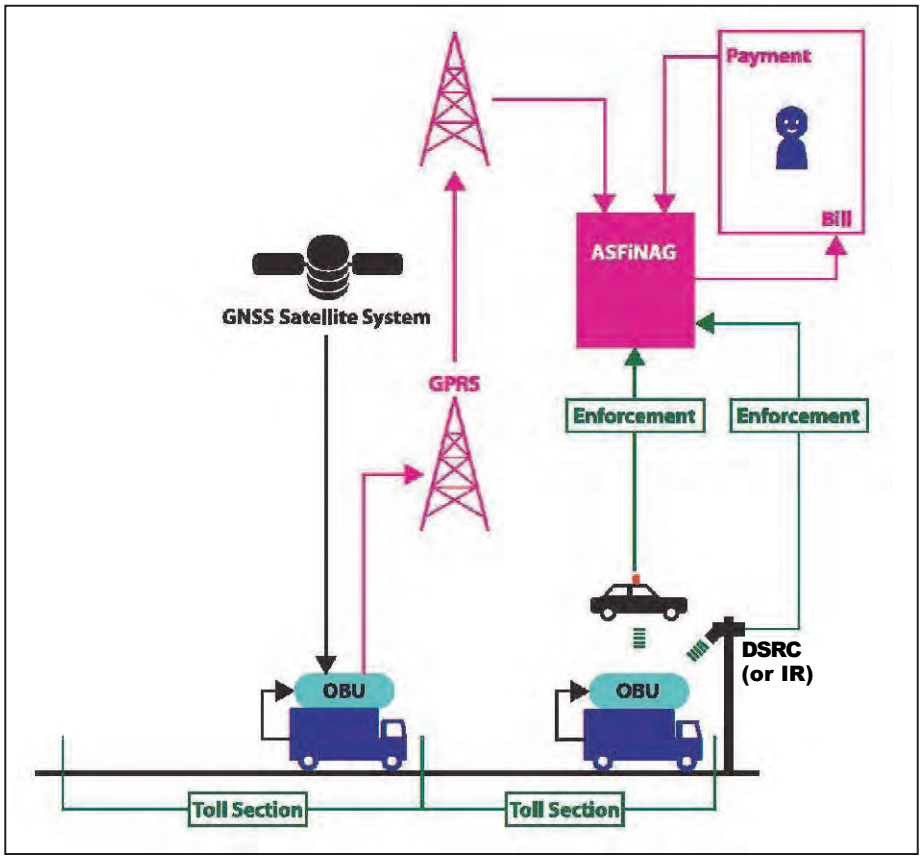
Roadside antenna for Passive-DSRC or Passive RF-Tag requires higher cost than that for Active-DSRC according to the following reasons:

- Roadside equipment of Touch&go at lower cost than that of ETC is not available in Passive RF-Tag
- Additional transmitting power is necessary for roadside equipment of Passive RF-Tag to store temporary data for distance proportional tariff in OBU.

10) International Trend to Next-generation ETC

In the ITS World Congress 2011 in USA, the technology of GPS/GSM for ETC is presented by many organizations as a next-generation ETC. This method realizes ETC by technologies of GPS (Global Positioning System) and GSM (Global System for Mobile Communications) generally without roadside equipment. In this method, DSRC or IR is used for enforcement

Figure 7.31 Next-generation ETC based on GPS and DSRC (or IR)



Source: ITS Integration Project (SAPI) Study Team

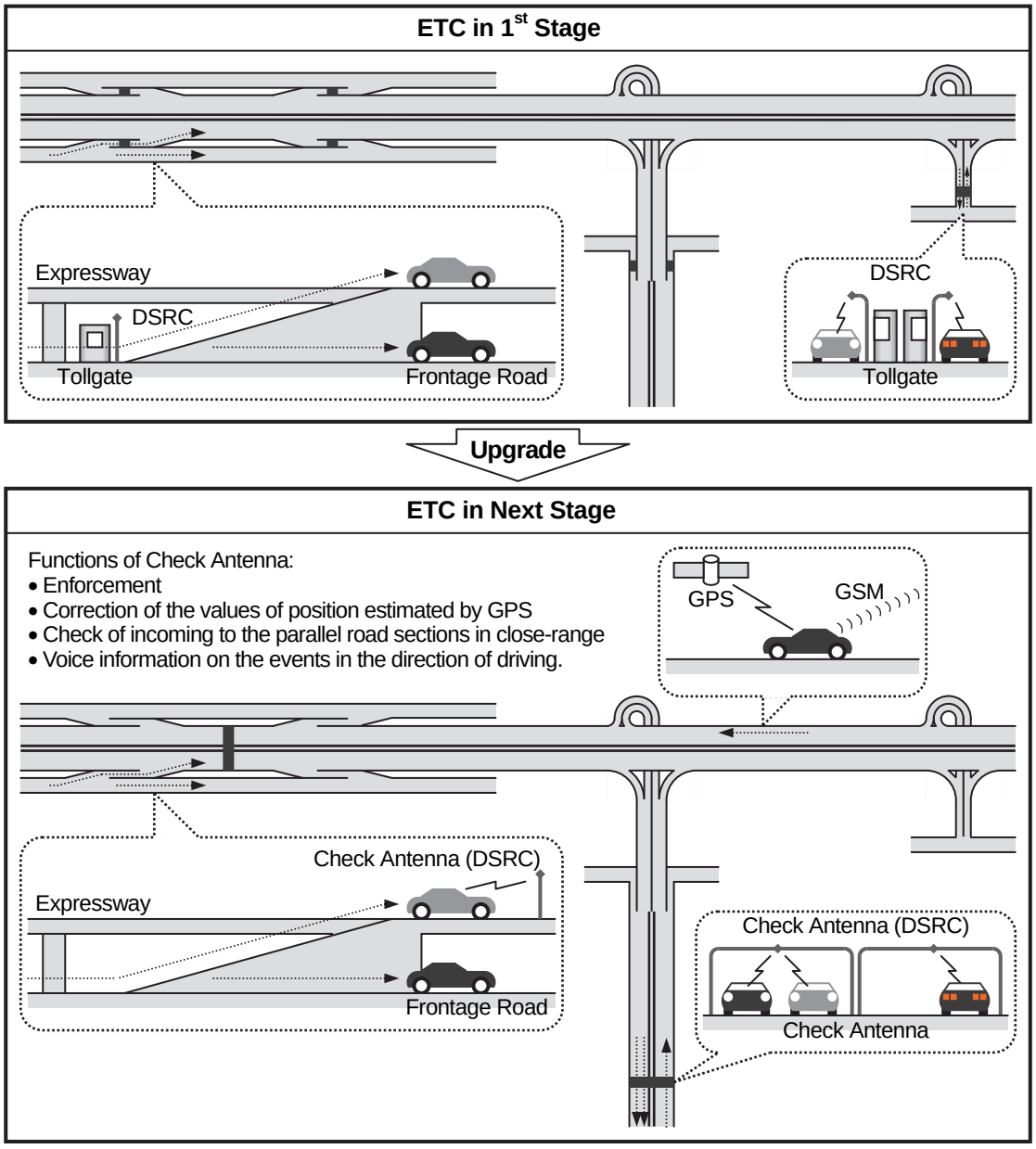
and check of incoming to the parallel road sections in close-range. However, Active and Passive RF-Tag is outside of the concept of the next-generation ETC.

11) Concept of Upgrading to Next-generation ETC

Toward the next stage, an upgrading to next-generation ETC can be proposed. Roadside equipment at tollgate and OBUs based on the technology of DSRC are to be installed for ETC in the 1st stage. The technology and roadside equipment can be utilized for the purposes below in the next stage as well as the technologies of GPS and GSM.

- Enforcement
- Correction of the values of position estimated by GPS
- Check of incoming to the parallel road sections in close-range
- Voice information on events in the direction of driving (→ only by Active-DSRC).

Figure 7.32 Upgrading to Next-generation ETC

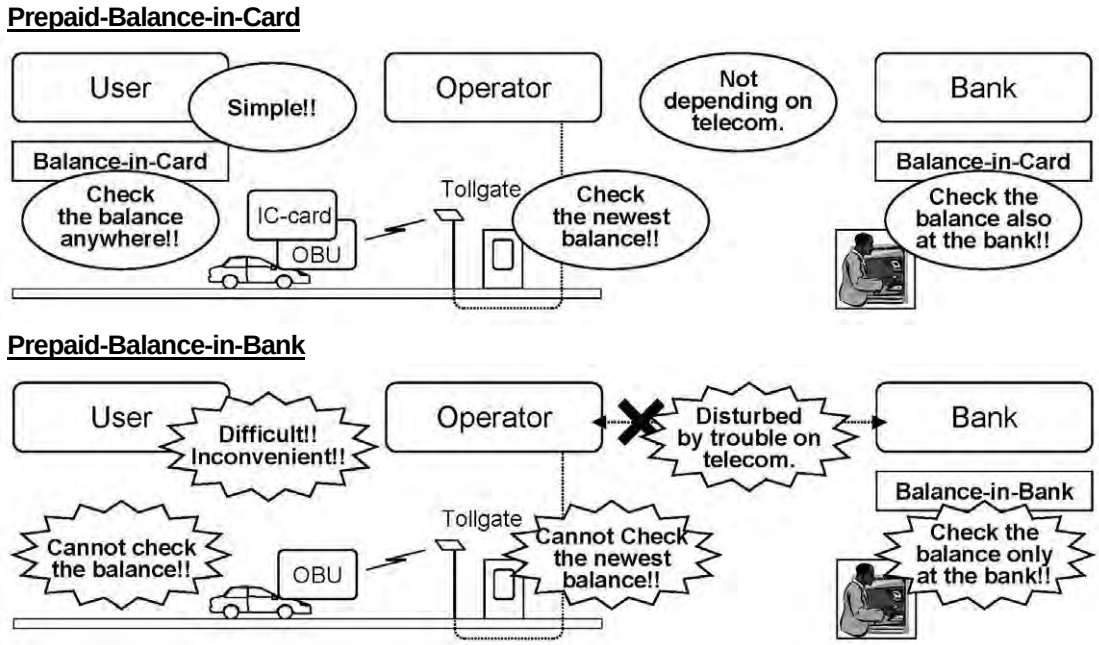


Source: ITS Integration Project (SAPI) Study Team

7.7 Method of Checking Prepaid Balance

Prepaid balance can be managed in two different ways: prepaid-balance-in-card and prepaid-balance-in-bank. Prepaid-balance-in-card allows users to check the prepaid balance anywhere, on the other hand, prepaid-balance-in-bank limits checking the prepaid balance only to a bank. For this reason, prepaid-balance-in-card is recommended for ETC and Touch&go.

Figure 7.33 Methods for Checking Prepaid Balance

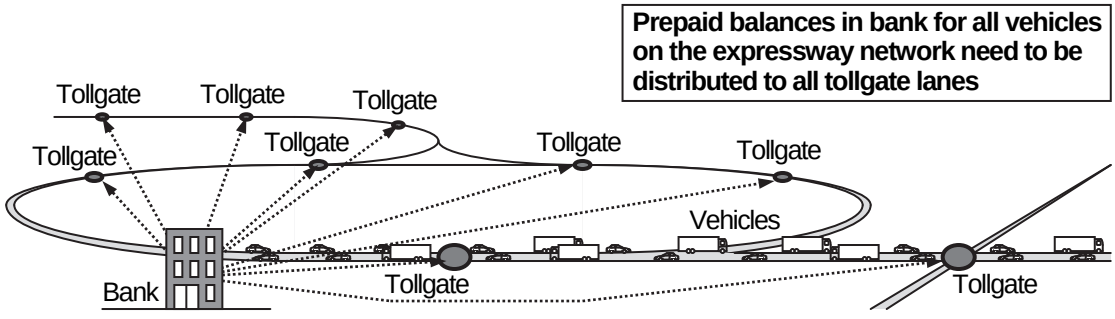


Source: VITRANSS2 Study Team

1) Difficulty in Prepaid Balance Distribution to All Tollgate Lanes

In the case of prepaid-balance-in-bank, the prepaid balance data (or the insufficient-balance-user-list) for all vehicles on the expressway network needs to be distributed from the bank to all tollgate lanes. However, in near future, the data volume of distribution will become very large corresponding to the increasing number of the vehicles on the expressway network; hence, the distribution cannot be done continuously but done only by batch processing in a certain time interval. In Europe, the delivery of insufficient-balance-user-list is generally done once a day or less.

Figure 7.34 Prepaid Balance Distribution to All Tollgate Lanes

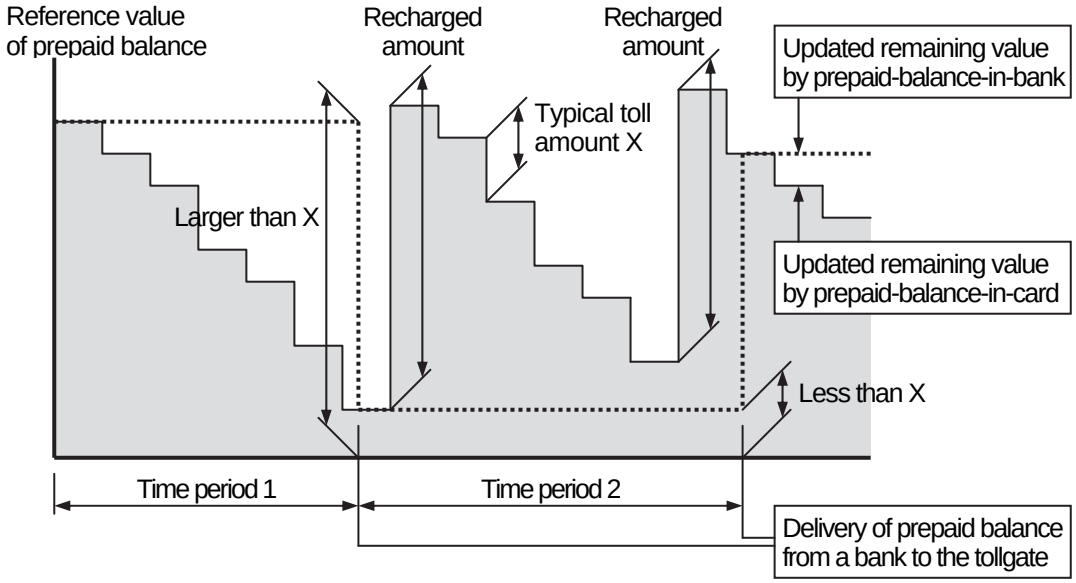


Source: ITS Standards & Operation Plan Study Team

2) Problem Due to Update Interval of Prepaid Balance

As shown in the figure below, remaining value of prepaid balance is updated every time the vehicle passes through the tollgates in the case of prepaid-balance-in-card. However, in the case of prepaid-balance-in-bank, remaining value is updated only at times the prepaid balance is distributed from the bank to the tollgate, accordingly remaining value is far lager than typical toll amount X throughout time period 1, but remaining value keeps less than X throughout time period 2.

Figure 7.35 Problem Due to Update Interval of Prepaid Balance



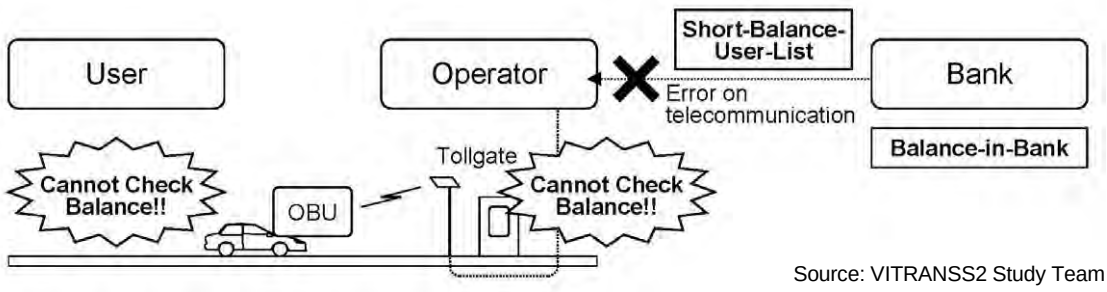
Source: ITS Standards & Operation Plan Study Team

3) Problems Caused by Low-quality Telecommunication

In the ETC trials in Malaysia, low-quality telecommunication interferes with the data exchange and causes the following problems:

- Even in the case a user's balance is not enough, the system cannot verify his balance and the operator cannot stop him,
- Even in the case a user recharged his balance, the system cannot check his balance and he cannot pass a tollgate.

Figure 7.36 Problems Caused by Low-quality Telecommunication



Source: VITRANSS2 Study Team

7.8 Contact-less IC-Card Type

There are three major types of contact-less IC-cards using 13.56MHz:

- TYPE-A (including some improved version such as TYPE A + Mifare)
- TYPE-B
- Felica

Advantages and disadvantages of each type of contact-less IC-card are summarized in the table below. TYPE-A (Mifare) and Felica are recommended for the use of ETC and Touch&Go in Vietnam.

Table 7.14 Comparison on Specification of Contact-less IC-card

		TYPE A (Mifare)	TYPE A	TYPE B	Felica
Transaction Speed		> 106kbps (depending on variety)	> 106kbps	106kbps	212kbps
International Standards	ISO 14443	Compliant	Compliant	Compliant	Not compliant
	ISO 18092	Compliant	Compliant	Not compliant	Compliant
Crypto-graphy	RSA	Applicable	Applicable	Applicable	Applicable
	AES	Applicable (depending on variety)	Applicable	Applicable	Not applicable
Multi-Reaction (Anti-Collision method)		Bit Collision /or/ Time Slot method	Bit Collision /or/ Time Slot method	Slot Marker method	Bit Collision /or/ Time Slot method
Usage Track Records for Transportation		Asia, Europe (e.g. fuel fee payment in Vietnam)	Asia, Europe	Europe	Asia (e.g. subway fare payment in Vietnam)
Usage Track Records in Vietnam		Many	None	A line of MRT (in near future)	Many lines of MRT (in near future)
Competitive Suppliers		Many	Many	Many	A few
Production Cost		Low	Low	Middle	High
Grading		Recommended	Not Suitable	Not Suitable	Recommended

Source: ITS Standards & Operation Plan Study Team

(1) Transaction Speed

"Felica" has more advantages than the others and has about twice the transaction speed as other systems.

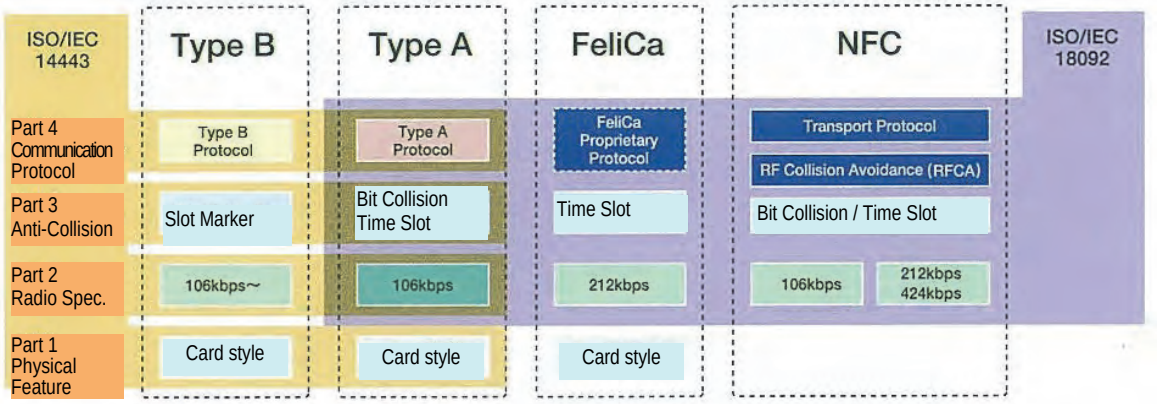
(2) International Standard

International standards for contact-less IC-card are ISO/IEC1443 and ISO/IEC18092 issued in 2003.

ISO/IEC18902 regulates contact-less IC-card based on data transaction within 10 cm using 13.56 MHz radio wave. Transaction speed can be selected from these alternatives: 106, 212 and 424 Kbps.

ISO/IEC18092 defines only standards for communication method between equipments, not specific physical shape/sizes. Therefore, there is flexibility for products shape/sizes.

Figure 7.37 Relationship between ISO/IEC14443 and ISO/IEC18902



Source: VITRANSS2 Study Team

(3) Cryptography (for security)

"RSA" and "AES" are the major cryptography algorithms discussed below.

- **RSA**: In cryptography, RSA is an algorithm for public-key cryptography. RSA is widely used in electronic commerce protocols, and is believed to be secure given sufficiently long keys and the use of up-to-date implementations.
- **AES:** In cryptography, AES (the Advanced Encryption Standard) is a symmetric-key encryption standard adopted by the U.S. government. The AES ciphers have been analyzed extensively and are now used worldwide. AES have no advantage over RSA, however the processing speed is higher than RSA.

"TYPE-A" has several types such as Mifare Classic, Mifare Plus, Mifare Desfire and so on; however, it is reported that "Mifare Classic" has faced a security problem recently, and secure cryptography algorithm "AES" cannot be applied to it.

(4) Anti-Collision Method (Multi-Reaction)

Anti-collision method is used for processing IC-cards when two or more IC-cards exist in the area of a reader/writer (R/W). There are three different types of anti-collision methods.

- **Time Slot method:** Each IC-card creates a random number based on R/W's request, and then IC-card will respond in accordance with created number. R/W can identify each IC-card based on the response timing.
- **Bit Collision method:** R/W can identify each card based on the response with a unique series of "Bit" such as "1" or "0" until R/W recognizes without any duplication of the bits.
- **Slot Marker method:** R/W assigns a random number to IC-card to identify each card.

Table 7.15 Anti-Collision Method

Anti-Collision Method	Characteristics
Time Slot method	Only one request from R/W at initiation stage is needed, therefore, it has less number of transactions.
Bit Collision method	It takes time because R/W requires judging all of the Bit series.
Slot Marker method	It takes time because R/W requests to all cards.

Source: ITS Standards & Operation Plan Study Team

(5) Usage Track Records for Transportation

Asian Region

Asian region is one of the advanced examples to spread Contact-less IC-card, such as "Octopus Card" in China and Hong Kong and "ez-link" in Singapore.

In Soul, Korea, "T-money" IC-card was introduced as a new concept based on the revision of urban transport system in July, 2004.

Recently, the rapid economic developing cities of Shenzhen, Guangzhou, Shanghai and Dalian in China, have promoted Contact-less IC-card as a transportation card.

In Asia, TYPE A or Felica techniques are applied in many cities and TYPE B has a few case of usage. Especially in Vietnam in near future, Felica is to be applied many lines of MRT in Ha Noi and HCMC and TYPE B is to be applied a line in Ha Noi.

European Region

In European region, IC-card is popularized as a additional function with Debit Card (ATM card) in order to realize "Coin-less Payment", such as "Geldkarte" in Germany, "Danmont" in Denmark, "Proton" in Belgium, "Moneo" in France, and "Chipkaart" in Netherlands.

The transport agencies in France, Italy, Portugal and Germany are studying to introduce contact/contact-less IC-card and box type terminal units for data exchange from contact IC card to contact-less IC card.

In European region, TYPE A and TYPE B are applied in many cities.

(6) Competitive Suppliers

"TYPE-A (Mifare)" and "Felica" are supplied by small number of suppliers. The detail specifications of these types are not disclosed by the suppliers.

(7) Production Cost

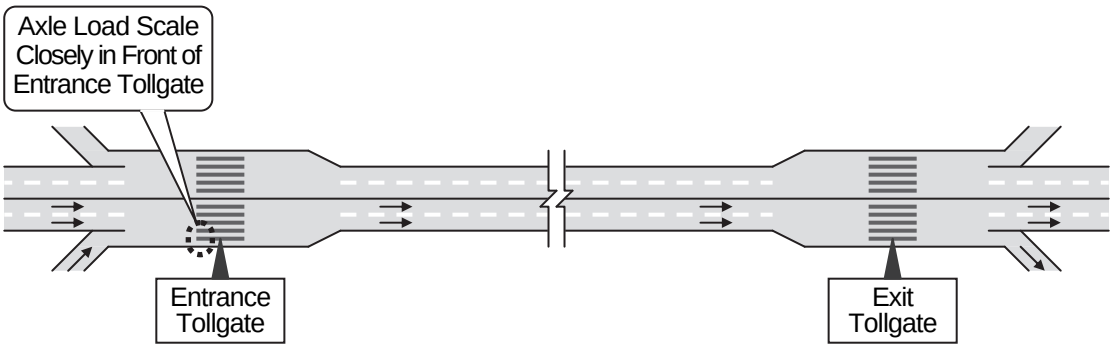
In consideration of IC-cards and reader/writers (R/W), "TYPE-A (especially Mifare Classic)" can be supplied at the lowest cost, and "TYPE-B" can be supplied at lower cost than "Felica".

7.9 Axle Load Scale Arrangement

Axle load scale is to be installed for the purpose of overloading regulation; however, there are three alternatives of axle load scale arrangement.

- **Alternative 1:** Axle load scale installed in front of entrance tollgate with the requirement for overloaded trucks to go out from the expressway at the next interchange.

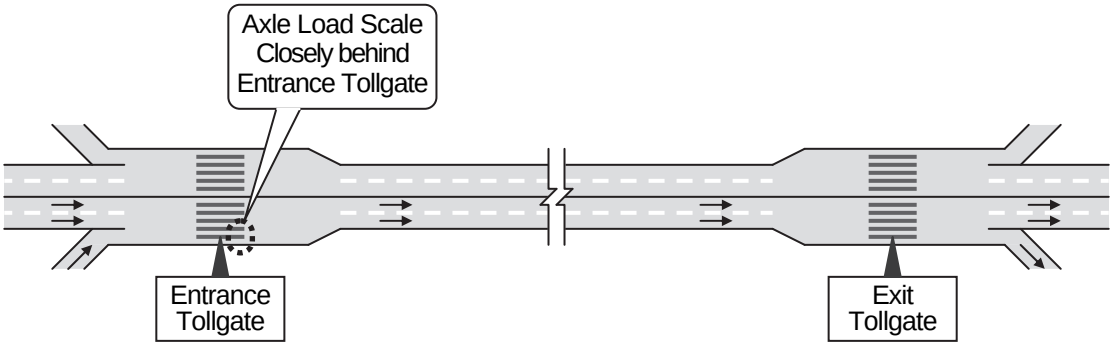
Figure 7.38 Alternative 1: Axle Load Scale in Front of Entrance Tollgate



Source: ITS Integration Project (SAPI) Study Team

- **Alternative 2:** Axle load scale installed behind of entrance tollgate with the requirement for overloaded trucks to go out from the expressway at the next interchange.

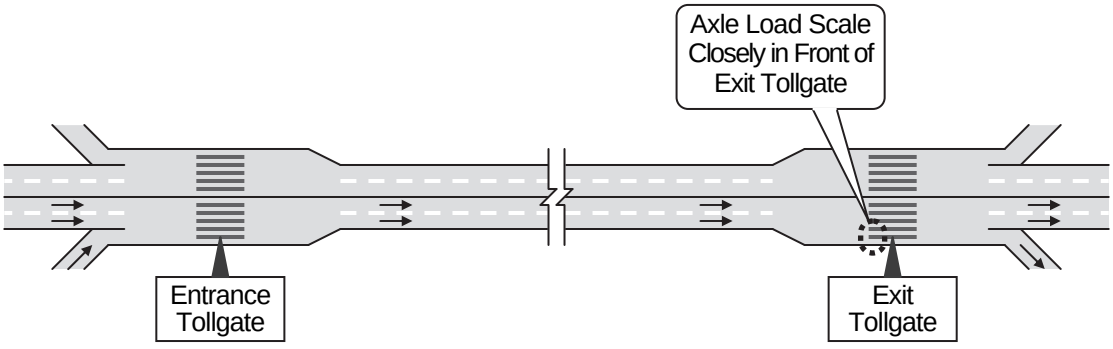
Figure 7.39 Alternative 2: Axle Load Scale behind Entrance Tollgate



Source: ITS Integration Project (SAPI) Study Team

- **Alternative 3:** Axle load scale installed in front of exit tollgate with the requirement for the overloaded trucks to pay high amount of penalty at the tollgate.

Figure 7.40 Alternative 3: Axle Load Scale in Front of Exit Tollgate



Source: ITS Integration Project (SAPI) Study Team

Table 7.16 Comparison on Alternatives of Axle Load Scale Arrangement

	Alternative 1	Alternative 2	Alternative 3
Intended Level of Penalty for Overloaded Trucks	Average Penalty	Avarege Penalty	High Penalty
Installation of Axle load Scale in to All Tollgates to Prevent Avoidance	Possible	Possible	Possible
Control/Stop of Overloaded Trucks	Easy	Not Easy	Easy
Accuracy of Measurement	Enough (within Tollgate Lane)	Enough (within Tollgate Lane)	Enough (within Tollgate Lane)
Additional Installation of Weigh-bridges to Impose a Penaly	Necessary	Necessary	Not Necessary
Preparation of Additional Legal Framework	Necessary	Necessary	Necessary and Difficult
Grading	Recommended	Comparable	Comparable

Source: ITS Integration Project (SAPI) Study Team

The location closely in front of exit tollgates is recommended for axle load scale from the comparison shown in the table above.

Required Condition:

Axle load scale installation in the Project is the 1st stage of implementation of the system for overloading regulation.

The system for overloading regulation is to be implementation stepwise; however, additional measures are necessary as shown by underlines.

In the Project :1st Stage

1) Axle load scales are to be installed in front of the entrance tollgate.
2) The total weight of a truck is to be estimated from the total value of measured axle loads and the license number is to be captured.
3) A ticket for indicating measured weight is to be handed to the driver of the truck beyond the limit of measured weight, and the driver is required to pay penalty and to go out from the expressway at the next (or nearest) exit tollgate: however, it is necessary for the Government to prepare a legal framework to impose penalty by measuring axle loads.
4) Road operators are never to permit the truck beyond the limit to enter any expressway by referring to the captured license number.

In the Future :Next Stage

1) A weighbridge is to be installed additionally at the place along expressways (or at the exit tollgate) with enough space appropriately based on the accumulated data by axle load

measurement.

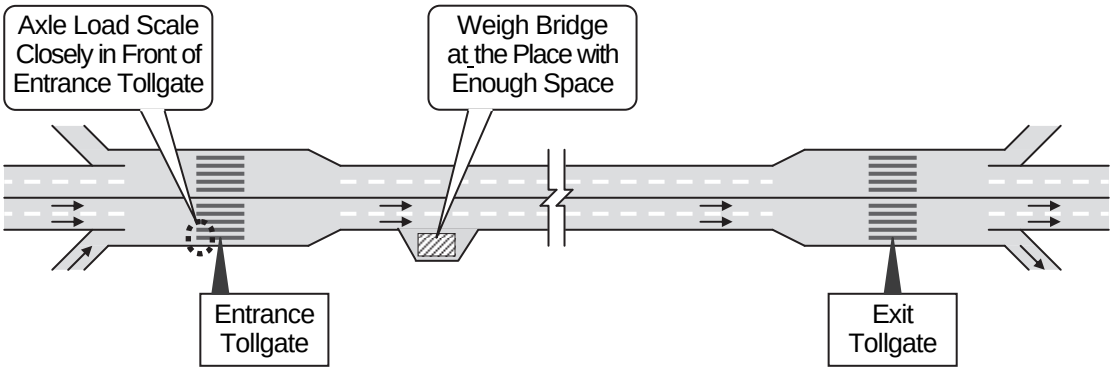
2) The total weight of a truck is to be estimated from the total value of measured axle loads and the license number is to be captured.

3) A ticket for indicating measured weight is to be handed to the driver of the truck beyond the limit of measured weight, and the driver is required to go to the place of weighbridge and to measure the total weight of the truck.

4) In the case the total weight is beyond the limit value, the driver of the truck is required to pay a penalty and to reduce the total weight of truck by reshipment.

5) Road operators are never to permit the truck enter any expressway unless otherwise the payment of the penalty and reducing of the total weight; however, it is necessary for the Government to prepare a legal framework against unlawful drivers who ignores payment of penalty (or toll).

Figure 7.41 Axle Load Scale in Front of Entrance Tollgate (In Future)



Source: ITS Integration Project (SAPI) Study Team

7.10 Integration of Roadside Equipment Control

1) Roadside Equipment for Traffic Information/Control

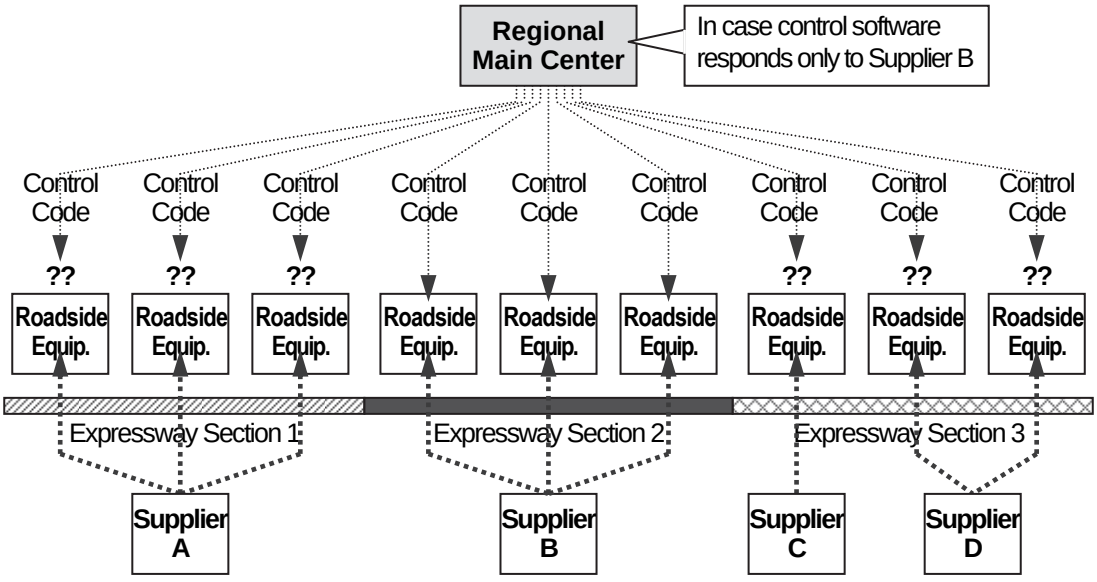
(1) Necessity of Integration of Roadside Equipment Control

As mentioned in Chapter 6, routine monitoring and control of traffic is to be conducted by controlling pieces of roadside equipment under the Regional Main Center. Actual roadside equipment control is performed through control codes transmitted from the Regional Main center.

On the other hand, implementation of roadside equipment is conducted in construction projects of individual road sections based on the expressway construction schedule. Consequently, it is usual that pieces of roadside equipment are different according to the road sections and the suppliers who install them.

In many cases, control codes are not compatible among the pieces of roadside equipment manufactured by different suppliers. In such cases, it is necessary to take countermeasures to make it possible to control all pieces of roadside equipment spread on the different road sections directly by the system installed at the center construction.

Figure 7.42 Control Codes Incompatible among Different Suppliers



Source: ITS Standards & Operation Plan Study Team

A large number of additional CCTV cameras are to be installed for traffic information/control with the increase in the total length of expressways. Also to hold down rising video image data volume from the CCTV cameras, the integration of roadside equipment control is necessary.

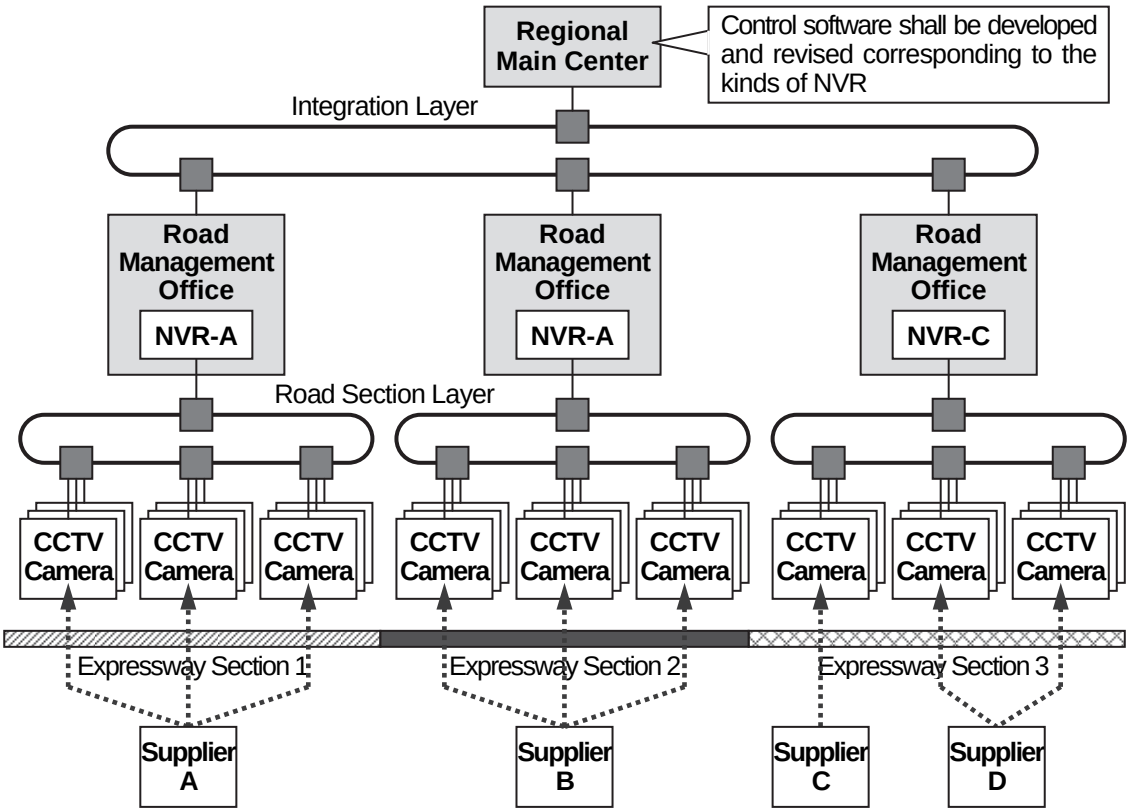
Integration measures for controlling roadside equipment including CCTV camera and VMS are discussed in the following.

(2) Integration of CCTV Camera Control

NVR (Network Video Recorder) is an integration tool useful for controlling many CCTV cameras installed by different suppliers. In the Study, NVRs are assumed to be installed at communication nodes or in road management offices as shown in the figure below. The figure shows that control codes need to be generated only for NVR-A and NVR-C in the Regional Main Center to reduce the variety of control codes. Concurrently, video image data volume sent to integration layer can be reduced as well.

However, disclosure of control codes is indispensable for installing NVR and control software in the Regional Main Center needs to be revised responding to the rise in the number of NVR.

Figure 7.43 Integration of CCTV Camera Control



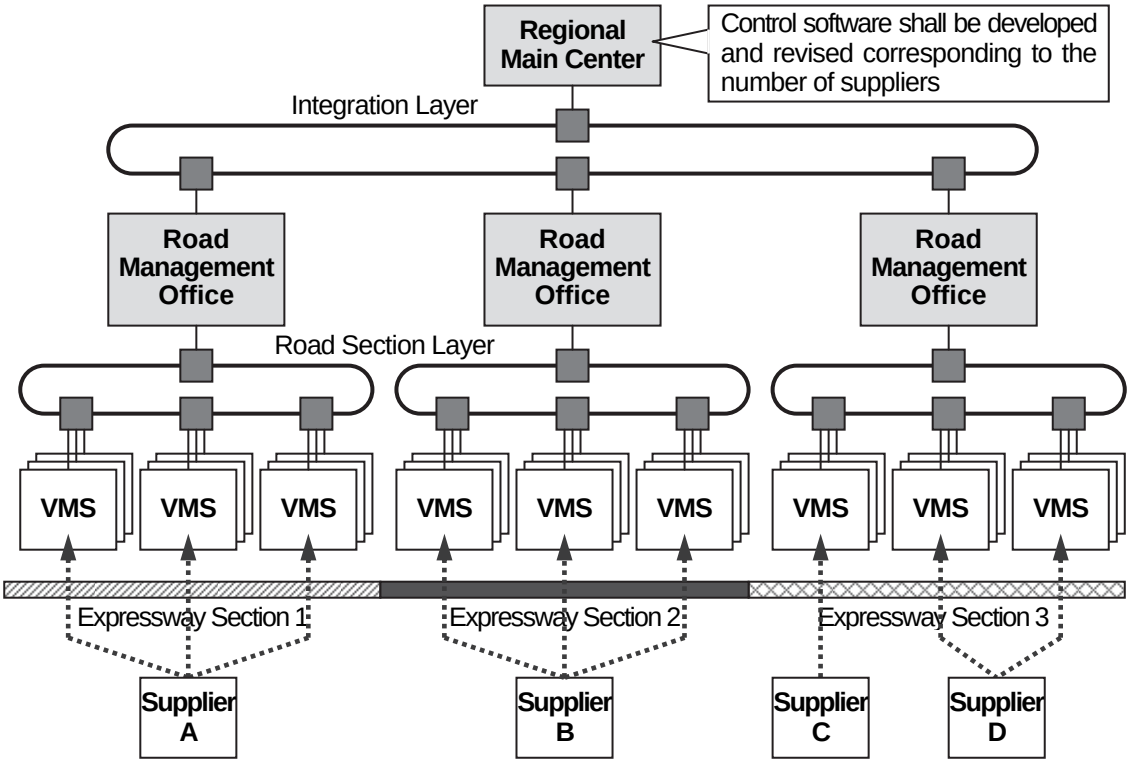
Note: NVR can be installed at communication nodes or in road management offices.

Source: ITS Standards & Operation Plan Study Team

(3) Integration of VMS Control

There is no effective integration tool for controlling many VMSs installed by different suppliers, and control codes need to be generated in the Regional Main Center as many as the number of suppliers who installed VMS. Hence, for VMS installation, suppliers need to be obligated to disclose technological information, and the VMS control software in the Regional Main Center needs to be revised responding to new entrants of suppliers.

Figure 7.44 Integration of VMS Control

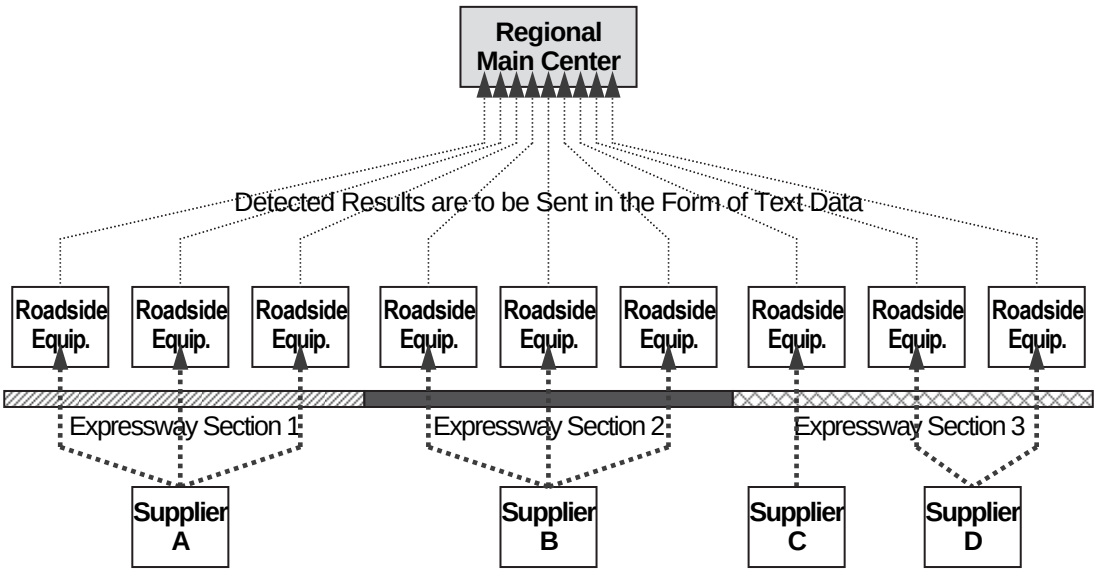


Source: ITS Standards & Operation Plan Study Team

(4) Other Detectors/Sensors

Excluding CCTV camera and VMS, other detectors/sensors need not particular control codes generally. All kinds of detected results are converted to text data and are sent simply to the Regional Main Center. Hence, there are no causes for problems on integration of control, even in the case pieces of equipment are installed by different suppliers.

Figure 7.45 Transmission of Detected Results by Detectors/Sensors

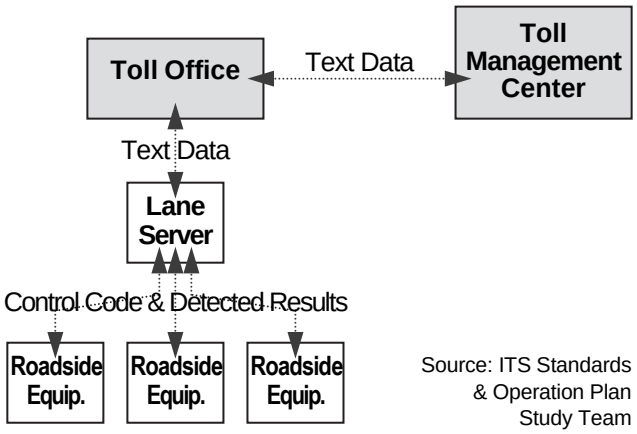


Source: ITS Standards & Operation Plan Study Team

2) Roadside Equipment for Automated Toll Collection

Pieces of roadside equipment for automated toll collection are controlled by a lane server and their detected results also managed by the server. Data exchanges with higher level systems in toll office and others are conducted by using text data, which has no problem on integration of control.

Figure 7.46 Roadside Equipment Control and Transmission of Detected Results for Automated Toll Collection



3) Roadside Equipment for Overloading Regulation

Similar to the case of automated toll collection, pieces of roadside equipment for overloading regulation are controlled under a roadside server and their detected results also managed by the server. Data exchanges with higher level systems are conducted by using text data, which has no problem on integration of control.

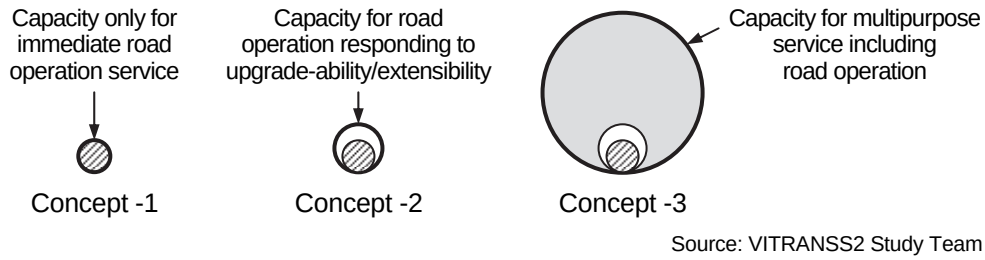
7.11 Transmission Method

Transmission Capacity

Transmission capacity is one of the most important factors for selecting suitable transmission method, which is to respond to the scope of services provided through it. Three typical concepts are proposed for setting target capacity of the communication network for ITS:

- Concept -1: Capacity only for immediate road operation service
- Concept -2: Capacity for road operation service with upgrade-ability/extensibility
- Concept -3: Capacity for multi-purpose service including road operation.

Figure 7.47 Concepts of Target Capacity of Communication Network for ITS



Source: VITRANSS2 Study Team

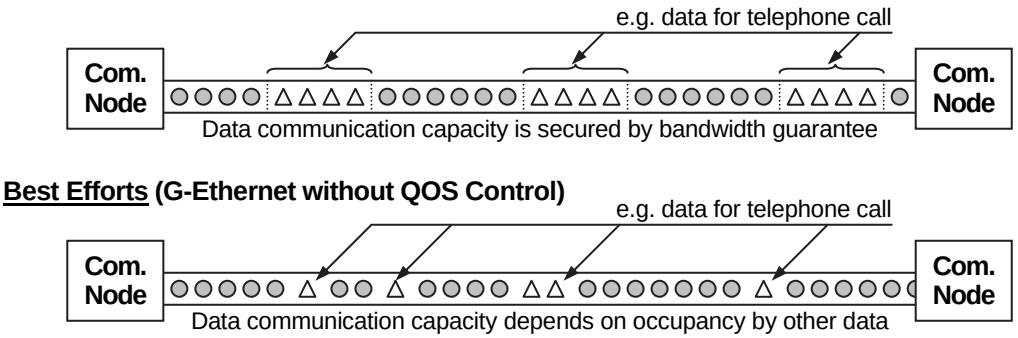
Generally, the target capacities of Concept-2 and Concept-3 are suitable for expressway operation using ITS. IP over SDH and IP over G-Ethernet are to be recommended as suitable transmission methods for realizing Concept-2.

However, the communication system can produce profits through its operation and is to be used for the broader purpose to achieve efficient road operation. For such purpose, IP over SDH/ DWDM and IP over TDM/DWDM are suitable transmission method for realizing Concept-3.

Bandwidth Guarantee

Telephone is to be used for emergency calls and directives any time the need arises, and that requires bandwidth guarantee to create a stable link between the initiating and receiving parties. SDH and G-Ethernet can provide this function and is suitable for the integration layer of the hierarchical communication network for ITS.

Figure 7.48 Concepts of Bandwidth Guarantee and Best Efforts



Source: ITS Standards & Operation Plan Study Team

Table 7.17 Comparison on Transmission Methods

	IP over ATM	IP over G-Ethernet	IP over SDH	IP over ATM/DWDM	IP ovrer SDH/DWDM
Communication Node	ATM	Media Converter	SDH	DWDM	DWDM
Interface of Ethernet	Available	Available	Available	Available	Available
Maximum Capacity	0.6 Gbps (Concept-2)	40 Gbps (Concept-3)	40 Gbps (Concept-3)	1 Tbps (Concept-3)	1 Tbps (Concept-3)
Capacity for ** Additional Service	Not Sufficient	Not Sufficient	Not Sufficient	Sufficient	Sufficient
Bandwidth Guarantee	Capable	Capable	Capable	Capable	Capable
Network Management	Capable	Capable	Capable	Capable	Capable
Compatibility	Low	High	High	High	High
Implementation Cost	Low	Average	Average	High	High
Track Records in Telecom Service	--	--	--	--	Adopted by Viettel
Grading	Not Suitable	Recommended	Comparable	Not Suitable	Not Suitable

Note: **: Leasing of lines as a simple additional services using the remaining capacity of communication network.

Source: ITS Standards & Operation Plan Study Team

7.12 Selected Key System Policies

In the Study, the key policies, as premises for structuring ITS, are discussed from an objective and neutral stand point free from the intentions of individual organizations/firms who have relations with the expressway construction in Vietnam. The discussion is conducted in such a manner as to involve the policies/candidates in on-going expressway construction projects and the following reasoned conclusions are reached.

(1) Arrangement of CCTV Camera for Monitoring
→At 2km intervals continuously along the expressway (→See Table 7.2 and Figure 7.4)

(2) Arrangement of CCTV Camera for Event Detection
→On the through lanes and the ramps on trial (→See Table 7.3, Figures 7.7 and 7.9)

(3) Vehicle Detector Arrangement
→Midway between a pair of interchanges (→See Table 7.4 and Figure 7.12)

(4) Type of Vehicle Detector
→Image recognition type (→See Table 7.5)

(5) Upgrading to Next-generation System based on CCTV Camera for Multi-purpose
(→See Figure 7.10)

(6) System Policy of Traffic Information/Control
→By using Traffic Event Data (→See Table 7.6 and Figure 7.23)

(7) Road-to-Vehicle Communication Method for ETC
→Active-DSRC (→See Table 7.10)

(8) Tollgate Lane Operation
→Combined use with Touch&Go (→See Figure 7.29)

(9) Upgrading to Next-generation ETC based on GPS/GSM/DSRC
(→See Figure 7.32)

(10) Checking of Prepaid Balance
→By prepaid-balance-in-card (→See Section 7.7)

(11) Contact-less IC-Card Type
→TYPE-A and Felica as the candidates for conclusive selection through field trial (→See Table 7.14)

(12) Axle Load Scale Arrangement
→ Closely in front of entrance tollgates (→See Table 7.16 and Figure 7.41)

(13) Integration of Roadside Equipment Control
→Combination of NVR introduction and technological disclosure obligation to suppliers (→See Section 7.10)

(14) Transmission Method
→G-Ethernet (→See Table 7.17)

It is necessary, additionally, to finalize the selected results and verify them in ITS integration project as the first stage of system implementation to be compliant with the Draft ITS Standards.