7 OPERATION FRAMEWORK OF ITS

7.1 General

In the chapter 7, the following frameworks for operating ITS are illustrated and institutional issues and its countermeasures are discussed in consideration of the system architecture shown in Chapter 5 and *Appendix 1*.
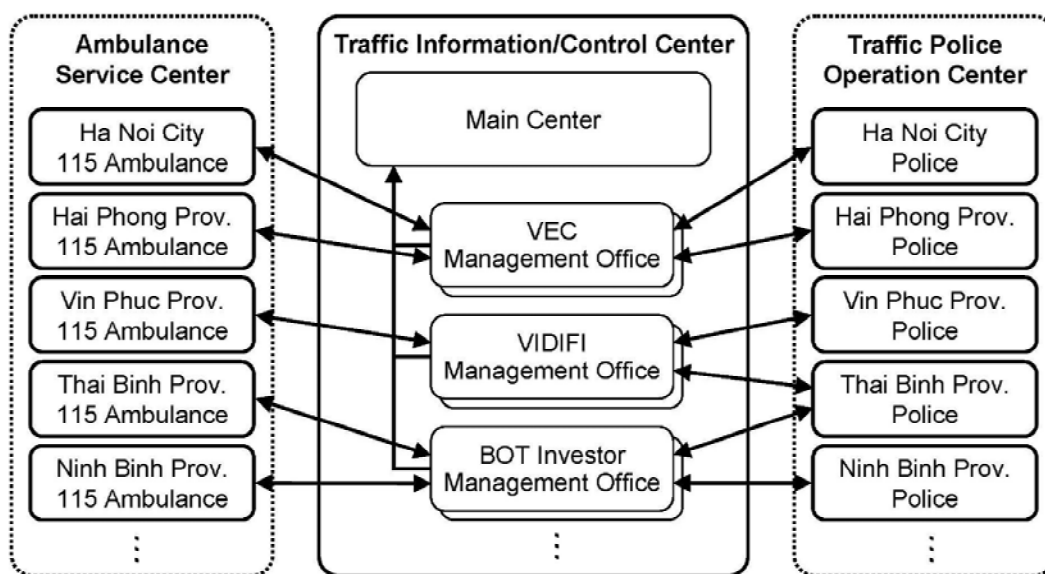
(i)   Framework for incident notification

(ii)   Framework for DSRC probe

(iii)   Framework for GPS/WL probe

(iv)   Framework for traffic information

(v)   Framework for OBU management

(vi)   Framework for IC-card operation

(vii) Framework for toll clearance

(viii) Framework for toll enforcement

(ix)   Framework for heavy truck control.

The results above are integrated conclusively into the total framework of ITS and the rolls of organizations in the framework are discussed and compiled in a table.

7.2 Framework for Incident Notification

Occurrence of incidents can be notified by the road operator through monitoring by CCTV or emergency telephone installed on roadside. However, in many instances, the road users who encounter incidents call the police. Accordingly, the incident notifications are achieved by exchanging information among the management offices of the road operators and the traffic police offices as shown in the following page. In addition, information on the incident notifications need to be shared with the ambulance service centers to ask for the rescue of injured persons. Present conditions are mentioned in Section 6.3.

Figure 7.2.1   Framework for Incident Notification

Source: VITRANSS 2 Study Team

All information on incident notifications is to be consolidated at the main center of the road operator in order to enforce restrictions appropriately for the severity of the incidents and to disseminate the information to the road users.
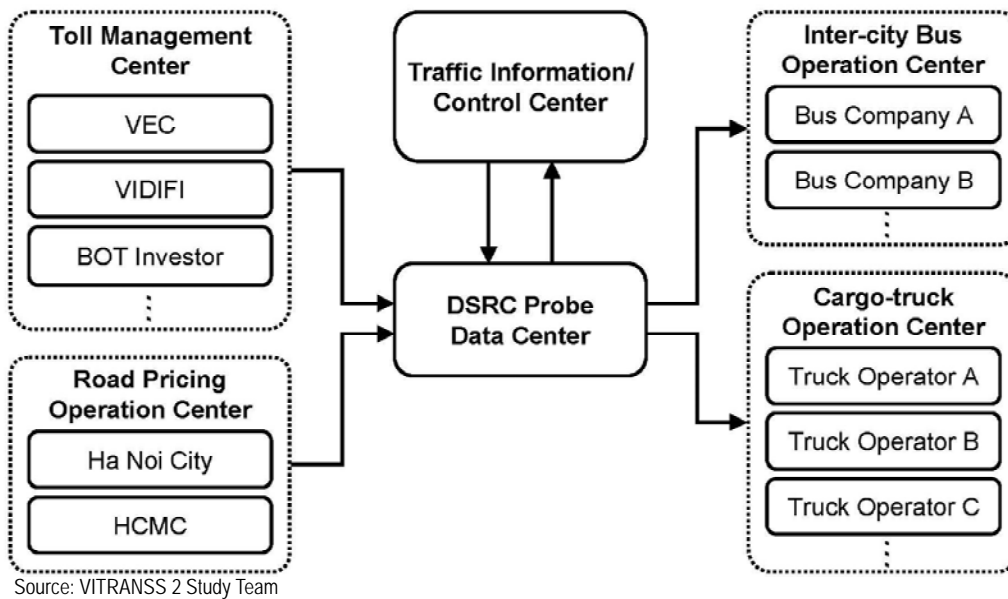
(1) Issues and Measures

The jurisdictions of the management offices of the road operators are generally not in one-to-one correspondence with that of the traffic police offices and that of the ambulance services centers. Accordingly, the following measures need to be considered:

(i) Definition of the competent traffic police office and ambulance services center for each management office,

(ii) Arrangement of a police car to the management office,

(iii) Arrangement of the ambulance to the management office that has not any competent ambulance services center within the allowable distance.

7.3   Framework for DSRC Probe

DSRC probe data are generated from the data of vehicle passages at the communication spots of roadside antennas, which are sent from the centers of toll collection and road pricing. The traffic information/control center receives the data from the DSRC probe center, then generates the traffic information such as travel-time and sends it to the operation centers of inter-city buses and the cargo-trucks. The DSRC probe center and the traffic information/control center can be located in the same place.

Figure 7.3.1   Framework for DSRC Probe

Source: VITRANSS 2 Study Team

(1) Issues and Measures

Sufficient number of vehicle passage data is required for the DSRC probe; consequently, sufficient percentage (usually around 5%) of vehicles needs to be equipped by OBU for DSRC.   On that account, the following measures need to be introduced:

(i)   Installation of a certain number of OBUs as the on-board sensors of DSRC probe using public fund of the road operator,

(ii)   Issuance of the official requirement to install OBU to the inter-city busses and the cargo- trucks by the government,

(iii) Traffic information provision at no charge as the incentive for the inter-city bus operators and the cargo-truck operators to install OBUs in their vehicles.

Additionally, roughness in the time intervals of positioning by DSRC can be complemented by combining with the GPS/WL probe.

7.4 Framework for GPS/WL Probe

GPS/WL probe data are generated from the positioning data by GPS, which are sent from the vehicles such as the inter-city busses and the cargo-trucks through WL (Wireless Communication). The traffic information/control center receives the data from the GPS/WL probe center, then generates the traffic information such as travel-time and sends it to the operation centers of the inter-city buses and the cargo-trucks. The GPS/WL probe centers, such as Vina-Track and VECOM-FMS, are already set up for providing the service of driving recorder. (→ See Sections 2.5 and 2.6)

Figure 7.4.1   Framework for GPS/WL Probe
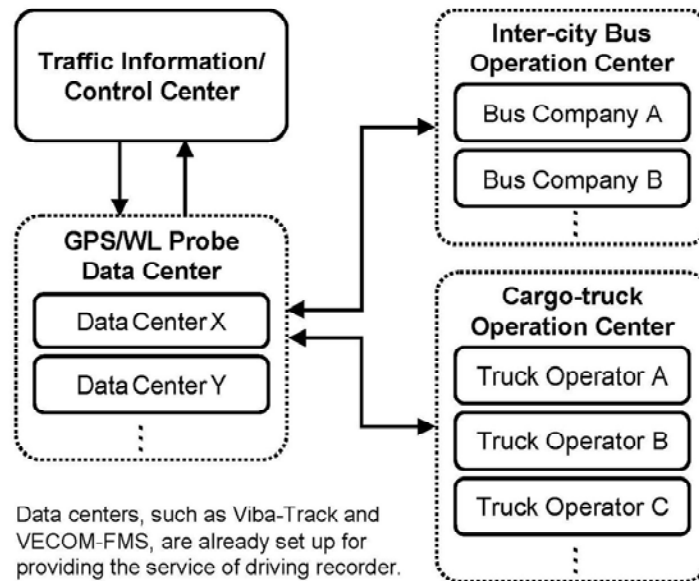
Source: VITRANSS2 Study Team

(1) Issues and Measures

Sufficient number of vehicle position data is required for the GPS/WL probe; consequently, sufficient percentage (usually around 5%) of vehicles needs to be equipped by OBU for GPS and WL. On that account, the following measures need to be introduced:

(i)   Issuance of the official requirement to install OBU both for GPS and WL to the inter-city busses and the cargo- trucks by the government,

(ii)   Traffic information provision at no charge as the incentive for the inter-city bus operators and the cargo-truck operators to install OBUs in their vehicles.

Additionally, the accuracy of GPS insufficient to distinguish the expressway paralleling closely with the other road can be complemented by combining with the DSRC probe.

7.5 Framework for Traffic Information

Traffic information compiled at the traffic information/control center is to be uploaded to the Internet and to be referred to by the operators of the centers of traffic police, ambulance service, TV/radio broadcasting and information service as well as the management offices of the road operator. Present conditions are mentioned in Section 6.4.

**Figure 7.5.1   Framework for Traffic Information**
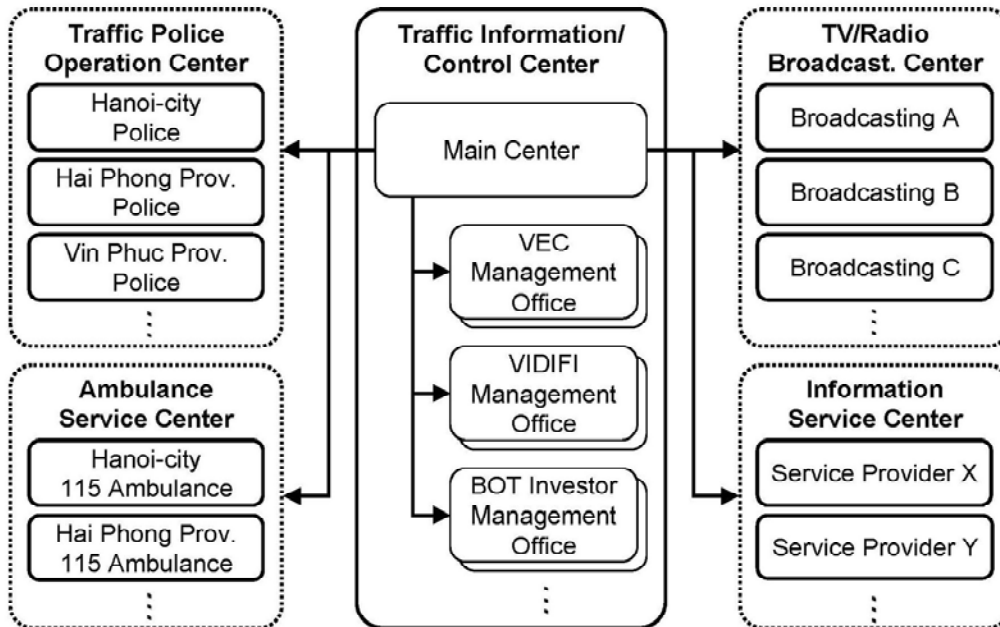
Source: VITRANSS 2 Study Team

(1) Issues and Measure

In general, the traffic information needs to be processed secondarily in the centers of TV/radio broadcasting and information service for dissemination to the road users; accordingly, the data of the traffic information are required to be downloaded by such centers, and the data needs to be updated at every 15 minutes according to the minimal service requirements. (→ See Section 4.4.)

7.6 Framework for OBU Management

OBU is to be issued at the OBU shop to the road user, and the OBU registration data inputted at the shops are to be consolidated/stored in the OBU registration center. Notifications of the lost OBUs from the users are also to be consolidated in the OBU registration center, and the list of lost OBUs is transmitted to the toll management centers of the road operators for invalidating the OBUs over the whole expressways and other toll roads.

Figure 7.6.1   Framework for OBU Management

Source: VITRANSS 2 Study Team
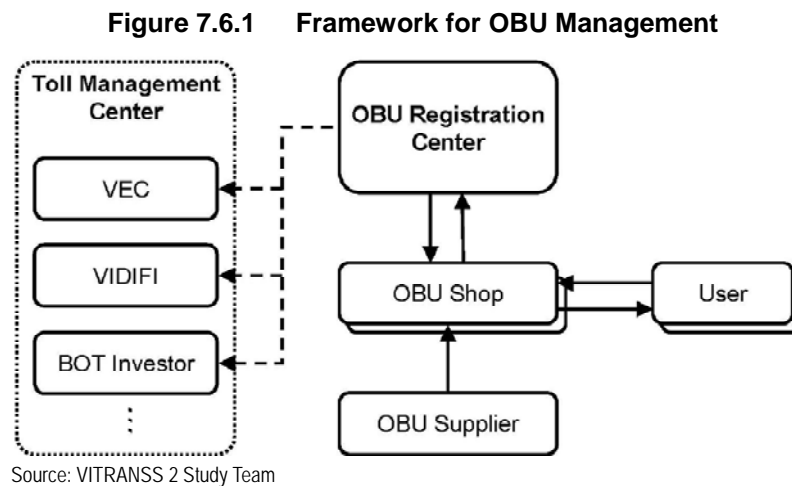
7.7 Framework for Toll Clearance

Toll clearance is to be conducted by using contact-less IC-cards for prepayment for many different road operators over all expressways and other toll roads. Issue/recharge of contact-less IC-card is to be utilized conveniently in the city as well as the roadside.   For toll clearance, adequate data exchange needs to be conducted between the toll management center of the road operator and the prepayment service center such as the center of the bank. Present conditions are mentioned in Section 6.6.

Appropriate and reliable apportionment of the toll revenue among the road operators by prevention of unfair billings to the prepayment service center is required for establishing the sustainable toll clearance system. The toll clearance system is to be improved stepwise for convenience of the users.

The following frameworks are to be compared for actualizing the toll clearance:

(i)   TYPE-0 on unshared IC-cards issued by road operators

(ii)   TYPE-1' on shared IC-cards issued by a bank

(iii) TYPE-1 on shared IC-cards issued by banks

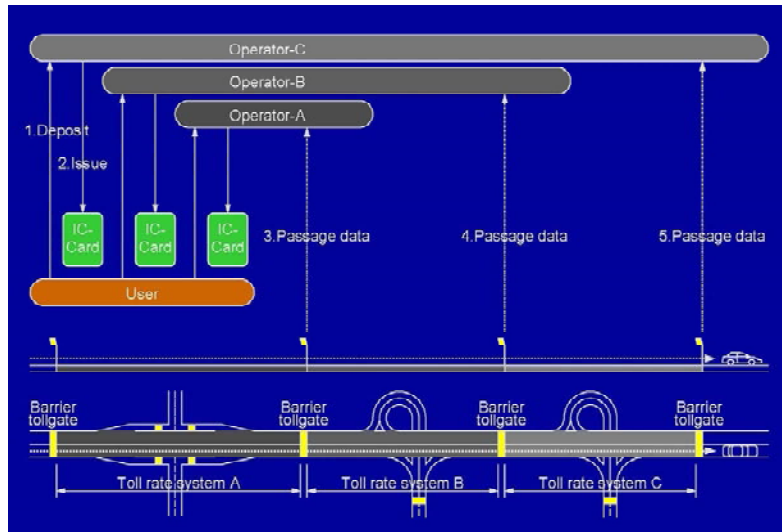(iv) TYPE-2 on shared IC-cards Issued by road operators.

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

This framework for toll clearance is based on many different unshared IC-cards issued by the road operators; however, that has the following problems:

(i)   User needs to prepare many different IC-cards for passing continuously through the road sections operated by different road operators,

(ii)   Users can receive issue/recharge service of the IC-cards only at the roadside of the expressways and the toll roads,

(iii) All road operators need to prepare the whole equipment for the issue/recharge of IC-cards and the car park for convenience of the users,

(iv) Congestion tends to take place on the road around the car parks for the issue/recharge of IC-cards,

(v) Diffusion of OBU and IC-card tends to be slow.

Figure 7.7.1   TYPE-0 on Unshared IC-cards Issued by Road Operators

Source: VITRANSS 2 Study Team

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

This framework for toll clearance is based on a single IC-card shared by different road operators. (→ To be referred to Section 8.2.)   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 2nd stage as shown in the figures in the next page. Stepwise implementation of the framework for toll clearance achieves the following advantages:

(a) 1st Stage

- User can use a single IC-card through the whole expressways and toll roads,
- User can receive issue/recharge service of the IC-card at many places in the city using the equipment prepared by the bank,
- The road operators need not to prepare equipment for the issue/recharge service of the IC-card and the relevant car parks,
- OBU and IC-card tends to be diffused rapidly.

(b) 2nd Stage

- User receive issue/recharge service of the IC-card more conveniently,
- Driver needs not to stop the vehicle many times on the road for getting the issue/recharge of IC-cards,
- Congestion on the road can be removed.

However, for integrating the road operators and the banks, the clearing center needs to be discussed in the 1st stage and is to be established by the beginning of 2nd stage.

Figure 7.7.2   TYPE-1' on Shared IC-cards Issued by a Bank (in the 1st Stage)
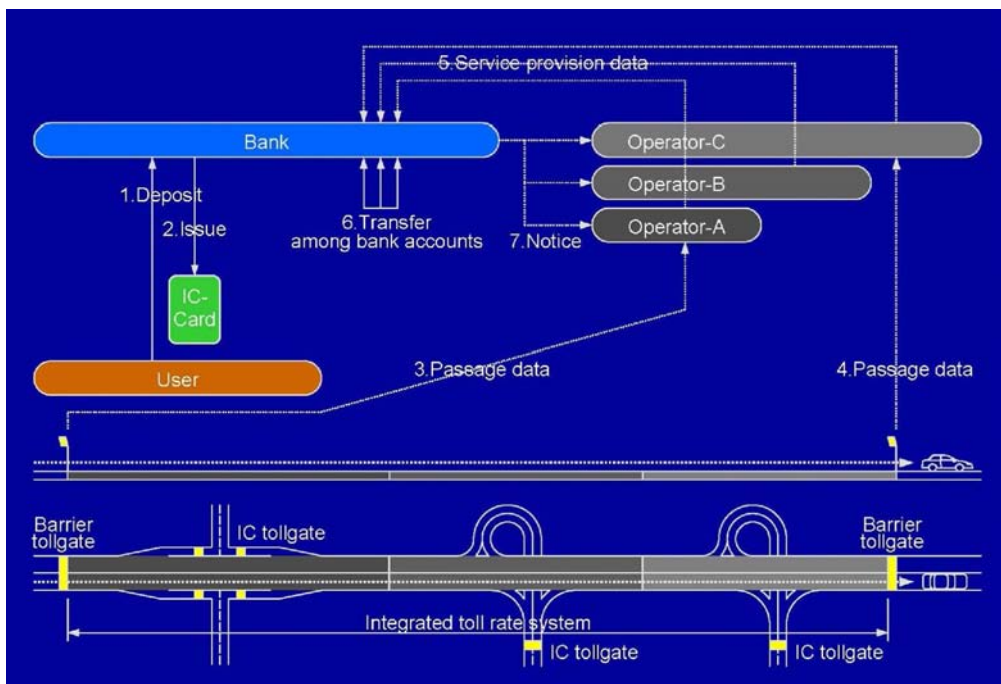
Source: VITRANSS 2 Study Team

**Figure 7.7.3   TYPE-1 on Shared IC-cards Issued by Banks (in the 2nd Stage)**
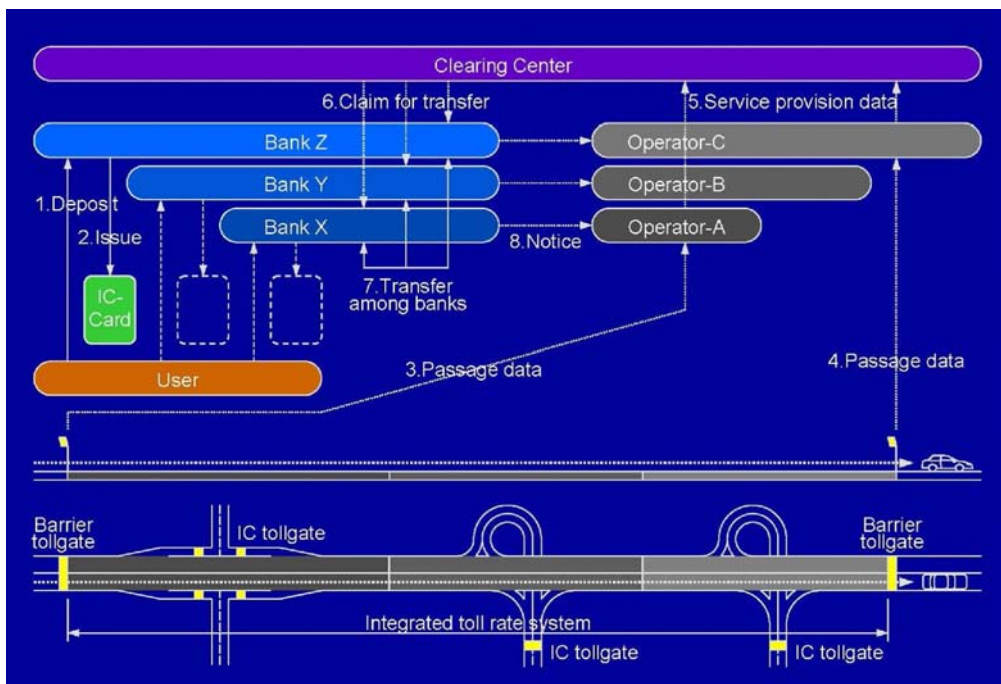
Source: VITRANSS 2 Study Team

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

This framework for toll clearance is based on a shared IC-card shared by different road operators and provides the same advantages as TYPE-1; however, this framework also requires establishment of a clearing center for integrating the road operators and the banks.

Figure 7.7.4   TYPE-2 on Shared IC-cards Issued by Road Operators
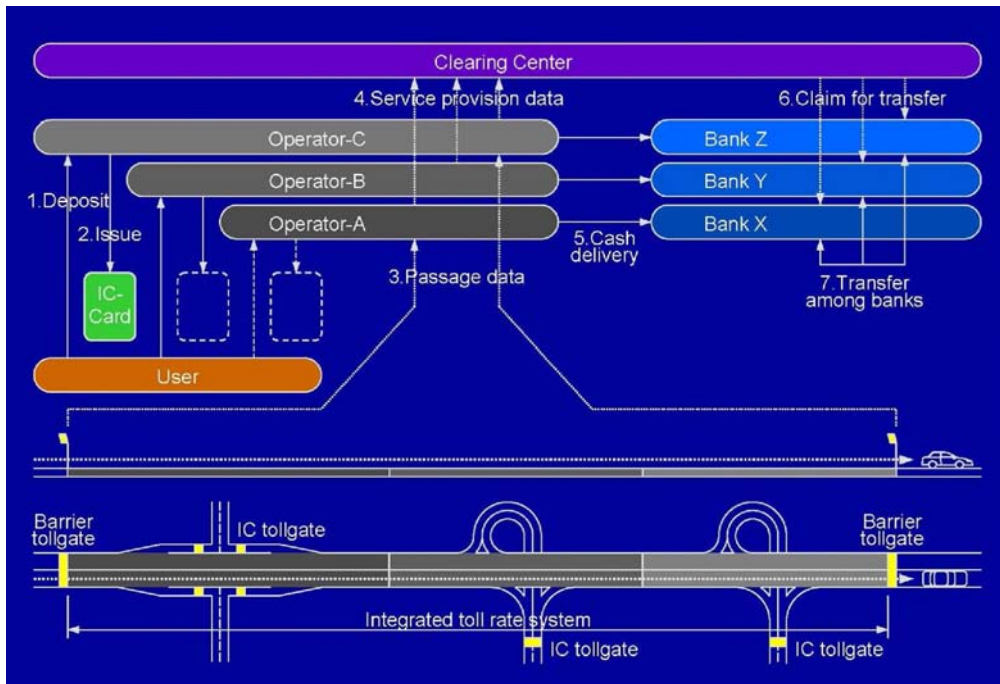
Source: VITRANSS 2 Study Team

(4) Comparison of Toll Clearance Framework

The comparison of the aforementioned toll clearance frameworks is summarized below.

Table 7.7.1   Comparison of Frameworks for Toll Clearance

|	Type-0	Type-1'	Type-1	Type-2
IC-card Issue Organization	Road Operators	A Bank	Banks	Road Operators
Convenience of IC-card Recharge for the User	Average	High	Very High	Average
Needed Number of IC-cards for a User	Two or More	One	One	One
Clearing House	Not Necessary	Not Necessary	Necessary	Necessary
Cost-cutting on IC-card Operation for Road Operator	Incapable	Capable	Capable	Incapable
Tollgate-to-center Cash Delivery for Road Operator	Not Necessary	Not Necessary	Not Necessary	Necessary
Revenue by IC-card Business for Road Operator	Expected	None	None	Expected
Grading	Not Suitable	Useful for the 1st Stage	Recommended	Comparable

Source: VITRANSS 2 Study Team

7.8   Framework for IC-Card Operation

IC-card is to be issued at the issue window to the road user, and the IC-card issue data are to be consolidated/stored in the prepayment service center for prevention of illegal recharge.   Notifications of the lost IC-cards from the users are also to be consolidated in the prepayment service center, and the list of lost IC-cards is transmitted to the toll management centers of the road operators (through the clearing center) for invalidating the IC-cards over the whole expressways and other toll roads.

In the case of TYPE-2, the prepayment service center and the toll management center are arranged in the same organization as shown below.

Figure 7.8.1   Framework for IC-card Operation
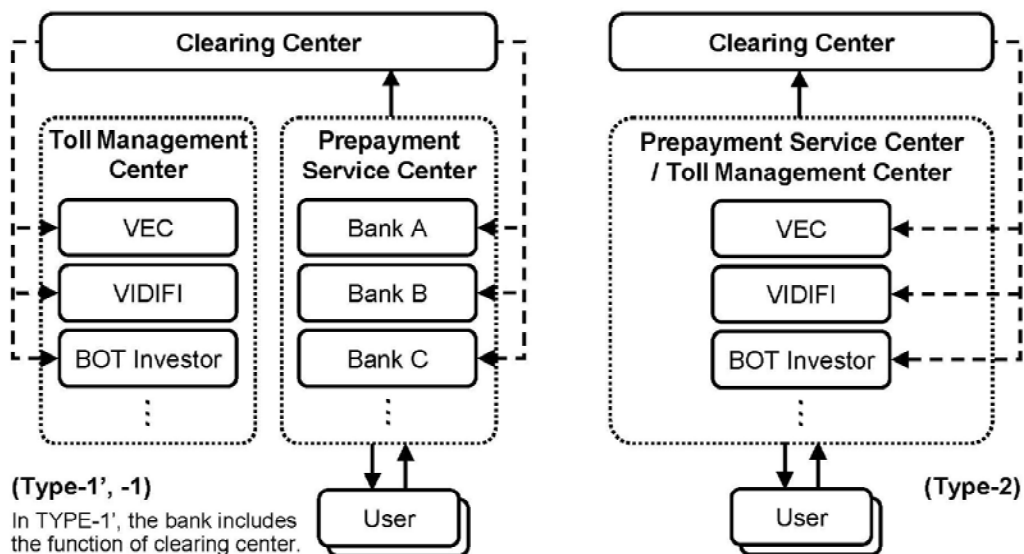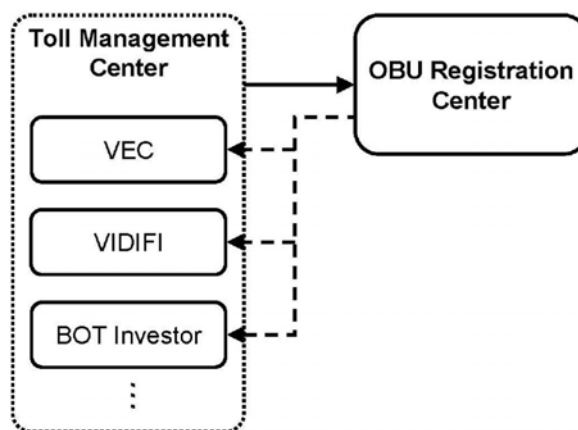

Source: VITRANSS 2 Study Team

(1) Issues and Measures

The clearing center needs to be established for integrating the road operators and the banks excluding the case of TYPE-1'.

7.9 Framework for Toll Enforcement Assistance

A framework is to be established for the assistance of toll enforcement based on the negative list. The negative list consists of the license plate numbers of the vehicles of unlawful passage without adequate toll payment responding to the vehicle classification. The list is to be updated/managed by the OBU management center and to be delivered every two hours to all road operators and all toll management centers of the whole expressways and other toll roads.

Figure 7.9.1   Framework for Toll Enforcement Assistance

Source: VITRANSS 2 Study Team

(1) Issues and Measures

Enforcement support procedure in Vietnam shall be discussed based on the following policy:

(i)   Capability to establish secure enforcement of toll collection

(ii)   Possibility to install system in limited space without additional land acquisition

(iii) Installation/operation at low cost by utilizing legal system and existing manpower

(iv) Capability of shift to multi-lane free-flow without major system replacement.

Toll collection system needs the enforcement support procedure to address the following cases:

(i)   Mistake: Not turning on OBU, not putting IC-card into OBU, or not preparing enough prepaid balance of IC-card

(ii)   Failure: Abnormality in function of OBU or IC-card

(iii) Spoofing: Re-installing OBU to other vehicle not registered, revamping OBU, falsifying the license number in OBU, or tampering the bank account in IC-card

(iv) Cheating: Deforming or masking the license plate, falsifying the vehicle class data in OBU, or tampering the prepaid balance in IC-card

(v)   Violation: Unlawful passage without toll payment or available payment method.

In these cases, some kind of spoofing can be detected automatically by using sensors; however, it is difficult to distinguish cheating and violation from mistake and failure without manpower.

The following legal conditions needs to be prepared in advance of introducing ETC to complete the framework of enforcement:

(i)   The legal toll payer is to be defined: such as IC-card owner.

(ii) Mistakes are restrained by back tax: such as 2-fold of the regular toll amount.

(iii) Crimes are deterred by punishment: such as 10-fold of the regular toll amount.

Present conditions of the penalty informative for toll enforcement are shown in Section 6.7.

Countermeasures for enforcing toll collection shall be prepared as shown below.

Figure 7.9.2   Concept of Countermeasures for Enforcing Toll Collection
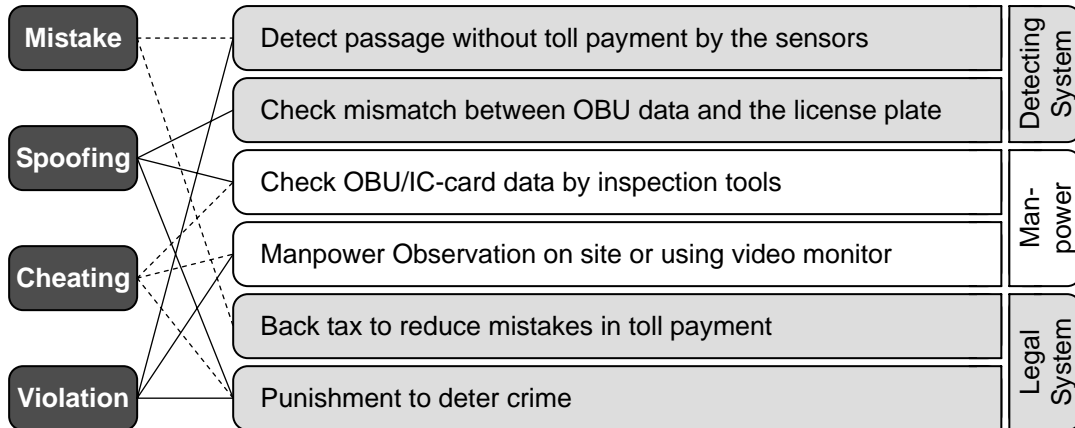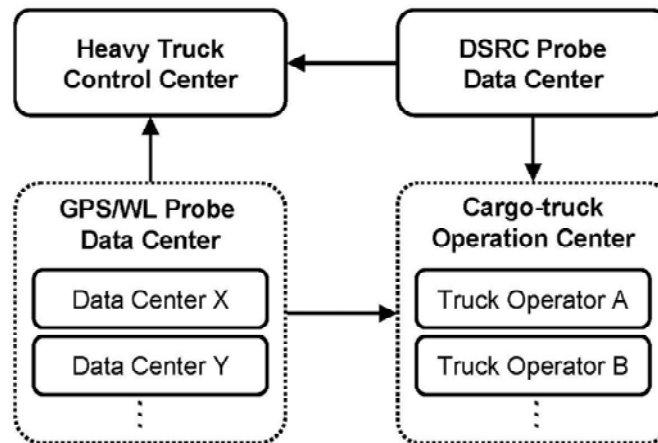

Source: VITRANSS 2 Study Team

7.10   Framework for Heavy Truck Control

Positioning data of the heavy/hazardous-material trucks are to be generated in the centers of DSRC probe and GPS/WL probe, and are to be provided to the centers of heavy truck control and cargo-truck operation. The GPS/WL probe centers are already set up for providing the service of driving recorder, such as Vina-Track and VECOM-FMS, and issue/register the on-board sensors to the cargo-truck operators. ($\rightarrow$ See Sections 2.5 and 2.6.)

Figure 7.10.1   Framework for Heavy Truck Control

Several companies already began the service for driving recorder such as Viba-Track and VECOM-FMS.
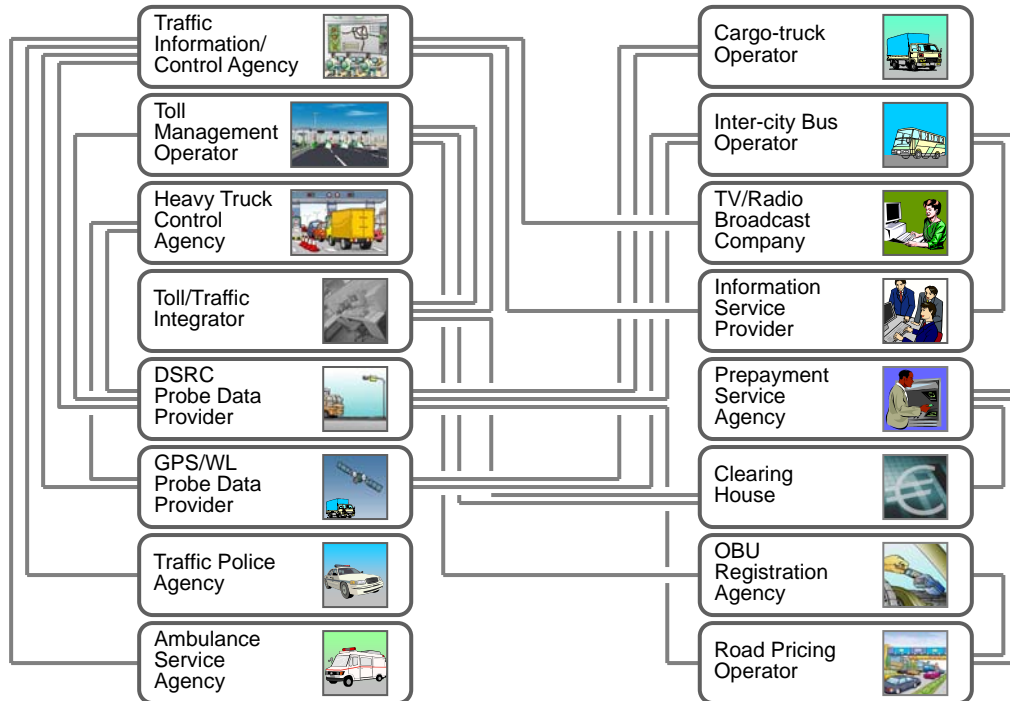Source: VITRANSS 2 Study Team

This framework can be obtained by combining the frameworks for DSRC probe and GPS/WL probe aforementioned. This combination provides the sufficiency in the time intervals of positioning vehicle and the accuracy to distinguish the expressway paralleling closely with the other road for the vehicle operation.

7.11 Total Framework and Roles of Organizations

By compiling the results of the discussion on the operating frameworks in the foregoing sections and the system architecture shown in *Appendix 1*, the total framework of ITS operation is illustrated by the figure below.

Figure 7.11.1   Total Framework of ITS Operation

Source: VITRANSS 2 Study Team

The roles of each operating organizations in the framework above are summarized in the following tables.

Table 7.11.1   Roles of Organizations (1)

Operating Organizations	Operation Outline
Traffic Information/ Control Agency	• Operation of the traffic information/control center • (Patrol car operation, incident notification, traffic event data generation/ storage, and incident/traffic information dissemination) • Operation of roadside equipment for traffic information/control • (CCTV monitoring, image recognition, emergency telephone reception, vehicle detection, weather sensing, and VNS/GSM indication) • Operation of in-vehicle equipment for traffic information/control • (Patrol car radio communication).

Toll Management Operator	• Operation of the toll management center
	  (Toll management, and vehicle passage data provision for DSRC probe)
	• Operation of roadside equipment for non-stop toll collection
	  (Toll collection, vehicle identification/classification, DSRC, lane control, and CCTV monitoring).

Source: VITRANSS 2 Study Team

Table 7.11.2   Roles of Organizations (2)

Operating Organizations	Operation Outline
Heavy Truck Control Agency	● Operation of the heavy truck control center (Overloading check, and truck tracking) ● Operation of roadside equipment for heavy truck control (Axle-load weighing).
Toll/Traffic Integrator	● Operation of the toll/traffic integration center (Toll/traffic data crosscheck).
DSRC Probe Data Provider	● Operation of the DSRC probe data center (Vehicle passage tracking by DSRC probe)
GPS/WL Probe Data Provider	● Operation of the GPS/WL probe data center (Vehicle position tracking by GPS/WL probe) ● Operation of in-vehicle equipment for heavy truck control (GPS/WL on-board sensor issuance/registration).
Traffic Police Agency	● Operation of the traffic police operation center (Patrol car operation, incident notification, and incident/traffic information reception).
Ambulance Service Agency	● Operation of the ambulance service center (Ambulance operation, and incident/traffic information reception).
Cargo-Truck Operator	● Operation of the cargo-truck operation center (Cargo-truck operation, and incident/traffic information reception) ● Operation of in-vehicle equipment for DSRC and GPS/WL probe (OBU operation, and GPS/WL sensor operation).
Inter-city Bus Operator	● Operation of the inter-city bus operation center (Inter-city bus operation, and incident/traffic information reception) ● Operation of in-vehicle equipment for DSRC and GPS/WL probe (OBU operation, and GPS/WL sensor operation).
TV/Radio Broadcast Company	● Operation of the TV/radio broadcasting center (Incident/traffic information reception/dissemination)
Information Service Provider	● Operation of the information center ● (Incident/traffic information reception/dissemination)
Prepayment Service Agency	● Operation of the prepayment service center (Bank account management, total prepayment amount management, and issued/lost IC-card management) ● Operation of in-vehicle equipment for non-stop toll collection (IC-card issue/recharge service).
Clearing House	● Operation of the clearing center (Claim for toll payment settlement, and IC-card list management)
OBU Registration Agency	● Operation of the OBU registration center (Issued/lost OBU management, and negative list management) ● Operation of in-vehicle equipment for non-stop toll collection (OBU issue/registration).
Road Pricing Operator	● Operation of the road pricing operation center (Road pricing operation, and vehicle passage data provision for DSRC probe).

Source: VITRANSS 2 Study Team

8 FRAMEWORK OF ROAD OPERATION USING ITS

8.1 General

Conceivable types of functional allocation for road operation are discussed first in this chapter, and the recommended type is indicated through the comparisons among them. The basic policies are subsequently mentioned on the following items of ITS implementation:

(i) Function allocation for road operation

(ii) Arrangement and cooperation of the centers

(iii) Stepwise implementation of ITS.

In this context, communication network for ITS is discussed from the following three aspects:

(i) Structure of backbone network

(ii) Installation of fiber optic cable

(iii) Transmission method.

8.2 Function Allocation for Road Operation

The following types are compared as the functional allocation for the road operation using ITS:

(i) TYPE-0 on integrated traffic information/control

(ii) TYPE-1 on shared IC-cards issued by banks

(iii) TYPE-1a on toll/traffic crosscheck

(iv) TYPE-1b on communication system operated by new organization.

All functions for road operation are allocated only to the road operator in the case of TYPE-0. On the other hand, in the other cases, IC-card is issued by the banks and functions are allocated respectively to the appropriate organizations other than the road operator.

(1) TYPE-0 on Integrated Traffic Information/Control

As shown in the figure in the following page, equipment for toll collection, traffic information and other road facilities are installed on roadside, and communication equipment is implemented for making a network among them.

Management offices of the road operators are arranged on the road network for operating and managing roadside equipment separated into the following four lines, which are mentioned in Table 4.2.1:
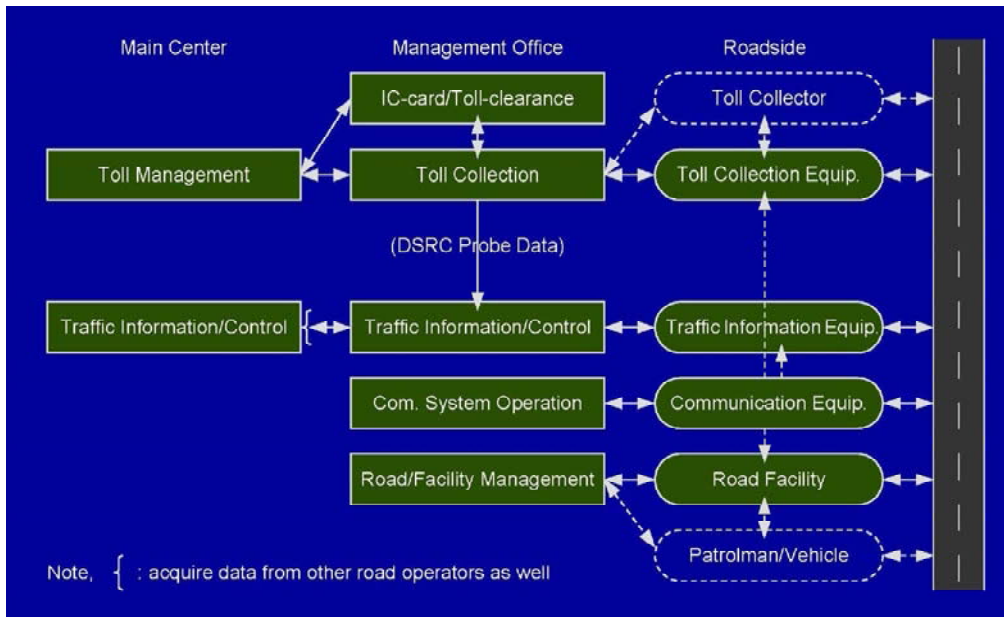
(i) Toll collection

(ii) Traffic information/control

(iii) Road/facility management

(iv) Communication system management.

These four lines are consolidated within each road operator; in addition, the traffic information/ control needs to be performed covering the road network that includes many neighboring road sections operated by different road operators. The traffic

information/control is to be integrated by the main center.

**Figure 8.2.1   TYPE-0 on Integrated Traffic Information/Control**

Source: VITRANSS 2 Study Team

(2) TYPE-1 on Shared IC-cards Issued by Banks

In TYPE-1, the functions of IC-card operation and toll clearance are separated from toll collection and allocated in the banks outside of the road operator for efficiency of road operation and convenience to the users, which is shown in Figure 8.2.2 from another perspective.

**Figure 8.2.2   TYPE-1 on Shared IC-cards Issued by Banks**
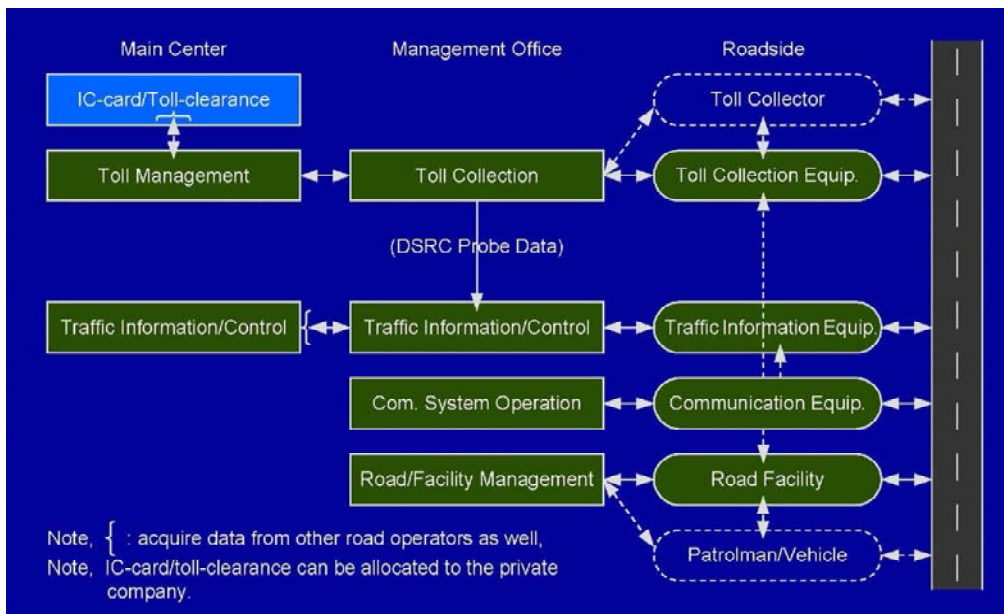
Source: VITRANSS2 Study Team

(3) TYPE-1a on Toll/Traffic Crosscheck

In TYPE-1a, the function for crosscheck between toll revenue and traffic volume are established. Appropriate and reliable apportionment of toll revenue among the road

operators by prevention of unfair billings to the prepayment service center is secured for setting up a sustainable concession system for road operation.

**Figure 8.2.3   TYPE-1a on Toll/Traffic Crosscheck**
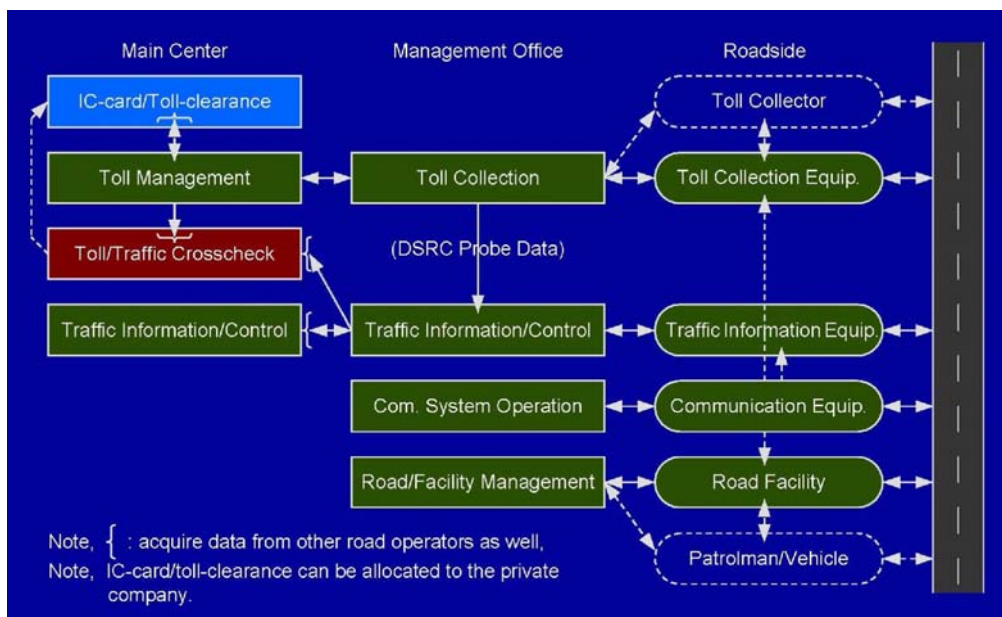
Source: VITRANSS 2 Study Team

(4) TYPE-1b on New Organization for Communication System Operation

In TYPE-1b, the function of communication system operation is allocated to the exclusive organization outside of the road operator, for cutting costs, as below.

Figure 8.2.4   TYPE-1b on New Organization for Communication System Operation
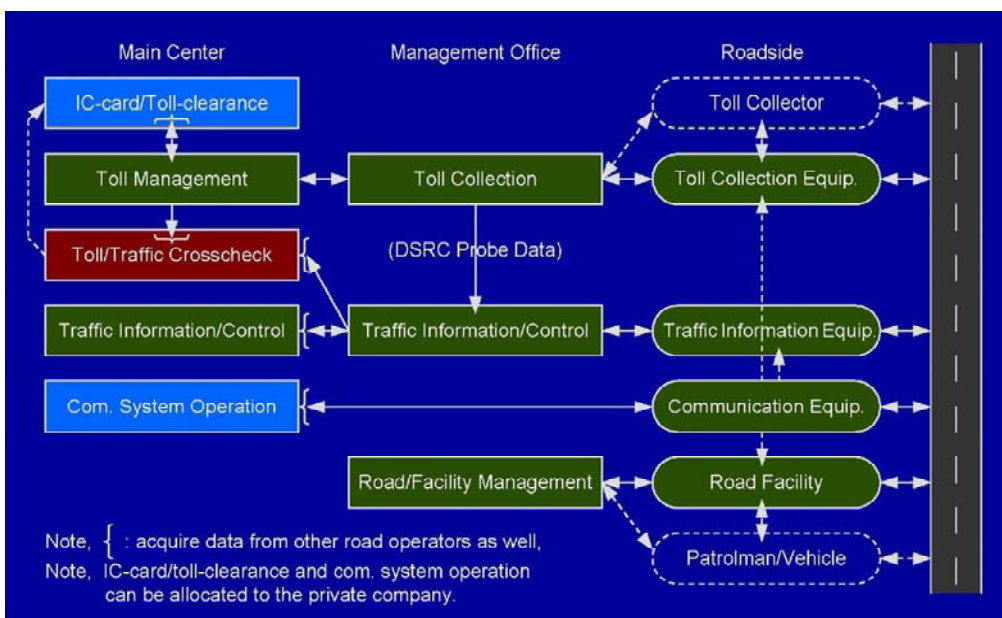
Source: VITRANSS 2 Study Team

A communication system operated exclusively for road operation brings only the cost.   On the other hand, a communication system operated for broader use, including telecommunication service brings large profits.   It is necessary to discuss setting up a new organization, such as a private company, for the communication system operation.

(5) Comparison of Function Allocation

The advantages/disadvantages of the four types of function allocations aforementioned are summarized in the table below, and TYPE-1b is recommended.

Table 8.2.1   Comparison of Function Allocations

	TYPE-0	TYPE-1	TYPE-1A	TYPE-1B
Traffic Information/Control Integration at Main Center	Established	Established	Established	Established
IC-card Issue Organization	Road Operator	Bank	Bank	Bank
Cost-cutting on IC-card Operation for Road Operator	Incapable	Capable	Capable	Capable
Toll/Traffic Crosscheck	Not Established	Not Established	Established	Established
Reliability on Toll Revenue	Not High	Not High	High	High
Communication Network Management Organization	Road Operator	Road Operator	Road Operator	New Organization
Cost-cutting on Com-net. Management for Road Operator	Incapable	Incapable	Incapable	Capable
Grading	Not Suitable	Not Suitable	Comparable	Recommended

Source: VITRANSS 2 Study Team