4 ROAD OPERATION/MAINTENANCE SERVICE TO BE PROVIDED

4.1 General

Outlines of the road operation/maintenance are mentioned in this chapter. The policy of a combined toll rate system is proposed for the road network in the metropolitan area. The policies of toll revenue are mentioned and the policy of vehicle classification is assumed for the discussion in the following chapters.

Finally, the minimal service requirements for expressways are proposed for discussing the required service level of ITS quantitatively in the Master Plan.

4.2 Road Operation/Maintenance

1) Outlines of Road Operation/Maintenance

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

Table 4.2.1 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 serve a safe and comfortable drive and smooth traffic flow.	
(4) Communication System Management Fiber optic cable network system operation and management.	

Source: VITRANSS 2 Study Team

There can be the case where a single organization is in charge both of construction and operation/maintenance of the road section; however, some parts of them can be transferred to the other organization under contract.

(1) Road/Facility Management

Road/facility management includes the service items below and the scope and purpose of each are to be standardized.

(i) Energy and water supply

(ii) Cleaning-up (for safety)

(iii) Green space management (for environment conservation)

(iv) Checkups of structure and facility

(v) Disaster recovery.

These service items are to be carried out by the road operator itself or by other organization under contract. Some items need to be carried out at any cost referring to the relevant decrees/laws; however, some items can be decreased in frequency for labor saving. The frequency shall be defined for each service item and is to be readjusted considering the number of claims from road users and the number of incidents occurred.

Performance of the service item shall be evaluated using the outcome index as below:

(i) Rate of accident

(ii) Hours of traffic regulation

(iii) Rate of road structure conservation.

(2) Toll Collection

Toll collection includes the service items below and the scope and purpose of each are to be standardized.

(i) Toll collection process at the roadside

(ii) Toll management/clearance

(iii) IC-card/OBU operation

(iv) Toll enforcement.

These service items need to be carried out by the road operator itself or by other organization under contract according to the regulated toll rate system and the relevant decrees/laws.

Performance of the service item shall be evaluated using the outcome index as below:

(i) Average vehicle processing time

(ii) Rate of ETC vehicles

(iii) Rate of enforced illegal passage.

(3) Traffic Information/Control

Traffic information/management includes the service items below and the scope and purpose of each are to be standardized.

(i) Routine patrol

(ii) Regulation against illegal vehicles

(iii) Traffic surveillance/information-provision

(iv) Traffic regulation/control.

These service items are to be carried out by the road operator itself or by other organization under contract. Some items need to be carried out at any cost referring to the relevant decrees/laws; however, some items can be decreased in frequency for labor saving. The frequency shall be defined for each service item and is to be readjusted considering the number of claims from road users and the number of incidents occurred.

The regulation criteria shall be defined on weight limits, speed limits and lane controls. The speed limits shall respond to the weather conditions and the existence of incident/obstruction.

Performance of the service item shall be evaluated using the outcome index as below:

(i) Rate of accident

(ii) Number of fatalities/injuries

(iii) Hours of delay by traffic congestion.

(4) Communication System Management

Communication system management includes the service items below and the scope and purpose of each are to be standardized.

(i) System management

(ii) Data communication service

(iii) Network lease service.

These service items need to be carried out by the road operator itself or by other organization under contract according to the regulated toll rate system and the relevant decrees/laws.

Performance of the service item shall be evaluated using the outcome index as below:

(i) Actual data traffic

(ii) Hours of system-down.

(5) Maintenance

Subjects of maintenance are as shown below and the scope and purpose of maintenance of each are to be standardized.

(i) Pavement

(ii) Bridge

(iii) Tunnel

(iv) Semi-underground structure

(v) Architectural structure

(vi) Mechanical equipment

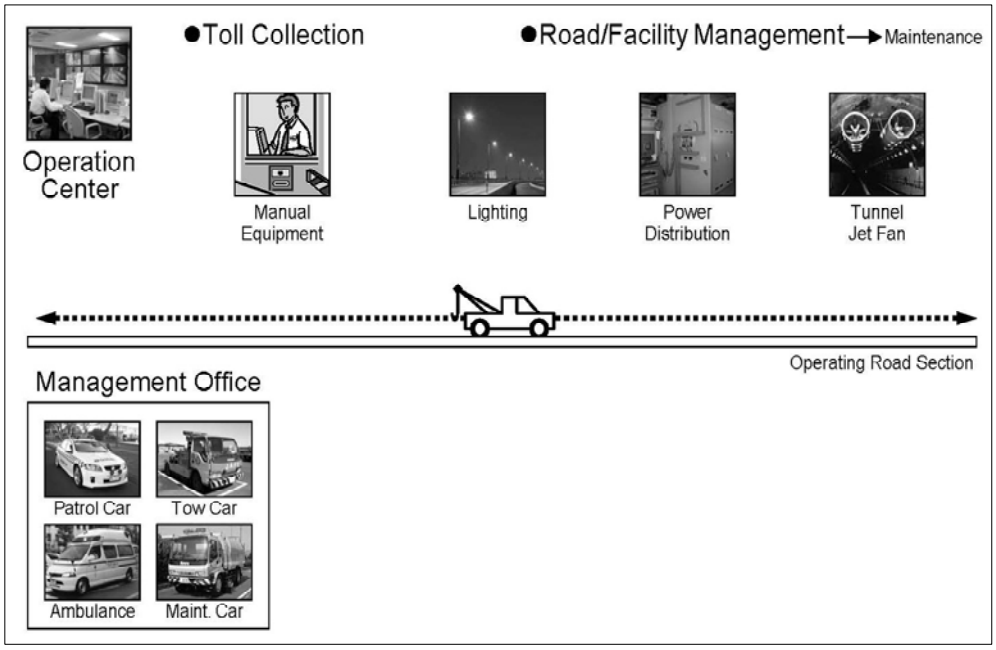
(vii) Electrical equipment.

The evaluation criteria and frequency for maintenance shall be defined for each subject, and the frequency shall be readjusted considering the number of claims from road users and the number of incidents occurred.

2) Road Operation Using ITS

Traditional road operation is based on the standalone systems. That needs to be largely supported by manpower and is likely to waste time.

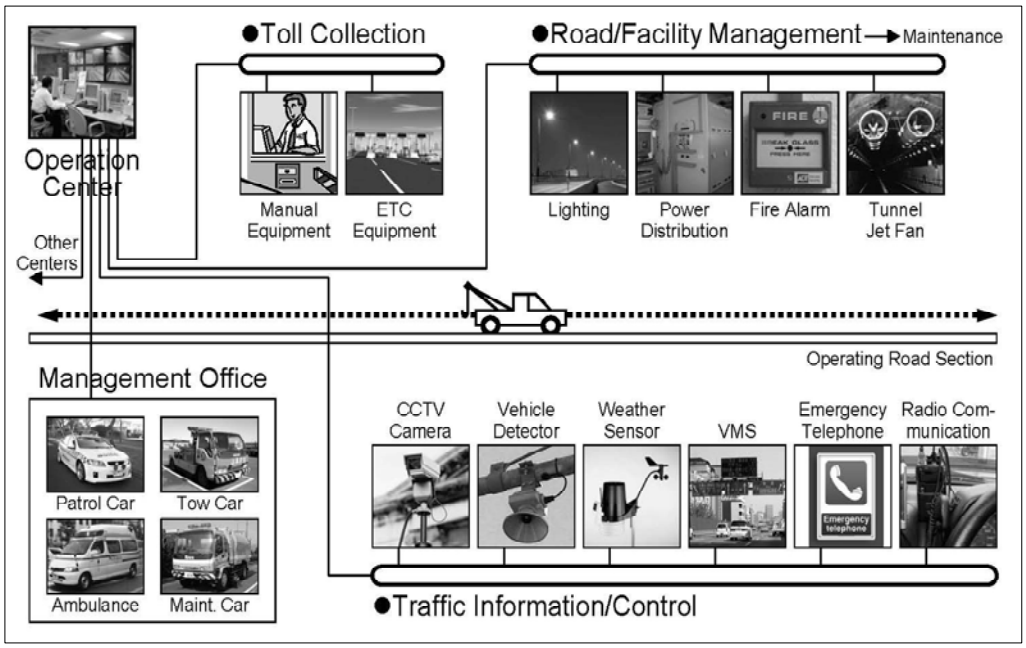
Figure 4.2.1 Traditional Road Operation based on Standalone Systems



Source: VITRANSS 2 Study Team

Advanced way of the road operation is based on ITS and is supported by data change on the communication network. That allows proper judgment and prompt action for the road operator.

Figure 4.2.2 Advanced Road Operation using ITS



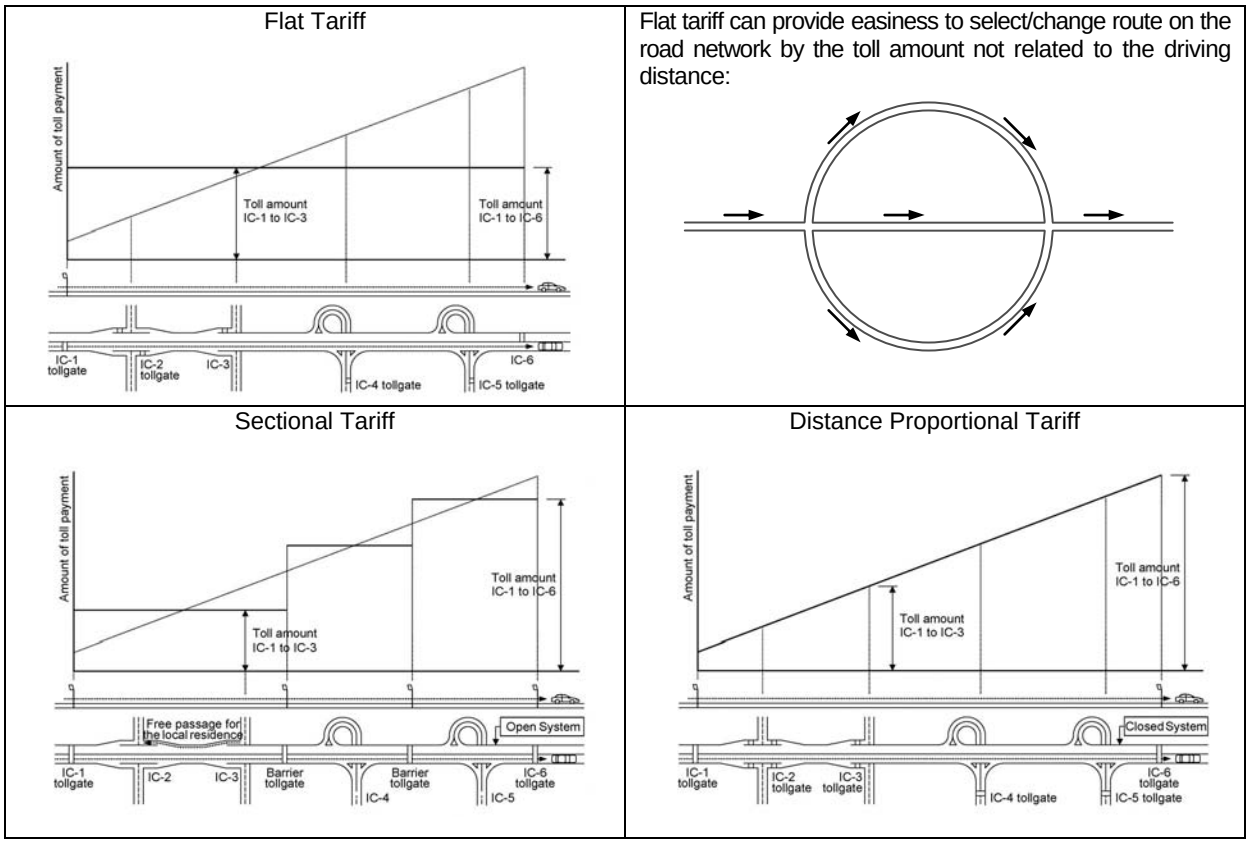
Source: VITRANSS 2 Study Team

4.3 Toll Rate System

1) Policy of Toll Rate System

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

Figure 4.3.1 Three Typical Toll Rate Systems



Source: VITRANSS 2 Study Team

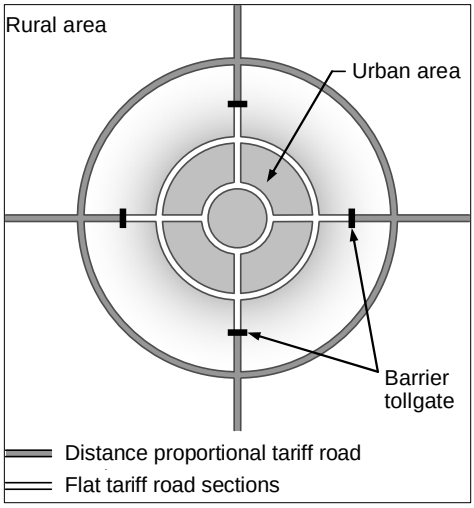
A comparison of these typical toll rate systems is shown in the table below.

Table 4.3.1 Comparison on Typical Toll Rate Systems

	Flat Tariff	Sectional Tariff	Distance Proportional Tariff
Fairness for driving distance	Not secured	Secured	Secured
Evenness of alternative driving route	Secured	Not secured	Not secured
Free passage for the local residents	Not available	Available (Open system)	Not available (Closed System)
Need to stop on the through lanes	Few times	Many times	Few times
Total number of tollgates	Average	Average	Large
Applicability to the inter-city expressways	Not Suitable	Average	Suitable
Applicability to the metropolitan expressways	Suitable	Average	Not Suitable

Source: VITRANSS 2 Study Team

Figure 4.3.2 Combined Toll Rate System for the Metropolitan Area



Source: VITRANSS 2 Study Team

Distance proportional tariff is suitable for the inter-city road network in the rural area. However, in the near future, effective utilization of the road network by dispersing concentrated traffic will become main issue in urban areas in Vietnam. Flat tariff is suitable for such cases. On that account, a combined toll rate system shown in the figure is to be adopted for the metropolitan areas in common with the metropolises in other countries, such as Tokyo and Jakarta.

Accordingly, in the Master Plan, the three toll rate systems aforementioned shall be considered in the discussion of a toll collection system.

2) Toll Levels

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

(i) Costs of construction and operation/maintenance of the road (or the expressway)

(ii) Benefits that road users can obtain by using the road (or the expressway)

(iii) Harmonization with the tariff rates of the existing national highways and the existing inter-city buses/railways

(iv) Financial independence/profitability of the road operator (or the expressway operator).

Toll amount can be set at the different levels as below.

(a) **Toll Level [A]:** This level requires collecting the toll equivalent to the economic benefits that road users can obtain totally by using the road. This level can be estimated by economic analysis based on the traffic demand.

(b) **Toll Level [B]:** This level requires collecting the toll for total cost of the road including construction cost and operation/maintenance cost. This level can be estimated by cost analysis.

(c) **Toll Level [C]:** This level requires collecting the toll for operation/maintenance cost of the road. This level can be estimated by cost analysis.

(d) **Toll Level [D]:** This level requires collecting the toll amount which road users feel acceptable (in consideration of the obtained benefits). The amount can be estimated by researching the willingness-to-pay of the road users.

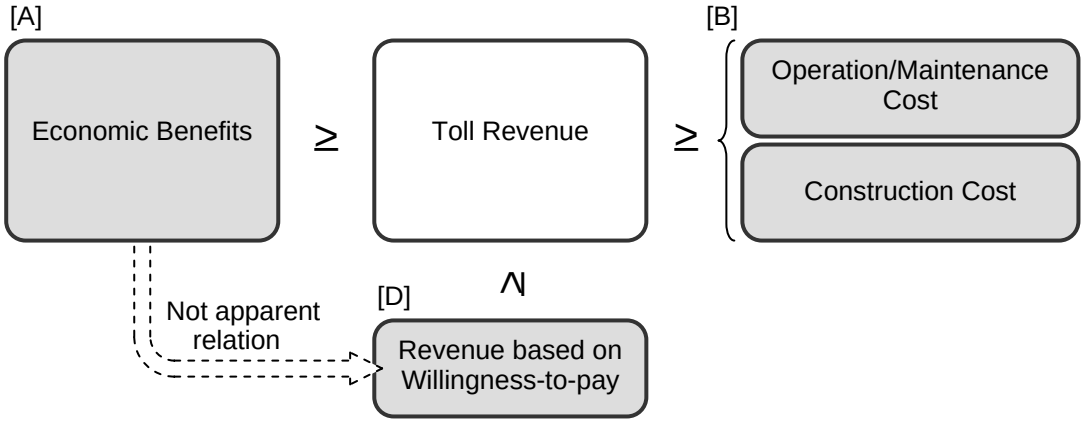
3) Target Level of Toll Revenue

The policy on defining the target toll revenue for the road including the expressway network is to be selected from the alternatives such as mentioned below.

(1) To Cover Total Cost

Target level of toll revenue can be set to cover the total cost of the road, less than or equivalently to the economic benefits that road users can totally obtain, where Toll Level [A] ≥ Toll Level [B]. That is the happiest condition for collecting the toll. Financial independence/profitability of the road operator can be secured only by the toll revenue.

Figure 4.3.3 Toll Revenue to Cover Total Cost

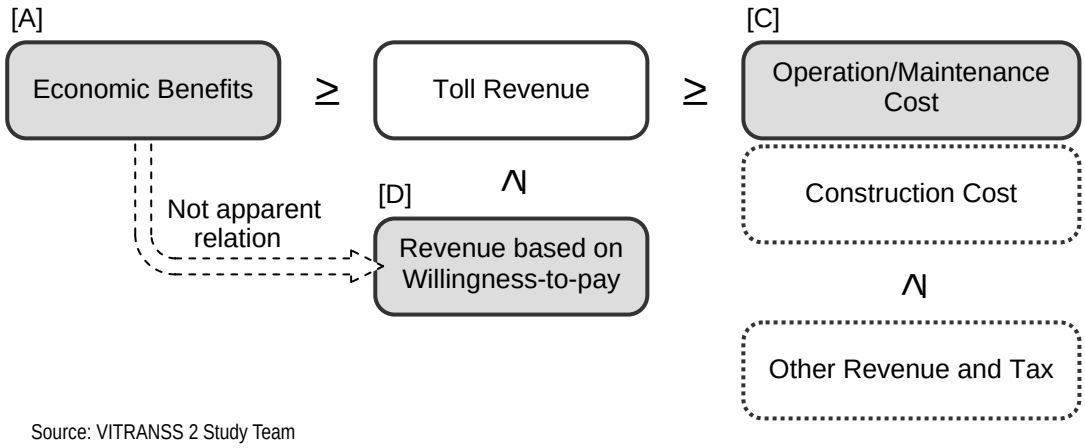


Source: VITRANSS 2 Study Team

(2) To Cover Operation/Maintenance Cost

Target level of toll revenue can be set to cover the operation/maintenance cost of the road, less than or equivalently to the economic benefits that road users can totally obtain, where Toll Level [B] > toll Level [A] ≥ Toll Level [C]. That is likely to exist in Vietnam because income level of the road uses is not so high. Financial independence/profitability of the road operator is secured by the revenue of toll and other business and tax. Other business can be developed by utilizing the communication network of ITS. (→ See Table 4.3.4.)

Figure 4.3.4 Toll Revenue to Cover Operation/Maintenance Cost



Source: VITRANSS 2 Study Team

4.4 Minimal Service Standard

1) Role Sharing on Road Operation/Maintenance

The ownership of the road facility is in public organization; however the role sharing between the public and private organizations shown in the table below needs to be considered in the discussion on the road operation/maintenance.

Table 4.4.1 Role Sharing between Public and Private Organization

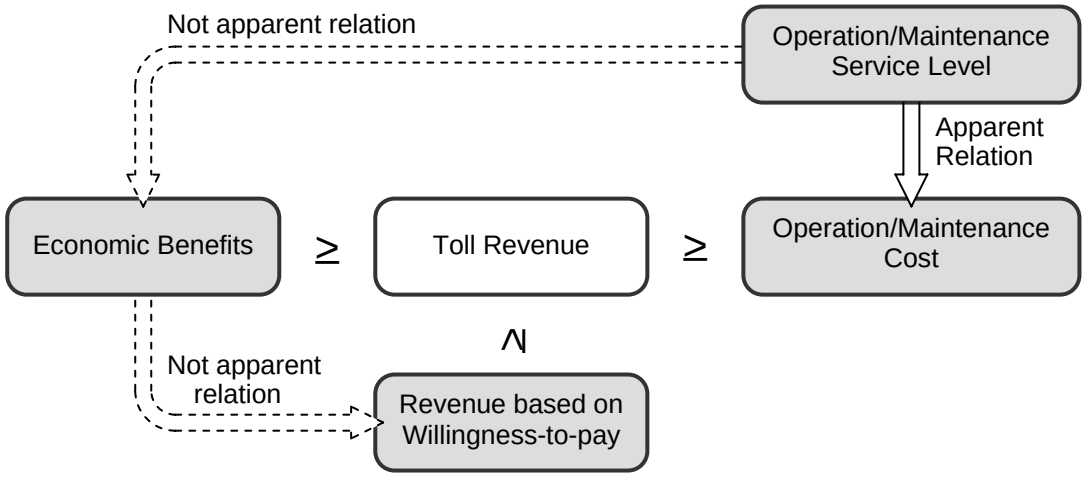
	Service Contract	Management Contract	Lease Contract	O/M Concession
Roles of Public Org.	• Ownership of the road facility. • Responsible for O/M service, funding capital investments and tariff setting.	• Ownership of the road facility. • Ultimately responsible for O/M service, and responsible for funding capital investments and tariff setting.	• Ownership of the road facility. • Responsible for new and replacement investments, establishing performance standard and monitoring.	• Ownership of the road facility. • Responsible for establishing performance standard and monitoring.
Roles of Private Org.	• Transferred O/M services only in working level by fee payment from public org.	• Transferred O/M services including daily management level by fee payment from public org. • Responsible for preparation of working capital.	• Responsible for service provision including O/M, collecting toll and making a specified lease payment to public org. • Responsible for working capital and rehabilitation cost.	• Responsible service provision including O/M and collecting toll based on the concession contract. • Responsible for all capital investment as well as for working capital.
Revenue Risk	Public	Public	Private	Private

Source: VITRANSS 2 Study Team

2) Necessity of Minimal Service Standard

Improvement in the road operation/maintenance causes apparently a cost rise and a decrease in profits for the road operator. However, it is not easy to raise the toll amount, because the increase in benefit and willingness-to-pay of the road users is not apparent. On that account, the operator tends to be effortless in improvement of the road operation/maintenance.

Figure 4.4.1 Relation between O/M Service Level and Toll Revenue

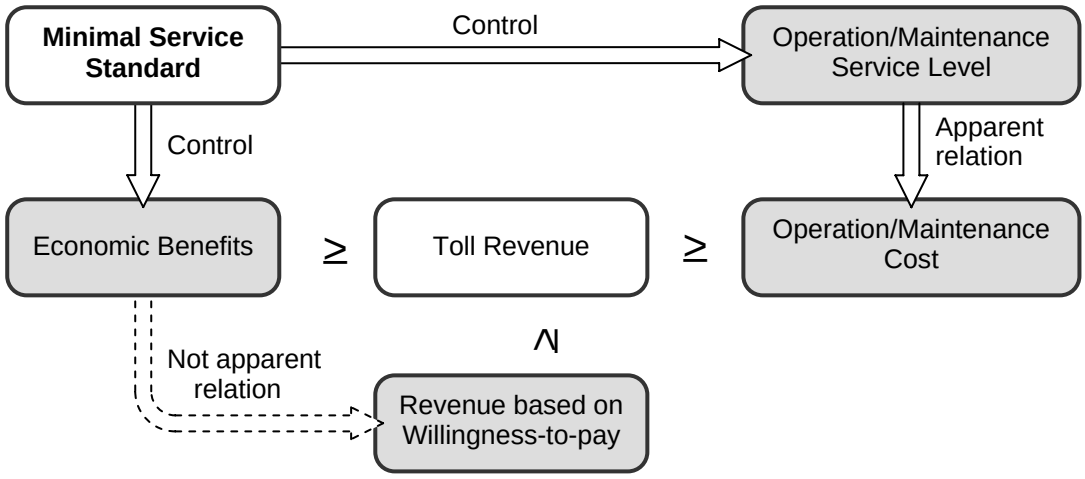


Source: VITRANSS 2 Study Team

Consequently, minimal service level of the road operation/maintenance shall be defined as the standard. The minimal service standard allows to control the operation/maintenance service level of the road operators as shown in the figure below. In addition, a rise in the

specific toll amount is to be accepted responding to the degree of achievement of the minimal service level by the road operator.

Figure 4.4.2 Minimal Service Standard for Controlling O/M Service Level



Source: VITRANSS 2 Study Team

3) Minimal Service Requirements for the Expressways

The service substances below are to be described in the minimal service standard.

(i) Road conditions
(ii) Accessibility
(iii) Mobility
(iv) Safety
(v) Response to incident
(vi) Environmental protection.

For the discussion of ITS in the Master Plan, the following conditions of service substances are proposed as the minimal service requirements for the expressways.

(1) Road Conditions

- Overloading regulation to restrain damage by heavy vehicles to the road structures.

(2) Accessibility

- Average service-time less than 4.5sec/vehicle by non-stop toll collection,
- Average service-time less than 6.0sec/vehicle by one-stop toll collection,
- Reliable toll collection with error ratio on evaluating sufficiency of prepaid balance less than 0.01%.

(3) Mobility

- Average travel speed more than 60 km/h
- Surveillance and information dissemination of traffic congestion (vehicle speed continuously less than 40 km/h on the expressway)
- Information update for dissemination every 15 minutes.

(4) Safety and Response to Incident

- Surveillance and information dissemination of incidents (including left obstruction and natural disaster on the road)
- Establishment of the management office facilitated by the monitoring equipment for surveillance and the operation vehicles (including a patrol car, an ambulance, a tow car and a maintenance car)
- Time required to send the operation vehicles to the incident site less than 1 hour from the occurrence of incident
- Notification of the occurrence of the incident to the road operator within 10 minutes even in the mountainous areas.

5 IMPLEMENTATION PACKAGES AND SYSTEM ARCHITECTURE

5.1 General

The concept of implementation packages is clarified first in this chapter. Subsequently, the specific implementation packages and their alternatives are defined responding to the priority ITS user services by using the following descriptions:

(i) Service requirements
(ii) Breakdown of implementation packages
(iii) System descriptions
(iv) Supplementary explanation.

As the result of discussion on the implementation packages, the total system architecture is illustrated for ITS implementation on the inter-city road network. The details necessary for specifying the requirements of ITS standards are shown in ***APPENDIX-1***. Finally, the recommendations on the alternatives of the following technologies are mentioned:

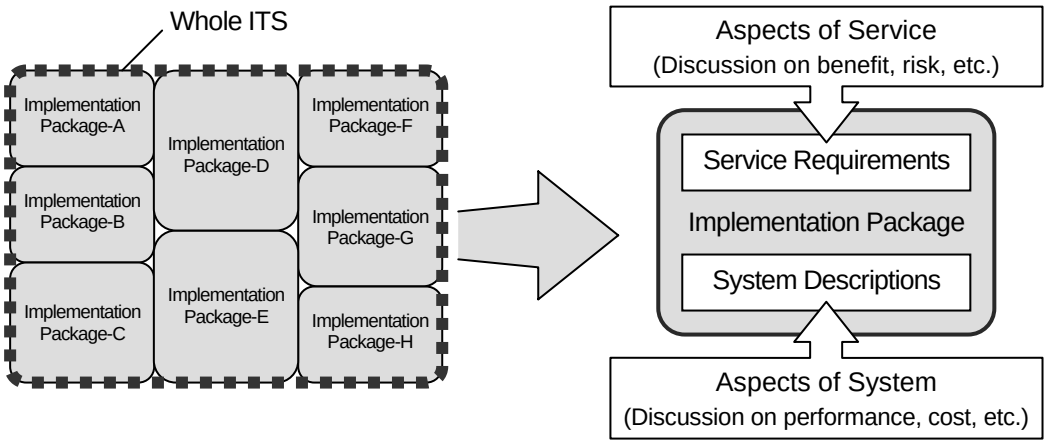
(i) CCTV camera
(ii) Vehicle detection
(iii) VMS (Variable Message Sign)
(iv) Road-to-vehicle communication for ETC
(v) Contact-less IC-card.

(Relevant international standards are shown in ***APPENDIX-2***.)

5.2 Concept of Implementation Package

As a whole, ITS consists of a number of packages suitable for stepwise implementation and for the selection suited to regional properties. These are named as implementation packages in the Master Plan. The concept of implementation packages provides a common ground for the discussion of two aspects as shown below and allows sharing of specific recognition of ITS among the persons in charge.

Figure 5.2.1 Concept of Implementation Package



Source: VITRANSS 2 Study Team

Implementation packages for the priority ITS user services are specified in the following.

5.3 Implementation Packages for Traffic Information/Control

1) Service Requirements

Traffic information/control is the priority ITS user service whose implementation is to be started in the 1st stage (by 2015) as shown in Chapter 3. That can be detailed and defined by the following service requirements. Reference numbers attached to the subtitles indicate the corresponding implementation packages and the alternatives to be hereinafter described.

(1) Incident Information → 1-(a), (b)

(a) 1st Stage

(i) Receiving information of incident occurrence/place/situation, including left obstruction and natural disaster on the road, from the person concerned or the witness by 10 minutes at the latest,

(ii) Round-the-clock surveillance at the incident-prone spots,

(iii) Notification to the road operation vehicles immediately after receiving the information of incident,

(iv) Arrival of the road operation vehicles at the site by 1 hour at the latest from the incident occurrence,

(v) Decision/implementation of traffic restriction immediately after arrival of the road operation vehicles,

(vi) Incident/restriction information dissemination to the drivers en-route on adjacent section immediately after the decision of restriction, and prevention of the secondary incidents,

(vii) Information update every 15 minutes for dissemination,

(viii) Prompt incident/restriction information dissemination to the drivers en-route for reducing vehicles to the concerned section,

(ix) Prompt incident/restriction information dissemination to the drivers in advance.

(b) 3rd Stage

(i) Round-the-clock surveillance on the selected continuous road sections,

(ii) Compiling/storing/providing data for incident information.

Figure 5.3.1 Incident Information

Source: Southern Vietnam Expressway FS by JETRO

(2) Weather Information → 4

(a) 1st Stage

(i) Round-the-clock monitoring of rainfall, wind direction/velocity and temperature at every interchange on the expressway network,

(ii) Weather information dissemination, as needed, to the drivers en-route/in-advance,

(iii) Information update every 15 minutes for dissemination,

(iv) Compiling/storing/providing data for weather information.

(3) Center-to-center Data Exchange for Incident Notification → 9-1

(a) 1st Stage

(i) Round-the-clock information reception of incident occurrence/situation/place at the traffic information/control center from the traffic police operation center,

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

(b) 2nd Stage

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

(4) Traffic Congestion Information → 2-(a), (b), (c), (d), (e)

(a) 1st Stage

(i) Receiving information of congestion caused by an incident from the road operation vehicle,

(ii) Round-the-clock surveillance at the congestion-prone section,

(iii) Detecting the congestion with length of 1 km or further,

(iv) Analyzing property of existing traffic excluding disturbing factors,

(v) Decision/implementation of the restriction of incoming traffic as needed at the interchange,

(vi) Traffic congestion information dissemination to the drivers en-route on adjacent section immediately after grasping the congestion for prevention of the collision from behind, and to the drivers en-route/in-advance as needed,

(vii) Prompt restriction information dissemination to the drivers en-route/in-advance.

(viii) Information update every 15 minutes for dissemination.

(b) 3rd Stage

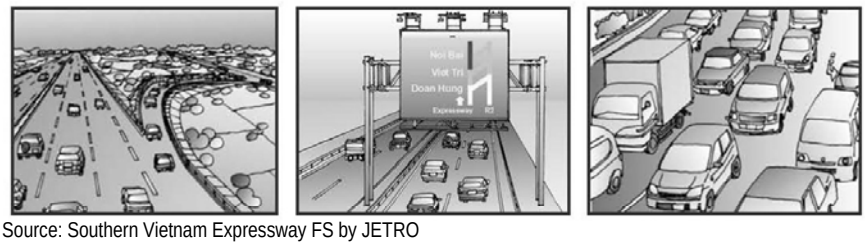
(i) Round-the-clock surveillance on the selected continuous road sections,

(ii) Analyzing property of traffic, and forecasting the congestions,

(iii) Congestion forecast information dissemination to the drivers en-route/in-advance.

(iv) Compiling/storing/providing data for traffic congestion information.

Figure 5.3.2 Traffic Congestion Information



Source: Southern Vietnam Expressway FS by JETRO

(5) Center-to-center Data Exchange for DSRC Probe → 9-2

(a) 2nd Stage

(i) Generating DSRC probe data at the DSRC probe data center using data from the toll management center and the road pricing operation center and excluding disturbing factors caused by the measurement,

(ii) Provision of the generated data to the traffic information center, the cargo-truck operation center and the inter-city bus operation center,

(iii) Data update every 15 minutes for provision.

(6) Center-to-center Data Exchange for GPS/WL Probe → 9-3

(a) 2nd Stage

(i) Generating GPS/WL probe data at the GPS/WL probe data center using data from the cargo-truck operation center and the inter-city bus operation center and excluding disturbing factors caused by the measurement,

(ii) Provision of the generated data to the traffic information center, the cargo-truck operation center and the inter-city bus operation center,

(iii) Data update every 15 minutes for provision.

(7) Travel-time Information → 3-(a), (b), (c), (d)

(a) 2nd Stage

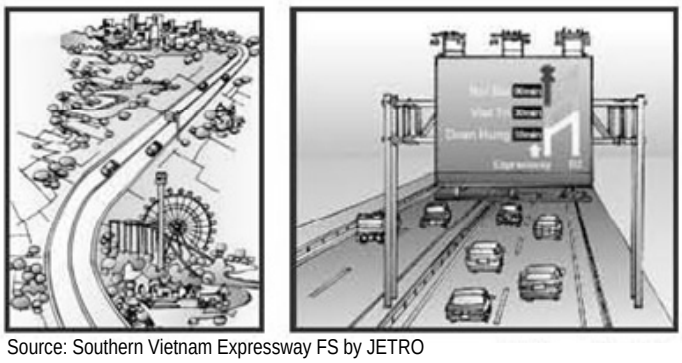
(i) Analyzing/estimating travel-time between the interchanges and the junctions on the whole expressway network excluding disturbing factors,

(ii) Travel-time information dissemination to the drivers en-route/in-advance as needed,

(iii) Information update every 15 minutes for dissemination,

(iv) Compiling/storing/providing data for travel-time information.

Figure 5.3.3 Travel-time Information



Source: Southern Vietnam Expressway FS by JETRO

(8) Center-to-center Data Exchange for Travel Information → 9-4

(a) 1st Stage

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

(b) 3rd Stage

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

(9) Traffic Control Assistance → 5-(a), (b), (c), (d), (e)

(a) 1st Stage

(i) Notification to the road operation vehicles immediately after receiving the information of incident,

(ii) Arrival of the road operation vehicles at the site by 1 hour at the latest from the incident occurrence,

(iii) Decision/implementation of traffic restriction immediately after arrival of the road operation vehicles,

(iv) Incident/restriction information dissemination to the drivers en-route on adjacent section immediately after the decision of restriction, and prevention of the secondary incidents,

(v) Prompt incident/restriction information dissemination to the drivers en-route for reducing vehicles to the concerned section,

(vi) Traffic congestion information dissemination to the drivers en-route on adjacent section immediately after grasping the congestion for prevention of the collision from behind,

(vii) Decision/implementation of the restriction of incoming traffic at the interchange as needed,

(viii) Prompt restriction information dissemination to the drivers en-route,

(ix) Information update every 15 minutes for dissemination.

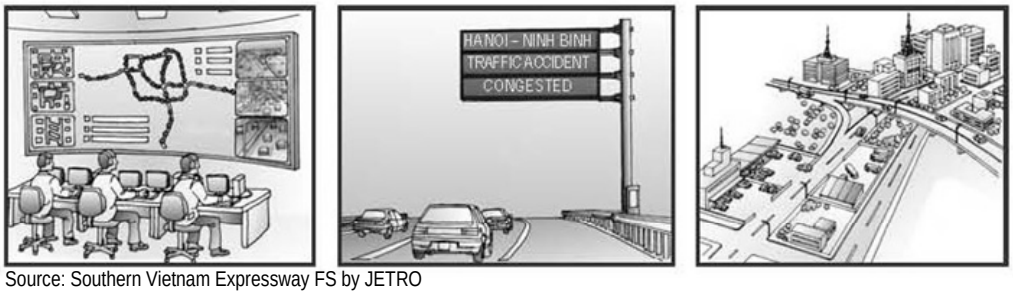
(b) 2nd Stage

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

(c) 3rd Stage

(i) Congestion forecast information dissemination to the drivers en-route.

Figure 5.3.4 Traffic Control Assistance

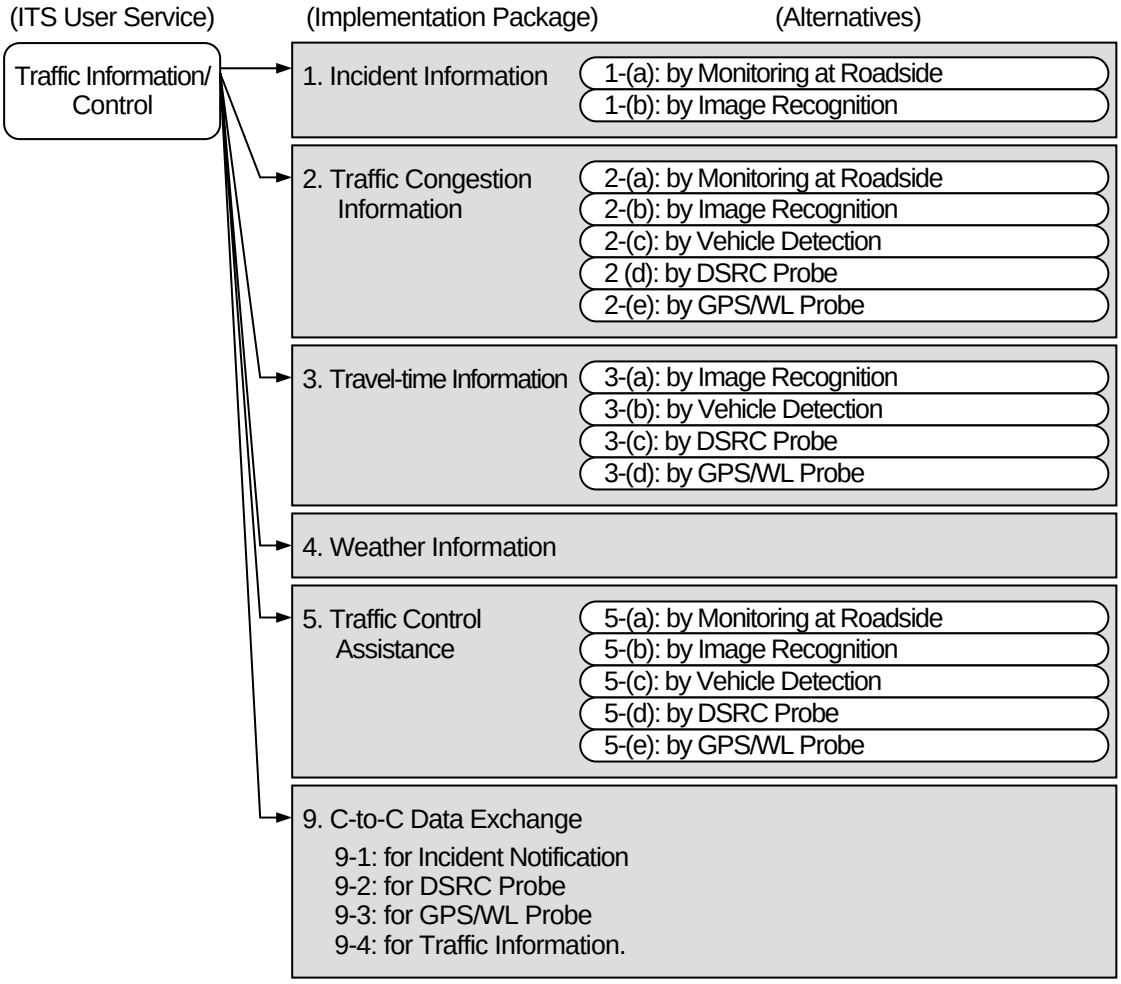


Source: Southern Vietnam Expressway FS by JETRO

2) Breakdown of Implementation Packages

Traffic information/control can be broken down into six implementation packages as shown below. Each package has one or more alternatives, and four use cases are assumed for the package of center-to-center data exchange.

Figure 5.3.5 Implementation Packages and Alternatives of Traffic Information/Control



	by Monitoring at Roadside	by Image Recognition	by Vehicle Detection	by DSRC Probe	by GPS/WL Probe
Key-device of Alternative					

Source: VITRANSS 2 Study Team / Oriental Consultants Co., Ltd.

System descriptions for the traffic information/control are shown in the following pages and in ***Appendix 1***, corresponding to the implementation packages and the alternatives above.

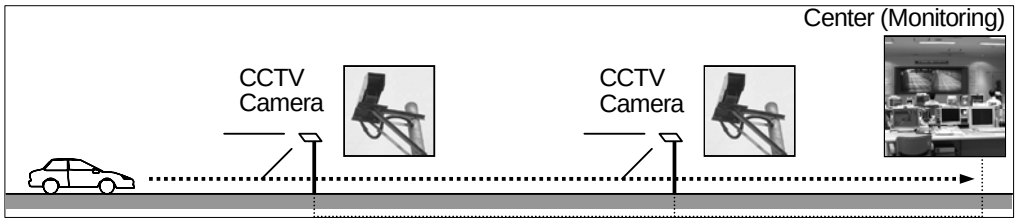
3) System Descriptions

(1) Incident Information

(a) Monitoring at Roadside

Road traffic condition is captured by the camera at roadside with adequate location and angle of view. Human operator identifies traffic accidents, broken-down vehicles, left obstructions and natural disaster by monitoring the captured video image. The data is compiled into the message of incident information and disseminated through VMS and other channels to the drivers.

Figure 5.3.6 Monitoring at Roadside



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.1)).

(ii) **System Architecture: (**shown by the collaboration diagram in ***Appendix 1*** (A1.1)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.1)).

(iv) **Needed Standardization:**

- Shooting performance, image quality and installation of CCTV camera,
- Functions and interface of CCTV controller,
- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Segmentation of incident (such as traffic accident, breakdown vehicle, left obstruction, etc.),
- Detailed classification of incident,
- Message template/sequence of incident information,
- Display priority of incident information (using segmentation and detailed classification).

(v) **Advantages:**

- No necessity of intricate machinery/software by decision by the surveillance staff,
- Capability of concurrent use with congestion surveillance.

(vi) **Disadvantages:**

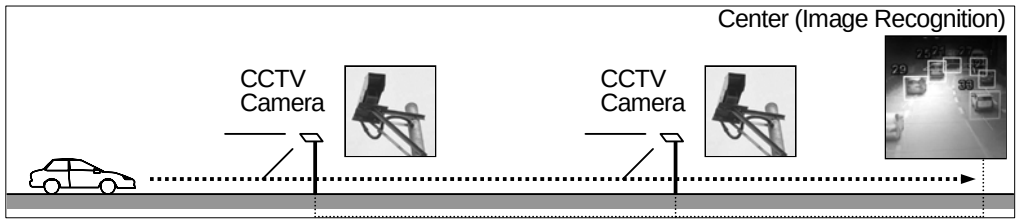
- Necessity of resident surveillance staff at the center,
- Inapplicability to the surveillance of large number of places,
- Unevenness of surveillance quality is affected by human-factor of the surveillance staff,
- Necessity of communication network with sufficient capacity for video transmission.

(vii) **Grading:** Useful as a complement.

(b) Image Recognition

Road traffic condition is captured by camera at the roadside with adequate location and angle of view. Traffic accidents, broken-down vehicles and left obstructions are identified by analyzing the captured video image. The data is compiled into the message of incident information and disseminated through VMS and other channels to the drivers.

Figure 5.3.7 Image Recognition



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.1)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.1)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.1)).

(iv) **Needed Standardization:**

- Shooting performance, image quality and installation of CCTV camera,
- Functions and interface of CCTV controller,
- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Segmentation of incident (such as traffic accident, breakdown vehicle, left obstruction, etc.),
- Detailed classification of incident,
- Message template/sequence of incident information,
- Display priority of incident information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Uniformity of surveillance quality excluding human-factor,
- Capability of concurrent use with congestion surveillance and travel time surveillance.

(vi) **Disadvantages:**

- Necessity of communication network with sufficient capacity for video transmission,
- Necessity of image recognition processor and system set-up/maintenance at high cost.

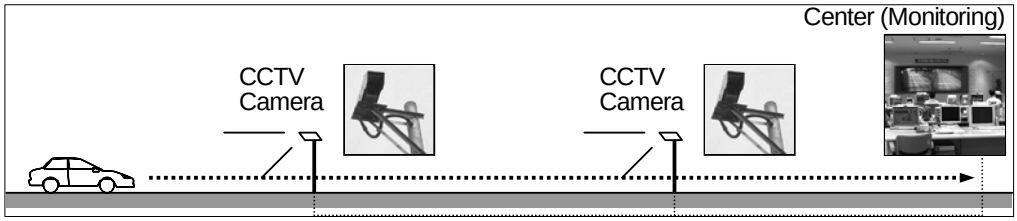
(vii) **Grading:** Recommended.

(2) Traffic Congestion Information

(a) Monitoring at Roadside

Road traffic condition is captured by camera at the roadside with adequate location and angle of view. Human operator assumes vehicle speed and determines traffic congestion by monitoring the captured video image. The data is compiled into the message of traffic congestion information and disseminated through VMS and other channels to the drivers.

Figure 5.3.8 Monitoring at Roadside



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.1)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.1)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.1)).

(iv) **Needed Standardization:**

- Shooting performance, image quality and installation of CCTV camera,
- Functions and interface of CCTV controller,
- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Definition of congestion (as a segmentation),
- Detailed classification of congestion,
- Message template/sequence of congestion information,
- Display priority of congestion information (using segmentation and detailed classification).

(v) **Advantages:**

- No necessity of intricate machinery/software by decision by the surveillance staff,
- Capability of concurrent use with incident surveillance.

(vi) **Disadvantages:**

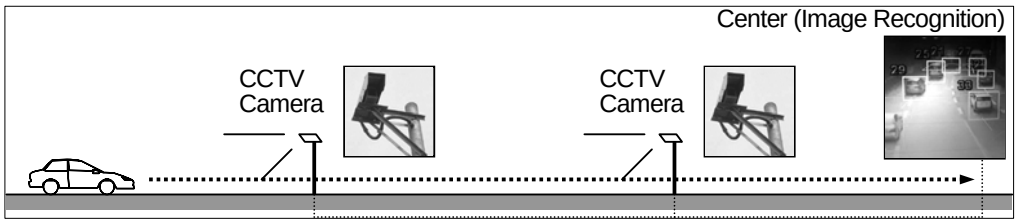
- Necessity of resident surveillance staff at the center,
- Inapplicability to the surveillance of large number of places,
- Unevenness of surveillance quality is affected by human-factor of the surveillance staff,
- Necessity of communication network with sufficient capacity for video transmission.
- Necessity of other system for travel time surveillance.

(vii) **Grading:** Useful as a complement.

(b) Image Recognition

Behavior of each vehicle is captured by camera at the roadside with adequate location and angle of view. Vehicle speed and number of vehicles are calculated by analyzing the captured video image, and traffic congestion can be estimated from the results. The data is compiled into the message of traffic congestion information and disseminated through VMS and other channels to the drivers.

Figure 5.3.9 Image Recognition



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.2)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.2)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.2)).

(iv) **Needed Standardization:**

- Shooting performance, image quality and installation of CCTV camera,
- Functions and interface of CCTV controller,
- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Definition of congestion (as a segmentation),
- Detailed classification of congestion,
- Message template/sequence of congestion information,
- Display priority of congestion information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Capability to survey congestion/traffic-volume quantitatively in real time excluding human- factor,
- Capability of concurrent use with incident surveillance and travel-time surveillance.

(vi) **Disadvantages:**

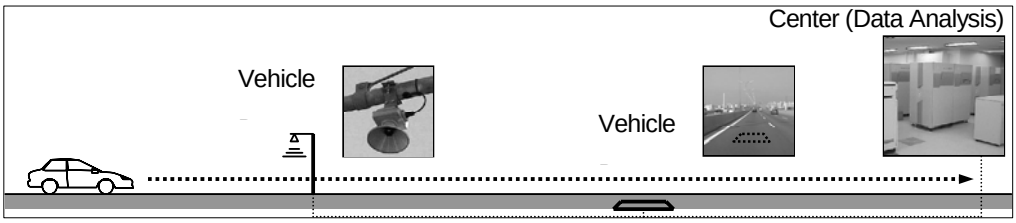
- Necessity of communication network with sufficient capacity for video transmission,
- Necessity of image recognition processor and system set-up/maintenance at high cost.

(vii) **Grading:** Useful as a complement.

(c) Vehicle Detection

Vehicle passage is captured by the vehicle detector installed in adequate location on the road. Vehicle speed and number of vehicles are calculated based on the captured data, and traffic congestion can be estimated from the results. The data is compiled into the message of traffic congestion information and disseminated through VMS and other channels to the drivers.

Figure 5.3.10 Vehicle Detection



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.2)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.2)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.2)).

(iv) **Needed Standardization:**

- Performance and installation of vehicle detector,
- Interface of vehicle detector controller,
- Logic and processing of traffic analysis,
- Definition of congestion (as a segmentation),
- Detailed classification of congestion,
- Message template/sequence of congestion information,
- Display priority of congestion information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Capability to survey congestion/traffic-volume quantitatively in real time excluding human- factor,
- Capability of concurrent use with travel-time surveillance.

(vi) **Disadvantages:**

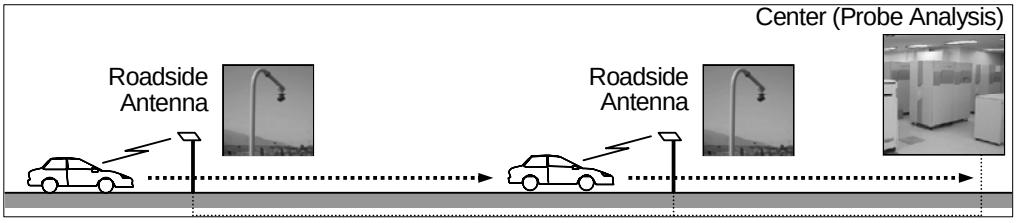
- Necessity of other system for incident surveillance.

(vii) **Grading:** Recommended.

(d) DSRC Probe

Movement of the vehicle with OBU is traced by DSRC antenna at the specific point on the road. The trace can be complemented by using GPS-unit in the vehicle. Travel speed is calculated based on the traced data, and traffic congestion can be estimated from the results. The data is compiled into the message of traffic congestion information and disseminated through VMS and other channels to the drivers.

Figure 5.3.11 DSRC Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.2)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.2)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.2)).

(iv) **Needed Standardization:**

- Performance, interface and installation of roadside antenna,
- Performance and interface of OBU and IC-card,
- Logic and processing of traffic analysis,
- Definition of congestion (as a segmentation),
- Detailed classification of congestion,
- Message template/sequence of congestion information,
- Display priority of congestion information (using segmentation and detailed classification).

(v) **Advantages:**

- Capability of concurrent use of infrastructure with toll collection,
- Capability to survey congestion quantitatively,
- Capability of concurrent use with travel-time surveillance,
- Additional function to provide information for the drivers in future.

(vi) **Disadvantages:**

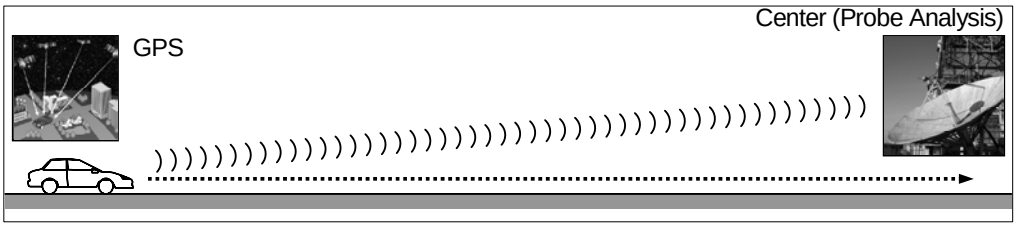
- Accuracy lowering by distribution of the vehicle with OBU (probe cars),
- Inevitable delay in surveillance,
- Necessity of other system for incident surveillance.

(vii) **Grading:** Not suitable.

(e) (GPS/WL Probe

Movement of the vehicle is traced by GPS-unit in the vehicle, and is transmitted by wireless communication to the center. Travel speed is calculated based on the traced data, and traffic congestion can be estimated from the results. The data is compiled into the message of traffic congestion information and disseminated through VMS and other channels to the drivers.

Figure 5.3.12 GPS/WL Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.2)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.2)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.2)).

(iv) **Needed Standardization:**

- Interface of radio (wireless) communication,

- Logic and processing of traffic analysis,
- Definition of congestion (as a segmentation),
- Detailed classification of congestion,
- Message template/sequence of congestion information,
- Display priority of congestion information (using segmentation and detailed classification).

(v) **Advantages:**

- No necessity of implementation/maintenance of infrastructure,
- Capability to survey congestion quantitatively at any point,
- Capability of concurrent use with travel-time surveillance.

(vi) **Disadvantages:**

- Necessity of both GPS and radio terminal with sufficient communication bandwidth,
- Necessity of data communication at high running cost,
- Accuracy lowering by distribution of the vehicle with GPS-unit (probe cars),
- Rare necessity of GPS-unit for private sedan,
- Inevitable delay in surveillance,
- Incapability to distinguish closely paralleling two roads,
- Necessity of other system for incident surveillance.

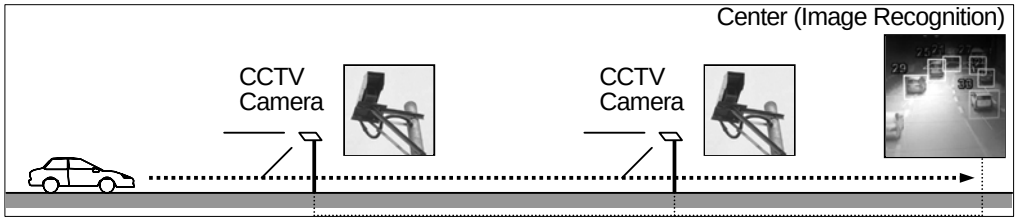
(vii) **Grading:** Not suitable.

(3) Travel-time Information

(a) Image Recognition

Behavior of each vehicle is captured by camera at the roadside with adequate location and angle of view. Vehicle speed and number of vehicles are calculated by analyzing the captured video image, and travel-time can be estimated from the results. The data is compiled into the message of travel-time information and disseminated through VMS and other channels to the drivers.

Figure 5.3.13 Image Recognition



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.3)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.3)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.3)).

(iv) **Needed Standardization:**

- Shooting performance, image quality and installation of CCTV camera,
- Functions and interface of CCTV controller,

- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Definition of calculating travel-time,
- Message template/sequence of travel-time information,
- Display priority of travel-time information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Capability of concurrent use with incident surveillance and congestion surveillance.

(vi) **Disadvantages:**

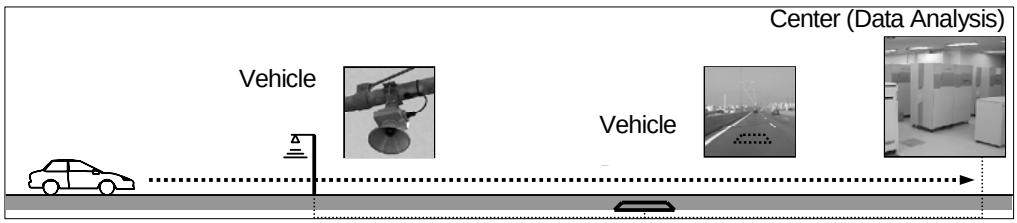
- Necessity of communication network with sufficient capacity for video transmission,
- Necessity of installation of vehicle detector with a short spacing less than 1km,
- Necessity of image recognition processor and system set-up/maintenance at high cost.

(vii) **Grading:** Not suitable.

(b) Vehicle Detection

Vehicle passage is captured by the vehicle detector installed in adequate location on the road. Vehicle speed and number of vehicles are calculated based on the captured data, and travel-time can be estimated from the results. The data is compiled into the message of travel-time information and disseminated through VMS and other channels to the drivers.

Figure 5.3.14 Vehicle Detection



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.3)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.3)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.3)).

(iv) **Needed Standardization:**

- Performance and installation of vehicle detector,
- Interface of vehicle detector controller,
- Logic and processing of traffic analysis,
- Definition of calculating travel-time,
- Message template/sequence of travel-time information,
- Display priority of travel-time information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Capability of concurrent use with congestion surveillance,

(vi) **Disadvantages:**

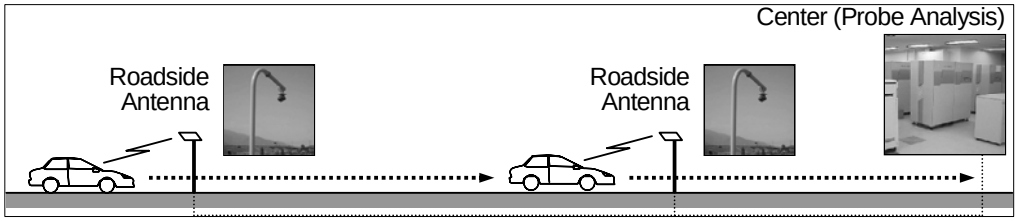
- Necessity of installation of vehicle detector with a short spacing less than 1km,
- Necessity of other system for incident surveillance,

(vii) **Grading:** Not suitable.

(c) DSRC Probe

Movement of the vehicle with OBU is traced by DSRC antenna at the specific point on the road. The trace can be complemented by using GPS-unit in the vehicle. Travel speed is calculated based on the traced data, and travel-time can be estimated from the results. The data is compiled into the message of travel-time information and disseminated through VMS and other channels to the drivers.

Figure 5.3.15 DSRC Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.3)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.3)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.3)).

(iv) **Needed Standardization:**

- Performance, interface and installation of roadside antenna,
- Performance and interface of OBU and IC-card,
- Definition of travel-time,
- Logic and processing of traffic analysis,
- Definition of calculating travel-time,
- Message template/sequence of travel-time information,
- Display priority of travel-time information (using segmentation and detailed classification).

(v) **Advantages:**

- Capability of concurrent use of infrastructure with toll collection,
- Capability to survey travel-time directly,
- Capability of concurrent use with congestion surveillance,
- Additional function to provide information to the drivers in future.

(vi) **Disadvantages:**

- Accuracy lowering by distribution of the vehicle with OBU (probe cars),

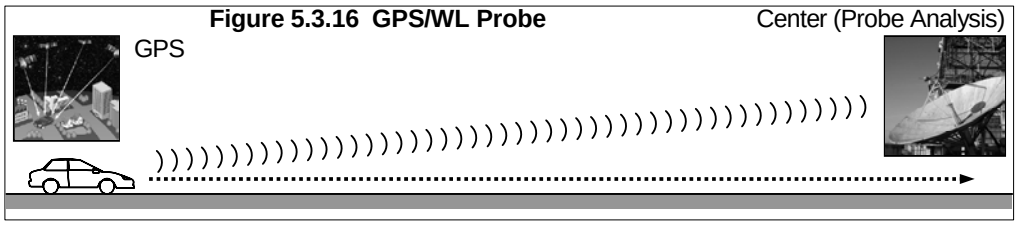
- Inevitable delay in surveillance,
- Necessity of other system for incident surveillance.

(vii) **Grading:** Recommended.

(d) GPS/WL Probe

Movement of the vehicle is traced by GPS-unit in the vehicle, and is transmitted by wireless communication to the center. Travel speed is calculated based on the traced data, and travel-time can be estimated from the results. The data is compiled into the message of travel-time information and disseminated through VMS and other channels to the drivers.

Figure 5.3.16 GPS/WL Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.3)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.3)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.3)).

(iv) **Needed Standardization:**

- Interface of radio (wireless) communication,
- Definition of travel-time,
- Logic and processing of traffic analysis,
- Definition of calculating travel-time,
- Message template/sequence of travel-time information,
- Display priority of travel-time information (using segmentation and detailed classification).

(v) **Advantages:**

- No necessity of implementation/maintenance of infrastructure,
- Capability to survey travel-time directly at any point,
- Capability of concurrent use with travel-time surveillance.

(vi) **Disadvantages:**

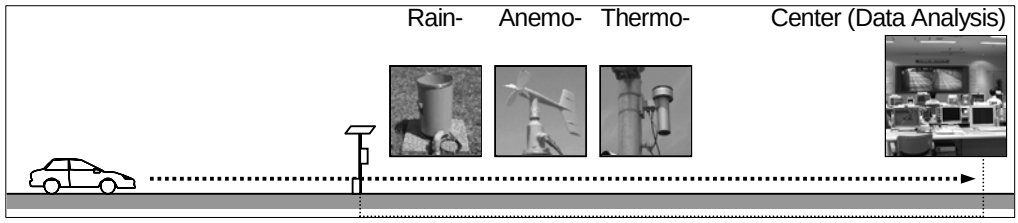
- Necessity of both the GPS on-board unit and the radio terminal with sufficient bandwidth,
- Necessity of data communication at high running cost,
- Accuracy lowering by distribution of the vehicle with GPS-unit (probe cars),
- Rare necessity of GPS-unit for private sedan,
- Inevitable delay in surveillance,
- Incapability to distinguish closely paralleling two roads,
- Necessity of other system for incident surveillance.

(vii) **Grading:** Useful as a complement.

(4) Weather Information

Rainfall, wind direction/velocity and temperature are measured by the sensors, and are transmitted through telemeter to the center. The data is compiled into the message of weather information and disseminated through VMS and other channels to the drivers.

Figure 5.3.17 Weather Sensors



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.4)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.4)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.4)).

(iv) **Needed Standardization:**

- Definition of measurement/description of rainfall
- Definition of measurement/description wind direction/velocity
- Definition of measurement/description temperature
- Message template/sequence of weather information,
- Display priority of weather information (using segmentation and detailed classification).

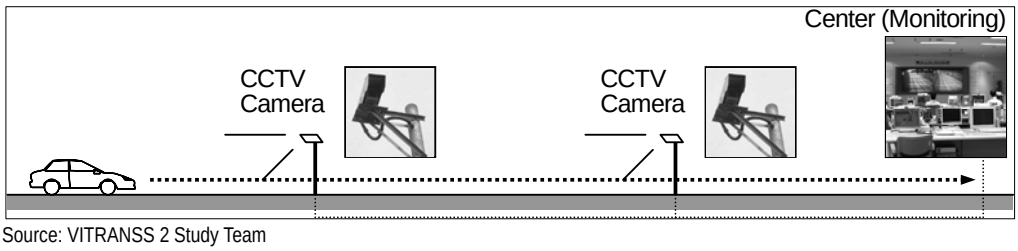
(v) **Grading:** Necessary.

(5) Traffic Control Assistance

(a) Monitoring at Roadside

Human operator identifies incidents and traffic congestion by monitoring the video image. The road operation vehicles are notified of the occurrence of incident and traffic congestion, and traffic restriction is to be determined/implemented by the operator. The message of traffic information is compiled and disseminated through VMS and other channels to the drivers.

Figure 5.3.18 Monitoring at Roadside



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.5)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.5)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.5)).

(iv) **Needed Standardization:**

- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Segmentation of incident (such as traffic accident, breakdown vehicle, left obstruction, etc.),
- Definition of congestion and calculating travel-time,
- Detailed classification of incident and congestion,
- Message template/sequence of incident, congestion and travel-time information,
- Display priority of information (using segmentation and detailed classification).

(v) **Advantages:**

- No necessity of intricate machinery/software by decision by the surveillance staff,
- Capability to detect all vehicles (not depending on OBU).

(vi) **Disadvantages:**

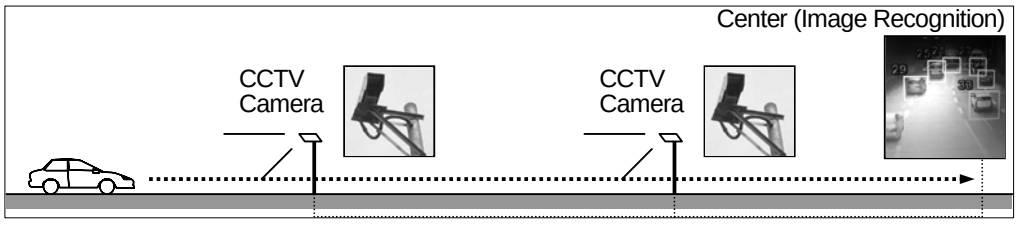
- Necessity of resident surveillance staff at the center,
- Inapplicability to the surveillance of large number of places,
- Unevenness of surveillance quality is affected by human-factor of the surveillance staff,
- Necessity of communication network with sufficient capacity for video transmission,
- Necessity of other system for travel time surveillance.

(vii) **Grading:** Useful as a complement.

(b) Image Recognition

Incidents and traffic congestion are identified by analyzing the video image. The road operation vehicles are notified of the occurrence of incident and traffic congestion, and traffic restriction is to be determined/implemented by the operator. The message of traffic information is compiled and disseminated through VMS and other channels to the drivers.

Figure 5.3.19 Image Recognition



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.5)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.5)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.5)).

(iv) **Needed Standardization:**

- Display quality and interface of monitoring screen,
- Logic and processing of traffic analysis,
- Segmentation of incident (such as traffic accident, breakdown vehicle, left

obstruction, etc.),

- Definition of congestion and calculating travel-time,
- Detailed classification of incident and congestion,
- Message template/sequence of incident, congestion and travel-time information,
- Display priority of information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Capability to survey incident/congestion/traffic-volume/travel-time in real time excluding human-factor,
- Capability to detect all vehicle (not depending on OBU).

(vi) **Disadvantages:**

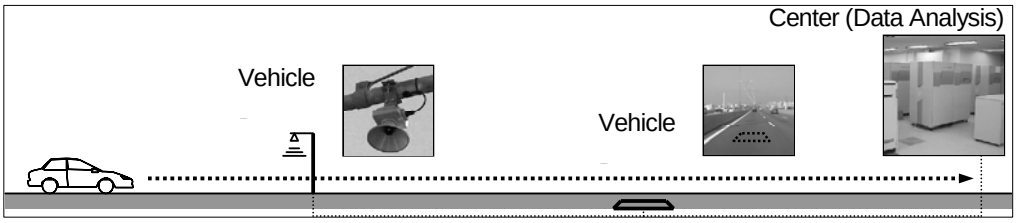
- Necessity of communication network with sufficient capacity for video transmission,
- Necessity of image recognition processor and system set-up/maintenance at high cost.

(vii) **Grading:** Necessary.

(c) Vehicle Detection

Traffic congestion is identified using the data acquired by vehicle detection. The road operation vehicles are notified of the occurrence of traffic congestion, and traffic restriction is to be determined/implemented by the operator. The message of traffic information is compiled and disseminated through VMS and other channels to the drivers.

Figure 5.3.20 Vehicle Detection



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.5)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.5)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.5)).

(iv) **Needed Standardization:**

- Logic and processing of traffic analysis,
- Definition of congestion and calculating travel-time,
- Detailed classification of incident and congestion,
- Message template/sequence of incident, congestion and travel-time information,
- Display priority of information (using segmentation and detailed classification).

(v) **Advantages:**

- Availability of monitoring at many different points for 24 hours without surveillance staff,
- Capability to survey congestion/traffic-volume/travel-time in real time excluding human- factor,
- Capability to detect all vehicle (not depending on OBU).

(vi) **Disadvantages:**

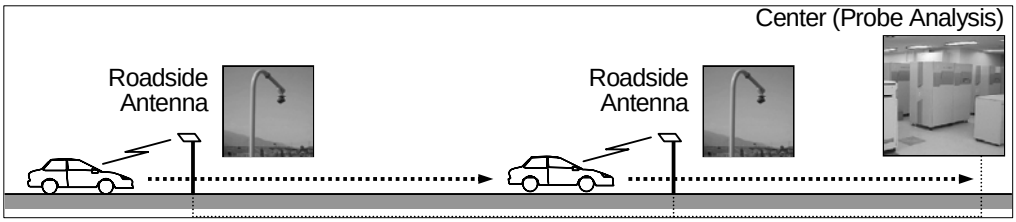
- Necessity of other system for incident surveillance.

(vii) **Grading:** Necessary.

(d) DSRC Probe

Traffic congestion is identified using probe data acquired by the DSRC antenna. The road operation vehicles are notified of the occurrence of traffic congestion, and traffic restriction is to be determined/implemented by the operator. The message of traffic information is compiled and disseminated through VMS and other channels to the drivers.

Figure 5.3.21 DSRC Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.5)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.5)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.5)).

(iv) **Needed Standardization:**

- Logic and processing of traffic analysis,
- Definition of congestion and calculating travel-time,
- Detailed classification of incident and congestion,
- Message template/sequence of incident, congestion and travel-time information,
- Display priority of information (using segmentation and detailed classification).

(v) **Advantages:**

- Capability of concurrent use of infrastructure with toll collection,
- Capability to survey travel-time,
- Additional function to provide information to the drivers in future.

(vi) **Disadvantages:**

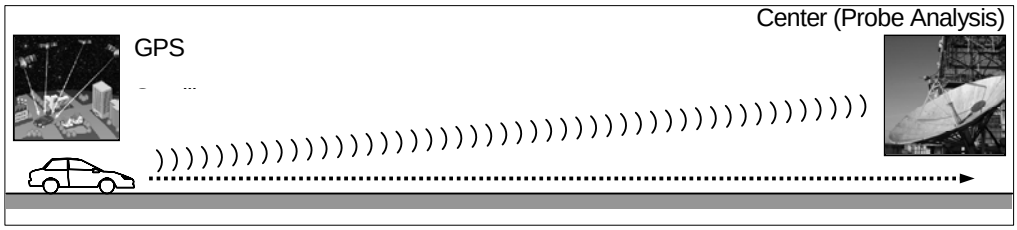
- Accuracy lowering by distribution of the vehicle with OBU (probe cars),
- Inevitable delay in surveillance,
- Necessity of other system for precise incident surveillance.

(vii) **Grading:** Necessary.

(e) GPS/WL Probe

Traffic congestion is identified receiving the GPS probe data through wireless communication. The road operation vehicles are notified of the occurrence of traffic congestion, and traffic restriction is to be determined/implemented by the operator. The message of traffic information is compiled and disseminated through VMS and other channels to the drivers.

Figure 5.3.22 GPS/WL Probe



Source: VITRANSS 2 Study Team

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.5)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.5)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.5)).

(iv) **Needed Standardization:**

- Logic and processing of traffic analysis,
- Definition of congestion and calculating travel-time,
- Detailed classification of incident and congestion,
- Message template/sequence of incident, congestion and travel-time information,
- Display priority of information (using segmentation and detailed classification).

(v) **Advantages:**

- No necessity of implementation/maintenance of infrastructure.
- Capability to survey congestion quantitatively at any point.

(vi) **Disadvantages:**

- Necessity of both GPS and radio terminal with sufficient communication bandwidth,
- Necessity of data communication at high running cost.
- Accuracy lowering by distribution of the vehicle with GPS-unit (probe cars),
- Rare necessity of GPS-unit for private sedan,
- Inevitable delay in surveillance,
- Incapability to distinguish closely paralleling two roads.
- Necessity of other system for incident surveillance.

(vii) **Grading:** Useful as a complement.

(6) Center-to-center Data Exchange

(a) Incident notification is performed by exchanging messages/data among the servers installed in the traffic information control center, the traffic police operation center and the ambulance service center.

(b) DSRC probe is performed by exchanging messages/data among the servers installed in the traffic information control center, the DSRC probe data center, the toll management center, the road pricing operation center, the cargo-truck operation center and the inter- city bus operation center.

(c) GPS/WL probe is performed by exchanging messages/data among the servers installed in the traffic information control center, the GPS/WL probe data center, the cargo-truck operation center and the inter- city bus operation center.

(d) Traffic information is performed by exchanging messages/data among the servers installed in the traffic information control center, the traffic police operation center, the ambulance service center, the TV/radio broadcasting center and the information service center.

(i) **Message Sequence:** (shown in ***Appendix 1*** (A1.9)).

(ii) **System Architecture:** (shown by the collaboration diagram in ***Appendix 1*** (A1.9)).

(iii) **Functions & Installations:** (shown in ***Appendix 1*** (A1.9)).

(iv) **Needed Standardization:**

- Definitions of the concepts of incident and its segmentation, congestion and its classification, travel-time and its calculation, segmentation of weather conditions, segmentation of traffic event, and segmentation of road section
- Definitions of the message/data of traffic accident, breakdown, left obstruction, congestion, weather, and other basic data.

(v) **Grading:** Necessary.

4) Detailed Discussion on Traffic Information/Control

(1) Recommendations on Alternatives

The foregoing recommendations on the alternatives for traffic information/control (discussed in the ITS Working Group shown in ***APPENDIX-5***) are summarized in the table below.

Table 5.3.1 Recommendations on Alternatives for Traffic Information/Control

	Incident Information	Traffic Congestion Information	Travel-time Information	Weather Information	Traffic Control Assistance
by Monitoring at Roadside	Useful as a Complement 1-(a)	Useful as a Complement 2-(a)	-	-	Useful as a Complement 5-(a)
by Image Recognition	Recommended 1-(a)	Useful as a Complement 2-(b)	Not Suitable 3-(a)	-	Necessary 5-(b)
by Vehicle Detection	-	Recommended 2-(c)	Not Suitable 3-(b)	-	Necessary 5-(c)
by DSRC Probe	-	Not Suitable 1-(d)	Recommended 3-(c)	-	Necessary 5-(d)
by GPS/WL Probe	-	Not Suitable 1-(e)	Useful as a Complement 3-(db)	-	Useful as a Complement 5-(e)
by Weather Sensor	-	-	-	Necessary 4	

Source: VITRANSS 2 Study Team

(2) Alternative Methods of Emergency Calling

Emergency calling has the following two functions:

(i) Notification of occurrence of incident,

(ii) Identification of the location of incident site (for rescue and clearance).

The first function can be provided by mobile phones the road users should have; however, the second function is not to be substituted by mobile phones. The following two methods can be proposed for emergency calling.

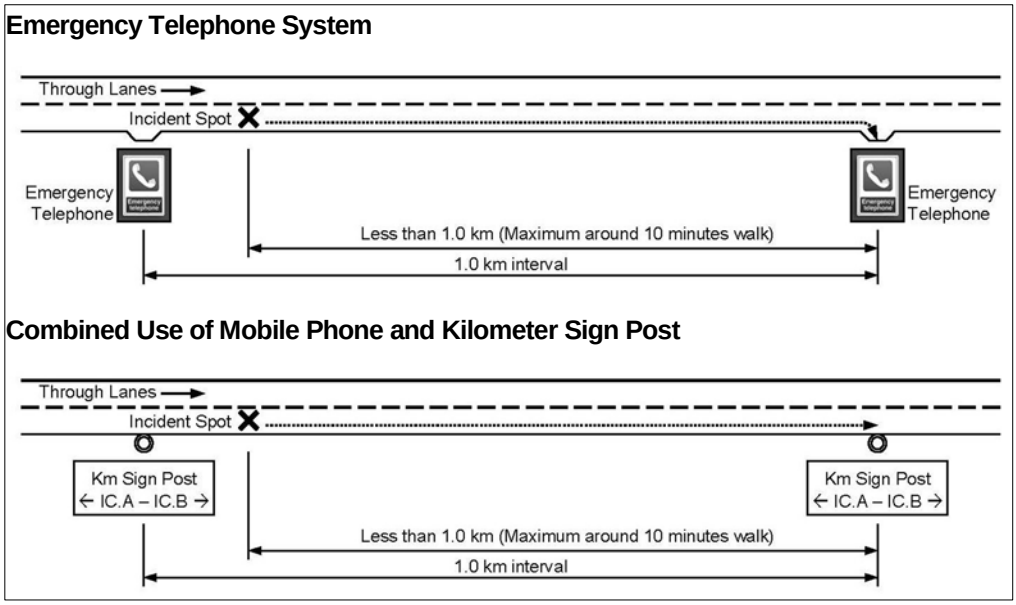
(i) Emergency telephone system,

(ii) Combined use of mobile phone and kilometer signpost.

The choice between these two methods is depending on the sufficiency of coverage of the mobile phone service and on the maintenance level of the kilometer signposts. However, it is not clear whether these conditions can be secured at all inter-city road networks, especially in mountainous areas.

Accordingly, the emergency telephones need to be installed every km on the inter-city expressways in mountainous areas allowedly including tunnel sections. In addition, well-marked and well-maintained kilometer sign posts for the combined use with mobile phones are to be installed on the metropolitan expressway network.

Figure 5.3.23 Alternative Methods of Emergency Calling



Source: VITRANSS2 Study Team
Note IC.: Interchange

(3) Location of Management Office

The management office needs to be facilitated by the monitoring equipment of surveillance and the operation vehicles including a patrol car, an ambulance, a tow car and a maintenance car as shown in the minimal service requirements proposed in Chapter 4. And for the prompt response to the incident (within 1 hour), the intervals of the management office on the expressway network needs to be less than 80 km as shown in Figure 5.3.23.