MINISTRY OF TRANSPORT, VIETNAM

STUDY FOR SUPPORTING ITS STANDARDS & OPERATION PLAN DEVELOPMENT IN VIETNAM

APPENDIX 1

January 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

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

EID
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11-012

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APPENDIX 1:
DRAFT DESIGN STANDARDS

This volume of the Draft Design Standards defines basic concept, general architecture and actualization method as a unified form for designing the system, which organized by 3 volumes corresponding to the priority ITS user services below.

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

DRAFT DESIGN STANDARDS (1)

Traffic Information/Control

(Ver.1.0: Final Version of the Study Results)

Documents and Volumes of Draft ITS Standards

The Draft ITS Standards consist of the following Documents:

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

The Draft ITS Standards organized by 26 volumes shown below.

Draft Design Standards (3 Volumes)	(1) Traffic Information/Control (2) Automated Toll Collection	(3) Heavy Truck Control
Draft General Specifications (21 Volumes)	(1) Telephone Exchange (2) CCTV Monitoring (3) Event Detection (by Image) (4) Vehicle Detection (5) Traffic Analysis (6) Weather Monitoring (7) Traffic Event Data Management (8) Traffic Supervision (9) VMS Indication (10) Mobile Radio Communication (11) Traffic Information	(12) Lane Monitoring (13) Vehicle/Class Identification (14) Lane Control (15) Road-to-Vehicle Communication (16) IC-card Recording (17) Toll Management (18) OBU Management (19) Axle Load Measurement (20) Overloading Management (21) Center/Roadside Communication (including Ducts)
Draft Message/Data Standards (1 Volume)	Message List	Data Dictionary
Draft Communication System Plan (1 Volume)	General Communication System Plan	Design Standards of Communication System

TABLE OF CONTENTS

1. General Outlines

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

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

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

(1) Telephone Exchange
(2) CCTV Monitoring
(3) Event Detection (by Image)
(4) Vehicle Detection
(5) Traffic Analysis
(6) Weather Monitoring
(7) Traffic Event Data Management
(8) Traffic Supervision
(9) VMS Indication
(10) Mobile Radio Communication
(11) Traffic Information.

In the Draft Design Standards, the basic concept and actualization method of the system are defined according to the following basic contents:

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

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

Table 1.1 Basic Contents Defined for Functional Package in the Draft Design Standards (1)

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

2. Scope

This Draft Design Standards deal with the equipment components and software to be installed at roadside on the expressway network throughout Vietnam, including access sections of arterial roads, and in the Main Centers, road management offices and toll office of the expressway network for actualizing this functional package.

3. Relevant Regulations and Standards

The clauses in the Draft Standards of Traffic Information/Control are developed on the basis of or in reference to the following relevant regulations and standards. Some of the relevant regulations and standards need to be applied to specific ITS implementation projects in combination with the clauses in the Draft Standards of Traffic Information/Control.

(1) ITU-T G.107: The E-model: a computational model for use in transmission planning
(2) ITU-T G.114: One-way transmission time
(3) ITU-T G. 1541: Network performance objectives for IP-based services
(4) ITU-T H.320: Standards for video conferencing
(5) ITU-T H323: Visual Telephone systems and equipment
(6) IEEE 802.3: Ethernet (Carrier Sense Multiple Access with Collision Detection)
(7) ITU-T G.803: Architecture of transport networks based on the synchronous digital hierarchy (SDH)
(8) ITU-T G.703: Physical/Electronical characteristics of hierarchical digital interface
(9) ITU-T G.652: Characteristics of a single-mode optical fibre and cable
(10) ITU-T G.655: Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
(11) ITU-T Y1541: QoS Standards for IP Networks and Services
(12) BS 7430: 1998: Code of practice for earthing
(13) BS 6651:1999 Lightning Protection
(14) NEXCO Design Manual
(15) QCVN 9:2010/BTTTT: National technical regulation on earthing of telecommunication stations
(16) QCVN 2:2010/BTTTT: National technical regulation on physical/electrical characteristics of hierarchical digital interfaces

(17) QCVN 3:2010/BTTTT: National technical regulation on bit error rate of digital transmission path
(18) QCVN 7:2010/BTTTT: National technical regulation on optical interfaces for network interconnection equipments relating to the Synchronous Digital Hierarchy
(19) TCN 68-153:1995 : Cable duct and cable connected box Technical standard
(20) TCN 68-254:2006: Telecommunication outside plants Technical specifications
(21) ISO/IEC 11179: Information technology – specification and standardization of data elements
(22) ISO/DIS 14817: Transport information and control systems – requirements for an ITS/TICS central data registry and ITS/TICS data dictionaries
(23) WMO-No.544 Manual on the Global Observing System (WMO)
(24) ANSI/IEC 60529: Degrees of Protection provided by Enclosure (IP Code)
(25) ISO/IEC 14496-2 : Information technology -- Coding of audio-visual objects -- Part 2: Visual
(26) ISO/IEC 14496-10 : Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding
(27) ISO 8877 (RJ-45) connector
(28) ISO 14813-1:2007 Intelligent transport systems – Reference model architecture(s) for the ITS centor – Part 1: ITS service domains, service groups and services
(29) ISO/IEC 13818-1:2000 Information Technology – Generic coding of moving pictures and associated audio information: Systems
(30) ISO/IEC 13818-2:2000 Information Technology – Generic coding of moving pictures and associated audio information: Video (ITU-T Recommendation H.262)
(31) ISO/IEC 13818-3:2000 Information Technology – Generic coding of moving pictures and associated audio information: Part 3: Audio
(32) ISO/CD 24533: Data directory and Message set for tracking of freight and It's intermodal transfer
(33) 22 TCN 331-05. Biển chỉ dẫn trên đường cao tốc
(34) ISO 15784-1 Intelligent transport systems (ITS) -- Data exchange involving roadside modules communication -- Part 1: General principles and documentation framework of application profiles
(35) ISO/WD 15784-2 Transport Information and Communication System — Data Exchange involving Roadside Modules Communication — Part 2: AP-TMP
(36) ISO 15784-3 Intelligent transport systems (ITS) -- Data exchange involving roadside modules communication -- Part 3: Application profile-data exchange (AP-DATEX)
(37) IETF/RFC 791, 768, 792, 793: Transmission Control Protocol/Internet Protocol v4 (TCP/IP v4)

The requirement standardization criteria in Viet Nam and the referential relation with the relevant regulations/standards are summarized in the following table.

<Standardization Criteria>

- National: To be standardized by the Government
- Local: to be standardized by MOT

<Referential relation with the Relevant Regulations/Standards>

- The clause is developed on the basic of ##: the relevant regulations/standards
- The clause is developed originally in reference to ##: the relevant regulations/standards
- The clause is to be applied specific ITS implementation project in combination/reference with ##: the relevant regulations/standards.

Table 9.1 Standardization Criteria and Referential Relation with Relevant Regulation/Standards

Clause	Standardization Criteria	Referential Relation with Relevant Regulation/Standards
Telephone Exchange (8)		
• System Architecture (8.2)	Local	→ See the Draft Communication System Plan
• Function design (8.3)	Local	→ See the Draft Communication System Plan
• Message Exchange (8.4)	Local	→ See the Draft Communication System Plan
• Transmission design (8.5)	Local	→ See the Draft Communication System Plan
CCTV Monitoring (9)		
• System Architecture (9.2)	Local	Developed on the basis of (28) Developed originally in reference to (14)
• Function design (9.3)	Local	Developed originally in reference to (14), (25), (26) Developed on the basis of (24)
• Message Exchange (9.4)	Local	Developed originally in reference to (14) Developed on the basis of (22)
• Transmission design (9.5)	Local	Developed originally in reference to (6), (7), (37)
Event Detection (10)		
• System Architecture (10.2)	Local	Developed originally in reference to (14)
• Function design (10.3)	Local	Developed originally in reference to (14), (25), (26), (34), (35), (36)
• Message Exchange (10.4)	Local	Developed originally in reference to (14) Developed on the basis of (22)
• Transmission design (10.5)	Local	Developed originally in reference to (6), (7), (37)
Vehicle Detection (11)		
• System Architecture (11.2)	Local	Developed on the basis of (28) Developed originally in reference to (14)
• Function design (11.3)	Local	Developed originally in reference to (14), (34), (35), (36)
• Message Exchange (11.4)	Local	Developed originally in reference to (14) Developed on the basis of (22)
• Transmission design (11.5)	Local	Developed originally in reference to (6), (7), (37)
Traffic Analysis (12)		
• System Architecture (12.2)	Local	Developed originally
• Function design (12.3)	Local	Developed originally in reference to (14)
• Message Exchange (12.4)	Local	Developed originally
• Transmission design (12.5)	Local	Developed originally
Weather Monitoring (13)		

• System Architecture (13.2)	Local	Developed originally in reference to (14)
• Function design (13.3)	Local	Developed originally in reference to (14)
• Message Exchange (13.4)	Local	Developed originally
• Transmission design (13.5)	Local	Developed originally
Traffic Event Data Management (14)		
• System Architecture (14.2)	Local	Developed originally
• Function design (14.3)	Local	Developed originally in reference to (14)
• Message Exchange (14.4)	Local	Developed originally
• Transmission design (14.5)	Local	Developed originally
Traffic Supervision (15)		
• System Architecture (15.2)	Local	Developed originally
• Function design (15.3)	Local	Developed originally in reference to (14)
• Message Exchange (15.4)	Local	Developed originally
• Transmission design (15.5)	Local	Developed originally
VMS indication (16)		
• System Architecture (16.2)	Local	Developed on the basis of (27) Developed originally in reference to (14)
• Function design (16.3)	Local	Developed originally in reference to (14), (25), (26), (34), (35), (36)
• Message Exchange (16.4)	Local	Developed originally in reference to (14) Developed on the basis of (22)
• Transmission design (16.5)	Local	Developed originally in reference to (6), (7), (37)
Mobile Radio Communication (17)		
• System Architecture (17.2)	Local	→ See the Draft Communication System Plan
• Function design (17.3)	Local	→ See the Draft Communication System Plan
• Message Exchange (17.4)	Local	→ See the Draft Communication System Plan
• Transmission design (17.5)	Local	→ See the Draft Communication System Plan
Traffic Information (18)		
• System Architecture (18.2)	Local	Developed originally
• Function design (18.3)	Local	Developed originally
• Message Exchange (18.4)	Local	Developed originally
• Transmission design (18.5)	Local	Developed originally
Location of Functional Packages (19)	Local	Developed originally in reference to (14)
Preparation of Stepwise Implementation (20)	Local	Developed originally

4. Definitions of Terms

- **CCTV Camera:** Closed-Circuit Television Camera, which is used for producing images or recordings for surveillance purposes, and can be either video camera, or digital stills camera. Video cameras are either analogue or digital, so that they work on the basis of sending analogue or digital signals to a storage device such as a video tape recorder or computer. Video cameras are network cameras or IP cameras when embedded a video server having an IP address for video and audio streaming.
- **Data Element:** A unit of data for which the definition, identification, representation and permissible values are specified by means of a set of attributes.
- **Data Set:** A set of data elements included in a message with a strong relationship among them.
- **Draft Communication System Plan:** The Draft Communication System Plan provides the General Plan and the Draft Design Standards of communication system in order to establish connectability of communication network.
- **Draft Design Standards:** One of the document of the Draft ITS Standards, which defines basic concept, general architecture and actualization method as a unified form for designing the system.
- **Draft General Specifications:** The Draft General Specifications defines required processing functions, performance, interfaces and installation of equipment in order to establish compatibility of equipment components.
- **Draft Message/Data Standards:** The Draft Message/Data Standards defines message list and data dictionary in order to establish inter-operability of message and data.
- **Event Detection (by Image):** This functional package allows the road operators to automatically recognize occurrence of traffic accidents, broken-down vehicles and left obstacles on the expressways and to send notification to the Main Centers and road management offices by analyzing video images from cameras installed at bottleneck spots where traffic can be easily stuck and at long tunnel sections.
- **Event Detector:** A software application that uses computer algorithms to uses computer algorithms to intelligently monitor real-time video for automatically detecting incident occurrences and their types, such as traffic accidents, breakdown vehicles, left obstacles, driving in the reverse direction, vandalism and natural disasters.
- **Fixed Camera:** The traditional camera type where the camera and the direction in which it is pointing are clearly visible. This camera may come with a fixed or varifocal lens so that it has a fixed field of view (normal/telephoto/wide-angle) once it is mounted.
- **Functional Package:** A group of subsystems that have strong relationship to realize a certain function. Particulars of the Draft Design Standards and volumes of the Draft General Specifications are to be set up corresponding to the functional packages.
- **Image Recognition:** Software technology that uses computer algorithms to intelligently monitor real-time video for automatically recognizing license plate number of vehicle,

vehicle speed, the occurrence of traffic accidents, broken-down vehicles, and left obstacles.

- **Incident:** An unusual and unplanned event that affects or impedes the normal flow of traffic, such as traffic accidents, broken-down vehicles, left obstacles, reversing vehicles, vandalism and natural disaster on the road.
- **Interchange:** A junction connecting an expressway network and an arterial road network. That comprises grade separation and ramps to permit traffic on the expressway to pass through the junction without directly crossing other traffic on the arterial road.
- **Interface:** a connection for distributing information between two different subsystems, or between a subsystem and an object outside of ITS, and that is important target for discussing the standardization.
- **ISO:** The International Organization for Standardization is an international-standard-setting body composed of representatives from various national standards organizations. Founded on February 23, 1947, the organization promulgates worldwide proprietary industrial and commercial standards.
- **ITS User Service:** A service to be provided by an ITS application to the users directly or indirectly.
- **ITS:** Intelligent Transport Systems (ITS) are systems to support transportation of goods and humans with information and communication technologies in order to efficiently and safely use the transport infrastructure and transport means (cars, trains, planes, ships...)
- **ITU:** The International Telecommunication Union is an agency of the United Nations which regulates information and communication technology issues. ITU coordinates the shared global use of the radio spectrum, promotes international cooperation in assigning satellite orbits, works to improve telecommunication infrastructure in the developing world and establishes worldwide standards.
- **Junction:** A location on an expressway network where traffic can change between different travelling routes or directions. That comprises grade separation and ramps to permit traffic on the expressways to pass through the junction without directly crossing any other traffic stream.
- **Main Center:** The Center in charge of traffic monitoring, traffic control and traffic information dissemination, and is to be cooperated with road management offices.
- **Message Sequence Diagram:** A diagram to be indicated by a set of messages/activities and their contents necessary for realizing the implementation package to discuss interoperability of the data.
- **Message:** A set of data to be exchanged between subsystems for transferring information.
- **Mobile Radio Communication:** This functional package allows the road operators to exchange information between road operation vehicles/workers on the expressway and the road management office by using radio communication.
- **Node:** A node is a connection point is a connection point, either a redistribution point or a communication endpoint (some terminal equipment). The definition of a node depends on the network and protocol layer referred to. A physical network node is an active electronic

device that is attached to a network, and is capable of sending, receiving, or forwarding information over a communications channel

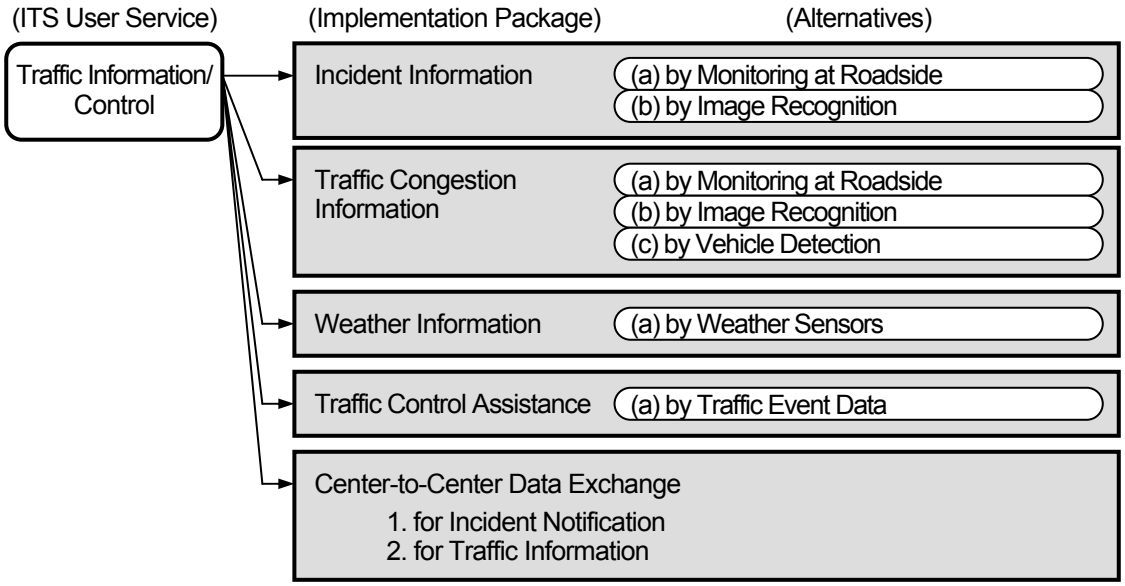
- **SDH:** Synchronous Digital Hierarchy are standardized multiplexing protocols that transfer multiple digital bit streams over optical fiber using lasers or light-emitting diodes (LEDs). Lower data rates can also be transferred via an electrical interface.
- **Traffic Information/Control:** An ITS user service for providing accurate surveillance of traffic conditions on the roads, assisting prompt action of the road operator and emergency vehicles by notifying occurrences of traffic accidents, significant weathers and traffic congestions, allowing the road operator to control road traffic and the drivers to avoid the influence of the incidents by providing accurately updated information.
- **Traffic Information:** This functional package allows the road operators to provide other organizations with the information organized as traffic events on the expressways by using the Internet.
- **Vehicle Detection:** This functional package allows the road operators to measure actual traffic volume, heavy vehicle ratio and vehicle velocity on the expressways for developing road operation/ improvement plans by using vehicle detectors installed at important points on the throughway and the tollgates.
- **Vehicle Detector:** A sensor either embedded in the pavement or mounted above the expressway to provide vehicle volume, speed, counts, headway, queue lengths, and vehicle classifications.
- **Vehicle Identification:** This functional package allows the road operators to identify individual vehicle by using a license plate scanner and other equipment installed in a separated lane such as a tollgate lane of the expressway.
- **VMS Indication:** This functional package allows the road operators to provide road users on the expressways with the information organized as traffic events by using VMS (Variable Message Sign) installed at the place short of entrances, exits, tollgates, junctions and tunnels.
- **VMS:** Variable Message Sign, which is an electronic sign installed along or above expressway and other highways that provide dynamic messages to alert the motoring public of incidents, congestion, construction, or other information. VMS is also known-as Changeable Message Sign and Dynamic Message Sign.
- **Weather Monitoring:** This functional package allows the road operators to estimate dangerous conditions for road traffic on the expressways by using data acquired by the sensors installed at the interchanges and at the road sections where undesired weather conditions for traffic safety frequently take place.
- **Weather Sensor:** A sensor installed at a specific point on the road for measuring rainfall, wind speed, visibility, air temperature and road surface temperature.

5. Implementation Packages

The following implementation packages are defined for discussing the general system architecture of traffic information/control:

- Incident information
- Traffic congestion information
- Weather Information
- Traffic control assistance
- Center-to-center data exchange

Figure 5.1 Implementation Packages and Alternatives of Traffic Information/Control



6. General System Architecture

Diagrams of general system architecture of the implementation packages of traffic information/ control are shown in the following pages.

Figure 6.1 Incident Information by Monitoring at Roadside (G.S.A.)

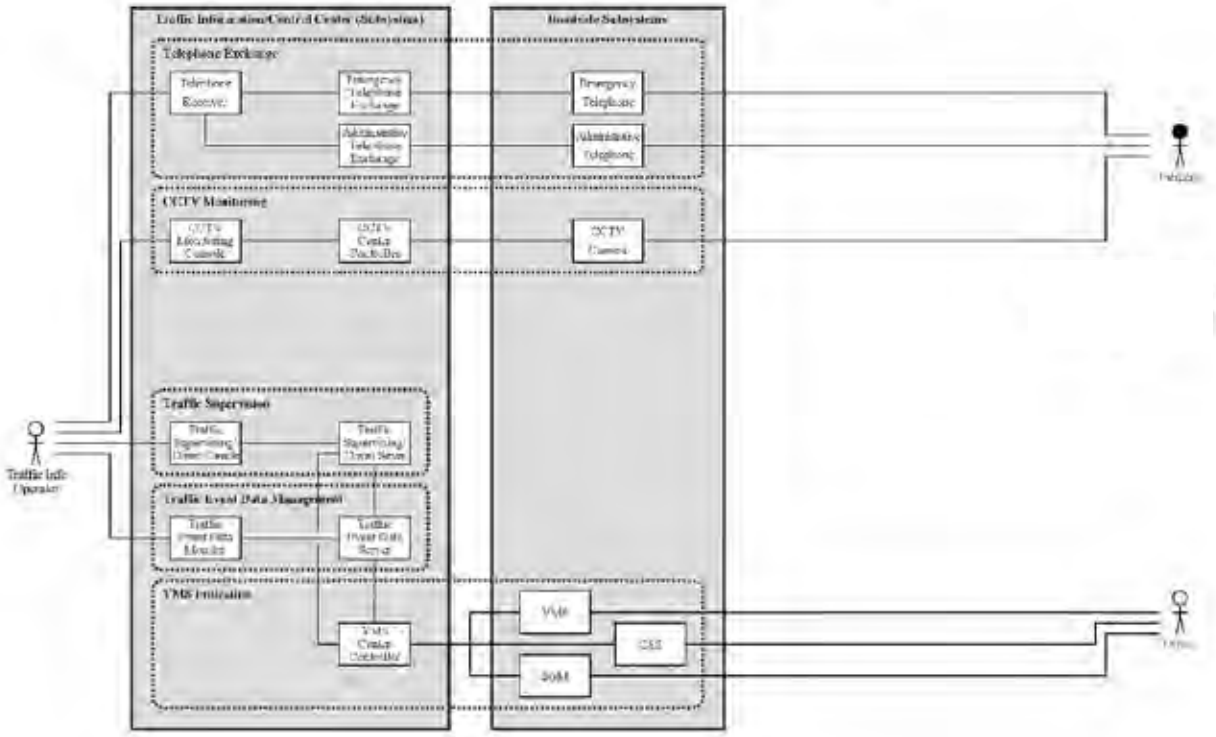


Figure 6.2 Incident Information by Image Recognition (G.S.A.)

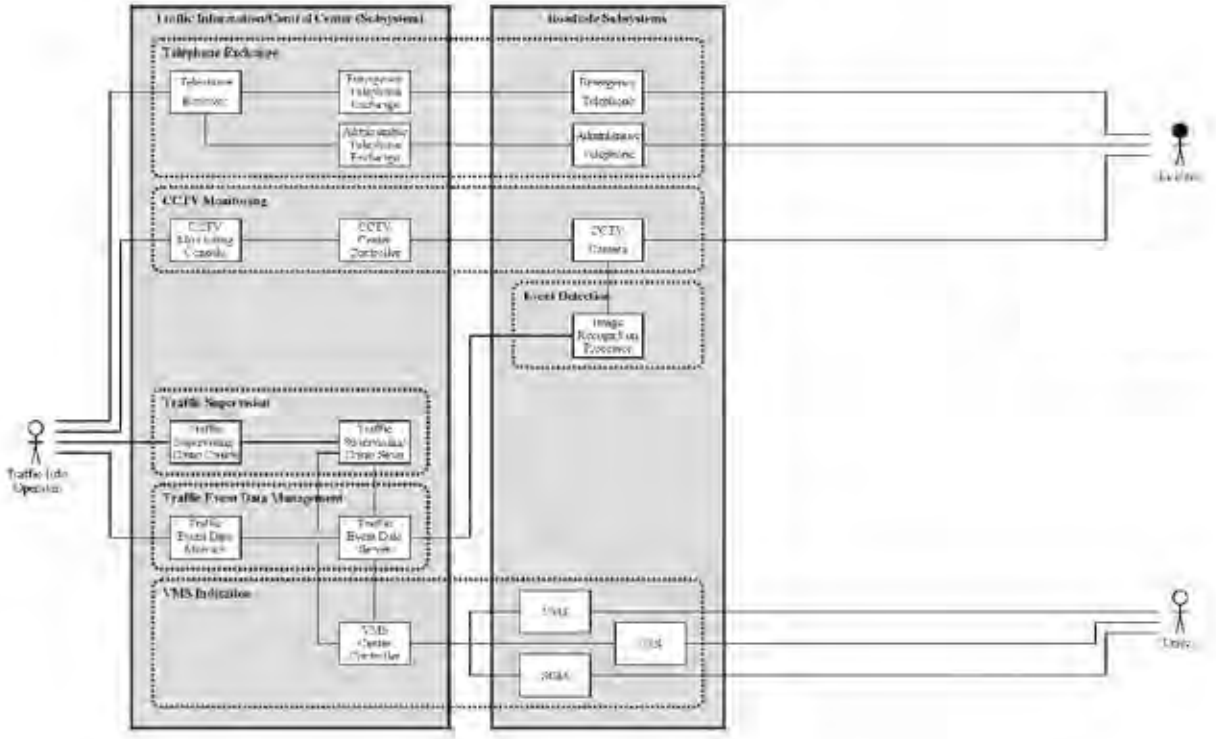


Figure 6.3 Traffic Congestion Information by Monitoring at Roadside (G.S.A.)

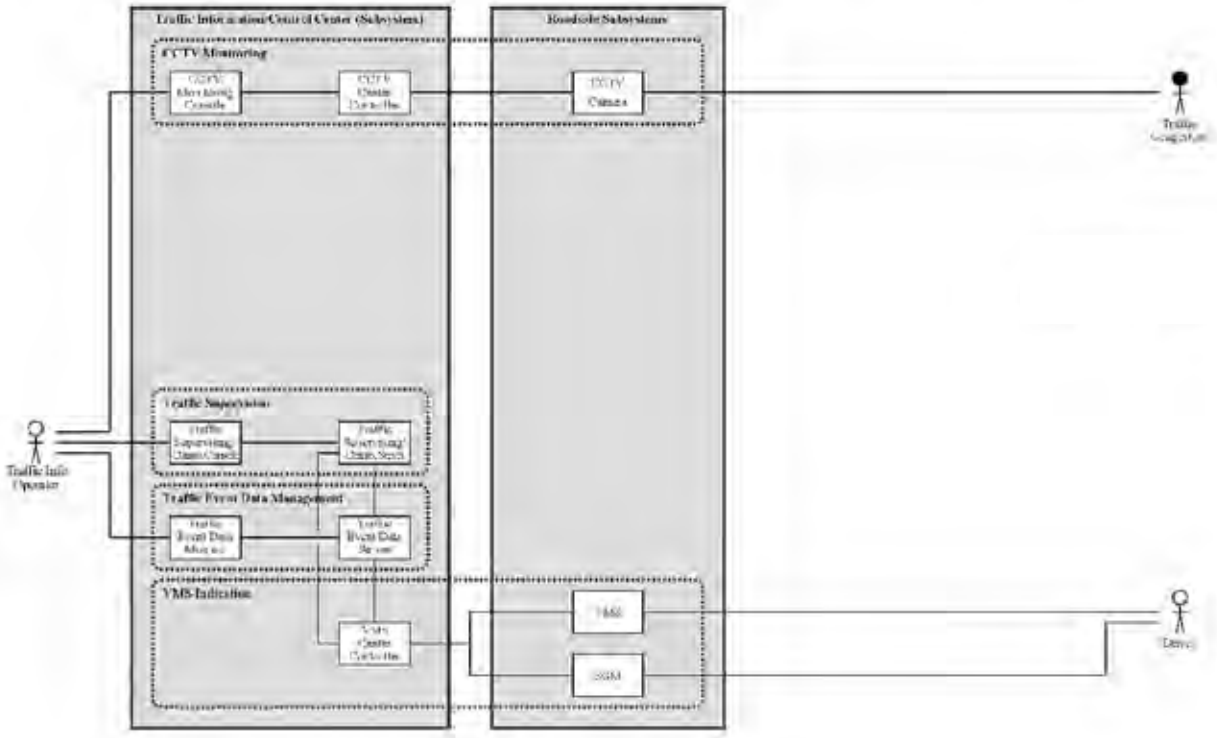


Figure 6.4 Traffic Congestion Information by Image Recognition (G.S.A.)

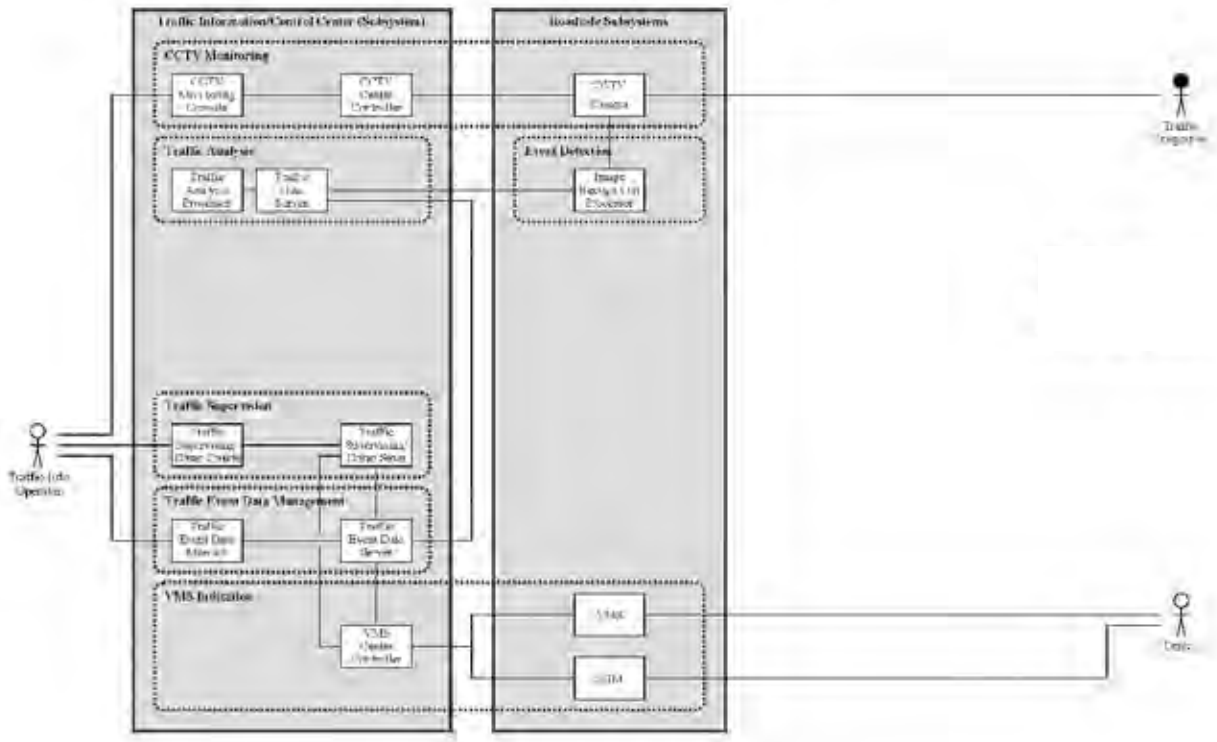


Figure 6.5 Traffic Congestion Information by Vehicle Detection (G.S.A.)

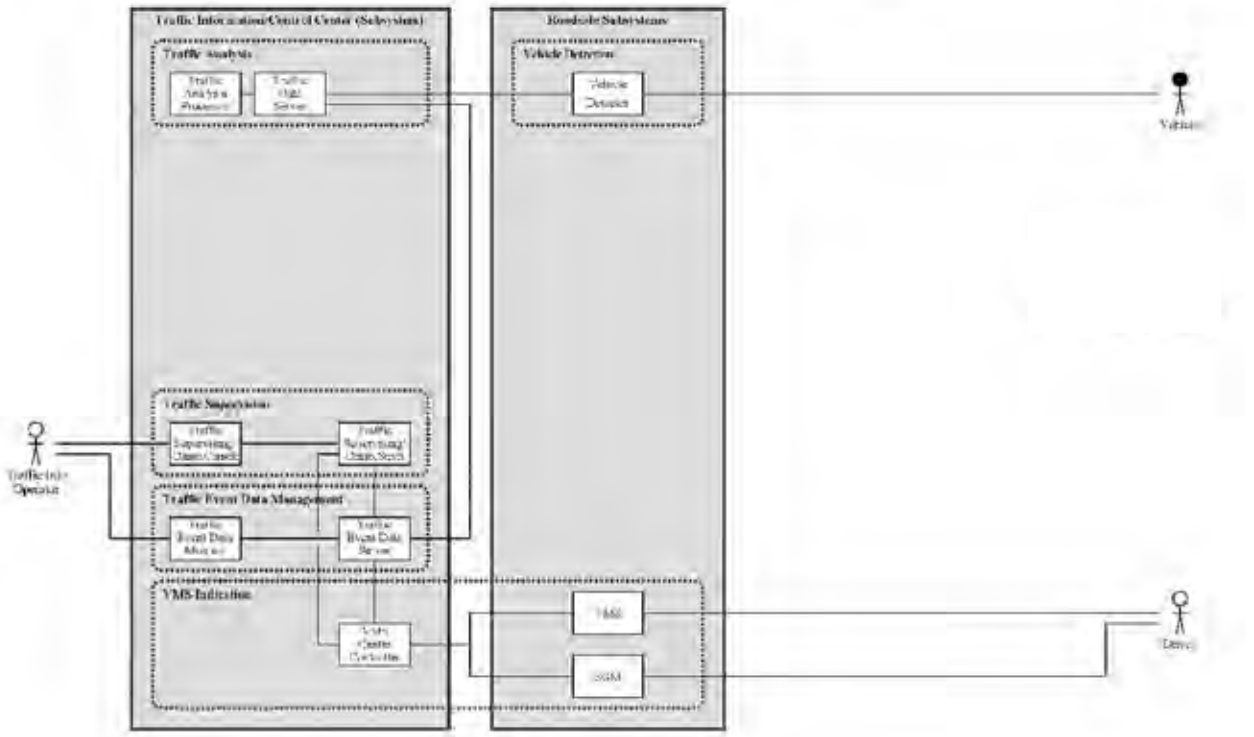


Figure 6.6 Weather Information (G.S.A.)

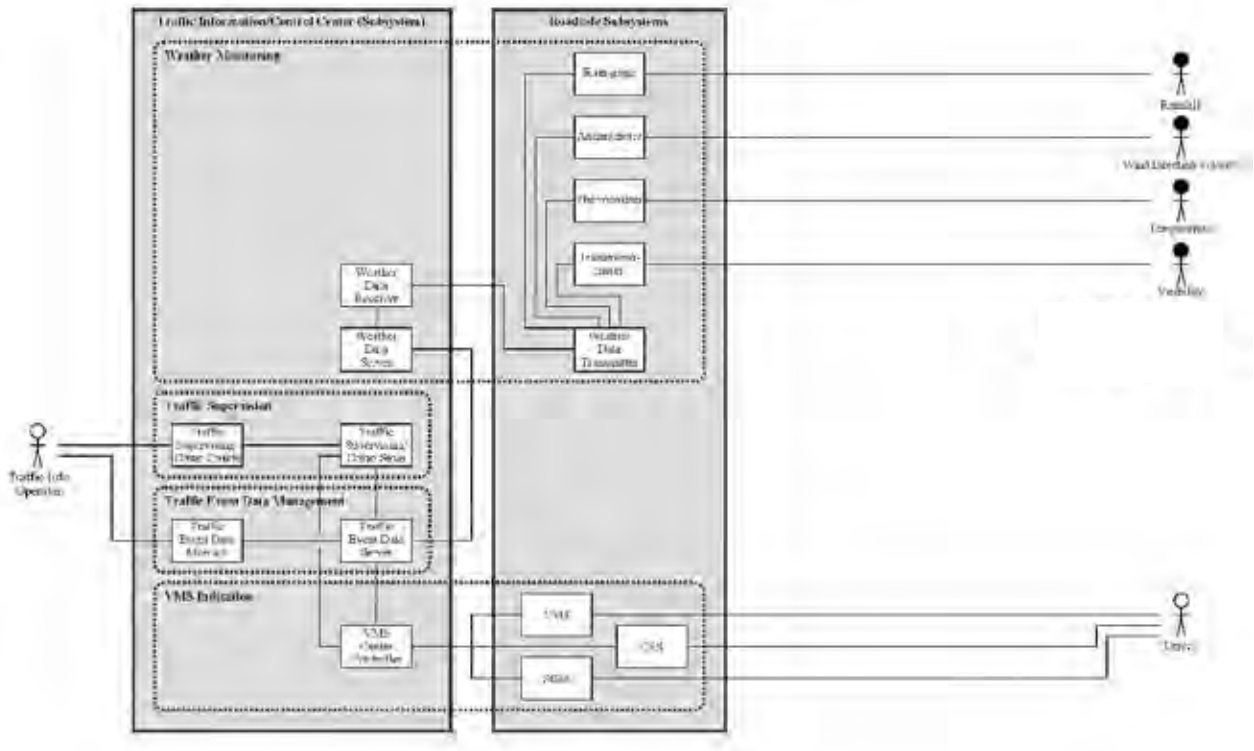
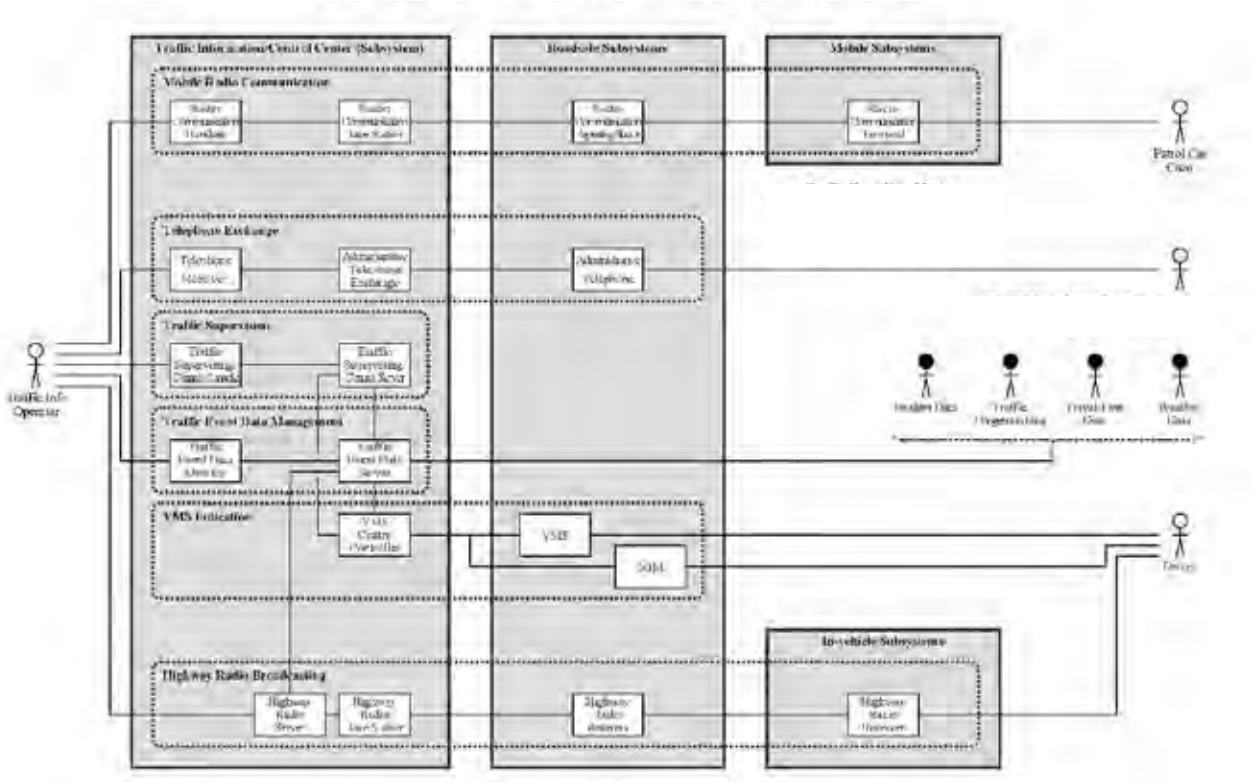


Figure 6.7 Traffic Control Assistance by Traffic Event Data (G.S.A.)



7. Required Functional Packages

The following functional packages are required for structuring the system for traffic information/ control system:

(1) Telephone Exchange
(2) CCTV Monitoring
(3) Event Detection (by Image)
(4) Vehicle Detection
(5) Traffic Analysis
(6) Weather Monitoring
(7) Traffic Event Data Management
(8) Traffic Supervision
(9) VMS Indication
(10) Mobile Radio Communication
(11) Traffic Information.

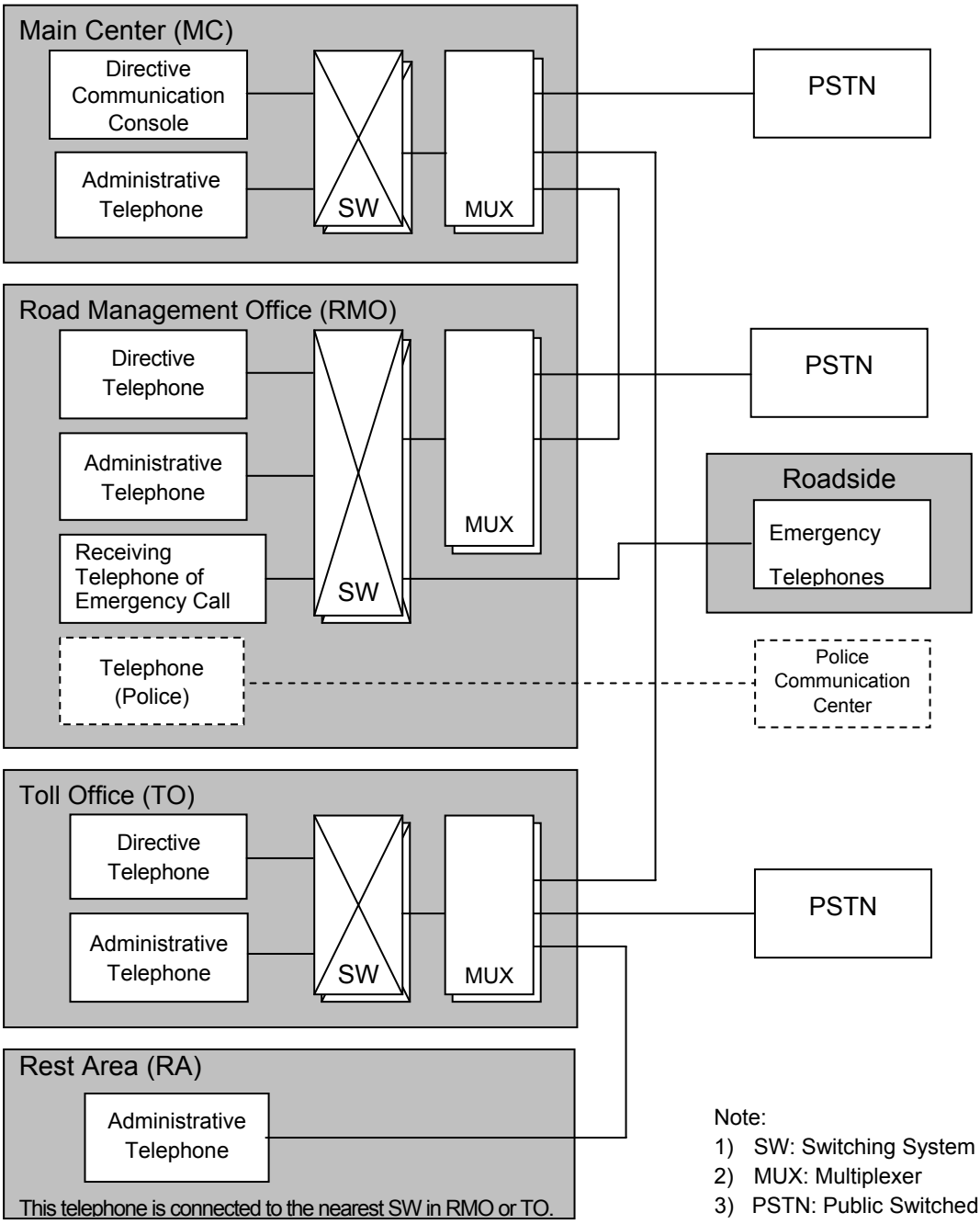
8. Telephone Exchange

8.1 Outlines

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

8.2 System Architecture

Figure 8.1 System Architecture for Telephone Exchange



8.3 Functional Design

→ Refer to the Draft Communication System Plan.

8.4 Message Exchange

→ Refer to the Draft Communication System Plan.

8.5 Transmission Design

→ Refer to the Draft Communication System Plan.

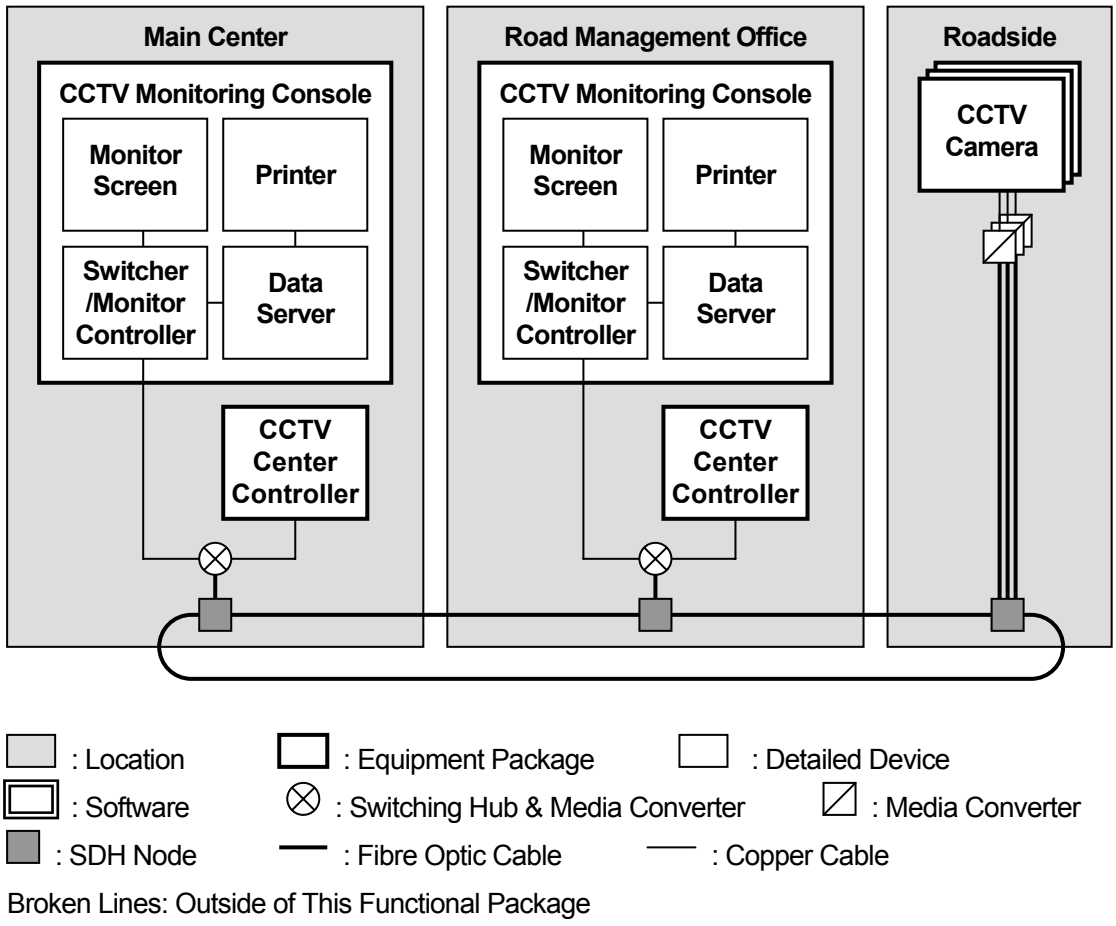
9. CCTV Monitoring

9.1 Outlines

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

9.2 System Architecture

Figure 9.1 System Architecture for CCTV Monitoring



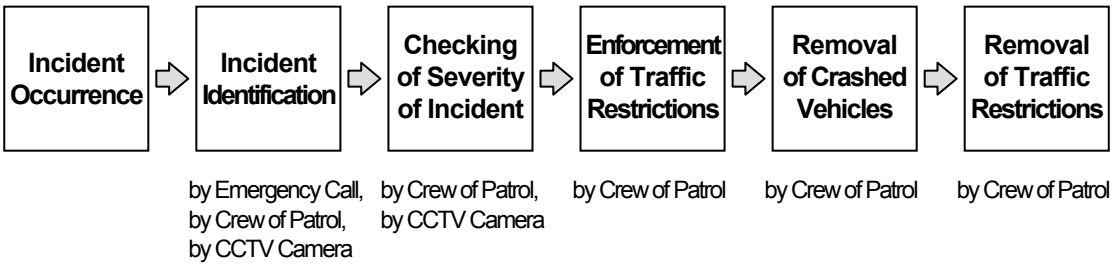
9.3 Functional Design

1) Functions

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

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

Figure 9.2 Procedure of Addressing Incidents



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

2) Required Values for CCTV Camera

Scope of View of CCTV cameras will be estimated based on the location and height of camera and objective of the monitoring. In the design, the monitoring range and the viewpoint will be calculated based on the following example, in case of monitoring the diverging or merging traffic flows at the interchanges,

In the design, the monitoring range is assumed as shown in Figure 9.3.2. CCTV camera is to be installed on the roadside around the merging point (or on the median around the diverging point).

All the monitoring range is shall be shooting by using CCTV camera. Therefore, it is possible to compare such as following cameras;

Typical Camera 1:
- Capable for automatic Day / Night,
- Capable for installation at the outside,
- Capable for autofocus.

Typical Camera 2:
- Capable for zooming (optical),
- Capable for automatic Day / Night,
- Capable for installation at the outside,
- Capable for autofocus.

Table 9.1 Typical Performance of CCTV Camera

	Typical Camera 1	Typical Camera 2
Width of image sensor	6.5mm (1/2" sensor)	6.5mm (1/2" sensor)
Focal length of lens	3.8mm	3.8mm
Resolution	640-480pixel	704-480pixel
Illumination	2-100,000(Day mode) 0.2-100,000(Night mode)	2-100,000(Day mode) 0.3-100,000(Night mode)
Encoding	MPEG4, M-JPEG	MPEG4, M-JPEG
Ingress Protection	IPX4 *1	IP66 *2
Zooming (optical)	-	10x optical
Flame rate	30fps (Max.)	30fps (Max.)
Vertical dead ground length	5.72m	5.72m (57.18m in use zooming)
Maximum range of surveillance *3	109.99m	109.99m (1099.94m in use zooming)

*1. IPX4: Water splashing against the enclosure from any direction shall have no harmful effect only.
*2.IPX66: No ingress of dust; complete protection against contact. Water projected in powerful jets against the enclosure from any direction shall have no harmful effects.
*3. It is calculated depend on the monitoring conditions. Calculation and results as follows on next pages;

Horizontal Resolution: A man with normal eyesight can recognize a slit of 1.5mm width of the Landolt Ring from a distance of 5m. Hence, the required value of horizontal resolution is calculated at 339 lines at least by the following formula:

HR= (0.75B / 1.5) x (5 / d)

Where 0.75: the aspect ratio of the screen
B: the width of screen is 406.4mm (20-inch display)
d: the distance from the operator to the screen is 3m

Maximum Range of Surveillance: For a vehicle 1.5m wide to be recognized by the operator, the vehicle needs to be displayed clearly on the screen using more than 3lines. Hence, the minimum size of the vehicle image on a 20-inch display in the operation center is calculated at 3.6mm by the following formula:

V'= 3x (B/HR)

Where B: the width of screen is 406.4mm (20-inch display)

The CCTV camera shall provide the fineness by using a wide-angle lens to secure a sufficient depth of the field. For meeting this requirement, a maximum range of surveillance is calculated at 109.99m by the following formula:

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

Where b: the width of image sensor is 6.5mm (1/2-inch image sensor)
0.9: over-scanning ratio
V: the width of an actual vehicle is 1,500mm
V': the width of the displayed vehicle is 6mm, and
f: the focal length of lens of the CCTV camera is 3.8mm

Installation of CCTV Camera: The camera shall be installed attached on the median around the diverging point being aimed at the travelling direction of the vehicles. The

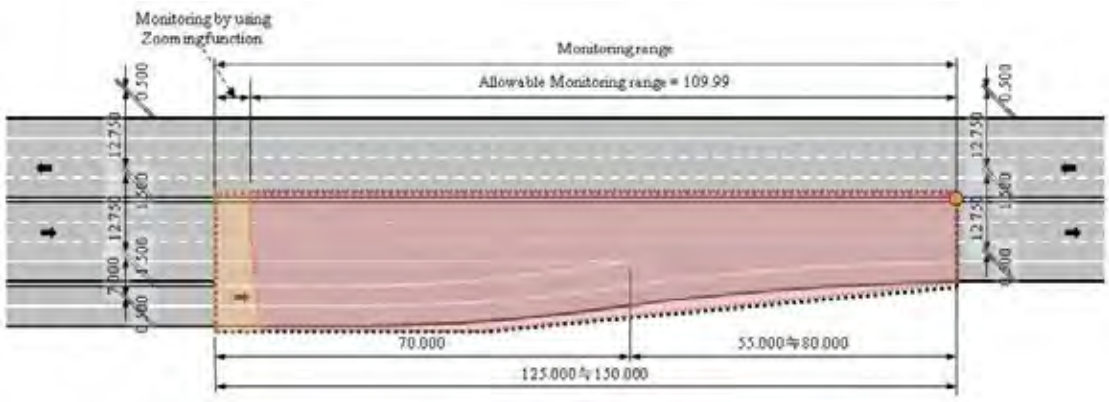
maximum of surveillance of the CCTV camera is calculated at 119.160m.

- Monitoring range is needed 150m (approx.) at merging point and 55m (approx.) at diverging point. It is showed in Figure 9.3.
- Allowable Monitoring Range is calculated about 2 type of CCTV camera in Table 3. It is either 109.99m without zooming function. It is not enough range for monitoring at merging point. In case of CCTV camera is used for monitoring at the merging point, shall be installed 2 cameras. However, remaining range (40m approx.) is allows to monitor by using zooming function. Therefore, shall be selected the camera which has got a **Zooming** function.

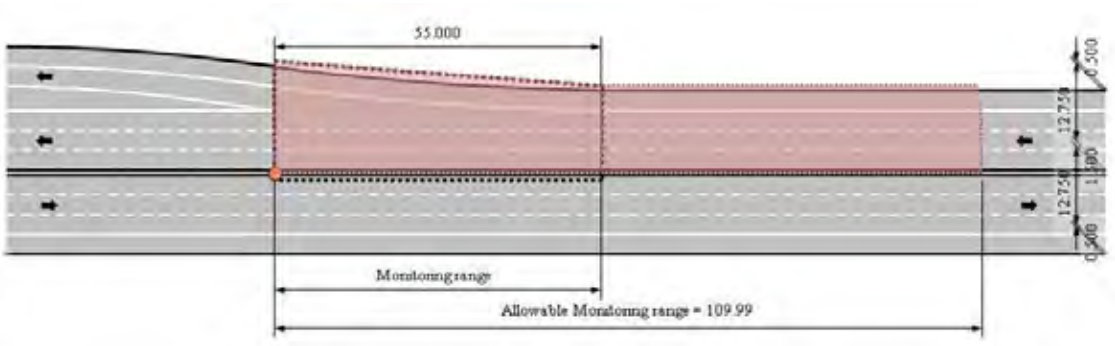
→ Refer to the Draft General Specification for CCTV Monitoring

Figure 9.3 Monitoring Range of CCTV Camera

Merging point (Hypothetical Monitoring range)



Diverging point (Hypothetical Monitoring range)



3) Sensitivity and Mechanical Capabilities

Sensitivity and mechanical capabilities:

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

Fixed Camera: The camera shall "Not" have mechanical capability of zooming and

panning for focusing the objective of interest for traffic surveillance.

Table 9.2 Comparison of CCTV Camera

	PTZ Camera	Fixed camera
Width of image sensor	6.5mm (1/2" sensor)	6.5mm (1/2" sensor)
Focal length of lens	3.8-38.0mm	3.0mm
Resolution	704-480pixel	640-480pixel
Illumination	2-100,000(Day mode) 0.3-100,000(Night mode)	0.65-100,000(Day mode) 0.08-100,000(Night mode)
Encoding	MPEG4, M-JPEG	MPEG4, M-JPEG
Ingress Protection	IP66 *1	IPX3 *2
Panning	+/- 170 degrees	—
Tilting	180 degrees	—
Zooming	10x optical	—
Flame rate	30fps (Max.)	45fps (Max.)
Vertical dead ground length	5.72m (57.18m in use zooming)	4.51m
Maximum range of surveillance *3	109.99m (1099.94m in use zooming)	86.84m

*1.IPX66: No ingress of dust; complete protection against contact. Water projected in powerful jets against the enclosure from any direction shall have no harmful effects.

*2. IPX3: Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect only.

*3. It is calculated depend on the monitoring conditions. Calculation and results as follows on next pages;

4) Monitoring Range

PTZ Camera

The CCTV camera shall provide the fineness by using a wide-angle lens to secure a sufficient depth of the field. For meeting this requirement, a maximum range of monitoring is calculated at 109.99m by the following formula:

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

Where b: the width of image sensor is 6.5mm (1/2-inch image sensor)
0.9: over-scanning ratio
V: the width of an actual vehicle is 1,500mm
V': the width of the displayed vehicle is 3.6mm, and
f: the focal length of lens of the CCTV camera is 3.8mm

Installation of CCTV camera: The camera shall be installed attached on the median around the diverging point being aimed at the travelling direction of the vehicles. The maximum of surveillance of the CCTV camera is calculated at 109.99m.

Fixed Camera

The CCTV camera shall provide the fineness by using a wide-angle lens to secure a sufficient depth of the field. For meeting this requirement, a maximum range of monitoring is calculated at 86.84m by the following formula:

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

Where b: the width of image sensor is 6.5mm (1/2-inch image sensor)
0.9: over-scanning ratio
V: the width of an actual vehicle is 1,500mm
V': the width of the displayed vehicle is 3.6mm, and
f: the focal length of lens of the CCTV camera is 3.0mm

Installation of CCTV camera: The camera shall be installed attached on the median around the diverging point being aimed at the travelling direction of the vehicles. The maximum of surveillance of the CCTV camera is calculated at 86.84m.

- In case of 500m distance of road surveillance, allowable monitoring range and required quantity of camera of PTZ camera is shown at Figure 9.4. Also, Fixed camera is shown at Figure 9.5.
- Accordingly, PTZ camera shall be needed to 6 cameras as against Fixed camera shall be needed 14 cameras. Therefore, shall be selected the camera which has got a **Panning** and **Tilting** function.

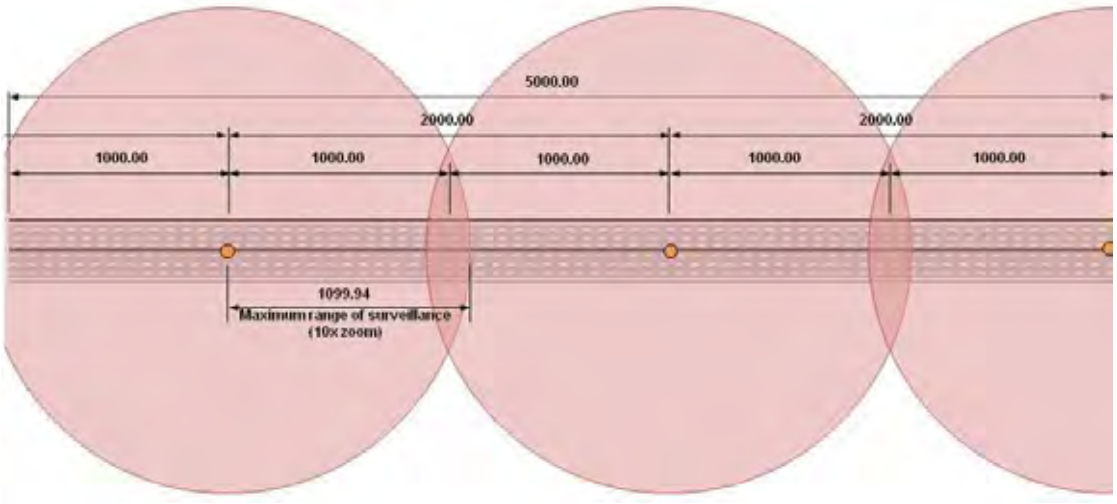
→ Refer to the Draft General Specification for CCTV Monitoring.

PTZ Camera

In case of using PTZ camera; 10x zoom (Maximum range of surveillance 1099.94m)

Approx. 3 cameras shall be installed at the roadside between 5,000m.

Figure 9.4 Monitoring Range of PTZ Camera

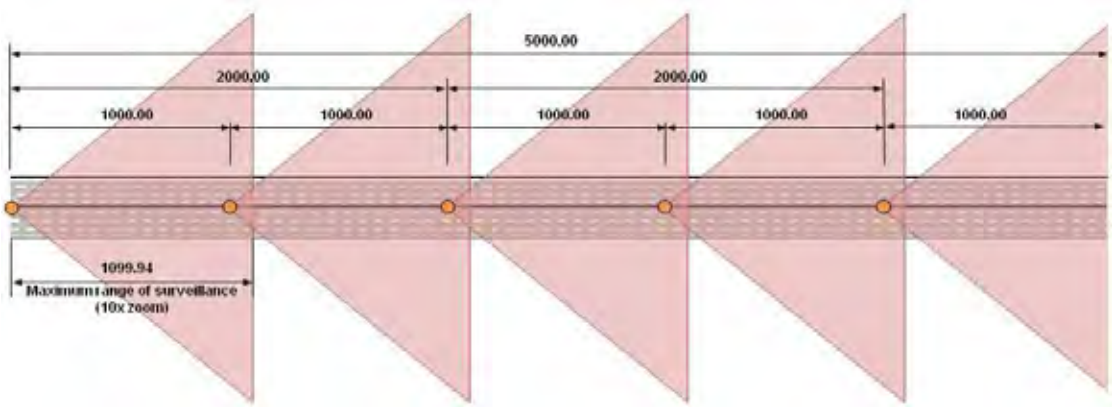


Fixed Camera

In case of using Static camera; 10x zoom

Approx. 5 cameras shall be installed at the roadside between 5,000m.

Figure 9.5 Monitoring Range of Fixed Camera



5) Antiweatherability

CCTV camera shall be protected against dust and water ingress, if it will be installed outdoor in road typical section in accordance with IP66, in tunnel section in accordance with IP64 of the international standards IEC 60529 or equivalent.

Reference about IPXX: The IP Code (or International Protection Rating, sometimes also interpreted as Ingress Protection Rating) consists of the letters IP followed by two digits and an optional letter. As defined in international standard IEC 60529, it classifies the degrees of protection provided against the intrusion of solid objects (including body parts like hands and fingers), dust, accidental contact, and water in electrical enclosures. The standard aims to provide users more detailed information than vague marketing terms such as waterproof.

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

Table 9.3 Mean of First Digit on IPXX

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

Second Digit: Protection of the equipment inside the enclosure against harmful ingress of water.

Table 9.4 Mean of Second Digit on IPXX

Level	Protected against	Details
0	not protected	—
1	dripping water	Dripping water (vertically falling drops) shall have no harmful effect.
2	dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15° from its normal position.
3	spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.
4	splashing water	Water splashing against the enclosure from any direction shall have no harmful effect.
5	water jets	Water projected by a nozzle against enclosure from any direction shall have no harmful effects.
6	powerful water jets	Water projected in powerful jets against the enclosure from any direction shall have no harmful effects.
7	immersion up to 1 m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).
8	immersion beyond 1 m	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer.
		NOTE: Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that produces no harmful effects.

6) Human Machine Interfaces

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

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

However, some issues are envisioned as follows:

- The space of monitoring room may not be enough to locate all necessary monitor screens.
- The number of operators is not enough for monitoring all CCTV images displayed on

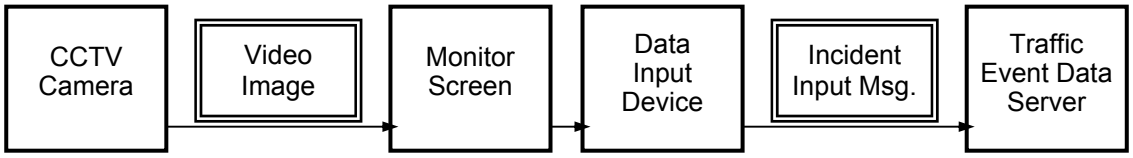
Monitor Screens.

- Therefore, number of monitors should be considered as follows:
- Multi images shall be separately displayed on the same Monitor Screen.
- Images of different cameras shall be displayed on the same Monitor Screen in defined rotating interval.

9.4 Message Exchange

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

Figure 9.6 Major Message Exchanges for Generating Incident Data



1) Video Data

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

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

2) Camera Control Signal

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

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

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

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

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

3) Incident Data Input

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

Table 9.5 Data Set/Elements in Incident Input Message

Data Set	Data Elements	Definition
Incident Data Set	Date	Day/month/year of identifying an incident
	Time	Hour/minute/second of identifying an incident
	Roadside Equipment ID	Roadside equipment ID code of CCTV camera
	Incident Status	Class of incident input referring to the video image, which can have a value shown in Table 9.6.

Note, * : Data by automatic input, ** : Data by manual input.

The incident status can have a value of the traffic event categories/classes shown in the following table:

Table 9.6 Categories/Classes of Incident

Traffic Event Category	Traffic Event Class		Definition
Incident	Traffic Accident	1	Serious traffic accident with issuing Closure
		2	Traffic accident with issuing lane/speed restriction
		3	Traffic accident without traffic regulation
	Broken-down Vehicle		Vehicle stopping on road due to disorder
	Left Obstacle		Object on road which may prevents vehicle traffic (excluding vehicles)
	Reversing Vehicle		Vehicle running in the reverse direction
	Vandalism		Wilful destruction of road facilities or obstruction of vehicles
	Natural Disaster		Natural disaster which may prevent car passing

9.5 Transmission Design

The establishment of 3 Main Centers is considered: one in Hanoi for the northern area, one in Danang for the central area and one in Ho Chi Minh city for the southern area. In case of monitoring roads using CCTV cameras in Main Center, there would be some possible issues regarding transmission as the following;

Point of Issues

- If all the Video image from CCTV installed within the area are observed in the Main Center at the same time, the traffic volume of communication line would be excessive.
- It's contemplated that difference manufacture's CCTV is installed by each road operators for competition. However, since there has been no International Standard for Protocol of controlling CCTV's functions including Zooming, panning, tilting, it is difficult to control all CCTVs installed within the Main Center Area.

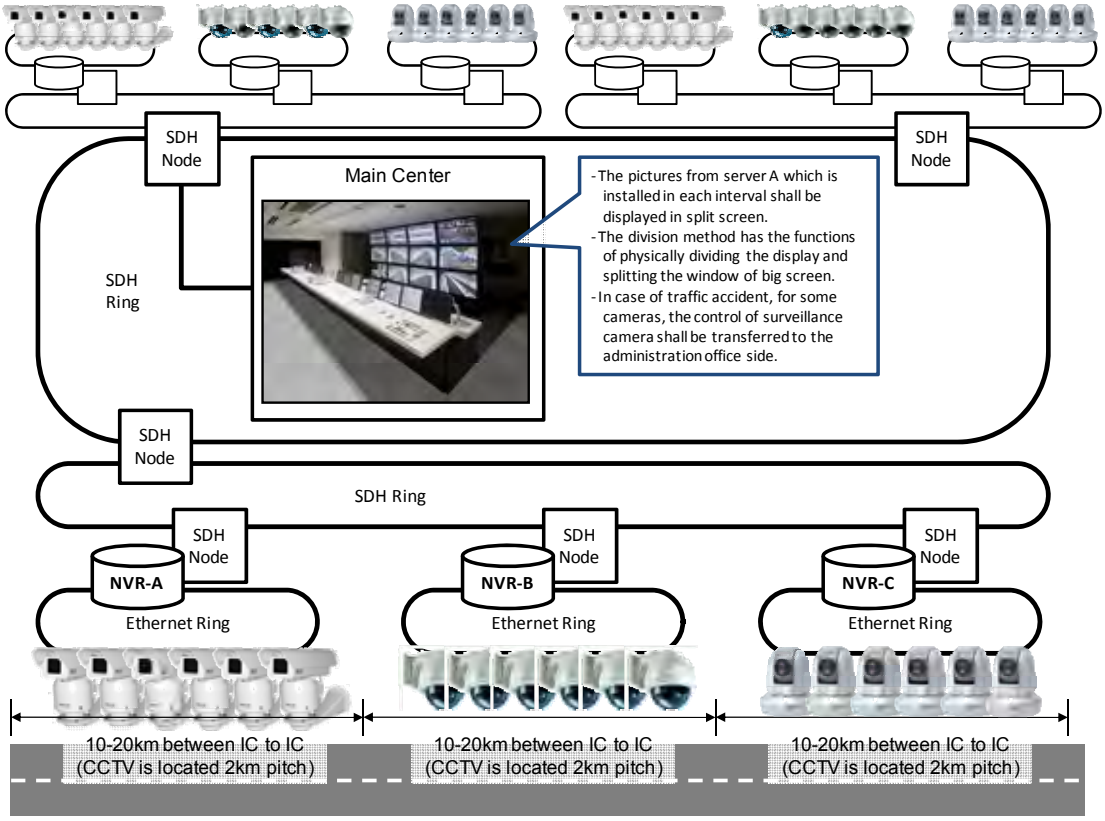
Attempt Solutions

NVR is used for the one of attempt solution. NVR (Network Video Recorder) is an internet protocol based device that sits on network. Because it is IP based, NVR can be managed remotely via LAN or over the Internet giving you greater flexibility. The basic function of an NVR is the simultaneous recording and remote access of live video streams from IP

camera. NVR will feature flexible recording and playback capability, an intuitive remote control unit, a user-friendly GUI, intelligent motion detection, and Panning-Tilting-Zooming camera control.

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

Figure 9.7 Relation of Main Center and NVR on Network



→ Further concepts and methodologies are to be referred to the Draft Communication System Plan.

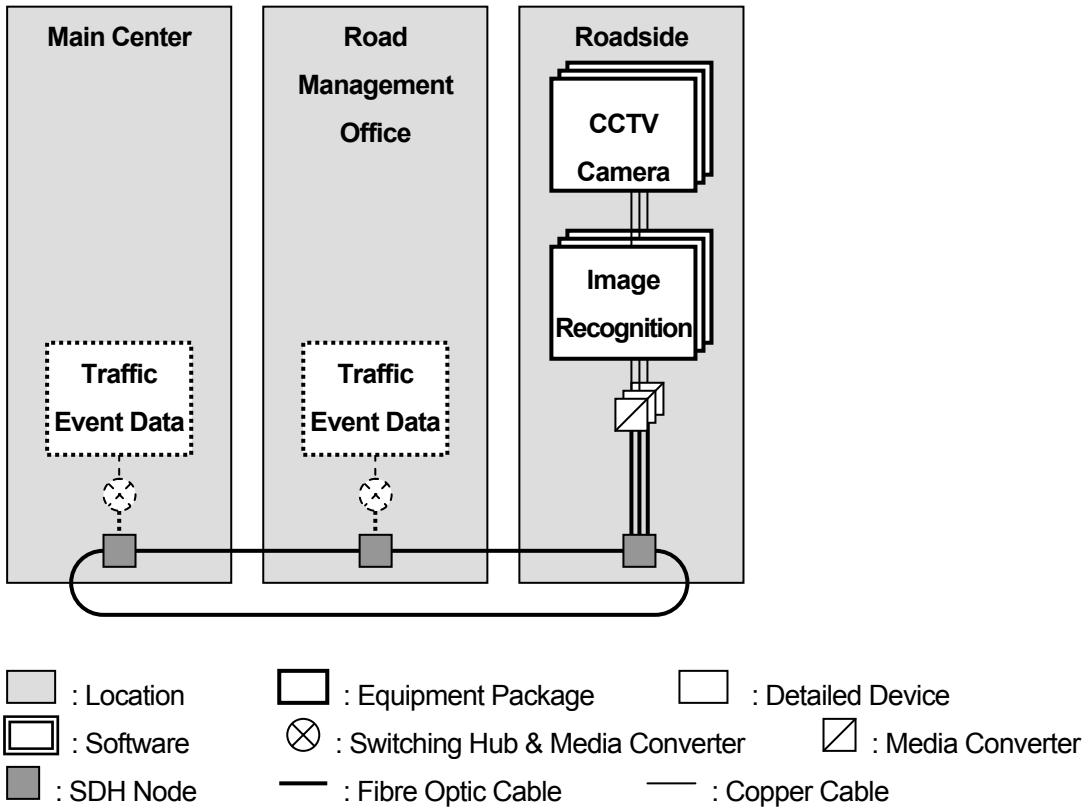
10. Event Detection (by Image)

10.1 Outlines

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

10.2 System Architecture

Figure 10.1 System Architecture for Event Detection



10.3 Functional Design

1) Functions

Event detection is an equipment which is capable of automatically detecting the occurrence of an accident, a broken vehicle or a falling object and give notice to main center and road management office by analyzing pictures taken by cameras which are installed in road bottlenecks or long tunnels where traffic hazards on expressway are likely to occur.

Event detection comprises of camera unit and image recognition unit. The image recognition unit can be installed in the center of in roadside.

In case the image recognition unit is installed in the center, it is not necessary to repair or replace at roadside if a failure such as malfunction in the image recognition unit occurs. However, since it is necessary to transfer constantly the camera pictures to image recognition unit in the center, this causes heavy load on communication line capacity.

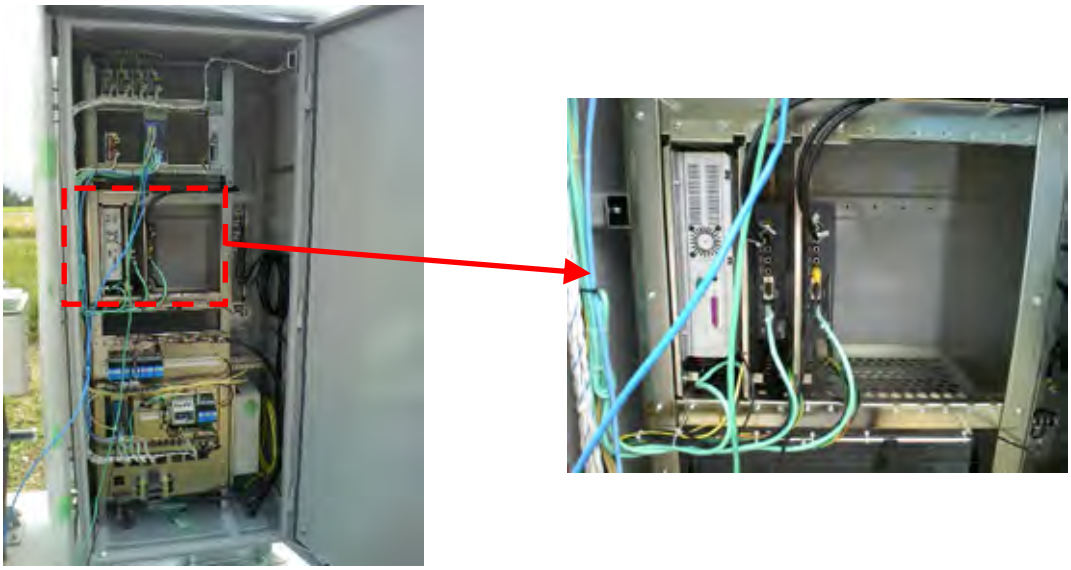
In case the image recognition unit is installed at roadside, in order to transmit data to traffic event server in center side only when an emergent event of any kind is detected, it is unnecessary to transmit camera pictures constantly, therefore the load on communication line can be reduced. However, it is necessary to repair or replace at roadside if a failure such as malfunction in the image recognition unit occurs.

In the future, if the number of event detection is increased, due to the further load growth on the communication line, the installment of image recognition unit at roadside is preferable.

Table 10.1 Comparison of Location of Image Recognition Unit

	At Center	At Roadside
Strengths	When a malfunction in image recognition unit occurs, it is possible to handle in center side.	Load on the communication is low.
Weaknesses	It is necessary to transmit camera pictures constantly to the center, the load on communication line is heavy.	It is necessary to repair or replace at roadside if a failure in the image recognition unit occurs.

Figure 10.2 Example of Image Recognition unit at Roadside



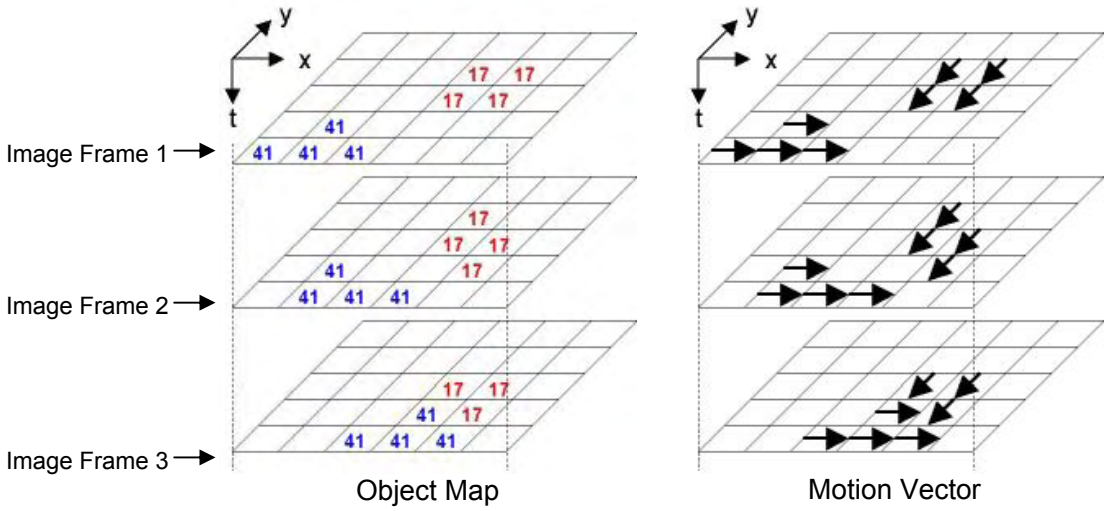
2) Image Recognition Method

There are analyzing image system in multi-categories. Analyzing image system on highway needs the vehicle detection which existence and position on the road, the system require that the vehicle identification technique shown on image suitably. Image analysis technique in about 10 previous years met with difficulties in analyzing when having both vehicle and motorcycle, objects move on one screen according to many different ways. However, with present analysis technique improved accuracy when analyzing image and applied on many vehicles.

This section presents in general about one image analysis method called ”S-T MRF Model (Space-time Markov Random Field Model)”. S-T MRF Model is probability model to divide Space-time image area. S-T MRF Model focus on mutual relationship between time-scale directions of Space-time image enlarge like Space-time model. Normal MRF Model often divides area according to each pixel. There is one principle at S-T MRF Model; however, in fact, in case of comparing between image frames, vehicle move from a few pixels to a dozens of pixels, therefore dividing area according to each Pixel is very difficult.

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

Figure 10.3 Recognition Imagery of S-T MRF Model



※Processing image that change gradually of Image Frame1 to 3, analysing, comparing, detecting movement and existing position of object

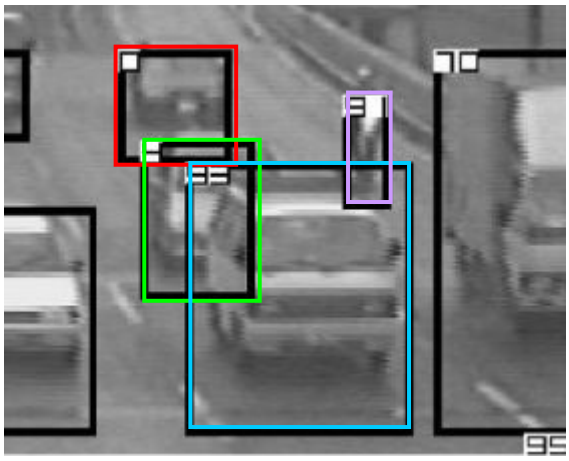
Besides, by applying probabilistic relaxation model, in case of arising occlusion due to different vehicles, still be able to request to analyze moving object line most suitably. Time/space MRF model only focus on moving vectors of object in order to divide area, but not exist at category of object.

Example: In case of monitor is constructed 640 pixel × 480 pixel then divide into block 8 pixel × 8 pixel after that distribute blocks at 80 block × 60 block.

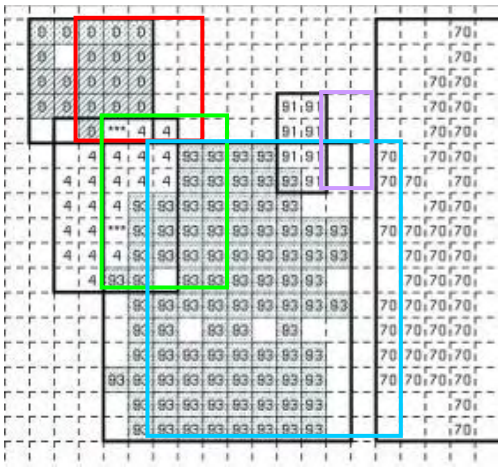
At Figure 10.4: processing image of image on the left, after that show status of object identification by object map on the right. Vehicle in green frame is identified in range of 5 block x 7 block (written on Object Map is No.4) is overlapped vehicle in blue frame (written on Object Map is No.93). Arising occlusion here, however still detect exactly.

By this image analyze improved vehicle detection technique. And from received information by image analyze can detect incident occurrence by reducing speed or stop moving unexpectedly of vehicle. Therefore, can detect what happened by image analyze, however, due to it's impossible to analyze reason when incident occur such as traffic accident or broken down vehicles so it's necessary to confirm by CCTV or patroller.

Figure 10.4 Recognition Sample of S-T MRF Model



CCTV Image



Object Map

3) Notandum on Image Recognition

An accuracy of image processing device depends on angle of view of CCTV camera. In short, images that difficult to see by human also effect to accuracy when identifying in image analyze. In order to maintain accuracy of measurement/detector, it's necessary to investigate completely before installing event detector to avoid installing for places having image as before installing.

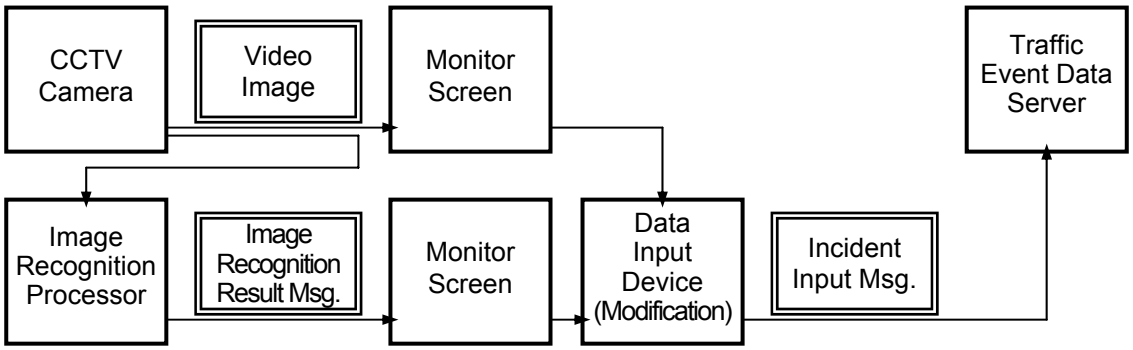
For example, on the left image: small passenger car is hiding in shade of truck. This angle of view is undesirable. On the right image: pictured above of skyline therefore may be it's effected by sunshine depend on time or camera direction

Figure 10.5 Sample of Undesirable Angle of View

10.4 Message Exchange

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

Figure 10.6 Major Message Exchanges for Generating Incident Data



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

Table 10.2 Data Set/Element in Image Recognition Results Message

Data Set	Principal Data Element	Update Cycle
Image Recognition Result Data set	Date	Day/month/year of detecting event
	Time	Hour/minute/second of detecting event
	Roadside Equipment ID	Roadside equipment ID code of image recognition processor
	Image Recognition Result Status	Status analyzed by image recognition processor, which can have a value shown in Table 10.3

The image recognition result status can have a value of the image recognition result classes shown in the following table:

Table 10.3 Classes of Image Recognition Result

Image Recognition Result Class	Definition
Existence of Slowdown Object	Condition that slowdown object is recognized in the field of view.
Existence of Slowdown/Stopped Object	Condition that slowdown and stopped object is recognized in the field of view.
Existence of Reversing Object	Condition that reversing object is recognized in the field of view.
None	Condition without any slowdown, stopped or reversing object

Referring to the results by image recognition indicated on the monitor screen, a message for generating incident data is to be input by an operator to the traffic event data server as mentioned in the forgoing CCTV monitoring.

10.5 Transmission Design

All the signals and data are transferred via Internet and communication Protocol is transferred via TCP/IP.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Further concepts and methodologies are to be referred to the Draft Communication System Plan.

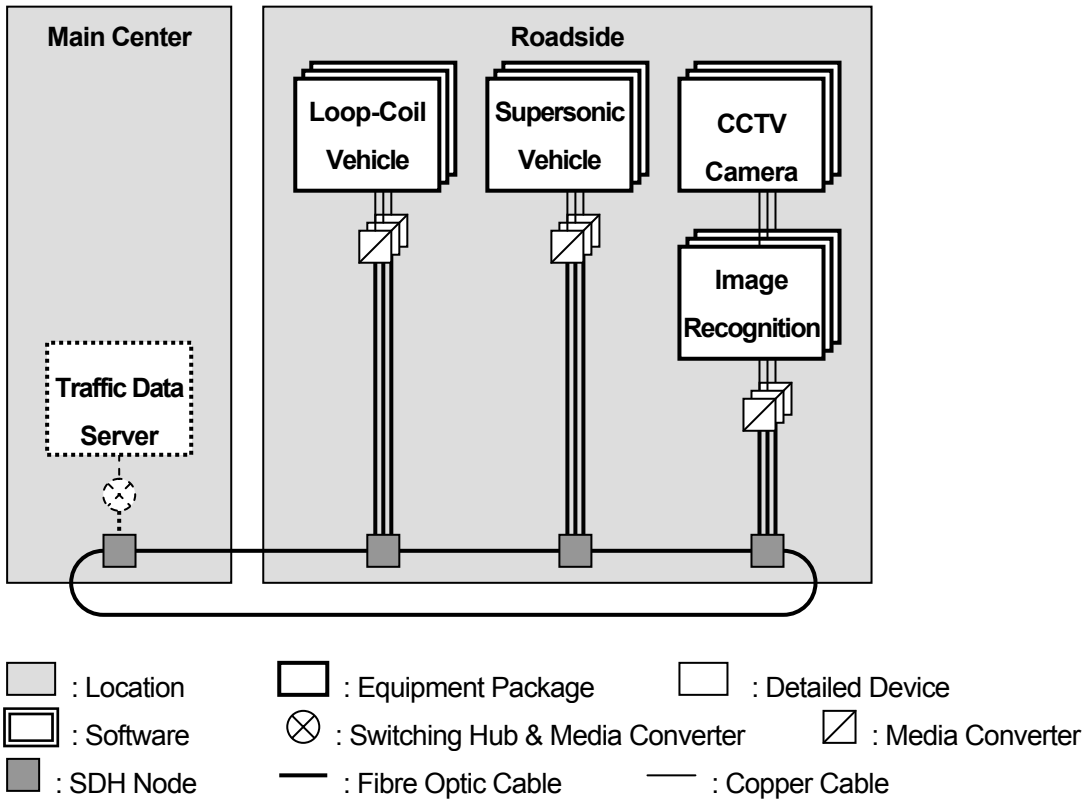
11. Vehicle Detection

11.1 Outlines

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

11.2 System Architecture

Figure 11.1 System Architecture for Vehicle Detection



11.3 Functional Design

1) Functions

Vehicle detection is an equipment which is capable of grasping the percentage of traffic volume and large-sized vehicles on expressway, the running speed of vehicles by a vehicle detector installed in the junction between expressway main lain and interchange. The measurement of following values is required.

- Traffic volume (of each cross section, lane, vehicle category and hourly)
- Vehicle Length
- Vehicle Speed
- Average speed (every 1 minute)

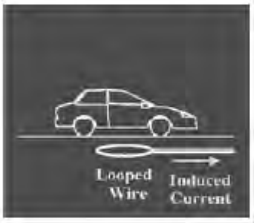
2) Comparison of Vehicle Detection

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

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

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

Table 11.1 Comparison of Vehicle Detection

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

3) Comparison of Vehicle Detection

There are three types of vehicle detection: a) Loop-coil type, b) Ultrasonic type and c) Image recognition type. Vehicle detectors can be categorized into in-road sensors and over-road sensors. a) Loop-coil type is mainly used in in-road sensors whereas b) Ultrasonic type and c) Image recognition type are mainly used in over-road sensors. Each type of vehicle

detector is described in Table 11.2 and Table 11.3 below.

Table 11.2 Traffic output data of Vehicle Detection

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

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

Loop-coil Type:
Loop-coil type can be utilized for measuring Traffic volume.

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

$V_V = L_S / TD_S$

V_V : Vehicle Velocity
L_S : Distance between each loop coils
TD_S : Time difference between detection timing of each loop coils

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

$VL_V = V_V \times RT_S$

VL_V : Vehicle Lengthy
L_V : Vehicle Velocity
RT_S : Reaction Time of loop coil

Ultrasonic Type:
Ultrasonic type is capable of measuring traffic volume, but it is not recommended for measuring vehicle velocity and vehicle length,

Image Recognition Type:
Image recognition type is capable of determining the motion and dimension of each Vehicle from image captured by camera based on image analysis function, as well as measuring traffic volume, vehicle velocity and vehicle length. Additionally, though one camera can cover several lanes. However, the cost per one camera is still expensive in comparison with other methods.

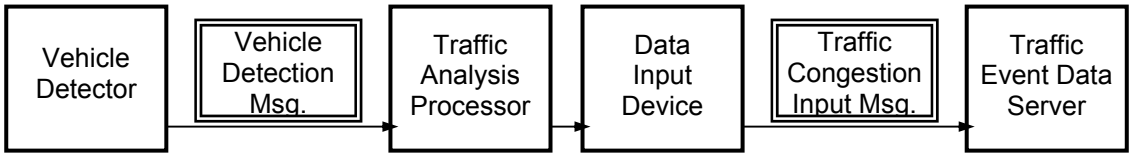
Table 11.3 Strengths and Weaknesses of Vehicle Detection

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

11.4 Message Exchange

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

Figure 11.2 Major Message Exchanges for Generating Traffic Congestion Data



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

Table 11.4 Data Set/Elements in Vehicle Detection Message

Data Set	Data Elements	Definition
Vehicle Detection Data Set	Date	Day/month/year of detecting vehicles
	Time	Hour/minute/second of detecting vehicles
	Roadside Equipment ID	Roadside equipment ID code of Vehicle Detector
	Cumulative Number of Vehicles	Cumulative number of Vehicles which is detected by Vehicle Detector
	Vehicle Speed (1)	Vehicle speed which is detected by Vehicle Detector
	Vehicle Length (2)	Vehicle Length which is detected by Vehicle Detector
	:	:
	Vehicle Speed (N)	Vehicle speed which is detected by Vehicle Detector
	Vehicle Length (N)	Vehicle Length which is detected by Vehicle Detector

Note: Self-diagnostic result identifiers, having values as “Normal” or “Abnormal” for a detector and a data logger, need to be included in the message.

11.5 Transmission Design

All the signals and data are transferred via Internet and communication protocol is transferred via TCP/IP.

However, the transmission mode between data logger unit and vehicle detector unit is not defined.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Further concepts and methodologies are to be referred to the Draft Communication System Plan.

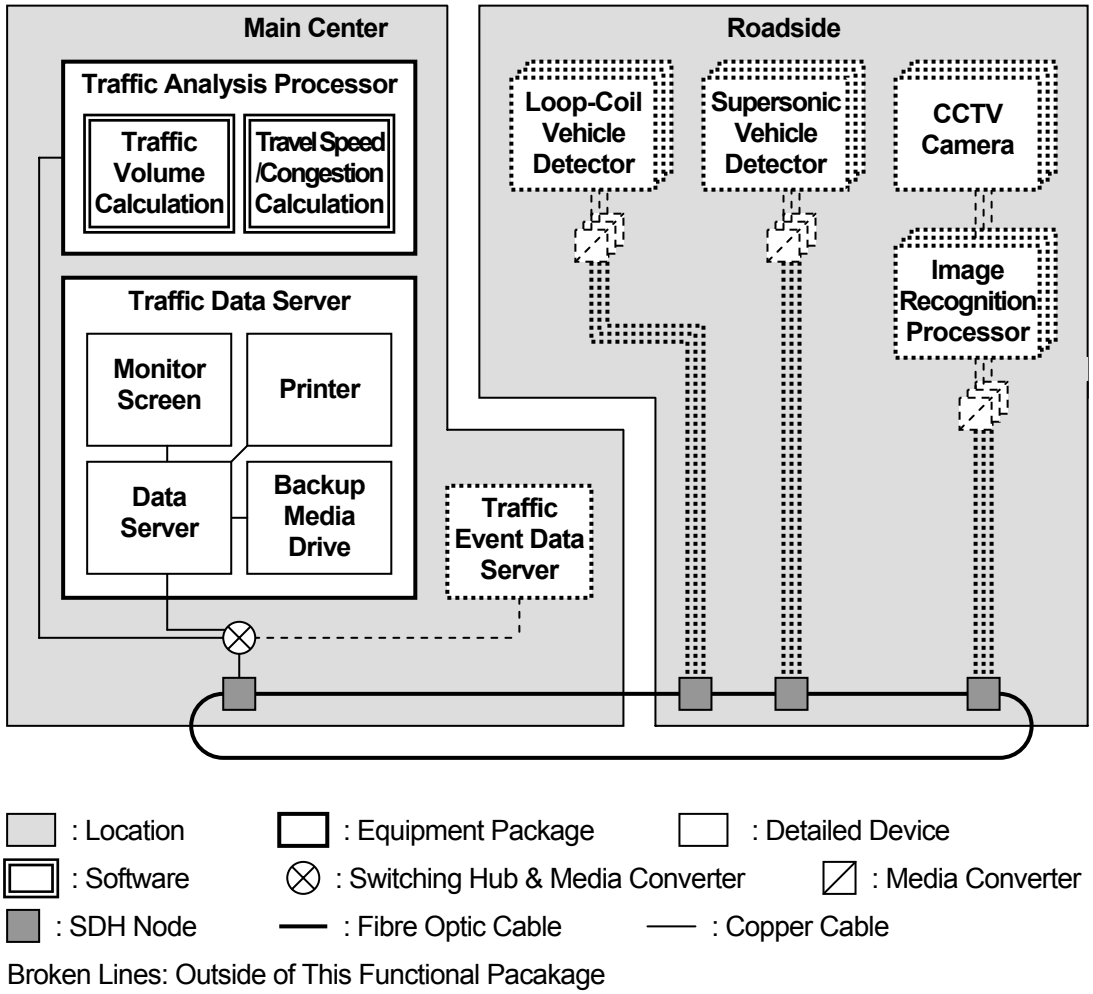
12. Traffic Analysis

12.1 Outlines

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

12.2 System Architecture

Figure 12.1 System Architecture for Traffic Analysis



12.3 Functional Design

1) Synthesizing of Traffic Volume

(1) Data Input

Suppose that data input to synthesize traffic volume collected through vehicle detectors such as:

- Loop-Coil Vehicle Detector
- Supersonic Vehicle Detector
- Image Recognition Processor

(2) Synthesis Unit and Synthesis Method

Synthesize automatically traffic volume for each vehicle category at each correlative fixed traffic volume position is divided into: vehicle with the length less than 12.0m and other vehicles according to each second and save in data server to input data of vehicle receiving from detector,

Synthesize automatically traffic volume for each vehicle category according to month, traffic volume for each vehicle category according to date, traffic volume for each vehicle category according to hour at each fixed position base on vehicle data stored in data server,

Traffic volume synthesis is plus of traffic volume of one lane at one position.

It's possible to synthesize minimum content as follows:
- Traffic volume (cross section, lane category, vehicle category, category according to time)
- Traffic volume according to lane and according to vehicle category of each time in total time of one year (24hours x 365days = 8760 hours)

Show synthesis result of traffic volume according to each vehicle category by table and chart.

2) Calculation of Average Speed

Average speed is defined as average value of vehicle speed data of vehicles received from vehicle detector that is installed five detectors with 500m distance that the head is contiguous point of extending start point at junction point of highway.
－Average speed (in 1 minute, in 15 minutes, according to time)

Average speed calculation is weighted average investigation of data when traffic volume and speed of each lane in one section when these 2 value are unlike 0.

Automatically calculate average speed according to moth (km/h), date, hour of each vehicle detector base on data of speed of each vehicle stored in Traffic Data Server

Show statistical data of speed of each vehicle detector by table and chart.

3) Calculation of Rate of Large-sized Vehicle Traffic

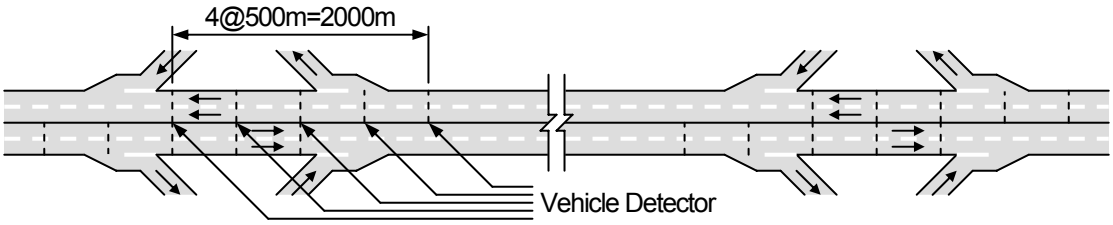
Classify traffic volume calculation according to each vehicle received from vehicle detector as normal vehicle (length of vehicle is less than 12.0m) and large-sized vehicle (length of vehicle is more than 12.0m), after that automatically synthesize and calculate rate of big size vehicle.

4) Evaluation of Traffic Congestion

(1) Congestion

Congestion shall be estimated automatically by the software in the condition that an average speed detected in each minute for each lane is ≤40km/h and a vehicle queuing more than 1km at such low speed continues to exist ≥15 minutes.

Figure 12.2 installing of Vehicle detectors



In the case vehicle detectors are installed at 500 m spacing continuously along the expressway as shown in the figure above, the congestion shall be evaluated when such condition is detected by vehicle detectors ≥3 continuously that an average speed ≤40km/h is kept ≥15 minutes.

Table 12.1 Image of Congestion Evaluation Method

Detector-5	Detector-4	Detector-3	Detector-2	Detector-1	Congestion Evaluation
50km/h	45km/h	40km/h	35km/h	30km/h	Congested
60km/h	50km/h	45km/h	45km/h	40km/h	Not Congested
40km/h	50km/h	60km/h	35km/h	35km/h	Not Congested
60km/h	50km/h	45km/h	45km/h	50km/h	Not Congested

※Distance for installing vehicle detectors is 500m

(2) Crowdedness

Crowdedness shall be estimated automatically by the software in the condition that an average speed detected in each minute for each lane is ≤50km/h and such low speed situation continue to exist ≥15 minutes.

(3) Analysis of Traffic Congestion

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

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

(4) Data Storage

Store the congestion evaluation result in Data Server together with average speed. When evaluating congestion, data of section which are evaluated as congestion, time, and average speed are sent to traffic event data.

In order to promote statistics value using for preparing draft of street plan and inflow regulation, to provide traffic information relating to stored data, data server also has following functions:

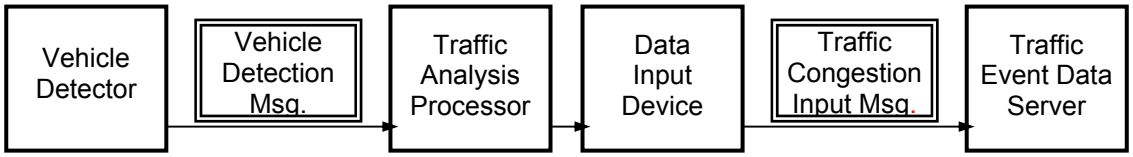
- Display call out on the screen when needing calculation results such as traffic volume, average speed, congestion status
- Store calculation results such as traffic volume, average speed, congestion situation of one year.
- Backup data by setting up date, hour
- Restore data backup
- Duplicate important devices of server such as CPU, memory, HDD...

Software shall be capable of saving the compiled data in CSV form. It shall be capable of access and modification using commercially application software (such as Microsoft Excel).

12.4 Message Exchange

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

Figure 12.3 Major Message Exchanges for Generating Traffic Congestion Data



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

Table 12.2 Data Set/Elements in Traffic Congestion Input Message

Data Set	Data Elements	Definition
Traffic Congestion Data Set	Date*	Day/month/year of detecting vehicles
	Time*	Hour/minute/second of detecting vehicles
	Roadside Equipment ID*	Roadside equipment ID code of Vehicle Detector
	Cumulative Number of Vehicles*	Cumulative number of Vehicles which is detected by vehicle detector
	Average Vehicle Speed*	Average of values of detected vehicle speed
	Traffic Congestion Status**	Class of traffic congestion input referring to the results of vehicle detection, which can have a value shown in Table 12.3

Note, * : Data to be automatically generated, ** : Data to be manually input.

The traffic congestion status can have a value of the traffic event categories/classes shown in the following table:

Table 12.3 Categories/Classes of Traffic Congestion

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

12.5 Transmission Design

All the signals and data are transferred via Internet and communication Protocol is transferred via TCP/IP.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Further concepts and methodologies are to be referred to the Draft Communication System Plan.

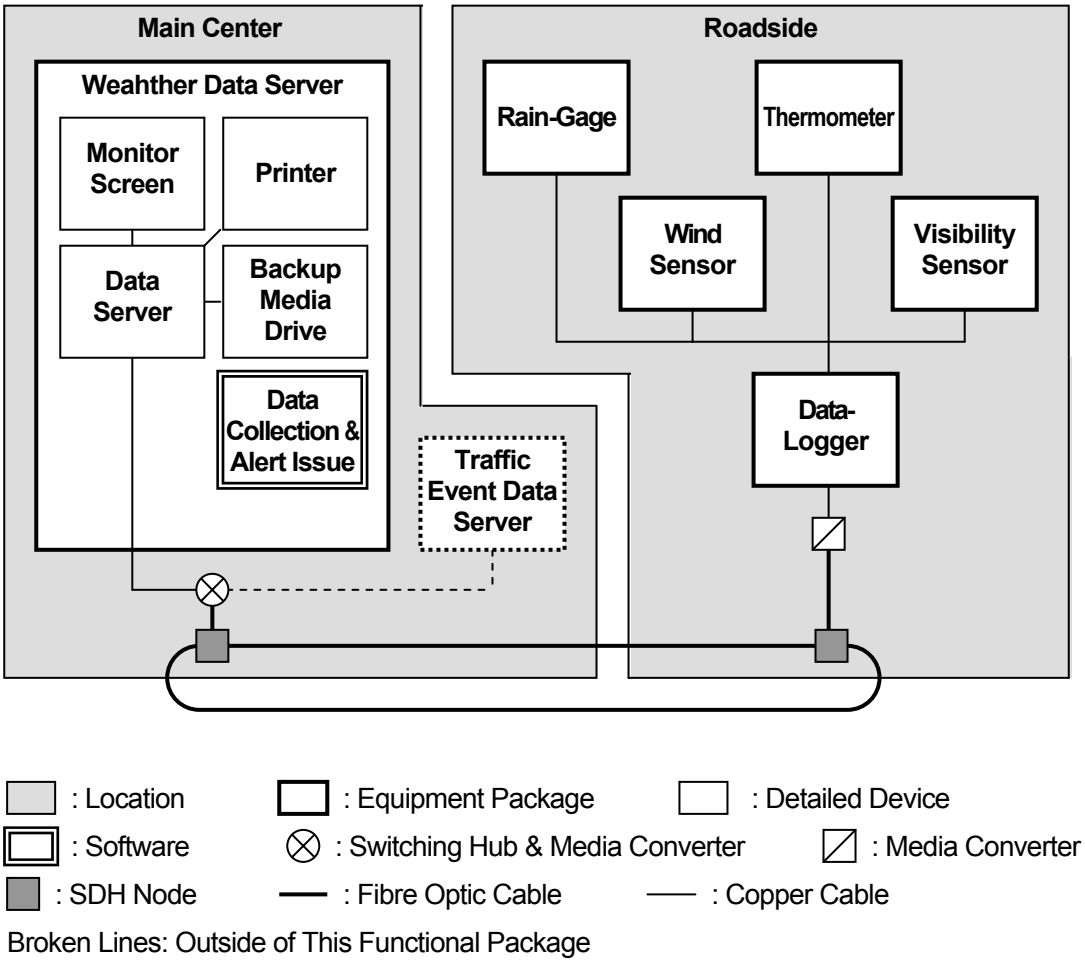
13. Weather Monitoring

13.1 Outlines

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

13.2 System Architecture

Figure 13.1 System Architecture for Weather Monitoring



13.3 Functional Design

1) General

(1)Preconditions of Weather Monitoring

The weather monitoring is implemented under the following preconditions.

- The weather observation site is to be selected where undesired weather conditions for traffic safety frequently take place basically. The number of site per 80km road management section is approximately two (2) locations.
- The weather observation sensors are to be installed at roadside basically in order to comprehend the weather conditions of expressway more precisely.
- The weather observation data is updated every 5 minutes.
- In case the observed data exceeds the threshold, its result is sent from Weather Data Server to Traffic Event Data Server. The thresholds are subject to the “Criteria of Enforcing Traffic Regulation”.

(2) System Development

The draft design standard specifies necessary standards and approach commonly and generally. The specific design shall be intended to be rational based on the essential point of the design standard and taking the site conditions into account. In order to improve the efficiency of the specific project, the design standard shall be intended to be applied flexibly.

2) Meteorological Observation Functions

(1) Objective Meteorological Observation Elements and Observation Method

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

Table 13.1 Observation elements and observation method

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

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

(2) Conditions for Equipment Component Installation

In order to comprehend weather condition of expressway, the weather sensors and related equipment components are to be installed at roadside and out of the guard rail basically. Each sensor’s installation height is shown in the above table. Those heights are ranged to comprehend the weather conditions which affect the driving vehicles of expressway. Therefore some of them are different from WMO standard.

(3) Maintenance of Weather Sensors and Related Equipment Components

It is recommended to make a contract on maintenance service of weather sensors between road management authority and manufacturer of the sensors and related equipment component such as data logger, and it is recommendable to implement periodical maintenance service for the sensors and related equipment component.

(4) Self-diagnostic Function

The operation conditions of the equipment components are monitored by this self-diagnostic function, and in-case some failure is detected, measurement and further process is halted. The self-diagnostic information is to be transmitted always to the data logger automatically regardless the diagnostic result whether it is normal or failure.

(4-1) Self-diagnostic result

The following self-diagnostic result is required to monitor:

- Normal: the status of “Normal” is defined that there is no fault, failure or defect found by the self-diagnostic and the measurement result is reliable.
- Failure: the status of “Failure” is defined that some failure is detected and measurement result is not reliable. This status is automatically set once some failure of the equipment component is detected by the self-diagnostic function.

(4-2) Notification function of self-diagnosic result

Self-diagnostic result is transmitted to the data logger at all time. In case status of “failure” is detected, the self-diagnostic result is required to identify what kind of failure it is, and that status is required to transmit to the data logger.

3) Data Processing Functions

The following functions are required for data processing at least.

Table 13.2 Data Processing Functions

Function	Description	Processing equipment component (sample)
Data collection function from each sensor	Data collections function from each sensor.	Data Logger
Data conversion function	Data conversions function for collected data from sech sensors. The raw data is required to convert to the format which is able to process statistically.	Data Logger
Data storage function	Before transmitting weather data to the Weather Data Server, data is required to be stored temporary at data logger. Minimum two (2) hours data is able to be stored.	Data Logger
Data transmitting function	The data transmitting function in response to the request from the Weather Data Server	Data Logger
Data screening function	If collected data is out of measurement range or unclear, it must be added some code (such as 999) to express exception of such data	Data Logger or Weather Data Server
Data collection function from data logger	Data collection function from data logger located at each site	Weather Data Server
Statistical processing function	Collected data is compiled with site, with observation element and with time series. Then average, maximum and minimum values of every 10 minutes are calculated. As for the precipitation, in addition to the 10 minutes values, accumulation from commencement of the rain fall is required to calculate. Those processes are required to compare its threshold.	Weather Data Server
Database function	Processed data which is able to compare with threshold are compiled into database.	Weather Data Server
Alert Issue function	Detailed descriptions are shown in the next item.	Weather Data Server
Search function	Search function for compiled data	Weather Data Server
Printout function	Printouts function of the compiled data as site basis data, observation element basis data, and time series data.	Weather Data Server

4) Alert Functions

(1) Alert Issue Function

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

Table 13.3 Criteria of Enforcing Traffic Regulation

Traffic event categories	Observed data or processed data	Categories of regulation		
		Issuing of closure	Issuing of lane restriction and speed restriction	Issuing of warning information
Heavy rain	Hourly rainfall	40mm or more after reaching 100mm rainfall in 1 hour	20mm or more	10mm or more
	Accumulated precipitation	250mm or more	200mm or more	—
Strong wind	10 min. average wind speed	25 m/s or more	15 m/s or more	10 m/s
Heavy fog	Visibility	50m or less	100m or less	200
High temperature	10 min. average temperature	—	—	40 degree centigrade

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

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

The detected result is required to be categorized into corresponding traffic event category and traffic event class shown in the following table. The following table is the extraction of significant weather from the original one stipulated in item 14: Traffic Event Data Management.

Table 13.4 Categories/Class of Significant Weather

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

(2) Alert Recording Function

The issued alert is to be recorded in the traffic event data server together with sensor ID including observation site information, date, time, all observed data.

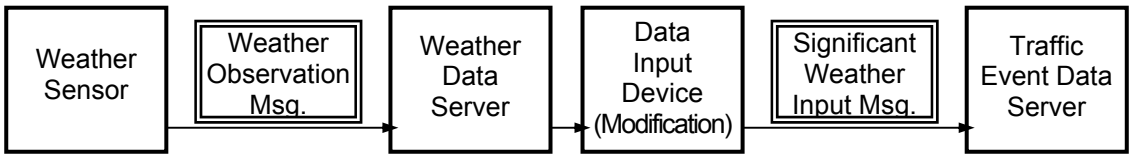
(3) Alert Cancellation Function

Alert cancellation is to be made by operator manually when operator judges that there will be no longer threat related to the issued alert. Therefore there is no function in Weather Data Server to issue "Alert Cancellation" to Traffic Event Data Server automatically.

13.4 Message Exchange

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

Figure 13.2 Major Message Exchanges for Generating Significant Weather Data



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

Table 13.5 Data set/Elements in Weather Observation Message

Data Set	Data Element	Definition
Weather Observation Data Set	Date	Day/month/year of observation
	Time	Hour/minutes/second of observation
	Roadside Equipment ID	Character or number identifying location
	Measurement date	Year, month, day, hour, minutes, second
	Precipitation	Accumulated precipitation during specific 5 minutes
	Wind speed	Average, minimum, and maximum observed wind speed during specific 5 minutes
	Visibility	Average, minimum, and maximum observed visibility during specific 5 minutes
	Temperature	Average, minimum, and maximum observed temperature during specific 5 minutes
	Alert status of precipitation	Alert to be issued when specific level of precipitation aforementioned is detected.
	Alert status of wind speed	Alert to be issued when specific level of wind speed aforementioned is detected
	Alert status of visibility	Alert to be issued when specific level of visibility aforementioned is detected
	Alert status of temperature	Alert to be issued when specific level of temperature aforementioned is detected

Note: Self-diagnostic result identifiers, having values as "Normal" or "Abnormal" for sensors and a data logger, need to be included in the message.

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

Table 13.6 Data set/Elements in Significant Weather Input Message

Data Set	Data Element	Definition
Weather Data Set	Date*	Day/month/year of observation
	Time*	Hour/minutes/second of observation
	Roadside Equipment ID*	ID code of roadside equipment used for weather monitoring
	Precipitation*	Hourly accumulated precipitation (converted by 10 min. data) measured by rain guage
	Wind Speed*	Wind speed (10 min. average) measured by wind sensor
	Visibility*	Visibility (10 min. average) measured by visibility sensor
	Temperature*	Temperature (10 min. average) measured by thermometer
	Heavy Rain Status**	Specifying significant weather in traffic event category and corresponding class of heavy rain in traffic event class
	High Wind Status**	Specifying significant weather in traffic event category and corresponding class of high wind speed in traffic event class
	Low Visibility Status**	Specifying significant weather in traffic event category and corresponding class of lowering of visibility in traffic event class
	High Temperature Status**	Specifying significant weather in traffic event category and high temperature warning in traffic event class

Note, * : Data to be automatically generated, ** : Data to be manually input.

13.5 Transmission Design

Transmission design is required for two (2) different transmission sections. The one is a section between weather sensors and data logger to be installed at meteorological observation site and another one is a section between weather data server to be installed at main center and data logger to be located at each observation site.

In the section between weather sensors and data logger, data transmission system and protocol is not determined in this part.

However in order to realize self-diagnostic from data logger to each weather sensor, necessary protocol, device driver and other necessary information is required to disclose for system integration.

Data Transmission between Weather Data Server and data logger is considered to conform to TCP/IP, Ethernet, and the system for integration layer and road section layer such as SDH. The data transmitting procedure is originating and fetching from the Weather Data Server basically.

→ Further concepts and methodologies are to be referred to the Draft Communication System Plan.

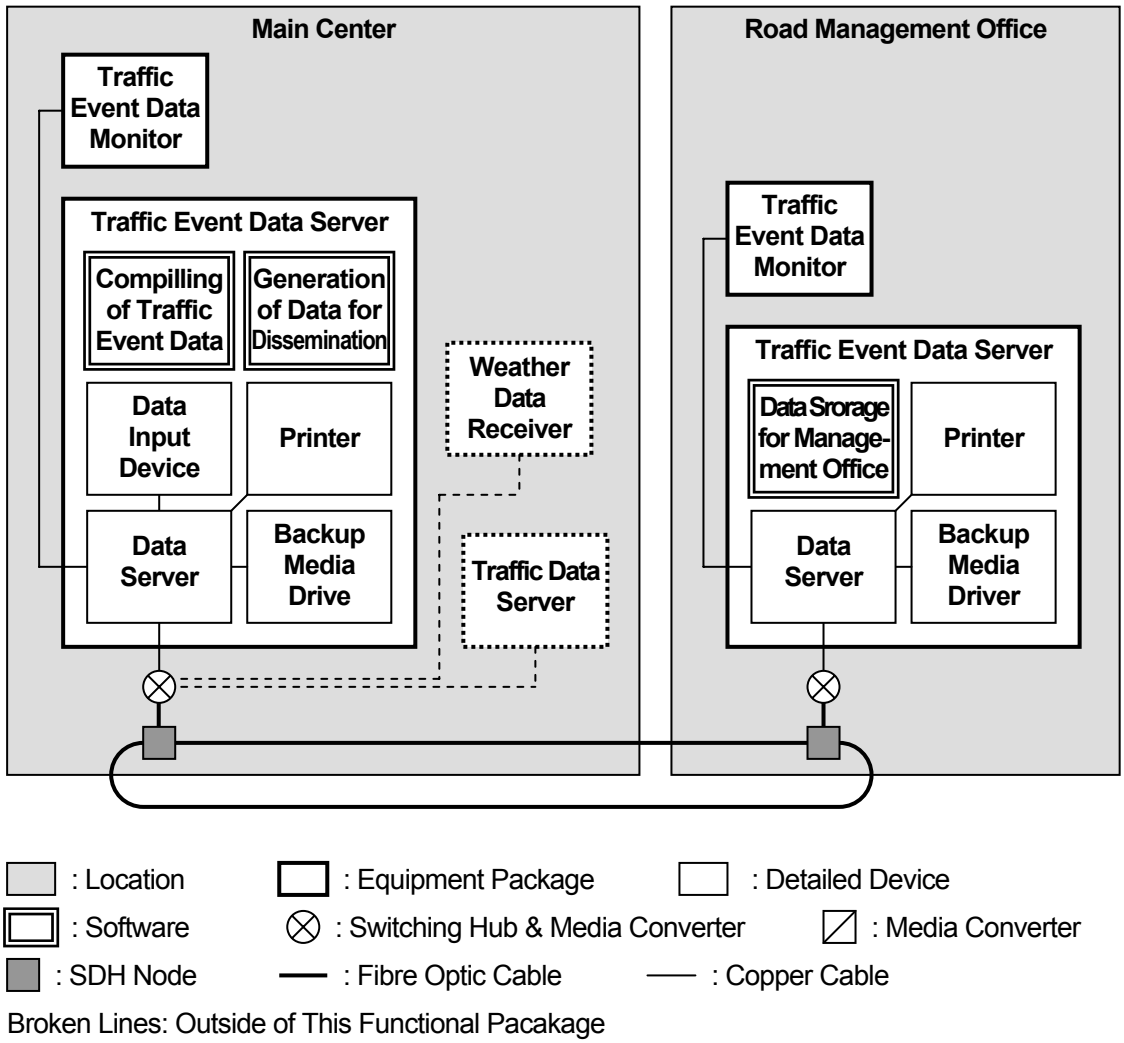
14. Traffic Event Data Management

14.1 Outlines

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

14.2 System Architecture

Figure 14.1 System Architecture for Traffic Event Data Management



14.3 Functional Design

Generation of traffic event data and the process to be used for provision and control of traffic information are composed of the following two functions.

- Compiling of Traffic Event Data
- Generation of Data for Dissemination

1) Compiling of Traffic Event Data

(1) Categories/Classes of Traffic Event

Traffic event data are classified into the following 5 categories and contents of each category, i.e. traffic event classes are shown in the next table.

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

Table 14.1 Categories/Classes of Traffic Event

Traffic Event Category	Traffic Event Class		Definition
Incident	Traffic Accident	1	Serious traffic accident with issuing Closure
		2	Traffic accident with issuing lane/speed restriction
		3	Traffic accident without traffic regulation
	Broken-down Vehicle		Vehicle stopping on road due to disorder
	Left Obstacle		Object on road which may prevents vehicle traffic (excluding vehicles)
	Reversing Vehicle		Vehicle running in the reverse direction
	Vandalism		Wilful destruction of road facilities or obstruction of vehicles
	Natural Disaster		Natural disaster which may prevent car passing
Traffic Congestion	Congestion		State where passing cars run very slow on average
	Crowdedness		State where passing cars run slow on average
Significant Weather	Heavy Rain	1	Significant heavy rain with issuing Closure
		2	Heavy rain with issuing lane/speed restriction
		3	Heavy rain with issue of warning information
	High Wind	1	Significant high wind with issuing Closure
		2	High wind with issuing lane/speed restriction
		3	High wind with issue of warning information
	Dense Fog	1	Significant dense fog with issuing Closure
		2	Dense fog with issuing lane/speed restriction
		3	Dense fog with issue of warning information
	High Temperature		High temperature or high road surface temperature with issue of warning information
Construction Work	Construction Work		Improvement/repair of road facilities
Traffic Regulation	Closure		Regulation to ban flow in all lanes of the through traffic
	Lane Closure		Regulation to ban flow of part of lanes of the through traffic
	Entry Closure		Regulation to ban inflow into the through traffic at entry point
	Speed Limitation		Regulation to restrict the fastest speed of the through traffic
	Warning Information		Information to arouse care of the passing drivers

Traffic accident and bad weather are classified into the following three levels; the standard of issuing traffic restriction is as shown in the table below.

Table 14.2 Criteria of Enforcing Traffic Regulation

Traffic event categories	Standard to issue car stoppage	Standard to issue lane restriction and speed restriction	Standard to issue warning information
Traffic accident	Accident to block all lanes and to have danger of secondary rear-ender accident and to require long time to deal with.	Accident to block one lane and to have danger of secondary rear-ender accident or to require long time to deal with. → Lane restriction	Other accident
Heavy rain	Time when continuous rainfall is about 250 mm or more or when hourly rainfall is about 40 mm or more per hour after reaching an hourly rainfall of 100 mm	Time when continuous rainfall is about 200 mm or hourly rainfall is 20 mm or more → Speed restriction down to 50 km/hr	Time when hourly rainfall is about 10 mm or more
Strong wind	Time when 10-minutes average wind velocity is 25 m/s or more	Time when 10-minutes average wind velocity is 15 m/s or more → Speed restriction down to 50 km/hr	Time when 10-minutes average wind velocity is about 10 m/s
Heavy fog	Visibility of about 50 m or less	Visibility of about 100 m or less → Speed restriction down to 50 km/hr	Visibility of about 200 m or less
High temperature	–	–	Temperature of about 35°C or more
High lane temperature	–	–	Lane temperature of 55°C or more

(2) Data Generation

In the case that the functional package for data-collection is image recognition, vehicle detection or weather monitoring, the traffic event data for actual use is to be generated by modifying automatically generated traffic event candidates by operators through data input terminals.

In case the following alarm are sent from Functional package for data collection, the operator shall be notified by buzzer sound and monitor screen display.

- Alarm on accident occurrence from Image Recognition
- Alarm on congestion occurrence from Vehicle Detector
- Alarm on bad weather occurrence from Weather Monitoring

In the case that the other functional packages, traffic event data is to be directly inputted by operators through data input terminals based on the live video images from CCTV monitoring or the information of incident occurrences, construction works or enforcement of traffic regulation provided by the persons in charge through telephone exchange.
The following three procedures are to be allowed for inputting traffic event data:

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

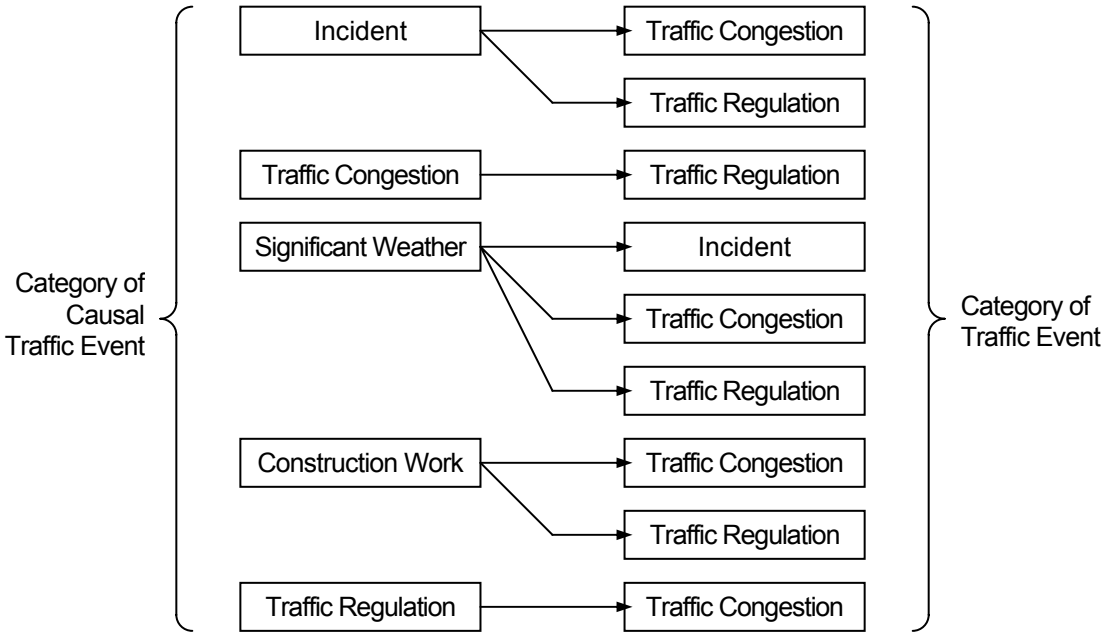
It is required in either case to receive approval of responsible persons in the Main Center and the road management office. The inputted data without the approval by the Main Center and/or that by the road management office is to be given the status non-approved, and is not to be used for traffic information/Control.

(3) Data Correlation

It is often the case that causal relation exists between two of traffic events and this relation is important factor of traffic information; hence, it is required to define linkage between such two of generated/sorted-out traffic events.

Causal relations assumed in the system are shown in the figure below.

Figure 14.2 Correlations between Traffic Event Categories



In actual operation of this system, the definition of linkage between traffic events is to be inputted manually by operators in the Main Center according to the information by on-site report and making certain of the dates/venues of event occurrences.

Changing status from “existing” to “removed” is also to be done manually according to the information by on-site report when incident clearance or construction work is completed or when traffic restriction is removed.

2) Generation of Data for Dissemination

(1) Data for VMS Indication

Pairs of traffic event data, which are linked by causal relation, are the basic form of data for VMS indication (e.g. in two lines). Traffic event data without any causal relation are to be indicated in isolation (e.g. in a line).

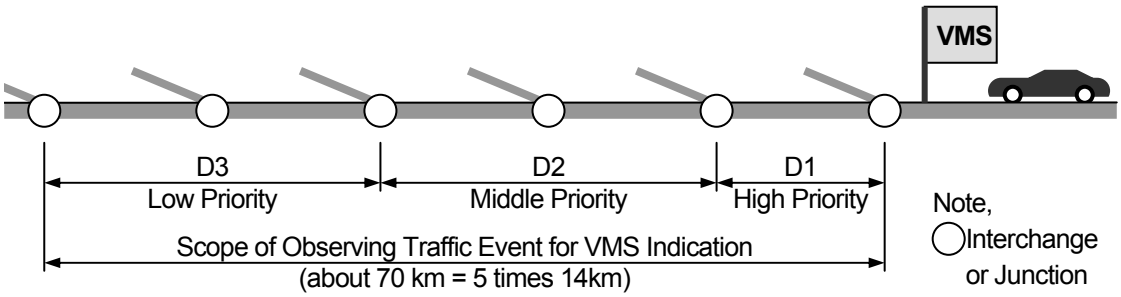
(2) Prioritization for VMS Indication

It is usual a number of traffic events exist on a road network at the same time; however, only a pair of traffic events can be indicated on a VMS. Hence, prioritization of data for VMA indication is needed.

In this system, scope of observing traffic event for VMS indication is to be assumed 5 times interchange interval on the expressway, which is about 70 km. Traffic events data are to be prioritized by the distance from VMS as follows:

D1: Traffic events in the long distance from VMS are high priority
D2: Traffic events in the middle distance from VMS are middle priority
D3: Traffic events in the long distance from VMS are low priority

Figure 14.3 Priorities of traffic event data for VMS Indication

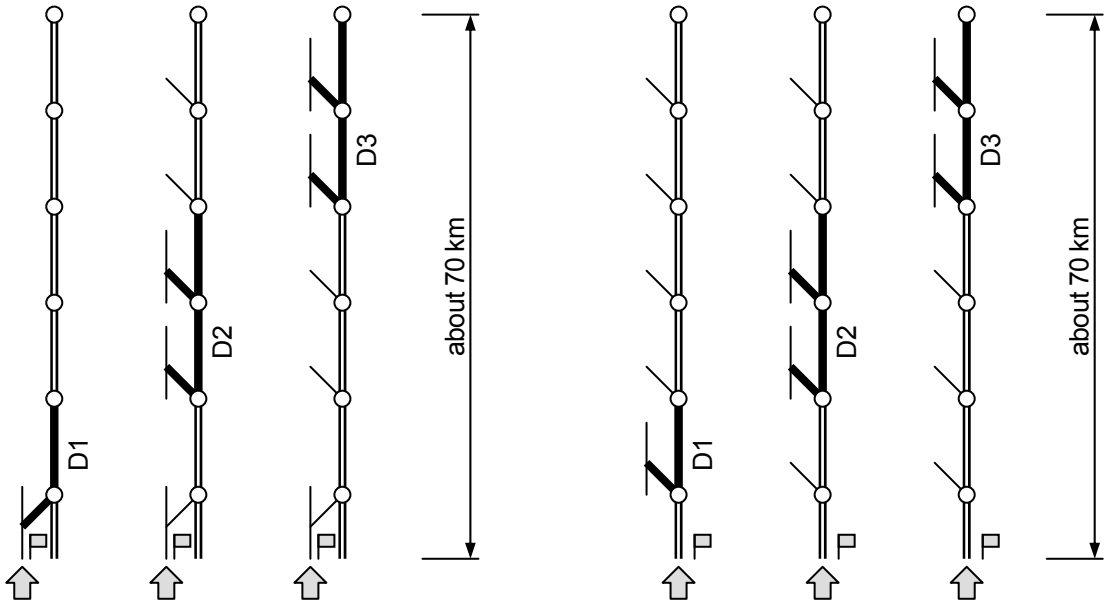


The priority order of traffic event data for VMS indication are determined automatically by traffic event data category and the distance between VMS and traffic event as shown in the following pages.

Table 14.3 Priority order in accordance with Traffic Event Class

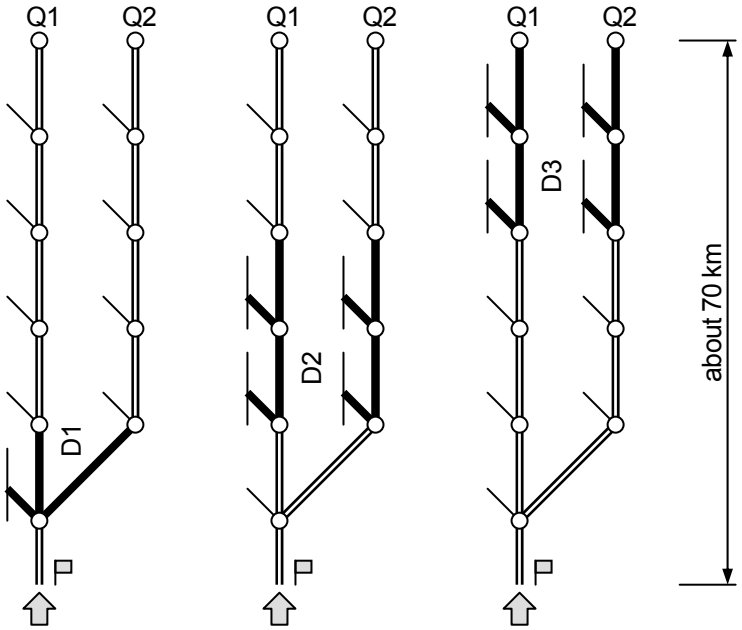
	Traffic Event Class
High Priority	Traffic Event associated with traffic closure and entrance restriction (traffic accident, heavy rain, strong wind, dense fog)
	Natural Disaster
	Traffic Event associated with Lane Regulation and Speed Limit (traffic accident, heavy rain, strong wind, dense fog)
	Congestion
	Traffic Event associated with information calling for attention (traffic accident, heavy rain, strong wind, dense fog)
	Traffic accident without traffic regulation
	Broken-down Vehicle, Left Obstacle, Reversing Vehicle, Vandalism
	Construction Work
Low Priority	Crowdedness - Heavy traffic

Figure 14.4 Example of Prioritization (1)



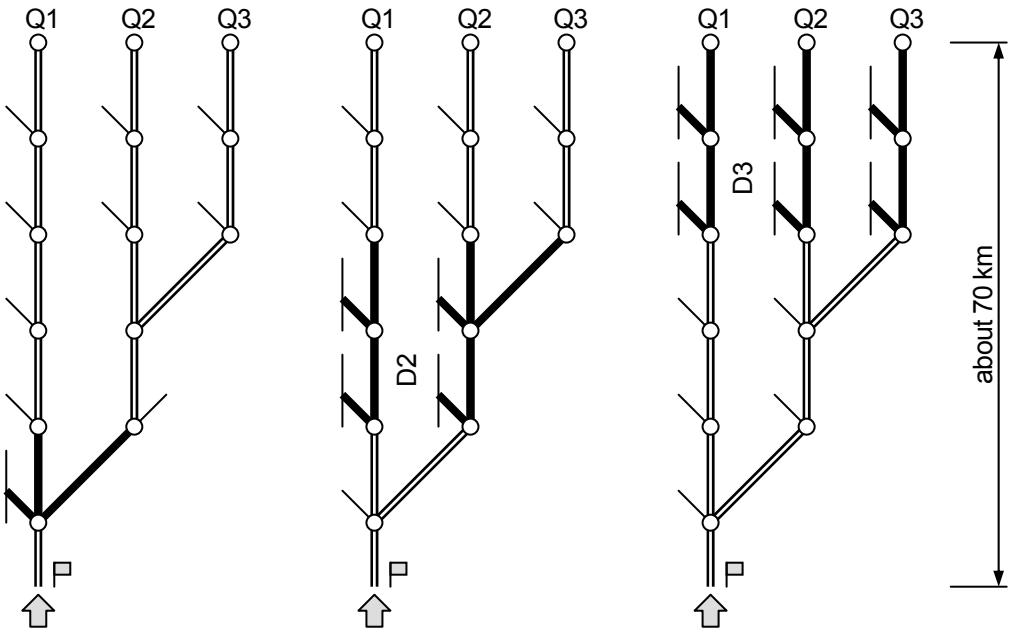
Traffic Event Category	Traffic Event Class		D1	D2	D3
Incident	Traffic Accident	1	1	2	12
		2	5	13	21
		3	8	16	24
	Broken-down Vehicle		9	17	25
	Left Obstacle		9	17	25
	Reversing Vehicle		9	17	25
	Vandalism		9	17	25
	Natural Disaster		3	4	20
Traffic Congestion	Congestion		6	14	22
	Crowdedness		11	19	27
Significant Weather	Heavy Rain	1	1	2	12
		2	5	13	21
		3	7	15	23
	High Wind	1	1	2	12
		2	5	13	21
		3	7	15	23
	Dense Fog	1	1	2	12
		2	5	13	21
		3	7	15	23
	High Temperature		7	15	23
Construction Work	Construction Work		10	18	26
Traffic Regulation	Closure		1	2	12
	Entry Closure		1	28	29
	Lane Closure		5	13	21
	Speed Limitation		5	13	21
	Warning Information		7	15	23

Figure 14.5 Example of Prioritization (2)



Traffic Event Category	Traffic Event Class		D1		D2		D3	
			Q1	Q2	Q1	Q2	Q1	Q2
Incident	Traffic Accident	1	1	2	3	4	23	24
		2	9	10	25	26	41	42
		3	15	16	31	32	47	48
	Broken-down Vehicle		17	18	33	34	49	50
	Left Obstacle		17	18	33	34	49	50
	Reversing Vehicle		17	18	33	34	49	50
	Vandalism		17	18	33	34	49	50
	Natural Disaster		5	6	7	8	39	40
Traffic Congestion	Congestion		11	12	27	28	43	44
	Crowdedness		21	22	37	38	53	54
Significant Weather	Heavy Rain	1	1	2	3	4	23	24
		2	9	10	25	26	41	42
		3	13	14	29	30	45	46
	High Wind	1	1	2	3	4	23	24
		2	9	10	25	26	41	42
		3	13	14	29	30	45	46
	Dense Fog	1	1	2	3	4	23	24
		2	9	10	25	26	41	42
		3	13	14	29	30	45	46
	High Temperature		13	14	29	30	45	46
Construction Work	Construction Work		19	20	35	36	51	52
Traffic Regulation	Closure		1	2	3	4	23	24
	Entry Closure		55	-	56	57	58	59
	Lane Closure		9	10	25	26	41	42
	Speed Limitation		9	10	25	26	41	42
	Warning Information		13	14	29	30	45	46

Figure 14.6 Example of Prioritization (3)



Traffic Event Category	Traffic Event Class		D1			D2			D3		
			Q1	Q2	Q3	Q1	Q2	Q3	Q1	Q2	Q3
Incident	Traffic Accident	1	1	2	-	3	4	5	25	26	27
		2	11	12	-	28	29	30	52	53	54
		3	17	18	-	37	38	39	61	62	63
	Broken-down Vehicle		19	20	-	40	41	42	64	65	66
	Left Obstacle		19	20	-	40	41	42	64	65	66
	Reversing Vehicle		19	20	-	40	41	42	64	65	66
	Vandalism		19	20	-	40	41	42	64	65	66
	Natural Disaster		6	7	-	8	9	10	49	50	51
Traffic Congestion	Congestion		13	14	-	31	32	33	55	56	57
	Crowdedness		23	24	-	46	47	48	70	71	72
Significant Weather	Heavy Rain	1	1	2	-	3	4	5	25	26	27
		2	11	12	-	28	29	30	52	53	54
		3	15	16	-	34	35	36	58	59	60
	High Wind	1	1	2	-	3	4	5	25	26	27
		2	11	12	-	28	29	30	52	53	54
		3	15	16	-	34	35	36	58	59	60
	Dense Fog	1	1	2	-	3	4	5	25	26	27
		2	11	12	-	28	29	30	52	53	54
		3	15	16	-	34	35	36	58	59	60
	High Temperature		15	16	-	34	35	36	58	59	60
Construction Work	Construction Work		21	22	-	43	44	45	67	68	69
Traffic Regulation	Closure		1	2	-	3	4	5	25	26	27
	Entry Closure		73	-	-	74	75	-	76	77	78
	Lane Closure		11	12	-	28	29	30	52	53	54
	Speed Limitation		11	12	-	28	29	30	52	53	54
	Warning Information		15	16	-	34	35	36	58	59	60

(3) Data for Internet

As there is no limitation of displayable information amount in the Internet, the stored traffic event can be transmitted without modification. The system will enable optimal selection by designating date, time, line and kilometer post.

3) Data storage

The created traffic event data and VMS display data shall be stored in traffic event data server. The traffic event data server shall be capable of calling up and displaying on monitor screen the relevant data from stored traffic event data and VMS indication data, based on the search condition which are input in data input device by the operator in the Main center and road management office. The operator shall read and modify data based on data displayed on monitor screen.

Generation of traffic event data and the process to be used for provision and control of traffic information are composed of the following two functions.

- Compiling of traffic event data
- Generation of data for dissemination

14.4 Message Exchange

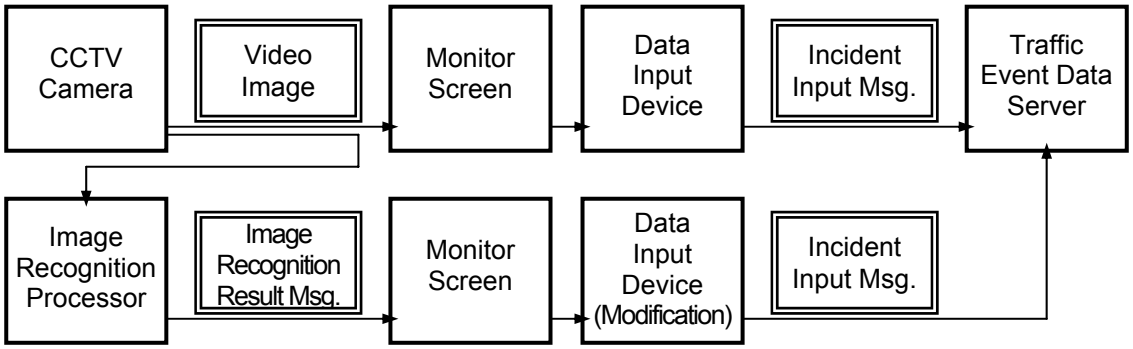
1) Data Generation

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

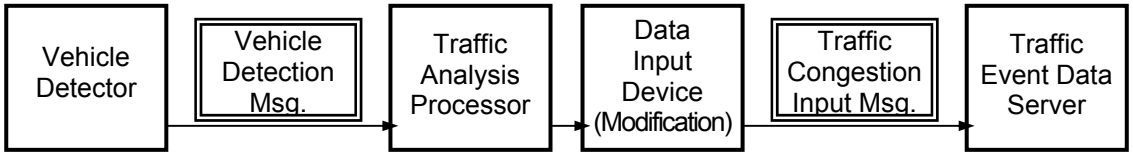
- Incident
- Traffic congestion
- Significant weather
- Construction work
- Traffic regulation

Figure 14.7 Major Message Exchanges for Generating Traffic Event Data

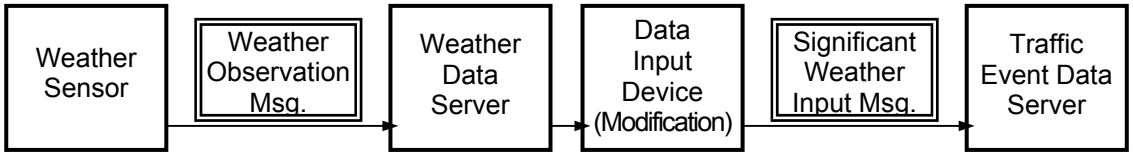
a) Incident Data



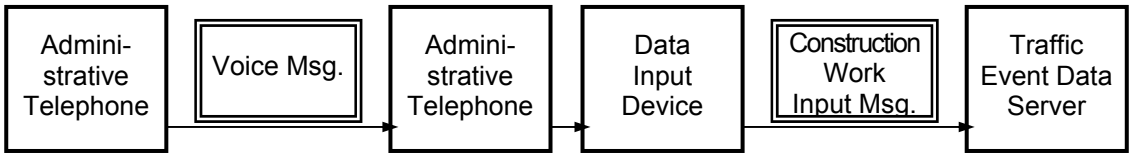
b) Traffic Congestion Data



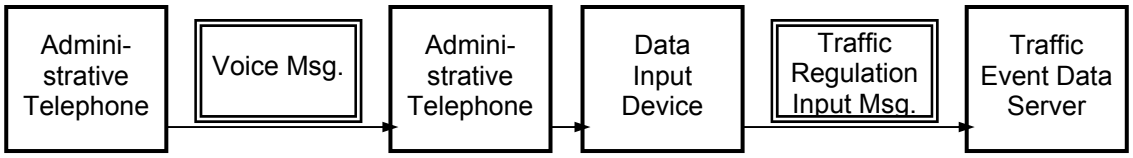
c) Significant Weather Data



d) Construction Work Data



e) Traffic Regulation Data



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

Table 14.4 Data Sets/Elements in Generated Traffic Event Data

Data Set	Data Elements	Definition
Incident Data Set	Date	Day/month/year of identifying an incident
	Time	Hour/minute/second of identifying an incident
	Roadside Equipment ID	Roadside equipment ID code of CCTV camera
	Incident Status	Class of incident input referring to the video image.
Traffic Congestion Data Set	Date	Day/month/year of detecting vehicles
	Time	Hour/minute/second of detecting vehicles
	Roadside Equipment ID	Roadside equipment ID code of vehicle detector
	Cumulative Number of Vehicles	Cumulative number of vehicles which is detected by vehicle detector
	Average Vehicle Speed	Average of values of detected vehicle speed
	Traffic Congestion Status	Class of traffic congestion input referring to the results of vehicle detection
Weather Data Set	Date	Day/month/year of observation
	Time	Hour/minutes/second of observation
	Roadside Equipment ID	ID code of roadside equipment used for weather monitoring
	Precipitation	Hourly accumulated precipitation measured by a sensor
	Wind Speed	Wind speed measured by a sensor
	Visibility	Visibility measured by a sensor
	Temperature	Temperature measured by a sensor
	Heavy Rain Status	Class of heavy rain input referring to the results of weather monitoring
	High Wind Status	Class of high wind input referring to the results of weather monitoring
	Low Visibility Status	Class of lowering of visibility input referring to the results of weather monitoring
	High Temperature Status	Class of high temperature input referring to the results of weather monitoring
Construction Work Data Set	Date	Day/month/year of starting a construction work
	Time	Hour/minute/second of starting a construction work
	Line ID	Line number of the road where a construction work applied
	Kilometer Post	Kilometer post of the place where a construction work applied
	Construction Work Status	Class of construction work.
Traffic Restriction Data Set	Date	Day/month/year of starting a traffic restriction
	Time	Hour/minute/second of starting a traffic restriction
	Line ID	Line number of the road where a traffic restriction applied
	Kilometer Post	Kilometer post of the place where a traffic restriction applied
	Traffic Restriction Status	Class of traffic restriction.

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

Table 14.5 Data Set/Elements for Traffic Event Dissemination

Data Set	Data Elements	Definition
Traffic Event Data Set	Traffic Event Data ID	ID code of the traffic event data
	Causal Traffic Event Data ID	ID code of the causal traffic event data
	Date	Day/month/year when a traffic event occurred
	Time	Hour/minute/second when a traffic event occurred
	Line ID	Line number of the road where a traffic event occurred
	Kilometer Post	Kilometer post of the place where a traffic event occurred
	Road Link ID	Road link number of the place where the traffic event occurred
	Place Name ID	ID code of the place name where the traffic event occurred
	Traffic Event Category ID	Number of traffic event data category
	Traffic Event Class ID	Number of traffic event data class
	Main Center Check Status	Approval/disapproval of the Main Center
	Office Check Status	Approval/disapproval of the road management office
	Existing/Removed Status	Existence/removal of traffic event

2) Data for VMS Indication

The traffic event data server, based on the stored traffic event data, shall extract automatically the information displayed in each VMS as the traffic event of highest priority and create VMS indication data.

The data set which is to be used for VMS indication is shown in the table below

Table 14.6 VMS Indication Data Set

Data Set	Data Elements	Definition
VMS Indication Data Set	Roadside Equipment ID	ID code of Roadside equipment for VMS indication
	Date	Day/month/year of VMS indication
	Time	Hour/minute/second of VMS indication
	Traffic Event Class ID	ID code of traffic event data
	Place Name ID	ID code of the place name where a traffic event occurred
	Causal Traffic Event Class ID	ID code of the causal traffic event data
	Causal Place Name ID	ID code of the place name of causal traffic event

3) Data for Internet

As there is no limitation of displayable information amount in the Internet, the stored traffic event can be transmitted without modification. The system will enable optimal selection by designating date, time, line and kilometer post.

4) Message Sequence Diagram

Message sequence diagrams corresponding to the forgoing general system architecture, which illustrate the procedure of generation/indication of the traffic event data, are shown in the following pages.

Figure 14.8 Incident Information by Monitoring at Roadside (M.S.D.)

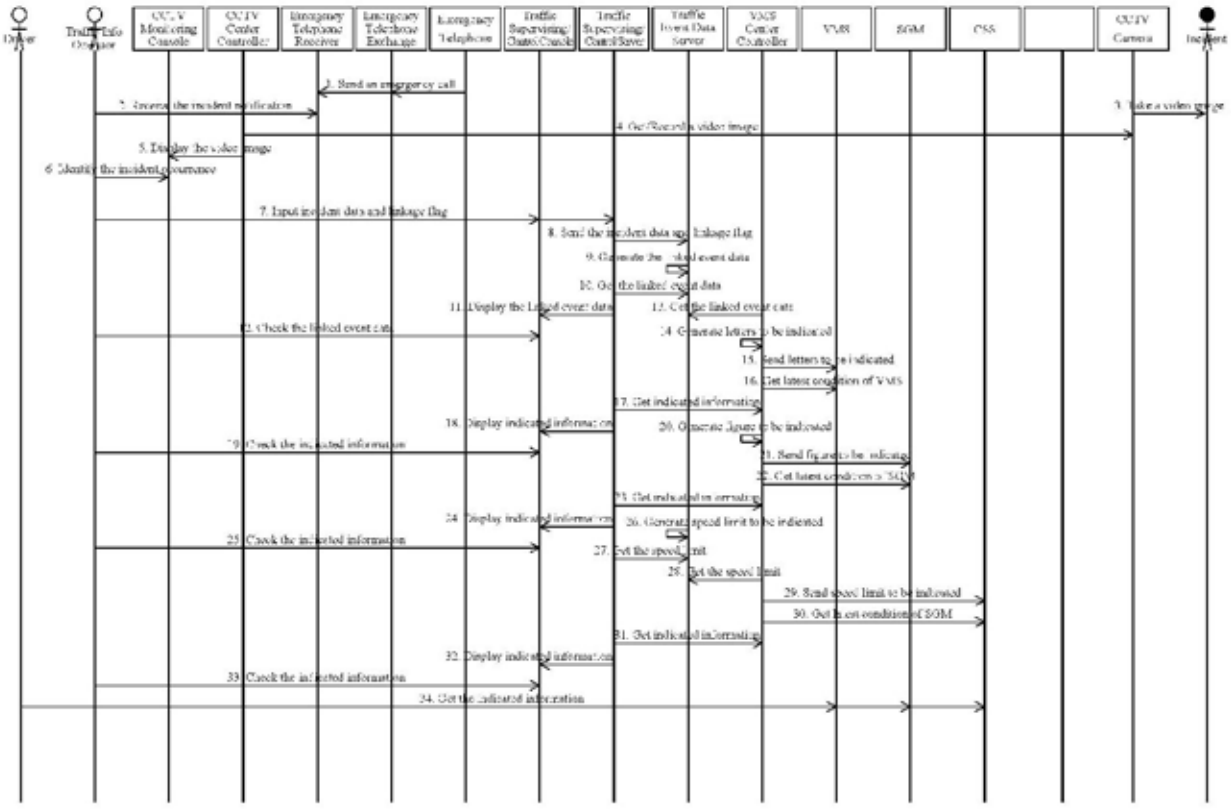


Figure 14.9 Incident Information by Image Recognition (M.S.D.)

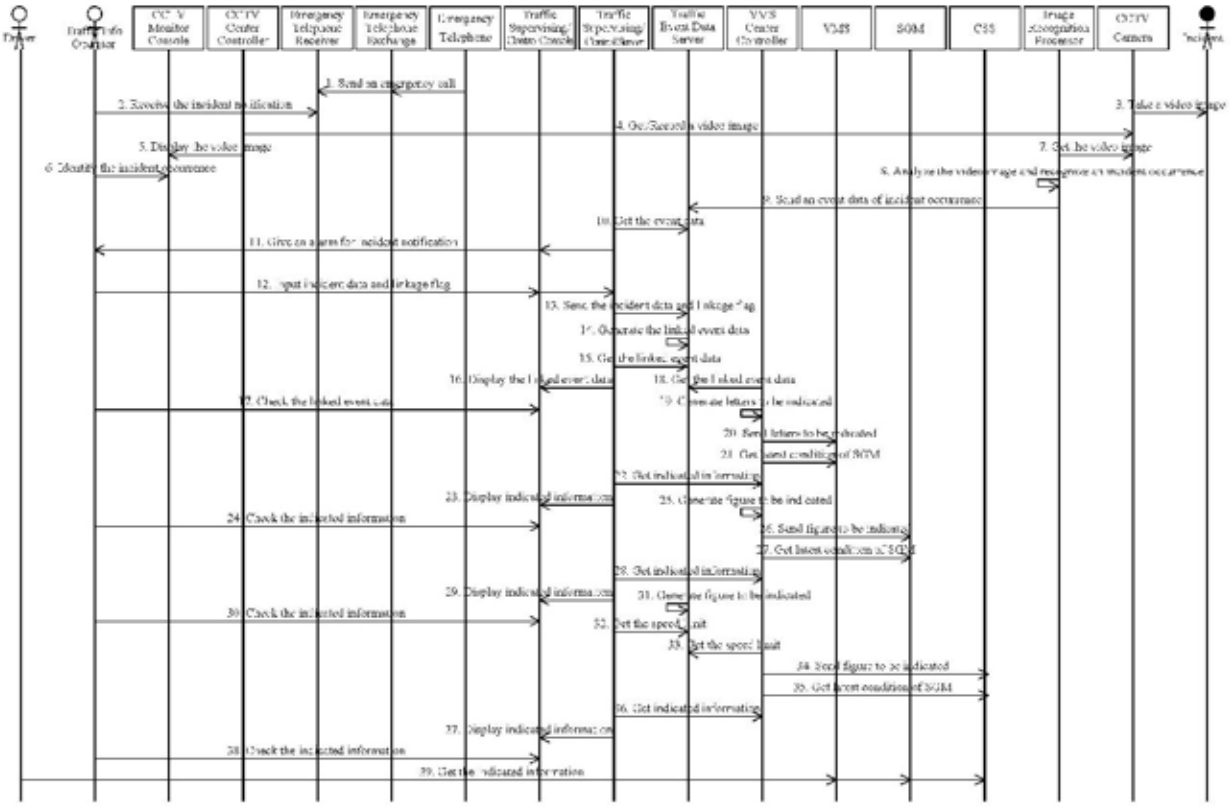


Figure 14.10 Traffic Congestion Information by Monitoring at Roadside (M.S.D.)

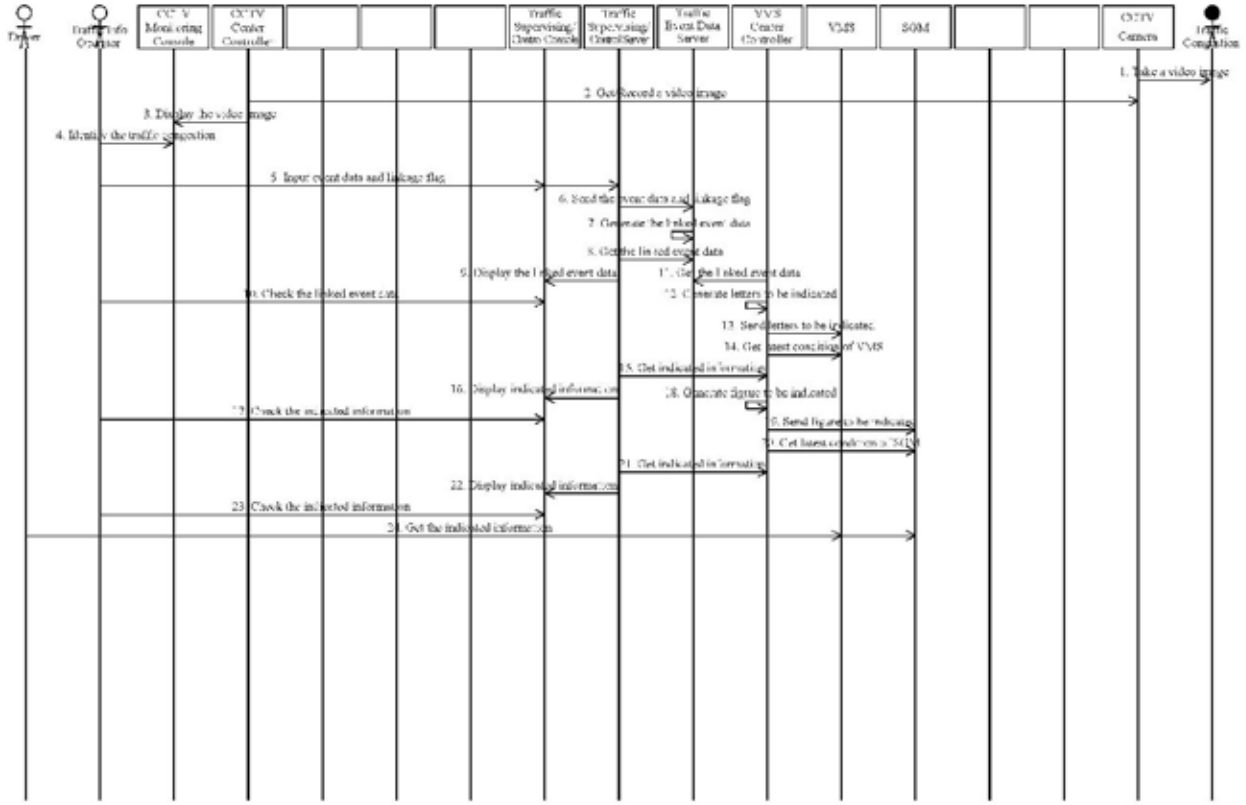


Figure 14.11 Traffic Congestion Information by Image Recognition (M.S.D.)

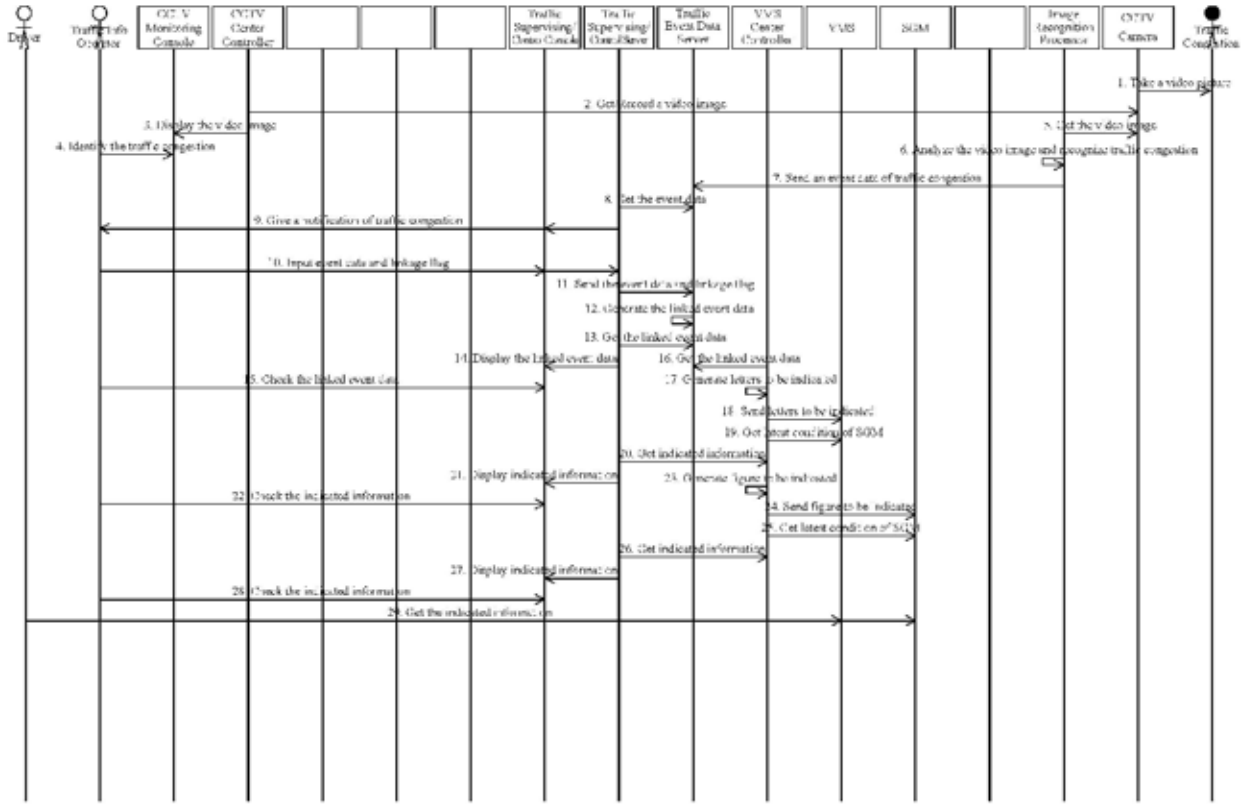


Figure 14.12 Traffic Congestion Information by Vehicle Detection (M.S.D.)

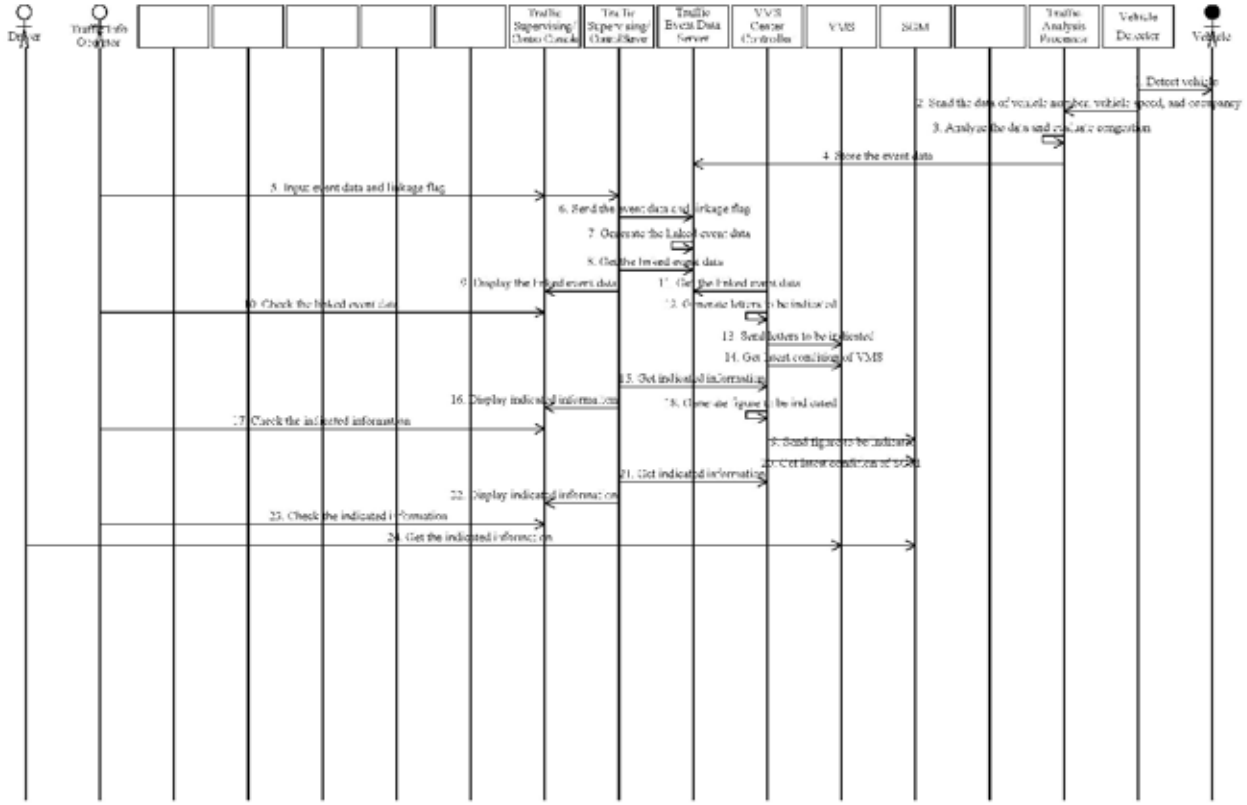


Figure 14.13 Weather Information (M.S.D.)

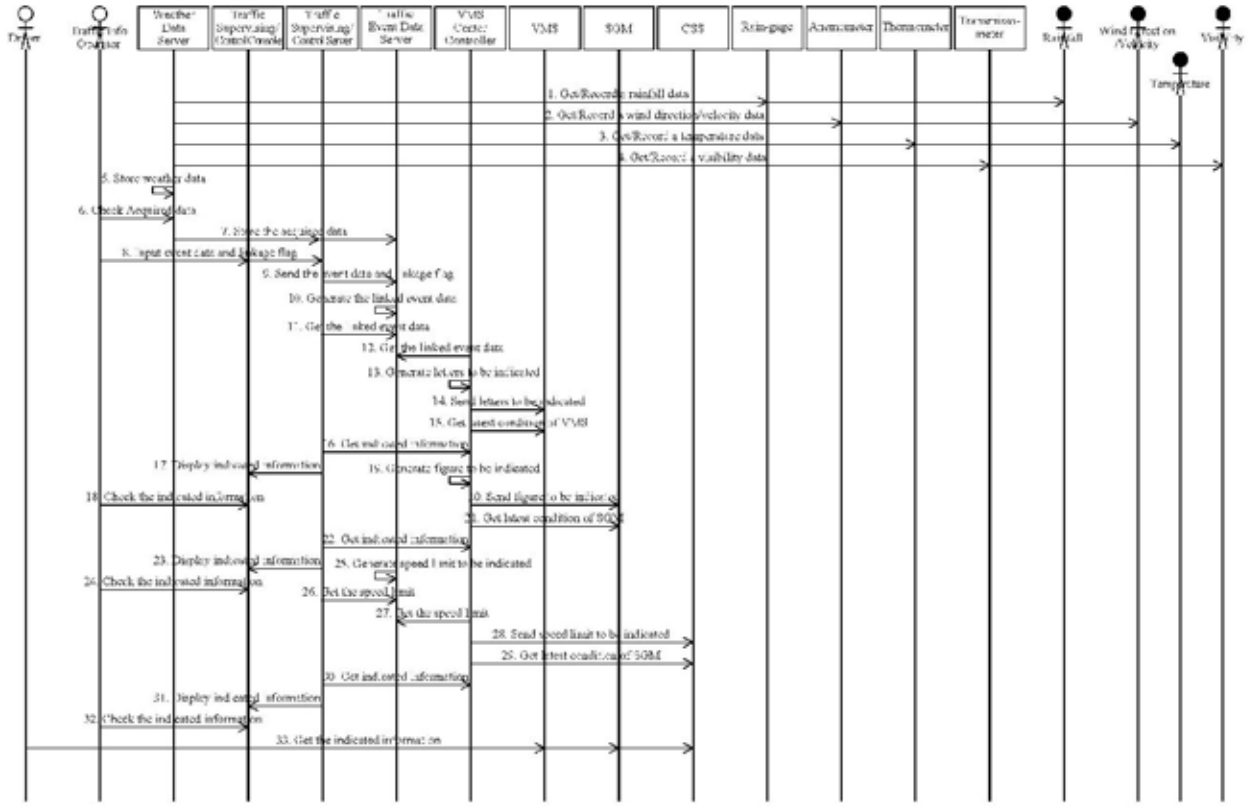
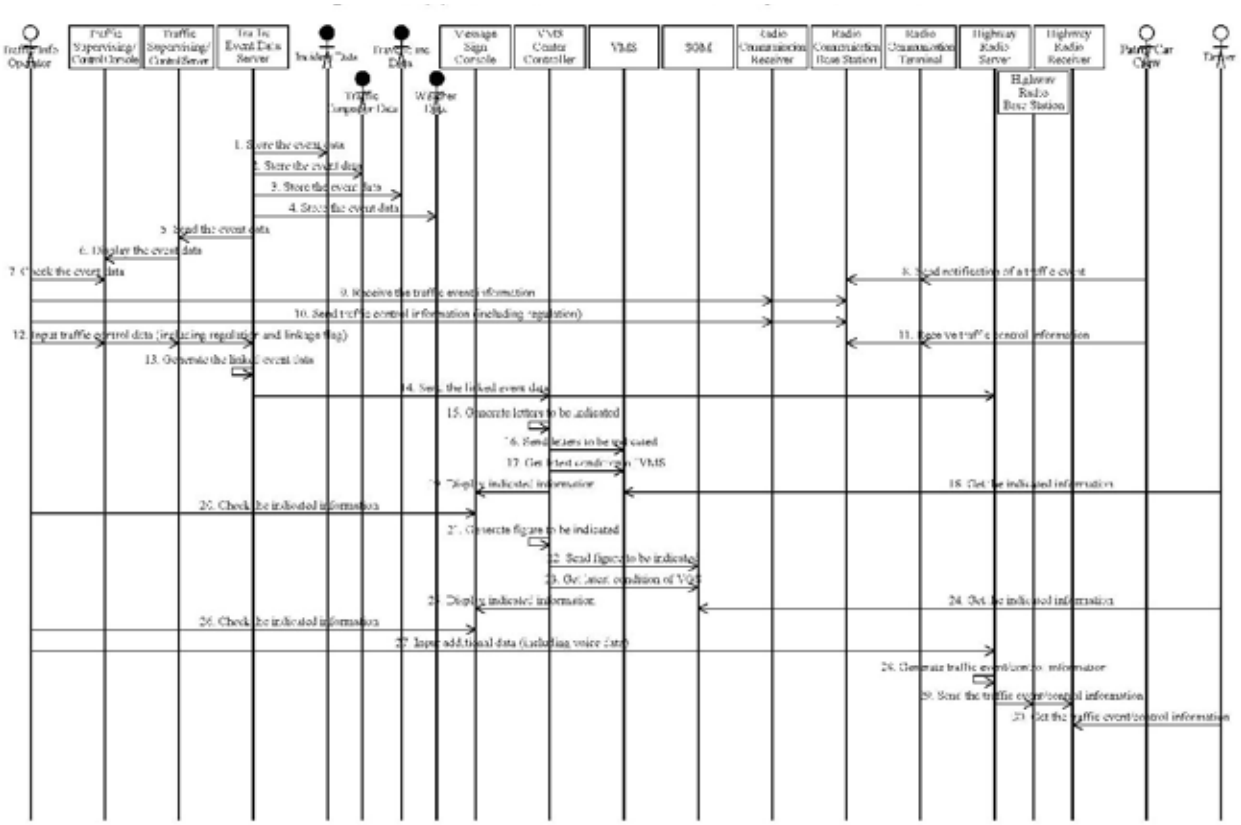


Figure 14.14 Traffic Control Assistance by Traffic Event Data (M.S.D.)



14.5 Transmission Design

All the signals and data are transferred via Internet and communication Protocol is transferred via TCP/IP.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Further concepts and methodologies are to be referred to the Draft Communication System Plan.

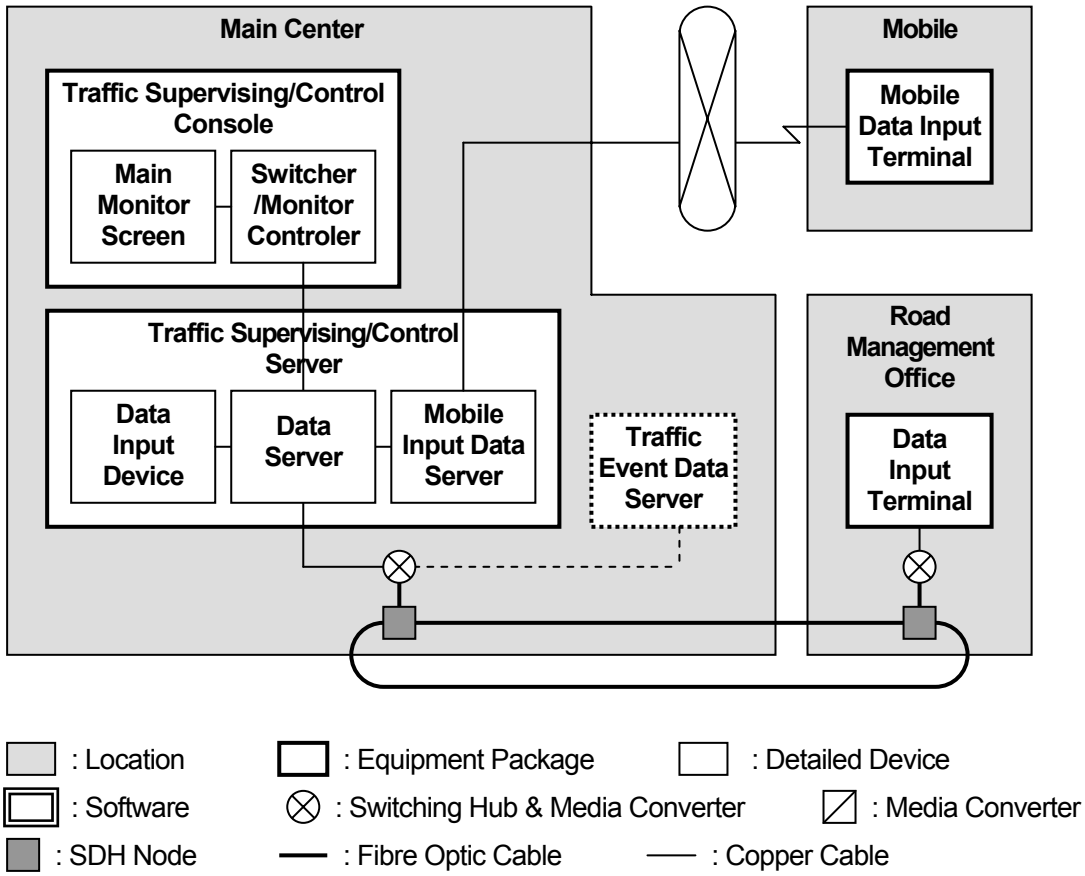
15. Traffic Supervision

15.1 Outlines

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

15.2 System Architecture

Figure 15.1 System Architecture for Traffic Supervision



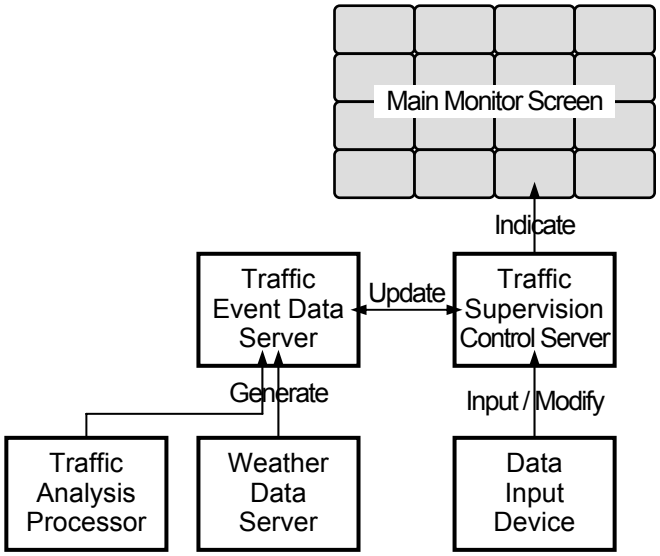
15.3 Functional Design

1) Methods of Traffic Event Data Input

Traffic event data is to be generated by either of the following two methods. The generated data is to be indicated on the main monitor screen installed in the Main Center and to be stored in the traffic event data server.

- In the case that the functional package for data-collection is image recognition, vehicle detection or weather monitoring, the traffic event data for actual use is to be generated by modifying automatically generated traffic event candidates by operators through data input terminals.
- In the case that the other functional packages, traffic event data is to be directly inputted by operators through data input terminals based on the live video images from CCTV monitoring or the information of incident occurrences, construction works or enforcement of traffic regulation provided by the persons in charge through telephone exchange.

Figure 15.2 Traffic Event Data Input



2) Procedure of Traffic Event Data Input

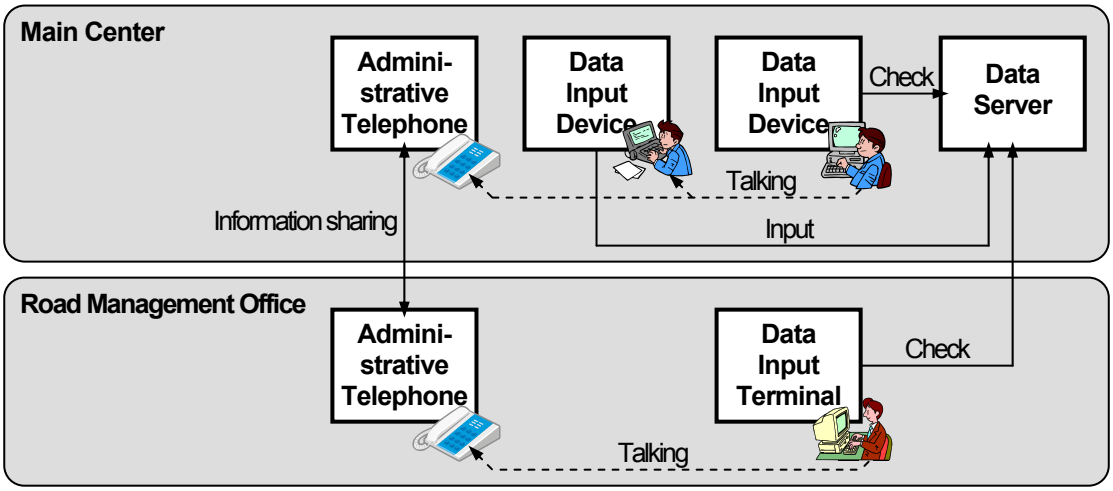
The following three procedures, of which details are shown in the following figures, are to be allowed for inputting traffic event data:

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

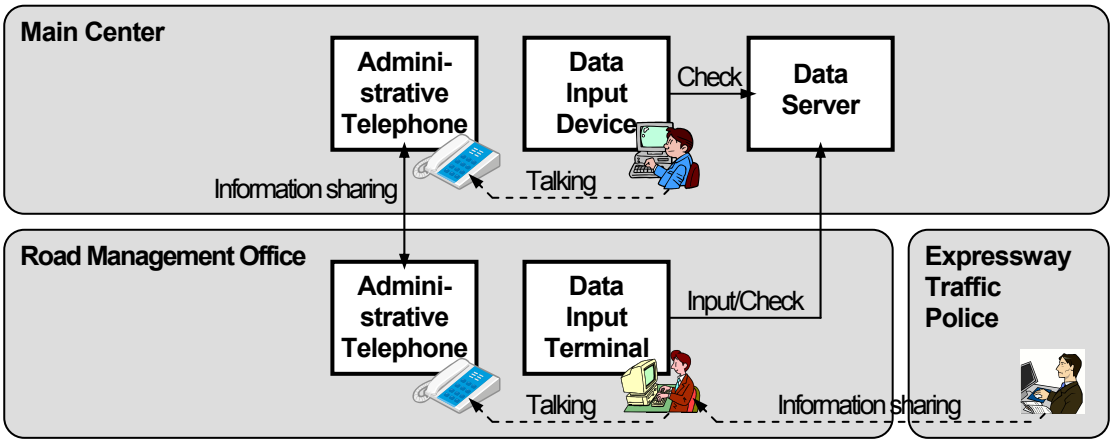
It is required in either case to receive approval of responsible persons in the Main Center and the road management office. Through this doubled approval, traffic event data can be generated appropriately even in the case that operating body of the Main Center who is in charge of traffic information/control and that of road management office who is in charge of patrol for current traffic condition surveillance are different. The inputted data without the approval by the Main Center and/or that by the road management office is to be given the status non-approved, and is not to be used for traffic information/Control.

Figure 15.3 Procedures of Traffic Event Data Input

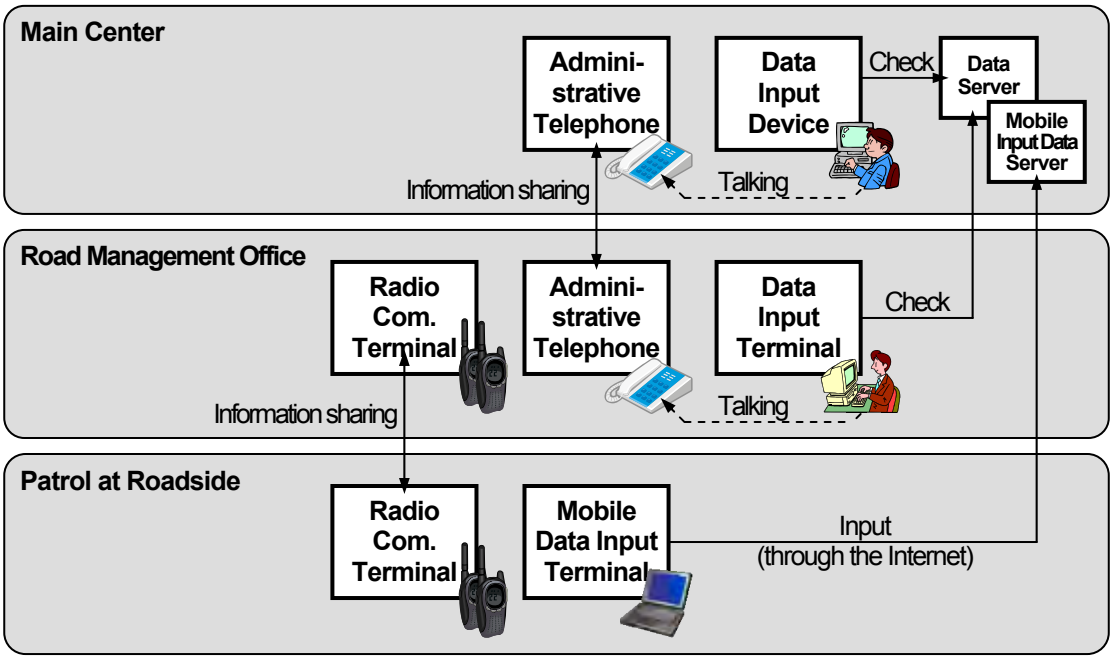
(1) Input by Staff in the Main Center



(2) Input by Staff in Road Management Office



(3) Input by Patrol Staff at Roadside



Furthermore, in the case causal relation between two of traffic events exists, it is required to define linkage between them. The definition of linkage between traffic events is to be inputted manually by operators in the Main Center according to the information by on-site report and making certain of the dates/venues of event occurrences.

Changing status from "existing" to "removed" is also to be done manually according to the information by on-site report when incident clearance or construction work is completed or when traffic restriction is removed.

3) Screen Pages for Data Input

In this functional package, generation/modification/inspection/approval of traffic event data is to be allowed through the following 8 screen pages:

- Page for Inputting Traffic Event Data
- Page for Modifying Traffic Event Data
- Page for Warning Occurrence of Traffic Event
- Page for Inspecting Traffic Event Data
- Page for Linking Traffic Event Data
- Page for Approving Traffic Event Data by Main Center
- Page for Approving Traffic Event Data by Road Management Office
- Page for Removing Traffic Event Data

(1) Page for Inputting Traffic Event Data

Input of the following traffic event data shall be allowed through the browser screen by the operators in the main Center and road management office and by site patrol staff.

- Day/month/year when a traffic event occurred
- Hour/minute/second when a traffic event occurred
- Line number of the road where a traffic event occurred
- Kilometer post of the place where a traffic event occurred
- Number of traffic event data class.

The following data shall be generated from these input data above.

- ID code of the traffic event data
- Road link number of the place where the traffic event occurred
- ID code of the place name where the traffic event occurred
- Number of traffic event data category.

Further, default values of the following event will be automatically generated.

- Approval/disapproval of the Main Center (default: no approval)
- Approval/disapproval of the road management office (default: no approval)
- Existence/removal of traffic event (default: existence)

(2) Page for Modifying Traffic Event Data

By inputting "ID code of the traffic event data" and call the traffic event data corresponding to the ID number, modification is to be conducted to the data input from the "page for

inputting traffic event data".

(3) Page for Warning Occurrence of Traffic Event

Giving the following warnings, the data automatically generated by functional package for data-collection are to be displayed as the traffic event data candidate which operator should input. If the data is inappropriate, that is to be modified using the page for modification.

- Accident occurrence warning from image recognition
- Congestion occurrence warning from vehicle detection
- Bad weather warning from weather monitoring.

(4) Page for Inspecting Traffic Event Data

By input of the criteria listed below, list of the traffic events that are stored in the server are to be displayed.

- Day/month/year for the search
- Start and end (second/minute/hour/day/month/year) of the period for the search
- Line ID of the road for the search
- Start and end (line ID and kilometer posts) of the sections for search
- ID code of traffic event data class for the search
- ID code of traffic event data category for the search
- Approval/disapproval of the Main Center
- Approval/disapproval of road management office
- Existence/removal of traffic event

(5) Page for Linking Traffic Event Data

By inputting "ID code of the traffic event data", the traffic event data corresponding to the ID code is picked up to enable input of "ID code of the causal traffic event data."

(6) Page for Approving Traffic Event Data by Main Center

By inputting "ID code of the traffic event data," the traffic event data corresponding to the ID code is picked up to enable input of "Approval/disapproval of the Main Center." If the data is inappropriate, that is to be modified using the page for modification.

(7) Page for Approving Traffic Event Data by Road Management Office

By inputting "ID code of the traffic event data," the traffic event data corresponding to the ID code is picked up to enable input of "Approval/disapproval of road management office. If the data is inappropriate, that is to be modified using the page for modification.

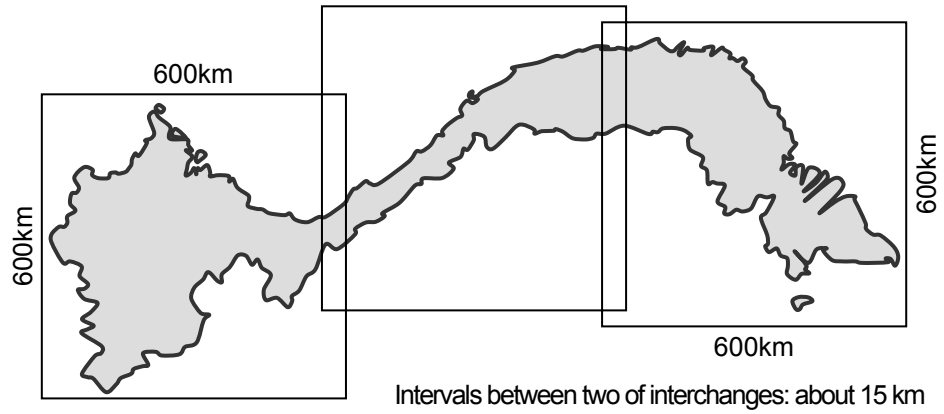
(8) Page for Removing Traffic Event Data

By inputting "ID code of the traffic event data," the traffic event data corresponding to the ID code is picked up to enable input of "existence/removal of traffic event."

4) Main Monitor Screen

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

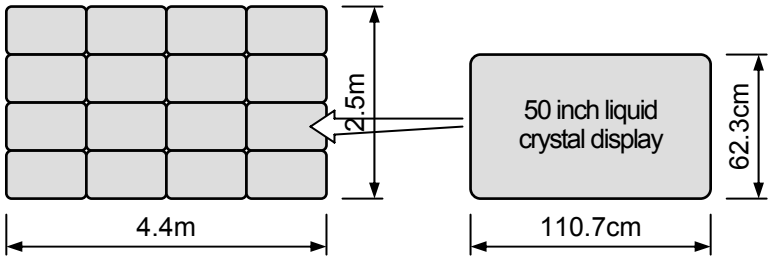
Figure 15.4 Required Size of Required Main Monitor Screen



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

As the expressway network will be patterned on the main monitor screen, the height of patterned network can be compressed to about 60% as compared to the width. Therefore, the main monitor screen can be constructed by combining 50-inch liquid crystal display as shown below.

Figure 15.3.4 Structure of Main Monitor Screen

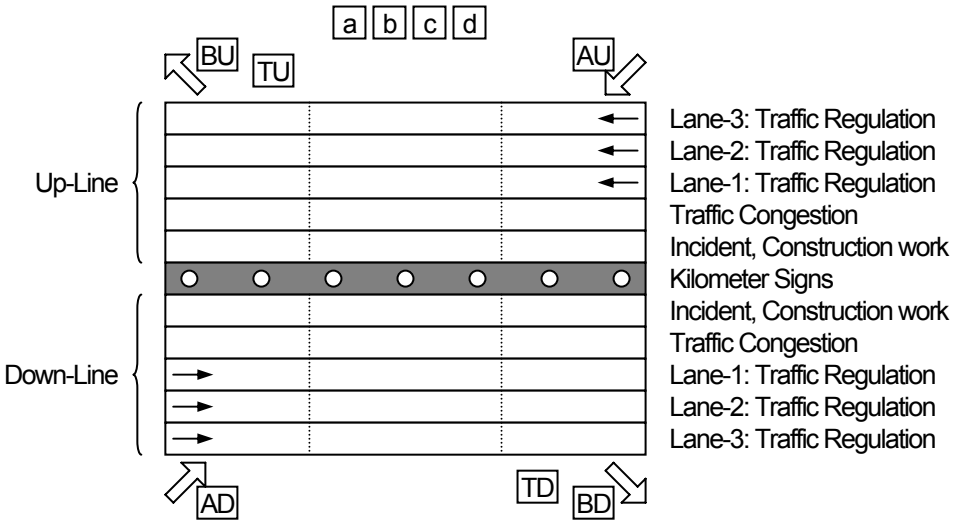


5) Indication Items on Main Monitor Screen

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

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

Figure 15.5 Indication Items on Main Monitor Screen (for Each Section)



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

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

Figure 15.1 Indicating Methods on Main Monitor Screen

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

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

6) Activities of an operator in the Main center

Responding to the in formation indicated on the main monitor screen, the staff in the Main Center and the road management offices are to be required to perform the activities shown in the table below.

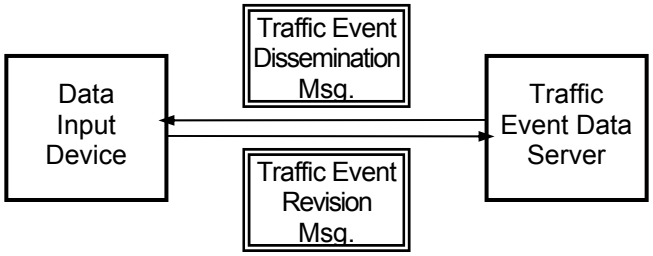
Figure 15.2 Required Activities of Road Operators

Traffic Event Category	Activities of an operator in the Main center
Incident	Routine traffic monitoring using CCTV Contact with road management offices to dispatch patrol crews Contact with road management offices to mobilize patrol cars, fire engines, ambulances, tow cars or other operation vehicles Contact with road management offices for enforcing/removing restrictions Contact with the traffic police office for enforcing/removing restrictions Traffic information dissemination using VMS and through the Internet
Traffic Congestion	Routine traffic monitoring using CCTV Traffic information dissemination using VMS and through the Internet
Significant Weather	Routine traffic monitoring using CCTV Contact with road management offices to dispatch patrol crews Contact with road management offices to mobilize patrol cars, fire engines, ambulances, tow cars or other operation vehicles Contact with road management offices for enforcing/removing restrictions Contact with the traffic police office for enforcing/removing restrictions Traffic information dissemination using VMS and through the Internet
Construction Work	Routine traffic monitoring using CCTV Traffic information dissemination using VMS and through the Internet
Traffic Regulation	Routine traffic monitoring using CCTV Contact with road management offices for enforcing/removing restrictions Contact with the traffic police office for enforcing/removing restrictions Traffic information dissemination using VMS and through the Internet

15.4 Message Exchange

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

Figure 15.6 Major Message Exchanges for Checking/Revising Traffic Event Data



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

operator, and to be sent back to and stored in the traffic event data server.

Table 15.3 Data Set/Elements in Traffic Event Dissemination/Revision Message

Data Set	Data Elements	Definition
Traffic Event Data Set	Traffic Event Data ID	ID code of the traffic event data
	Causal Traffic Event Data ID	ID code of the causal traffic event data
	Date	Day/month/year when a traffic event occurred
	Time	Hour/minute/second when a traffic event occurred
	Line ID	Line number of the road where a traffic event occurred
	Kilometer Post	Kilometer post of the place where a traffic event occurred
	Road Link ID	Road link number of the place where the traffic event occurred
	Place Name ID	ID code of the place name where the traffic event occurred
	Traffic Event Category ID	Number of traffic event data category
	Traffic Event Class ID	Number of traffic event data class
	Main Center Check Status**	Approval/disapproval of the Main Center
	Office Check Status**	Approval/disapproval of the road management office
	Existing/Removed Status**	Existence/removal of traffic event

Note, ** : Data to be manually input after check and revision.

The check statuses can have a value of the traffic event classes shown in the following table:

Table 12.3 Classes of Traffic Event Data Check

Traffic Event Data Check Class	Definition
Checked	Condition that all data elements are checked already by an operator
None	Condition that data elements are not checked yet by an operator

15.5 Transmission Design

All the signals and data are transferred via Internet and communication Protocol is transferred via TCP/IP.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Details are to be referred to the Draft Communication System Plan.

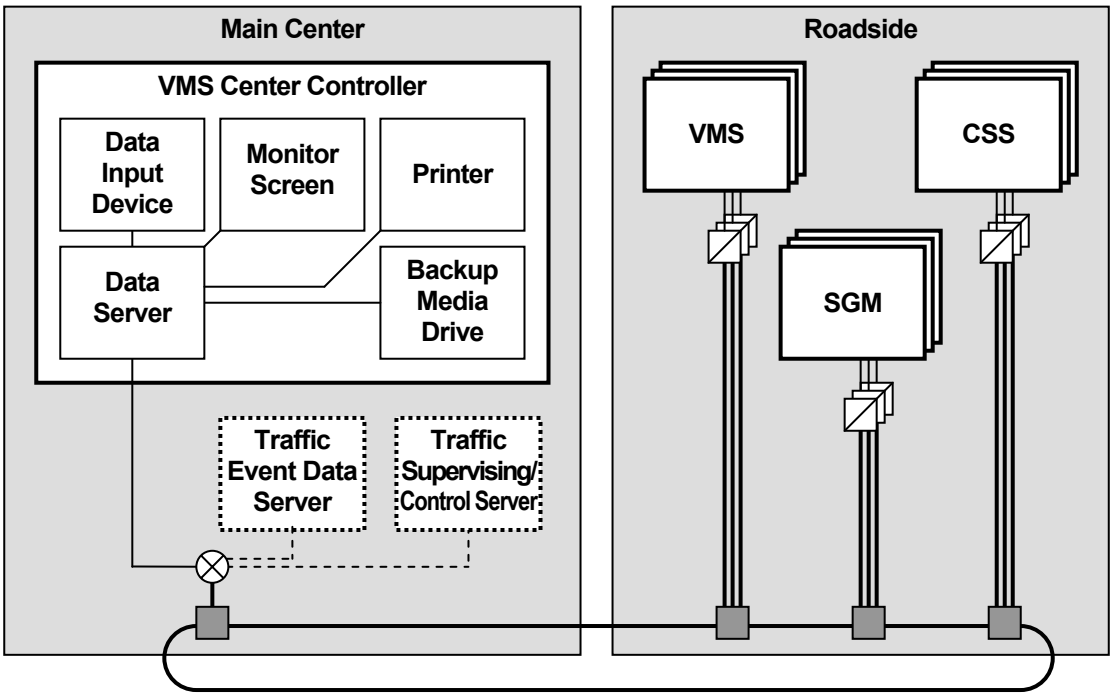
16. VMS Indication

16.1 Outlines

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

16.2 System Architecture

Figure 16.1 System Architecture for VMS Indication



: Location : Equipment Package : Detailed Device
: Software : Switching Hub & Media Converter : Media Converter
: SDH Node : Fibre Optic Cable : Copper Cable
Broken Lines: Outside of This Functional Package

16.3 Functional Design

1) Functions

VMS is an equipment component which is capable of providing road users with traffic event as organized information by information board installed in back from the tollgates, junctions, etc.

Table 16.1 Variety of VMS

Location	Intended use
Back from a tollgate	Install in the front of tollgate to call attention to traffic current status of expressway, current status of traffic regulation, incident occurrence, etc.
Back from a junction	Install in front of junction to call attention to traffic current status of each side in traveling direction, current status of traffic regulation, incident occurrence, etc.
Back from a diverging section	Install in the front of diverging section (including IC exit interchange lamp) to call attention to traffic current status of expressway main lane in traveling direction, current status of traffic regulation, incident occurrence, etc.
Back from a barrier tollgate	Install in the front of a barrier tollgate to call attention to traffic current status of expressway through lanes in traveling direction, current status of traffic regulation, incident occurrence, etc.

2) Display letter size for VMS (Variable Message Sign)

(1)Examples of letter size on traffic sign board on highways in other countries.

-USA-
Letter height: >250 mm
Letter width: 50-100% of letter height
Line thickness: 10-20 % of letter height (15% is ideal)
-Germany-
Letter height: >280 mm
-Japan-
Letter height: 450 mm
Letter width: 84% of letter height
Line 44thickness: 10% of letter height

(2)Letter height of traffic sign in Vietnam

Letter height on traffic sign in Viet Nam is expected to be “22-TCN-331-05 BIỂN CHỈ DẪN TRÊN ĐƯỜNG CAO TỐC”
According to the guideline, drivers would recognize the traffic sign, understand and start action 10 seconds before the sign.

Table 16.2 Correlation with Decipher required distance and Letter height

Decipher required distance	250m	325m	400m
Letter height (Vietnamese)	200mm	300mm	400mm

Source: 22-TCN-331-05 BIỂN CHỈ DẪNTRÊN ĐƯỜNG CAO TỐC

When driving at 120 km/h on Vietnam highway, 10 seconds would require 333.33 m distance from the sign, thus from the Table, letter height needs to be more than 400 mm. However, since VMS displays letters by LED (Light Emitting Diode) dots, letter height should be more than 450 mm considering Vietnamese circumflex representation.

(3)Letter width of traffic sign in Vietnam

Character width on traffic signs in Vietnam must comply with the standard "22-TCN-331-05 ROAD SIGNS ON HIGHWAY which is illustrated in the Table 11 and 12
Width of numbers 0-9 must be 25%-72% of their heights. Letters A-Z comprise circumflex with the width of 16%~86% of their heights.
Therefore, in the case of applying this standard for the width of character on VMS then character height on VMS is 450mm, the width of each character is illustrated in column "For VMS" in the Table 11 and 12.

Table 16.3 Letter width of number

	Letter width (mm)							
	22TCN331-05 BIẾN CHỈ DẪN TRÊN ĐƯỜNG CAO TỐC						For VMS / CSS	
Letter height (mm)	200	Ratio to Letter Height	300	Ratio to Letter Height	400	Ratio to Letter Height	450	Ratio to Letter Height
1	50	25%	74	25%	98	25%	108	24%
2	137	69%	205	68%	274	69%	306	68%
3	137	69%	205	68%	274	69%	306	68%
4	149	75%	224	75%	298	75%	306	68%
5	137	69%	205	68%	274	69%	306	68%
6	137	69%	205	68%	274	69%	306	68%
7	137	69%	205	68%	274	69%	306	68%
8	137	69%	205	68%	274	69%	306	68%
9	137	69%	205	68%	274	69%	306	68%
0	143	72%	214	71%	286	72%	324	72%
Average	130	65%	195	65%	260	65%	288	64%

Table 16.4 Letter width of alphabet

	Letter width (mm)							
	22TCN331-05 BIẾN CHỈ DẪN TRÊN ĐƯỜNG CAO TỐC						For VMS	
Letter Height (mm)	200	Ratio to Letter Height	300	Ratio to Letter Height	400	Ratio to Letter Height	450	Ratio to Letter Height
A, Â	170	85%	225	75%	340	85%	378	84%
B	137	69%	205	68%	274	69%	306	68%
C	137	69%	205	68%	274	69%	306	68%
D	137	69%	205	68%	274	69%	306	68%
Đ	155	78%	232	77%	310	78%	342	76%
E, Ê	124	62%	186	62%	248	62%	279	62%
F	124	62%	186	62%	248	62%	279	62%
G	137	69%	205	68%	274	69%	306	68%
H	137	69%	205	68%	274	69%	306	68%
I	32	16%	48	16%	64	16%	72	16%
J	127	64%	190	63%	254	64%	279	62%
K	140	70%	210	70%	280	70%	315	70%
L	124	62%	186	62%	248	62%	279	62%
M	157	79%	236	79%	314	79%	351	78%
N	137	69%	205	68%	274	69%	306	68%
O, Ô, Ơ	143	72%	214	71%	286	72%	315	70%
P	137	69%	205	68%	274	69%	306	68%
Q	143	72%	214	71%	286	72%	315	70%
R	137	69%	205	68%	274	69%	306	68%
S	137	69%	205	68%	274	69%	306	68%
T	124	62%	186	62%	248	62%	279	62%
U	137	69%	205	68%	274	69%	306	68%
Ư	167	84%	250	83%	334	84%	378	84%
V	152	76%	229	76%	304	76%	342	76%
X	137	69%	205	68%	274	69%	306	68%
Y	171	86%	257	86%	342	86%	387	86%
Z	137	69%	205	68%	274	69%	306	68%
Average	133	67%	198	66%	267	67%	297	68%

(4)Distance between disappearance point and sign

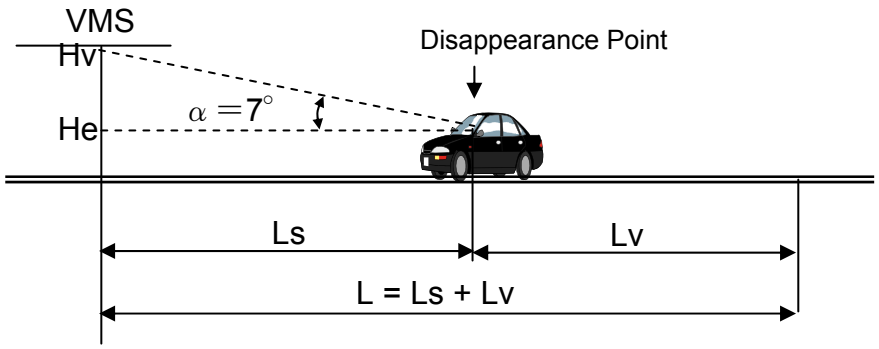
Distance between disappearance point and sign (Ls) can be calculated from driver's visual limit, position of traffic sign (VMS), and size of VMS.

When vertical visual limit is $\alpha = 7^\circ$, eye-level of the driver is 1.2m, height of VMS is 6.25 m, Ls can be calculated to be about 51 m.
The upper-edge of the VMS board was set at 6.25 m to fulfil structural height limit of 4.75 m determined by local guideline, and VMS board height is 1.50 m (3 rows of 450 mm high letters).

Ls = (Hv – He) / tan α

Where Hv: Upper-edge of the VMS board (m)
He: Eye-level of the driver (m)
α : Vertical visual limit (degree)

Figure 16.2 Relation between Hv, He, Ls, Lv and L



(4)Decipher required distance (Lv)

Decipher required time (or number of letters) and running speed. When decipher required time is t, and running speed is V=120 km/h, Lv would become Lv＝120× t ／3.6＝33.3 t .

Lv = V x t / 3.6

Where V: Running Speed (km/h)
t: Decipher Required Time (sec)

(5)Visual recognition distance (L)

From (3) and (4), visual recognition distance can be calculated from below:

L=Ls + Lv

Thus, L = 51m + 33.3t

(6)Decipherable letter number

According to Germany standard from the table, the following formulae can be given by the fact 167 m sight distance required at letter height of 450 mm.

t = (L – 51m) / 33.3 = (167m – 51m) / 33.3
= 3.48 sec = 3.5 sec (approx.)

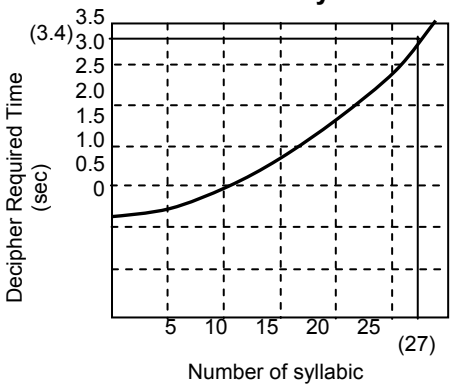
From the Figure graph below, 30 letters are legible in 3.5 second decipher time.

Table 16. 5 Relation between Character Height and sight Distance

Alphabet Font Type	Character Height to Sight Distance	Character Height		
		30cm	45cm	60cm
Narrow	300h	90cm	130cm	180cm
Normal	370h	111	167	222
Wide	450h	135	203	270

Source: German Standard

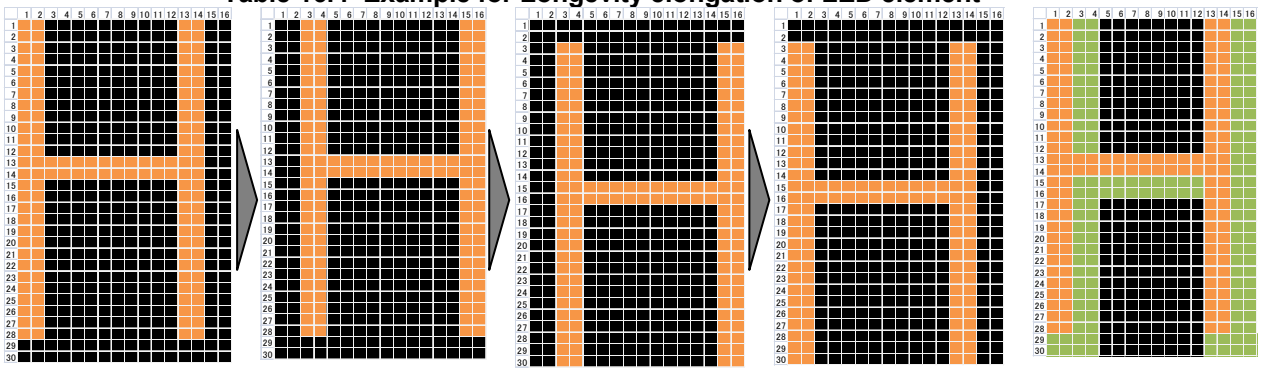
Figure 16.3 Relation between Decipher time and Number of Syllabic



3) Examination on longevity elongation of LED element

LED element takes 35,000-50,000 hours for its light intensity to decrease for 50%.
The picture represents the example of letter display, assuming the resolution to be 30 pixels vertical vs 16 pixels horizontal.
In case of Vietnamese, display will employ alphabets from A to Z, and circumflex in addition.
On the display there will be highly frequently used LED elements, and others rarely used.
When LED elements burn out, the replacement will be made not by individual elements but by a unit of certain number of LED elements. For example, if the display is made by 160 x 160 mm LED element unit with 15 mm pitch, replacement is done by unit of 144 dots (12 x 12).
Individual LED elements are ideally degraded equally for VMS to last longer.
For such purpose, shifting lighting LED elements by time to time can equalize the frequency of lighting time of each element. However, it is not the case when all elements are lit for picture display.

Table 16.4 Example for Longevity elongation of LED element



Move 2 columns to right | Move 2 rows downward | Move 2 columns to left | Total LED use

4) Human Machine Interfaces

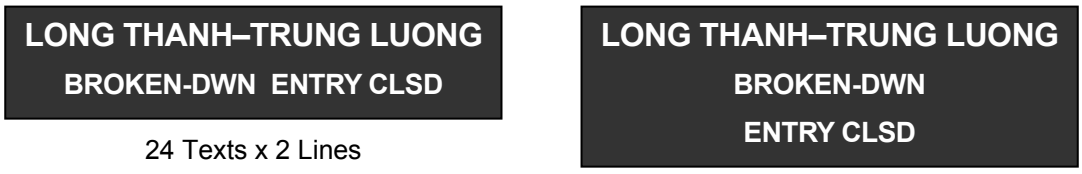
(1) Text Arrangement on VMS

The followings are the maximum numbers of the texts for indicating traffic events and place names:

- Traffic event: 11
- Causal traffic event: 11
- Place name: 24

Hence, each line of VMS shall be capable of indicating 24 characters.

Figure 16.5 Text Arrangement of VMS



24 Texts x 2 Lines

24 Texts x 3 Lines

(2) Location of VMS

VMS shall be installed at the following spots in the 1st stage:

- Short of the entrance
- Short of junction
- Short of the exit

VMS shall be installed at the following spots in the 2nd stage:

- Short of the tollgate
- Midway between two of interchanges

Table 16.6 Reference of VMS, SGM and CSS

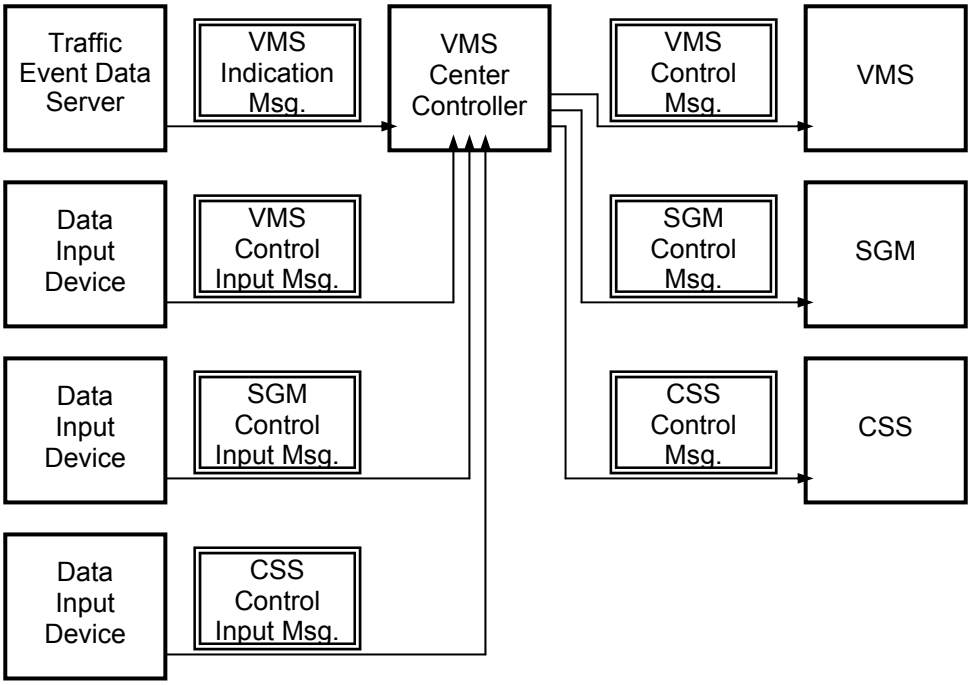
	Variable Message Sign (VMS)	Simple Graphical Message (SGM)	Changeable Speed limit Sign (CSS)
Appearance			
Function	By using text information, call attention to current status of expressway, current status of traffic regulation, incident occurrence, etc.	By using graphic, call attention to current status of expressway, current status of traffic regulation, incident occurrence, etc.	This regulatory speed sign is used in cases where it is necessary to change regulatory speed due to dense fog or heavy rain.
Location**	- back from a tollgate - back from a junction - back from a diverging section - back from barrier tollgate - on the through lanes midway between ICs	- back from a junction	- on the through lanes midway between ICs

Note, ** : See Chapter 19

16.4 Message Exchange

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

Figure 16.6 Major Message Exchanges for Generating Data for Indication



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

(1) VMS Indication Message

The VMS indication message sent from the traffic event data server is to include the data set/elements shown in the table below. Information on VMS basically displays two rows including traffic event and traffic event which is the relevant cause; however, the traffic event which has no cause-effect relationships can be displayed in a single row.

Table 16.7 Data Set/Elements for VMS Indication Message

Data Set	Data Elements	Definition
VMS Indication Data Set	Roadside Equipment ID	ID code of Roadside equipment for VMS indication
	Date	Day/month/year of VMS indication
	Time	Hour/minute/second of VMS indication
	Traffic Event Class ID	ID code of traffic event data
	Place Name ID	ID code of the place name where a traffic event occurred
	Causal Traffic Event Class ID	ID code of the causal traffic event data
	Causal Place Name ID	ID code of the place name of causal traffic event

(2) Traffic Event Class

Details of Traffic event data are declared in the following tables.

Table 16.8 Traffic Event Categories/Classes

Traffic Event Category	Traffic Event Class		Definition
Incident	Traffic Accident	1	Serious traffic accident with issuing Closure
		2	Traffic accident with issuing lane/speed restriction
		3	Traffic accident without traffic regulation
	Broken-down Vehicle		Vehicle stopping on road due to disorder
	Left Obstacle		Object on road which may prevents vehicle traffic (excluding vehicles)
	Reversing Vehicle		Vehicle running in the reverse direction
	Vandalism		Wilful destruction of road facilities or obstruction of vehicles
	Natural Disaster		Natural disaster which may prevent car passing
Traffic Congestion	Congestion		State where passing cars run very slow on average
	Crowdedness		State where passing cars run slow on average
Significant Weather	Heavy Rain	1	Significant heavy rain with issuing Closure
		2	Heavy rain with issuing lane/speed restriction
		3	Heavy rain with issue of warning information
	High Wind	1	Significant high wind with issuing Closure
		2	High wind with issuing lane/speed restriction
		3	High wind with issue of warning information
	Dense Fog	1	Significant dense fog with issuing Closure
		2	Dense fog with issuing lane/speed restriction
		3	Dense fog with issue of warning information
	High Temperature		High temperature or high road surface temperature with issue of warning information
Construction Work	Construction Work		Improvement/repair of road facilities
Traffic Regulation	Closure		Regulation to ban flow in all lanes of the through traffic
	Lane Closure		Regulation to ban flow of part of lanes of the through traffic
	Entry Closure		Regulation to ban inflow into the through traffic at entry point
	Speed Limitation		Regulation to restrict the fastest speed of the through traffic
	Warning Information		Information to arouse care of the passing drivers

Table 16.9 Indication of Traffic Event

Traffic Event Class	Indication	No. of Texts	Traffic Event Class	Indication	No. of Texts
Traffic Accident	ACCIDENT	8	Heavy Rain	HEAVY RAIN	10
Broken-down Vehicle	BROKEN-DWN	10	High Wind	HIGH WIND	9
Left Obstacle	OBSTACLE	8	Dense Fog	DENSE FOG	9
Reversing Vehicle	REVERSE DRV	11	High Temperature	HIGH TEMP	9
Vandalism	VANDALISM	8	Construction Work	CONST WORK	10
Natural Disaster	DISASTER	8	Closure	CLOSED	6
Congested	CONGESTED	9	Lane Closure	LANE CLSD	9
Crowded	CROWDED	7	In-coming Closure	ENTRY CLSD	10
			Speed Limitation	50KM/H LMTD	11
			Warning Information	WARNING	7

(3) Place Name

Place name for VMS indication data is to be generated using place name class and specific place name as shown in the table below.

Table 16.10 Definition and Indication of Place Name Classes

Place Name Category	Place Name Class	Indication	Specific Place Name	No. of Texts	Definition
Point	Entrance	ENT	N1	14	Merging point on expressway from public road
	Exit	EXT	N1	14	Merging point on public road from expressway
	Tollgate	TG	N1	14	Toll station is for road
	Barrier Tollgate	BTG	N1	14	Toll station is located on the Main line of Expressway
	Interchange	IC	N1	14	Traffic intersection is to link public road and expressway
	Junction	JCT	N1	14	Traffic intersection is to link two expressways
Section	Section	–	N1, N2	24	Road section is limited between two positions
	Bridge	BRD	N1	14	Road section is corresponding to a bridge
	Tunnel	TNL	N1	14	Road section is corresponding to a tunnel
Ancillary Facility	Rest Area	RA	N1	14	Rest area are on road
	Bus Stop	BS	N1	14	Bus-stops aerated on road-side

Table 16.11 Indication of Place Name (Example)

N1	N1	N1–N2 (Section)
ENT HA NOI	EXT TRUNG LUONG	HA NOI–CAU GIE
ENT CAU GIE	TG TRUNG LUONG	CAU GIE–NINH BINH
ENT NINH BINH	BTG TRUNG LUONG	HCMC–LONG THANH
ENT HCMC	IC TRUNG LUONG	LONG THANH–DAU GIAY
ENT LONG THANH	JCT TRUNG LUONG	HCMC–TRUNG LUONG
ENT DAU GIAY	BRD TRUNG LUONG	LONG THANH–TRUNG LUONG
ENT TRUNG LUONG	BS TRUNG LUONG	

(4) VMS Control Input Message

The data set/elements are to be input as the VMS control input message using the data input device.

Table 16.12 Data Set/Elements for VMS Control Input Message

Data Set	Data Elements	Definition
VMS Control Input Data Set	Roadside Equipment ID	Roadside equipment identification number to be used to display on VMS.
	Free Text	The character what is inputted by using “Data Input Device”
	Indication of “Under Repair”	Indication when under Maintenance or Repair.
	Turn Off/On	Switch On/Off

(5) VMS Control Message

VMS control message is to be generated using the data elements in the VMS indication message and the VMS control input message, and to be sent from the VMS center controller

to VMS at roadside.

Table 16.13 Data Set/Elements for VMS Control Message

Data Set	Data Elements	Definition
VMS Control Data Set	Roadside Equipment ID	Roadside equipment identification number to be used to display on VMS.
	LED Elements Control Data	The data which for control On/Off of LED elements on VMS
	Turn Off/On	Switch On/Off

(6) CSS Control Input Message

The data set/elements are to be input as the CSS control input message using the data input device.

Table 16.14 Data Set/Elements for CSS Control Input Message

Data Set	Data Elements	Definition
CSS Control Input Data Set	Roadside Equipment ID	Roadside equipment identification number to be used to display on VMS.
	Free Digit	The digit what is inputted by using “Data Input Device”
	Turn Off/On	Switch On/Off

(7) CSS Control Message

CSS control message is to be generated using the data elements in the VMS indication message and the CSS control input message, and to be sent from the VMS center controller to CSS at roadside.

Table 16.15 Data Set/Elements for CSS Control Message

Data Set	Data Elements	Definition
CSS Control Data Set	Roadside Equipment ID	Roadside equipment identification number to be used to display on VMS.
	LED Elements Control Data	The data which for control On/Off of LED elements on VMS
	Turn Off/On	Switch On/Off

16.5 Transmission Design

All the signals and data are transferred via Internet and communication Protocol is transferred via TCP/IP.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Details are to be referred to the Draft Communication System Plan.

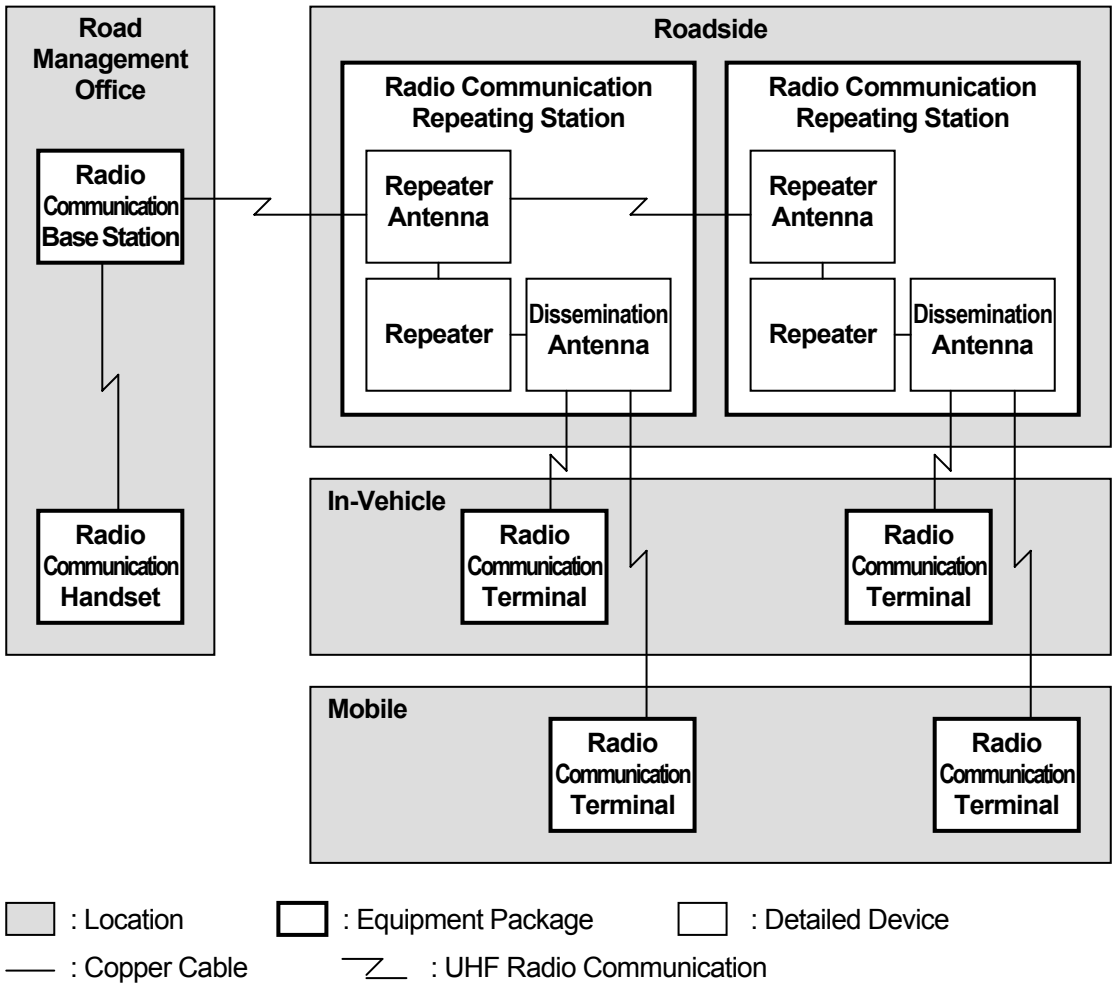
17. Mobile Radio Communication

17.1 Outlines

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

17.2 System Architecture

Figure 17.1 System Architecture for Mobile Radio Communication



17.3 Functional Design

→ Refer to the Draft Communication System Plan.

17.4 Message Exchange

→ Refer to the Draft Communication System Plan.

17.5 Transmission Design

→ Refer to the Draft Communication System Plan.

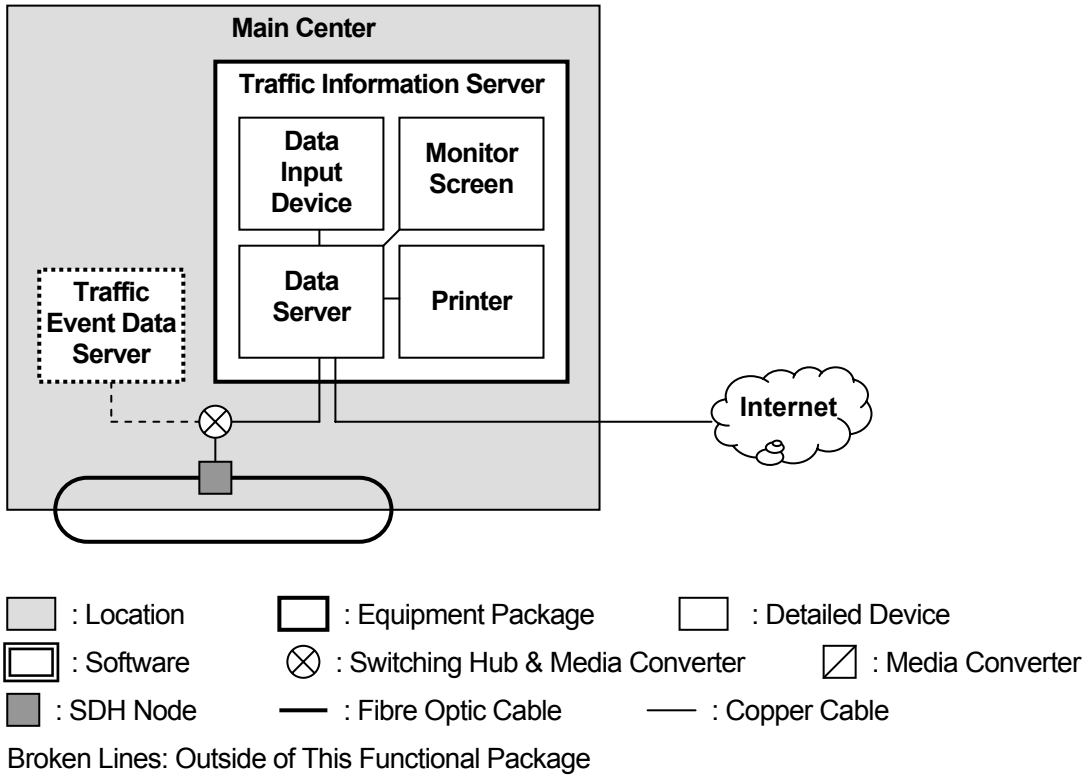
18. Traffic Information

18.1 Outlines

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

18.2 System Architecture

Figure 18.1 System Architecture for Traffic Information



18.3 Functional Design

1) Traffic Data Collection

The traffic information server shall be capable of will automatically retrieving traffic event data from traffic event data server when being received query information from internet user.

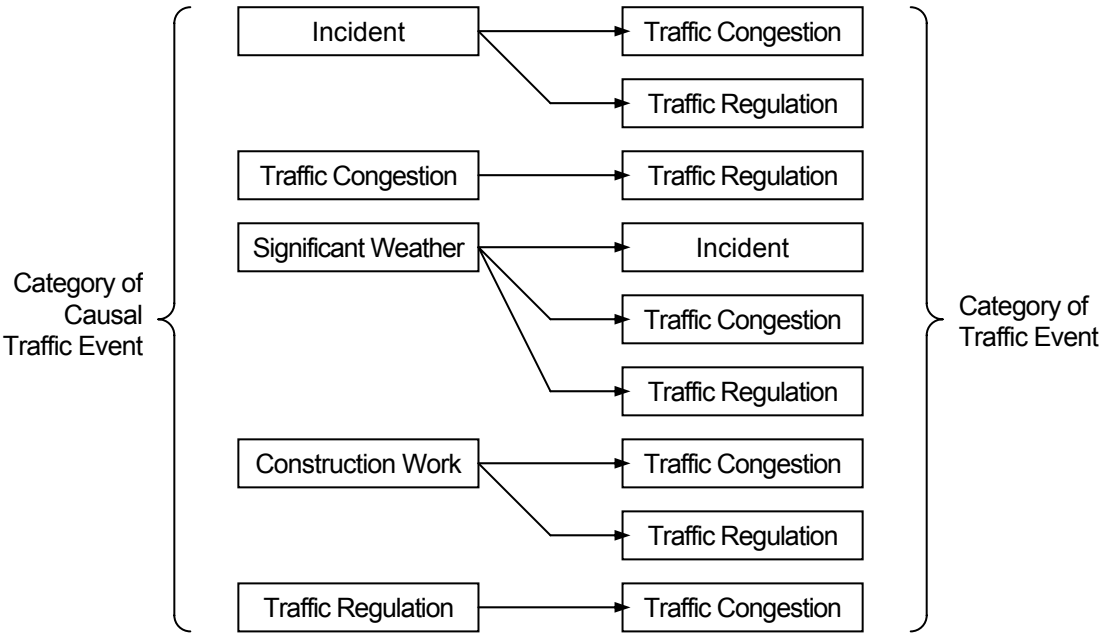
Traffic event data are classified into the following 5 categories as: Incident, Traffic congestion, Significant weather, Construction work, and Traffic regulation. Each category can contain one or more traffic event classes as described in the following table.

Table 18.1 Traffic event classification

Traffic Event Category	Traffic Event Class		Definition
Incident	Traffic Accident	1	Serious traffic accident with issuing Closure
		2	Traffic accident with issuing lane/speed restriction
		3	Traffic accident without traffic regulation
	Broken-down Vehicle		Vehicle stopping on road due to disorder
	Left Obstacle		Object on road which may prevents vehicle traffic (excluding vehicles)
	Reversing Vehicle		Vehicle running in the reverse direction
	Vandalism		Wilful destruction of road facilities or obstruction of vehicles
	Natural Disaster		Natural disaster which may prevent car passing
Traffic Congestion	Congestion		State where passing cars run very slow on average
	Crowdedness		State where passing cars run slow on average
Significant Weather	Heavy Rain	1	Significant heavy rain with issuing Closure
		2	Heavy rain with issuing lane/speed restriction
		3	Heavy rain with issue of warning information
	High Wind	1	Significant high wind with issuing Closure
		2	High wind with issuing lane/speed restriction
		3	High wind with issue of warning information
	Dense Fog	1	Significant dense fog with issuing Closure
		2	Dense fog with issuing lane/speed restriction
		3	Dense fog with issue of warning information
	High Temperature		High temperature or high road surface temperature with issue of warning information
Construction Work	Construction Work		Improvement/repair of road facilities
Traffic Regulation	Closure		Regulation to ban flow in all lanes of the through traffic
	Lane Closure		Regulation to ban flow of part of lanes of the through traffic
	Entry Closure		Regulation to ban inflow into the through traffic at entry point
	Speed Limitation		Regulation to restrict the fastest speed of the through traffic
	Warning Information		Information to arouse care of the passing drivers

The traffic event data retrieved from Traffic Event Data Server shall be in form of casual relations between traffic event categories. The cause relations between traffic event categories are assumed to be shown in the following figure.

Figure 18.2 Correlations between Traffic Event Categories



Some other traffic data need to be inputted in traffic information server such as toll price for each road section, service areas and parking areas availability of services by each road operators.

The detailed data to be inputed are described in Item 18.4

2) Traffic Information Web Application Design

(1) Principles for Web application Design

a) Information must be legible

The user must be able to easily determine what appears on the screen under all circumstances. The fonts must be large enough to be seen. The colours and luminance levels selected must provide adequate contrast; threshold legibility is not acceptable. Moving text is also discouraged

b) Information must be readable

Given the user can see what is presented, they must be able to decipher its meaning. This involves understanding how a page is organized and the use of language the user can comprehend

c) Pages and page elements should be consistent

The site's appearance and the way the user interacts with the site should remain consistent throughout the site in order to remain consistent with the user's expectations. Similar actions should lead to similar results.

d) Minimize the number of actions required by the user to reach information

Users should never be required to enter the same request multiple times to reach the information they desire. A balance must be achieved between presenting the user with too many options at once (which clutters the screen) and burying the information too deeply in the site (requiring the user to dig for the information). The impact of this principle is to minimize task-completion time.

e) The user's status should be always apparent

Constant feedback must be provided to the user regarding what page in the hierarchy is currently being shown and what options are currently available. Information must also be provided on the status of information retrieval tasks (what is being retrieved, how much has been retrieved, and when the task will be completed).

f) Links should be apparent and their actions should be predictable

Clickable objects and text should be distinct and apparent to users. However, the users must also be able to predict where a link will lead, and what will happen when a link is clicked.

g) Plan for error correction

Users make lots of mistakes, so actions should be quickly and easily reversible. Allow users to readily back up to previous states

h) Support for novice and expert users

Systems are used by a wide range of users, many of whom know much less about the domain than the developer

(2) Specific Design Requirements

<u>Site Organization Requirements</u>

a) Site Organization

Provide explicit navigation cues and link labels. Since there is no preferred method for organizing a web site, do not assume that a user will follow or understand the sites structure.

b) Avoid orphan pages

Tie each page clearly to the overall site with consistent logos, colours, menu bars, or navigation bars. Each page should provide a set of common links or exits including one to the main index or home page

c) Avoid links to unfinished pages

Avoid links to pages which say "coming soon, under construction, or feature not yet implemented." If a page is not completed, disable the links to it.

d) URL naming structure

Keep URL addresses readable and useful:

- Avoid long and complex URLs.
- Avoid capital letters.
- Use descriptive directory and file names.
- Avoid naming structures that must change frequently

e) Screen Size and Scrolling

Design the site to be function on a 1024x768 screen resolution to reach the widest range of users, even if the page is optimized for use on a higher resolution monitor.

f) Use of Frames

Implement frames in a way that prevents problems with bookmarking, searches, the browser's back function, and the question of where information will appear when a link is clicked.

Site Navigation

a) Menu bar location

Place menu or navigation bars at the top or bottom of each page, rather than down the sides of the page

b) Using a menu bar as a site identifier

Use a consistent menu bar header or footer on every page as a site identifier. The site identifier should contain at least 2 links, one to the site's home page and one to its search page

c) Menu bar Appearance

Make the menu bars should be visually distinct from the rest of the page, and make the links within the menu bar visually distinct from each other

d) Menu bar consistency

Use a consistent location and format for menu bars from page to page. The core menu bar should not add items, lose items, or change the order of items from page to page

e) Location feedback on the menu bar

Indicate the user's current location in the web site on the menu bar, and disable any redundant menu bar links to the current page (i.e., a page should not link to itself).

f) Page titles and headings

Use page titles and headings that (1) are consistent with the links to the page, (2) accurately reflect the content of the page, and (3) reflect the user's language and expectations.

g) Links and link labels

Avoid ambiguous link labels. Instead, use link labels that accurately and descriptively preview the page to which the link leads

Real-Time Traffic Information Presentation

a) Background Map Layers

The system shall display background map layers including the following:

- Provincial Boundary
- National Road Network
- National Expressway Network
- Water body

b) Real-time traffic information overview

Format the real-time traffic information so that a single web page (either a real-time map or travel-time table) can give users an overview of traffic conditions (including incidents and construction for an entire expressway network area.

c) Real-time information status

Display the date and time for the currently displayed real-time information prominently on all real-time map pages, travel-time overview pages, and video images

d) Travel-time format

Include (1) the road name and number, (2) the direction of travel, (3) the start point, (4) the end point, (5) the distance, (6) the current estimated travel time, and (6) reference to all major construction and incidents in all travel-time tables. As the technology becomes available, customized travel-time reports should replace or supplement static travel-time tables.

e) Accessing detailed information from the real-time map

Format the real-time map such that clicking on an item on the real-time map produces location-specific information. A click on the map should not bring up a list of options

f) Limiting the clickable area on the map

Format the real-time map so that areas of the real-time map that do not link to location specific information are not clickable (i.e., the default for the map should not be a link or an error message which states that the user should only click on the certain items). Since the cursor on most browsers provides feedback as to when it is over a link (by changing from a black pointer to a white hand), making only the parts of the map that provide location-specific information clickable will aid the user in distinguishing what on the map is a link.

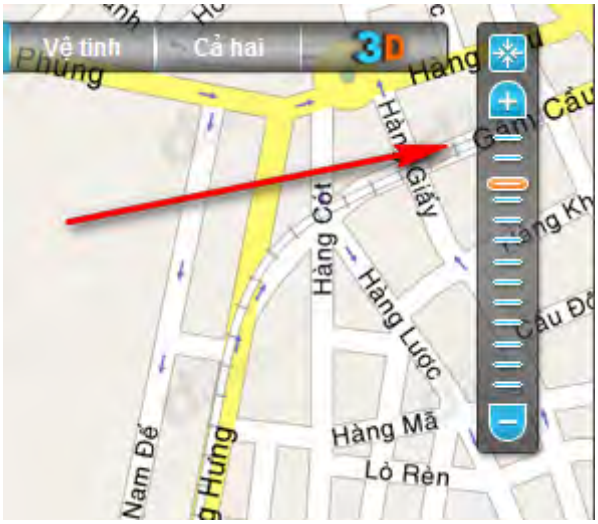
g) Using the browser status window

Provide feedback to the user as to what the cursor is over (on the real time map) through use of the browser's status window.

h) Map pan and zoom controls

Provide well labeled controls and an orientation map to support map pan, zoom, and pre-selected area functions.

Figure 18.3 Examples of visible map pan and zoom controls



i) Orientation overview maps

Provide feedback on the currently displayed map location through an orientation map instead of providing feedback through headings and labels which may be missed or misinterpreted by users

j) Map pan and zoom controls through the orientation overview map

Provide explicit cues to preview what will happen when the user clicks on the orientation overview map.

k) Displaying real-time information accessed from the map

Display real-time information accessed from the map in a consistent manner and location. It is also recommended that location-specific information accessed through the map appear without replacing the real-time map.

Real-Time Map Colours, Symbols, and Design

a) Display Contrast

Assure that the colour choices for symbols, text, and the map background have sufficient contrast to be easily readable. Avoid dark map backgrounds. Dark text on a light background is preferred

b) Redundant coding

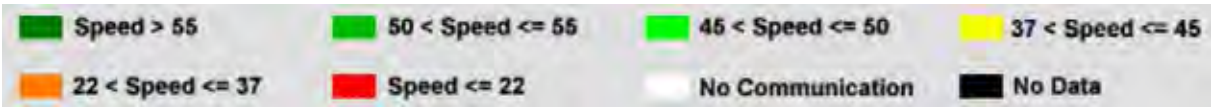
Avoid differentiating between multiple types of information by using only one coding method (e.g., colour). Multiple codes (e.g., shape and colour) should be used to differentiate icons representing different kinds of traffic information

Figure 18.4 Icons used for incidents and construction on Traffic Englang web site

c) Number of colours to use to represent information

Limit the number of colours used to represent real-time data to between 5 and 7, and avoid using shades of a single colour as a method for coding multiple levels of a particular piece of traffic data (e.g. speed). Separate colours should also be used for not monitored, no data, and construction. As the number of colours or shades of a single colour increase into the 5 to 9 range (the generally accepted short-term memory limits), the task ofinterpreting the colours changes from an absolute judgment task (where the user can immediately interpret the colours on the map) to a task of relative judgment, comparing the map to the legend (which slows the user)

Figure 18.5 Colour coding legend used on the Arizona Trailmaster (USA) web site



d) Colour coding consistency

Use a consistent colour-coding scheme throughout the web site. The colours used for congestion should also match regardless of the medium used to measure congestion (e.g., slow ramp meters should be coded the same as slow traffic or heavy congestion).

e) Similarity between icons and real-world objects

Base icons on easily recognized symbols or on real-world objects and are be meaningfully related to the object it is referring to. The degree to which an icon represents the object of interest can influence the users' ability to read or interpret the information efficiently.

Cross-browser Compatibility

It's important that the web application is usable across all major media, whether it be popular browsers, mobile devices, or any other web browsing devices.

Not every internet users use the same web browser. Similar to how everyone is running on a different operating system, so it is impossible to expect all people to be using the same web browsing tool.

To ensure the cross-browser compatibility of the web application, the designer shall develop in accordance with World Wide Web Consortium's recommendations.

Figure 18.6 Example of Web browsers accessed to a website and analyzed by Google Analytics

	Browser None	Visits ↓	Visits
1.	Internet Explorer	39,628	54.59%
2.	Firefox	24,719	34.05%
3.	Chrome	5,673	7.82%
4.	Opera Mini	875	1.21%
5.	Safari	821	1.13%
6.	Opera	705	0.97%
7.	Mozilla Compatible Agent	92	0.13%
8.	Mozilla	40	0.06%
9.	NetFront	12	0.02%
10.	HTC_HD_T8585 Opera	3	> 0.00%

18.4 Message Exchange

→ Refer to Section 14.4.

18.5 Transmission Design

All the signals and data are transferred via Internet and communication Protocol is transferred via TCP/IP.

The system is constructed after disclosing the availability of trouble, necessary information, procedure and Interface software according to the self-diagnosis by center side equipment on sensors installed at roadside.

→ Further concepts and methodologies are to be referred to the Draft Communication System Plan

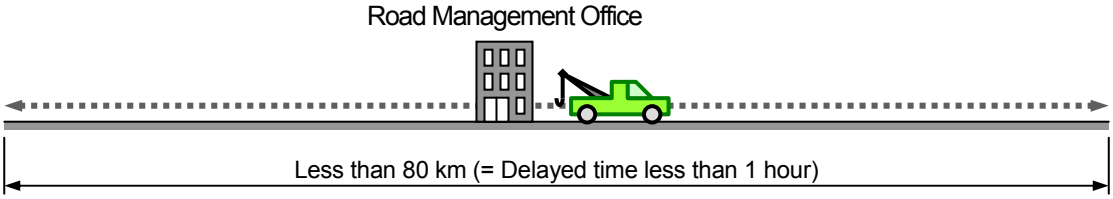
19. Location of Functional Packages

1) Jurisdiction of Road Management Office

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

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

Figure 19.1 Jurisdiction of Road Management Office



2) Arrangement criteria

Arrangement criteria of roadside equipment for detection/identification are defined responding to frequency of occurrence of events.

Table 19.1 Arrangement Criteria of Roadside Equipment for Detection/Identification

	Low Frequency	Average Frequency	High Frequency
Incident Identification	CCTV Camera Arrangement Criteria 1	CCTV Camera Arrangement Criteria 1	CCTV Camera Arrangement Criteria 2
Traffic Congestion Identification	Vehicle Detector Arrangement Criteria 1	Vehicle Detector Arrangement Criteria 2	Vehicle Detector Arrangement Criteria 3
Significant Weather Identification	Weather Sensor Arrangement Criteria	Weather Sensor Arrangement Criteria	Weather Sensor Arrangement Criteria

Arrangement criteria of roadside equipment for information dissemination are defined responding to locations on the expressway network.

Table 19.2 Arrangement Criteria of Roadside Equipment for Information Dissemination

	Back from Entrance	Back from Tollgate	Midway between two of interchanges	Back from Junction	Back from Exit
Information Dissemination	Entrance VMS Arrangement Criteria	Tollgate VMS Arrangement Criteria	Midway VMS Arrangement Criteria	Junction VMS Arrangement Criteria	Exit VMS Arrangement Criteria

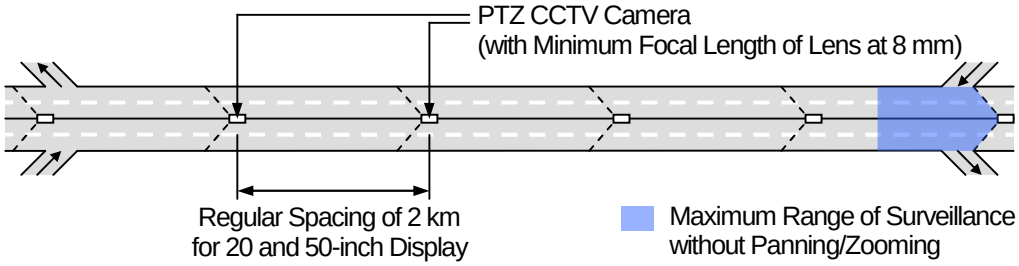
3) Incident Identification

(1) CCTV Camera Arrangement Criteria 1

In the case of the arrangement criteria 1, CCTV cameras need to be installed continuously

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

Figure 19.2 CCTV Camera Installation Continuously along the Expressway



(2) CCTV Camera Arrangement Criteria 2

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

Figure 19.3 Additional Fixed CCTV Camera Installation for Event Detection

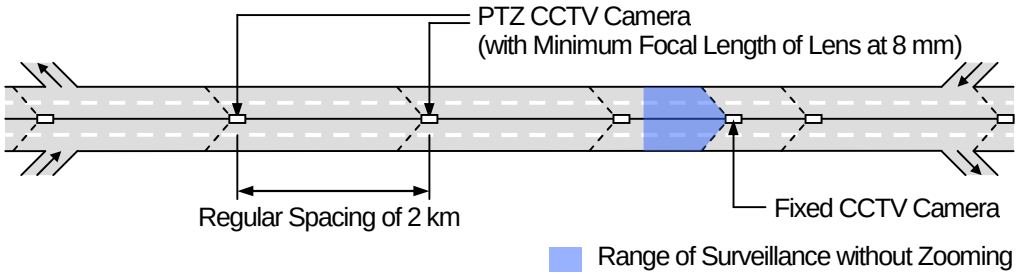
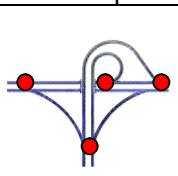
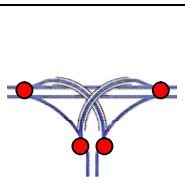
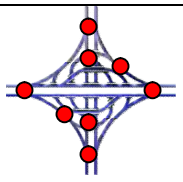
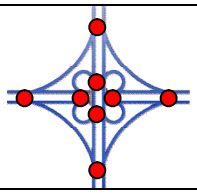
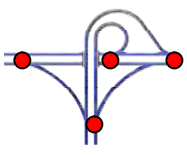
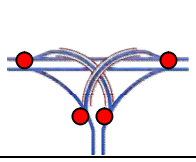
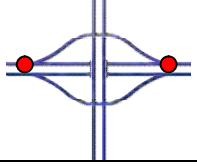


Table 19.3 Installation Outlines of Fixed CCTV Cameras at Junction and Interchange

Junction Type	Trumpet	Directional T	Turbine	Cloverleaf
Outlines				
Number of Fixed Camera	4	4	8	8

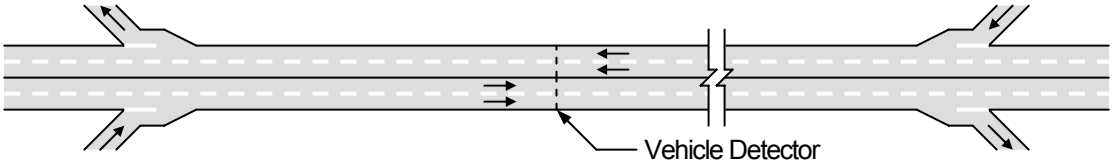
Interchange Type	Trumpet	Directional T	Diamond
Outlines			
Number of Fixed Camera	4	4	2

4) Traffic Congestion Identification

(1) Vehicle Detector Arrangement Criteria 1

In the case of the arrangement criteria 1, vehicle detectors need to be installed at a midway point between a pair of interchanges on the expressway in order to measure traffic volume on a section between them.

Figure 19.4 Vehicle Detector Installation at Midway between a Pair of Interchanges



(2) Vehicle Detector Arrangement Criteria 2

In the case of the arrangement criteria 2, vehicle detectors need to be installed at small spacing (e.g. 500 m) in congestion-prone sections on the expressway in order to measure vehicle velocity at the sections and surely to identify traffic congestion

Figure 19.5 Vehicle Detector Installation at Congestion-prone Sections on the Expressway

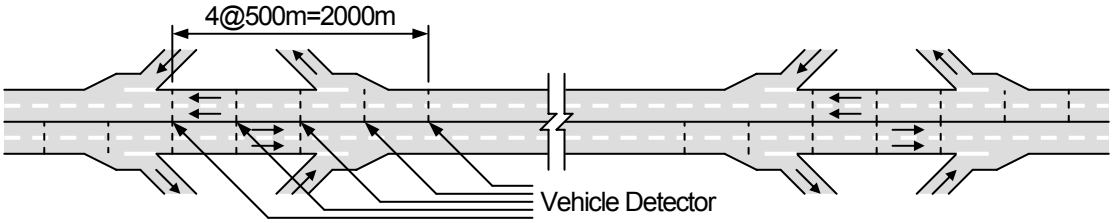
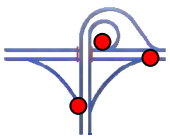
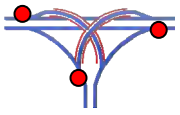
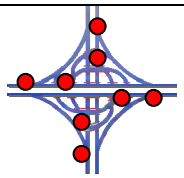
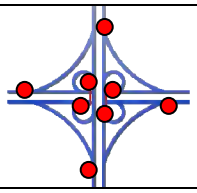
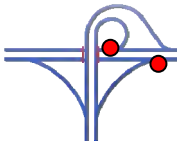
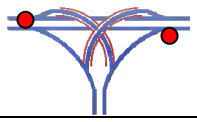
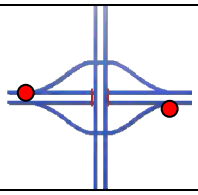


Table 19.4 Installation Outlines of Vehicle Detectors at Junction and Interchange

Junction Type	Trumpet	Directional T	Turbine	Cloverleaf
Outlines				
Number of Vehicle Detectors	15 (=5x3)	15 (=5x3)	40 (=5x8)	40 (=5x8)

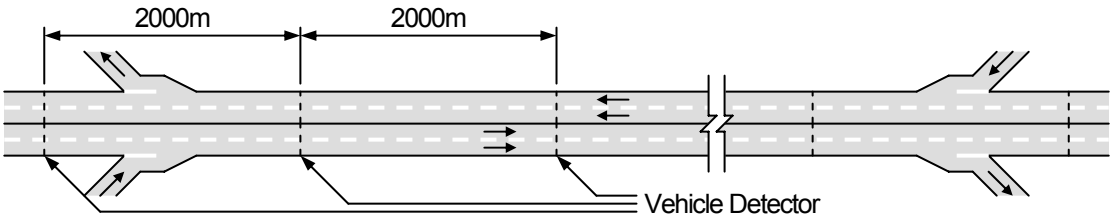
Interchange Type	Trumpet	Directional T	Diamond
Outlines			
Number of Vehicle Detectors	10 (=5x2)	10 (=5x2)	10 (=5x2)

In the case loop type or ultra-sonic type is installed, numbers shown above are multiplied by the number of lanes.

(3) Vehicle Detector Arrangement Criteria 3

In the case of the arrangement criteria 3, vehicle detectors need to be installed continuously along the expressway in order to measure vehicle velocity throughout the expressway and roughly to identify traffic congestion

Figure 19.6 Vehicle Detector Installation Continuously along the Expressway

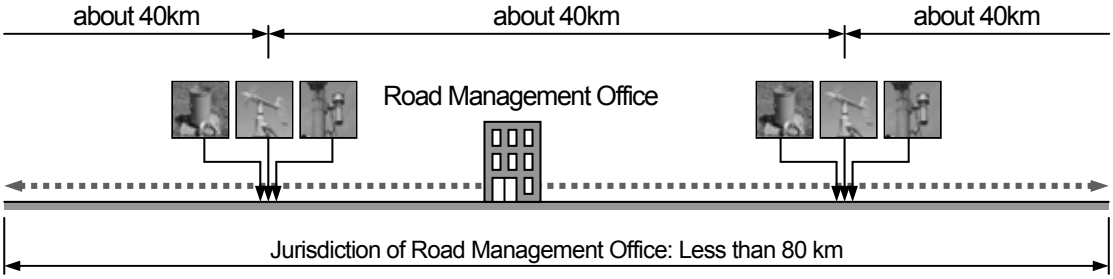


5) Significant Weather Identification

(1) Weather Sensor Arrangement Criteria

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

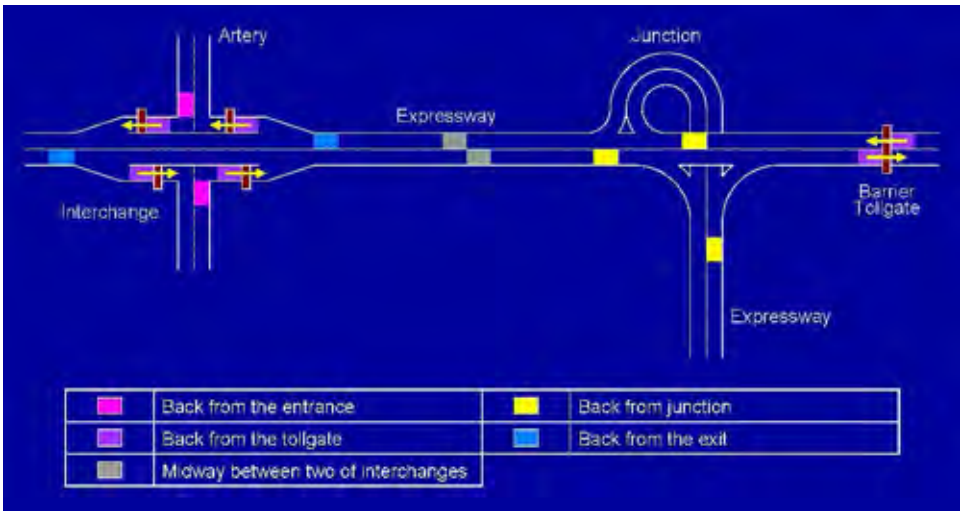
Figure 19.7 Illustration of Advanced Road Operation Using ITS



6) Information Dissemination

VMS arrangement criteria are defined responding to the locations of sections for information dissemination shown in the figure below.

Figure 19.8 Location of Sections for Information Dissemination



(1) Entrance VMS Arrangement Criteria

In front of entrance into expressway on roads in general which connect with expressway, in order to indicate road/weather/traffic conditions and traffic restrictions, the entrance VMS is installed. Especially, in case the incoming traffic volume is high (such as more than 5000 vehicles/day), and in case it is impossible for the U-turn on the connecting road between entrance and tollgate, the instalment of an entrance VMS is indispensable. However, the instalment of an entrance VMS in the following cases can be omitted.

- In the case the traffic volume in the connecting road between entrance and tollgate with the length below 500m is small (such as less than 2500 vehicles/day), and U-turn is possible
- In the case the automated toll collection in the tollgate is introduced, and the traffic volume is extremely small (such as less than 500 vehicles/day) and U-turn is possible.

(2) Tollgate VMS Arrangement Criteria

In the tollgate, the tollgate VMS is installed on the tollgate. Especially, in the tollgates with high traffic volume, in order to control the traffic crowdedness due to vehicles' U-turn in its neighbouring area, the instalment of a tollgate VMS is indispensable.

(3) Midway VMS Arrangement Criteria

In the case where the interchange interval is comparatively long and the traffic volume in through lane of the expressway is high (such as more than 50000 vehicles/day), the instalment of a midway VMS for the indication of the road/weather/traffic conditions and traffic restrictions of the road ahead is preferable. Especially, the instalment in front of places where Significant Weather and traffic congestion occur frequently is effective.

(4) Junction VMS Arrangement Criteria

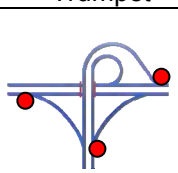
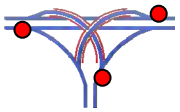
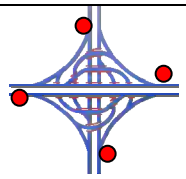
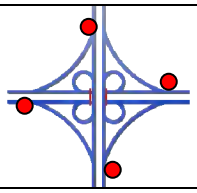
In the place of 750~1000m ahead of junction where a through lane of the expressway diverges, in order to help drivers to choose safe route, a junction VMS for the indication of the road/ weather/traffic conditions and traffic restrictions of the road ahead is installed.

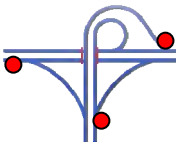
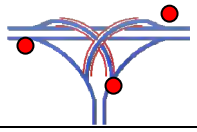
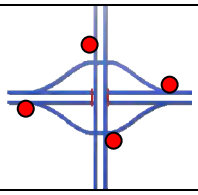
- In the case of divergence into 2 lanes, it is necessary to install 2 VMS corresponding to each lane and to indicate information
- In the case of divergence into 3 lanes, it is necessary to install 3 VMS or 2 VMS corresponding to each lane and indicate information.

(5) Exit VMS Arrangement Criteria

In the exit of the expressway, in order to help vehicles to decelerate and exit safely, from the starting point of added lane for deceleration to the place of 200m ahead of it, an exit VMS is installed. In exit VMS, the indication of road/weather/traffic conditions and traffic restrictions of roads in general, which connect with expressway, is preferable.

Table 19.5 Installation Outlines of VMS at Junction and Interchange

Junction Type	Trumpet	Directional T	Turbine	Cloverleaf
Outlines				
Number of Vehicle Detectors	3	3	4	4

Interchange Type	Trumpet	Directional T	Diamond
Outlines			
Number of Vehicle Detectors	3	3	4

In the case loop type or ultra-sonic type is installed, numbers shown above are multiplied by the number of lanes.

20. Preparation for Stepwise Implementation

The solutions for unification of system architecture, basic concept and actualization methods of traffic information/control are discussed in this volume of the Draft Design Standards. Further solutions are to be referred in other volumes as below.

(1) Establishment of connectability of communication network →Draft Communication System Plan
(2) Establishment of inter-operability of message/data →Draft Message/Data Standards
(3) Establishment of compatibility of equipment components →Draft General Specifications

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