MINISTRY OF TRANSPORT, VIETNAM

STUDY FOR SUPPORTING ITS STANDARDS & OPERATION PLAN DEVELOPMENT IN VIETNAM

MAIN REPORT

January 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

ORIENTAL CONSULTANTS CO., LTD.
NEXCO EAST ENGINEERING CO., LTD.
ALMEC CORPORATION

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TABLE OF CONTENTS

TABLES

FIGURES

1. Summary

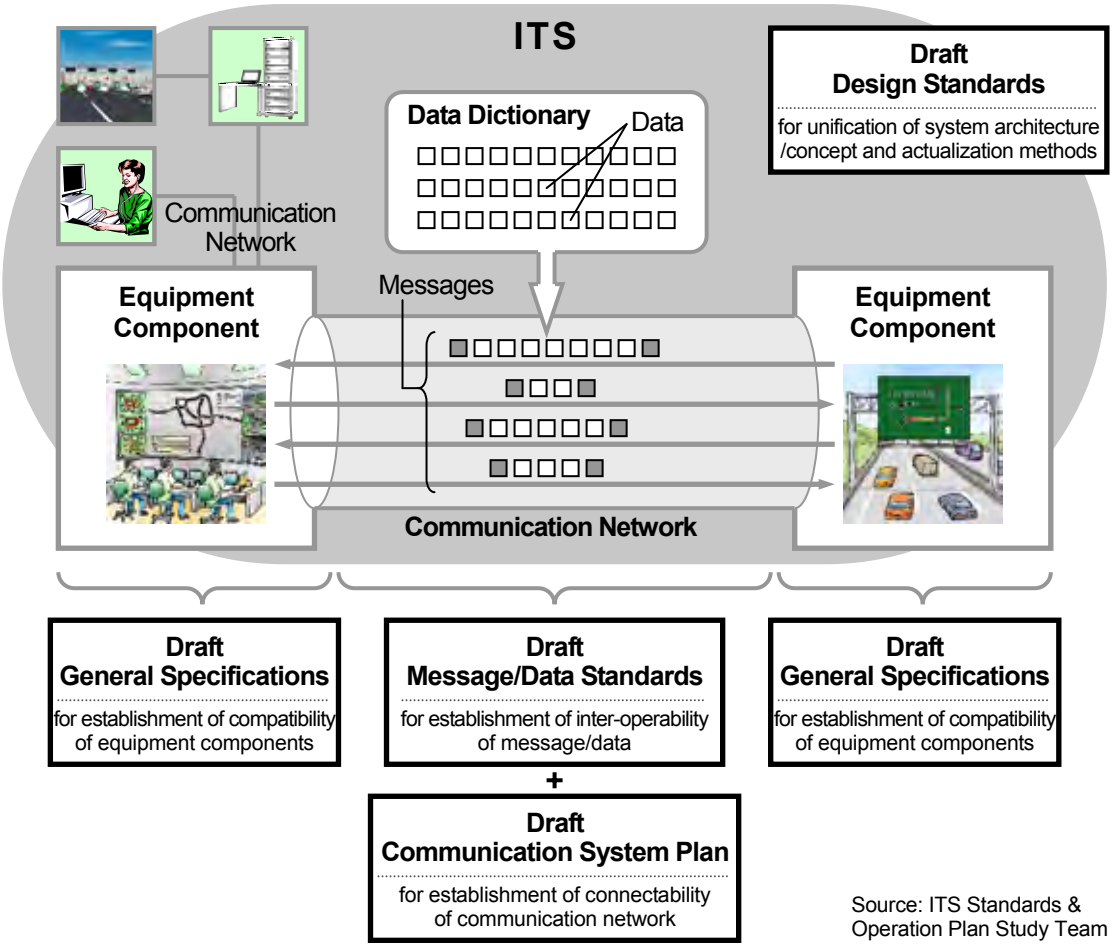
1.1 Main Results of Study

In Vietnam, where expressway construction is underway nationwide, it has become an urgent issue to perform ITS implementation in an integrated way over many different road sections. In such situation, the following issues are examined and the reasoned results are presented in this Report and the Draft ITS Standards in the Study.

(1) Definition of road map of ITS implementation
(2) Definition of service levels of expressway operation
(3) Proposals on frameworks needed for expressway operation using ITS
(4) Selected key policies as premises for structuring ITS
(5) Documents of the Draft ITS Standards
- Draft Design Standards →for unification of system architecture/concept and actualization methods
- Draft General Specifications →for establishment of compatibility of equipment components
- Draft Message/Data Standards for →for establishment of inter-operability of message/data
- Draft Communication System Plan →for establishment of connectability of communication network

(6) ITS Pilot Project Plan for integrating expressways

Figure 1.1 Conceptual Illustration of the Draft ITS Standards



Source: ITS Standards & Operation Plan Study Team

1.2 Definition of Road Map of ITS Implementation

In the ITS Master Plan of VITRANSS2, the road map focuses on three priority ITS user services, each of which has three proposed stages to allow stepwise ITS implementation.

Figure 1.2 Road Map for Priority ITS User Services

	1st Stage 2015	2nd Stage 2020	3rd Stage 2030
Traffic Information /Control	• Incident information by monitoring • Traffic congestion information focusing on bottle-neck spots • Weather information • Traffic control assistance responding to incidents • Center-to-center data exchange for non-stop toll collection 	• Traffic congestion information continuously along the express-ways • Travel time information • Traffic control assistance	• Automated incident identification continuously along the express-ways
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 • Parking fee collection • Integrated fee collection for park&bus-ride • Center-to-center data exchange for park&bus-ride fee collection • Cooperation with road pricing in urban areas
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	

Source: ITS Standards & Operation Plan Study Team

In this Study, the Draft ITS Standards are developed according to the road map, focusing on the contents of the priority ITS user services to be introduced in the 1st stage.

1.3 Definition of Service Levels of Expressway Operation

For the discussion in the Study, several basic conditions needed for expressway operation are set as minimal service requirements, such as:

(1) Mobility: provision of smooth traffic flow with average travel speed more than 60 km/hr through traffic information/control services responding to locations on the road network and traffic volume.
(2) Safety: dispatch of road operation vehicles to an incident site with delayed time less than 1 hour from the incident occurrence.
(3) Accessibility: provision of sufficient vehicle processing capacity at tollgate by non-stop and one-stop toll collection responding to traffic volume.
(4) Preservation of road structure: reduce damage to road structure by overloading regulation for heavy trucks.

1.4 Frameworks Needed for Expressway Operation Using ITS

In this Study, the following frameworks needed for expressway operation using ITS are discussed, and major issues for creating these frameworks are itemized.

- Total framework of expressway operation
- Control of expressway operation service levels
- Framework for traffic control
- Procedure of incident notification
- Procedure of road/traffic monitoring
- Procedure of traffic event data management
- Framework for traffic information
- Toll rate system for expressway network
- Framework for toll management
- Framework for toll settlement
- Framework for IC-card operation
- Framework for OBU management
- Framework for toll enforcement
- Framework for overloading regulation
- Framework for communication network management
- Radio frequency allocation.

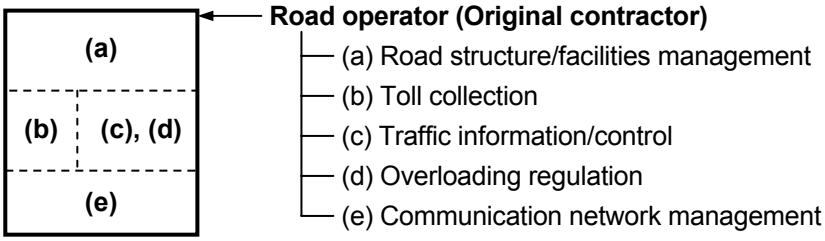
1) Example of Discussion on Framework Needed

As an example, the following the total framework of expressway operation are discussed and Framework 2 is recommended in the Study.

(1) Framework 1: Operations performed by the road operator (the original contractor)

In this framework, the road operator (the original contractor) is required to perform many different parts of expressway operation by preparing skilled manpower. All parts of operation need to be financed solely by toll revenue.

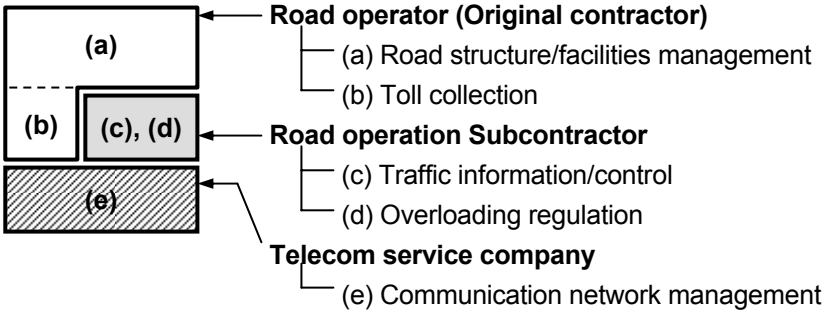
Figure 1.3 Burden Sharing in Framework 1



(2) Framework 2: Operations shared by the road operator, a road operation sub-contractor and a telecom service company

In this framework, the road operator (the original contractor) can concentrate on managing toll revenue for paying implementation/maintenance cost of road structure and facilities, and a road operation subcontractor 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 1.4 Burden Sharing in Framework 2



2) Major Issues on Setting up Frameworks for ITS

In the Study, the Draft ITS Standards are based on the premise that frameworks for expressway operation using ITS are created in advance and the following issues are addressed.

Table 1.1 Major Issues on Setting up Frameworks for ITS

Major Issues	Responsible Ministry
<Traffic Information/Control>	
(1) Selection of an organization, including the case of setting up a subcontractor, to conduct traffic information/ control in an integrated way	MOT (Department of Transport Infrastructure)
(2) Setting up a scheme of traffic police for the expressways, with jurisdictions corresponding to road management offices	MOPS (Road and Railway Traffic Police Department), MOT (Department of Transport Infrastructure)
<Automated Toll Collection>	
(3) Definition of vehicle classification for toll rate of the expressway	MOF, MOT (Department of Finance, Directorate for Vietnam Road Administration)
(4) Setting up a scheme for toll settlement by each road operator as an original contractor	MOT, The State bank of Vietnam
(5) Definition on the number of banks for issuing IC-cards for toll collection and on a clearing center necessary in case the number is larger than one	The State Bank of Vietnam
(6) Selection of an organization for checking the charged amounts of toll fare by road operators against traffic volumes in order to secure fairness and reliability of the toll settlement	MOF, MOT
(7) Selection of an organization for conducting OBU registration including the case to newly set it up	MOT
(8) Clarification of the establishment of a back tax system for reducing mistakes and failures on toll payment and penalty system to deter unlawful passage at tollgate	MOF, MOT (Department of Finance)
<Overloading Regulation>	
(9) Definition of role-sharing for enforcement of overloading regulation among the organizations such as the road operators and the traffic inspector	MOT
<Communication System>	
(10) Selection of an organization, including the case to set up a telecom service company, to conduct communication network management in an integrated way	MOT, MIC
(11) Decision on radio frequency allocation necessary/ sufficient for radio communication to be used in ITS	MIC (Radio Frequency Directorate), MOT

Note: MOT: Ministry of Transport, MOPS: Ministry of Public Security, MOF: Ministry of Finance, MIC: Ministry of Information & Communication

Source: ITS Standards & Operation Plan Study Team

1.5 Selected Key Policies as Premises for Structuring ITS

In the Study, 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 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) CCTV Camera Arrangement
→At 2 km intervals continuously along the expressway

(2) Vehicle Detector Arrangement
→Midway between a pair of interchanges, at congestion-prone sections or at 2 km intervals responding to traffic volumes

(3) Contact-less IC-Card Type
→TYPE-A and Felica as the candidates for conclusive selection through field trial

(4) Checking of Prepaid Balance →By prepaid-balance-in-card

(5) Tollgate Lane Arrangement →For combined use of ETC with Touch&Go/Manual

(6) Road-to-Vehicle Communication Method for ETC
→Active-DSRC and Passive-DSRC as the candidates for conclusive selection through field trial, and RF-Tag to be followed up

(7) Axle Load Scale Arrangement →Closely in front of exit tollgates

(8) Integration of Roadside Equipment Control
→Combination of NVR introduction and technological disclosure obligation to suppliers

(9) Transmission Method →Combination of IP over SDH and IP over G-Ethernet

It is necessary to finalize the selected results and verify them in a pilot project as the first stage of system implementation to be compliant with the Draft ITS Standards.

1.6 Documents of Draft ITS Standards

In the Study, the following documents are developed as the Draft ITS Standards.

- Draft Design Standards (volumes organized by priority ITS user services)
- Draft General Specifications (volumes organized by functional packages)
- Draft Message/Data Standards
- Draft Communication System Plan

The Draft ITS Standards organized in 26 volumes shown below.

Table 1.2 Documents of Draft ITS Standards

Draft Design Standards (3 Volumes)	(1) Traffic Information/Control (2) Automated Toll Collection	(3) Heavy Truck Control
Draft General Specifications (21 Volumes)	(1) Telephone Exchange (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) Lane Monitoring (13) Vehicle/Class Identification (14) Lane Control (15) Road-to-Vehicle Communication (16) IC-card Recording (17) Toll Management (18) OBU Management (19) Axle Load Measurement (20) Overloading Management (21) Center/Roadside Communication (including Ducts)
Draft Message/Data Standards (1 Volume)	Message List	Data Dictionary
Draft Communication System Plan (1 Volume)	General Communication System Plan	Design Standards of Communication System

Source: ITS Standards & Operation Plan Study Team

1.7 ITS Pilot Project Plan for Integrating Expressways

Striving toward the development of the ITS Standards in Vietnam, a pilot project is proposed and summarized in the Study, which aims to unify the ITS implementation levels covering the whole road network including a number of expressway sections, to verify/establish a procedure for integrating systems, to initiate the expressway operation/management using ITS, and to show the method to utilize ITS for solving traffic issues in metropolitan areas.

The Scope of the Pilot Project covers:

(1) To verify/establish the procedure for integrating ITS that developed by road section and to unify the service level of ITS

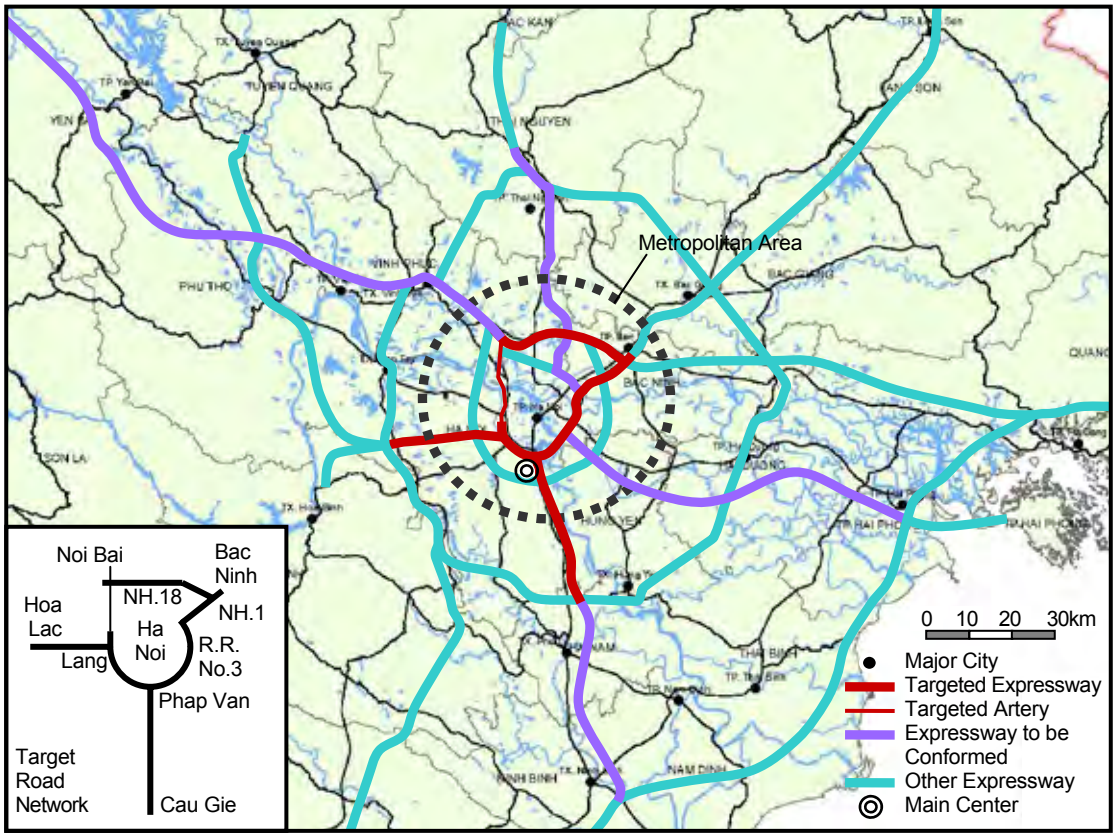
- Road traffic information/control system
- Automatic toll collection system
- Heavy Truck control system
- Communication network

(2) To verify practicality of the key policies on system for the expressway operation that are

selected in the Draft ITS Standards.

For the implementation of the Pilot Project, it is considered that setting up of the frameworks for expressway operation using ITS is required as mentioned in Chapter 6 and that the structure of expressway network system in the Southern Region still remains undefined. Consequently, in the Study, it is proposed that the Pilot Project in Northern Region is to be implemented on a high priority basis.

Figure 1.5 Target Road Network of Pilot Project in North



Source: ITS Standards & Operation Plan Study Team

2. Introduction

2.1 Background of Study

In Vietnam, expressway construction is underway nationwide to support rapid development of the economy. The funding of the construction is shared by various organizations: Official Development Assistance (ODA) of many different countries, Asian Development Bank (ADB), World Bank (WB), and investment from private companies under the scheme for Build Operate Transfer (BOT). The construction includes the introduction of ITS (Intelligent Transport Systems) on every expressway section in Vietnam.

However, a unified policy and standard for ITS is not yet established in Vietnam, covering toll collection/management, traffic information/control and communication network operation/ maintenance. Accordingly, incompatible systems based on different design concepts are proposed for different expressway sections. If the expressway construction continues to go this way, non-conformity and lack of coordination among adjacent sections will become apparent. In addition, there will be wasteful spending in implementation/operation cost, limitation of smooth flow of road transport, and inconveniences in expressway usage.

The ITS Master Plan was developed in the VITRANSS2 Study, beginning in 2008, to promote efficient ITS implementation on inter-city expressways and arteries and to provide appropriate ITS applications for road operations in Vietnam. Goals of ITS, ITS user services to be provided, road map of ITS implementation, requirements of ITS standards, location plan of communication network/centers and ITS operation framework in Vietnam are all proposed in the Master Plan.

As the following stage of the ITS Master Plan, development of ITS Standards and their actual application to expressway construction projects in Vietnam are urgent.

2.2 Objectives

The following three works are to be carried out in the Study:

(1) Draft ITS Standards development
(2) Pilot project plan development
(3) Technology transfer through the Study.

Additionally, the Study is to aid in the promotion of efficient implementation and adequate utilization of existing ITS technologies and to achieve the goals of ITS in the Master Plan.

Goals of ITS shown in the Master Plan	• Increase operational efficiency of the transportation system • Provide smooth and punctual transport • Improve safety and security of transport • Enhance convenience and comfort of transport • Decrease energy consumption and environmental costs • Activate industries through developing advanced technologies • Secure smooth access to urban arteries.

2.3 Scope

The scope of the Draft ITS Standards development study focuses on ITS service contents for implementation to be started in the 1st stage (by 2015). These include the following three priority ITS user services that are shown in the ITS Master Plan of VITRANSS2, together with communication system necessary for their implementation.

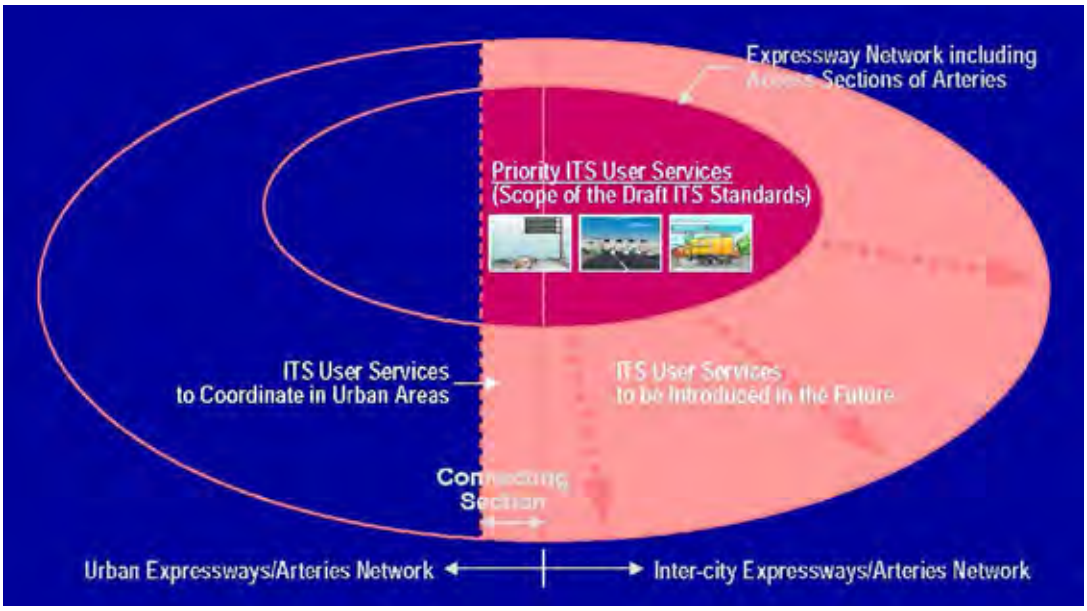
(1) Traffic information/control
(2) Non-stop toll collection
(3) Heavy truck control.

Additionally, the Pilot Project Plan will be developed aiming at application of the Draft ITS Standards to actual construction of expressway networks around the three major cities of Ha Noi, Da Nang and Ho Chi Minh. These consist of several different expressway sections including access sections of arterial roads.

2.4 Study Area

The Study deals with ITS on the expressway network throughout Vietnam, including access sections of arterial roads. However, the priority is to be given on the inter-city areas where the expressways will be constructed in the early stages.

Figure 2.1 Scope and Study Area of the Study



Source: VITRANSS2 Study Team

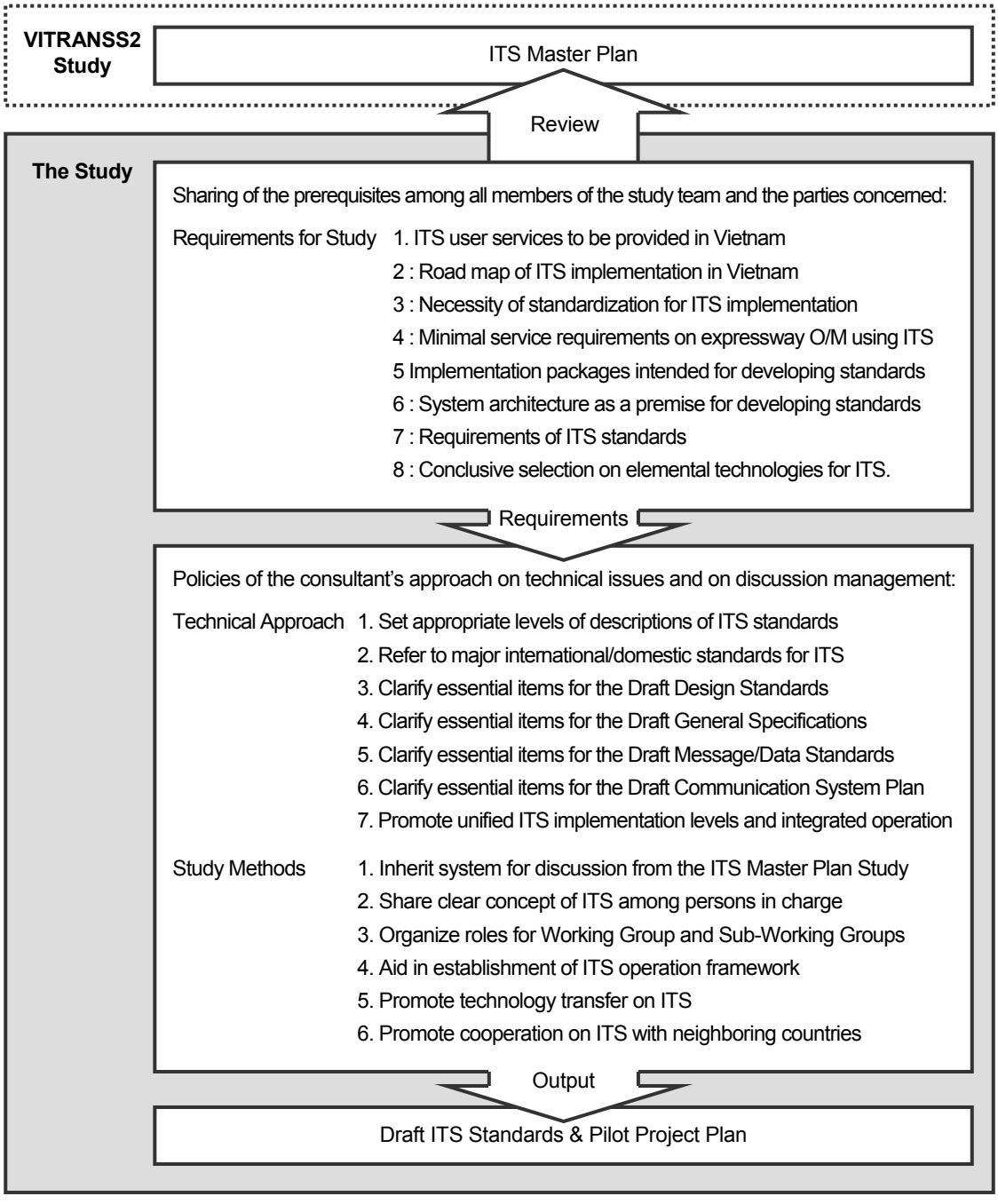
Figure 2.2 Expressway Network Plan in Vietnam

Source: VITRANSS2 Study Team

2.5 Study Framework

The study framework outlined in the figure below is as follows: first the results of the VITRANSS2 Study are reviewed and then understanding of the prerequisites for the Study is shared among all members of the Study team and parties concerned in Vietnam. The development of the Draft ITS Standards and the Pilot Project Plan are the outputs based on these shared prerequisites and the consultant's policies of the approach on technical issues and on study methods.

Figure 2.3 Study Framework



Note: O/M: Operation/Maintenance.

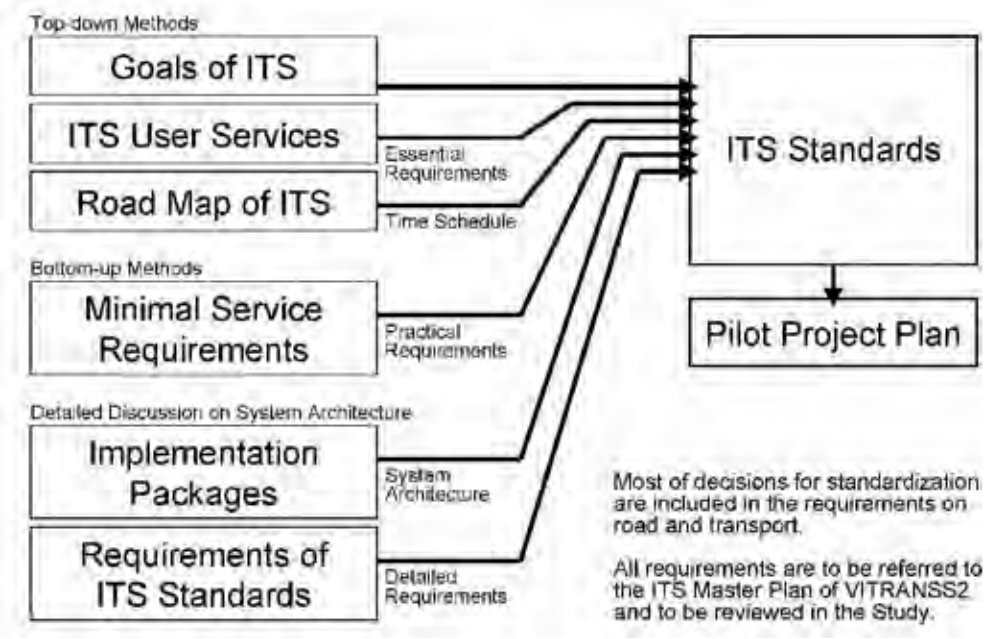
Source: ITS Standards & Operation Plan Study Team

3. Requirements for Study

In the Study, the ITS standards are based on the following requirements from the ITS Master Plan developed in the VITRANSS2 Study.

- Goals of ITS
- ITS user services
- Road map of ITS
- Minimal service requirements
- Implementation packages
- Requirements of ITS standards

Figure 3.1 Requirements of the Study



Source: ITS Standards & Operation Plan Study Team

3.1 Goals of ITS

Preparatory to the discussion in the Master Plan of VITRANSS2 study, seven goals shown below are proposed for ITS implementation of the inter-city road network in Vietnam.

- Increase operational efficiency of the transportation system
- Provide smooth and punctual transport
- Improve safety and security of transport
- Enhance convenience and comfort of transport
- Decrease energy consumption and environmental costs
- Activate industries through developing advanced technologies
- Secure smooth access to urban arteries.

3.2 ITS User Services

In the ITS Master Plan of VITRANSS2, the following ITS user services are defined:

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

} Priority ITS user services

- Inter-city bus assistance
- Convenient parking assistance

} ITS user services to be introduced in the future

- Road pricing. – ITS user services to cooperate in urban areas

In the Study, the ITS standards will be developed for the three priority ITS user services.

(1) Traffic information/control

This service provides accurate surveillance of traffic conditions on expressways and adjacent arterial roads. This service assists prompt action of the road operator and emergency vehicles by notifying occurrences of traffic accidents, broken-down vehicles and left 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 on crowdedness and estimated travel-time. This service makes it possible to measure actual traffic volume continuously for developing road improvement plans.

Figure 3.2 Traffic Information/Control

Source: Southern Vietnam Expressway FS by JETRO

(2) 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 of vehicles at interchanges. This service reduces the number of tollbooths and solves the problem of land acquisition, especially for tollgates in suburban areas where traffic congestion will become an issue in the near future. This service allows simple vehicle inspection at border crossings, and provides the road/vehicle operators with the time of vehicle passage at 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 the different road operators.

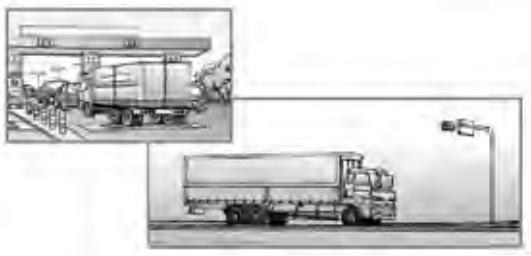
Figure 3.3 Non-stop Toll Collection

Source: Southern Vietnam Expressway FS by JETRO

(3) Heavy truck control:

This service eliminates overloading of heavy trucks by automatic execution of vehicle weighing at interchanges. It reduces damage to the road structure and extends its durable lifetime. This service reduces congestion caused by heavy trucks and allows freight transport 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 taking appropriate vehicle operation by keeping track of trucks on the expressway network.

Figure 3.4 Heavy Truck Control



Source: Southern Vietnam Expressway FS by JETRO

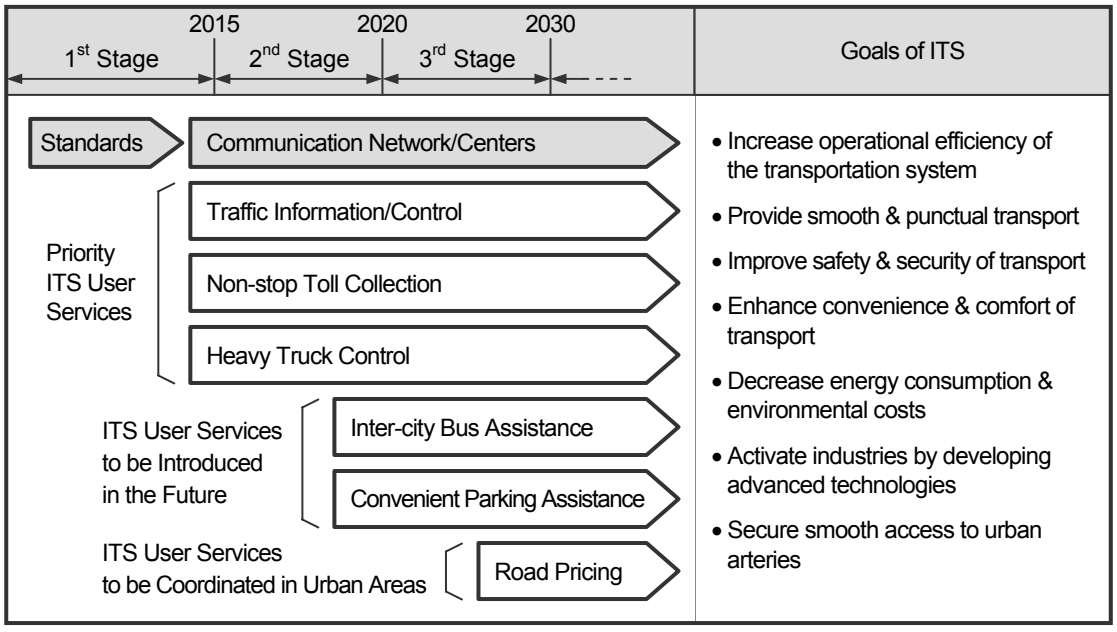
3.3 Road Map of ITS Implementation

The road map below consists of three stages proposed in the ITS Master Plan of VITRANSS2 to allow stepwise ITS implementation responding to progress of the expressway network construction, quantitative/qualitative changes in road traffic and changes in user needs.

In the Study, Draft ITS Standards are developed, according to the road map and focusing on contents of the priority ITS user services to be introduced in the 1st stage.

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

Figure 3.5 Road Map of ITS for Inter-city Expressway/Artery Network in Vietnam



Source: VITRANSS2 Study Team

Main objectives of each stage are clarified as shown in the following three tables. The items in the tables correspond to the ITS user services.

Table 3.1 Main Objectives of ITS in the 1st Stage

Main Objectives by 2015 : Priority ITS User Services in the 1st Stage			
Increase Operational Efficiency of Transportation System	Attainment of traffic information/control based on incident/congestion/ weather-condition monitoring at specific spots, non-stop toll collection and over-loading regulation. 1. Incident information by monitoring 2. Traffic congestion information focusing on bottle-neck spots 3. Weather information 4. Traffic control assistance responding to incidents 5. Center-to-center data exchange for traffic information and control 6. Non-stop toll collection at toll island 7. Center-to-center data exchange for non-stop toll collection 8. Overloading regulation by automatic vehicle weighing 9. Center-to-center data exchange for overloading regulation		
Provide Smooth & Punctual Transport	1, 2, 3, 4, 6, 8	Lower Energy Consumption & Environmental Costs	2, 4, 6, 8
Improve Safety & Security of Transport	1, 3, 4, 8	Activate Industries by Developing Advanced Tech.	1, 2, 3, 4, 5, 6, 7, 8, 9
Enhance Convenience & Comfort of Transport	1, 2, 3, 4, 6	Secure Smooth Access to Urban Area	–

Source: VITRANSS2 Study Team

Table 3.2 Main Objectives of ITS in the 2nd Stage

Main Objectives by 2020			
Increase Operational Efficiency of Transportation System	Attainment of traffic information/control based on day-to-day-congestion /travel-time monitoring, specific long-haul truck/bus tracking and crowdedness information for parking at rest areas. 1. Traffic congestion information continuously along the expressways 2. Travel-time information 3. Traffic control assistance 4. Heavy/hazardous-material truck tracking 5. Center-to-center data exchange for truck tracking 6. Bus tracking information provision 7. Center-to-center data exchange for bus tracking 8. Parking information provision 9. Center-to-center data exchange for convenient parking assistance.		
Provide Smooth & Punctual Transport	1, 2, 3, 4, 6, 8	Lower Energy Consumption & Environmental Costs	1, 3, 8
Improve Safety & Security of Transport	3, 4	Activate Industries by Developing Advanced Tech.	1, 2, 3, 4, 5, 6, 7, 8, 9
Enhance Convenience & Comfort of Transport	1, 2, 3, 6, 8	Secure Smooth Access to Urban Area	6

Source: VITRANSS2 Study Team

Table 3.3 Main Objectives of ITS in the 3rd Stage

Main Objectives by 2030			
Increase Operational Efficiency of Transportation System	Attainment of traffic information/control based on incident monitoring on continuous road section, ETC exclusive interchanges, parking fee collection at the rest area with amusement establishments, park&bus-ride and coordination with ERP in urban areas. 1. Automated incident identification continuously along the expressways 2. Non-stop toll collection on free-flow at ETC exclusive interchange 3. Automated border crossing 4. Parking fee collection for the highway-oasis 5. Integrated fee collection for park&bus-ride 6. Center-to-center data exchange for park&bus-ride fee collection 7. Cooperation with road pricing in urban areas.		
Provide Smooth & Punctual Transport	1, 2, 3, 4, 5, 7	Lower Energy Consumption & Environmental Costs	2, 4, 5, 7
Improve Safety & Security of Transport	1	Activate Industries by Developing Advanced Tech.	1, 2, 3, 4, 5, 6, 7
Enhance Convenience & Comfort of Transport	1, 2, 3, 4, 5, 6.	Secure Smooth Access to Urban Area	5, 7.

Source: VITRANSS2 Study Team

Traffic Information/Control

The centers and roadside equipment for traffic information/control will be implemented in stages according to the schedule proposed below.

Figure 3.6 Road Map for Traffic Information/Control

	1st Stage 2015	2nd Stage 2020	3rd Stage 2030
Services to be Provided	• Incident information by monitoring • Traffic congestion information focusing on bottle-neck spots • Weather information • Traffic control assistance responding to incidents • Center-to-center data exchange for non-stop toll collection	• Traffic congestion information continuously along the express-ways • Travel time information • Traffic control assistance	• Automated incident identification continuously along the express-ways
Equipment to be Installed	• Center equipment • CCTV camera • Event detector • Vehicle detector • Weather sensor • VMS	• Center equipment • On-board sensor	• SGM

Source: ITS Standards & Operation Plan Study Team
Southern Vietnam Expressway FS by JETRO

Non-stop Toll Collection

The centers and roadside equipment for non-stop toll collection will be implemented in stages according to the schedule proposed below.

Figure 3.7 Road Map for Non-stop Toll Collection

	1st Stage 2015	2nd Stage 2020	3rd Stage 2030
Services to be Provided	• 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 • Parking fee collection • Integrated fee collection for park&bus-ride • Center-to-center data exchange for park&bus-ride fee collection • Cooperation with road pricing in urban areas
Equipment to be Installed	• Center equipment • ETC • Touch&Go • Licence plate scanner • Lane control • OBU • IC-card • IC-card recharge terminal		

Source: ITS Standards & Operation Plan Study Team
Southern Vietnam Expressway FS by JETRO

Heavy Truck Control

The centers and roadside equipment for heavy truck control will be implemented in stages according to the schedule proposed below.

Figure 3.8 Road Map for Heavy Truck Control

	1st Stage 2015	2nd Stage 2020	3rd Stage 2030
Services to be Provided	• 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	
Equipment to be Installed	• Center equipment • Axle load scale • Licence plate scanner	• Center equipment • DSRC-antenna • On-board sensor	

Source: ITS Standards & Operation Plan Study Team
Southern Vietnam Expressway FS by JETRO

3.4 Minimal Service Requirements

The service details below are to be described in the minimal service requirements for expressway operation using ITS:

- Preservation of road structure
- Accessibility
- Mobility
- Safety & response to incident
- Environmental protection.

For the discussion in the Study, the following basic conditions needed for expressway operation are proposed as minimal service requirements in reference to the ITS Master Plan.

Table 3.4 Minimal Service Requirements

Preservation of Road Structure	- Rejection of the vehicles over the dimensional limits to reduce damage to road structure - Overloading regulation of heavy trucks to reduce damage to road structure.
Accessibility	- 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 - One-stop toll collection at average service-time less than 9.0 sec/vehicle - Fair and reliable toll collection: with error ratio by frequency less than 0.0001% on checking sufficiency of prepaid balance in consideration of vehicle class.
Mobility	- Establishment of road management offices equipped with traffic monitoring system and road operation vehicles for addressing incidents, enforcing/releasing traffic restrictions and restoring road functions - Provision of smooth traffic flow through routine patrol using road operation vehicles: more than 4 times a day - Provision of smooth traffic flow through traffic information/control services responding to locations on the road network and traffic volume - Maximum speed: 120 km/hr - 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) - Average travel speed: more than 60 km/hr - Traffic surveillance and information dissemination services with update intervals: 5 minutes.
Safety & Response to Incident	- Provision of traffic safety by sending road operation vehicles to an incident site with a delayed time less than 1 hour from the incident occurrence - Notification of incident occurrence to the road operator with a delay time less than 10 minutes from the incident occurrence (even in mountainous areas) - Information dissemination of incident with a delay time less than 1 hour.
Environmental Protection	- Promotion of non-stop toll collection service - Keeping smooth traffic flow by traffic information/control services.

Source: ITS Standards & Operation Plan Study Team

According to the minimal service requirements, the operator needs to provide road operation/ maintenance services for the road use as shown in the following table. The road operation, which includes road/facility management, toll collection, traffic information/control and communication system management, is to be supported by ITS.

Table 3.5 Road Operation/Maintenance Services

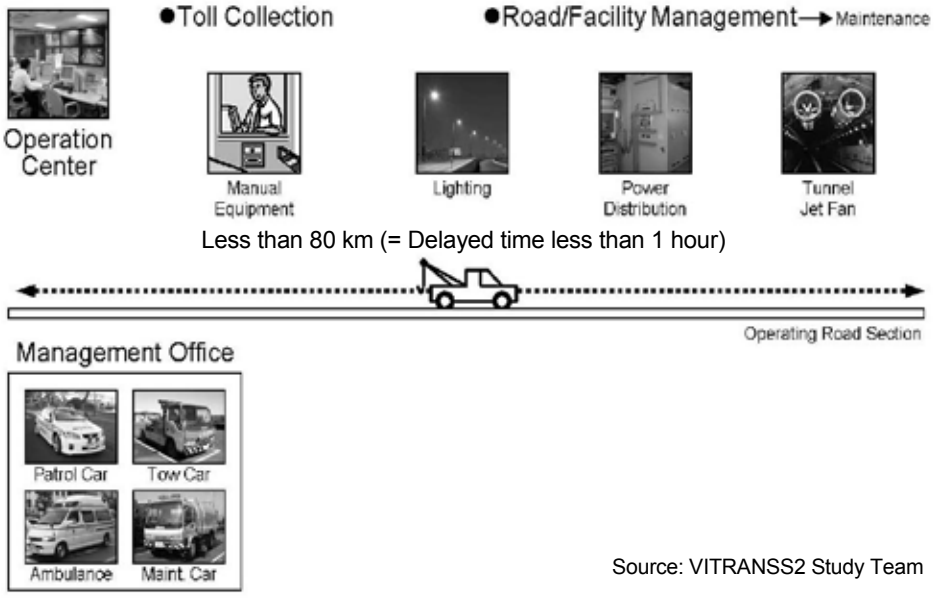
Operation	Maintenance
(1) Road/Facility Management Cleaning-up, green space management, disaster recovery, energy and water supply and checkups of structure and facility in order to secure safety and comfort in road use.	Maintenance for restoring structure and facility to their original state of function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

Source: VITRANSS2 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.

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

Figure 3.9 Illustration of Basic Road Operation



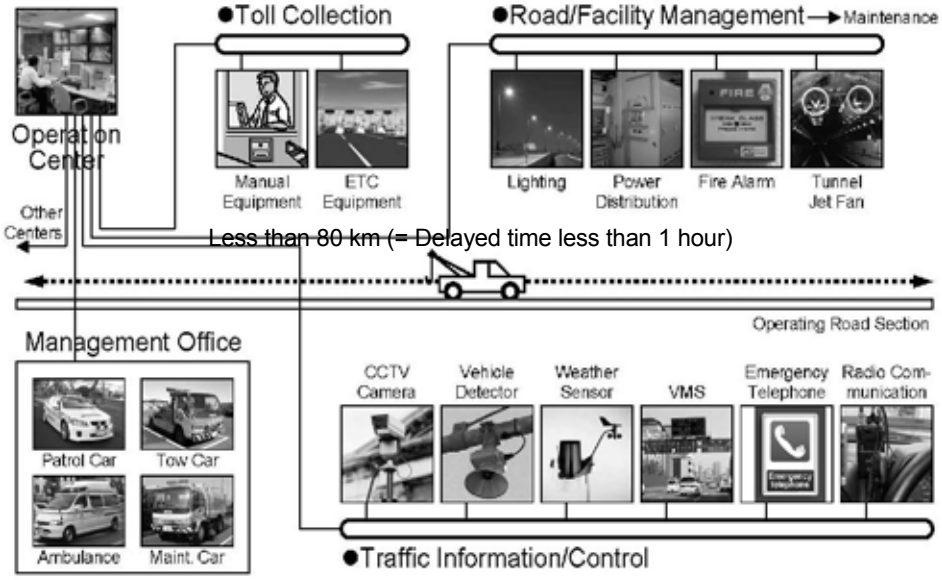
Source: VITRANSS2 Study Team

It is required that the time to send the operation vehicles to the incident site is to be less than 1 hour from the occurrence of incident, where notification of the occurrence of incident to the road operator is to be performed within 10 minutes and the lowest travel speed of the vehicles on the expressway network is to be 50 km/h as shown in the minimal service requirements. Hence, the maximum intervals of the management offices on the expressway network shall be less than 80 km.

Maximum interval of road management offices = 80 km < ((60–10) x 50 / 60) x 2

Furthermore, advanced method of road operation is based on ITS and is supported by data change on the communication network as shown below. This allows proper judgment and prompt action by the road operator.

Figure 3.10 Illustration of Advanced Road Operation Using ITS



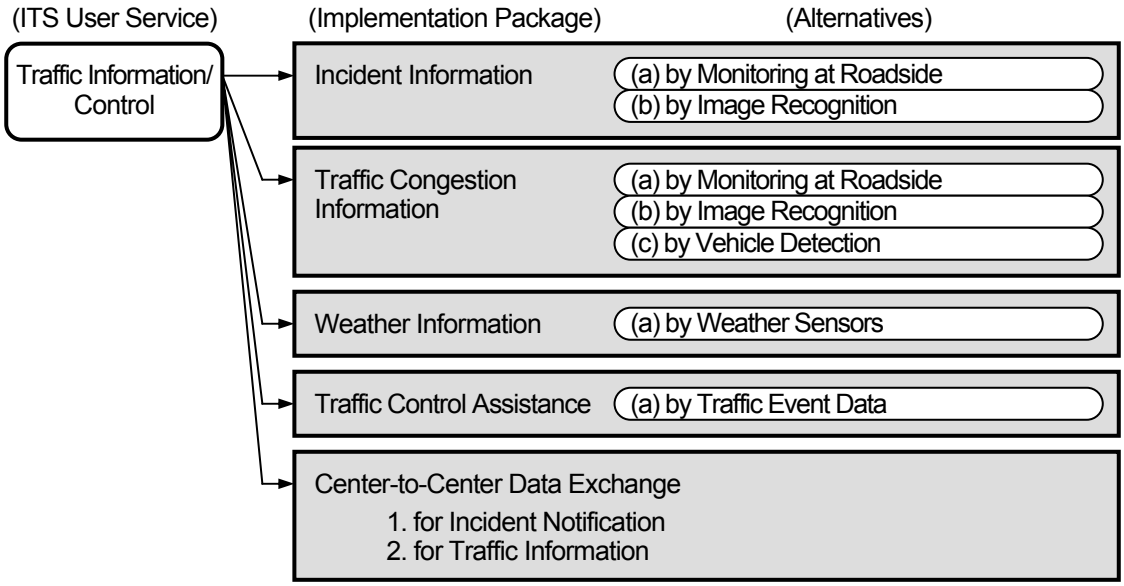
Source: VITRANSS2 Study Team

3.5 ITS Implementation Packages

The concept of implementation package is proposed in the ITS Master Plan for the purpose of permitting stepwise implementation of ITS and to respond to the various needs by locality. A set of implementation packages are defined to actualize an ITS user service.

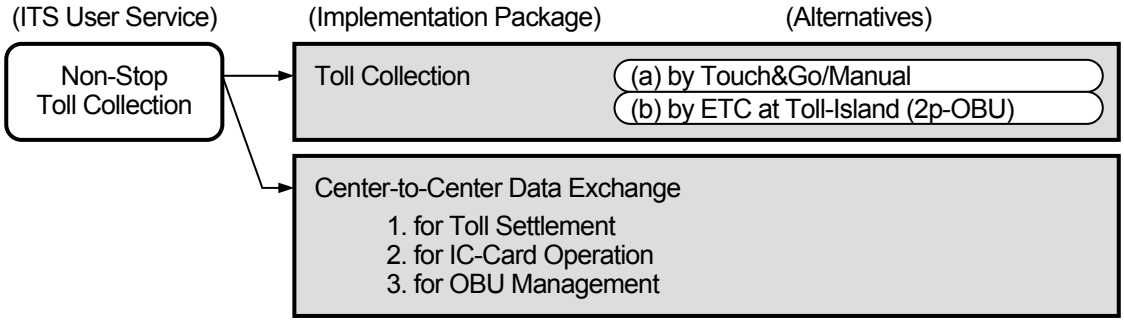
The three priority ITS user services comprises the implementation packages shown in the three figures below, with several alternative methods conceivable for actualizing each package. Discussion in the Study is based on the conclusions in the Master Plan.

Figure 3.11 Implementation Packages and Alternatives of Traffic Information/Control



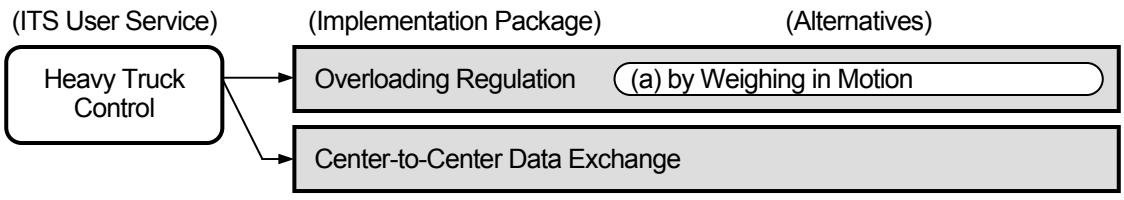
Source: ITS Standards & Operation Plan Study Team

Figure 3.12 Implementation Packages and Alternatives of Non-stop Toll Collection



Source: ITS Standards & Operation Plan Study Team

Figure 3.13 Implementation Packages and Alternatives of Heavy Truck Control

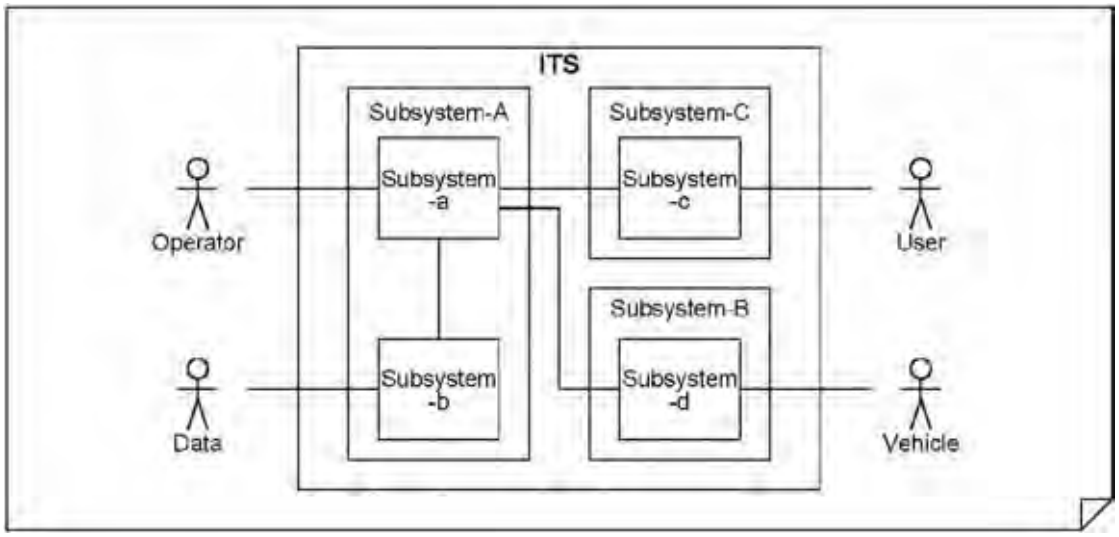


Source: ITS Standards & Operation Plan Study Team

Collaboration Diagram (System Architecture)

This diagram shows the combination of subsystems and interfaces necessary for realizing an implementation package in order to assist to share understanding of the system.

Figure 3.14 Collaboration Diagram

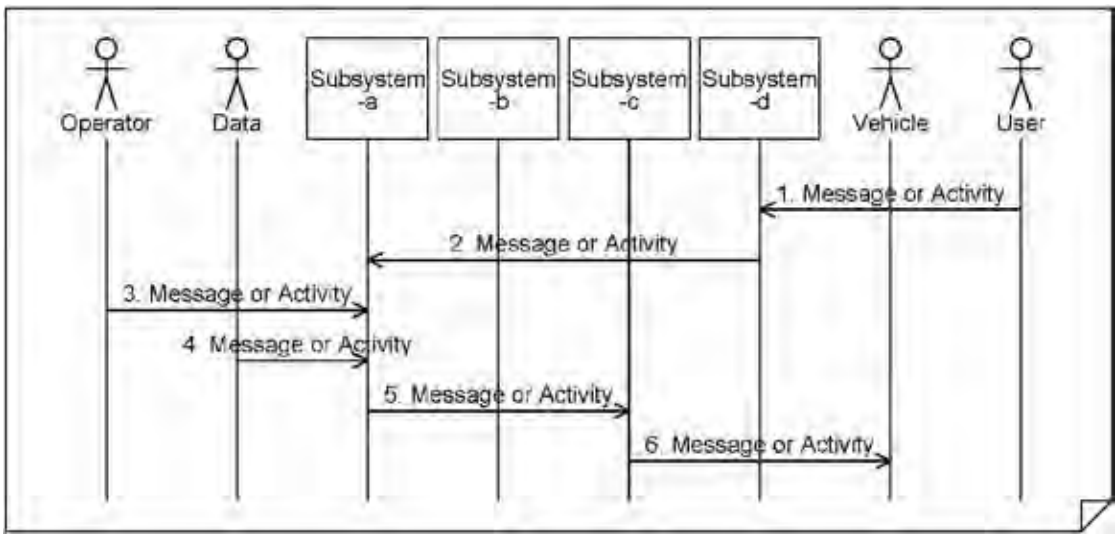


Source: ITS Standards & Operation Plan Study Team

Message Sequence Diagram (System Architecture)

This diagram shows the set of messages/activities and their contents necessary for realizing an implementation package in order to assist to discuss interoperability of the data.

Figure 3.15 Message Sequence Diagram



Source: ITS Standards & Operation Plan Study Team

Functional package

Functional package consists of a group of subsystems that have strong relationship to realize a certain function. Particulars of the Draft Design Standards and volumes of the Draft General Specifications will be set up corresponding to the functional packages.

3.6 Requirements of ITS Standards (in the Master Plan)

Requirements of standards shown in the ITS Master Plan of VITRANSS2 focus on parts of the three priority ITS user services and the communication system, which are to be implemented during the 1st and 2nd stages in the road map of ITS.

In the Study, the Draft ITS Standards are developed based on the requirements for service contents for implementation to be started in the 1st stage and the requirements for the communication system necessary for their implementation.

Table 3.6 Requirements on Traffic Information/Control

Recommended Actualization Methods	• Image recognition in combination with monitoring at roadside and emergency telephones for incident information. • Vehicle detection in combination with image recognition for traffic congestion information. • Weather sensors for weather information.
Performance/ Installation of Equipment	• Road management offices: to be located in intervals less than 80km on expressways. • CCTV cameras: to be equipped with a monitoring range covering three lanes, with sufficient resolution for identifying vehicles over a 150 m distance, adequate sensitivity for identifying rear tail lights of vehicles and communication interfaces with the Internet Protocol, and to be installed at incident-prone spots such as merging sections, diverging sections and tunnel sections. • Emergency telephones: to be installed every kilometer on expressways including the sections in mountainous areas and of tunnels. • Kilometer sign posts: to be well-marked and well-maintained for incident notification, and to be installed on the sections in urban areas. • Loop-coil type vehicle detectors: to be installed at the entrances, the tollgates, junctions and the exits on earthwork sections. • Ultrasonic type vehicle detectors: to be installed at the entrances, the tollgates, junctions and the exits on the long bridge sections. • Weather sensors: to be constructed of rain-gauges, anemometers and thermometers, to be installed at every interchange. • Variable message signs (VMS): to be actualized by information segmented and indicated by alphabets (3 lines with 18 letters/line) using LED on a matte black board, and to be installed short of the entrance, the tollgates and the exits. • Simple graphical message signs (SGM): to be actualized by information indicated by simple graphic symbols using LED on a matte black board, and to be installed short of junctions.
Needed Definitions on Message/Data	• Definitions of concepts/segmentations of the incident, traffic congestion and weather. • Definitions of traffic events such as traffic accident, broken-down vehicles, left obstacles, traffic congestion, rainy weather, strong wind, thick fog and traffic regulations. • Definitions of messages for the traffic information dissemination using traffic event data. • Definitions of data for describing messages. • Data update intervals for traffic information/control: less than 15 minutes.

Source: VITRANSS2 Study Team

Table 3.7 Requirements on Non-stop Toll Collection

Recommended Actualization Methods	• ETC at toll island (2-piece type OBU) in combination with toll collection by Touch&Go • A combination of the distance proportional tariff in rural areas and the flat tariff in urban areas assumed as toll rate system • Prepayment assumed as the method for paying toll.
Performance/ Installation of Equipment	• Lane operation: two or more exclusive lanes for ETC toward the middle side at the large tollgates in urban areas, and two or more lanes for Touch&Go/manual at the small tollgates in rural areas • Vehicle class identification: to be identified by using simple sensors • Prepaid contact-less IC-card: to be issued for combined use of ETC and Touch&Go • Prepaid balance: to be checked by balance-in-card using OBU • Toll Management: to secure a low error ratio less than 0.0001% for checking the prepaid balance with reference to the vehicle class • Road-to-vehicle communication: 3 candidates (Active-DSRC, Passive-DSRC and DSRC/IR) for the conclusive selection.
Needed Definitions on Message/Data	• Definitions of the segmentation of the vehicle classification and of the toll rate system (to be determined by MOF) • Definitions of messages for the toll management, the IC-card operation and the road-to-vehicle communication • Definitions of data for describing the messages.

Source: VITRANSS2 Study Team

Table 3.8 Requirements on Heavy Truck Control

Recommended Actualization Methods	• Overloading regulation based on weighing in motion by axle load measurement • Penalty to be collected at the exit tollgates based on the negative database of overloaded trucks.
Performance/ Installation of Equipment	• Axle load scale: to provide accurate weighing of heavy trucks at low speeds (around 20 km/h), to be installed in front of every exit tollgates.
Needed Definitions on Message/Data	• Definitions of the concept of overloading and classification of penalties • Definitions of messages for operating the negative database • Definitions of data for describing the messages.

Source: VITRANSS2 Study Team

Table 3.9 Requirements on Communication System

Performance/ Installation of Equipment	• The Inter-city Expressway Main Centers: three main centers around Ha Noi, Da Nang and Ho Chi Minh to be implemented for supervising the inter-city expressway network • The main centers for backup: to be constructed respectively around Ha Noi and Ho Chi Minh, and to function as the Metropolitan Main Center in the 2nd stage • Center function of roadside equipment control: to be installed in road management offices in the 1st stage, and to be transferred to the main centers for realizing more integrated forms of traffic information/control in the later stages • Hierarchical communication network structure: to consist of the backbone network (fibre optic ring) for connecting/integrating the main centers, road management offices and node spots and the access network from the node spots to roadside equipment • Transmission method of the backbone network: to be selected from among IP over SDH, IP over DWDM and their complex.

Source: VITRANSS2 Study Team

4. Technical Approach

The draft standards for ITS implementation in Vietnam are to be developed in the Study, adopting the following concepts as the technical policies based on the experiences of technical standards development for ITS in Asian countries and and the international standard review in ISO/TC204. According to that, the Pilot Project Plan is to be developed as well.

- Set appropriate levels of descriptions of ITS standards
- Refer to major international/domestic standards for ITS
- Pilot Project Plan to promote unification of ITS implementation levels and integration

1) Set appropriate levels of descriptions of ITS standards

The description of the Draft ITS Standards should precisely reflect user needs in Vietnam and enable efficient ITS development. It is however difficult to forecast the technology to be diffused in the future and developmental technology which lead to activation of industries in Vietnam. As incorporation of contents based on slanted predictions may cause unnecessary confusion, it must be avoided.

In the Study, the Draft ITS Standards are to be developed based on the following policies:

- The provisions in the Draft ITS Standards are theoretically to be specified in a manner consistent with the user needs indicated in the ITS Master Plan, and its appropriateness should be clearly explained.
- 3-phase description types are to be adopted for the Draft ITS Standards:
  (A) Clear/defined specifications: mainly covering the purpose of the system, the scope, functions to be equipped and interfaces between different systems.
  (B) Undefined item names: mainly covering individual processing methods and data processing precision within a system (independent of external interfaces), which are to be specified in the concession contract of each construction project.
  (C) Candidate technology names: covering several elemental technologies that can be alternative/competitive methods, such as contact-less IC-card and road-to-vehicle communication for ETC, which are to be selected by comparative tests in the pilot project.
- If any problem is caused during the road construction project by introduction of technologies that do not meet the concept of the Draft ITS Standards, the causes shall be reasoned from the descriptions in the Draft ITS Standards. The cause shall not be given from ambiguity in the provisions.
- Detailed description reflecting the results of introducing in the actual road construction project shall be added by Vietnamese institutions in the future.

2) Refer to major international/domestic standards for ITS

It is important for developing the Draft ITS Standards to appropriately utilize the existing technologies of ITS including technology transfer from other countries.

In the Study, the discussion shall proceed based on concepts of the international standards for system architecture and data of ITS and by referring to the domestic standards of various

countries and to the international standards for elemental technologies such as contact-less IC-card and road-to-vehicle communication for ETC.

3) Pilot Project Plan to promote unification of ITS implementation levels and integration

It is important to prepare a Pilot Project Plan in order to apply the developed Draft ITS Standards to actual road construction for promoting broad use of the Standards.

In the Study, the Pilot Project Plan will be developed through the discussions on application of the Draft ITS Standards to actual road construction for the expressway networks around the three major cities of Ha Noi, Da Nang and Ho Chi Minh. These consist of several different expressway sections including access sections of arteries. Through this application, implementation levels can be unified and integration of operation of ITS will be promoted.

Intended Road Network for Pilot Project Plan

- Arterial road network around Hanoi: these include the expressways of Cau Gie–Ninh Binh and Phap Van–Cau Gie, and the 3rd Ring Road
- Arterial road network around Da Nang: these include the expressway of Da Nang–Quang Ngai
- Arterial road network around Ho Chi Minh: these include the expressways HCMC–Dau Giay and HCMC–Trung Luong

Figure 4.1 Outlines of Pilot Project around Hanoi

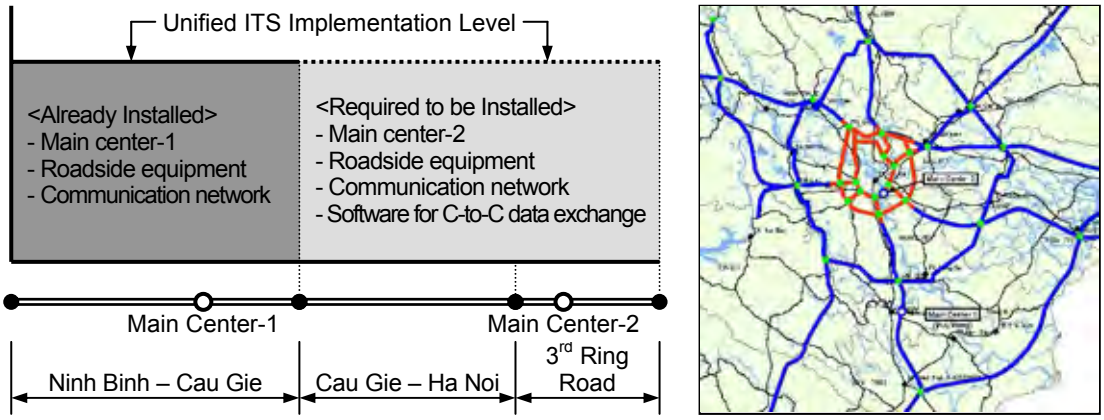
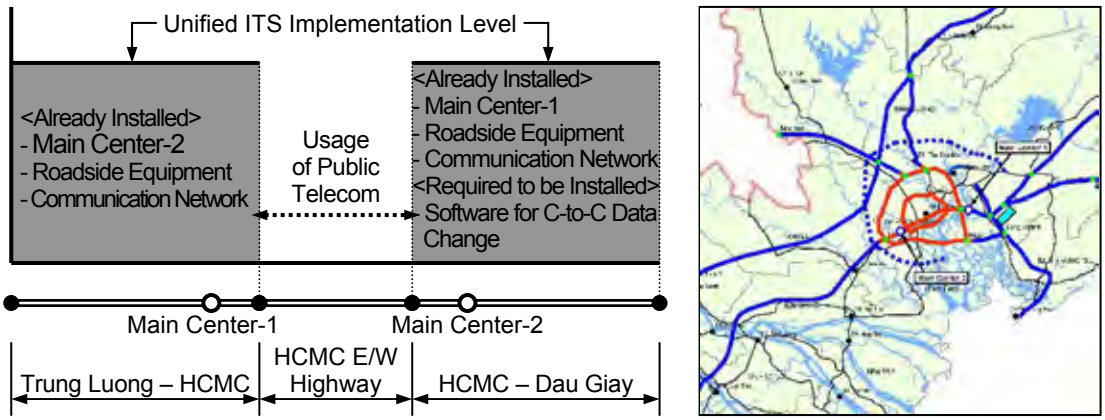


Figure 4.2 Outlines of Pilot Project around Ho Chi Minh



5. Study Methods

The draft standards for ITS implementation in Vietnam to be developed in the Study will adopt the following methods based on the experiences of technical standards development for ITS in Asian countries and and the international standard review in ISO/TC204. According to that, the Pilot Project Plan is to be developed as well.

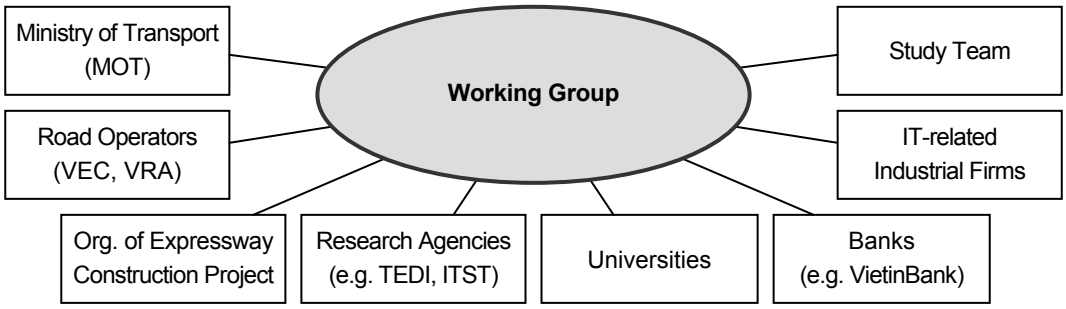
- Inherit system for discussion from the ITS Master Plan Study
- Share clear concept of ITS among persons in charge
- Organize roles for Working Group and Sub-Working Groups
- Aid in establishment of ITS operation framework
- Promote technology transfer on ITS
- Promote cooperation on ITS with neighboring countries.

1) Inherit system for discussion from the ITS Master Plan Study

For developing the Draft ITS Standards, an appropriate system to execute study is indispensable to smoothly conduct needs identification and consensus-building with the Government of Vietnam and related organizations.

In the Study, system for discussion on the Draft Technical Standards will be prepared by inheriting and expanding the systems built for the ITS Master Plan Study of VITRANSS2 through the 1st to 5th Working Groups and their Workshops.

Figure 5.1 Working Group for Discussing Draft ITS Standards



Source: ITS Standards & Operation Plan Study Team

2) Share clear concept of ITS among persons in charge

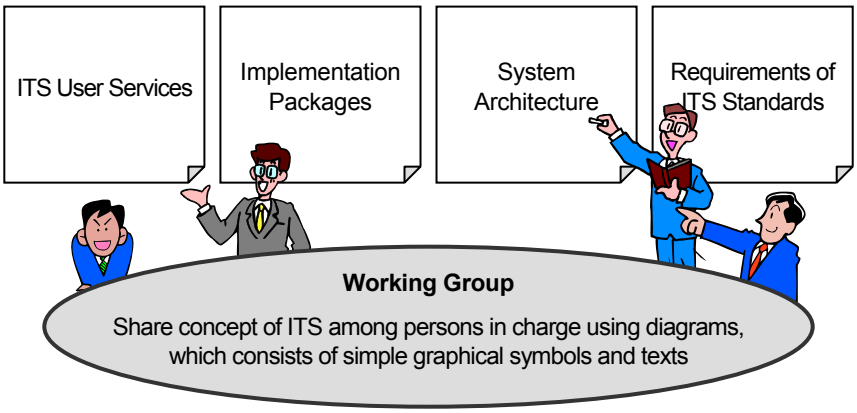
It is important in developing consensus of the Draft ITS Standards to share the concepts on prerequisites for ITS standardization among all persons in charge.

In the Study, all of the members of the study team and the persons in charge from the Government of Vietnam and related organizations shall review the items below from the results of the ITS Master Plan of VITRANSS2, and their contents shall be revised as necessary. The results of the review shall be presented in the Working Group and a clear concept of ITS shall be shared by all persons in charge of discussions.

- ITS user services to be provided in Vietnam
- Road map for ITS implementation in Vietnam

- Minimal service requirements on expressway operation/maintenance using ITS
- Implementation packages intended for developing standards
- System architecture as a premise for developing standards
- Requirements of ITS standards.

Figure 5.2 Sharing of Clear Concept of ITS in Working Group



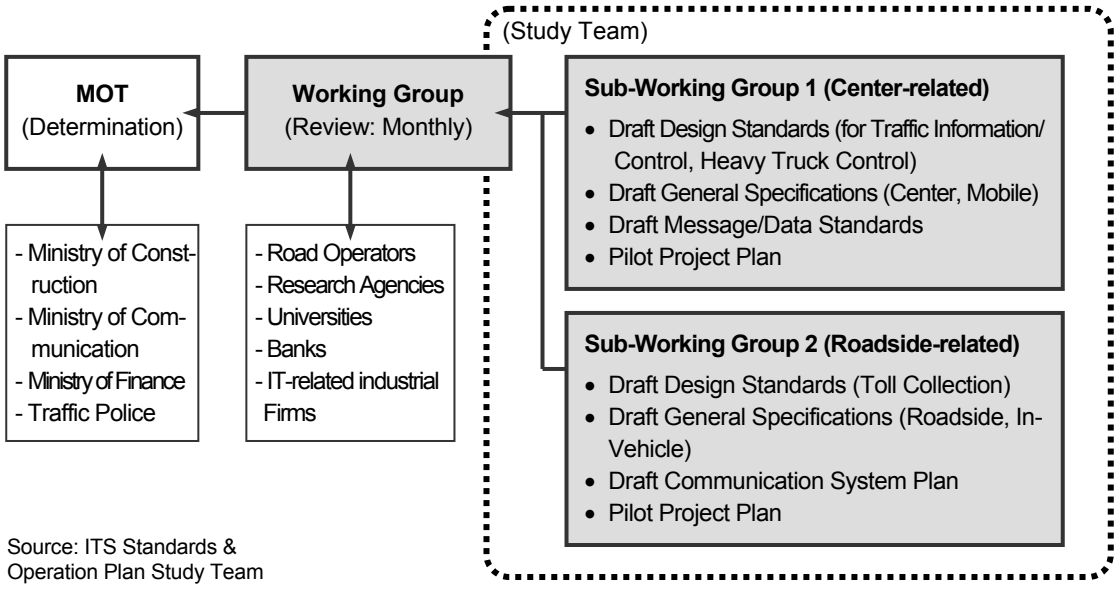
Source: ITS Standards & Operation Plan Study Team

3) Organize roles for Working Group and Sub-Working Groups

In developing the Draft ITS Standards, it is necessary to have work parties to discuss the technical contents and prepare documents, and a system to review the documents as suitable as the standards in Vietnam.

The Study will be performed by organizing two Sub-working Groups to discuss technical issues and prepare documents, and a Working Group to review the documents.

Figure 5.3 Organization of roles for Developing Draft ITS Standards



Source: ITS Standards & Operation Plan Study Team

4) Aid in establishment of ITS operation framework

To implement a pilot project by actual application of the Draft ITS Standards, it is necessary to assure that various operational framework items of ITS are built up in advance.

In the Study, basic matters and important points concerning the frameworks given below which were discussed in the Master Plan shall be enumerated to ensure smooth project implementation.

- Incident notification
- Traffic information dissemination
- Toll settlement
- IC-card/OBU operation and management
- Toll enforcement
- Overloading regulation.

In the case of toll settlement by shared prepaid card issued by the banks, the operation framework shown below is assumed, and it is necessary to designate the banks for settlement and to establish a clearing-center.

Concerning the framework for road operation/maintenance, road operators and other organizations have to organize roles to mutually check toll collections and traffic volume, enforcement of toll and overloading regulations, and operation of telecommunication system.

In this study, basic matters and important points to be kept in mind that require judgment and decision to build the framework shall be enumerated and presented to organizations concerned in Vietnam.

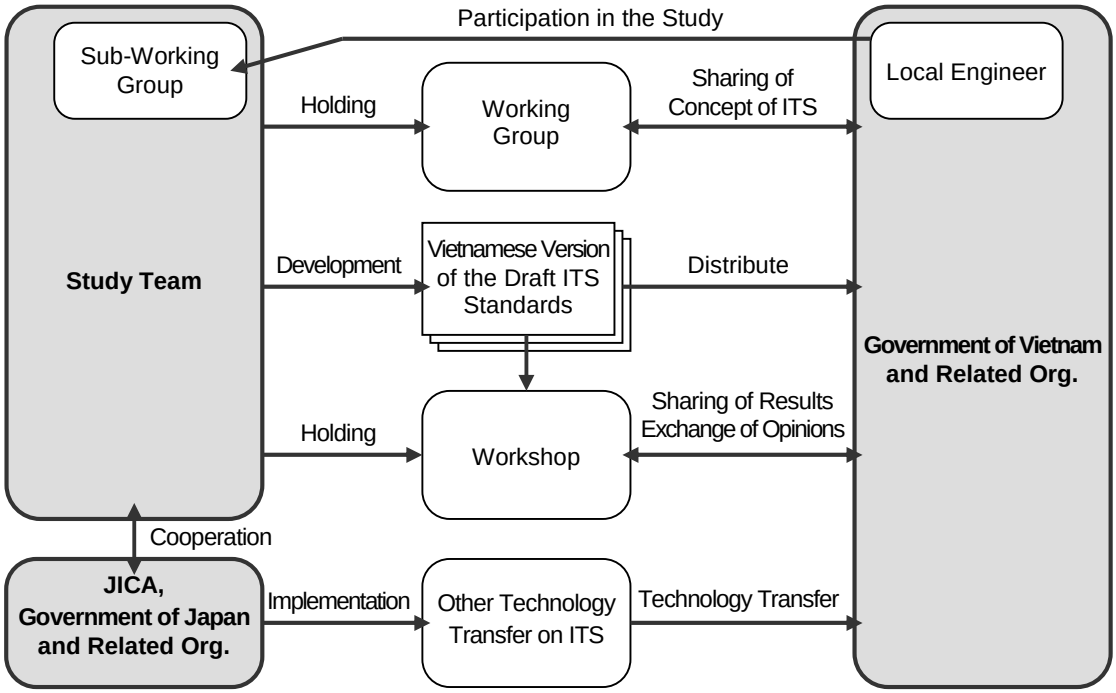
5) Promote technology transfer on ITS

In Vietnam, there are only a small number of engineers who understand and have learned the basic concepts, development methods and basic technologies of ITS; furthermore, there are few technical terms in Vietnamese to describe them. Solving these problems in addition to developing the Draft ITS Standards is indispensable in implementing ITS smoothly in Vietnam.

In the Study, technology transfer to Vietnam on ITS will be promoted by the following methods:

- Discussion and documentation of the Draft ITS Standards in the Sub-Working Groups with local engineers participation
- Sharing of clear concept of ITS among persons representing the Government of Vietnam and related organizations at the working group
- Sharing of results and exchange of opinions by a Workshop in the final phase of the Study
- Preparing and distribution of the Vietnamese version of the Draft ITS Standards
- Cooperation with the other technology transfer on ITS conducted by Japan for Vietnam

Figure 5.4 Promotion of technology transfer on ITS



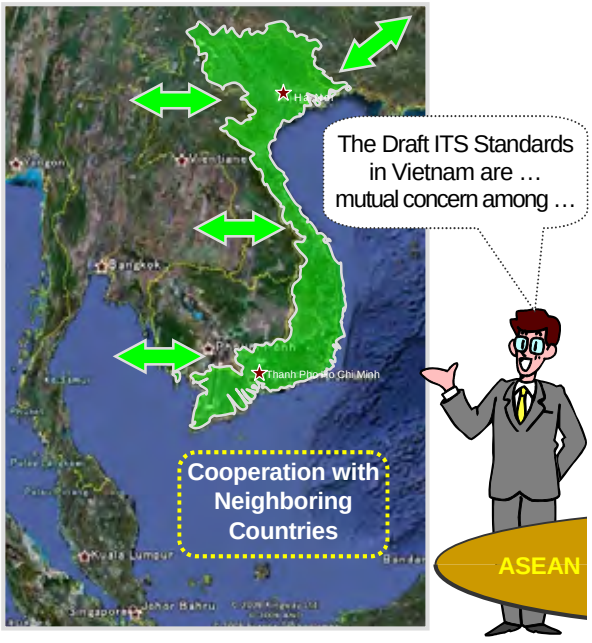
Source: ITS Standards & Operation Plan Study Team

6) Promote cooperation on ITS with neighbouring countries

Vietnam is linked with neighbouring countries by road network and communication network, and cooperation with them is extremely important in providing ITS services to road users.

In the Study, the results shall be released to ASEAN countries to promote cooperation on ITS with neighbouring countries giving support to the Ministry of Transport (MOT).

Figure 5.5 Promotion of Cooperation on ITS with Neighbouring Countries



Source: ITS Standards & Operation Plan Study Team

6. Frameworks Needed for Expressway Operation Using ITS

In this chapter, the following the frameworks needed for expressway operation using ITS are discussed, and major issues for creating these frameworks are itemized.

- Total framework of expressway operation
- Control of expressway operation service levels
- Framework for traffic control
- Procedure of incident notification
- Procedure of road/traffic monitoring
- Procedure of traffic event data management
- Framework for traffic information
- Toll rate system for expressway network
- Framework for toll management
- Framework for toll settlement
- Framework for IC-card operation
- Framework for OBU management
- Framework for toll enforcement
- Framework for overloading regulation
- Framework for communication network management
- Radio frequency allocation.

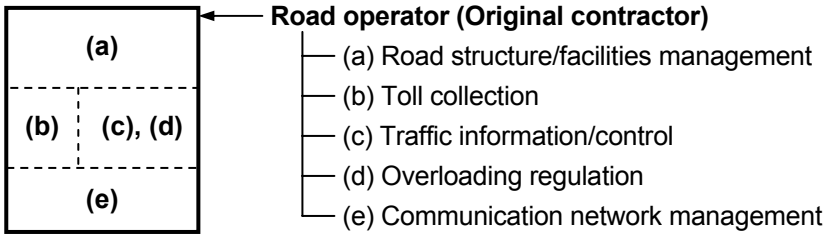
6.1 Total Framework of Expressway Operation

Several alternative frameworks are considered for expressway operation using ITS.

1) FW-1: Operations performed by the road operator (the original contractor)

In this framework, the road operator (the original contractor) is required to perform many different parts of expressway operation by preparing skilled manpower. All parts of operation need to be financed solely by toll revenue.

Figure 6.1 Burden Sharing in Framework FW-1



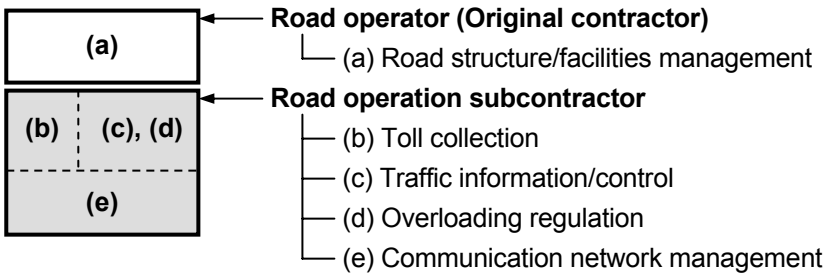
	Cost	Revenue
Road Operator (Original Contractor)	- Implementation/maintenance cost of (a) - Operation cost of (b), (c), (d), (e)	- Toll revenue

2) FW-2: Operations delegated to a road operation subcontractor

In this framework, the road operator (the original contractor) is required only to manage road

structure and facilities paying implementation/maintenance cost; however, a road operation subcontractor is required to perform many different parts of expressway operation by preparing skilled manpower. All parts of operation need to be financed solely by toll revenue.

Figure 6.2 Burden Sharing in Framework FW-2

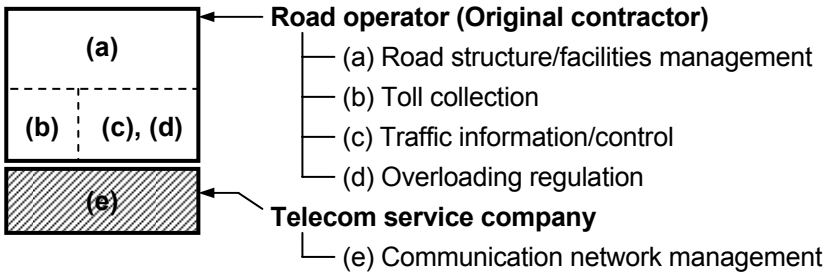


	Cost	Revenue
Road Operator (Original Contractor)	- Implementation/maintenance cost of (a) - Payment to the road operation subcontractor	- Toll revenue
Road Operation Subcontractor	- Operation cost of (b), (c), (d), (e)	- Payment by the road operator

3) FW-3: Operations shared by the road operator and a telecom service company

In this framework, communication network management is shared by a telecom service company; however, the road operator (the original contractor) is still required to perform many different parts of expressway operation by preparing skilled manpower. Communication service revenue can be obtained in addition to toll revenue.

Figure 6.3 Burden Sharing in Framework FW-3



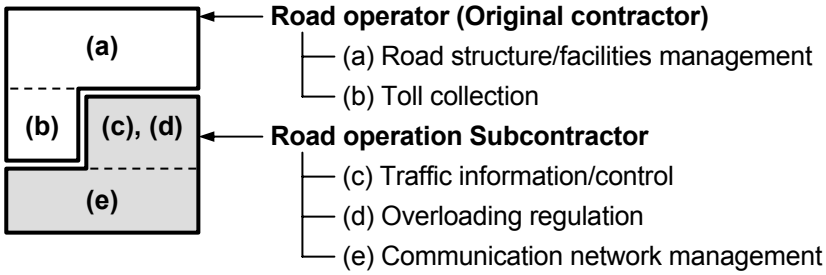
	Cost	Revenue
Road Operator (Original Contractor)	- Implementation/maintenance cost of (a) - Operation cost of (b), (c), (d)	- Toll revenue - Payment by the telecom service company
Telecom Service Company	- Operation cost of (e) - Payment to the road operator	- Communication service revenue

4) FW-4: Operations shared by the road operator and the road operation subcontractor

In this framework, the road operator (the original contractor) can concentrate on managing toll revenue for paying implementation/maintenance cost of road structure and facilities, and

a road operation subcontractor can concentrate on proper expressway operation and communication network management. All parts of operation need to be financed solely by toll revenue.

Figure 6.4 Burden Sharing in Framework FW-4

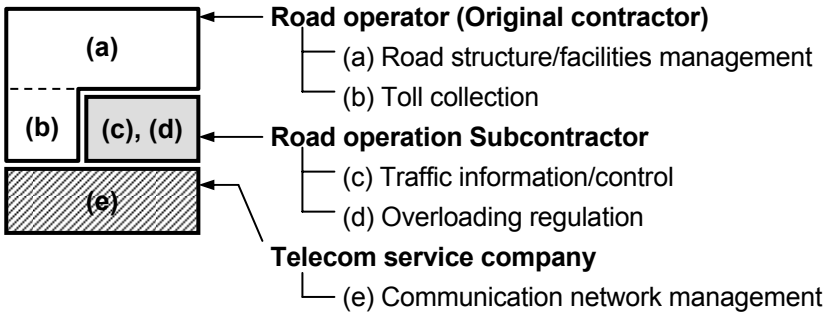


	Cost	Revenue
Road Operator (Original Contractor)	- Implementation/maintenance cost of (a) - Operation cost of (b) - Payment to the road operation subcontractor	- Toll revenue
Road Operation Subcontractor	- Operation cost of (c), (d), (e)	- Payment by the road operator

5) FW-5: Operations shared by the road operator, a road operation subcontractor and a telecom service company

In this framework, the road operator (the original contractor) can concentrate on managing toll revenue for paying implementation/maintenance cost of road structure and facilities, and a road operation subcontractor 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 6.5 Burden Sharing in Framework FW-5



	Cost	Revenue
Road Operator (Original Contractor)	- Implementation/maintenance cost of (a) - Operation cost of (b) - Payment to the road operation subcontractor	- Toll revenue - Payment by the telecom service company
Road Operation Subcontractor	- Operation cost of (c), (d)	- Payment by the road operator
Telecom Service Company	- Operation cost of (e) - Payment to the road operator	- Communication service revenue

6) Selection of Expressway Operation Framework

Advantages and disadvantages of each framework above are compared in the following table. FW-5 is recommended and FW-4 is regarded as reasonable.

Table 6.1 Advantage/Disadvantages of Frameworks

	Advantage	Disadvantage	Grading
FW-1	-	- Many different parts of expressway operation need to be done by the road operator - All parts of operation need to be covered only by the toll revenue.	Not Suitable
FW-2	-	- Many different parts of expressway operation need to be done by the road operation subcontractor - All parts of operation need to be financed solely by the toll revenue.	Not Suitable
FW-3	- Communication network management can be transferred to a dedicated telecom service company - Communication service revenue can be obtained.	- Many different parts of expressway operation need to be done by the road operator. - Dedicated telecom service company (existing or newly-organized) needs to be prepared.	Not Suitable
FW-4	- The road operator can concentrate to paying cost of implementation by managing toll revenue - The road operation subcontractor can concentrate on proper expressway operation and communication network management	- All parts of operation need to be financed solely by the toll revenue.	Reasonable
FW-5	- The road operator can concentrate on paying cost of implementation by managing toll revenue - The road operation subcontractor can focus only on proper expressway operation - Communication network management can be transferred to a dedicated telecom service company - Communication service revenue can be obtained.	- Dedicated telecom service company (existing or newly-organized) needs to be prepared.	Recommended

Source: ITS Standards & Operation Plan Study Team

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

7) Actual Total Framework for Expressway Operation

Expressway network will be constructed and operated by section. Road/system implementation and toll collection will be integrated by the head offices of the road operators, and proper expressway operation and communication network management will be integrated by the Main Center in the total framework FW-5 (or FW-4).

Head office of road operator
- (a) Road/system implementation
- (b) Toll collection

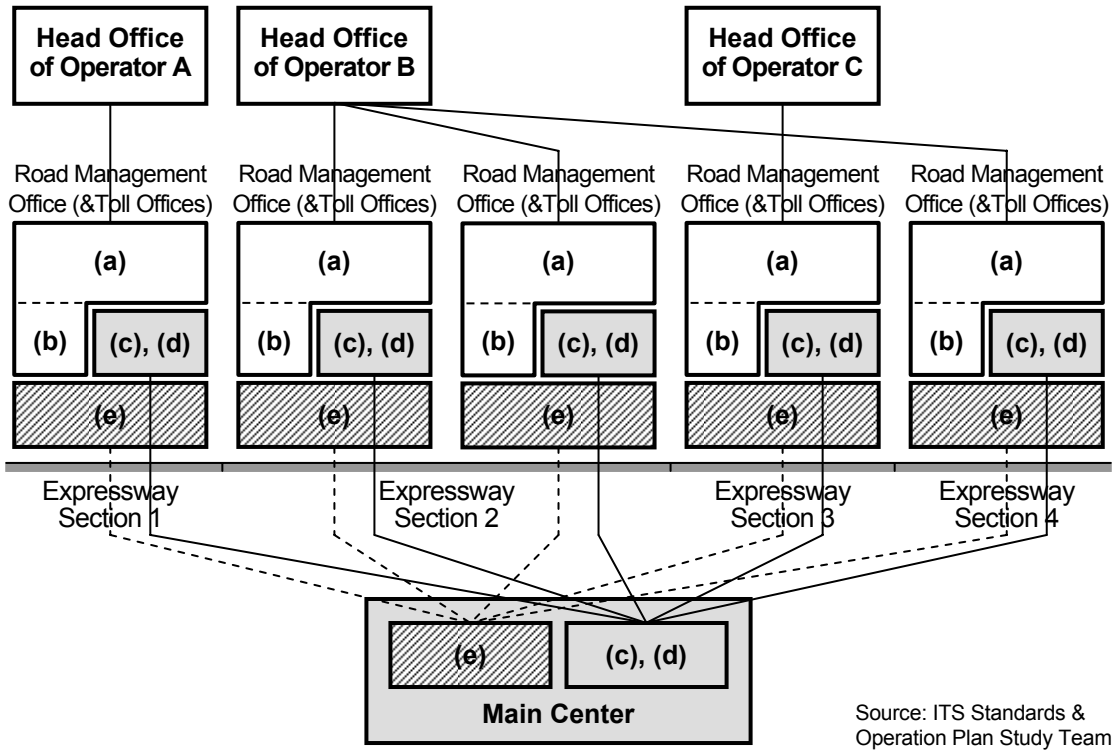
Main Center
- (c) Traffic information/control
- (d) Overloading regulation
- (e) Communication network management

An example of the total framework is illustrated in the figure below, which includes the following road operators:

- Road operator A: Operates an expressway section
- Road operator B: Operates many expressway sections
- Road operator C: Operates an expressway section.

An expressway section is to be operated by one or more road management offices located at adequate intervals on the expressway (generally less than 80 km) and by many toll offices at interchanges and barrier tollgates.

Figure 6.6 Example of Total Framework based on FW-5



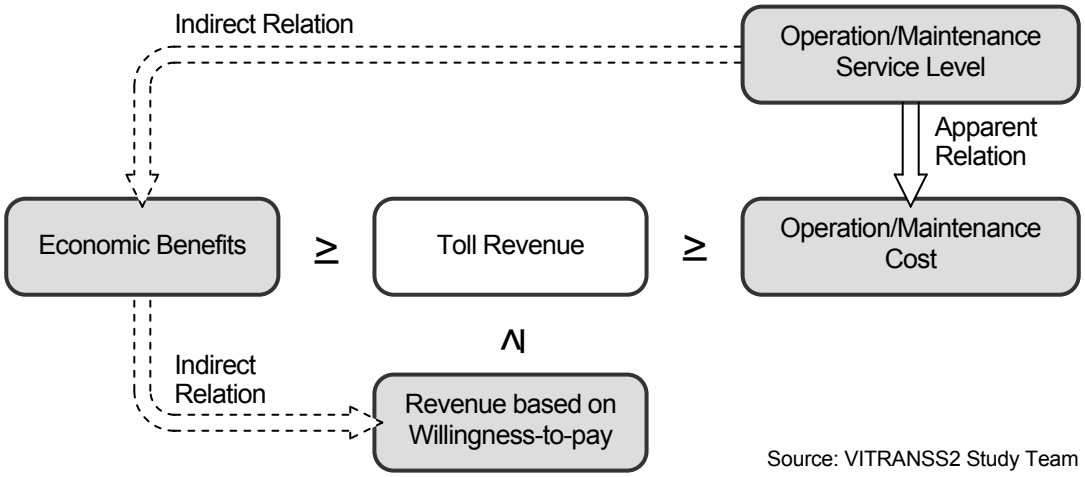
Source: ITS Standards & Operation Plan Study Team

6.2 Control of Expressway Operation Service Levels

Motivation for operation/maintenance is necessary to sustain the framework of expressway operation, because road operators tend to be negative to improve operation/maintenance for the reasons hereafter mentioned.

It is not easy to raise the toll amount, because economic benefits arising from improvement of road operation/maintenance are not apparent, while cost increase and profit decline are apparently caused by it.

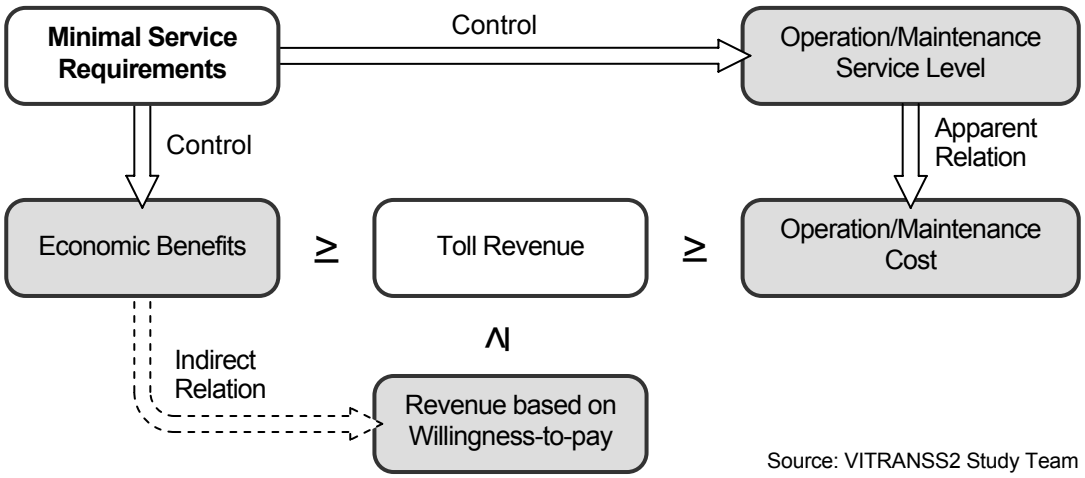
Figure 6.7 Vague Benefits from Improving Operation/Maintenance Service



Source: VITRANSS2 Study Team

Consequently, minimal service requirements of road operation/maintenance need to be defined as a standard. The standardized minimal service requirements allow control of operation/ maintenance service levels by road operators as shown in the figure below. In addition, a raise in toll amount by a road operator is to be approved only in response to its achievement of the minimal service requirements. Specific descriptions of the minimal service requirements assumed in the Study are discussed in Section 3.4.

Figure 6.8 Control of Operation/Maintenance Service Levels



Source: VITRANSS2 Study Team

6.3 Framework for Traffic Control

The expressway network operation in Vietnam will be shared by many different road operators; however, the total framework for expressway operation needs to be integrated into a hierarchical structure of the following elements.

- **Roadside Equipment and Toll Offices:** Many pieces of roadside equipment are to be connected to communication nodes in toll offices or outside. A toll office is located at a tollgate, which includes two or more tollbooths, and is in charge of toll collection.
- **Road Management Offices:** One or more road management offices need to be set up on an expressway section. The road management offices are in charge of patrol for surveying current traffic conditions on the expressway, and the toll offices and the communication nodes on the section are to be controlled by the road management office.
- **Main Centers:** The Main Centers need to be set up in principal cities such as Ha Noi, Da Nang and HCMC. The Main Center is in charge of traffic monitoring, traffic control and traffic information dissemination, and the management offices are to be integrated by the Main center.

The framework for traffic control is illustrated in the following figure, which consists of many different road operators and traffic police. This framework is based on the total framework FW-5 shown in Figure 6.6. This figure also illustrates that expressway traffic police need to be organized corresponding to the expressway sections that are respective jurisdictions of the road management offices.

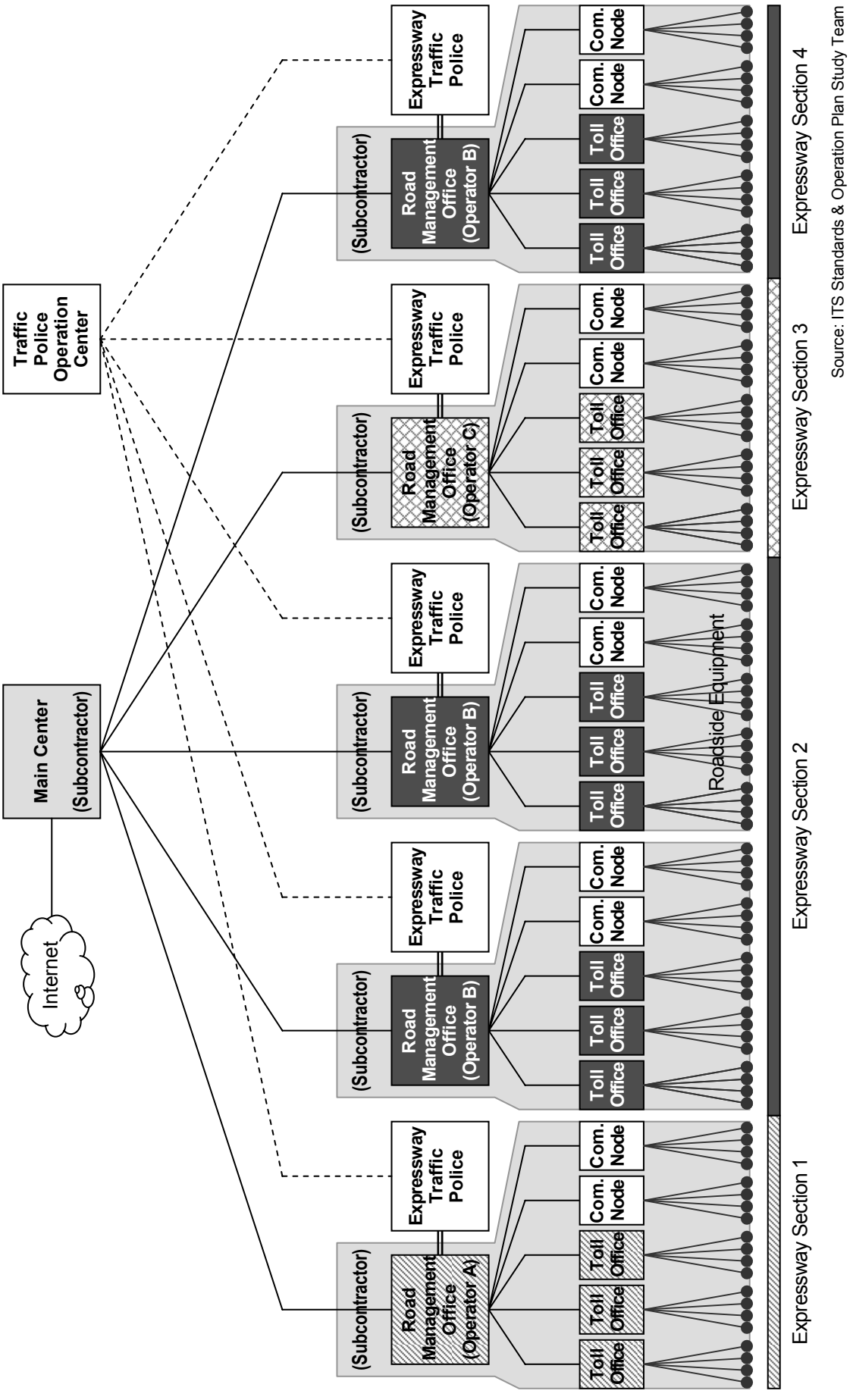


Figure 6.9 Framework for Traffic Control

Source: ITS Standards & Operation Plan Study Team

6.4 Procedure of Incident Notification

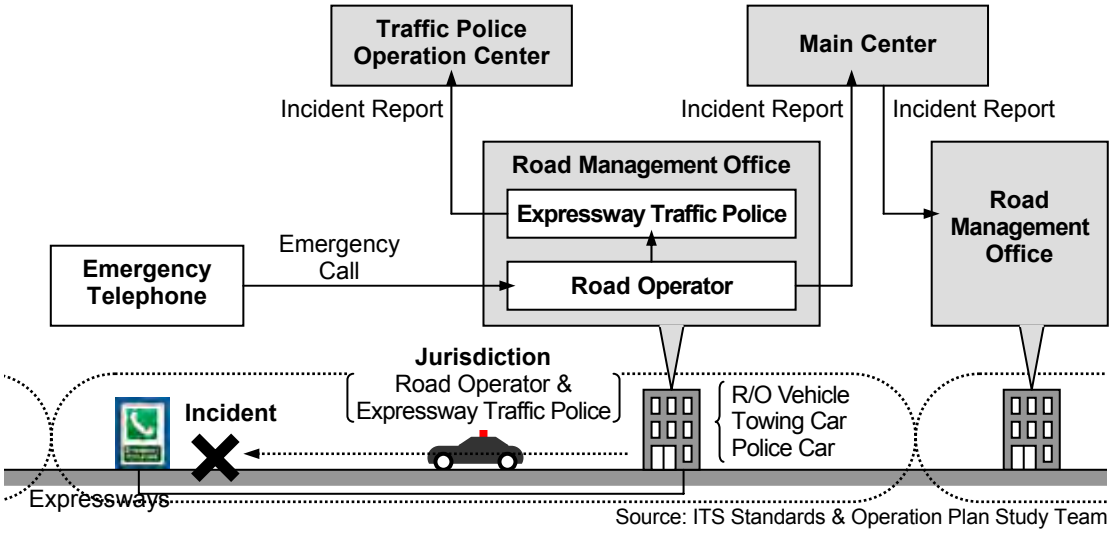
Two types of telephone systems are to be used for emergency call at an incident occurrence.

1) Case-1: Using Emergency Telephone

Advantages: - Ease to identify the location of incident site

Issues: - Setting up of expressway traffic police with jurisdictions corresponding to road management offices
- Higher implementation cost for road operator.

Figure 6.10 Using Emergency Telephone



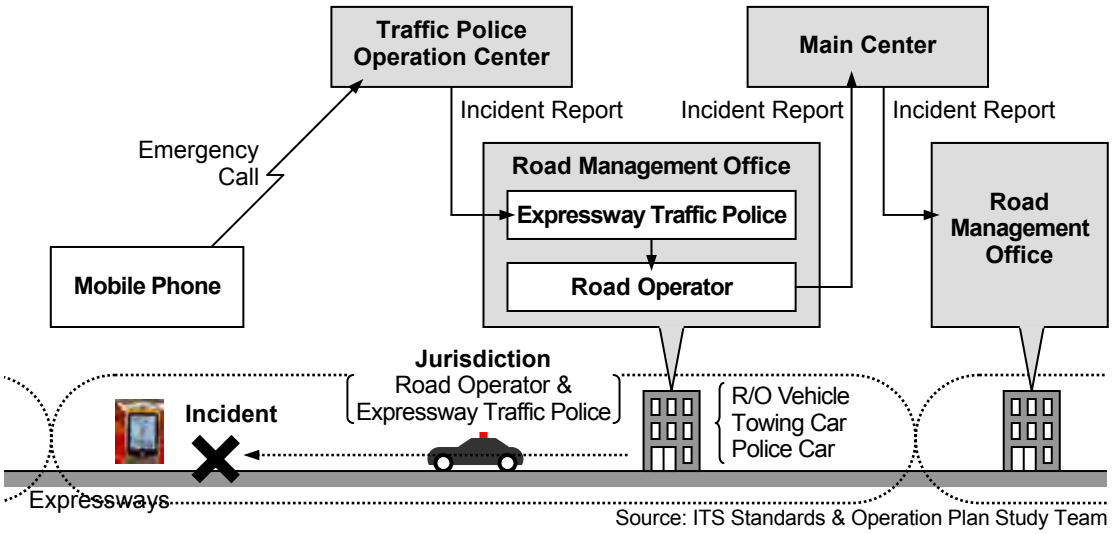
Source: ITS Standards & Operation Plan Study Team

2) Case-2: Using Mobile Phone

Advantages: - Lower implementation cost for road operator

Issues: - Setting up of expressway traffic police with jurisdictions corresponding to road management offices
- Coverage of mobile phone service on the expressway
- Difficulty to precisely identify the location of incident site.

Figure 6.11 Using Mobile Phone



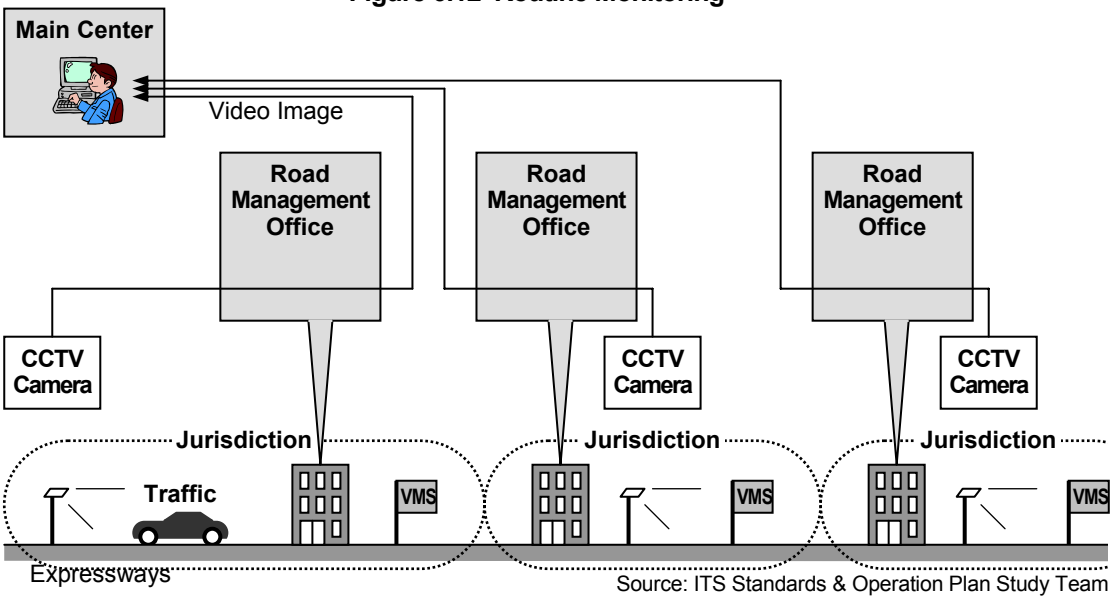
Source: ITS Standards & Operation Plan Study Team

6.5 Procedure of Road/Traffic Monitoring

1) Case-1: Routine Monitoring

Routine road/traffic monitoring is to be delegated to the Main Center for integrating traffic information/control with a wider view on the expressway network. CCTV cameras are to be controlled directly from the Main Center.

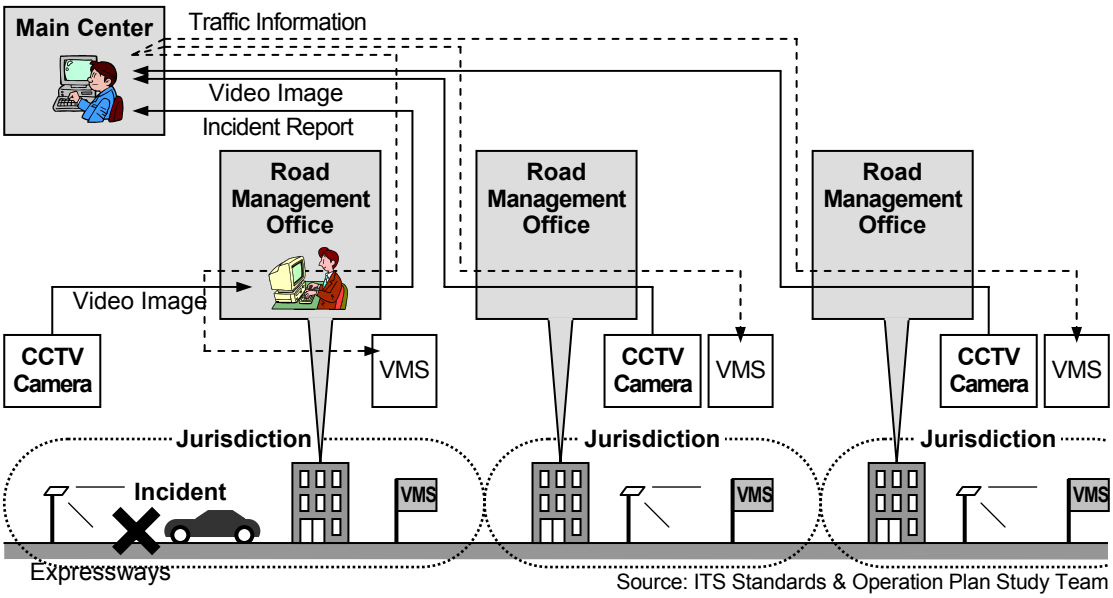
Figure 6.12 Routine Monitoring



2) Case-2: Monitoring at Occurrence of Incident

Road/traffic monitoring at incident site is to be conducted by the road management office in charge to appropriately address/clear the incident. CCTV cameras at incident site are to be controlled from the road management office in charge, and other CCTV cameras and VMS are to be controlled from the Main Center.

Figure 6.13 Monitoring at Occurrence of Incident



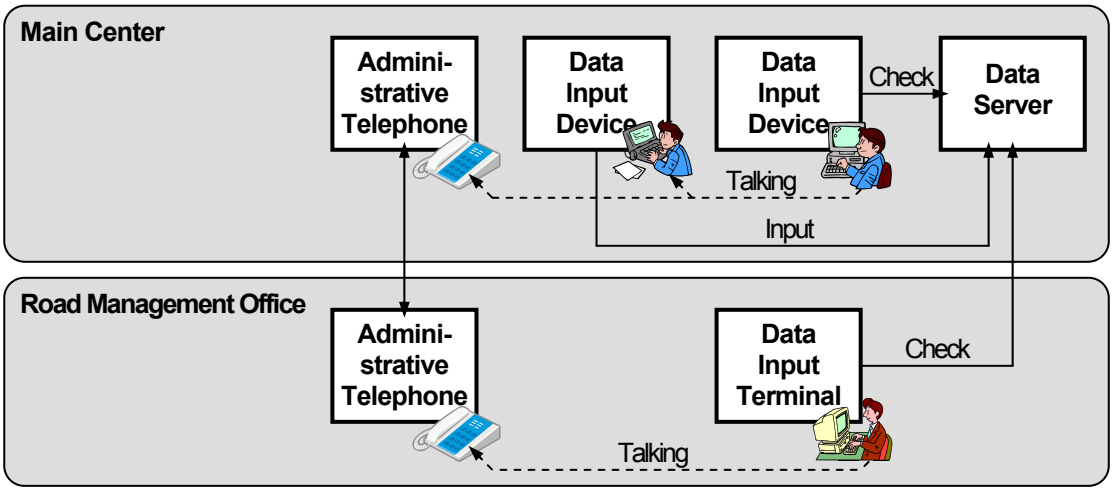
6.6 Procedure of Traffic Event Data Management

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

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

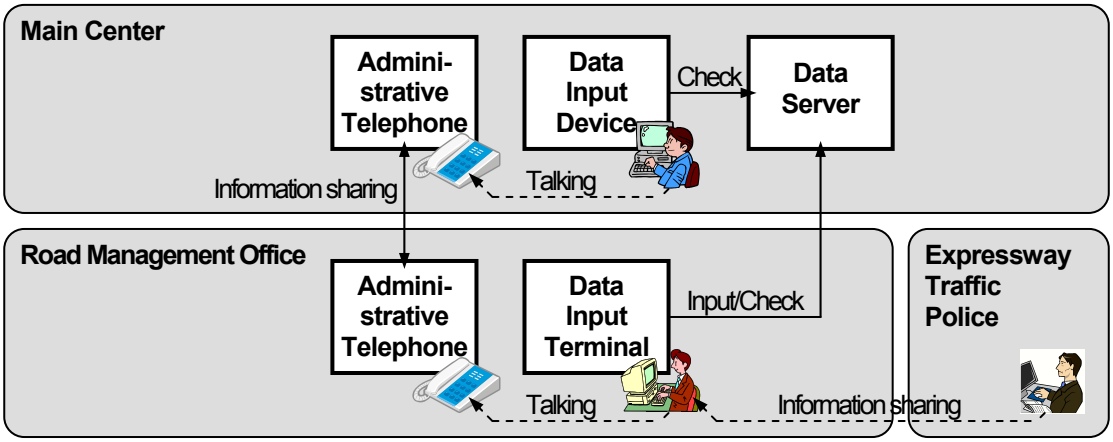
In all cases, it is required to receive approval of responsible persons in the Main Center and the road management office. Through this doubled approval, traffic event data can be generated appropriately even in the case that operating body of the Main Center which is in charge of traffic information/control is different from the road management office which is in charge of patrol for current traffic condition surveillance. Data input without the approval by the Main Center and/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 6.14 Traffic Event Data Input by "Staff in the Main Center"



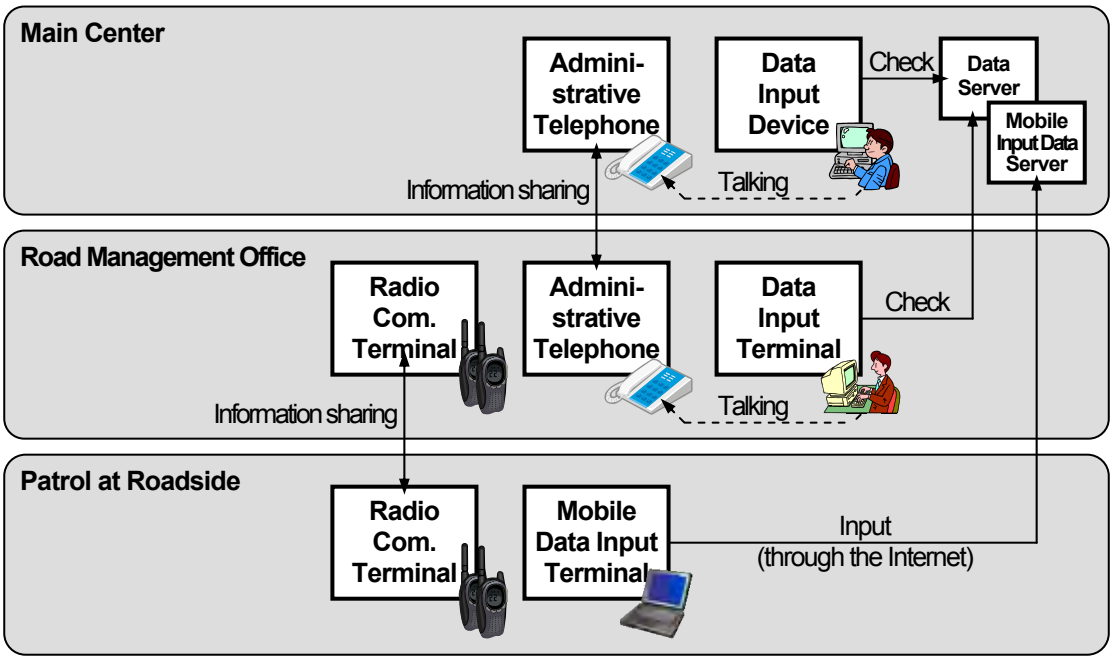
Source: ITS Standards & Operation Plan Study Team

Figure 6.15 Traffic Event Data Input by "Staff in Road Management Office"



Source: ITS Standards & Operation Plan Study Team

Figure 6.16 Traffic Event Data Input by "Patrol Staff at Roadside"

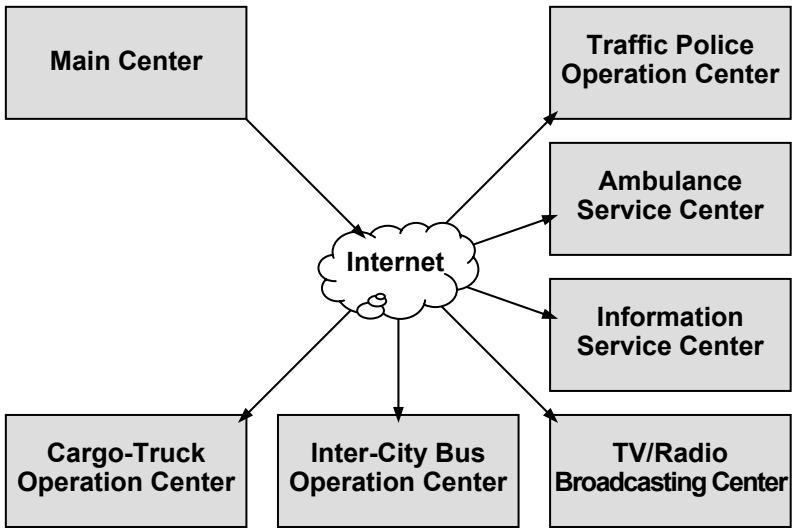


Source: ITS Standards & Operation Plan Study Team

6.7 Framework for Traffic Information

Traffic Information, which consists of standardised messages and standardised data elements, is to be disseminated to organizations concerned through the Internet.

Figure 6.17 Traffic Information Dissemination through Internet



Source: ITS Standards & Operation Plan Study Team

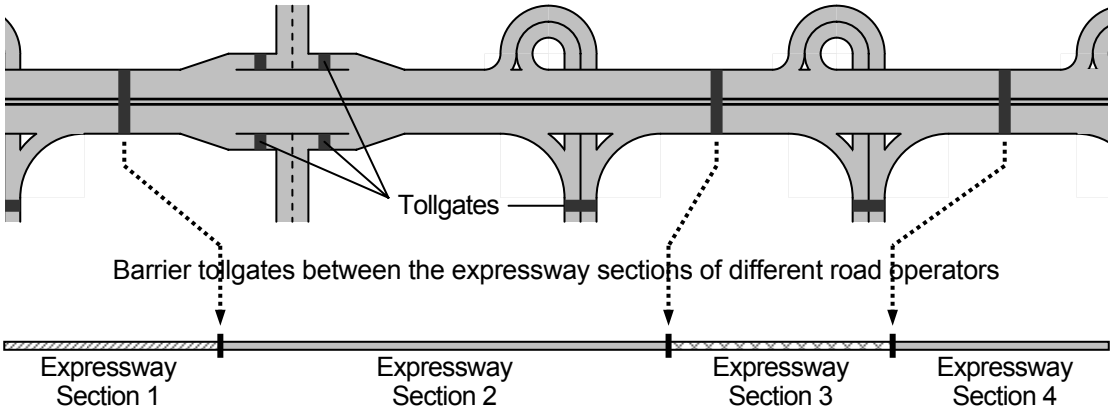
6.8 Toll Rate System for Expressway Network

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) Toll Rate System for Inter-city Expressways

Distance proportional tariff, which provides road users with fairness for driving distance, is suitable for the inter-city expressway network. Additionally, 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 road user who drives on many different expressway sections continuously and to clearly share such toll among different road operators.

Figure 6.18 Tollgate Arrangement of Distance Proportional Tariff for Inter-city Expressways



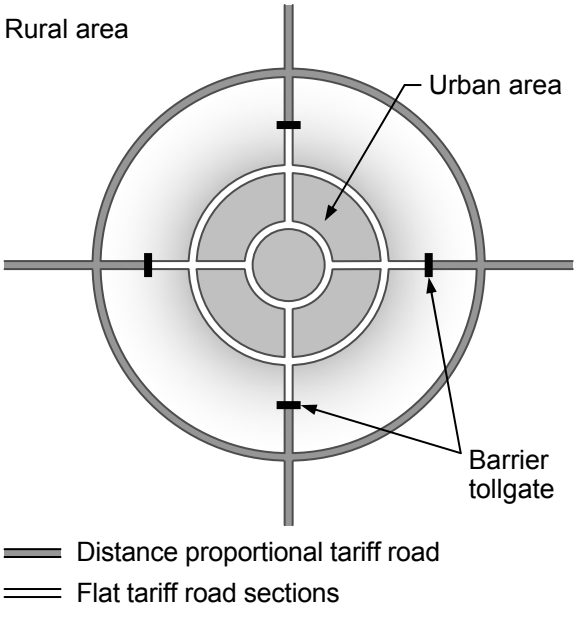
Source: ITS Standards & Operation Plan Study Team

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 effectively utilize the road network by dispersing concentrated traffic. Flat tariff is suitable for such cases. On that account, a combined toll rate system shown in the figure is to be adopted for metropolitan areas in parallel with the metropolises in other countries, such as Tokyo and Jakarta.

Accordingly, for ITS standards, the distance proportional tariff system and the flat tariff system will be considered for toll collection.

Figure 6.19 Combined Toll Rate System for Metropolitan Area



Source: VITRANSS2 Study Team

3) Vehicle Classification

Vehicle Classification in VIETNAM

In Vietnam, toll is based on the vehicle classification shown in the Circular No.90/2004/TT-BTC of MOF. 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 the adequate license plate system.

Table 6.2 Vehicle Classification in VIETNAM

Vehicle Class		Definition
Ordinary Vehicle	1	Two wheelers, three wheelers, mopeds and the like
	2	Motorcycles, rudimentary trucks, tractors
	3	Cars with seats of 12 or less, trucks with a capacity less than 2 tons, mass transit buses
	4	Cars seats between 12 and 30, trucks with a capacity between 2 and 4 tons
	5	Cars with seats of 30 or more, trucks with a capacity between 4 and 10 tons
	6	Trucks with a capacity between 10 and 18 tons, 20ft-container lorries
	7	Trucks with a capacity of 18 tons or more, 40ft-container lorries
Defence Ministry Vehicle	1	Military cars
	2	Military trucks
Police Force Vehicle	1	Cars with seats less than 7
	2	Cars with seats of 7 or more
	3	Specialized automobiles
	4	Trucks
	5	Two wheelers, three wheelers

Source: VITRANSS2 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 6.3 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 6.4 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 6.5 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 for Discussion in the 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, revised vehicle classification shall be defined in a later stage. Revised vehicle classification shall be realized by using simple sensors, such as the license plate scanners and treadles, for cutting costs. For example, the vehicle classification responding to the vehicle weight can be enforced using the number of axles without equipment for vehicle weight measurement.

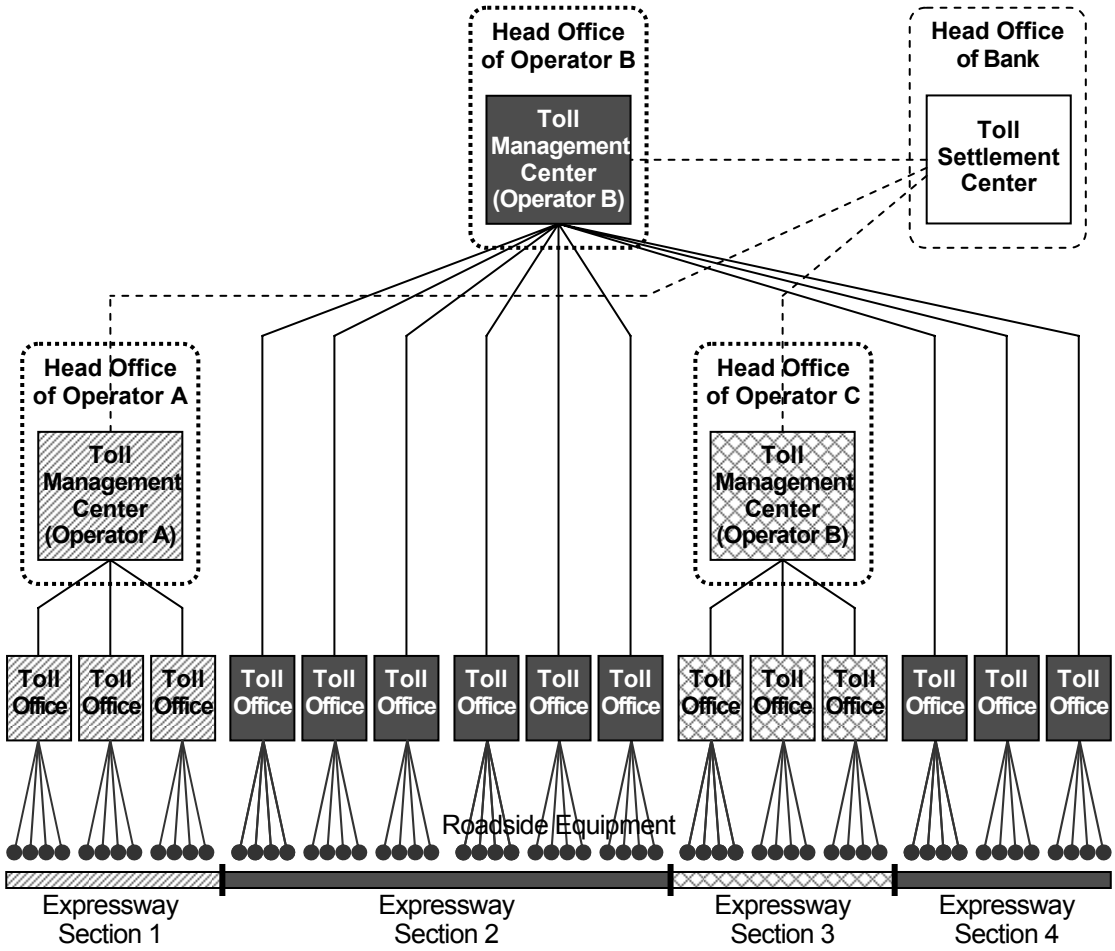
6.9 Framework for Toll Management

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

- **Expressway Sections:** Road sections are operated by the road operators, and the road sections of different road operators are to be separated by barrier tollgates.
- **Toll Offices:** A toll office is located at a tollgate, which includes two or more tollbooths, and it is in charge of toll collection.
- **Toll Management Center:** A toll management center is to be established in the head office of the road operator, and it is in charge of compiling toll rate and managing toll revenue.

The framework for toll management is illustrated in the figure below, which consists of many different road operators and a bank. This framework is premised on distance proportional tariff system and on the total framework FW-5 shown in Figure 6.6.

Figure 6.20 Framework for Toll Management



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

Source: ITS Standards & Operation Plan Study Team

6.10 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 6.6 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 operators, 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 operator and the toll settlement center in the bank.

2) Toll Settlement Frameworks

The following frameworks are compared for executing the toll settlement:

- TYPE-0 of unshared IC-cards issued by road operators
- TYPE-1' of shared IC-cards issued by a bank
- TYPE-1 of shared IC-cards issued by banks
- TYPE-2 of shared IC-cards Issued by road operators.

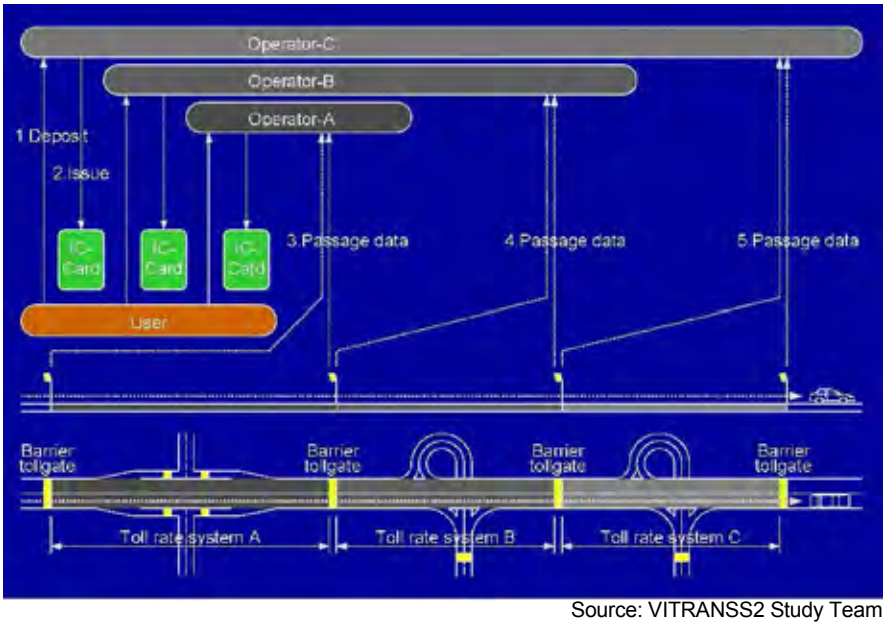
The following discussion on these four is premised on distance proportional tariff system.

(1) TYPE-0 of Unshared IC-cards Issued by Road Operators

This framework for toll settlement is based on many kinds of unshared IC-cards issued by different road operators and has the following problems:

- Users need to prepare many IC-cards for passing continuously through the expressway sections operated by different road operators.
- Users can receive issue/recharge service of the IC-cards only at the roadside of the expressways.
- Road operators 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 6.21 TYPE-0 of Unshared IC-cards Issued by Road Operators



Source: VITRANSS2 Study Team

(2) TYPE-1 of Shared IC-card Issued by Banks

This framework for toll settlement is based on a single kind of IC-card shared by different road operators. Issue/recharge service of the IC-card is to be provided by a single bank in the 1st stage and by several different banks in the later stages as shown in the figures in the next page. The staged implementation of the framework for toll settlement 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 operators need not prepare the equipment for IC-card issue/recharge service and the relevant car parks.
- OBU and IC-card tends to be diffused rapidly.

<in the later stages>

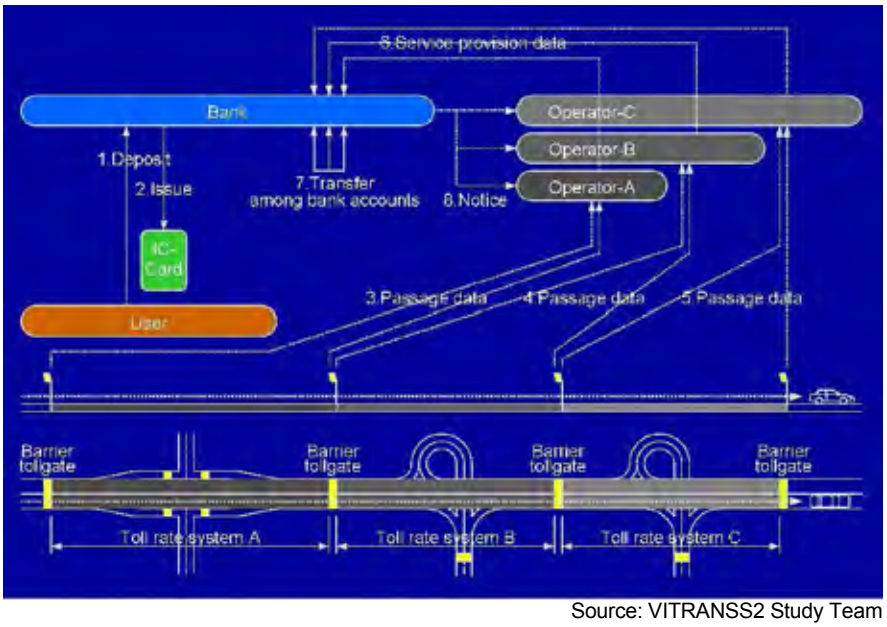
- Users can receive the IC-card issue/recharge service more conveniently.
- Driver needs not stop the vehicle many times on the expressway to get the IC-card

issue/recharge service.

- Congestion to access the IC-card issue/recharge service can be removed.

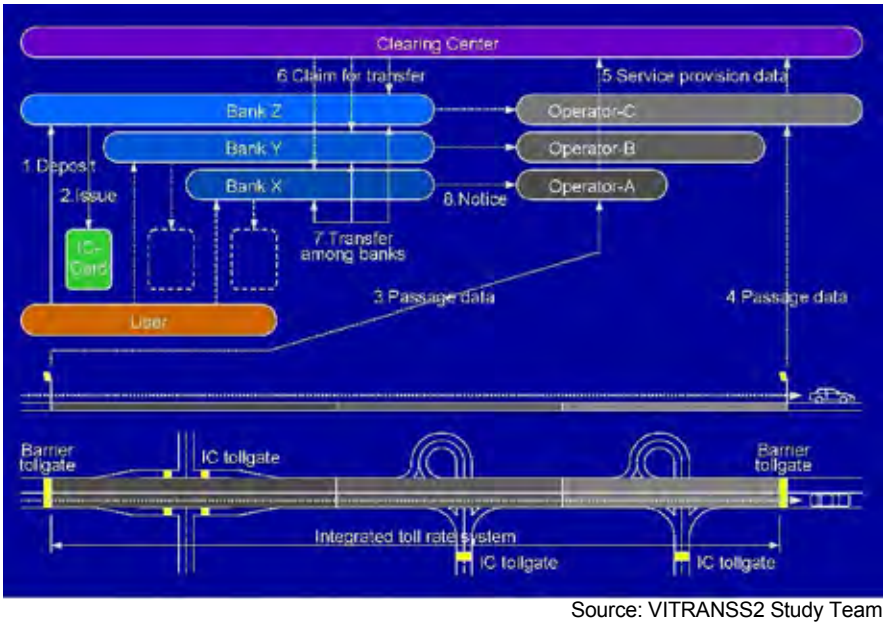
However, for integrating the road operators and the banks, a clearing center needs to be discussed to establish it in a later stage.

Figure 6.22 TYPE-1' of Shared IC-cards Issued by a Bank (in the 1st Stage)



Source: VITRANSS2 Study Team

Figure 6.23 TYPE-1 of Shared IC-cards Issued by Banks (in the Later Stages)



Source: VITRANSS2 Study Team

(3) TYPE-2 of Shared IC-card Issued by Road Operators

This framework for toll settlement is based on a single kind of IC-card shared by different road operators and can provide the same advantages as TYPE-1; however, this framework also needs establishment of a clearing center for integrating the road operators and the banks.

(4) Selection of Toll Settlement Framework

The comparison on the aforementioned toll settlement frameworks summarized below.

Table 6.7 Selection of Toll Settlement Framework

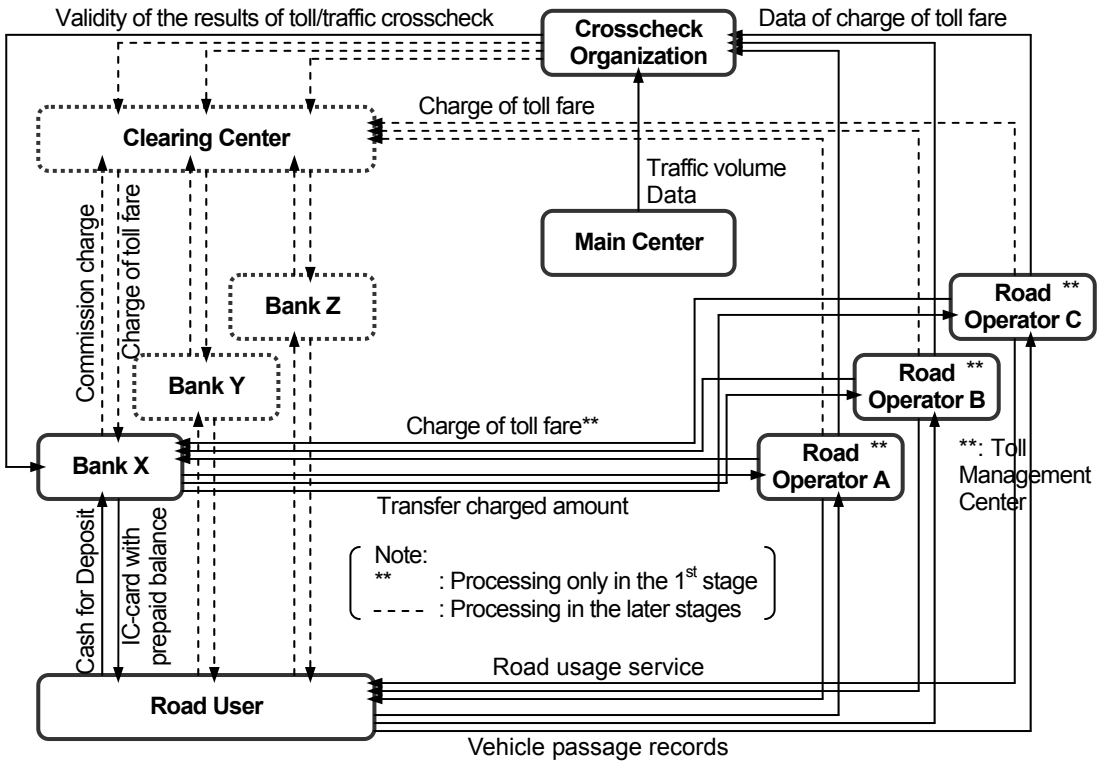
	TYPE-0	TYPE-1'	TYPE-1	TYPE-2
IC-card Issue Organization	Road Operators	A Bank	Banks	Road Operators
Cost-cutting on IC-card Operation for Road Operator	Incapable	Capable	Capable	Incapable
Tollgate-to-center Cash Delivery by Road Operator	Necessary	Not Necessary	Not Necessary	Necessary
Number of IC-cards Necessary for a User	2 or More	1	1	1
Convenience of IC-card Recharge for the User	Average	High	Very High	Average
Clearing Center	Not Necessary	Not Necessary	Necessary	Necessary
Grading	Not Suitable	Useful in the 1st Stage	Recommended	Not Suitable

Source: ITS Standards & Operation Plan Study Team

3) Toll Settlement Framework including Toll/Traffic Cross Check

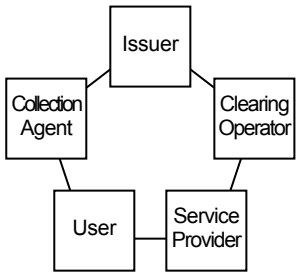
The toll settlement framework is created by integrating TYPE-1', TYPE-1 foregoing and toll/ traffic cross check as shown in the figure below. The toll fare is directly charged to a bank in the 1st stage; however, a clearing center needs to be set up in the later stage to allocate charged amount of toll fare to two or more banks. Additionally, a crosscheck organization needs to be set up to check the charged amounts by road operators against traffic volumes.

Figure 6.24 Toll Settlement Framework including Toll/Traffic Cross Check



Source: ITS Standards & Operation Plan Study Team

Table 6.8 Correspondence to the Basic Conceptual Model in ISO 14904

ISO 14904: "EFC Interface Specification for Clearing between Operators"			Case of TYPE-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 Operators
	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

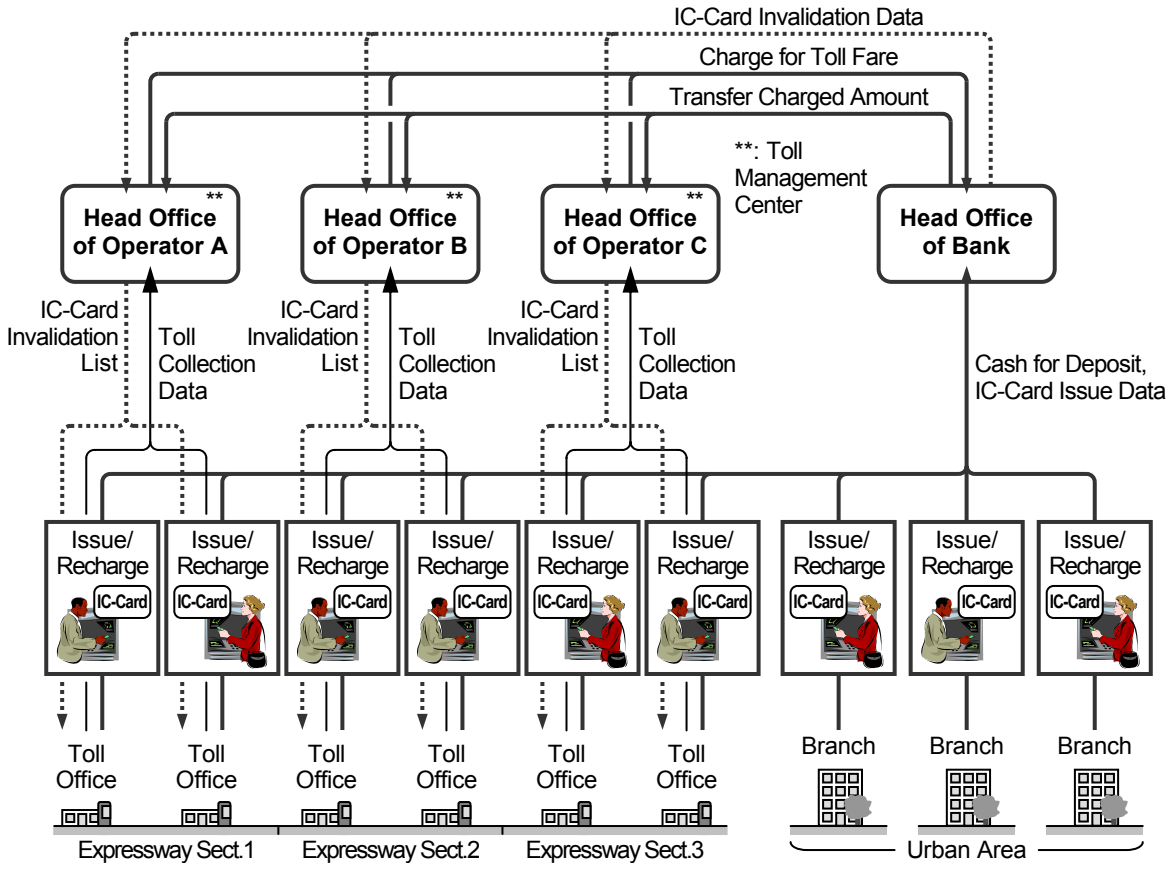
Note: EFC: Electronic fee collection.

Source: ITS Standards & Operation Plan Study Team

6.11 Framework for IC-Card Operation

IC-cards are to be operated for both Touch&Go and ETC by the unified framework shown in the figure below.

Figure 6.25 Framework for IC-Card Operation



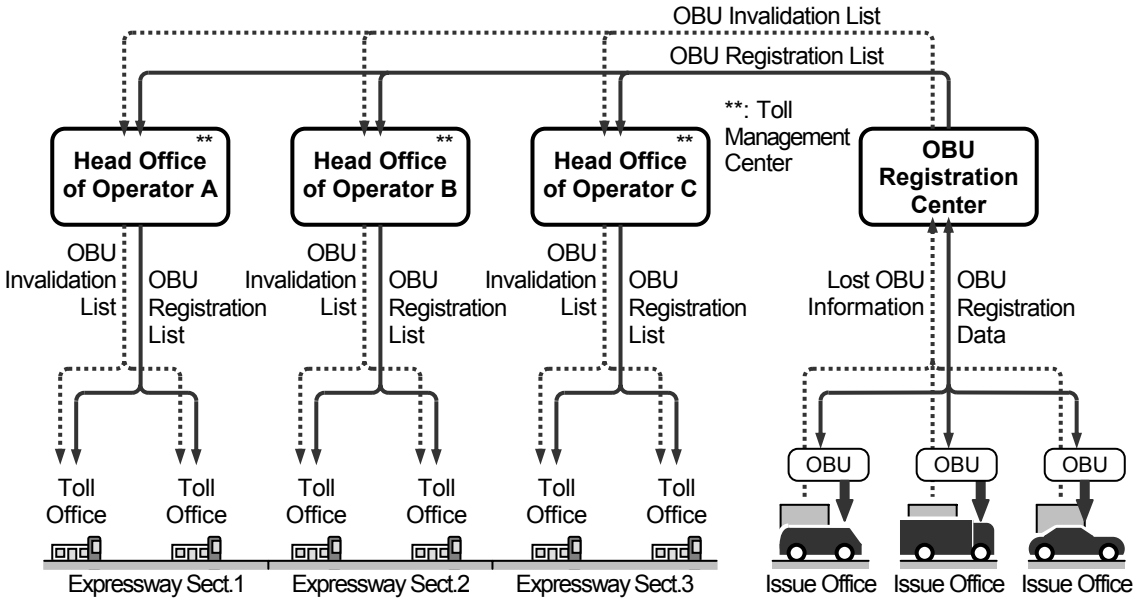
Source: ITS Standards & Operation Plan Study Team

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 operators 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.

6.12 Framework for OBU Management

OBUs are to be operated for ETC by the unified framework shown in the figure below.

Figure 6.26 Framework for OBU Management



Source: ITS Standards & Operation Plan Study Team

For creating the framework, OBU registration center needs to be set up to integrate offices for OBU issuance. The center compiles an OBU registration list responding to issuance of OBUs to users at regular intervals, and the list is to be delivered to toll offices through the head offices of road operators. Additionally, lost OBU information is compiled into an OBU invalidation list at the OBU registration center and the list is to be delivered to toll offices as well.

6.13 Framework for Toll Enforcement

1) 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

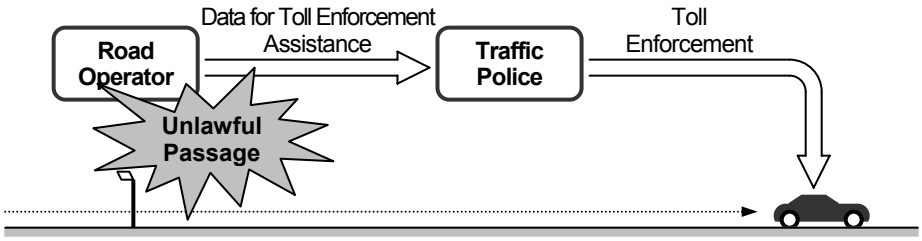
- Introduction of a highly reliable system intending a high exposure ratio for unlawful passages.

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.

Actual toll enforcement is to be performed in cooperation between the road operator and the traffic police as shown in the figure below.

Figure 6.27 Role-sharing for Toll Enforcement



Source: ITS Standards & Operation Plan Study Team

2) 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).

3) Assumed Cases

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

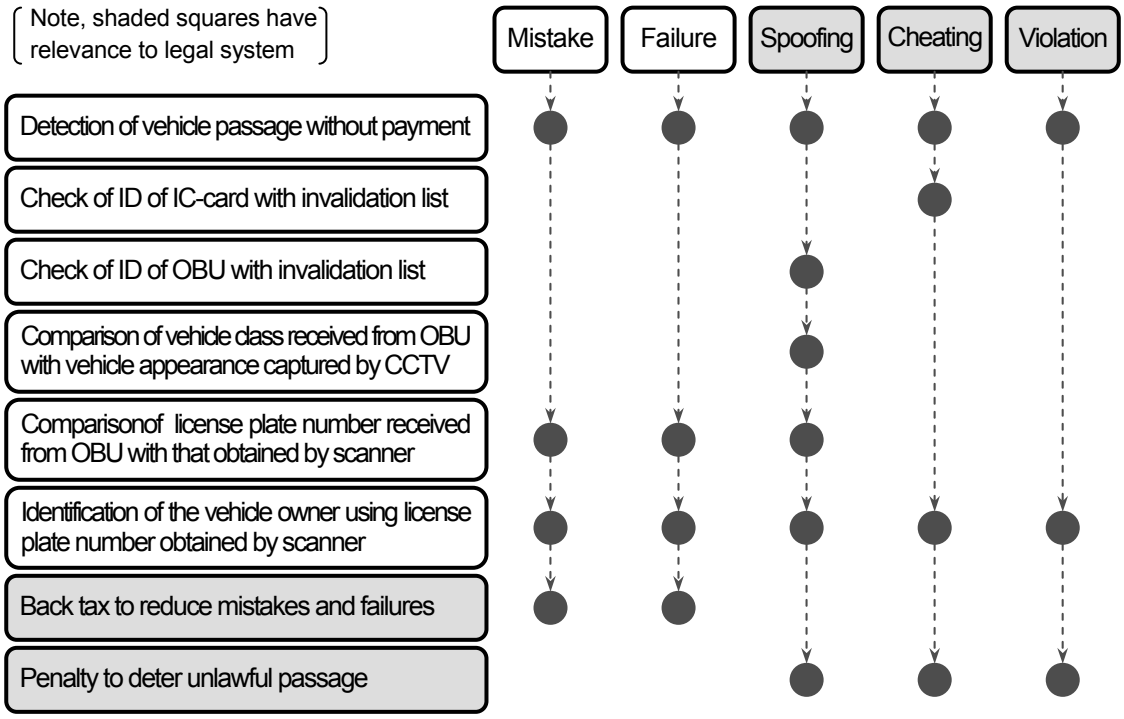
- Mistake: Passage not turning on OBU, not putting IC-card into OBU, or not preparing enough prepaid balance of IC-card
- Failure: Passage under function failure of OBU or IC-card
- Spoofing: Unlawful passage re-installing OBU to other vehicle or tampering with the vehicle class data in OBU
- Cheating: 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.

4) 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 6.28 Procedure of Toll Enforcement Assistance for ETC

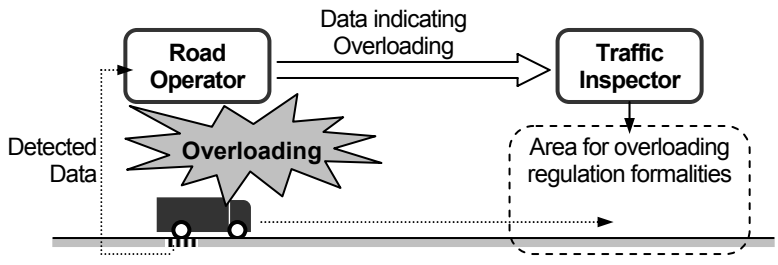


Source: ITS Standards & Operation Plan Study Team

6.14 Framework for Overloading Regulation

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. Therefore, the role of road operator is to transfer information to the inspector on the vehicle judged as overloading by weight measurement system and the data for indicating the fact of overloading.

Figure 6.29 Role-sharing to Enforce Overloading Regulation

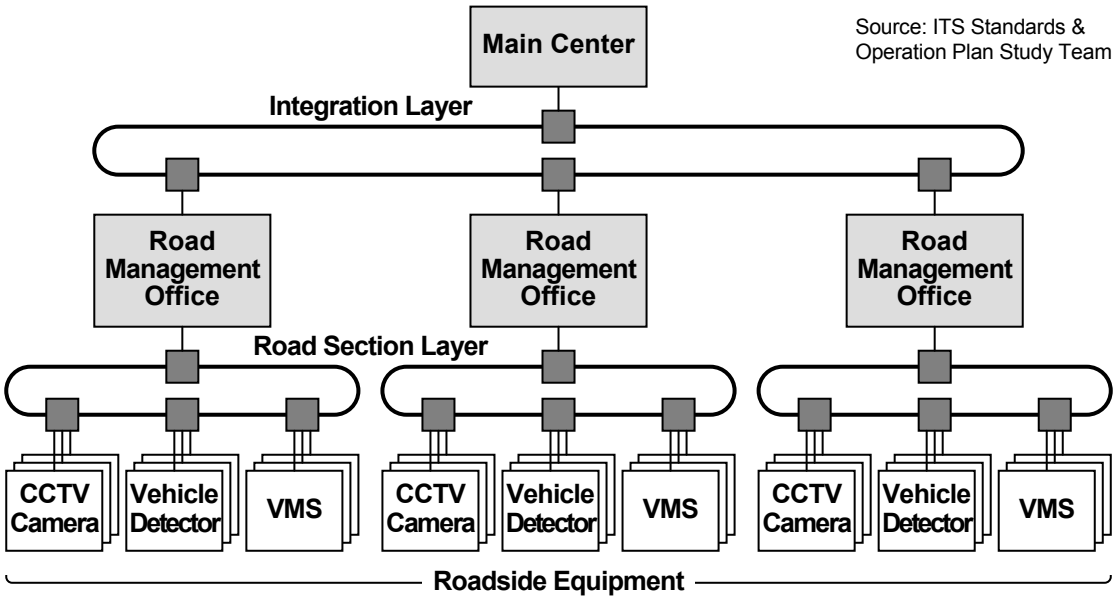


Source: ITS Standards & Operation Plan Study Team

6.15 Framework for Communication Network Management

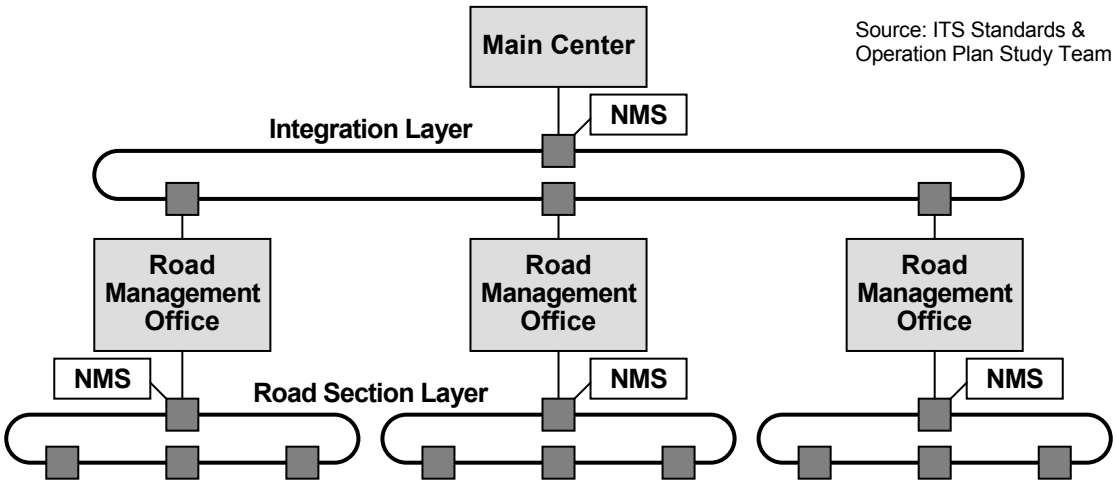
For road operation, a hierarchical communication network needs to be established. The reason is that fiber optic rings of road section layer for connecting a road management office and pieces of roadside equipment need to be installed section by section keeping pace with the road construction; however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

Figure 6.30 Hierarchical Network Topology



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 6.31 Communication Network Management

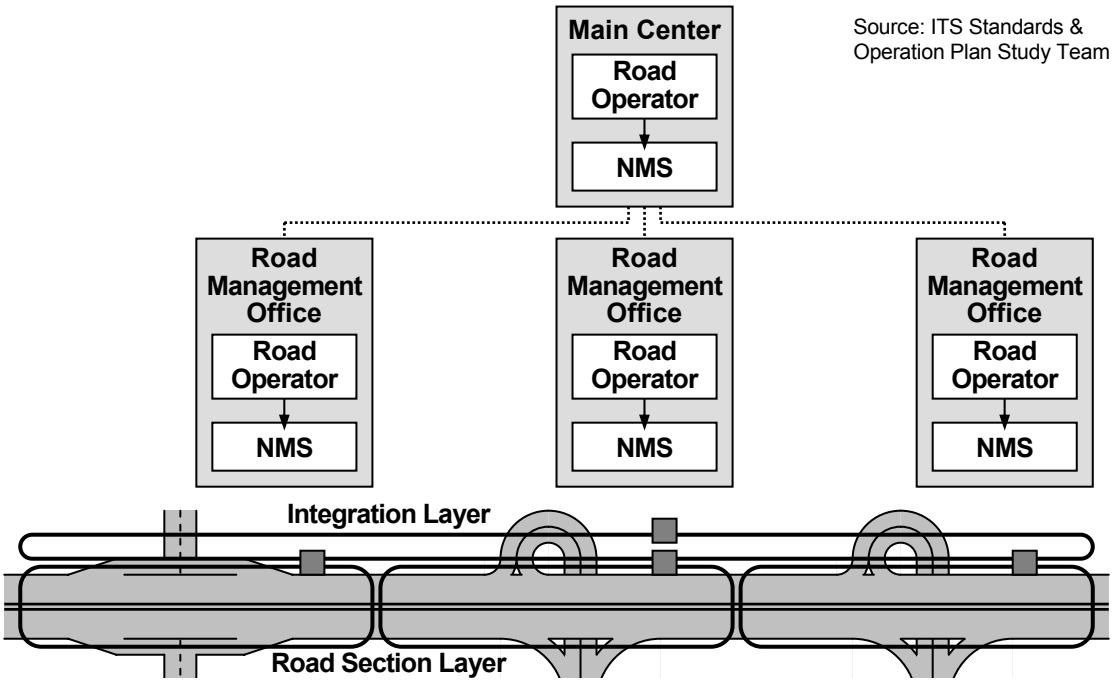


1) Case-1: Management Respectively by the Road Operators

Communication network consists of roadside layer and integration layer, and both layers are

to be managed by the respective road operators.

Figure 6.32 Management by the Respective Road Operators

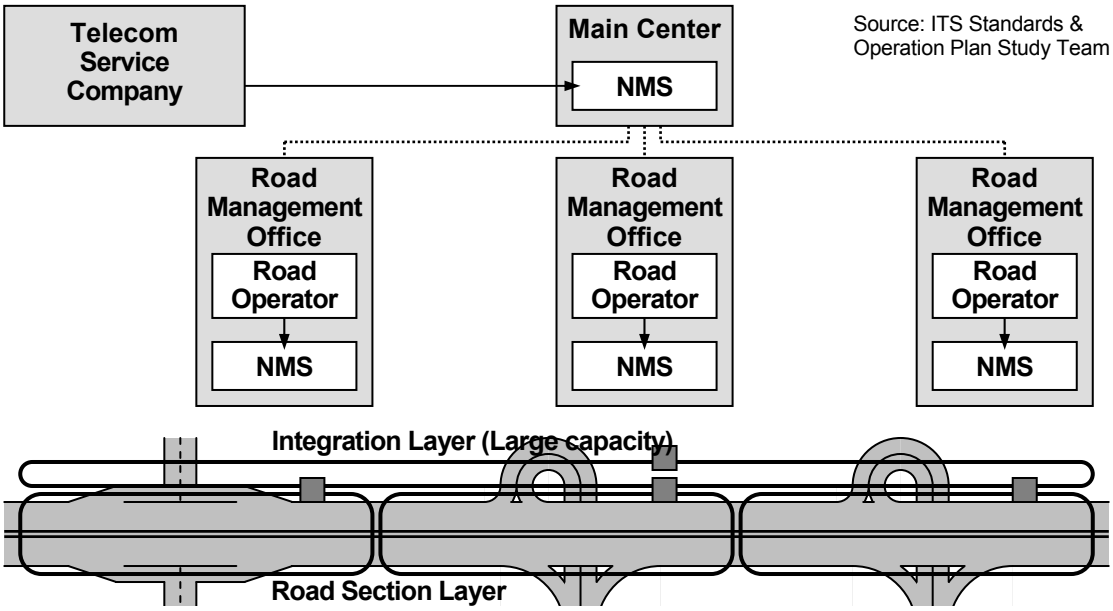


Note: Roadside layer: for connecting a road management office and pieces of roadside equipment, Integration layer: for connecting the Main Center and road management offices, NMS: Network Management System.

2) Case-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 6.33 Management by the Road Operators with Integration by a telecom service Company

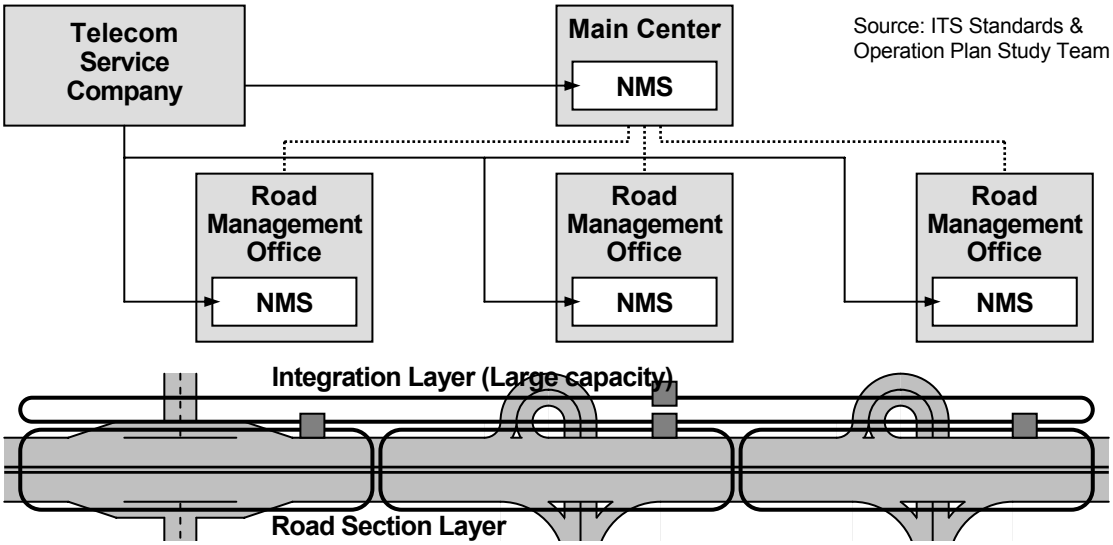


Note: Roadside layer: for connecting a road management office and pieces of roadside equipment, Integration layer: for connecting the Main Center and road management offices, NMS: Network Management System.

3) Case-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 6.34 Operation Totally by a Telecom Service Company

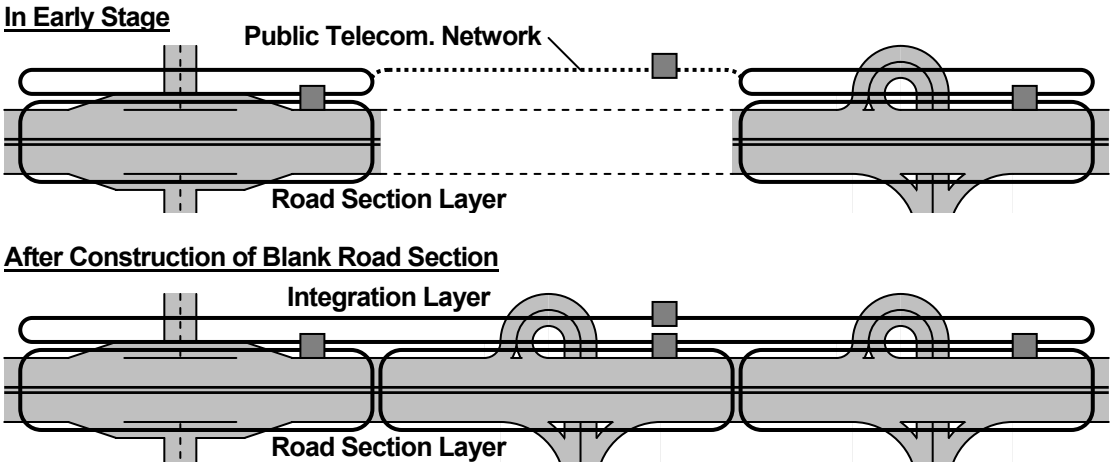


Note: Roadside layer: for connecting a road management office and pieces of roadside equipment, Integration layer: for connecting the Main Center and road management offices, NMS: Network Management System.

4) Case-4: 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 6.35 Stepwise Installation of Fiber Optic Cable



Source: ITS Standards & Operation Plan Study Team

6.16 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)

6.17 Major Issues on Setting up Frameworks for ITS

In the Study, the Draft ITS Standards are discussed on the premise that frameworks for expressway operation using ITS are created in advance and the following issues have been addressed.

Issues on Frameworks for Traffic Information/Control

(1) Selection of an organization, including the case of setting up a subcontractor, to conduct traffic information/control in an integrated way (→ See Figures 6.6 and 6.9)

(2) Setting up a scheme of traffic police for the expressways, with jurisdictions corresponding to road management offices (→ See Figures 6.10 and 6.11)

Issues on Frameworks for Automated Toll Collection

(3) Definition of vehicle classification for toll rate of the expressway (→ See Table 6.2)

(4) Setting up a scheme for toll settlement by each road operator as an original contractor (→ See Figures 6.6 and 6.20)

(5) Definition on the number of banks for issuing IC-cards for toll collection and on a clearing center necessary in case the number is larger than one (→ Table 6.7, Figures 6.22, 6.23 and 6.24)

(6) Selection of an organization for checking the charged amounts of toll fare by road operators against traffic volumes in order to secure fairness and reliability of the toll settlement (→ See Figure 6.24)

(7) Selection of an organization for conducting OBU registration including the case to newly set it up (→ See Figure 6.26)

(8) Clarification of the establishment of a back tax system for deterring mistakes and failures on toll payment and penalty system to deter unlawful passage at tollgate (→ See Section 6.13)

Issues on Frameworks for Overloading Regulation

(9) Definition of role-sharing for enforcement of overloading regulation among the organizations such as the road operators and the traffic inspector (→ See Section 6.14).

Issues on Frameworks for Communication System

(10) Selection of an organization, including the case to set up a telecom service company, to conduct communication network management in an integrated way (→ See Table 6.1, Figures 6.6, 6.32 and 6.33)

(11) Decision on radio frequency allocation necessary/sufficient for radio communication to be used in ITS (→ See Section 6.16).

Table 6.9 Major Issues on Setting up Frameworks for ITS

Major Issues	Responsible Ministry
(1) Selection of an organization, including the case of setting up a subcontractor, to conduct traffic information/ control in an integrated way	MOT (Department of Transport Infrastructure)
(2) Setting up a scheme of traffic police for the expressways, with jurisdictions corresponding to road management offices	MOPS (Road and Railway Traffic Police Department), MOT (Department of Transport Infrastructure)
(3) Definition of vehicle classification for toll rate of the expressway	MOF, MOT (Department of Finance, Directorate for Vietnam Road Administration)
(4) Setting up a scheme for toll settlement by each road operator as an original contractor	MOT, The State Bank of Vietnam
(5) Definition on the number of banks for issuing IC-cards for toll collection and on a clearing center necessary in case the number is larger than one	The State Bank of Vietnam
(6) Selection of an organization for checking the charged amounts of toll fare by road operators against traffic volumes in order to secure fairness and reliability of the toll settlement	MOF, MOT
(7) Selection of an organization for conducting OBU registration including the case to newly set it up	MOT (Vietnam Register)
(8) Clarification of the establishment of a back tax system for deterring mistakes and failures on toll payment and penalty system to deter unlawful passage at tollgate	MOF, MOT (Department of Finance)
(9) Definition of role-sharing for enforcement of overloading regulation among the organizations such as the road operators and the traffic inspector	MOT
(10) Selection of an organization, including the case to set up a telecom service company, to conduct communication network management in an integrated way	MOT, MIC
(11) Decision on radio frequency allocation necessary/ sufficient for radio communication to be used in ITS	MIC (Radio Frequency Directorate), MOT

Note: MOT: Ministry of Transport, MOPS: Ministry of Public Security, MOF: Ministry of Finance, MIC: Ministry of Information & Communication

Source: ITS Standards & Operation Plan Study Team

7. Selection of Key Policies on System

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

- CCTV camera arrangement
- Vehicle detector arrangement
- Contact-less IC-Card type
- Checking of prepaid balance
- Tollgate lane arrangement
- Road-to-vehicle communication method for ETC
- Axle load scale arrangement
- Network system for roadside equipment control
- Transmission method.

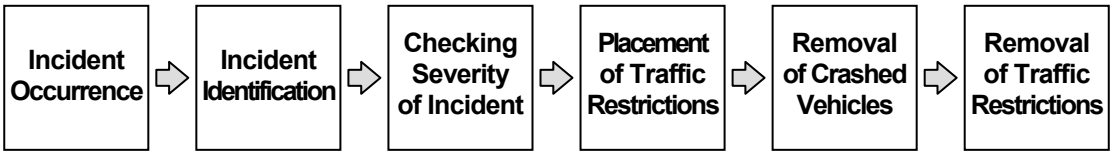
7.1 CCTV Camera Arrangement

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 incident identification.

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.

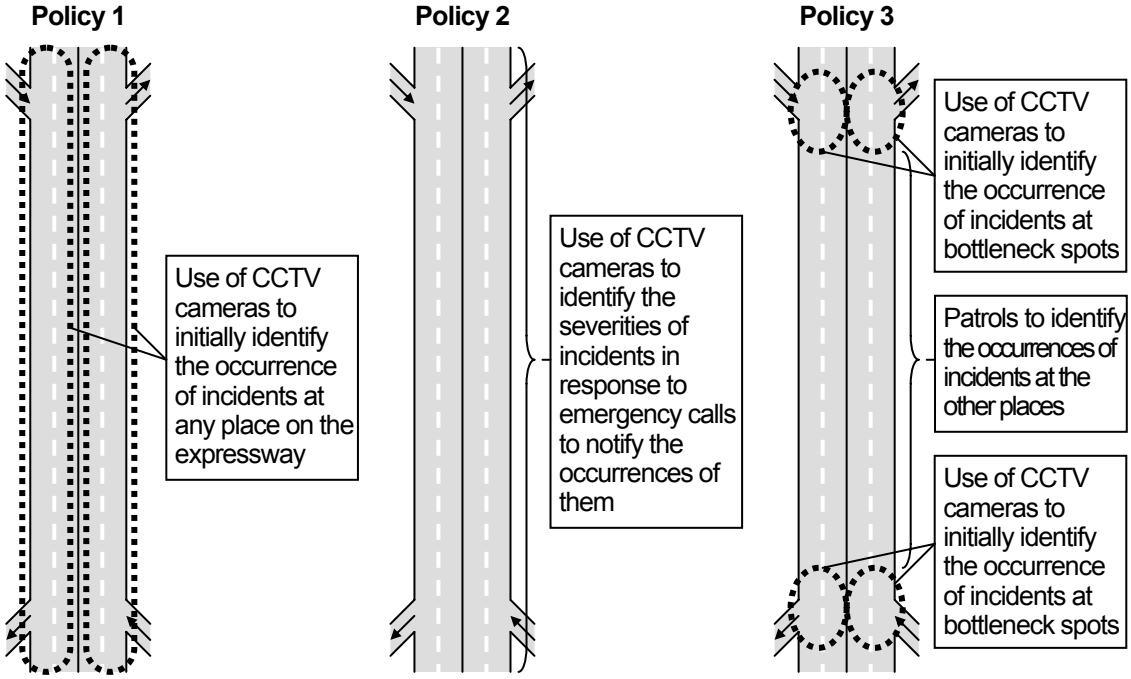
For this reason, effectiveness of CCTV camera is discussed in the following focusing on incident identification and checking of current situations.

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 CCTV Camera Installation/Operation Policies



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:

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

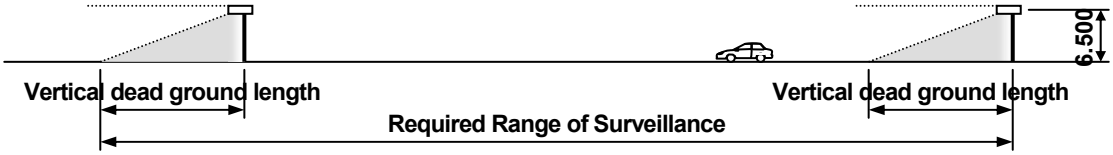
Where b: the size of image sensor (which is assumed as 6.5 mm for 1/2-inch image sensor), 0.95: over-scanning ratio, V: the width of an actual vehicle (which can be assumed as 1500 mm), V': the width of the displayed image of vehicle, and f: the focal length of lens of the CCTV camera (which is assumed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

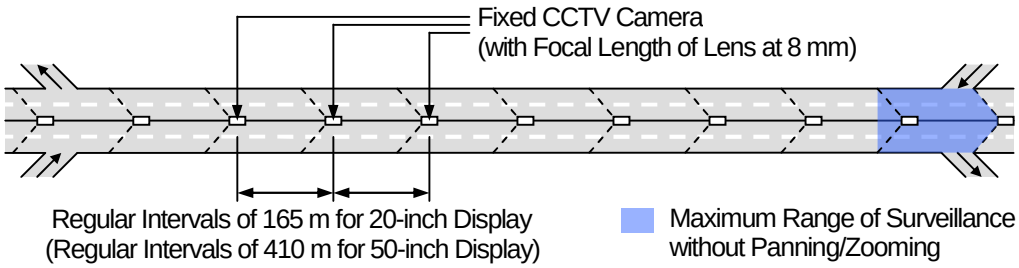
Note: ** : Focal length under 20 times zooming of 3.8 mm, *** : Focal length under 20 times zooming of 8.0 mm.

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

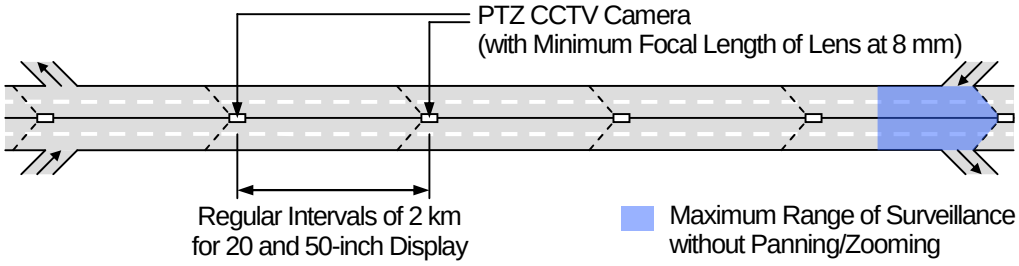


Source: ITS Standards & Operation Plan Study Team

(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.

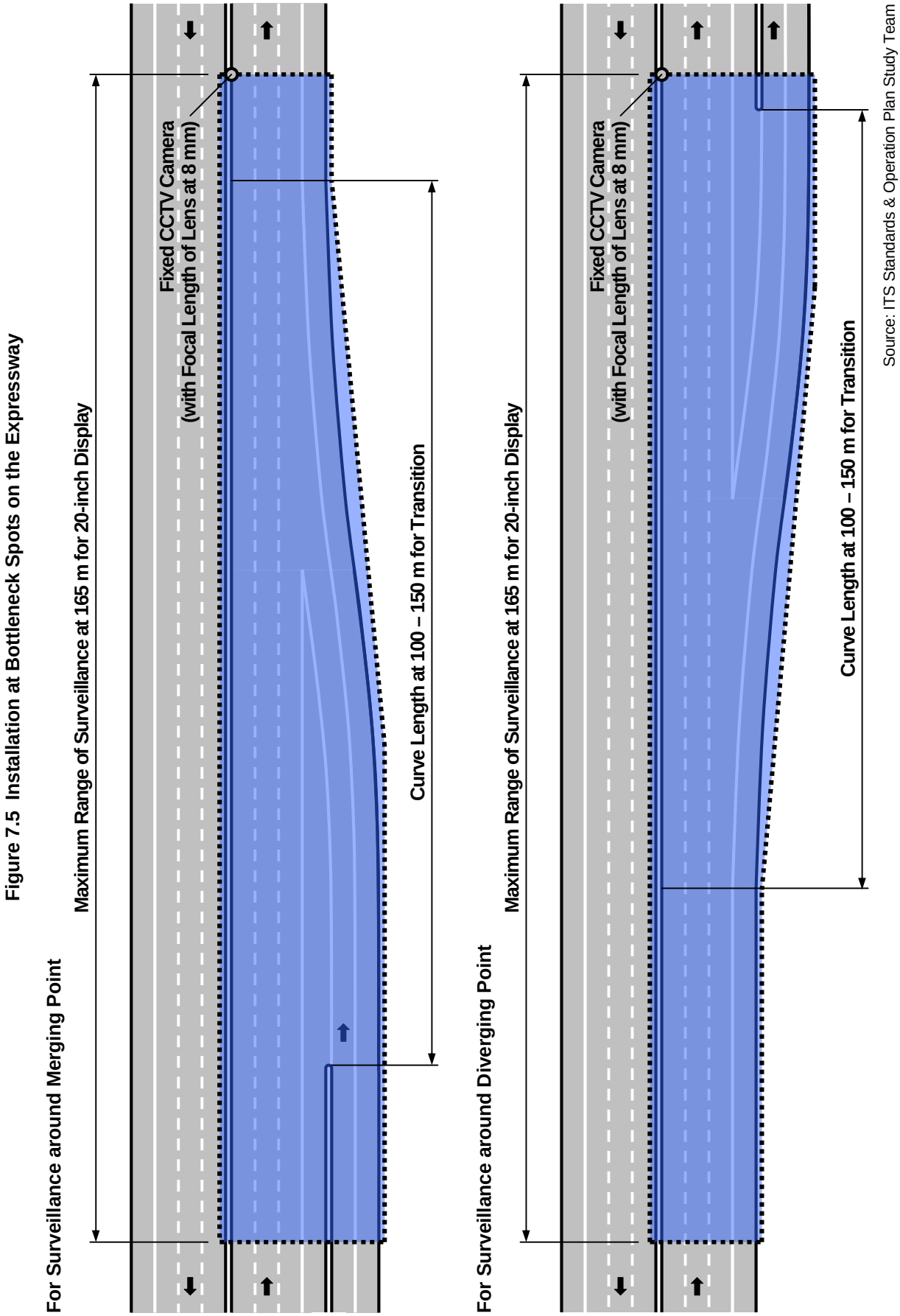


Figure 7.5 Installation at Bottleneck Spots on the Expressway

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 below.

Table 7.2 Comparison of Installation/Operation Policies of CCTV Camera

		Policy 1	Policy 2	Policy 3
Initial identification of the occurrences of incidents by CCTV cameras without patrol	At any place on the expressway	Capable	Impractical	Incapable
	At bottleneck spots on the expressway	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	Incapable
	At bottleneck spots on the expressway	Capable	Capable	Capable
Applicability of image recognition for reducing human errors		Applicable	Inapplicable	Applicable
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	HCMC – Trung Luong	HCMC – Long Thanh – Dau Giay
Grading		Not suitable	Recommended	Average

Note: * : It is assumed that five cameras can be monitored by a display by switching 5 times,
** : A 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

As shown in the table above, 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.

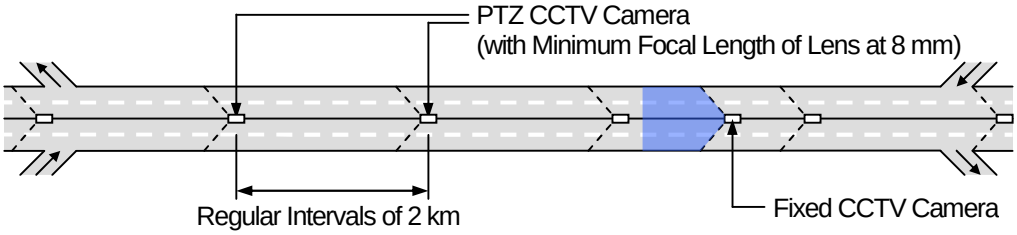
Policy 2 has difficulty of identification in heavy rain or in darkness of the night, but is effective at identifying severities of incidents at any place on the expressway and at optimizing dispatch of patrol crew to be insufficient for estimated incident frequency rate. Hence, according to this comparison,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

5) Additional Comparison on CCTV Camera for Event Detection

(1) CCTV Camera Arrangement for Policy 2-1

In the case of Policy 2-1, fixed CCTV cameras for event detection need to be installed additionally to the PTZ CCTV Cameras for monitoring.

Figure 7.6 Additional Fixed CCTV Camera Installation for Event Detection

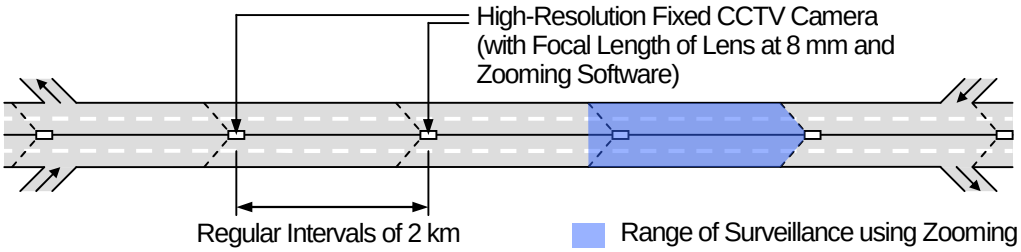


Source: ITS Standards & Operation Plan Study Team

(2) CCTV Camera Arrangement for Policy 2-2

In the case of Policy 2-1, Fixed CCTV Cameras equipped with high-resolution image sensor and zooming software both for monitoring and image recognition need to be installed continuously along the expressway.

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



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

Source: ITS Standards & Operation Plan Study Team

Policy 2-1 is recommended for event detection, because Policy 2-2 requires too much cost per 1000 km as shown in the comparison table below.

Table 7.3 Comparison of CCTV Camera Arrangement Policies for Event Detection

		Policy 2-1	Policy 2-2
Reliability in bad weather conditions (e.g. heavy rain, heating of pavement, darkness in the night)		High	Low (over large distance)
Required cost of system implementation for 1000 km length of the expressway network (Unit: Million USD)	Roadside Equipment including Camera	3.9	18.0
	Software for Image Recognition including Zooming	2.1	270.0
	Total	6.0	288.0
Cost for Maintenance		Average	Low
Grading		Recommended	Not Suitable

Source: ITS Standards & Operation Plan Study Team

7.2 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:

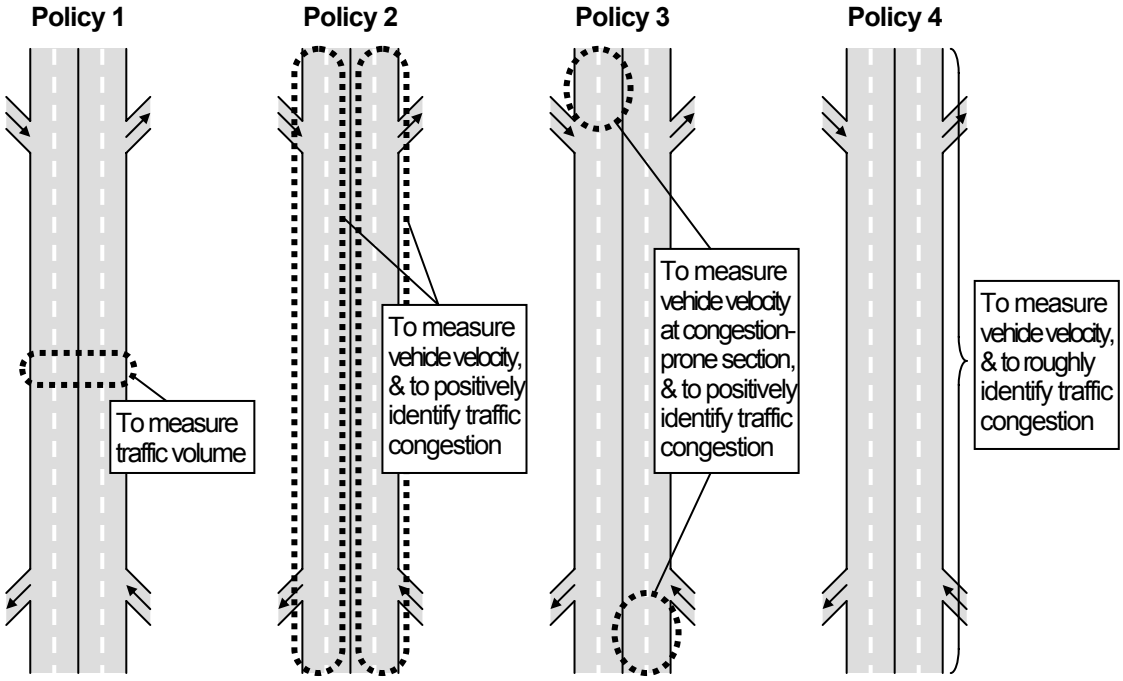
- Measurement of traffic volume
- Measurement of vehicle velocity
- Identification of traffic congestion
- Measurement of values of large vehicles.

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 7.8 Vehicle Detector Installation/Operation Policies



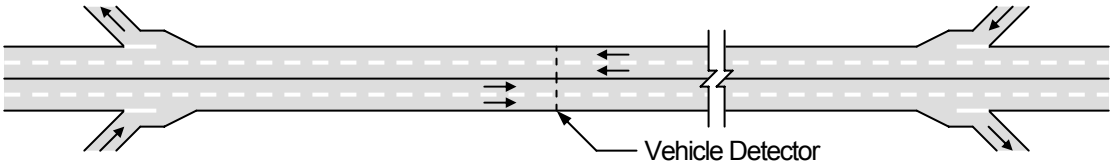
Source: ITS Standards & Operation Plan Study Team

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 7.9 Installation at Midway between a Pair of Interchanges

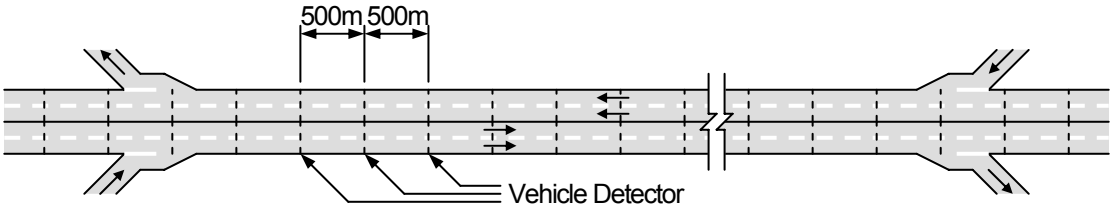


Source: ITS Standards & Operation Plan Study Team

(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 7.10 Installation at a Small Intervals Continuously along the Expressway

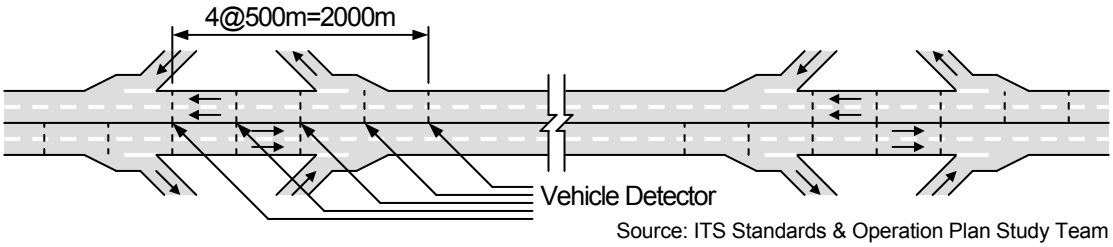


Source: ITS Standards & Operation Plan Study Team

(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 7.11 Installation at Congestion-prone Sections on the Expressway

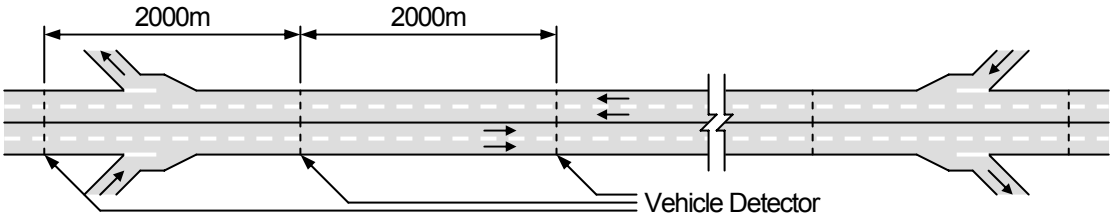


Source: ITS Standards & Operation Plan Study Team

(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 7.12 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			Depending on Traffic Volume	Not suitable	Recommended	Depending on Traffic Volume

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

Source: ITS Standards & Operation Plan Study Team

Policy 1 achieves only measurement of traffic volume and can be applicable to the road sections with small traffic volume but that is not sufficient for providing services to road users in the other road sections. As shown in the table above, Policy 2 requires very high cost of system implementation and is not suitable. Policy 4 is still costly and can be applicable only to the road sections with large traffic over the length of them.

Hence, according to this comparison, Policy 3 based on the vehicle detector installation at congestion-prone sections on the expressway is recommended for providing traffic congestion information.

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 bridge sections 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			
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	Bridge section	None	None
Implementation Cost	Low	Average	High
Applicability to Traffic Changing Lanes	Incapable	Incapable	Capable
Secondary Usage for Visual Judgment	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	Applicable	Applicable	Applicable

Source: ITS Standards & Operation Plan Study Team

7.3 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) is recommended and Felica is comparable for the use of ETC and Touch&Go in Vietnam.

Table 7.6 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)
Competitive Suppliers		A few	Many	Many	A few
Production Cost		Low	Low	Middle	High
Grading		Recommended	Available	Available	Comparable

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

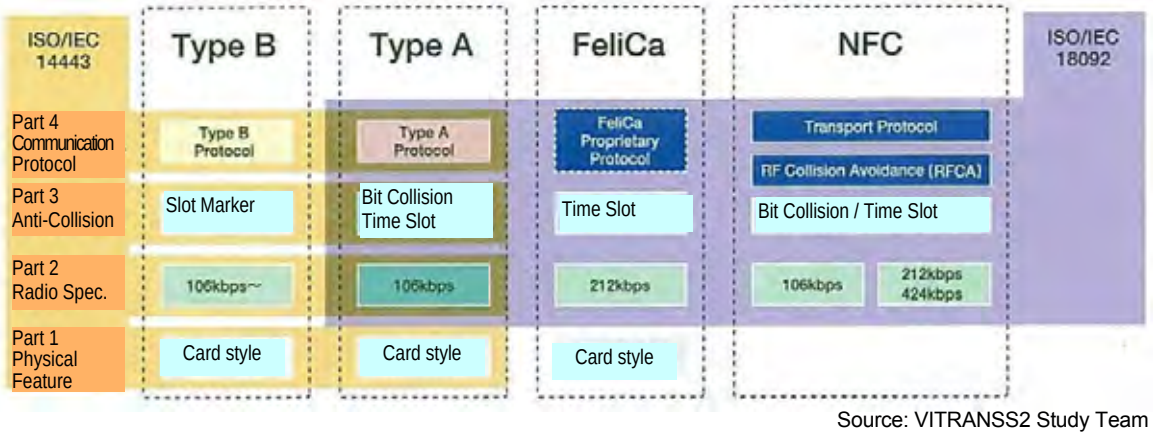
International standards for contact-less IC-card are ISO/IEC1443 and ISO/IEC18092 issued in 2003.

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 7.13 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 7.7 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.

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

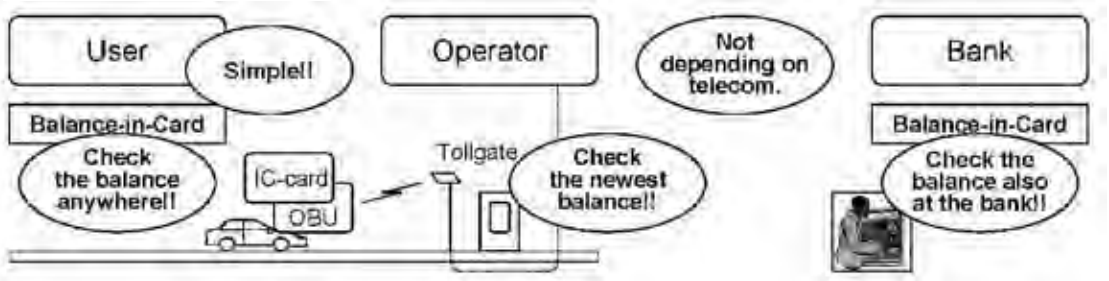
"TYPE-A" has more advantages than the others. In general, "TYPE-A (especially Mifare Classic)" can be supplied at the lowest cost, and "TYPE-B" can be supplied at lower cost than "Felica".

7.4 Checking of Prepaid Balance

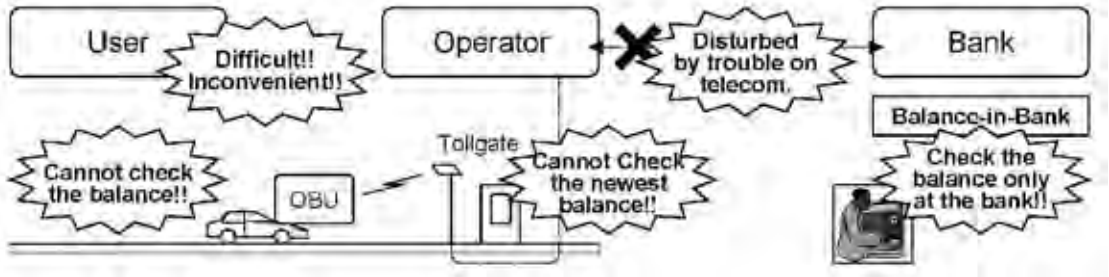
Prepaid balance can be managed in two different ways: prepaid-balance-in-card and prepaid-balance-in-bank. Prepaid-balance-in-card allows users to check the prepaid balance anywhere, on the other hand, prepaid-balance-in-bank limits checking the prepaid balance only to a bank. For this reason, prepaid-balance-in-card is recommended for ETC and Touch&go.

Figure 7.14 Two Ways for Checking Prepaid Balance

Prepaid-Balance-in-Card



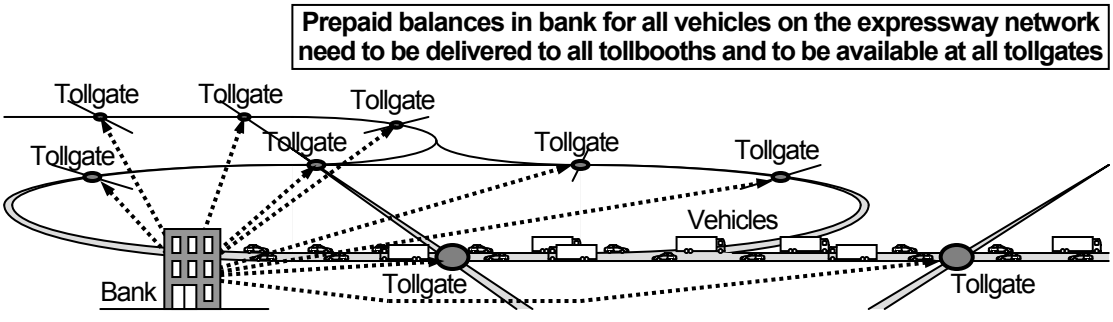
Prepaid-Balance-in-Bank



Source: VITRANSS2 Study Team

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 delivered from the bank to all tollgates and to be available at all tollbooths. However, in near future, the data volume to be delivered will become very large corresponding to the increasing number of the vehicles on the expressway network; hence, the delivery 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.

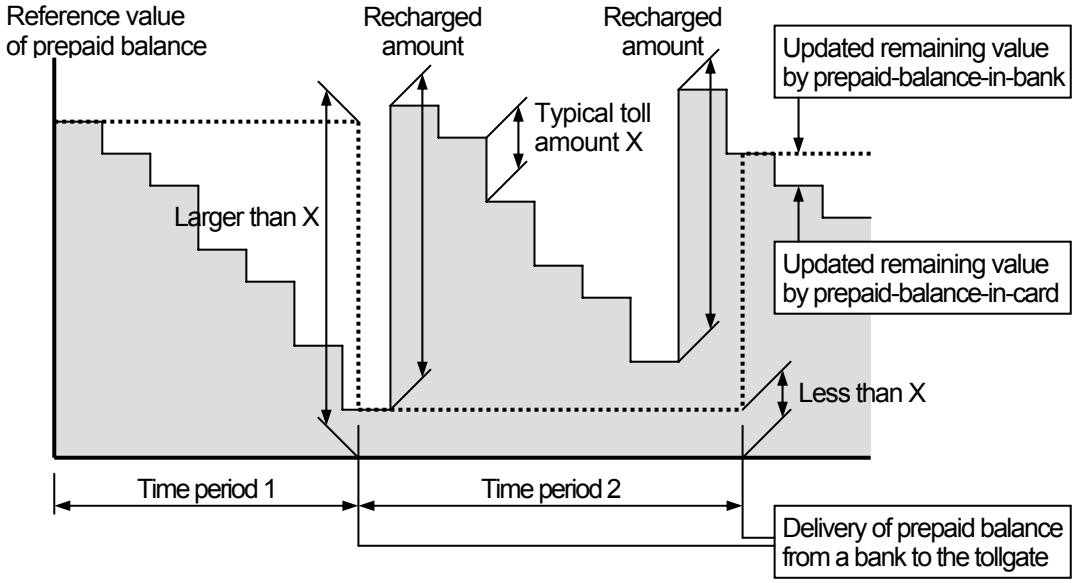
Figure 7.15 Delivery of Prepaid Balances from a Bank to All Tollbooths of All Tollgates



Source: ITS Standards & Operation Plan Study Team

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 delivered from bank to the tollgate, therefore 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 as shown below.

Figure 7.16 Comparison of Update Intervals of Prepaid Balance by Two Methods

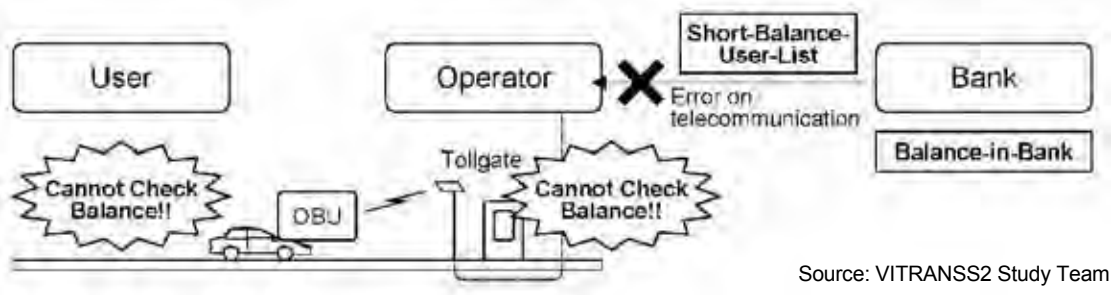


Source: ITS Standards & Operation Plan Study Team

Accordingly, low-quality telecommunications interfered with the data exchange in the trials in Malaysia and caused the following trouble:

- 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 7.17 Problem of Prepaid-balance-in-bank on Low-quality Telecommunication



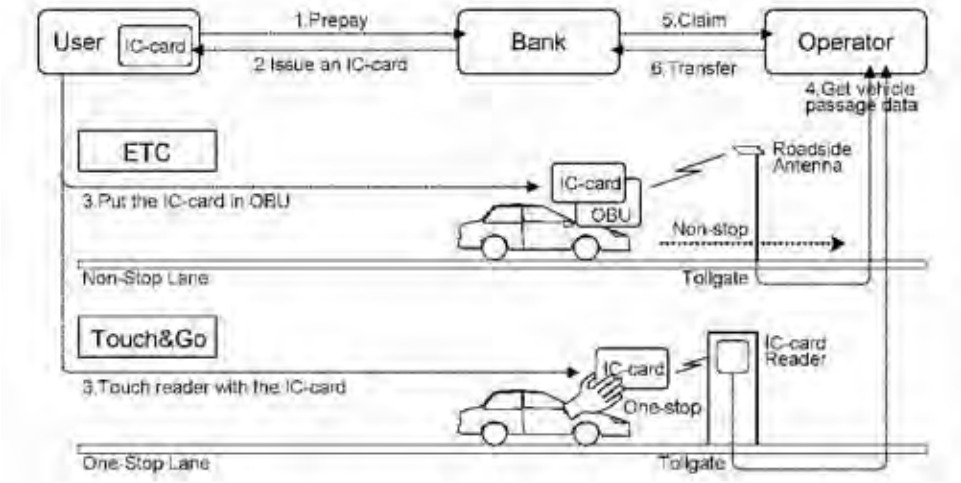
Source: VITRANSS2 Study Team

7.5 Tollgate Lane Arrangement

1) ETC 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 7.18 ETC Combined Use with Touch&Go

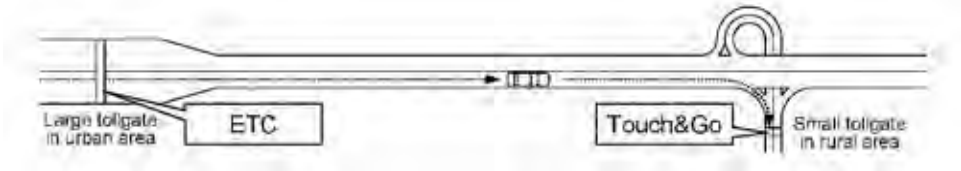


Source: VITRANSS2 Study Team

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.

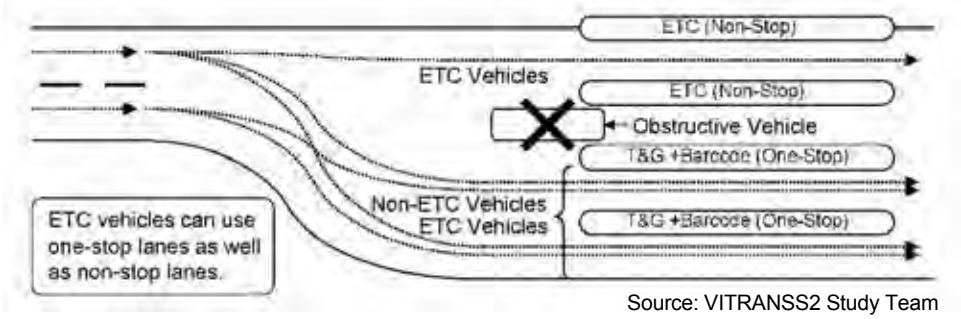
Figure 7.19 Combined Use of ETC and Touch&Go



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 7.20 Flexible Tollgate Lane Operation



Source: VITRANSS2 Study Team

2) ETC Lane Operation at Tollgate

Two types of ETC lane operation can be applied to the tollgates: ETC exclusive operation and ETC/manual mixed operation. The ETC exclusive operation is recommended based on the comparison table below mainly for large tollgates in urban areas.

Table 7.8 Comparison on Methods of ETC Lane Operation

	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 tollgate, - 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

7.6 Road-to-vehicle Communication Method for ETC

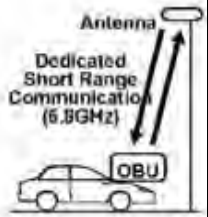
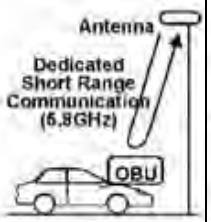
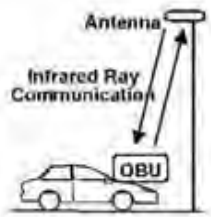
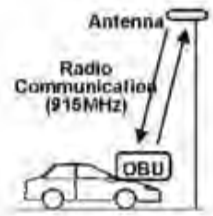
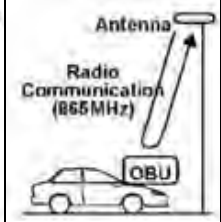
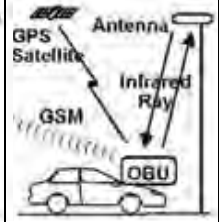
The advantage/disadvantages of the following six alternative road-to-vehicle communication methods for ETC are compared in the table on the next page.

- 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 both Active-DSRC, which has the largest number of advantages, and Passive-DSRC are competitive mainly from the view points of shared use and equipment costs. RF-Tag (Passive) needs to be followed up. The most appropriate road-to-vehicle communication for ETC will be selected from among these three methods through competitive experimental tests.

Table 7.9 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/IR
Outline							
Actual Use in Toll Collection	Many experiences	Many experiences	Many experiences	Many experiences	Many experiences	Few	None
Shared Use among Different Operators	Many experiences	Many experiences	A few experiences	Not shared	Not shared	Not shared	Not shared
Shared Suppliers in Actual Road Operation	12 (in Japan)	3 (in France)	7 (in Korea)	Not shared	Not shared	Not shared	Not shared
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 Communication	High (99.9999%)	No regulation	Lowering by Sunlight	Lowering by Sunlight	Relatively low	Relatively low	No regulation
Vehicle Deceleration	Not necessary	Not necessary	Not necessary	Necessary	Not necessary	Not necessary	Not necessary
2-piece Type OBU	Many experiences	For trial	Many experiences	Many experiences	No experience	No experience	No experience
Prepaid-Balance-in-Card	Capable	For trial	Capable	Capable	Not capable	Not capable	Not capable
Combined Use of ETC and Touch&Go	Capable	For trial	Capable	Capable	Capable	Capable	Not capable
Applicability to ERP	Applicable	Applicable	Not applicable	Not applicable	Applicable	Applicable	Applicable
OBU Cost	Average	Low (1-piece type)	Average	Average	Low (1-piece type)	Very low (1-piece type)	High (1-piece type)
Roadside Equipment Cost	Low	Average	High	Average	Low	Low	Very low
International Standard	Established	Established	Established	Patented	Established	Established	None
Grading (The Number of Advantages)	Competitive (12)	Competitive (8)	Not suitable (7)	Not suitable (4)	Not suitable (7)	To be followed up (7)	Not suitable (3)

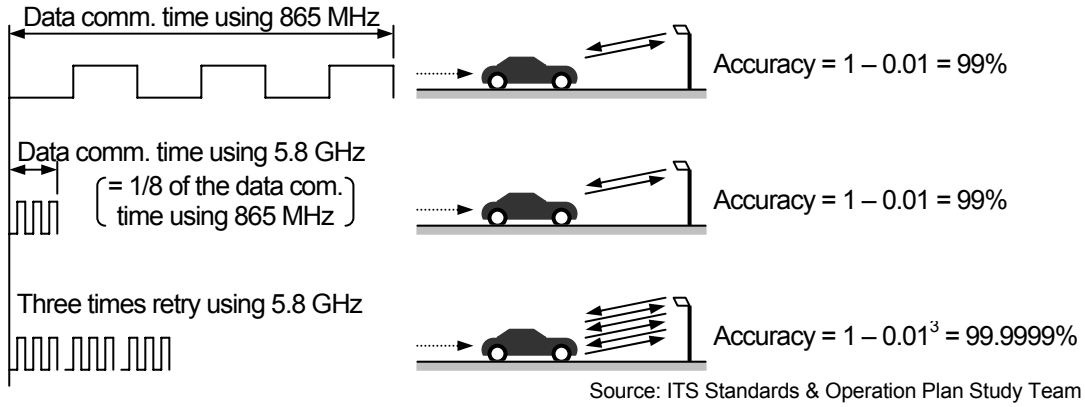
Note: ERP: ERP by multi-lane free-flow, OBU: OBU includes Tag, Underlined words: Fatal disadvantage

Source: ITS Standards & Operation Plan Study Team

Accuracy of Communication

Generally, accuracy of radio communication is around 99% in either cases using 5.8 GHz for DSRC or using 865MHz 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 radio frequency band, and this three times retry of message exchange achieves an accuracy of 99.9999% as shown in the figure below.

Figure 7.21 Comparison of Accuracy of Data Communication using Radio Frequency

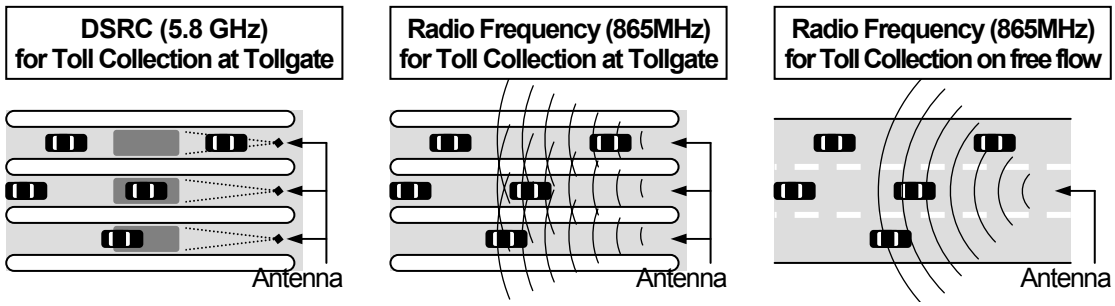


Source: ITS Standards & Operation Plan Study Team

The accuracy of ETC based on Active-DSRC is defined as 99.9999% in general specification of the expressways in Japan as shown in the figure above; however, there is no specification on accuracy of ETC using the other types of road-to-vehicle communication.

Additional features on accuracies of DSRC (5.8GHz) and Radio Frequency (865 MHz), and the needed deterrent effect by penalty system for unlawful passage are shown the figure below.

Figure 7.22 Comparison between DSRC (5.8GHz) and Radio Frequency (865 MHz)



- High accuracy of road-to-vehicle communication
- Ease in identifying the vehicle of 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 the vehicle of 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 the vehicle of 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

Vehicle Deceleration

The capacity of each type of the road-to-vehicle communication is shown below. The methods with sufficient capacity in comparison with 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) by multi-lane free-flow as well.

2-piece Type OBU

2 piece type OBU is adopted for the toll collection systems in many Asian countries, such as Active-DSRC in Japan, DSRC/IR in Korea and IR in Malaysia and Vietnam.

Roadside Equipment

Roadside antenna for Active-DSRC requires lower cost than that for Passive-DSRC. One of the reasons for that is that its transmitting power is not used for switching OBU.

Sharing of Toll System among Different Suppliers in Actual Road Operation

- **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 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.
- **RF-Tag (Active) 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.

  On the other hand, RF-Tag (Passive, 865 MHz) technology developed and internationally

standardized in Europe for the most part has little track record on toll collection. There are track records of application of RF-Tag (Passive and Active) technology in USA as shown in the table below.

Table 7.10 Track Records of RF-Tag for Toll Collection in USA

Installed System	Installed Location	Supplier
RF-Tag (Passive)		
eGo Tags	Georgia	TransCore
RF-Tag (Active)		
EZ-Pass	New York, New Jersey, Pennsylvania, Delaware, Maryland, Maine	MarkIV
Fast Lane	Massachusetts	MarkIV
I-Pass	Illinois	TransCore
Smart Tag	Virginia	TransCore
Sun Pass	Florida	TransCore
K-Tag	Kansas	TransCore
PIKEPASS	Oklahoma	TransCore
EZ TAG	Texas	TransCore
PAL PASS	South Carolina	SIRIT
FASTRAK	California	SIRIT

Source: ITS Standards & Operation Plan Study Team

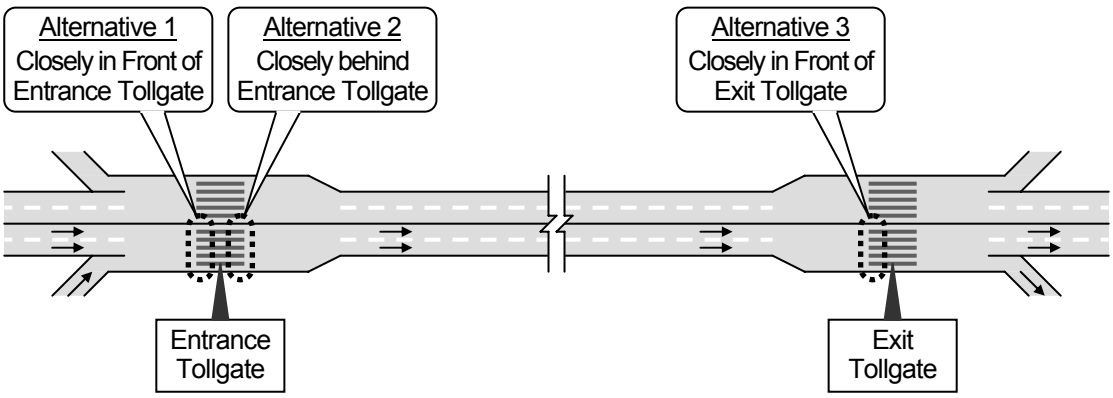
- **GPS/GSM/IR in Germany:** In the case of GPS/GSM/IR in Germany, vehicle passage at the tollgate is tracked by using GPS and the roadside antenna of IR. OBUs and the roadside antennas are manufactured by two suppliers; however, there is no sharing of OBU among the different suppliers.

7.7 Axle Load Scale Arrangement

Axle load scale is installed for the purpose of overloading regulation; however, the scale can be installed in the following three locations.

- Location alternative 1: Closely in front of entrance tollgates
- Location alternative 2: Closely behind entrance tollgates
- Location alternative 3: Closely in front of exit tollgates.

Figure 7.23 Location Alternatives of Axle Load Scale



Source: ITS Standards & Operation Plan Study Team

The location closely in front of exit tollgates is recommended for axle load scale comparing advantages and disadvantages of the three alternatives as summarized in the table below. However, a heavy penalty is to be imposed on overloaded trucks to achieve a large deterrent effect.

Table 7.11 Comparison on Location Alternatives of Axle Load Scales

	Location Alternative 1	Location Alternative 2	Location Alternative 3
Securing Conformance to Jurisdiction of Road Operator	Difficult	Capable	Capable
Securing Measuring Accuracy by Controlling Vehicle Trail	Capable (within Tollgate Lane)	Capable (within Tollgate Lane)	Capable (within Tollgate Lane)
Necessity of Large Land Acquisition for Rejecting Overloaded Vehicles	Necessary	Necessary	Not Necessary
Installation into Every Tollgate for Preventing Avoidance/Unfairness	Difficult	Difficult	Possible
Effects of Rejecting Overloaded Vehicles from the Expressway	Average	Average	High
Grading	Not Suitable	Comparable	Recommended

Source: ITS Standards & Operation Plan Study Team

7.8 Integration of Roadside Equipment Control

1) Roadside Equipment for Traffic Information/Control

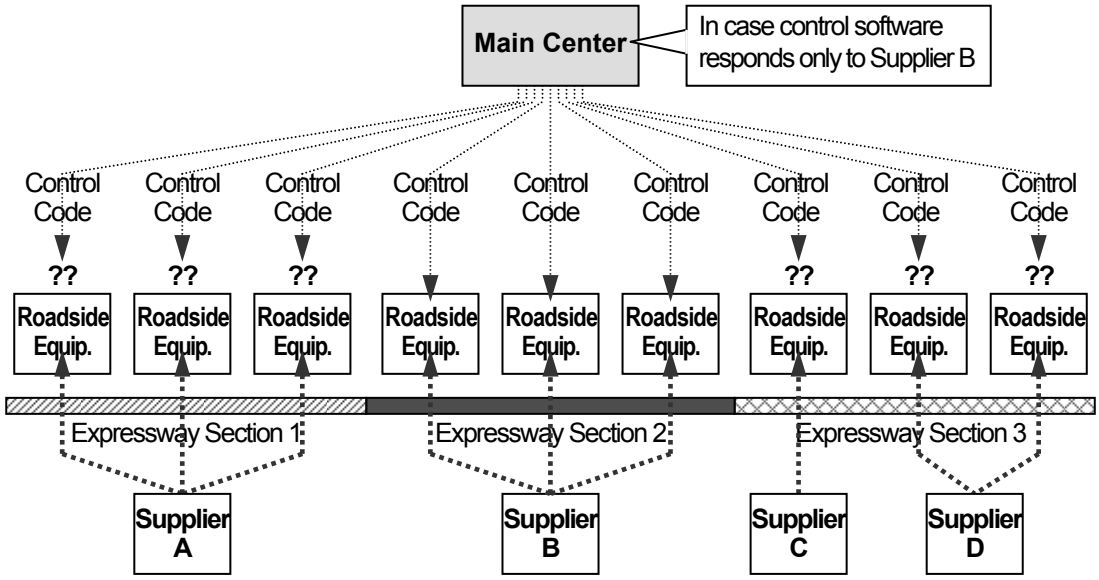
(1) Necessity of Integration of Roadside Equipment Control

As mentioned in Chapter 6, routine monitoring and control of traffic is to be conducted by controlling pieces of roadside equipment under the main center. Actual roadside equipment control is performed through control codes transmitted from the 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 7.24 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.

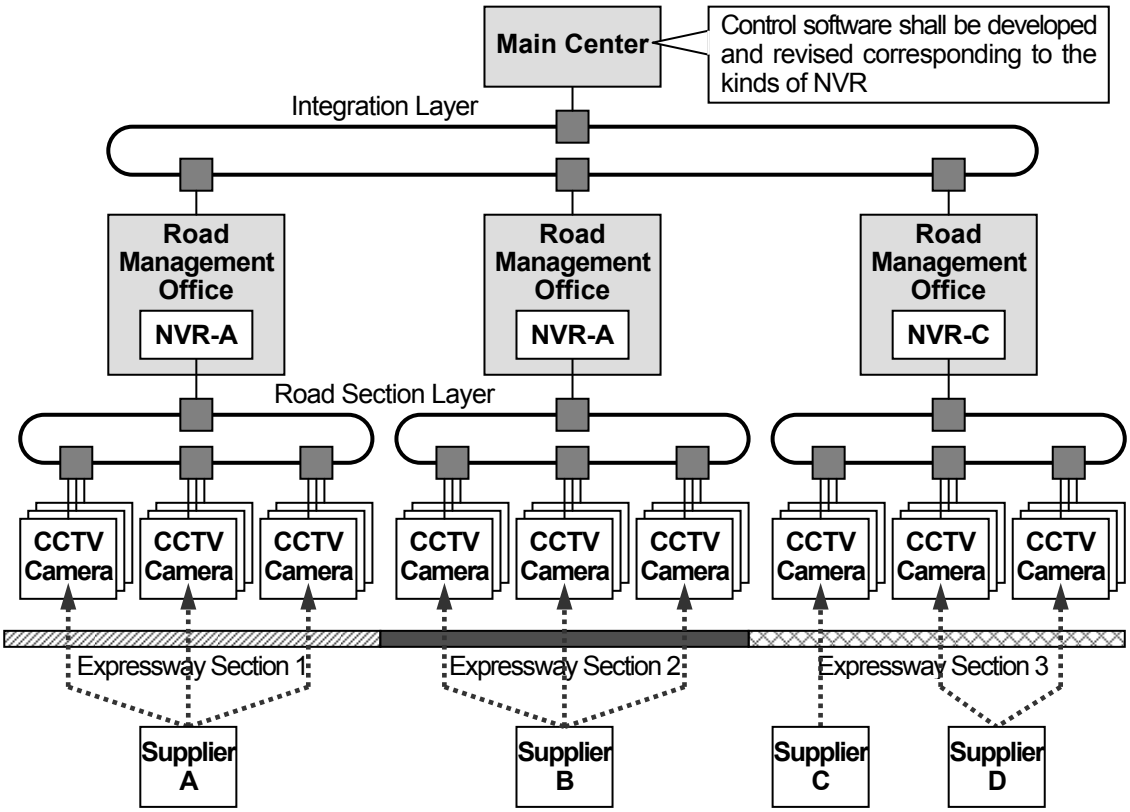
Integration measures for controlling roadside equipment including CCTV camera and VMS are discussed in the following.

(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 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 Main Center needs to be revised responding to the rise in the number of NVR.

Figure 7.25 Integration of CCTV Camera Control



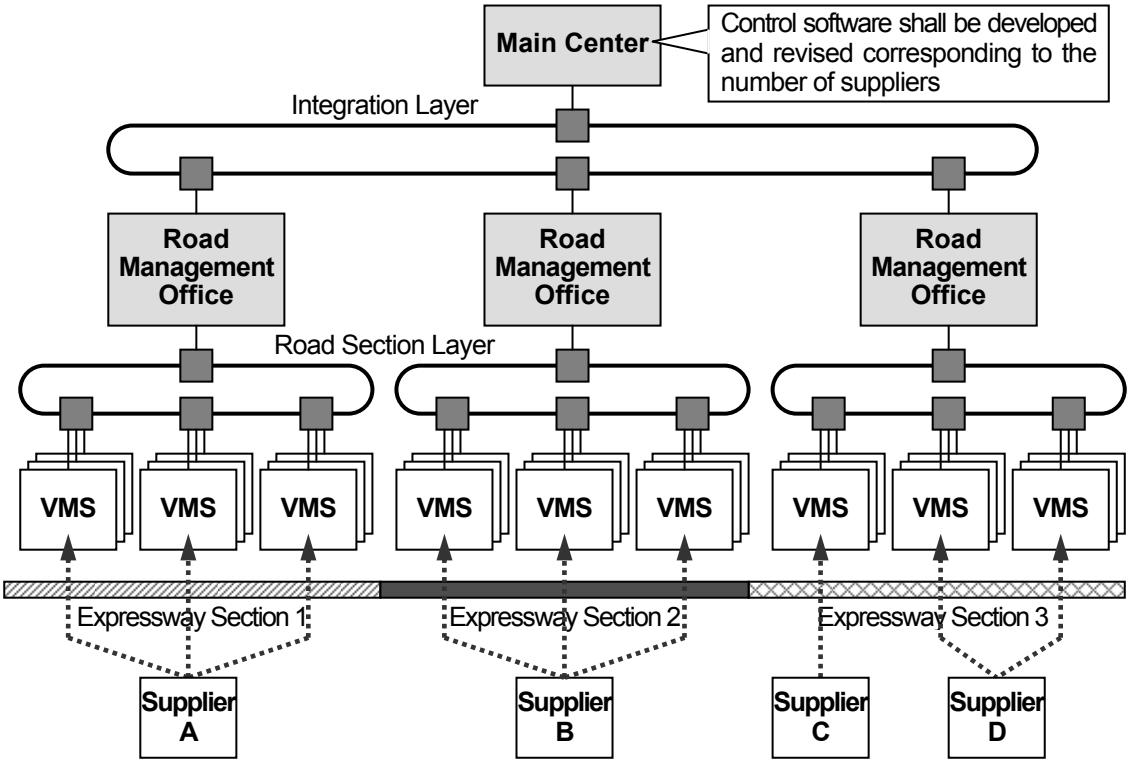
Note: NVR can be installed at communication nodes or in road management offices.

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 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 Main Center needs to be revised responding to new entrants of suppliers.

Figure 7.26 Integration of VMS Control

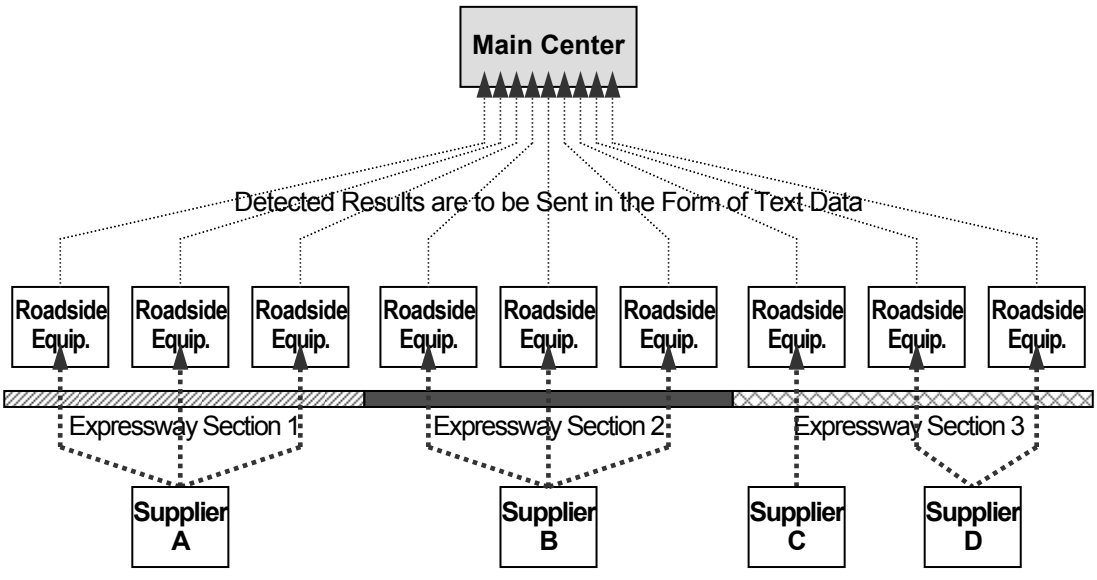


Source: ITS Standards & Operation Plan Study Team

(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 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 7.27 Transmission of Detected Results by Detectors/Sensors

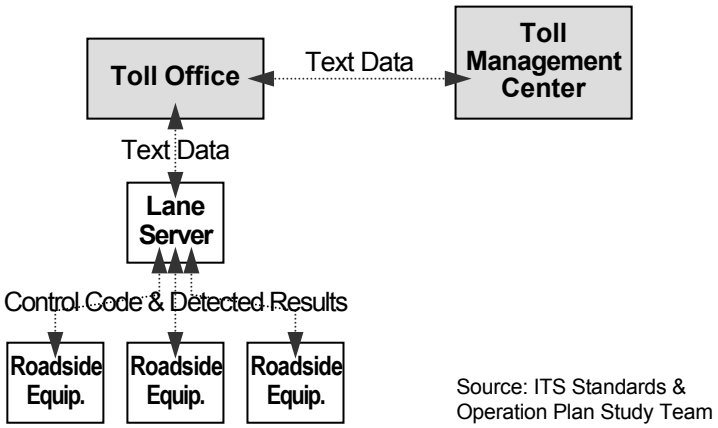


Source: ITS Standards & Operation Plan Study Team

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 7.28 Roadside Equipment Control and Transmission of Detected Results for Automated Toll Collection



Source: ITS Standards & Operation Plan Study Team

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.

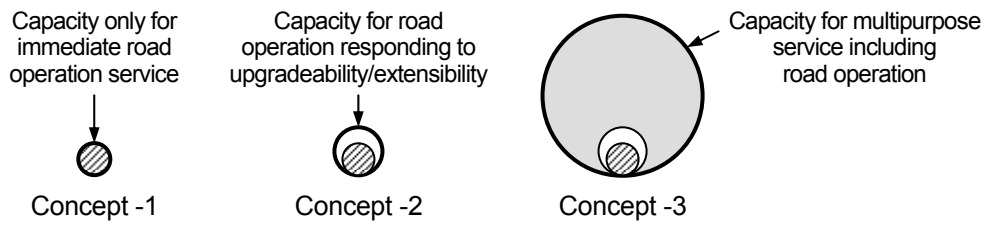
7.9 Transmission Method

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 upgradeability/extensibility
- Concept -3: Capacity for multi-purpose service including road operation.

Figure 7.29 Concepts of Target Capacity of Communication Network for ITS



Source: VITRANSS2 Study Team

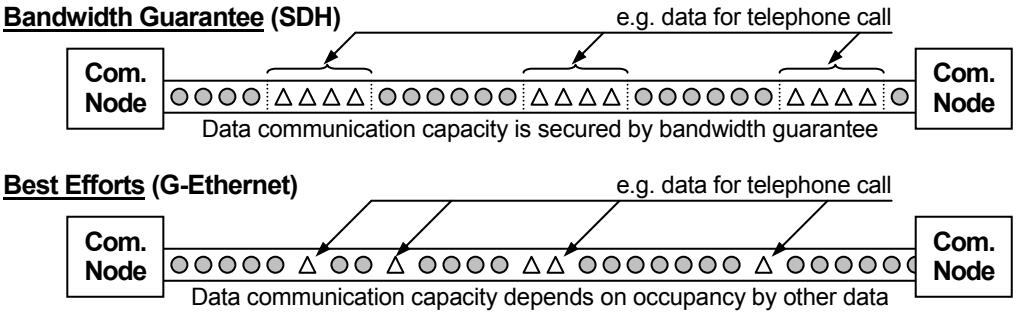
Generally, the target capacities of Concept-2 and Concept-3 are suitable for expressway operation using ITS. IP over SDH and IP over G-Ethernet are to be recommended as suitable transmission methods for realizing Concept-2.

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 guaranteed to create a stable link between the initiating and receiving parties. SDH can provide this function and is suitable for the integration layer of the hierarchical communication network for ITS.

Figure 7.30 Concepts of Bandwidth Guarantee and Best Efforts



Source: ITS Standards & Operation Plan Study Team

Table 7.12 Comparison of Transmission Methods

	IP over ATM	IP over G-Ethernet	IP over SDH	IP over ATM/DWDM	IP over TDM/DWDM	IP ovrer SDH/DWDM
Communication Node	ATM	Media Converter	SDH	DWDM	DWDM	DWDM
Interface of Ethernet	Available	Available	Available	Available	Available	Available
Maximum Capacity	0.6 Gbps	40 Gbps	40 Gbps	1 Tbps	1 Tbps	1 Tbps
Capacity for ** Additional Service	Not Sufficient	Not Sufficient	Not Sufficient	Sufficient	Sufficient	Sufficient
Bandwidth Guarantee	Capable	Not Capable	Capable	Capable	Capable	Capable
Network Management	Capable	Not Capable	Capable	Capable	Capable	Capable
Compatibility	Low	High	High	High	Low	High
Implementation Cost	Low	Average	Average	High	High	High
Track Records in Telecom Service	--	--	--	--	Adopted by VNPT	Adopted by Viettel
Grading	Not Suitable	Recommended	Recommended	Not Suitable	Comparable	Comparable

Note: **: Leasing of lines is one of the simple additional services using the remaining capacity of communication network.

Source: ITS Standards & Operation Plan Study Team

7.10 Selected Key Policies on System

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) CCTV Camera Arrangement
→At 2km intervals continuously along the expressway (→See Table 7.2 and Figure 7.4)

(2) Vehicle Detector Arrangement
→Midway between a pair of interchanges, at congestion-prone sections or at 2km intervals responding to traffic volumes (→See Table 7.4, Figures 7.10, 7.11 and 7.12)

(3) Contact-less IC-Card Type
→TYPE-A and Felica as the candidates for conclusive selection through field trial (→See Table 7.6)

(4) Checking of Prepaid Balance →By prepaid-balance-in-card (→See Section 7.4)

(5) Tollgate Lane Arrangement
→For combined use of ETC with Touch&Go/Manual (→See Section 7.5)

(6) Road-to-Vehicle Communication Method for ETC
→Active-DSRC and Passive-DSRC as the candidates for conclusive selection through field trial, and RF-Tag to be followed up (→See Table 7.9)

(7) Axle Load Scale Arrangement
→ Closely in front of exit tollgates (→See Table 7.11 and Figure 7.23)

(8) Integration of Roadside Equipment Control
→Combination of NVR introduction and technological disclosure obligation to suppliers (→See Section 7.8)

(9) Transmission Method
→Combination of IP over SDH and IP over G-Ethernet (→See Table 7.12)

It is necessary, additionally, to finalize the selected results and verify them in a pilot project as the first stage of system implementation to be compliant with the Draft ITS Standards.

8. Draft ITS Standards

In the Study, the following documents are developed as the Draft ITS Standards.

- Draft Design Standards (3 volumes corresponding to the priority ITS user services)
- Draft General Specifications (21 volumes corresponding to the functional packages)
- Draft Message/Data Standards
- Draft Communication System Plan

8.1 Draft Design Standards

The Draft Design Standards are organized in 3 volumes corresponding to the priority ITS user services as follows:

(1) Traffic Information/Control
(2) Automated Toll Collection
(3) Heavy Truck Control

1) Draft Design Standards (1): Traffic Information/Control

This volume of the Draft Design Standards defines basic concepts, general architecture and actualization methods as a unified form for designing the system of traffic information/control. The outline of the service to be provided by traffic information/control is described below.

This service provides accurate surveillance of traffic conditions on expressways and adjacent arterial roads. This service assists prompt action of the road operator and emergency vehicles by notifying occurrences of traffic accidents, broken-down vehicles and left 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 on crowdedness and estimated travel-time. This service makes it possible to measure actual traffic volume continuously for developing road improvement plans.

This volume of the Draft Design Standards includes the following functional packages:

(1) Telephone Exchange
(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.

In the Draft Design Standards, the basic concepts and actualization methods of the system are defined according to the following basic contents.

1. General Outlines
2. Scope
3. Relevant Regulations and Standards
4. Definitions of Terms
5. Implementation Packages
6. General System Architecture
7. Required Functional Packages
8. Respective Functional Package
8.1 Outlines
8.2 System Architecture
8.3 Functional Design
8.4 Message Exchange
8.5 Transmission Design
9. Location of Functional Packages
10. Preparation for Stepwise Implementation

The basic contents of each functional package in this volume of the Draft Design Standards (Version 1.0: Final Version of the Study Results) are defined as shown in the table below.

Table 8.1 Basic Contents Defined for Functional Package in the Draft Design Standards (1)

(Version 1.0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Outlines	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
System Architecture	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Functional Design	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Message Exchange	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Transmission design	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

Source: ITS Standards & Operation Plan Study Team

2) Draft Design Standards (2): Automated Toll Collection

This volume of the Draft Design Standards defines basic concepts, general architecture and actualization methods as a unified form for designing the system of automated toll collection. The outline of the service to be provided by non-stop toll collection is described below.

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 of vehicles at interchanges. This service reduces the number of tollbooths and solves the problem of land acquisition, especially for tollgates in suburban areas where traffic congestion will become an issue in the near future. This service allows simple vehicle inspection at border crossings, and provides the road/vehicle operators with the time of vehicle passage at 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 the different road operators.

This volume of the Draft Design Standards includes the following functional packages:

(1) Lane Monitoring
(2) Vehicle Identification

(3) Lane Control
(4) Road-to-Vehicle Communication
(5) IC-card Recording
(6) Toll Management
(7) OBU Management.

The basic contents of this volume are the same as the Draft Design Standards (1), in that of each functional package in this volume of the Draft Design Standards (Version 1.0: Final Version of the Study Results) are defined as shown in the table below.

Table 8.2 Basic Contents Defined for Functional Package in the Draft Design Standards (2)

(Version 1.0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outlines	XX	XX	XX	XX	XX	XX	XX
System Architecture	XX	XX	XX	XX	XX	XX	XX
Functional Design	XX	XX	XX	XX	XX	XX	XX
Message Exchange	XX	XX	XX	XX	XX	XX	XX
Transmission design	XX	XX	XX	XX	XX	XX	XX

Source: VITRANSS2 Study Team

3) Draft Design Standards (3): Heavy Truck Control

This volume of the Draft Design Standards defines basic concepts, general architecture and actualization methods as a unified form for designing the system of heavy truck control. The outline of the service to be provided by heavy truck control is described below.

This service eliminates overloading of heavy trucks by automatic execution of vehicle weighing at interchanges. It reduces damage to the road structure and extends its durable lifetime. This service reduces congestion caused by heavy trucks and allows freight transport 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 taking appropriate vehicle operation by keeping track of trucks on the expressway network.

This volume of the Draft Design Standards includes the following functional packages:

(1) Axle Load Measurement
(2) Overloading Management.

The basic contents of this volume are the same as the Draft Design Standards (1), in that of each functional package in this volume of the Draft Design Standards (Version 1.0: Final Version of the Study Results) are defined as shown in the table below.

Table 8.3 Basic Contents Defined for Functional Package in the Draft Design Standards (3)

(Version 1.0)	(1)	(2)
Outlines	XX	XX
System Architecture	XX	XX
Functional Design	XX	XX
Message Exchange	XX	XX
Transmission design	XX	XX

Source: VITRANSS2 Study Team

8.2 Draft General Specifications

The Draft General Specifications defines required processing functions, performance, interfaces and installation of equipment in order to establish compatibility of equipment components, which are organized in 21 volumes corresponding to the functional packages below.

(1) Telephone Exchange
(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) Lane Monitoring
(13) Vehicle Identification
(14) Lane Control
(15) Road-to-Vehicle Communication
(16) IC-Card Recording
(17) Toll Management
(18) OBU Management
(19) Axle Load Measurement
(20) Overloading Management
(21) Center/Roadside Communication (Including Ducts)

Each volume of the Draft General Specifications consists of the following basic contents.

1. General Outlines
2. Scope
3. Relevant Regulations and Standards
4. Definitions of Terms
5. Requirements
6. System Architecture
7. Particular Equipment Components
7.1 Functions
7.2 Structure
7.3 Performance (including Reliability)
7.4 Human Machine Interfaces
7.5 Communication Interface
7.6 Installation
8. Ambient Conditions
9. Power Supply
10. Maintainability (including Spares/ Consumables)
11. Quality Control
12. Testing/Inspection

The basic contents defined in each volume are shown in the following table.

Table 8.4 Basic Contents Defined for Functional Package in the Draft General Specifications

Basic Contents \ Functional Package	(1) Telephone Exchange	(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) Lane Monitoring	(13) Vehicle Identification	(14) Lane Control	(15) Road-to-Vehicle Communication	(16) IC-Card Recording	(17) Toll Management	(18) OBU Management	(19) Axle Load Measurement	(20) Overloading Management	(21) Center/Roadside Communication
1. General Outlines	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
2. Scope	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
3. Relevant Regulations and Standards	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
4. Definitions of Terms	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
5. Requirements	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
6. System Architecture	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7. Particular Equipment Components	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7.1 Functions	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7.2 Structure	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7.3 Performance (including Reliability)	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7.4 Human Machine Interfaces	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7.5 Communication Interface	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
7.6 Installation	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
8. Ambient Conditions	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
9. Power Supply	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
10. Maintainability (including Spares/Consumables)	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
11. Quality Control	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
12. Testing/Inspection	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Version	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Location of Equipment: Main Center	XX	XX			XX	XX	XX	XX	XX		XX									XX	XX
Location of Equipment: Road Management Office	XX	XX					XX			XX											XX
Location of Equipment: Toll Management Center																	XX				XX
Location of Equipment: Toll Office	XX											XX					XX				XX
Location of Equipment: Toll Booth												XX	XX	XX							XX
Location of Equipment: OBU Management Center																		XX			
Location of Equipment: OBU Issue Office																		XX			
Location of Equipment: Roadside	XX	XX	XX	XX		XX			XX	XX		XX	XX	XX	XX	XX			XX		XX
Location of Equipment: In-Vehicle										XX					XX			XX			
Location of Equipment: Mobile										XX						XX					

Source: ITS Standards & Operation Plan Study Team

The functional packages corresponding to 21 volumes of The Draft General Specifications are outlined below.

1) Telephone Exchange

This functional package allows road users to make an emergency call and request help to the Main Centers and road management offices at the occurrence of incident by telephones installed at roadsides, rest areas and tunnel sections. It also allows road operators to send information by administrative telephones installed at toll offices and send instant directives to the units concerned for clearing incidents and enforcing traffic regulations.

2) CCTV Monitoring

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

3) Event Detection (by Image)

This functional package allows road operators to automatically recognize occurrence of traffic accidents, broken-down vehicles and left obstacles on the expressways and to send notifications to the Main Centers and road management offices by analyzing 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 road operators to measure actual traffic volume, heavy vehicle ratio and vehicle velocity on the expressways for developing road operation/improvement plans by using vehicle detectors installed at important points on the through lanes and at the tollgates.

5) Traffic Analysis

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

6) Weather Monitoring

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

7) Traffic Event Data Management

This functional package allows road operators to conduct traffic control, regulation and information dissemination on the expressway, in a unified/integrated form, by categorizing

the results (acquired through emergency telephones, mobile radio communication, event detection, traffic analysis and weather monitoring) and by organizing them as the data of traffic events specified by the place/time of occurrence and the priority.

8) Traffic Supervision

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

9) VMS Indication

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

10) Mobile Radio Communication

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

11) Traffic Information

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

12) Lane Monitoring

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

13) Vehicle Identification

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

14) Lane Control

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

15) Road-to-Vehicle Communication

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

16) IC-Card Recording

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

17) Toll Management

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

18) 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.

19) Axle Load Measurement

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

20) Overloading Management

This functional package allows road operators to store/retrieve data of heavy trucks overloaded on the expressways by using computers and software installed in the road management office.

21) Center/Roadside Communication (Including Ducts)

This functional package allows road operators to exchange data for ITS among the main centers, the road management offices and pieces of roadside equipment by using the backbone network among the centers. The backbone network consists of fibre optic cables installed in the shoulder along the expressways and communication nodes, and access network between communication nodes and roadside terminals.

8.3 Draft Message/Data Standards

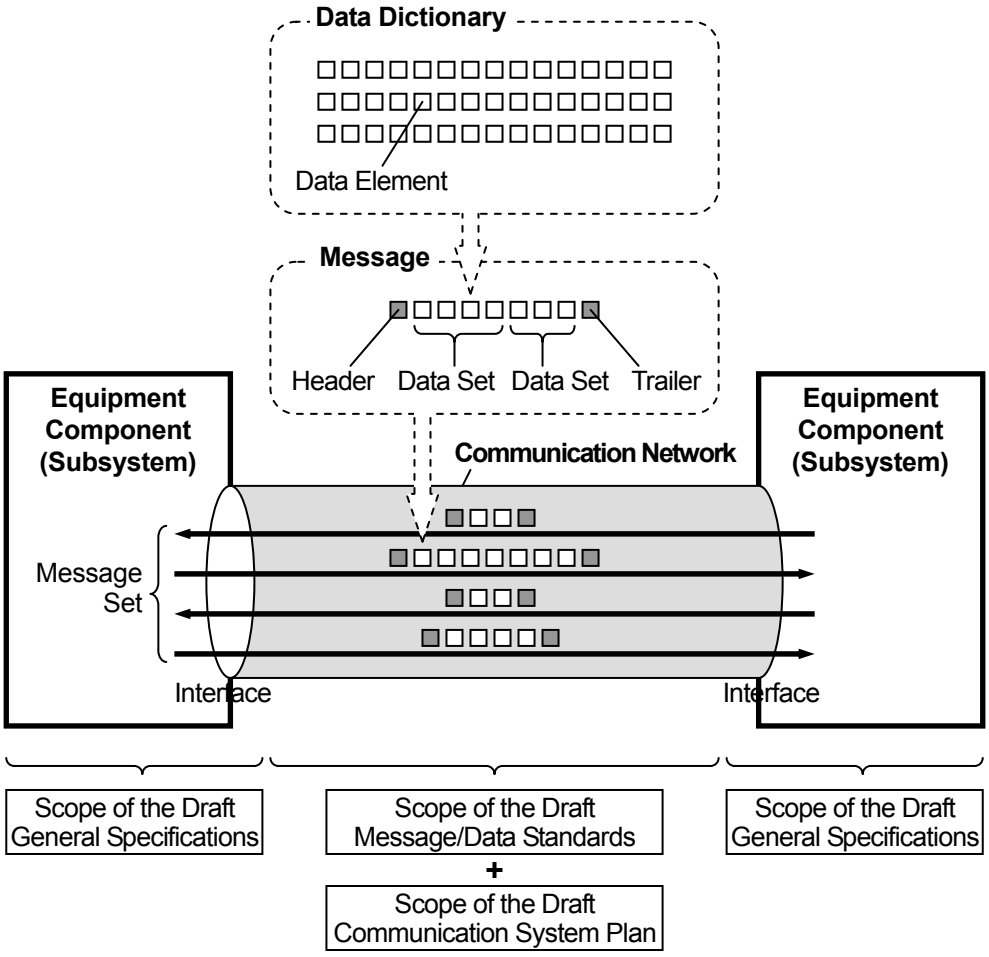
ITS consists of many equipment components, which are illustrated in the diagrams of system architecture in the Draft Design Standards and the Draft General Specifications. Provisions for securing compatibility of the equipment components are defined in the Draft General Specifications.

The equipment components need to be connected with each other by communication network in order to exchange messages and data among them, to realize the system and to provide intended services. For this purpose, inter-operability of message/data and connectability of interfaces need to be secured by preparing the standards for ITS as follows:

- Draft General Specifications → Compatibility of equipment components
- Draft Message/Data Standards → Inter-operability of message/data
- Draft Communication System Plan → Connectability of interfaces.

The Draft Message/Data Standards are developed in the Study in order to define a message list and a data dictionary and establish inter-operability of message and data.

Figure 8.1 Conceptual Illustration of Standards for ITS



Source: ITS Standards & Operation Plan Study Team

1) Message List

A multitude of messages need to be exchanged among equipment components for implementing services of ITS. Major messages are shown in the document by respectively specifying the items below.

- Name of message
- Equipment component on one side of interface
- Equipment component on the other side of interface
- Names of Included data sets
- Names of Major Included data elements.

2) Data Dictionary

Messages include a number of data sets consisting of data elements. Major data elements are shown in the document by respectively specifying the attributes below.

- Name of data element
- Definition
- Presentation category
- Form of representation
- Data type of data element values.

The attributes above are defined as mandatory in ISO/IEC 11179. In ISO/IEC 11179, three additional attributes listed below also are defined as mandatory; however, these are not included in the data dictionary because of insufficient discussion on them.

- Maximum size of data element values
- Minimum size of data element values
- Permissible data element Values

8.4 Draft Communication System Plan

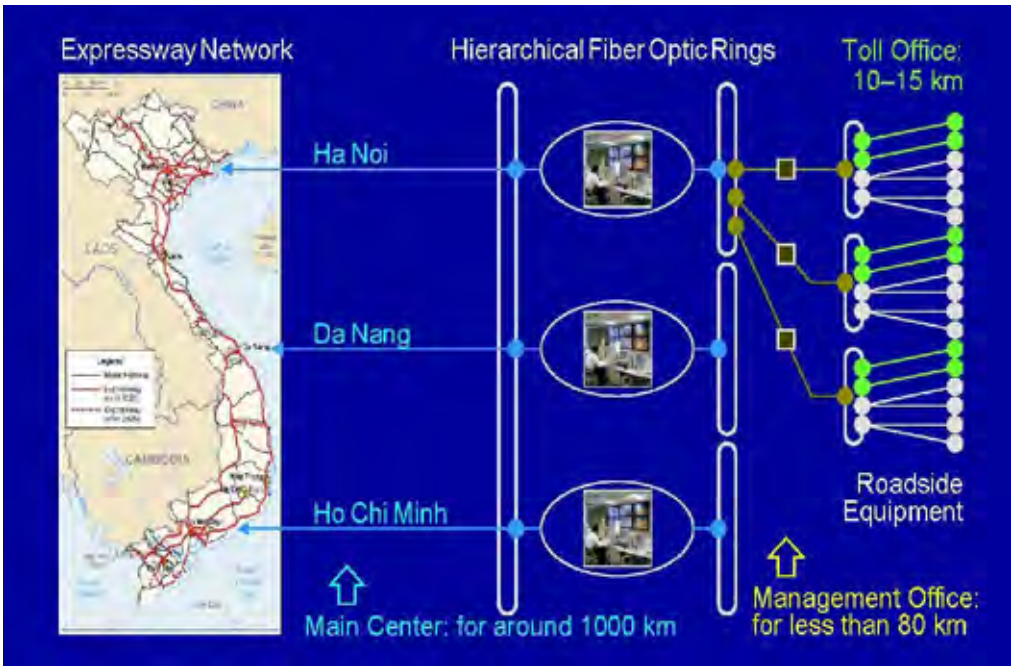
The Draft Communication System Plan includes the General Plan and the Draft Design Standards of communication system in order to establish connectability of communication network.

- General Plan of Communication System
- Draft Design Standards of Communication System.

The General Plan of Communication System shows the discussion results on the items below.

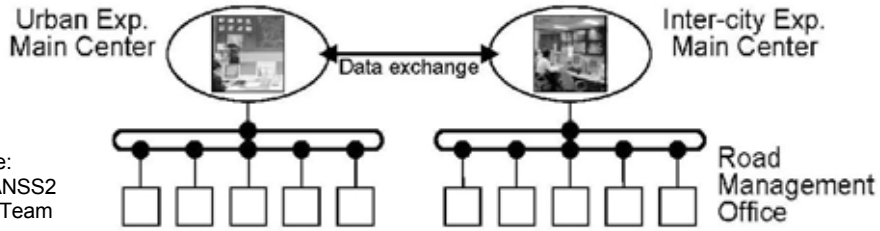
- Locations of Main Centers and network structure
- Communication network management
- Terminal layer for roadside equipment
- Basic procedure of expressway operation
- Integration of roadside equipment control
- Transmission method.

Figure 8.2 Locations of the Main Centers



Source: VITRANSS2 Study Team

Figure 8.3 Cooperation in Metropolitan Areas



Source: VITRANSS2 Study Team

The Design Standards of Communication System specifies required conditions to realize communications among the Main Centers, road management offices, toll offices, other offices and pieces of roadside equipment relative to expressway operation.

9. ITS Pilot Project Plan for Integrating Expressways

In this chapter, the pilot project plan is discussed for the target road networks assumed for the Northern, Central and Southern Areas, and rough costs are estimated for implementation of the pilot projects based on the discussion results shown in Chapter 6, Chapter 7 and the ITS Draft Standards. The conclusions on implementation of the Pilot Project are drawn from the results.

1) Background of the Project

The frameworks for expressway operation using ITS and the key policies on system have been presented and the Draft ITS Standards have been developed in the previous chapters.

Meanwhile, in Vietnam, a number of expressway sections are under design/construction using the funding of different donors including Japanese ODA. In consequence of that, many different policies on ITS are proposed respectively in different sections, and integration of ITS that have been developed independently by section has become a major issue. In addition, implementation of the communication network between the Main Center, which is planned to be in Noi Bai, and sections of the inter-city expressway is also a major issue.

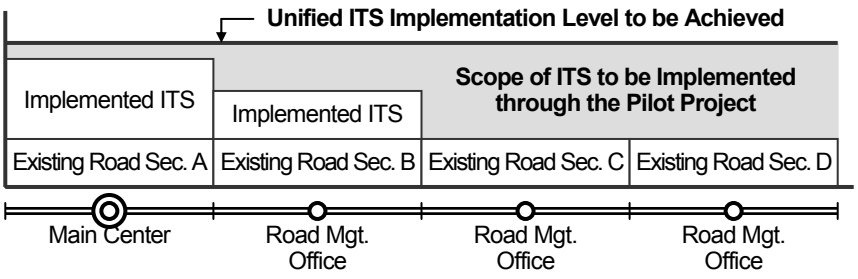
On the other hand, contrary to the rapid construction of radical expressways from Ha Noi and Ho Chi Minh city, the road construction in urban areas is said to be inadequate. In the future, traffic congestion is forecasted to become a daily routine especially on/around the ring roads that receive traffic from the expressways.

In such situation, as the next step for formulation of the Draft ITS Standard, it has become an urgent issue to establish an implementation procedure of ITS that provides integration covering different road sections and to show the way to utilize ITS for expressway operation/ management and to solve possible traffic problems in the metropolitan areas.

2) Objectives/Position of the Project

Striving toward the development of the ITS Standards in Vietnam, a pilot project is proposed and summarized in the Study. It aims to unify the ITS implementation levels covering the whole road network including a number of expressway sections, to verify/establish a procedure for integrating systems, to initiate the expressway operation/management using ITS and to show the way to utilize ITS for solving traffic issues in the metropolitan areas.

Figure 9.1 Unification of ITS Implementation Level through the Project

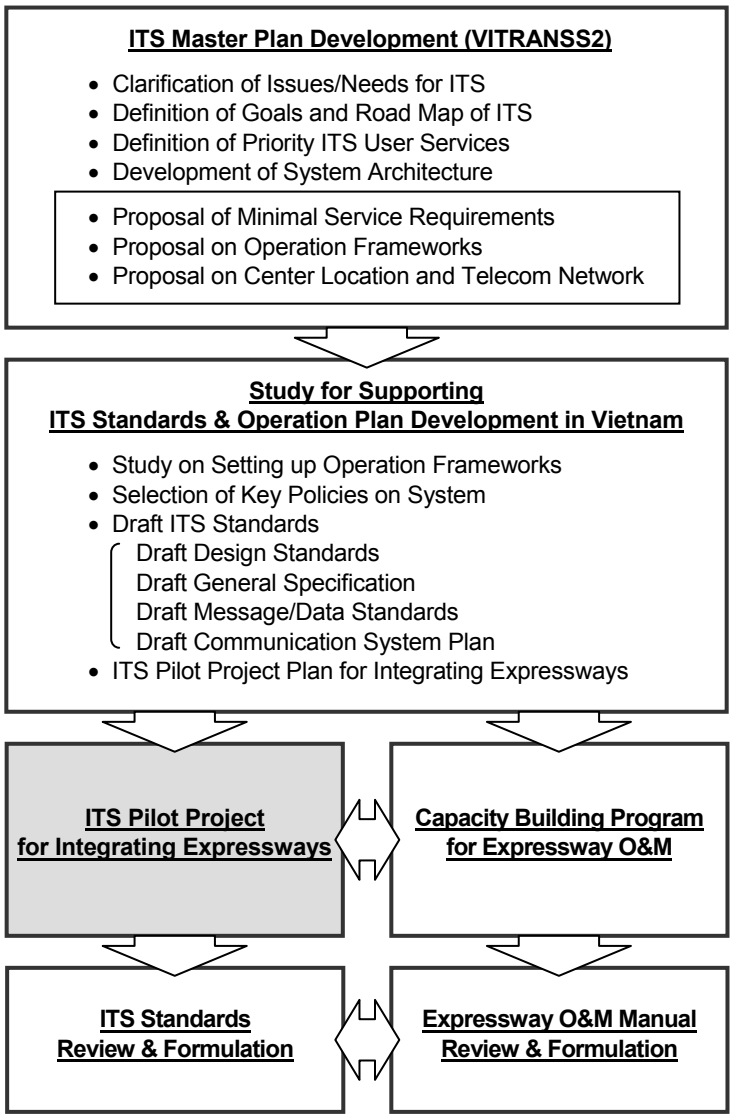


Source: ITS Standards & Operation Plan Study Team

The process from the development of ITS Master plan to the review/formulation of the Draft ITS Standards in Vietnam is shown in the following flowchart. The Project is positioned to be

a step for verifying the practicality and promoting the authorization of the Draft ITS Standards.

Figure 9.2 Position/Context of the Project



Source: ITS Standards & Operation Plan Study Team

3) Project Implementation Period

In order to address to the progress of on-going expressway construction, detailed design for the Project needs to be conducted immediately after the completion of this study of the Draft ITS Standards in order to schedule implementation within the period 2012 to 2013.

4) Scope of the Project

The target areas are the road networks including several expressway sections in the Northern and Southern Regions (see Figure 9.3 and Figure 9.10). The scope of the project consists of the items shown below.

(1) To verify/establish the procedure for integrating ITS that developed by road section and to unify the implementation level of ITS

- Road traffic information/control system
- Automatic toll collection system
- Heavy Truck control system
- Communication network

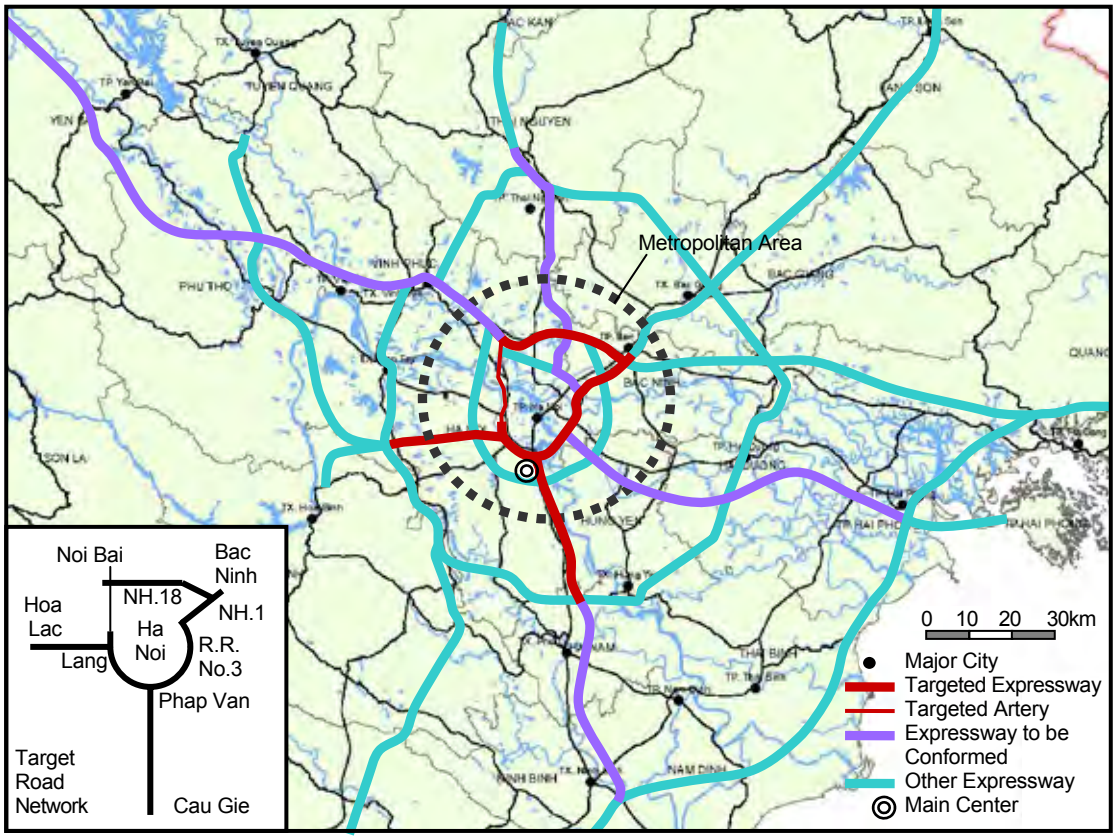
(2) To verify practicality of the key policies on system for the expressway operation that are selected in the Draft ITS Standards.

Target Road Network of the Project in North

The Project in North is to be implemented on the target road network, shown in the figure below, based on the following two premises:

- To include two or more motorway sections that will be mostly constructed by 2013 and need to be integrated
- To cover all road sections that form a ring road to provide the drivers with route selectivity.

Figure 9.3 Target Road Network of the Project in North



Road Section	Length	Grade	Construction/Operation	Current Status
Ring Road No.3	40 km	Exp.+FR	MOT / DRVN+HPC	Under Const.
Phap Van–Hoa Lac	30 km	Exp.	MOT / DRVN	Completed
Ha Noi–Cau Gie	40 km	Exp.	VEC / VEC	Completed
NH.1 (Ha Noi–Bac Ninh)	15 km	Exp.	MOT / DRVN	Completed
NH.18 (Noi Bai–Bac Ninh)	30 km	Exp.	MOT / DRVN	Completed
Total	155 km			
Expressways to be conformed	480 km			

Note: Exp.: Expressway, FR: Frontage Road

Source: ITS Standards & Operation Plan Study Team

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 9.4 Present Conditions on Target Road Network


Widening of Bridge on NH.1


Tollgate on NH.1


Through Lanes of Ring Road No.3


Signs on Ha Noi–Cau Gie

CCTV Camera on Ha Noi–Cau Gie


Overview of Ring Road No.3

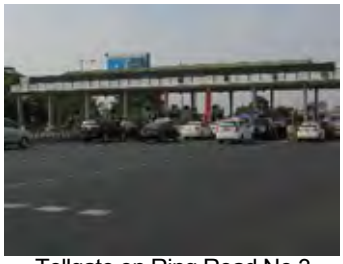

Overview of Ring Road No.3


VMS on Lang–Hoa Lac


Through Lanes of Lang–Hoa Lac


Ring Road No.3 at Mai Dich


VMS on Ring Road No.3


Tollgate on Ring Road No.3


JCT of Ring Road No.3 and NH.18


Through Lanes of NH.18


JCT of NH.18 and NH.1

Source: ITS Standards & Operation Plan Study Team

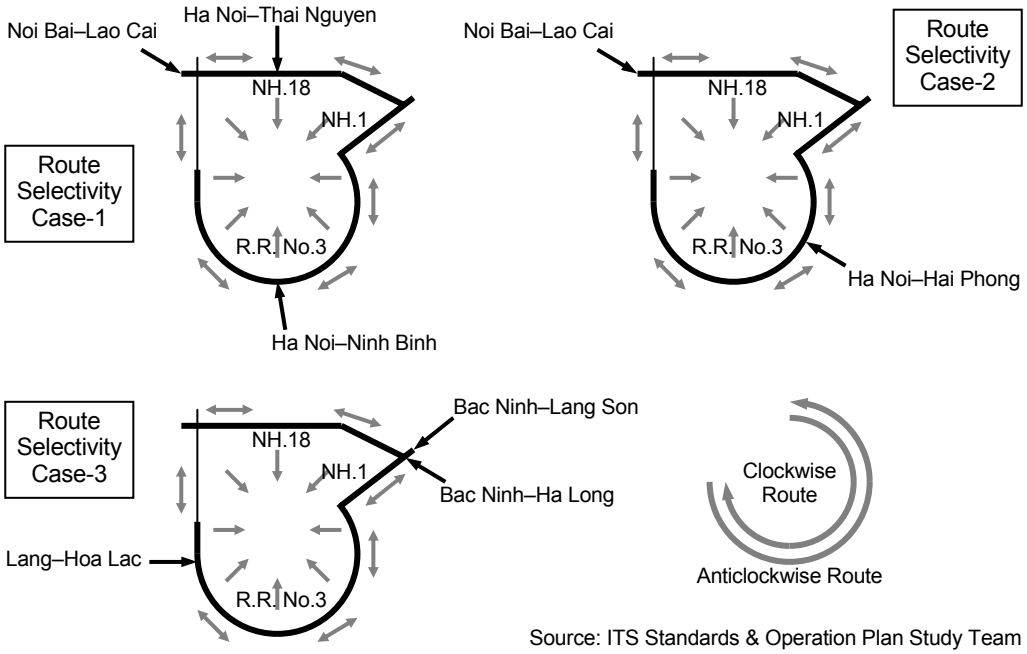
Measures for Traffic issues in the Metropolitan Area for Discussing the Project in North

Measure 1: Increase in Route Selectivity by Introducing ITS

It is useful for securing smooth traffic to install roadside equipment of traffic information/ control system along the ring-shaped motorway shown in the figures below and to disseminate information on the occurrences of incidents and traffic congestion for 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 and an exit interchange appropriately and to avoid obstructions.

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

Figure 9.5 Route Selectivity through Ring-shaped Motorway Equipped by ITS



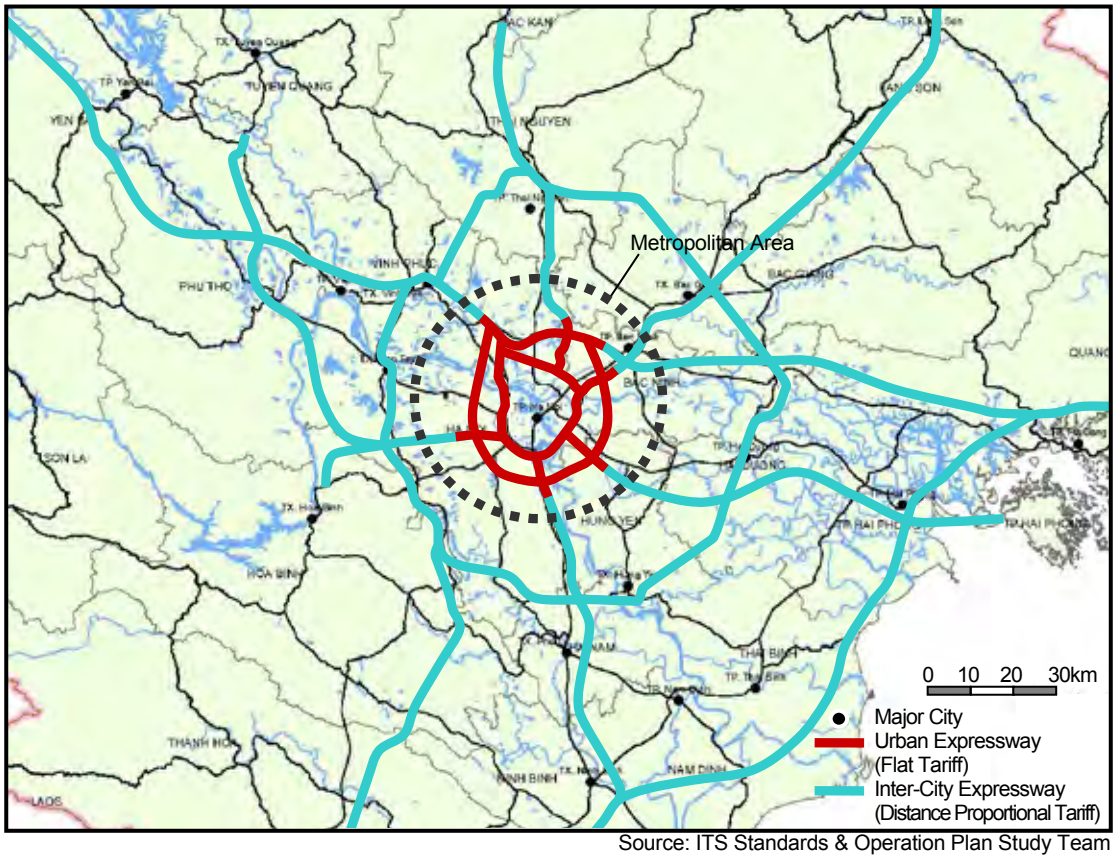
Source: ITS Standards & Operation Plan Study Team

Measure 2: Increase in Route Selectivity by Combined Toll Rate System

Application of a closed system to the expressways is defined by TCVN 5729/2007: Expressway Standard for Design in Vietnam, and introduction of a distance proportional tariff system is under consideration. The distance proportional tariff system is suitable for securing fairness among the road users in inter-city expressway network for long distance drives. However, for dispersing concentrated traffic in the metropolitan areas, it is effective to adopt the flat tariff system.

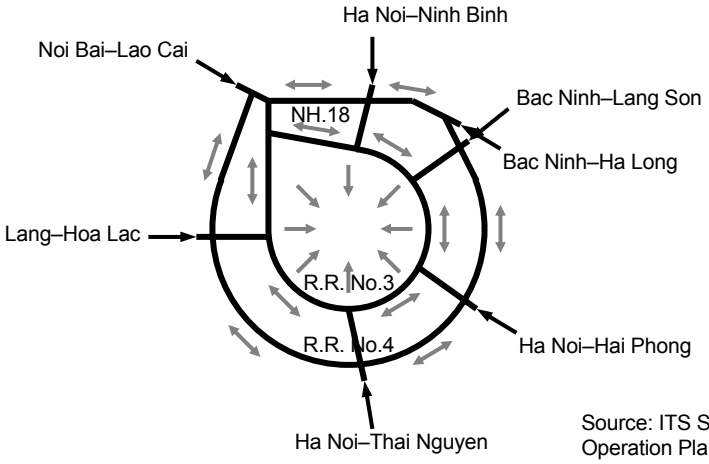
From this perspective, a combined toll rate system shown in the following figure is proposed as an ideal model for the future in Ha Noi Metropolitan Area. This system consists of the flat tariff system for the urban expressways inside of the Ring Road No.4 and the distance proportional tariff system for the inter-city expressways separated by barrier tollgates located right outside of the Ring Road No.4 on the radial expressway.

Figure 9.6 Combined Toll Rate System in Northern Region



Source: ITS Standards & Operation Plan Study Team

Figure 9.7 Route Selectivity through Ring Roads No.3 and No.4



Source: ITS Standards & Operation Plan Study Team

Through installation of roadside equipment of traffic information/control system along the ring roads No.3 and No.4 and eliminating bottlenecks by introducing ETC into the tollgates at interchanges, drivers can utilize the two ring roads in combination responding to the occurrences of incidents and traffic congestion, and a smooth traffic flow can be secured.

Measure 3: Setting Up of Cooperative Management System for Road Network

The Expressway Network Plan in the Northern Region including the road sections under planning is mentioned in “Decision 1734/QĐ-TTg: Approving the Vietnam Expressway Network

Development Master Plan toward 2020 and a vision beyond 2020" as shown in the following table.

Table 9.1 Expressway Network Plan for Northern Region

Road Section	Length	Grade	Operation
Ring Road No.3 *	56 km (106 km)	Exp.+FR	DRVN+HPC
Ring Road No.4 **	125 km (160 km)	Exp.+FR	DRVN+HPC
Urban Expressway Total	181 km (266 km)		
Lang–Hoa Lac–Hoa Binh ***	56 km (46 km)	Exp.	DRVN
Phap Van–Ninh Binh ***	90 km (80 km)	Exp.	VEC
Ha Noi–Hai Phong ***	105 km (95 km)	Exp.	
Noi Bai–Bac Ninh–Ha Long–Mong Cai ***	294 km (264 km)	Exp.	
Bac Ninh–Bac Giang–Lang Son ***	130 km (120 km)	Exp.	
Ha Noi–Thai Nguyen–Bac kan ***	90 km (80 km)	Exp.	
Ha Noi–Viet Tri–Lao Cai ***	264 km (254 km)	Exp.	
Ninh Binh–Hai Phong–Quang Ninh	160 km	Exp.	
Ring Road No.5		Exp.	
Inter-City Expressway Total	1189 km (1099 km)		

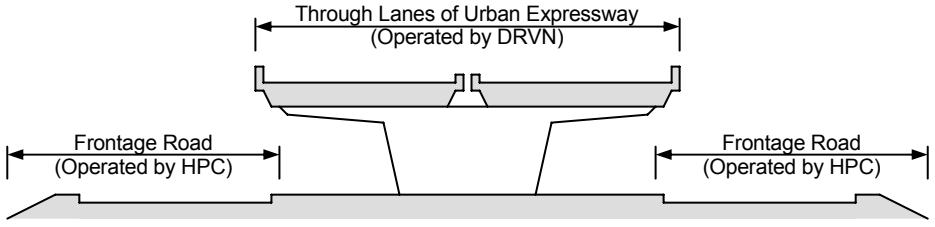
Note: Exp.: Expressway, FR: Frontage Road, * : Including radial expressways inside of Ring Road No.4, ** : Including National Highway No.18 inside of Ring Road No.4, ** : Outside of Ring Road No.4

Source: ITS Standards & Operation Plan Study Team

Excluding Ring Road No. 5 whose 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, and so a single main center is capable of managing the whole of network. However, it is assumed that the management of the expressway sections is to be shared not only by VEC but also by many different BOT investors.

In terms of road operation, a cooperative management is proposed in which DRVN is to operate urban expressways where traffic congestion occurs frequently, and VEC and BOT investors are to share operation of inter-city expressways within the framework mentioned in Sections 6.1 and 6.3.

Figure 9.8 Cooperative Management for Ring Roads No. 3 and No. 4

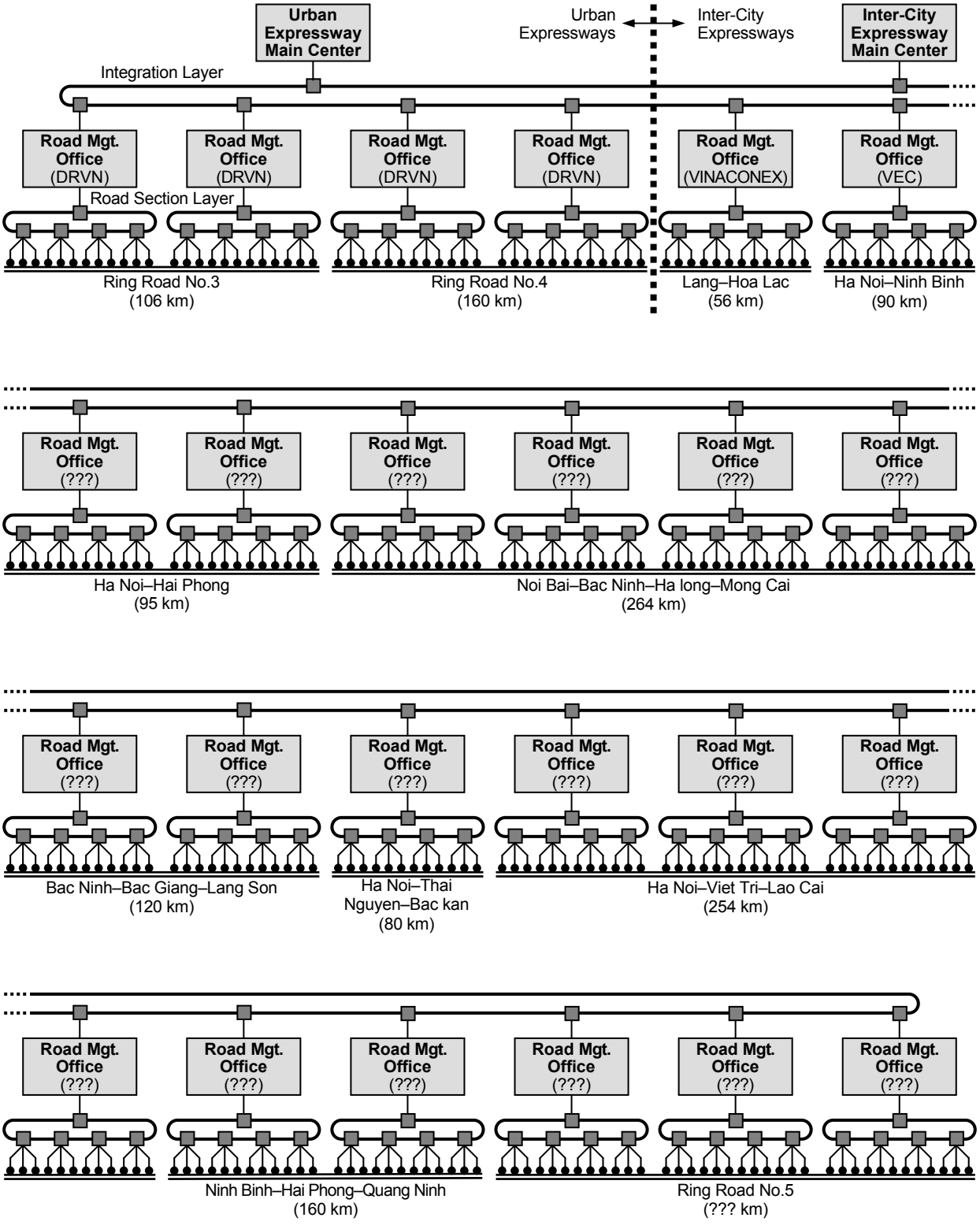


Source: ITS Standards & Operation Plan Study Team

The figure above illustrates the proposal for Ring Roads No.3 and No.4 whereby the frontage roads are to be operated by Ha Noi City as arterial roads and the through lanes are to be operated by DRVN as urban expressways.

Based on the above, this study provides further insights into the Project Plan in order to develop the structure of road management offices, in other words, to implement the cooperative management system for urban and inter-city expressway network in the Northern Region by the end of second stage (2020).

Figure 9.9 Cooperative Management System for Expressway Network in Northern Region



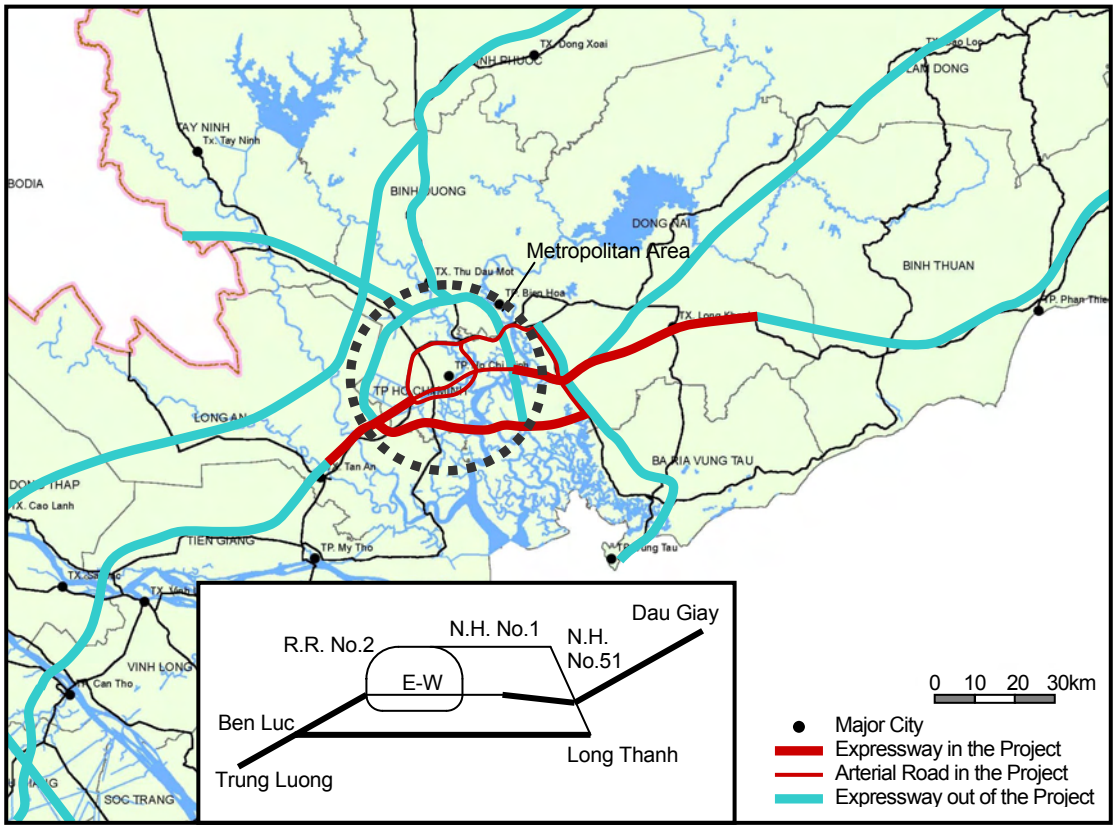
Source: ITS Standards & Operation Plan Study Team

Target Road Network of the Project in South

The Project in South is to be implemented on the target road network, shown in the figure below, based on the same two premises as in the North:

- To include two or more motorway sections that will be mostly constructed by 2013 and need to be integrated
- To cover all road sections that form a ring road to provide the drivers with route selectivity

Figure 9.10 Target Road Network of the Project in South



Road Section	Length	Grade	Construction/Operation	Current Status
HCMC – Trung Luong	40 km	Exp.	VIDB / VIDB	Completed
Ben Luc – Long Thanh	55 km	Exp.	VEC / VEC	Under Design
Ring Road No.2	40 km	Artery		
East-West Highway	25 km	Artery	HCMC / HCMC	Under Const.
National Highway No.1	20 km	Artery		Completed
National Highway No.51	30 km	Artery		Completed
HCMC – Dau Giay	60 km	Exp.	VEC / VEC	PQ for Const.
Total	270 km			

Source: ITS Standards & Operation Plan Study Team

Since the structure of expressway system network in the Southern Region still remains undefined, it is required to await further results of many other studies before indicating a combined toll rate system and an ideal model for cooperative management structure of the road network in Ho Chi Minh City metropolitan area including urban/inter-city expressways.

Hence, this study focuses on the issues such as the expressway development length as of the period 2012 to 2013, and estimates required cost for the implementation of the Pilot

Project in South only from a quantitative perspective.

Target Road Network for the Project in Central

Since the expressway planned to be constructed in the Central Region by the period 2012 to 2013 is only the Da Nang – Quang Ngai section, it is assumed to be too early to implement a pilot project, which aims to unify the ITS implementation levels covering the whole road network including a number of expressway sections and to integrate the systems. Hence, the Project Plan in the Central Region will not be discussed in the Study.

5) Outlines of the Project in North

(1) Content of Implementation in North

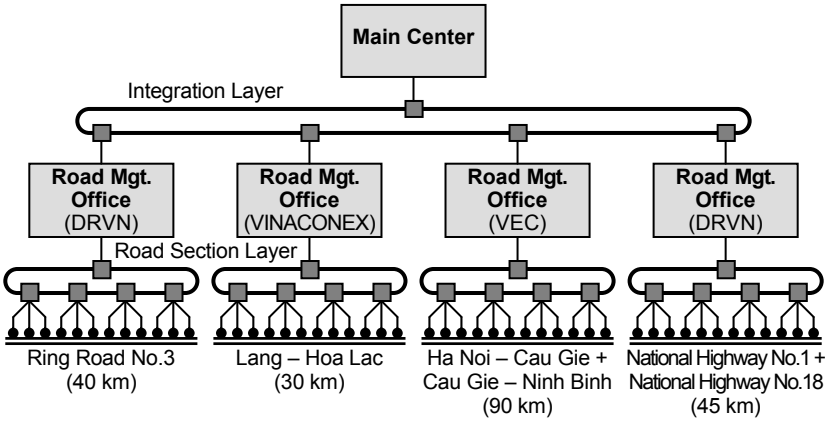
The following contents are to be implemented in the Project in North, which is necessary for unification of ITS implementation levels and system integration:

- Implementation of the Main Center and the communication network that covers road management offices and roadside equipment on the expressway sections; also the initiation of network management
- Implementation of the traffic information/control system that covers the target road network; and the initiation of traffic control.
- Implementation of the automatic toll collection system that covers the target road network; also the initiation of toll management, settlement and enforcement
- Implementation of the overloading regulation system that covers the target road network; also the initiation of enforcement.
- Supplementary construction of the buildings of the main center, road management offices and toll offices with insufficient capacity for system storage
- Verification/establishment of the procedure for integrating ITS that developed by road section and unification of the implementation level of ITS
- Feedback on the Draft ITS Standard based on the verification results of the procedure for integrating ITS.

(2) Road Management System in North

For the Project in North, the road management system is assumed to be as shown below.

Figure 9.11 Structure of Road Management Offices in North



Source: ITS Standards & Operation Plan Study Team

The cooperative management structure shown in Chapter 6 is assumed as the future vision in the Ha Noi Metropolitan Area. From this perspective, one of the road management offices implemented by the Project needs to be developed so that it can be transferred, in the future, to the metropolitan area main center.

(3) Major Figures of Target Road Network in North

Major figures of the target road network of the Project in North are as shown below.

- Expressway length: 205 km
- Number of interchanges: 15
- Number of junctions: 2
- Number of tollgates: 6 (6 tollgates are target of ETC, 3 tollgates are target of Touch & Go, 6 tollgates are target of axle load measurement)
- Number of locations where bad weather is assumed to occur frequently: 3
- Number of locations where accidents are assumed to occur frequently: 3
- Number of sections where traffic congestions are assumed to occur frequently: 3

(4) Major Quantities for Project Implementation

System architecture is defined and major quantities for implementing center equipment of the Project are estimated based on the discussion results shown in the following chapters and sections of the Report, the Draft Design Standards (DDS) and the Draft Communication System Plan (DCSP):

- System architecture →Chapter 6.1 of the Report, and DDS(1), DDS(2) and DDS(3)
- Location/function of the Main Center →Sections 6.2 and 6.6 of the Report, and Chapter 3 of DCSP
- Location/function of road management office →Section 3.4 of the Report, and Section 9.11 of DCSP
- Location/function of toll office →Section 6.9 of the Report, and Section 9.11 of DCSP

Major quantities of roadside equipment are estimated based on the discussion results shown in the following chapters and sections:

- CCTV camera arrangement →Section 7.1 of the Report, Chapter 19 of DDS(1)
- Vehicle detector arrangement →Section 7.2 of the Report, Chapter 19 of DDS(1)
- Weather sensor arrangement → Chapter 19 of DDS(1)
- VMS arrangement → Chapter 19 of DDS(1)
- Tollgate lane arrangement →Section 7.5 of the Report, and Chapter 15 of DDS(2)
- Axle load scale arrangement →Section 7.7 of the Report, and Chapter 10 of DDS(3)

Major quantities for implementing the communication network of the Project are estimated based on the discussion results shown in the following chapters and sections:

- Integration of roadside equipment control →Section 7.8 of the Report, and Chapter 7 of DCSP
- Transmission Method →Section 7.9 of the Report, and Chapter 8 and Section 9.11 of DCSP

Major quantities of functional packages and equipment components required for the Project in North are given in the following table.

Table 9.2 Major Quantities for Project Implementation in North

Item		Unit	Quantity
1	Main Center	Set	1
2	Road Management Office	Set	4
3	Toll Office (Tollbooth)	Set	6(48)
4	CCTV Camera	Set	78
5	Event Detector	Set	3
6	Vehicle Detector	Set	6
7	Weather Sensor	Set	3
8	VMS	Set	70
9	ETC Roadside Equipment	Set	16
10	Touch&Go Roadside Equipment	Set	10
11	OBU	Set	100,000
12	Axle Load Scale	Set	14
13	Fiber Optic Cable	Km	584
14	Conduit	Km	340

Source: ITS Standards & Operation Plan Study Team

(5) Rough Cost Estimated for Project Implementation

Rough Cost estimated for implementing the Project in North are shown in the table below.

Table 9.3 Rough Cost Estimated for Project Implementation in North

Item		Total Cost (equivalent in)	
		Thousand Yen	Million VND
1	Traffic Information/Control	1,479,643	365,344
2	Automated Toll Collection	1,736,417	428,745
3	Heavy Truck Control	177,657	43,866
4	Communication System	912,716	225,362
5	Electric Power Supply System	98,561	24,336
6	Sub-total (1+2+3+4+5)	4,404,994	1,087,653
7	Tax (10% of 6)	440,499	108,765
8	Grand Total (6+7)	4,845,493	1,196,418

Note: Construction cost of massive new buildings is not included in the results above.

Source: ITS Standards & Operation Plan Study Team

These rough costs are estimated based on the key policies on system selected in Chapter 7 of the Report and the discussion results shown in the Draft General Specification.

6) Outlines of the Project in South

(1) Content of Implementation in South

The following contents are to be implemented in the Project in South, which is necessary for unification of ITS implementation levels and system integration:

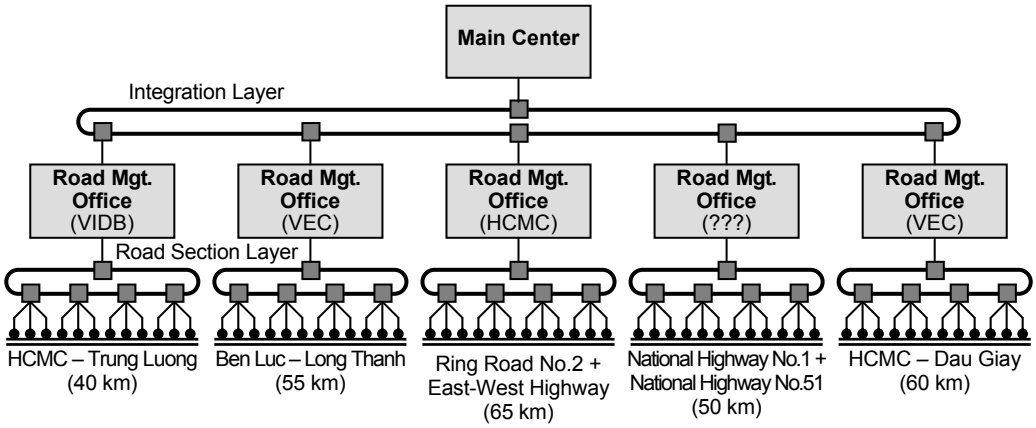
- Implementation of the Main Center and the communication network that covers road management offices and roadside equipment on the expressway sections; also the initiation of network management

- Implementation of the traffic information/control system that covers the target road network; and the initiation of traffic control.
- Implementation of the automatic toll collection system that covers the target road network; also the initiation of toll management, settlement and enforcement
- Implementation of the overloading regulation system that covers the target road network; also the initiation of enforcement.
- Supplementary construction of the buildings of the main center, road management offices and toll offices with insufficient capacity for system storage
- Verification/establishment of the procedure for integrating ITS that developed by road section and unification of the implementation level of ITS
- Feedback on the Draft ITS Standard based on the verification results of the procedure for integrating ITS.

(2) Road Management System in South

For the Project in South, the road management system is assumed to be as shown below.

Figure 9.12 Structure of Road Management Offices in South



Source: ITS Standards & Operation Plan Study Team

(3) Major Figures of Target Road Network in South

Major figures of the target road network of the Project in South are as shown below.

- Expressway length: 270 km
- Number of interchanges: 19
- Number of junctions: 1
- Number of tollgates: 8 (8 tollgates are target of ETC, 3 tollgates are target of Touch & Go, 8 tollgates are target of axle load measurement)
- Number of locations where bad weather is assumed to occur frequently: 3
- Number of locations where accidents are assumed to occur frequently: 3
- Number of sections where traffic congestions are assumed to occur frequently: 3

(4) Major Quantities for Project Implementation

System architecture is defined and major quantities for implementing center equipment of

the Project are estimated based on the discussion results shown in the following chapters and sections of the Report, the Draft Design Standards (DDS) and the Draft Communication System Plan (DCSP):

- System architecture →Chapter 6.1 of the Report, and DDS(1), DDS(2) and DDS(3)
- Location/function of the Main Center →Sections 6.2 and 6.6 of the Report, and Chapter 3 of DCSP
- Location/function of road management office →Section 3.4 of the Report, and Section 9.11 of DCSP
- Location/function of toll office →Section 6.9 of the Report, and Section 9.11 of DCSP

Major quantities of roadside equipment are estimated based on the discussion results shown in the following chapters and sections:

- CCTV camera arrangement →Section 7.1 of the Report, Chapter 19 of DDS(1)
- Vehicle detector arrangement →Section 7.2 of the Report, Chapter 19 of DDS(1)
- Weather sensor arrangement → Chapter 19 of DDS(1)
- VMS arrangement → Chapter 19 of DDS(1)
- Tollgate lane arrangement →Section 7.5 of the Report, and Chapter 15 of DDS(2)
- Axle load scale arrangement →Section 7.7 of the Report, and Chapter 10 of DDS(3)

Major quantities for implementing the communication network of the Project are estimated based on the discussion results shown in the following chapters and sections:

- Integration of roadside equipment control →Section 7.8 of the Report, and Chapter 7 of DCSP
- Transmission Method →Section 7.9 of the Report, and Chapter 8 and Section 9.11 of DCSP

Major quantities of functional packages and equipment components required for the Project in South are given in the following table.

Table 9.4 Major Quantities for Project Implementation in South

Item		Unit	Quantity
1	Main Center	Set	1
2	Road Management Office	Set	5
3	Toll Office (Tollbooth)	Set	8 (62)
4	CCTV Camera	Set	135
5	Event Detector	Set	3
6	Vehicle Detector	Set	6
7	Weather Sensor	Set	3
8	VMS	Set	88
9	ETC Roadside Equipment	Set	20
10	Touch&Go Roadside Equipment	Set	11
11	OBU	Set	100,000
12	Axle Load Scale	Set	18
13	Fiber Optic Cable	Km	933
14	Conduit	Km	584

Source: ITS Standards & Operation Plan Study Team

(5) Rough Cost Estimated for Project Implementation

Rough Cost estimated for implementing the Project in South are shown in the table below.

Table 9.5 Rough Cost Estimated for Project Implementation in South

Item		Total Cost (equivalent in)	
		Thousand Yen	Million VND
1	Traffic Information/Control	1,461,556	360,878
2	Automated Toll Collection	1,862,004	459,754
3	Heavy Truck Control	234,665	57,942
4	Communication System	1,286,807	317,730
5	Electric Power Supply System	190,548	47,049
6	Sub-total (1+2+3+4+5)	5,035,580	1,243,353
7	Tax (10% of 6)	503,558	124,335
8	Grand Total (6+7)	5,539,138	1,367,688

Note: Construction cost of massive new buildings is not included in the results above.

Source: ITS Standards & Operation Plan Study Team

These rough costs are estimated based on the key policies on system selected in Chapter 7 of the Report and the discussion results shown in the Draft General Specification.

7) Conclusion

For the implementation of the Pilot Project, it is considered that setting up of the frameworks for expressway operation using ITS is required as mentioned in Chapter 6 and it is assumed that the structure of expressway network system in the Southern Region still remains undefined. Consequently, in the Study, it is concluded that the Project in North shall be implemented on a high priority basis in order to promote establishment of the procedure for integrating ITS that have developed by road sections and for unification of the implementation level of ITS.

10. List of Solutions for Stepwise ITS Implementation

Up to the present, discussions on ITS for the expressway network in Vietnam have been conducted piecemeal in construction projects of individual expressway sections. Consequently, the discussions have not been done from the following view points that are necessary for integration of the whole expressway network.

- Definition of service levels of expressway operation
- Setting up frameworks needed for expressway operation using ITS
- Selection of key policies as premises for structuring ITS
- Unification of system architecture, basic concept and actualization methods
- Establishment of connectability of communication network
- Establishment of inter-operability of message/data
- Establishment of compatibility of equipment components

ITS includes construction of a system to control many pieces of equipment under a single center along with a communication network, which is quite different from ordinary information services realized simply by data exchange among two or more centers. For the construction, it is necessary to define the total policies and architecture of the system in advance.

Through the study, solutions for the issues above are discussed and the reasoned results are shown in the Report and the Draft Design Standards as follows.

(1) Definition of service levels of expressway operation →Section 3.4 of the Report
(2) Setting up frameworks needed for expressway operation using ITS →Chapter 6 of the Report
(3) Selection of key policies as premises for structuring ITS →Chapter 7 of the Report
(4) Unification of system architecture, basic concept and actualization methods →Draft Design Standards
(5) Establishment of connectability of communication network →Draft Communication System Plan
(6) Establishment of inter-operability of message/data →Draft Message/Data Standards
(7) Establishment of compatibility of equipment components →Draft General Specifications

As a further result of the Study, the Standardized ITS Introduction Project Plan is developed as the first stage of system implementation based on the Draft ITS Standards.

Even in the ITS to be implemented in many different expressway sections, consistency among systems can be secured based on the basic concept shown in the report and by complying with the provisions shown in the Draft ITS Standards. At the same time, the consistency among systems allows stepwise ITS implementation keeping pace with the expressway construction by section.