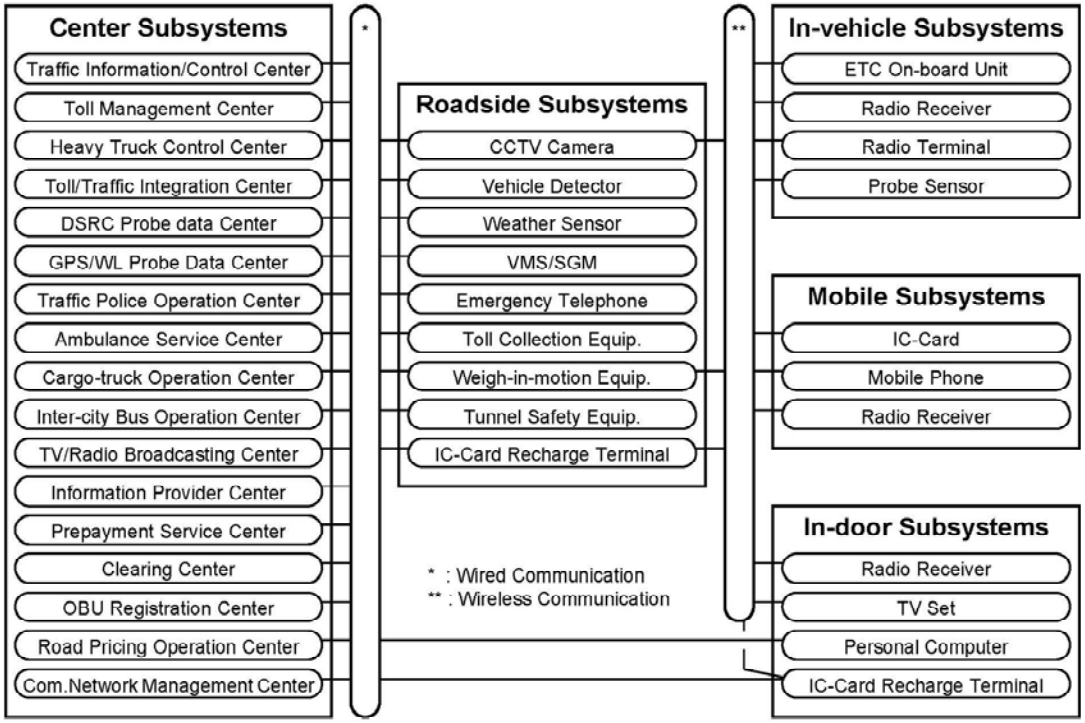
APPENDIX 1
System Architecture for Priority ITS User Services

Appendix 1

System Architecture for Priority ITS User Services

The whole discussion in the Master Plan is premised on the system architecture shown in this appendix, which is proposed for realizing the priority ITS user services on the inter-city road network in Vietnam. The total system architecture of ITS is shown below.

Figure 1 Total System Architecture of ITS



Source: VITRANSS 2 Study Team

The system architecture above is illustrated using only the top-level subsystems indicated by ( ), and that is called as the “Sausage Diagram”. The top-level subsystems are categorized into five groups: centre, roadside, in-vehicle, mobile and in-door, and these are connected through the wired communication and the wireless communication.

The lower-level subsystems are illustrated in the following three kinds of diagrams in this appendix as the detailed system architecture basically according to the notation of UML (Unified Modeling Language).

(a) **Use Case Diagram:** Illustration of the cases to use ITS, which is corresponding to the implementation packages and alternatives discussed in Chapter 5,

(b) **Message Sequence Diagram:** Illustration of the sequence of exchanging messages for realizing the implementation package,

(c) **Collaboration Diagram:** Illustration of the architecture of lower-level subsystems for realizing the implementation package.

The functions and installation of subsystems of the recommended/necessary alternative are summarized in the table attached to the collaboration diagram.

The descriptions/diagrams for each implementation package and alternative are shown in the pages in the table below.

Table 1 Page Table of Descriptions/Diagrams

Implementation Package	Alternatives	Service Requirements	System Descriptions	Service Requirements, Use Case Diagram	Message Sequence Diagram (MSD)	Collaboration Diagram (CD), Equipment & Installation
1. Incident	1-(a): by Monitoring at Roadside	5-2	5-7	A1-3	A1-4	A1-6
Information	1-(b): by Image Recognition		5-8		A1-5	A1-7
2. Traffic	2-(a): by Monitoring at Roadside	5-3	5-9	A1-8	A1-9	A1-14
Congestion	2-(b): by Image Recognition		5-10		A1-10	A1-15
Information	2-(c): by Vehicle Detection		5-11		A1-11	A1-16
	2-(d): by DSRC Probe		5-12		A1-12	A1-17
	2-(e): by GPS/WL Probe		5-13		A1-13	A1-17
3. Travel-time	3-(a): by Image Recognition	5-4	5-14	A1-18	A1-19	A1-23
Information	3-(b): by Vehicle Detection		5-15		A1-20	A1-23
	3-(c): by DSRC Probe		5-16		A1-21	A1-24
	3-(d): by GPS/WL Probe		5-17		A1-22	A1-25
4. Weather Information by Weather Sensors		5-2	5-18	A1-26	A1-27	A1-28
5. Traffic Control	5-(a): by Monitoring at Roadside	5-5	5-19	A1-29	A1-30	A1-35
Assistance	5-(b): by Image Recognition		5-20		A1-31	A1-36
	5-(c): by Vehicle Detection		5-21		A1-32	A1-37
	5-(d): by DSRC Probe		5-22		A1-33	A1-38
	5-(e): by GPS/WL Probe		5-23		A1-34	A1-39
6. Toll Collection	6-(a): by Touch&Go/Manual	5-27	5-30	A1-41	A1-42	A1-47
	6-(b): by ETC at Toll Island (2-piece)		5-31		A1-44	A1-48
	6-(c): by ETC at Toll Island (1-piece)		5-32		A1-45	A1-49
	6-(d): by ETC on Free-flow		5-33		A1-46	A1-50
7. Overloading	7-(a): by Weighing at Parking Space	5-42	5-44	A1-51	A1-52	A1-54
Regulation	7-(b): by Weighing in Motion		5-45		A1-53	A1-54
8. Heavy/HazMat	8-(a): by DSRC Probe	5-42	5-46	A1-56	A1-57	A1-58
Truck Tracking	8-(b): by GPS/WL Probe		5-47		A1-58	A1-59
9. C-to-C Data	9-1: for Incident Notification	5-3	5-24	A1-63	A1-64	A1-68
Exchange	9-2: for DSRC Probe	5-4			A1-64	A1-69
	9-3: for GPS/WL Probe	5-4			A1-65	A1-70
	9-4: for Traffic Information	5-4			A1-65	A1-71
	9-5: for OBU Management	5-28	5-34		A1-66	A1-72
	9-6: for Toll Clearance	5-28			A1-66	A1-73
	9-7: for IC-card Operation	5-28			A1-67	A1-74
	9-8: for Toll Enforcement Assistance	5-28			A1-67	A1-74
	9-9: for Heavy Truck Control	5-43	5-48		A1-68	A1-75

Source: VITRANSS 2 Study Team

A1.1 Incident Information

1) Service Requirements and Use Cases

(1) 1st Stage

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

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

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

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

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

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

(vii) Information update every 15 minutes for dissemination,

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

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

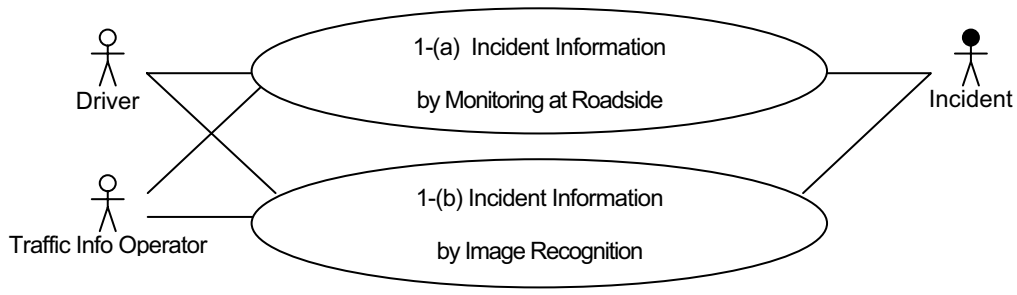
(2) 3rd Stage

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

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

The following five alternative use cases are to be considered in the discussion.

Figure A1.1.1 Use Case Diagram of Incident Information



Source: VITRANSS 2 Study Team

2) Message Sequence Diagram

The message sequence diagram (MSD) of the use cases above are shown in the following pages.

Figure A1.1-(a).MSD Incident Information by Monitoring at Roadside

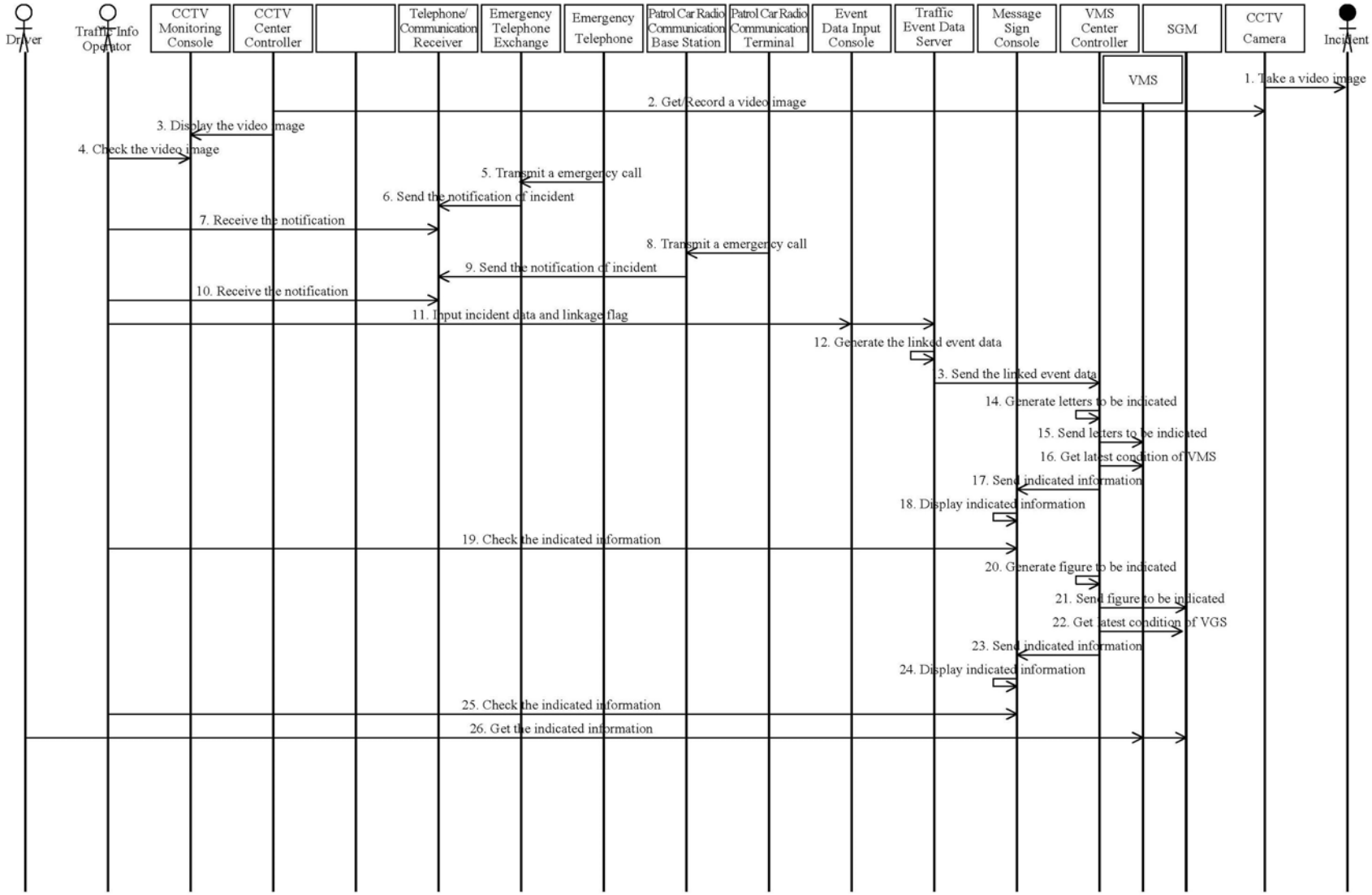
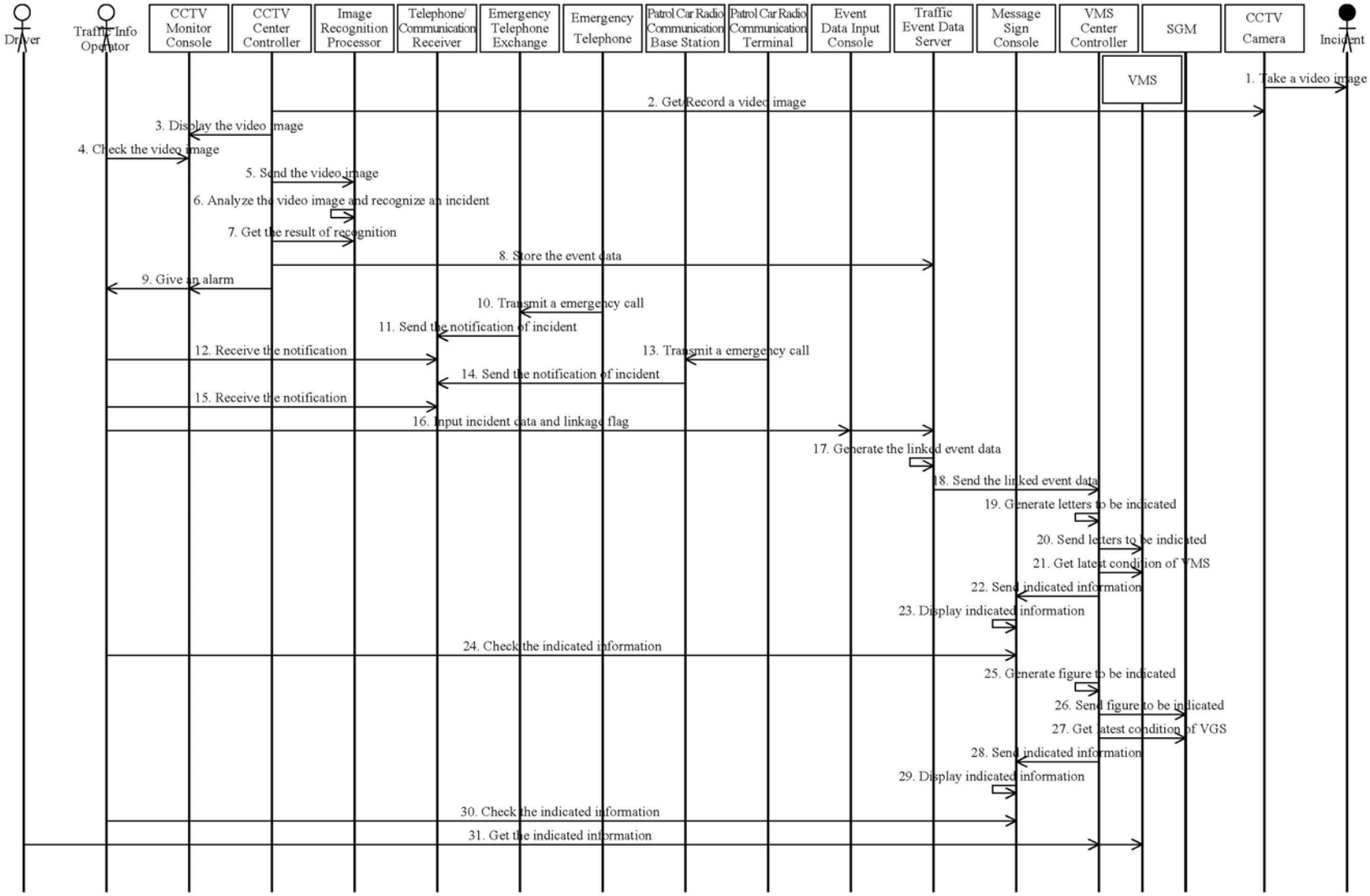


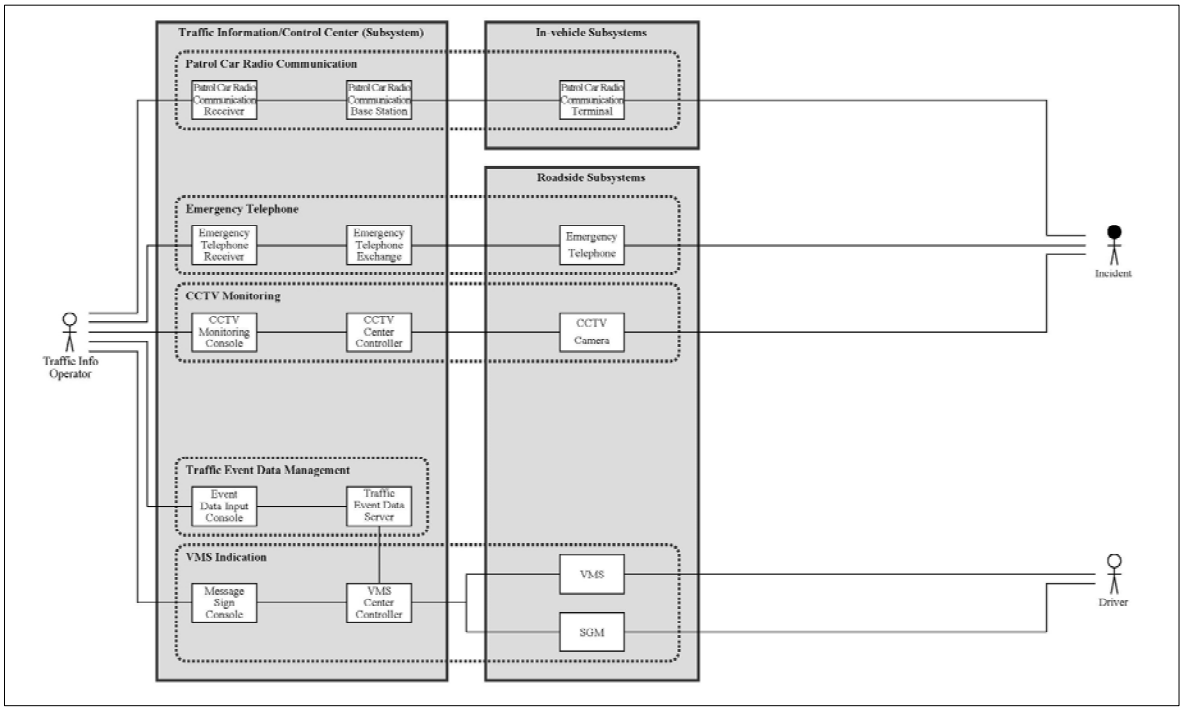
Figure A1.1-(b).MSD Incident Information by Image Recognition



3) Collaboration Diagram with Functions/Installation

The collaboration diagrams (CD) are derived respectively from the message sequence diagrams aforementioned.

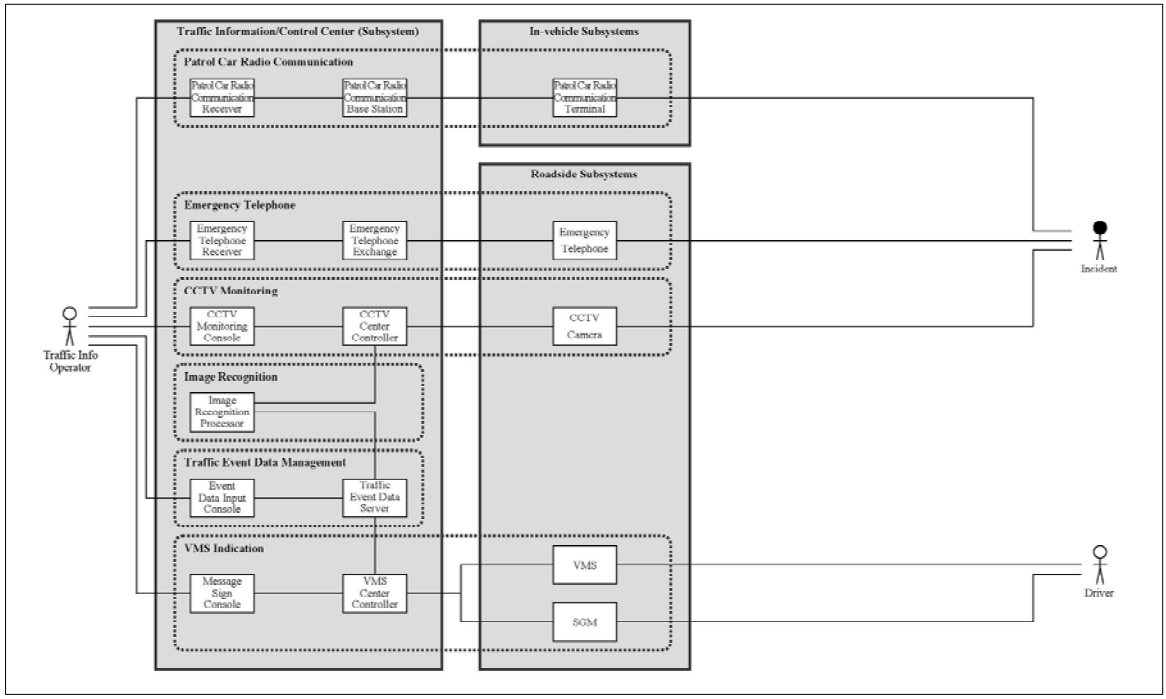
Figure A1.1-(a).CD Incident Information by Monitoring at Roadside (Graded as "Useful as a Complement")



Functions & Installation: 1-(a) by Monitoring at Roadside		
Function	Equipment	Installation
Patrol car radio communication	Receiver	Traffic information/control center **
	Base station	Traffic information/control center **
	Terminal	In-vehicle (1st ~)
Emergency telephone	Console	Traffic information/control center **
	Terminal	Roadside (1st ~ : every 1km, tunnel section)
CCTV monitoring (→ See Table 9.3.1)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	Camera	Roadside (1st ~ : merging section, tunnel section, incident-prone spot, 3rd : every 1km on incident-prone section)
Event data management	Console	Traffic information/control center **
	Computer	Traffic information/control center **
VMS indication (→ See Table 9.3.2)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	VMS	Roadside (1st ~ : short of exit diverging point, entrance point, tollgate, relevant spot))
	SGM	Roadside (3rd : short of junction)

Note, **: Three main centers shall be constructed in the 1st stage (→ See Section 8.4). Management offices shall be implemented every 50–80 km in the 1st–2nd stages keeping pace with the road construction (→ See Figure 8.3.2).

Figure A1.1-(b).CD Incident Information by Image Recognition (Graded as "Recommended")



Functions & Installation: 1-(b) by Image Recognition		
Function	Equipment	Installation
Patrol car radio communication	Receiver	Traffic information/control center **
	Base station	Traffic information/control center **
	Terminal	In-vehicle (1st ~)
Emergency telephone	Console	Traffic information/control center **
	Terminal	Roadside (1st ~ : every 1km, tunnel section)
CCTV monitoring (→ See Table 9.3.1)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	Camera	Roadside (1st ~ : merging section, tunnel section, incident-prone spot, 3rd : every 1km on incident-prone section)
Image recognition	Computer	Traffic information/control center **
Event data management	Console	Traffic information/control center **
	Computer	Traffic information/control center **
VMS indication (→ See Table 9.3.2)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	VMS	Roadside (1st ~ : short of exit diverging point, entrance point, tollgate, relevant spot))
	SGM	Roadside (3rd : short of junction)

Note, **: Three main centers shall be constructed in the 1st stage (→ See Section 8.4). Management offices shall be implemented every 50–80 km in the 1st–2nd stages keeping pace with the road construction (→ See Figure 8.3.2).

A1.2 Traffic Congestion Information

1) Service Requirements and Use Cases

(1) 1st Stage

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

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

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

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

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

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

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

(viii) Information update every 15 minutes for dissemination.

(2) 3rd Stage

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

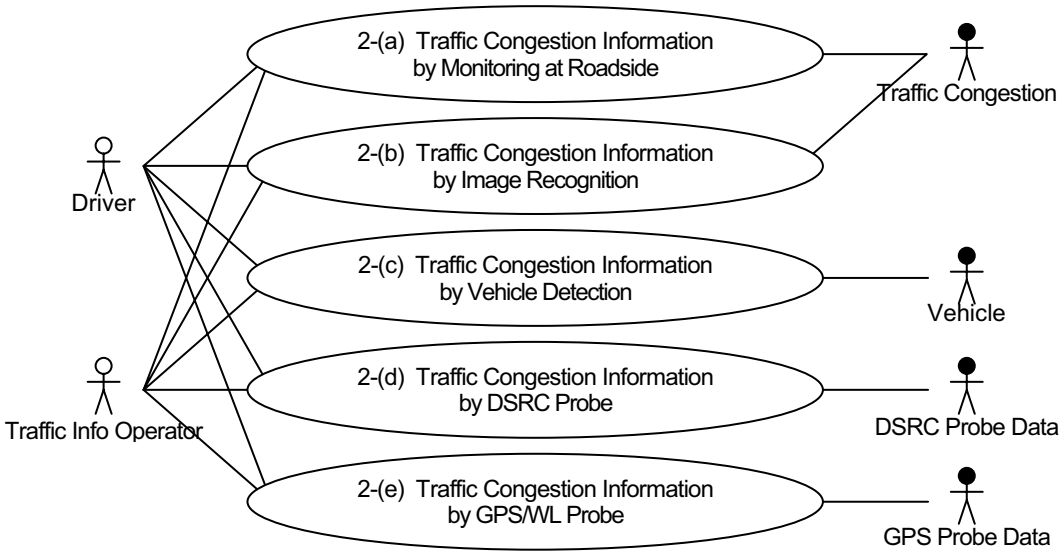
(ii) Analyzing property of traffic, and forecasting the congestions,

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

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

The following five alternative use cases are to be considered in the discussion.

Figure A1.2.1 Use Case Diagram of Traffic Congestion Information



Source: VITRANSS 2 Study Team

2) Message Sequence Diagram

The message sequence diagram (MSD) of the use cases above are shown in the following pages.

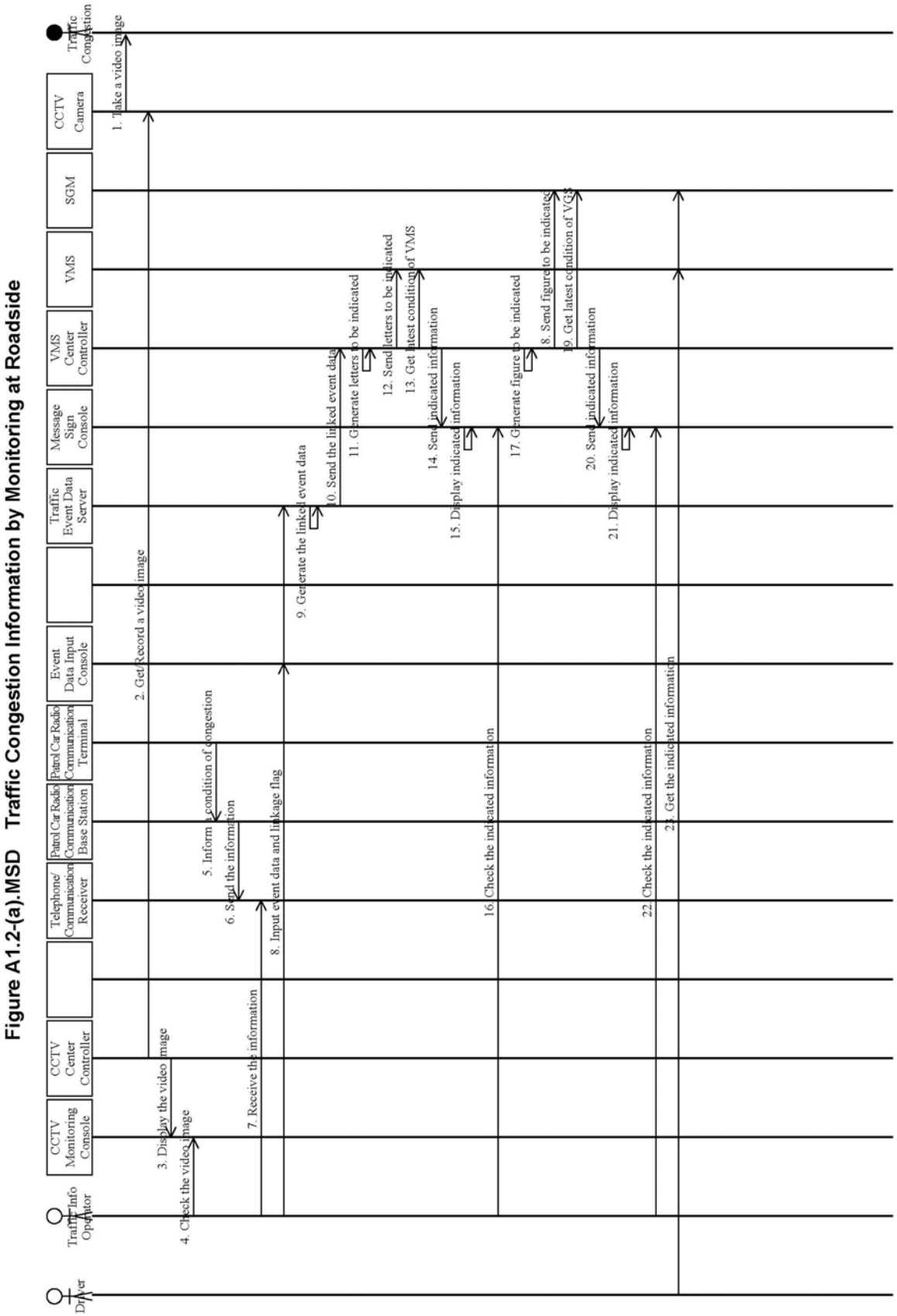


Figure A1.2-(a).MSD Traffic Congestion Information by Monitoring at Roadside

Figure A1.2-(b).MSD Traffic Congestion Information by Image Recognition

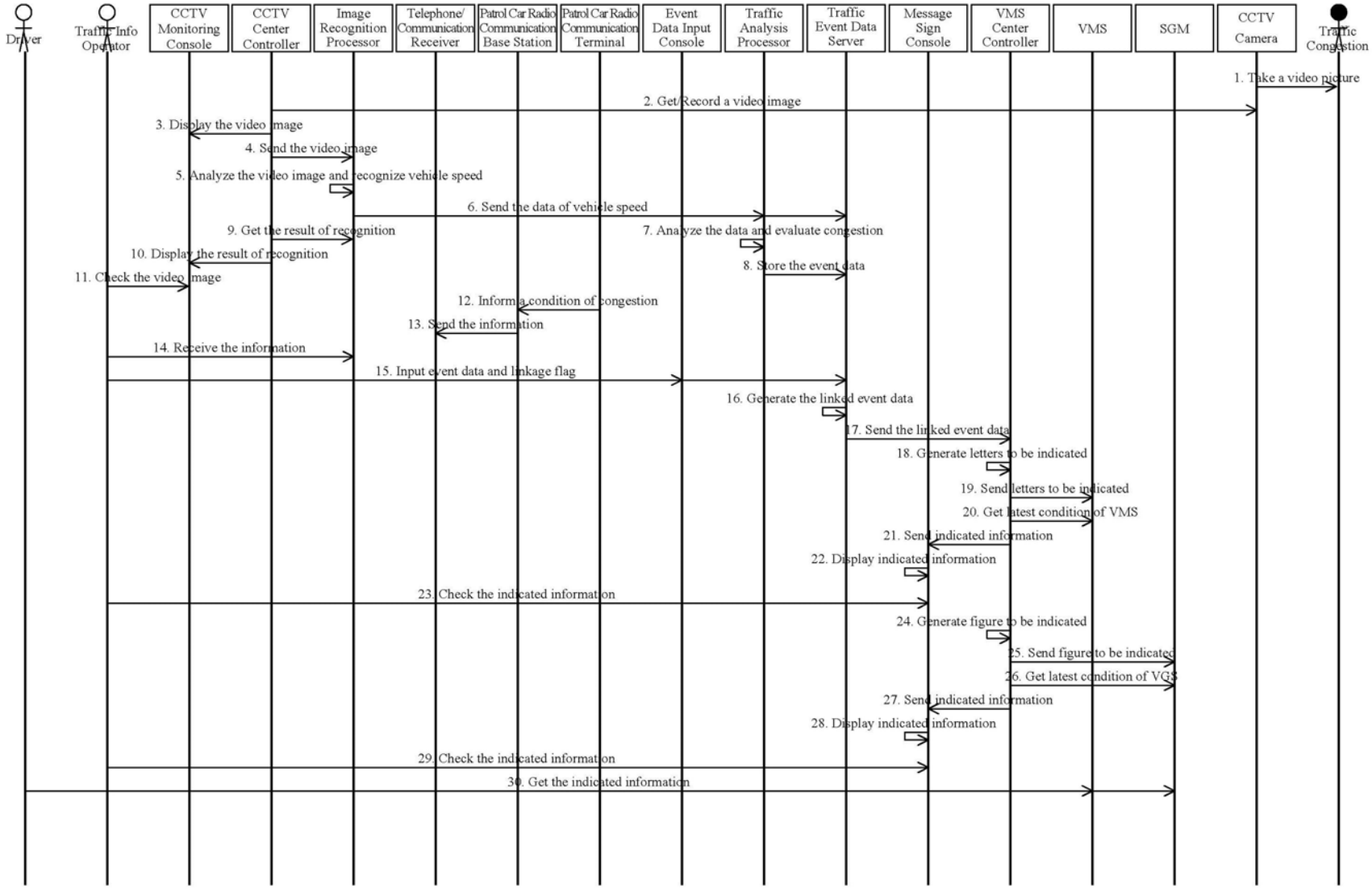


Figure A1.2-(c).MSD Traffic Congestion Information by Vehicle Detection

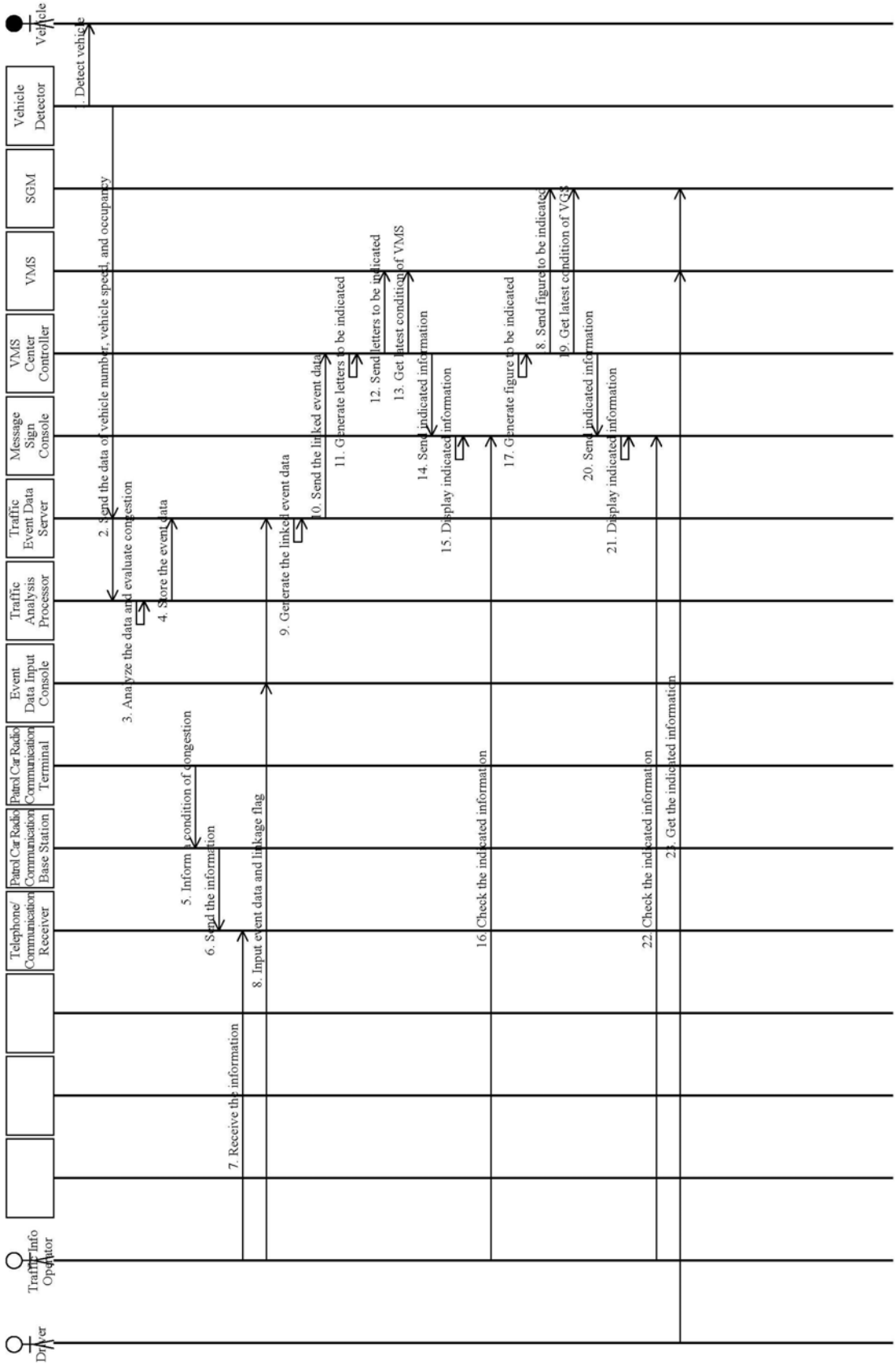


Figure A1.2-(d).MSD Traffic Congestion Information by DSRC Probe

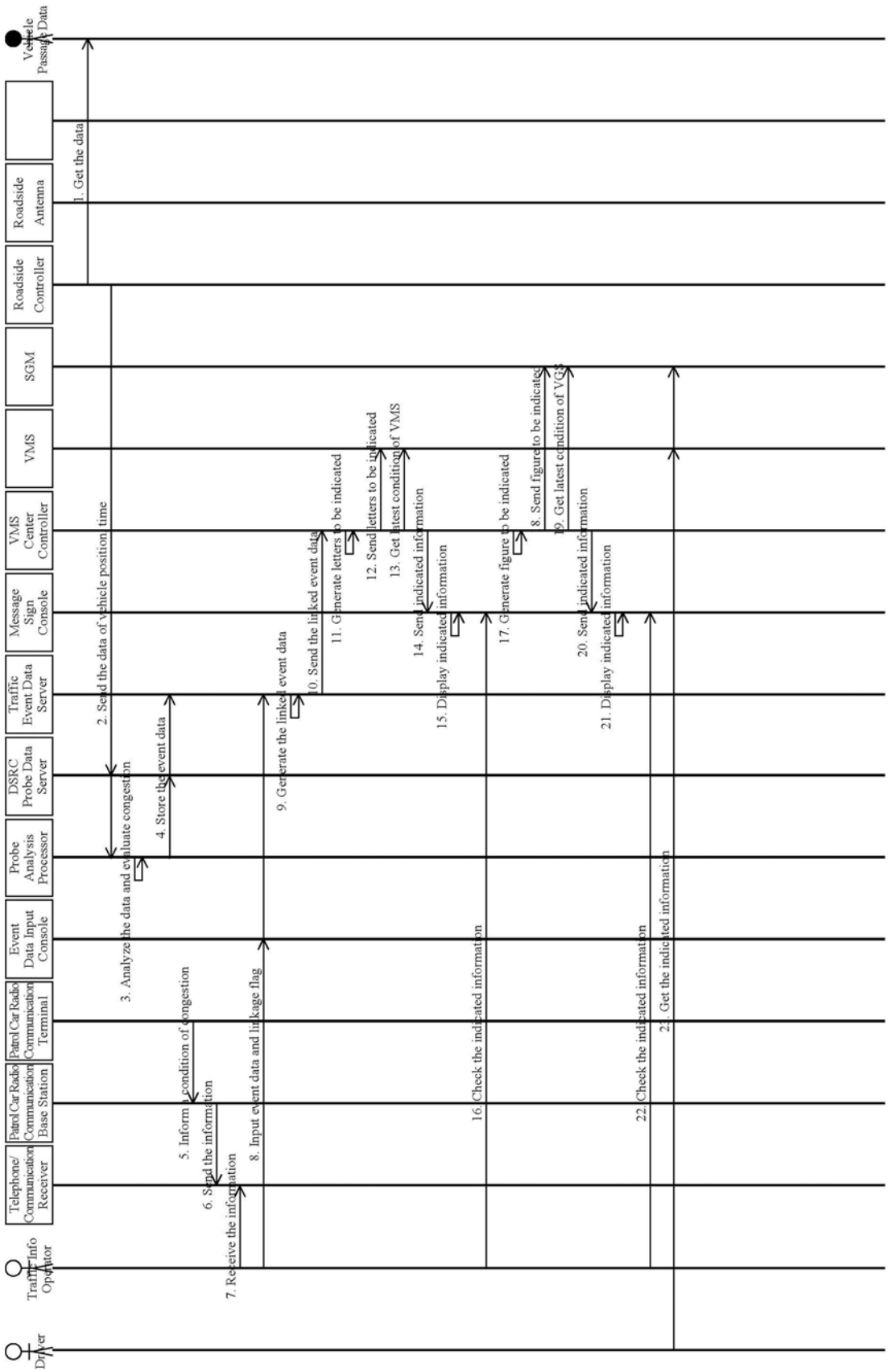
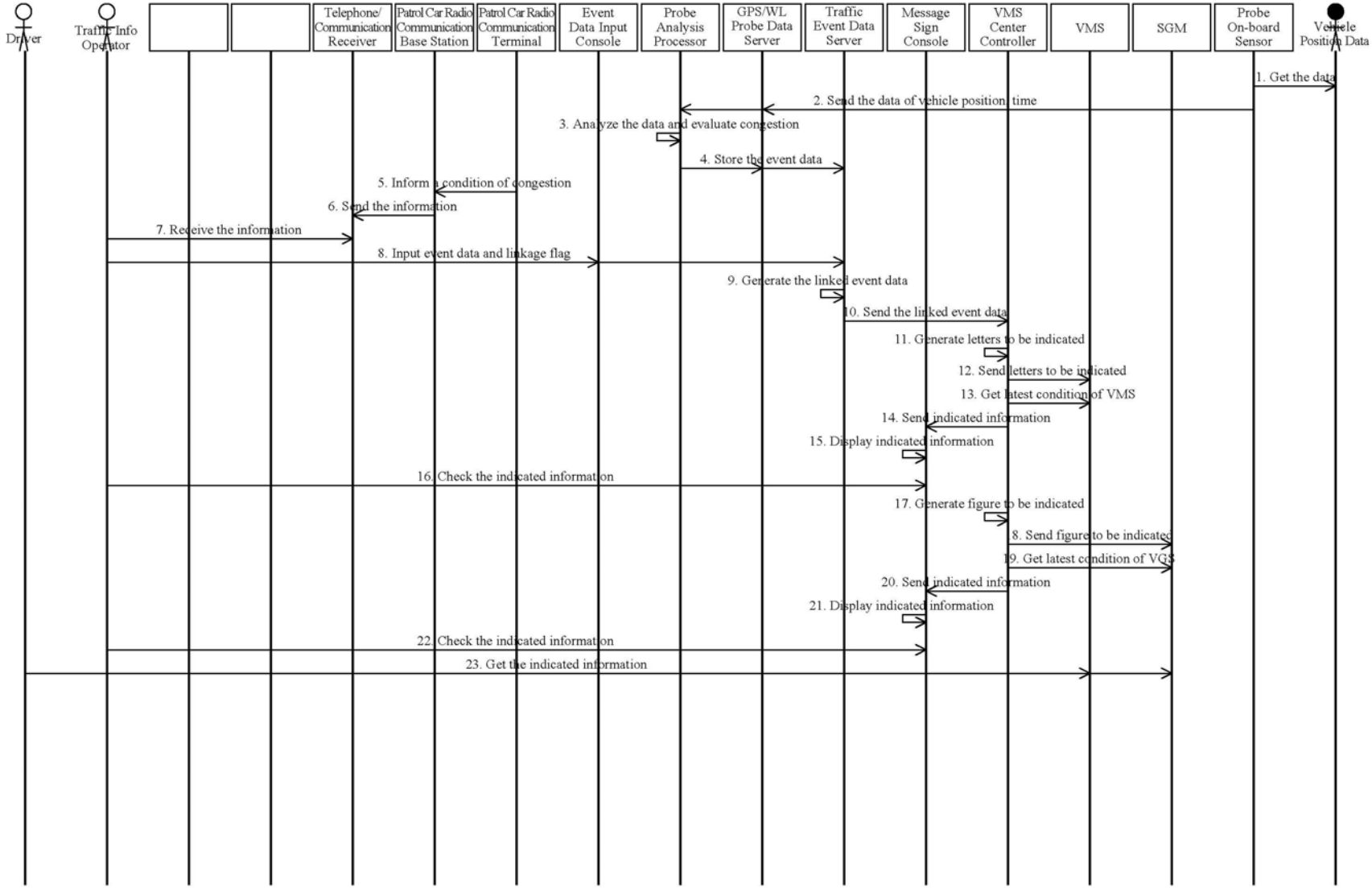


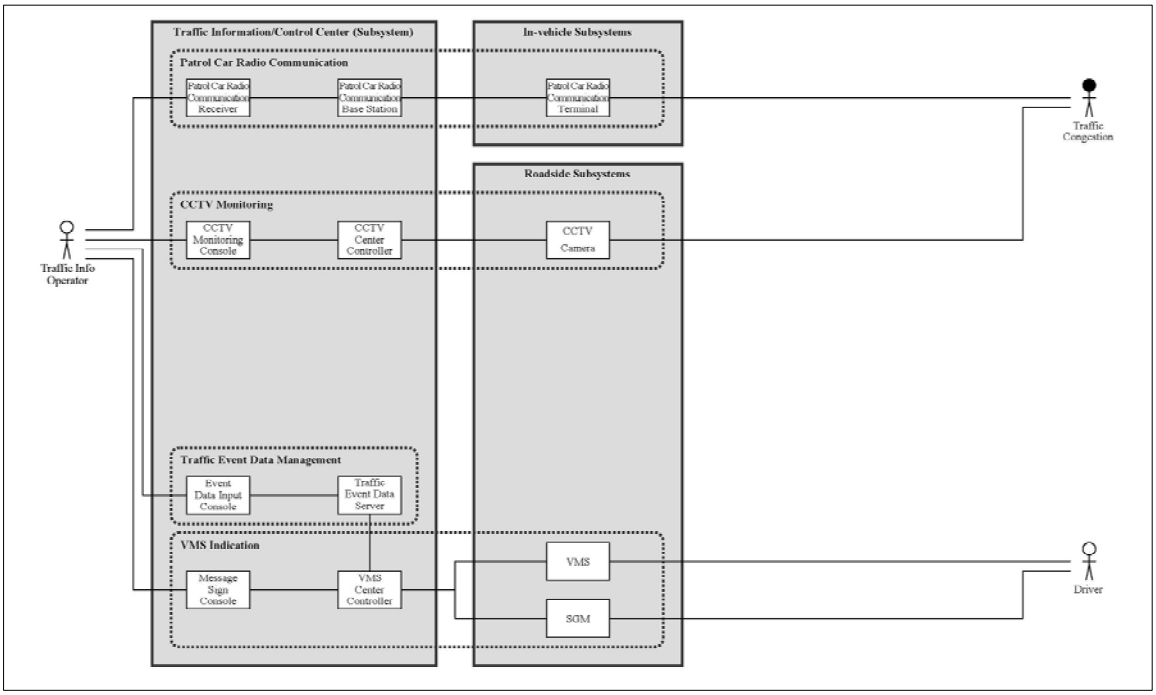
Figure A1.2-(e).MSD Traffic Congestion Information by GPS/WL Probe



3) Collaboration Diagram with Functions/Installation

The collaboration diagrams (CD) are derived respectively from the message sequence diagrams aforementioned.

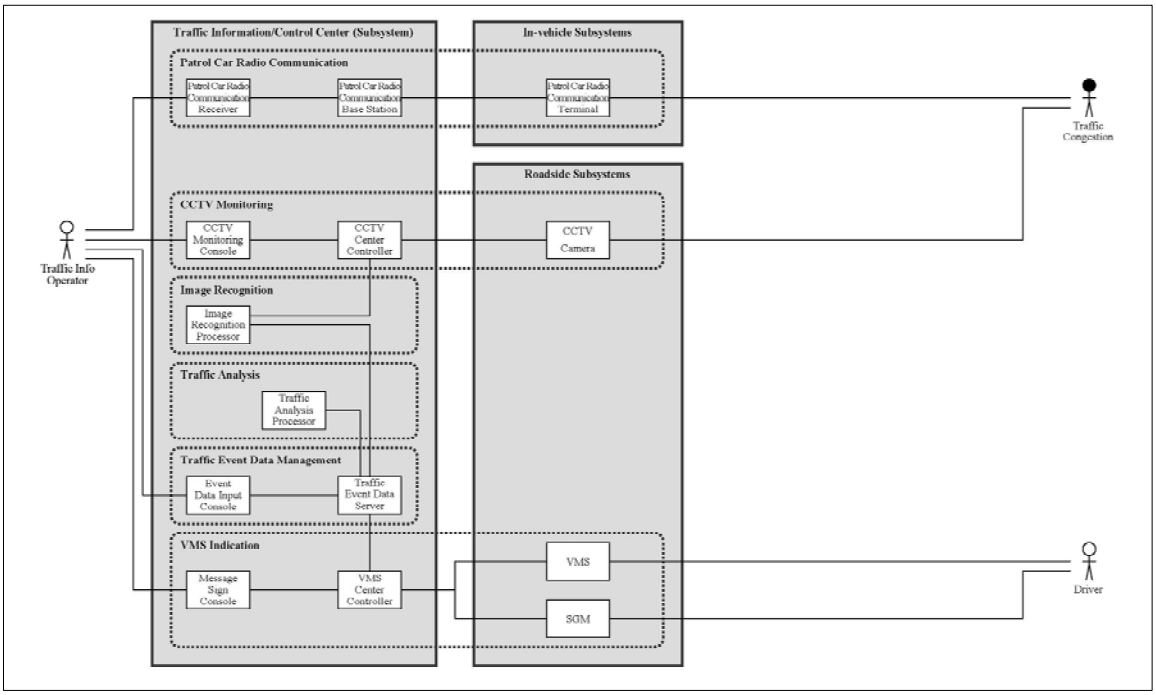
Figure A1.2-(a).CD Traffic Congestion Information by Monitoring at Roadside (Graded as "Useful as a Complement")



Functions & Installation: 2-(a) by Monitoring at Roadside		
Function	Equipment	Installation
Patrol car radio communication	Receiver	Traffic information/control center **
	Base station	Traffic information/control center **
	Terminal	In-vehicle (1st ~)
CCTV monitoring (→ See Table 9.3.1)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	Camera	Roadside (1st ~ : exit diverging section, merging section, congestion-prone spot)
Event data management	Console	Traffic information/control center **
	Computer	Traffic information/control center **
VMS indication (→ See Table 9.3.2)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	VMS	Roadside (1st ~ : short of exit diverging point, entrance point, tollgate, relevant spot))
	SGM	Roadside (3rd : short of junction)

Note, **: Three main centers shall be constructed in the 1st stage (→ See Section 8.4). Management offices shall be implemented every 50–80 km in the 1st–2nd stages keeping pace with the road construction (→ See Figure 8.3.2).

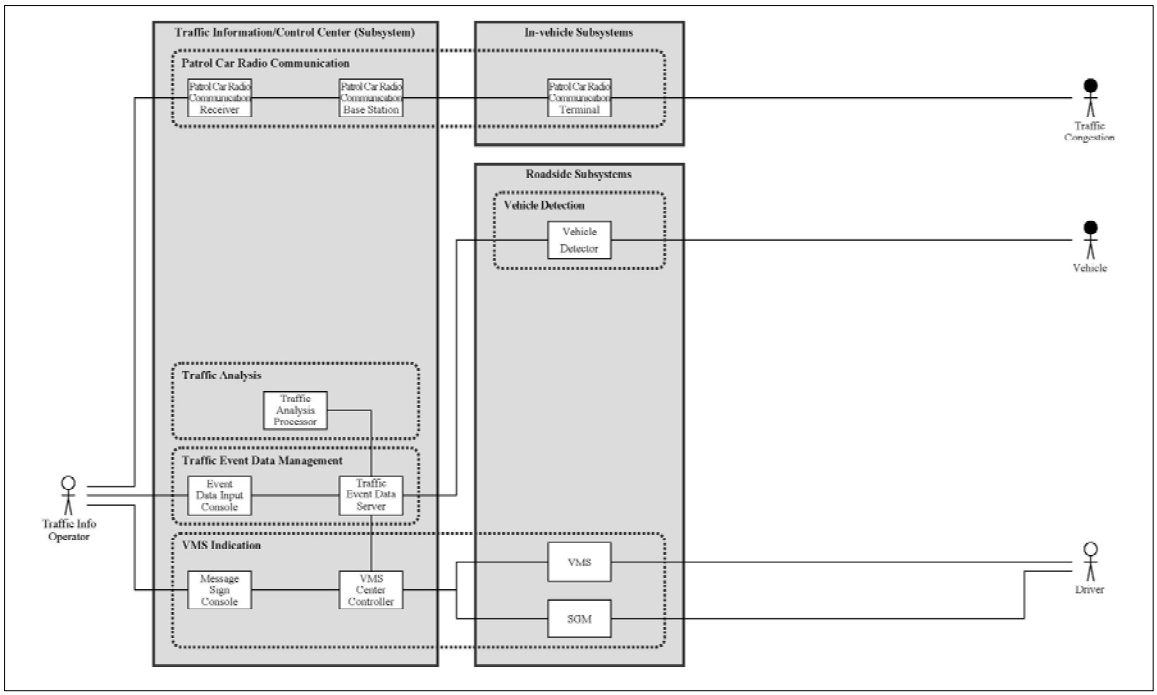
Figure A1.2-(b).CD Traffic Congestion Information by Image Recognition (Graded as "Useful as a Complement")



Functions & Installation: 2-(b) by Image Recognition		
Function	Equipment	Installation
Patrol car radio communication	Receiver	Traffic information/control center **
	Base station	Traffic information/control center **
	Terminal	In-vehicle (1st ~)
CCTV monitoring (→ See Table 9.3.1)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	Camera	Roadside (1st ~ : exit diverging section, merging section, congestion-prone spot)
Image recognition	Computer	Traffic information/control center **
Event data management	Console	Traffic information/control center **
	Computer	Traffic information/control center **
VMS indication (→ See Table 9.3.2)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
		Roadside (1st ~ : short of exit diverging point, entrance point, tollgate, relevant spot))
	VMS	
	SGM	Roadside (3rd : short of junction)

Note, **: Three main centers shall be constructed in the 1st stage (→ See Section 8.4). Management offices shall be implemented every 50–80 km in the 1st–2nd stages keeping pace with the road construction (→ See Figure 8.3.2).

Figure A1.2-(c).CD Traffic Congestion Information by Vehicle Detection (Graded as "Recommended")



Functions & Installation: 2-(c) by Vehicle Detection		
Function	Equipment	Installation
Patrol car radio communication	Receiver	Traffic information/control center **
	Base station	Traffic information/control center **
	Terminal	In-vehicle (1st ~)
Vehicle detection (→ See Table 9.3.1)	Detector	Roadside (1st ~ : exit diverging section, merging section, congestion-prone spot)
Traffic analysis	Computer	Traffic information/control center **
Event data management	Console	Traffic information/control center **
	Computer	Traffic information/control center **
VMS indication (→ See Table 9.3.2)	Console	Traffic information/control center **
	Computer	Traffic information/control center **
	VMS	Roadside (1st ~ : short of exit diverging point, entrance point, tollgate, relevant spot))
	SGM	Roadside (3rd : short of junction)

Note, **: Three main centers shall be constructed in the 1st stage (→ See Section 8.4). Management offices shall be implemented every 50–80 km in the 1st–2nd stages keeping pace with the road construction (→ See Figure 8.3.2).

Figure A1.2-(d).CD Traffic Congestion Information by DSRC Probe (Graded as “Not Suitable”)

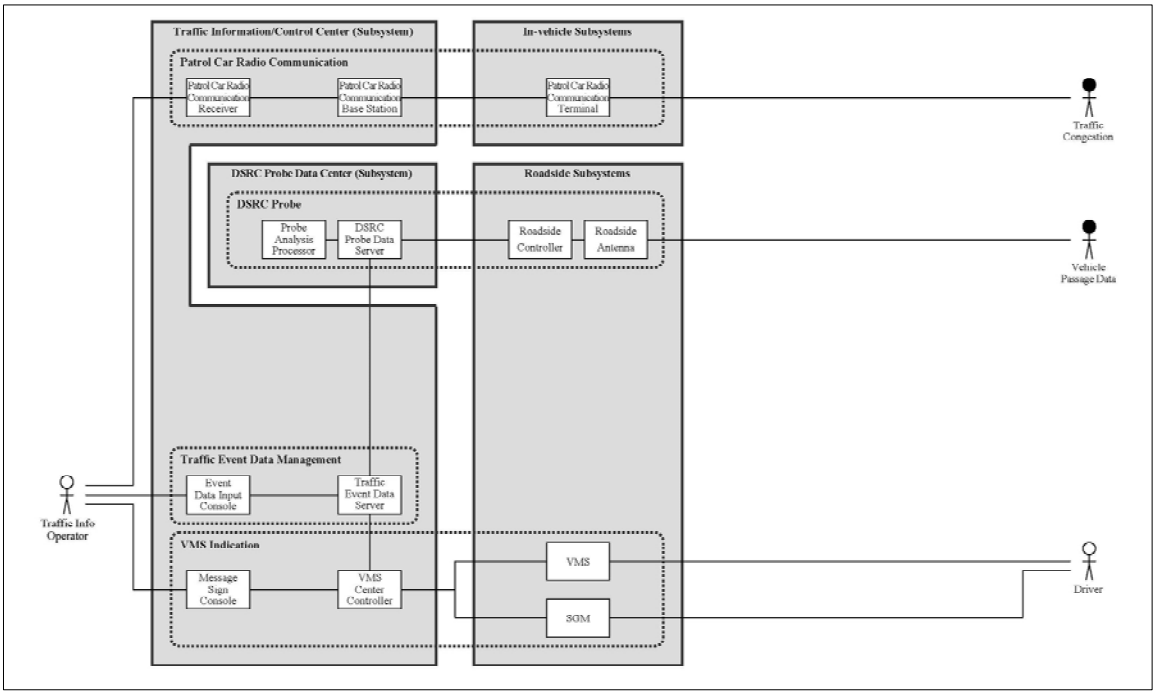


Figure A1.2-(e).CD Traffic Congestion Information by GPS/WL Probe (Graded as “Not Suitable”)