TECHNICAL SPECIFICATION

ISO/TS 15624

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Transport information and control systems — Traffic Impediment Warning Systems (TIWS) — System requirements

Systèmes de commande et d'information des transports — Systèmes d'avertissement des obstacles au trafic (TIWS) — Exigences des systèmes

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Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

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An ISO/PAS or ISO/TS is reviewed every three years with a view to deciding whether it can be transformed into an International Standard.

Attention is drawn to the possibility that some of the elements of this Technical Specification may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 15624 was prepared by Technical Committee ISO/TC 204, *Transport information and control systems*.

Annexes A to J of this Technical Specification are for information only.

Introduction

Once an accident occurs on a highway, the accident and congestion and other hazardous conditions may result in blocking of the lanes. This often leads to a situation where the safety of the traffic flow behind the accident cannot be guaranteed. Conventionally, it could take more than ten minutes before the occurrence of an accident is known, since accidents are generally reported by emergency telephones installed along the road. In the case of minor accidents, drivers usually drive away without reporting the incident. Detection, therefore, is very difficult, and there are cases where damaged facilities often obstruct traffic flow.

The main system function of a Traffic Impediment Warning System (TIWS) is to secure a smooth and safe flow of traffic subsequent to an accident, and can be achieved by: quick detection of an accident, rapid processing of the initial activities surrounding the accident and removal of impediments, dissipating traffic congestion at an early stage, and providing information to following vehicles.

The goal of TIWS is a partial automation of the traffic impediment information collection and provision, and the reduction of the workload of the driver with the aim to support and relieve the driver and the traffic system operator in a convenient manner.

This Technical Specification may be used as a system level standard by other standards, which extends the TIWS to a more detailed standard e.g. for specific sensor concepts or higher level of functionality. So, issues like specific requirements for the sensor function and performance or communication links for cooperative solutions will not be considered in this document.

Transport information and control systems — Traffic Impediment Warning Systems (TIWS) — System requirements

1 Scope

This Technical Specification specifies system requirements for Traffic Impediment Warning Systems (TIWS). The purposes of the warning system are that information collected by the infrastructure is automatically and quickly provided to vehicles and reported to the traffic system operator, so vehicles can avoid secondary accidents. A major function of the system is to save lives by speedier rescue activities and, a quicker clearing up of accident-caused congestion. This Technical Specification focuses on closed circuit television (CCTV) cameras as the sensors, to detect traffic impediments using image processing and variable message signs as the communication method to provide information to drivers.

2 Terms and definitions

For the purposes of this Technical Specification, the following terms and definitions apply.

2.1
Traffic Impediment Warning Systems
TIWS
system that automatically detects traffic impediments by employing sensors, reports occurrences of accidents to a traffic system operator, and provides information on the presence of traffic impediments to following vehicles before the cause is visible to them

NOTE See annex A.

2.2
stopped vehicles
vehicle that has stopped in a traffic lane or on the shoulder of the roadway

2.3
slow moving vehicles
vehicle travelling at or below “A” km/h within a traffic flow

NOTE The value for “A” is to be determined according to the road configuration and speed limit.

2.4
judgement distance
distance travelled by a vehicle until the driver judges what action is to be taken after having received information about a traffic impediment

2.5
reaction distance
distance travelled by a vehicle from the time the driver judged what action to take until the time the brake is applied after having been notified of a traffic impediment

2.6
braking distance
distance the vehicle needs in order to stop after the brakes have been applied

2.7
camera blind spot range
distance from the location where a camera is installed to the beginning of the area over which the camera is able to monitor traffic impediments

NOTE The camera is unable to monitor traffic impediments in this blind area.

2.8
out-of-sight range
distance from the point where a variable message sign becomes no longer readable to the place where the variable message sign is located

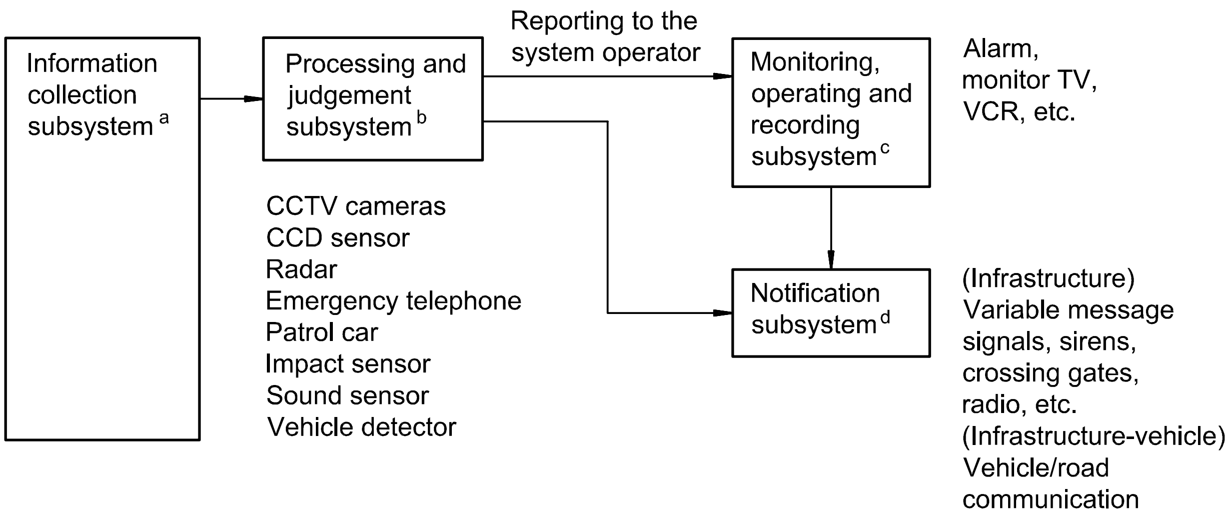
2.9
average spacing
average distance between the front of one vehicle and another in a continuous traffic flow

NOTE This parameter is inversely proportional to the density of traffic.

3 Specifications and requirements

3.1 General specifications

The system configuration should be in accordance with Figure 1.



[a] The information collection subsystems consist of equipment to detect traffic impediments by various sensors installed on, or alongside, a road. This Techical Specification focuses on the detection of traffic impediments from image processing by using CCTV cameras serving as sensors to automatically detect traffic impediments.

[b] The processing and judgement subsystem processes the information detected from a camera, and/or a sequence of cameras, and determines the occurrence of traffic impediments.

[c] The monitoring, operating and recording subsystem notifies the traffic system operator using an alarm or another method when a traffic impediment is detected. The subsystem, using monitor TV, allows the operator to confirm both the situation and the location of the impediment. The operator can then change the information provided to drivers as necessary, record the situation with a VCR, or take action.

[d] The notification subsystem provides information about the traffic impediments to drivers using variable message signs and other means. Alternatively, it can forcibly close roads or prohibit traffic through certain roads.

Figure 1 — System configuration

3.2 Classifications

Table 1 presents a conceptual basis of the system. The table indicates that secondary accidents can be avoided and drivers protected in the future because of the speedy detection and quick provision of information concerning traffic impediments. Current standardization subjects are those indicated by “X” in the table.

NOTE The detection of congestion is not within the range of the systems addressed in this Technical Specification. TIWS should detect stopped vehicles and/or slow moving vehicles at the tail of a congestion queue.

3.3 Objects constituting traffic impediments and detection coverage

3.3.1 Detection objects

3.3.1.1 Level 1: Stopped vehicles and slow moving vehicles, excluding motorcycles

3.3.1.2 Level 2: Level 1 + change in the movement of vehicles performed to avoid some obstacle or hazardous condition that is present

3.3.1.3 Level 3: Level 2 + motorcycles

3.3.1.4 Level 4: Level 3 + other obstacles

NOTE 1 Level 1 is currently being considered as a subject for standardization.

NOTE 2 Limits of the size of detectable obstacles related to Level 4 are not addressed in this Technical Specification.

NOTE 3 Vehicle includes three-wheeled vehicles.

3.3.2 Detection coverage

The detection coverage in transverse directions shall include all traffic lanes and shoulders. The detection coverage in longitudinal directions should be determined according to the sensor instrument performance, detection time, installation height and peripheral environment (see annex D).

Table 1 — System concept for TIWS

Detection systems			Detection objects				
			Level 1	Level 2	Level 3	Level 4	Information providing methods
Infrastructure system	Infrastructure-infrastructure	Class 1 [a]	X				Variable message sign
		Class 2 [b]	X				Variable
Cooperative system	Infrastructure-vehicle	Class 3 [c]					Beacon, leakage coaxial cable, variable message, sign, radio

NOTE Levels are defined in 3.3.

[a] Necessary traffic information that has been collected by the infrastructure and reported to the traffic system operator is provided to the travellers via variable message signs.

[b] Information collected by the infrastructure is automatically provided to equipment (i.e. variable message signs) which are installed in the infrastructure to improve the safe traffic flow of following vehicles. The information is also reported to the traffic system operator.

[c] Information collected by the infrastructure is automatically provided to devices installed in a vehicle (i.e. radio, navigation display) by various communication methods (i.e. beacon, leakage coaxial cable), to avoid secondary accidents. The information is also reported to the traffic system operator.

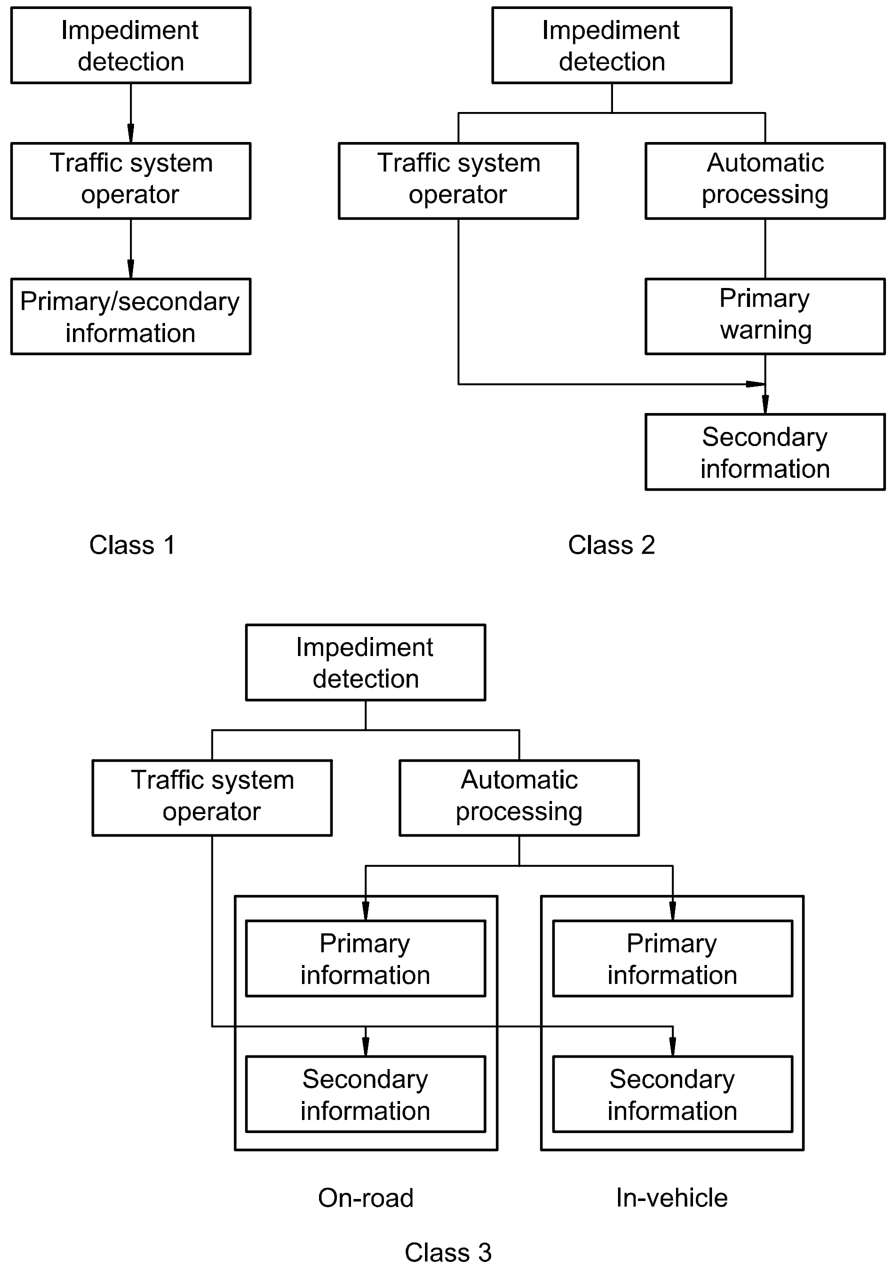


Figure 2 — Information providing flow with each class

3.4 Types of sensors

Various types of sensors are considered for use as shown in Figure 1. However, this Technical Specification focuses on CCTV cameras that are used for image processing.

3.5 Provision of information

3.5.1 Required functions for providing information

3.5.1.1 Provision of information to drivers

The system has many ways, as shown in Figure 2, to provide drivers with information, however, this Technical Specification focuses on variable message signs as the methods of provision.

3.5.1.2 Reporting to the traffic system operator

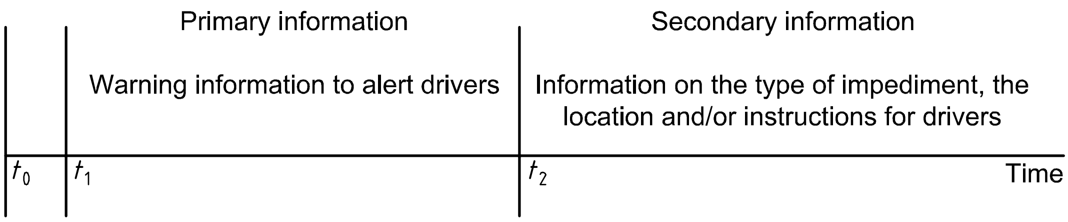
The occurrence of a traffic impediment shall be reported to the traffic system operator, who should be able to monitor the CCTV screen to confirm the impediment.

3.5.2 Event detection

The system detects stopped, or slow moving vehicles.

3.5.3 Levels of information

The system provides two levels of information, primary, and secondary information. The timing and levels of information are shown in Figure 3 (see annexes E and F).



t_0 time when the event occurred

t_1 time when the stopped vehicles or slow moving vehicles were detected

t_2 time when the traffic system operator confirmed the type of event, condition, location of the occurrence and any response action

Figure 3 — Levels of information

3.5.4 Types of information

Types of information can be classified as follows.

1) **Instructions for action:** Stop, limit speed, change lane.

2) **Attention:** Warning of a collision or a hazardous condition ahead.

3) **Explanation of present situation:** Type of impediment, route, location, traffic lane affected, any response, or traffic control actions.

4) **Forecast of situation:** Forecast of travel time, time estimated to clear the impediment.

The types of information provided for each level are shown in Table 2.

3.5.5 Out-of-order indication

In case of system failure, words or a readily recognizable symbol shall be used to indicate that the system is not able to provide traffic information.

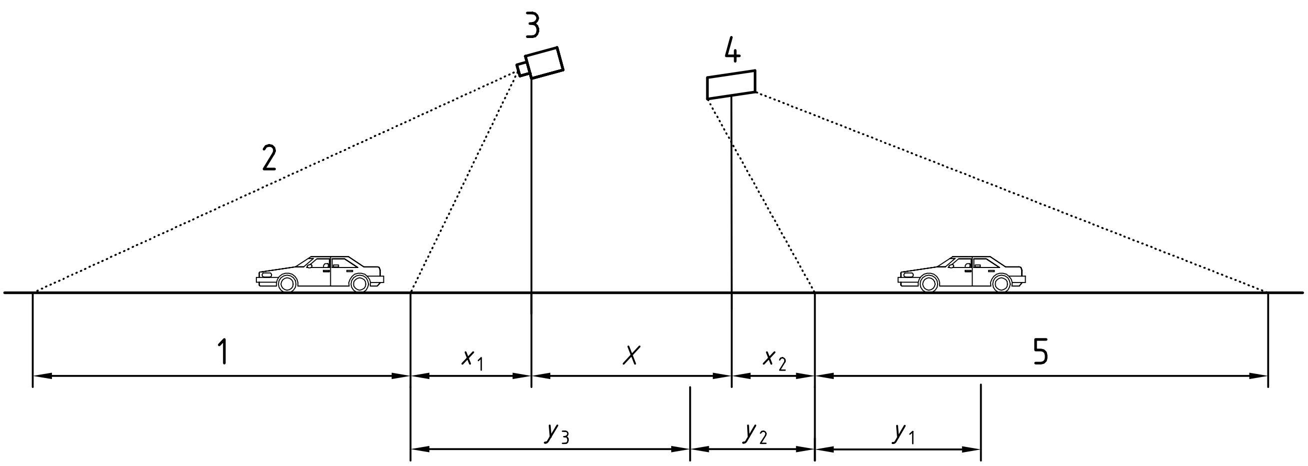
Table 2 — Levels and types of information

Information types	Message types	Message examples	Levels of information	
			Primary	Secondary
Instruction	Speed instruction	Stop, slow down, …		X
	Route changing instruction	Use alternative route		X
	Lane changing instruction	Use right lane, left lane closed, …		X
Attention	Caution for a rear-end collision	Stopped traffic ahead, slow moving traffic ahead,	X	X
	Caution to the hazardous condition ahead	Spilled load ahead, accident ahead		X
Explanation of present situation	Route of occurrence	Southbound Route 12 closed, …		X
	Location of occurrence	Accident 250 m ahead …		X
	Traffic lane of occurrence	One lane blocked, …		X
	Location of end of congestion queue	End of congestion queue, ahead		X
	Traffic control	Left lane closed, …		X
Forecast of situation	Forecast of travel time	About 20 min to XX, 30 min delay, …		X
	Estimated time of response action	Closed for 1 h,		X

3.6 Range of information provision to drivers

3.6.1 Locations for providing information

The locations where variable message signs are installed relative to the camera position, are as shown in Figure 4.



Key

1 Monitoring area
2 Occurrence of traffic impediment
3 CCTV camera
4 Variable message sign
5 Message sign recognition distance

X variable message sign installation interval
x_1 camera blind spot distance
x_2 out-of-sight distance
y_1 judgement distance
y_2 reaction distance
y_3 braking distance

Figure 4 — Locations where variable message signs are installed relative to camera position

The variable message sign should be installed a sufficient distance upstream from the CCTV camera so a vehicle can stop before reaching a traffic impediment after having received information about it (see annex G).

The minimum value of the distance, X, between the variable message sign and the CCTV camera is given by the following equation:

$$X = (y_2 + y_3) - (x_1 + x_2) \quad (1)$$

where

x_1 is the camera blind spot distance;

x_2 is the out-of-sight distance;

X is the variable message sign installation interval;

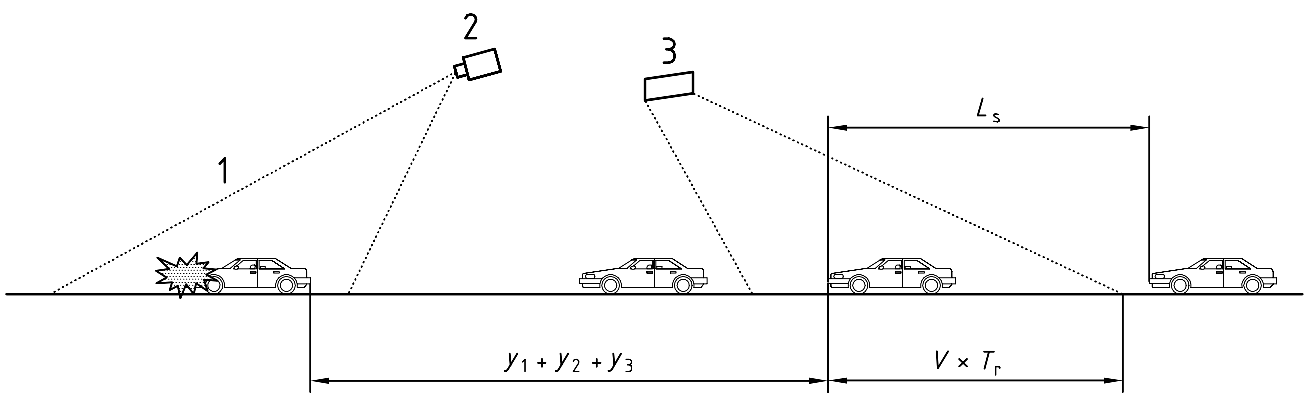
y_2 is the reaction distance;

y_3 is the braking distance.

During actual operation, it would be desirable to alert drivers as early as possible by using additional information equipment further upstream from the location of the variable message sign required by the above equation.

3.6.2 System reaction time (time from the occurrence of a traffic impediment until information is provided), T_r

The system reaction time should be minimized, so when a traffic impediment occurs, the number of vehicles that are unable to acquire necessary information is minimized. See Figure 5.



Key

1 Occurrence of traffic impediment

2 CCTV camera

3 Variable message sign

L_s average vehicle spacing

T_r system reaction time

V velocity of traffic flow

Figure 5 — Image of system reaction time in terms of distance

The following relationship exists for the number of vehicles, n, that are unable to acquire traffic impediment information (see annex H), if vehicles flow at the constant average spacing L_S.

$$n = (y_1 + y_2 + y_3 + V \times T_r) / L_S \qquad (2)$$

thus,

$$T_r = \{n \times L_S - (y_1 + y_2 + y_3)\} / V \qquad (3)$$

where

n is the number of vehicles unable to acquire traffic impediment information (vehicles/lane);

T_r is the system reaction time;

V is the velocity of traffic flow.

3.7 CCTV camera installation interval

Detection response time would be short at the point of a camera installed with a short interval, and long at the point of a camera installed with a long interval, therefore providing information delay time would depend upon the intervals of camera installation.

Quick detection response time should be requested at such poor visibility points as sharp curves, or in-tunnels, and proper detection response time should be requested at good visibility points on straight roads.

CCTV installation interval should be defined by the concept that information provision delay time would be relative to the location of information provision and monitoring area/points which would be specified according to CCTV installation conditions and the road configuration (see annex I).

4 System testing method

A system test should be composed of the system performance test and system function test (see annex J).

4.1 System performance test

The system performance test should be included with object detection test, range detection test, detection response test, detection accuracy test. This performance test should be conducted using some digitizing video data of the traffic scene, under normal and various impediment conditions, and/or a specified test scenario. Each test method should be defined by the specified conditions of CCTV installation conditions, and road configuration. This test may be conducted as a field test that has a test term of some months to estimate the detection accuracy rate, false alarm rate and other items.

4.2 System function test

The system function test should require that the system detect traffic impediments and provide information to drivers via variable message signs, and provide an alarm to the system operator including the monitoring, operating and recording subsystem and notification subsystem. The system function test should be defined by the system configuration and components.

A function to monitor the brightness level of the optical path and an out-of-order of CCTV using the image processing system and on-line health monitoring function may be required as an additional function.

Annex A
(informative)

Incidents of traffic impediment events

A.1 Event characteristics

In order to clarify the events in the objects of the system, events relating to drivers are arranged according to their characteristics (range of occurrence frequency of occurrence possibility of estimation, and impact and emergency for traffic flow; see Table A.2).

A.1.1 Definition of event characteristic

A.1.1.1 Range in which event occurred

It represents the geographical range of events that occurred at the same time. It classifies into two categories, one occurs in a local place, such as an accident, or fire, and the other occurs over a wide area, such as an earthquake.

A.1.1.2 Frequency of occurrence

It represents the frequency of events that occurred at a certain place. It can be classified into two categories, one that occurred suddenly, such as an unexpected accident or fire, and the other occurs repeatedly. Traffic congestion belongs to this category.

A.1.1.3 Possibility of estimation

It represents an event or occurrence that can be estimated from other factors. It has two possibilities, one is a predictable event which includes rain, snow, etc., and the other is an unpredictable event which includes an accident or fire.

A.1.1.4 Impact on traffic flow

It represents the degree of impact on the traffic flow due to the occurrence of an event. It can be classified into two degrees, one is a big impact, such as an event for closing off traffic due to a landslide, and the other is a small impact due to bad weather.

A.1.1.5 Correspondence of emergency

It represents the level of emergency to process the event that occurred. It has two levels of emergency, one is a high level to process the emergency, an accident or fire belongs to this level, and the other is low level to process. For instance, an emergency due to rain belongs to this processing level.

A.1.2 Selection of events from the objects

Events of traffic impediments among the objects in this system have the following characteristics:

- range of event occurrence is local;
- frequency of occurrence is sudden;
- possibility of estimation is unpredictable;

— impact on traffic flow is large;

— correspondence of emergency is high.

The events of characteristics described as above are shown in Table A.1.

Table A.1 — Events of traffic impediment in the objects

Classification of event	Contents of events
Sudden events	Accident, vehicle fire, shoulder fire, roadside fire, covering water Subsidence, collapse, fallen log, landslide, snowslide, road obstacles slow moving vehicle, fault vehicle
Congestion	Tail of congestion
Road maintenance	Slow moving vehicles at work area

Table A.2 — Arrangement of characteristics and events

Event		**Event characteristic**										
Classification	**Contents**	**Range of occurrence**		**Frequency of occurrence**		**Possibility of estimation**		**Impact of traffic**		**Correspondence of emergency**		**Objective**
		Local	Wide	Sudden	Repeated	Predictable	Unpredictable	Small	Big	High	Low	Event
Sudden occurrence of events	Accident	X		X	X	X		X	X	X		X
	Vehicle fire	X		X		X		X		X		X
	Shoulder fire	X		X		X		X		X		X
	Covering water	X		X		X		X		X		X
	Subsidence	X		X		X		X		X		X
	Collapse	X		X		X		X		X		X
	Fallen log	X		X		X		X		X		X
	High wave	X		X		X		X		X		X
	Landslide	X		X		X		X		X		X
	Snowslide	X		X		X		X		X		X
	Earthquake		X	X		X		X		X		X
	Road obstacles	X		X		X		X	X	X		X
	Slow moving vehicle	X		X		X		X	X	X	X	X
	Fault vehicle	X		X		X		X	X	X	X	X
Construction	Construction	X			X		X	X	X		X	
Weather	Rain		X		X		X		X		X	
	Snow		X		X		X	X			X	
	Blizzard		X		X	X	X	X			X	
	Fog		X		X		X	X			X	
	Strong wind		X		X	X	X	X	X		X	
Road condition	Humidity (wet)		X		X		X		X		X	
	Slippery		X		X	X	X	X			X	
	Icy		X		X		X	X			X	
	Packed snow		X		X		X	X			X	
Congestion	Congestion		X		X	X		X		X	X	
	Tail of congestion	X		X		X		X		X		X
Road maintenance	Slow moving vehicle at worksite	X		X		X	X	X	X	X	X	X
	Working on roadway	X		X			X		X		X	

Annex B
(informative)

Issues to be addressed and not addressed

B.1 Classification of issues

Table B.1 separates issues that are to be addressed as subjects of standardization and those that are not to be addressed. Reasons for not addressing the issues in column two are provided in clause B.2.

Table B.1 — Issues to be addressed and not addressed

Issues to be addressed	Issues not to be addressed
Classification	Means of communication
Detection objects	Detection accuracy
Detection range	
Types of sensors	
Detection response time	
Installation locations for providing information	
Test method	

B.2 Issues not to be addressed

B.2.1 Means of communication

The information collection and provision technologies, including the communication methods for road-vehicle and vehicle-vehicle communication are being developed. New sensor and communication technology can be expected to be developed; therefore standardization at this time would be premature.

B.2.2 Detection accuracy

Traffic flows change over time depending on road structure, road configuration, amount of traffic, weather conditions, etc. No single test method exists that comprehensively includes all these complex elements, especially the types of sensors, detection time and detection accuracy. These are issues which should be considered in the future.

Annex C
(informative)

Place for introducing a system

C.1 Needs of a driver and system operator

C.1.1 Needs of a driver

The following three needs represent those of a driver:

a) Need to know what events have happened up ahead:

— It is difficult to detect what events have happened in a tunnel, on a sharp curve, or at the crest of roadway.

— System is also available even in bad visibility, such as in a thick fog or at night.

b) Need to reduce a secondary disaster into minimum damage:

— It is difficult to avoid a secondary disaster at closed sections, such as a tunnel. Event can even be found at downhill slopes, wet road surfaces, icy roads and fallen snow, but they are rather difficult to avoid.

c) Need to provide forward information of traffic impediment at the front of a junction:

— Following vehicles need to be conducted to take an optimal route by providing advance information about a traffic impediment at the route selection point of a junction.

C.1.2 Need of a system operator

The following need represents that of a system operator. Because all needs requested at the occurrence of a traffic impediment are the needs of a system operator, discussion of establishing a place for introducing a system will not be considered here.

— Processing event quickly and keeping traffic flowing smoothly when events occur are necessary.

C.2 Establishing a place for introducing a system

The result of discussing places of introducing a system from road configuration and traffic circumstance based on system needs is shown in Table C.1.

Table C.1 — Places for introducing, and needs of a system

Needs of system	Places for introducing the system																			
	Road structure														Road traffic circumstances					
	Straight section					Curve		Tunnel	Bridge	Junction port			Toll gate		Abnormal weather area			Unusual road surface area		
	Flat	Up	Down	Sag	Crest	Dull	Sharp			Merging point	Diverging point	Junction	Interchange	Mainline TB	Heavy rain	Thick fog area	Fallen snow area	Wet area	Freezing area	Fallen snow area
a) Need for the driver to know what events have happened up ahead.					X		X	X							X	X	X			
b) Need to reduce secondary disasters and minimize damage at a location easily to the extending secondary disaster.			X					X										X	X	X
c) Need to provide advance information of a traffic impediment at the front of a junction.											X	X								

Annex D
(informative)

Specific example of CCTV camera monitoring range

D.1 Affecting factors

Examples of factors that affect the monitoring range of CCTV cameras are indicated below.

D.1.1 Sensor instrument performance

— Camera specifications (focal distance)

— Sensor detection time

D.1.2 Camera installation height

— 3,5 m, 6,5 m, etc.

D.1.3 Peripheral environment

— Weather (clear, cloudy, raining, fog, etc.)

— Day or night

— Road structure (lighted areas, in a tunnel, etc.)

— Lens soiling

D.2 Example of an actual system

An example of the performance of a system currently in operation is shown in Table D.1.

Table D.1 — Example of the performance of an actual system

Detection objects	Camera installation height m	Range of camera m	Sensor detection time s	Location of system introduced
Stopped vehicle	10	20 to 150	2,0	Open air
	5,5	20 to 120	2,0	Tunnel
	3,5	20 to 170	2,0	Tunnel
	6,5	20 to 90	2,0	Sharp curve
Slow moving vehicle	5,5	20 to 70	0,2	Tunnel
	3,5	20 to 70	0,2	Tunnel

Annex E
(informative)

Symbols

The examples of symbols given in this annex signify that a traffic impediment has occurred and drivers should take action to avoid rear-end collisions.

E.1 Primary information:

Figure E.1 shows examples of symbols for primary information. The “!” symbol should be used with either a triangular- or diamond-shaped sign.

Figure E.1 — Examples of symbols for primary information

E.2 Secondary information:

Figure E.2 shows examples of symbols that signify blocked lanes, lane change advisories, and general congestion, respectively. Additional information about the emergency lanes should be words and/or additional symbols.

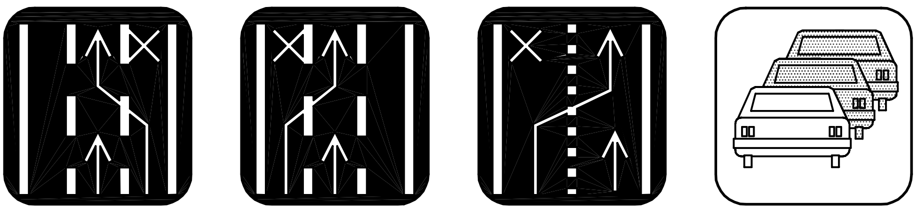


Figure E.2 — Examples of symbols for secondary information

Annex F
(informative)

Example for providing contents of information

Concrete contents of providing information for Level 1 of traffic impediments are shown in Table F.1. Contents of providing information may differ from establishing places to introduce a system in accordance with annex C.

Table F.1 — Example for providing contents of information

Providing level of information	Type of event	Providing contents of information	Example
Primary information	Stopped vehicles	Types of impediment, speed instruction	Stopped vehicles ahead, slow down
	Slow vehicles	Types of impediment, speed instruction	Slow moving vehicles ahead, slow down
Secondary information	Accident (fully blocked traffic lane)	Types of impediment, location occurrence, traffic lane occurrence, processing situation, stop instruction	Accident xx m ahead, slow down
	Accident (partially blocked traffic lane)	Types of impediment, location occurrence, traffic lane occurrence, processing situation, speed instruction on lane-change instruction	Accident left lane xx m ahead, slow down
	Fault vehicles	Types of impediment, location occurrence, traffic lane occurrence, processing situation, speed instruction on lane-change instruction	Stopped vehicles xx m ahead, slow down
	Slow moving vehicles	Types of impediment, location occurrence, traffic lane occurrence, processing situation, caution about collision	Slow moving vehicles left lane xx m ahead, caution
	End of congestion	Types of impediment, location occurrence, traffic lane occurrence, processing situation, speed instruction or caution about collision	End of congestion, xx m ahead, slow down.

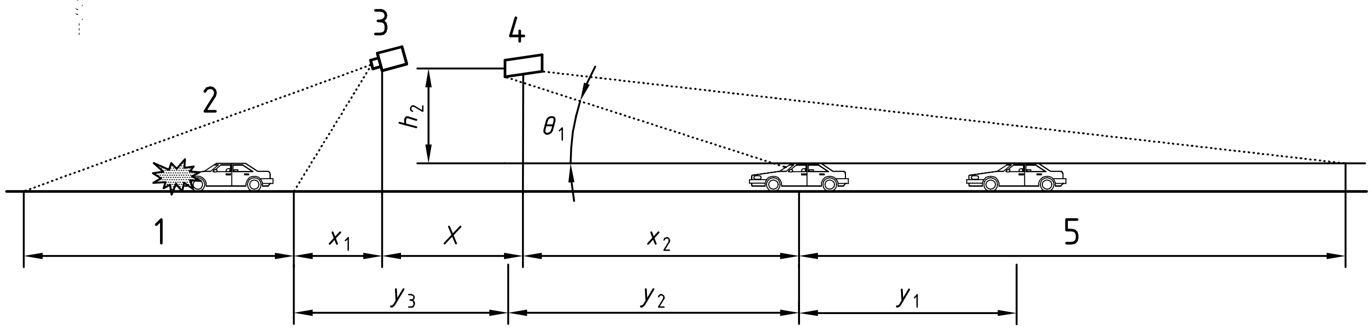
Annex G
(informative)

Specific example of variable message sign installation interval

G.1 Explanation of variable message sign installation interval

The following provides an explanation of those parameters that compose variable message sign installations at interval X. The equations and values used in this explanation were excerpted from the "Explanation and Application of Road Structural Laws" and "Road Sign Installation Standards and Their Explanation", published by the Japan Road Association.

G.1.1 Variable message sign located above traffic lane



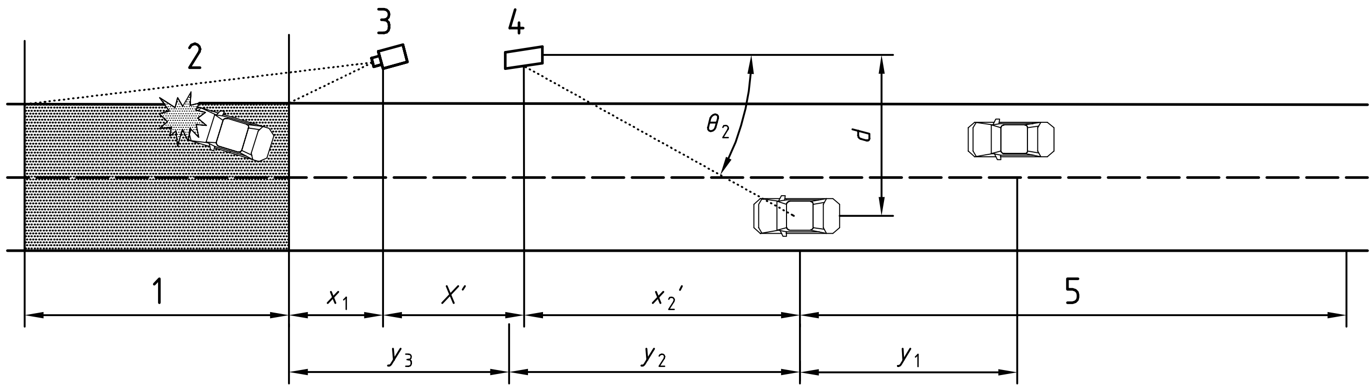
Key

1 Monitoring area
2 Occurrence of traffic impediment
3 CCTV camera
4 Variable message sign
5 Message sign recognition distance

θ_1 vertical out-of-sight angle
h_2 distance from level of driver's eyes to height of variable message sign
X variable message sign installation intervals
x_1 camera blind spot distance
x_2 out-of-sight distance
y_1 judgement distance
y_2 reaction distance
y_3 braking distance

Figure G.1 — Parameters relating to the installation of overhead variable message signs

G.1.2 Variable message sign located at the side of traffic lane



Key

1 Monitoring area

2 Occurrence of traffic impediment

3 CCTV camera

4 Variable message sign

5 Message sign recognition distance

θ_2 horizontal out-of-sight angle

X' variable message sign installation intervals

x_1 camera blind spot distance

x_2' out-of-sight distance

y_1 judgement distance

y_2 reaction distance

y_3 braking distance

d lateral distance from the position of the driver's eyes to the installation position of the variable message sign

Figure G.2 — Parameters relating to the installation of roadside variable message signs

G.1.3 Calculation of distance parameters

G.1.3.1 Calculation of out-of-sight distance

G.1.3.1.1 Out-of-sight distance for overhead variable message sign, x_2

$$x_2 = h_2/\tan \theta_1$$

where

h_2 is the upward distance from the level of the driver's eyes to the installation height of the variable message sign;

θ_1 is the vertical out-of-sight angle, equal to 7°.

G.1.3.1.2 Out-of-sight distance for roadside variable message sign, x_2'

$$x_2' = d/\tan \theta_2$$

where

d is the lateral distance from the position of the driver's eyes to the installation position of the variable message sign;

θ_2 is the horizontal out-of-sight angle, equal to 12°.

G.1.3.2 Calculation of judgement distance, y_1

$$y_1 = 1{,}5\ V$$

where

V is the velocity of traffic flow, expressed in metres per second;

1,5 represents the judgement time, expressed in seconds.

G.1.3.3 Calculation of reaction distance, y_2

$$y_2 = 1{,}0\ V$$

where

V is the velocity of traffic flow, expressed in metres per second;

1,0 represents the reaction time, expressed in seconds.

G.1.3.4 Calculation of braking distance, y_3

$$y_3 = V^2/(254 \times f)$$

where

V is the velocity of traffic flow, expressed in metres per second;

f is the vertical sliding friction coefficient (when road surface is wet).

G.2 Specific example

The results of calculating variable message sign installation intervals using the conditions indicated below are shown in Tables G.1 and G.2.

a) V = 60 km/h, 80 km/h, 100 km/h, 120 km/h, 140 km/h

b) x_1 = 20 m

c) x_2 = 30 m

d) x_2' = 38 m

Table G.1 — Overhead variable message sign installation intervals under various conditions

No.	V km/h	y_1 m	y_2 m	y_3 m	X m
1	60	42,9	16,7	25,0	9,6
2	80	81,3	22,2	33,3	53,5
3	100	131,2	27,8	41,7	109,0
4	120	195,5	33,3	50,0	178,8
5	140	266,1	38,9	58,3	255,0

Table G.2 — Roadside variable message sign installation intervals under various conditions

No.	V km/h	y_1 m	y_2 m	y_3 m	X' m
1	60	42,9	16,7	25,0	1,6
2	80	81,3	22,2	33,3	45,5
3	100	131,2	27,8	41,7	101,0
4	120	195,5	33,3	50,0	170,8
5	140	266,1	38,9	58,3	247,0

Annex H
(informative)

Specific example of system reaction time

The results of calculating system reaction time T_r using the various conditions shown below are indicated in Table H.1.

$$T_r = \{ n \times L_S - (y_1 + y_2 + y_3)\} / V \quad \text{(H.1)}$$

where

n is the number of vehicles unable to acquire impediment information, expressed in vehicles per lane;

L_S is the average vehicle spacing, expressed in metres;

V is the velocity of traffic flow, expressed in metres per second.

Table H.1 shows an example of a trial calculation.

n = 1, 2, 3 (vehicles/lane)

Q = 600, 1 200, 1 800 (vehicles/hour/lane)

V = 60, 80, 100, 120 (km/h)

The trial calculation of annex G was used for $y_1 + y_2 + y_3$.

Table H.1 — System reaction time under various conditions

No.	n vehicles/lane	Q vehicles/hour/lane	V km/h	T_r s	L_s m
1	1,0	600	60	0,9	100,0
2	2,0	600	60	6,9	100,0
3	3,0	600	60	12,9	100,0
4	1,0	600	80	–0,2	133,3
5	2,0	600	80	5,8	133,3
6	3,0	600	80	11,8	133,3
7	1,0	600	100	–1,2	166,7
8	2,0	600	100	4,8	166,7
9	3,0	600	100	10,8	166,7
10	1,0	600	120	–2,4	200,0
11	2,0	600	120	3,6	200,0
12	3,0	600	120	9,6	200,0
13	1,0	1 200	60	–2,1	50,0
14	2,0	1 200	60	0,9	50,0
15	3,0	1 200	60	3,9	50,0
16	1,0	1 200	80	–3,2	66,7
17	2,0	1 200	80	–0,2	66,7
18	3,0	1 200	80	2,8	66,7
19	1,0	1 200	100	–4,2	83,3
20	2,0	1 200	100	–1,2	83,3
21	3,0	1 200	100	1,8	83,3
22	1,0	1 800	60	–3,1	33,3
23	2,0	1 800	60	–1,1	33,3
24	3,0	1 800	60	0,9	33,3
25	1,0	1 800	80	–4,2	44,4
26	2,0	1 800	80	–2,2	44,4
27	3,0	1 800	80	–0,2	44,4

Annex I
(informative)

Camera installation interval

CCTV camera installation methods should depend on such road configuration as curvature, road width, design vehicle speed, and others.

I.1 Continuous coverage installation method

This method should apply to sharp curves, poor visibility points and others.

The installation interval between CCTV cameras is determined by the monitoring coverage of one camera coverage area that should have duplicate coverage as a vehicle length.

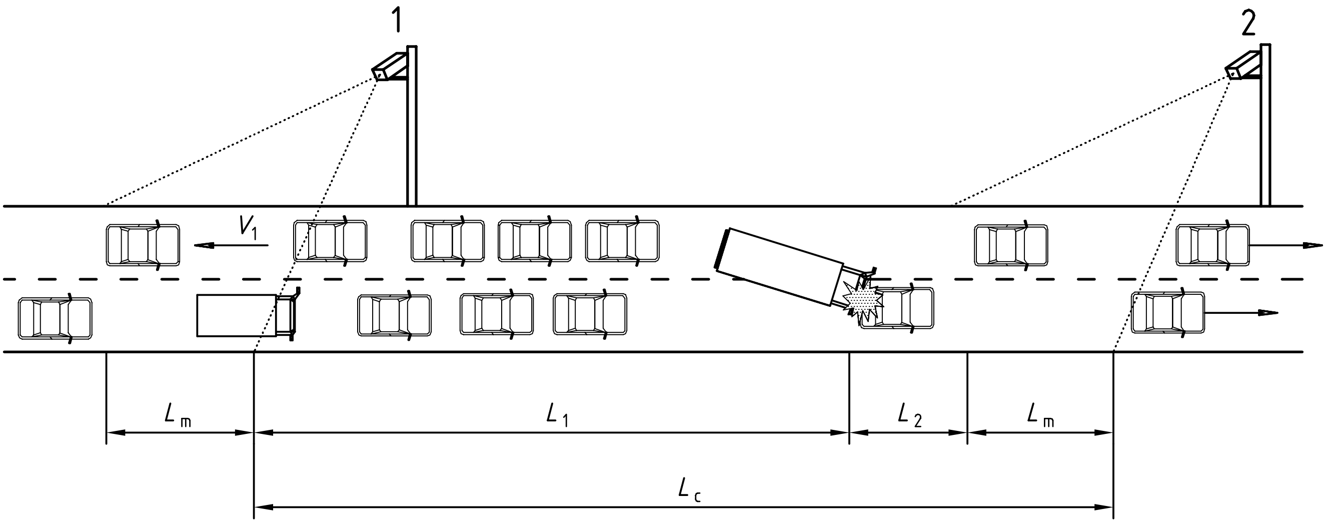
I.2 Discrete coverage installation method

This method should apply to a straight road with a long-range vision because of a low impediment occurrence rate. Camera installation intervals should be determined by the information collecting delay time which traffic data, i.e. traffic volume and speed, would be collected and processed, and the precise information that should be provided to the following vehicles.

Indirect detection methods using neural network technology and other technologies are varying in steps of development, and system response time and detection accuracy are influenced by the volume of lanes, traffic volume, etc. Essentially, cameras should be continuously installed and all traffic lanes should be covered. Then indirect detection methods may be treated as one step until a continuously monitoring system can be constructed, and should be considered an effect and a cost of the system introduction.

To detect traffic impediment using the indirect detection method needs the presence of a change in following traffic flow. If the following traffic flow would not have to change, a traffic impediment cannot be detected. Usually there is a little lag time to detect a traffic impediment by using the indirect detection method so providing information to vehicles following would be delayed.

A simple model for traffic impediments occurring out of the monitoring area is shown in Figure I.2. When a traffic impediment occurs and lanes are blocked as shown in Figure I.1, the following traffic flow would change to congestion a few minutes later, i.e. traffic volume downstream dwindles and the average speed upstream becomes slow.



Key

1 Location A

2 Location B

L_c camera interval

L_m monitoring area

V_1 congestion expansion velocity

Figure I.1 — Traffic impediment discrete monitoring model

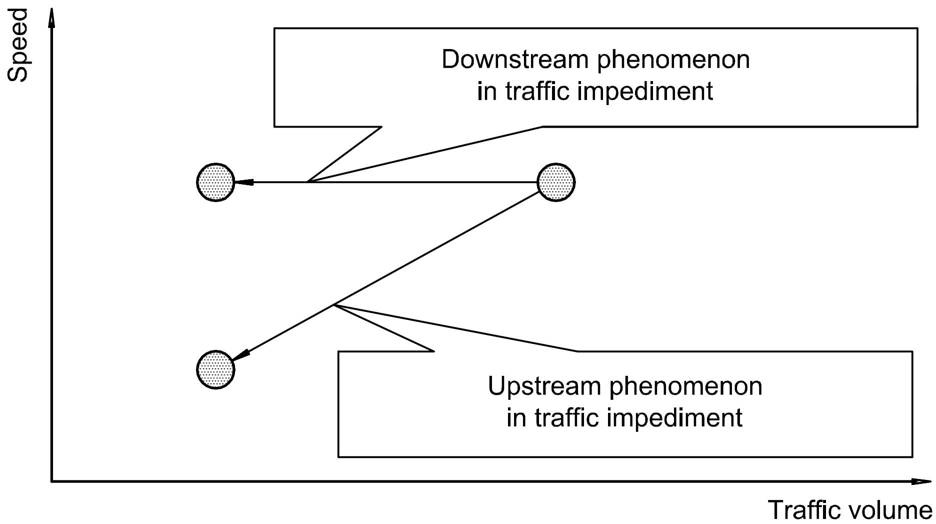


Figure I.2 — Traffic phenomenon model in a traffic impediment

Discrete camera intervals depend on a time lag that following vehicles are detected as slow moving vehicles and/or stopped vehicles. Delay time t_d is calculated by the length between the traffic impediment occurrence point and the monitoring point, divided by the congestion expansion velocity, and is shown in equation (I.1). Camera installation interval is shown in equation (I.2).

$$t_d = (L_c - L_m) / V_1 \quad \text{(I.1)}$$

$$L_c = t_d \times V_1 + L_m \quad \text{(I.2)}$$

where

L_c is the camera interval;

L_m is the camera coverage area.

$$V_1 = Q \times L_s \quad \text{(I.3)}$$

where

V_1 is the congestion expansion velocity;

Q is the traffic volume;

L_s is the average spacing.

Annex J
(informative)

System testing method

The performance test method should have three test phases. In the first phase, the basic performance of image processing should be tested at the manufacturing site using digitally recorded video signals of the traffic scene, under normal and various impediment conditions. A performance test should be composed of a detection object test, detection range test and detection response test.

In the second phase, the performance of the system should be tested at an actual site by using test vehicles for a few weeks.

In the final phase, a field test should be held at the real site to estimate the detection accuracy, false alarm rate, detection response time, etc., under various traffic and various weather conditions during a period of several months or more.

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