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Intelligent transport systems — External hazard detection and notification systems — Basic requirements

Systèmes intelligents de transport — Détection du danger externe et systèmes de notification — Exigences de base

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 204, *Intelligent transport systems*.

Introduction

External hazard detection and notification systems recognize vehicle conditions and their ambient environment using on-board remote sensing or cooperatively through communication between infrastructure and vehicle (I-V), or among vehicles (V-V), and warn or inform the driver about external hazards.

This document addresses a number of functions, such as slow vehicle indication, collision hazard warning, lane change assistance, red light warning, and intersection crossing assistance. There are common requirements for several external hazard detection and notification systems. Many other standard development organizations may consider systems that assist driving safety. The scope of ISO/TC 204 is to promote a positive experience of vehicle/roadway warning and control systems for the driver.

This document is not intended to provide requirements for particular systems defined in each individual standard, but basic requirements based on basic principles for external hazard detection and notification systems. They are common requirements in similar systems, such as safety systems on nomadic devices and systems developed in ISO/TC 204, and should become root or primal requirements to define each system's requirements. This document will be referred to when designing various systems in the future. It is expected to ensure uniformity and efficiency and building systems that reduce the likelihood of confusion for the driver.

For a better understanding of basic requirements, examples of typical formulae are shown in this document as informative elements. In addition, calculated examples of some services are given as information in the annex. Fruitful information on particular consideration is listed in the Bibliography.

Intelligent transport systems — External hazard detection and notification systems — Basic requirements

1 Scope

This document specifies basic requirements for systems to execute notifications such as warning and awareness messages to provide hazard information to a driver.

Requirements include principle of notifying, timing of notification, distance of notification, and information elements that should be included in messages.

NOTE 1 Methods of implementing functions such as hazardous conditions detection, communication, and presentation to drivers are not specified in this document.

NOTE 2 The formulae in Clause 5 and calculated concrete time or distance duration in Annex A are not normative elements but informative elements.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
hazard notification
information that is provided to a driver to notify of external hazards

3.2
warning
type of *hazard notification* (3.1) that requests action be taken immediately to avoid an external hazard

3.3
awareness message
type of *hazard notification* (3.1) that informs the driver about an external potential hazard within a short time in the future

3.4
hazardous condition
external conditions that have intrinsic risks of causing accidents or collisions

3.5
safe state
vehicle state that is achieved after avoiding a *hazardous condition* (3.4)

4 External hazard detection and notification systems

4.1 General

External hazard detection and notification systems distinguish hazardous conditions that occur currently, imminently, or potentially and notify the driver with a warning and/or awareness message to adjust steering and speed quickly enough to avoid such situations.

4.2 Categories of hazard notification

Hazard notifications given to a driver are classified into two categories according to response of the driver expected by the system as follows.

a) Warnings. Systems detect immediate hazardous conditions, assess need to perform an avoidance manoeuvre by the driver in a short time, and notify the driver with a warning. The driver is expected to respond accordingly with a corrective manoeuvre in a short time;

b) Awareness messages. Systems detect potentially hazardous conditions and assess that a probability of a hazard is high if the condition remains and the driver needs to perform avoidance action. The system then notifies the driver with an awareness message. The driver is expected to prepare to avoid a potential hazard within a short time in the future.

4.3 Types of external hazard detection and notification system

External hazard detection and notification systems collect information on a detected hazardous condition from various sources and assess its hazardous nature, then inform drivers via a hazard notification.

External hazard detection and notification systems are classified into two types according to how the information is acquired.

a) Autonomous external hazard detection and notification systems (autonomous type). Autonomous external hazard detection and notification systems assess the situation using information obtained solely on-board the subject vehicle and notify the driver of hazards;

b) Cooperative external hazard detection and notification systems (cooperative type). Cooperative external hazard detection and notification systems assess the situation using information obtained from external systems such as infrastructure or other vehicles via wireless communication and notify the driver of hazards.

   NOTE 1 Cooperative external hazard detection and notification systems may also use information from the subject vehicle, such as velocity of vehicle and location of vehicle.

   Cooperative type includes two types of systems.

   1) Infrastructure-vehicle cooperative external hazard detection and notification systems (I-V cooperative type). Infrastructure-vehicle cooperative external hazard detection and notification systems assess a situation using information from the subject vehicle and infrastructure and notify the driver of hazards;

   2) Vehicle-vehicle cooperative external hazard detection and notification systems (V-V cooperative type). Vehicle-vehicle cooperative external hazard detection and notification systems assess a situation using information from the subject vehicle and other vehicles and notify the driver of hazards.

   NOTE 2 There may be systems that use information from both infrastructure and other vehicles.

Types of external hazard detection and notification system are shown in Table 1.

Table 1 — Types of external hazard detection and notification system that function as sources of information

Direct source of information[a] Type		Own vehicle	Infrastructure[b]	External vehicle[b]
a) Autonomous type		X		
b) Cooperative type	1) I-V cooperative type	X	X	
	2) V-V cooperative type	X		X

[a] Information on subject vehicle such as speed, acceleration/deceleration, and location may be used regardless of system type.

[b] There may be cooperative systems that use information from both infrastructure and other vehicles.

4.4 Functional configuration

4.4.1 Basis of functional configuration

Systems described in the present standard include necessary functional blocks, which encompasses the following:

a) detection functional block;

b) assessment functional block;

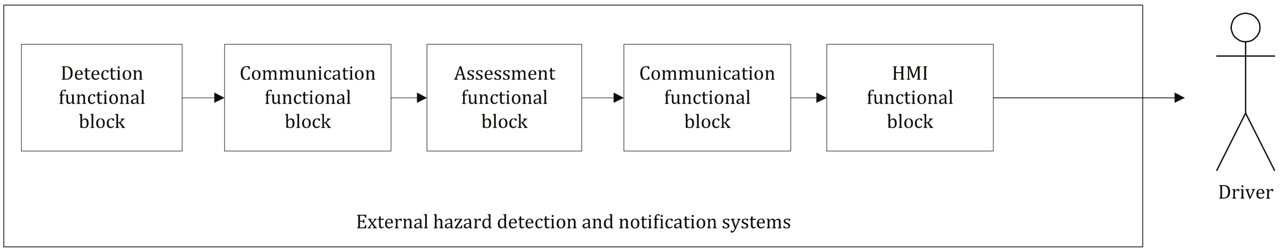
c) human machine interface (HMI) functional block.

NOTE 1 Where each function is allocated depends on system design. For example, the HMI notifies a driver of the same notification that may be assessed by devices in infrastructures or assessed in own vehicle. There are systems in which assessments or decisions are performed by infrastructure systems and an example of a system is described in A.2.

When hazardous conditions are detected by systems outside the vehicle and transmitted to the vehicle via wireless communication, communication functional blocks is added.

NOTE 2 Transmitting information between devices at the same location (e.g. between vehicle devices or between devices in the infrastructure) is not included in this functional block, but in other detection, assessment, or HMI functional block.

Abstract functional block configuration is shown in Figure 1.



NOTE Where to allocate the function of the communication functional block depends on system design.

Figure 1 — Abstract functional block configuration

Examples of function allocation are shown in Table 2.

Table 2 — Example of function allocation

	Infrastructure[a]	Other vehicle[a]	Subject vehicle[a]
Autonomous type	—	—	a) detection functional block b) assessment functional block c) HMI functional block
I-V cooperative type	a) detection functional block d) communication functional block (I-V)	—	d) communication functional block (I-V) b) assessment functional block c) HMI functional block
V-V cooperative type	—	a) detection functional block d) communication functional block (V-V)[b]	d) communication functional block (V-V) b) assessment functional block c) HMI functional block

[a] This function allocation is just an example. Each function may be allocated at other locations.

[b] Relaying communication via infrastructure (V-I to I-V) may be included.

4.4.2 Detection functional block

The detection functional block detects hazardous conditions using sensors or accumulated data and provides them to the assessment block. Hazardous conditions are not distinguished using only a simple measurement value but together with time course, other measurement values, and also other information. The detection functional block may be located in the subject vehicle, infrastructure, or other vehicles.

NOTE 1 Allocations of detection or related functions depend on system design.

Detection block includes detection function.

NOTE 2 There may be multiple different detection functions in the vehicle and/or infrastructure.

4.4.3 Assessment functional block

The assessment functional block handles information provided by the detection functional block and derives assessments needed to issue hazard notifications and provides information to the HMI functional block.

NOTE Allocation of functions for assessment or related functions depends on system design.

The assessment functional block includes sub-functions such as the following.

— Situation assessment function. Situation assessment function assesses hazardous situations using various detected information provided by the detection function.

EXAMPLE 1 To assess if a vehicle will experience a rear-end collision or not.

— Notification assessment function. Notification assessment function assesses implementation and content of hazard notifications based on hazard situation assessed function.

EXAMPLE 2 To assess which notification is suitable “apply brake” or “keep distance”.

4.4.4 Human machine interface (HMI) functional block

The HMI functional block issues hazard notifications to a driver using information provided by the Assessment functional block.

NOTE There may be two types of device that have HMI: one is designed exclusively for specific hazard notification; the other is used in common for multiple types of hazard notification or other information provision.

The HMI functional block includes sub-functions such as the following.

— Provision processing function. Provision processing function prepares information provided to a driver. In case multiple information is notified to the driver, the priority of each piece of information is assessed and hazard notification is provided appropriately.

— Presentation function. Presentation function renders hazard notification to the driver.

4.4.5 Communication functional block

The communication functional block transmits information to vehicles from the infrastructure or other vehicles via wireless communication.

The communication functional block includes communication function.

4.5 Time factors of hazard notification

4.5.1 General

Time factors needed from the point when a hazardous condition occurs or is detected to the point when the vehicle has avoided a hazard are shown in Table 3.

Table 3 — Time factor

Items			Time factors
Functions of external hazard detection and notification systems	Detection block	Detection function	Detection time
	Assessment block	Situation assessment function Notification assessment function	Situation assessment time Notification assessment time
	HMI block	Provision processing function Presentation function	Provision processing time presentation time
	Communication block	Communication function	Communication time
Out of function of external hazard detection and notification systems	Time factor after hazard notification		Driver reaction time Vehicle state variation time, until vehicle has reached a safe state

Each function may include a certain processing time. The time required to distribute information between devices should be included in the processing time of each function. Alternatively, the length of time may be zero depending on the layout of functions.

4.5.2 Detection functional block time factor

The detection functional block time factor is the time required to detect hazardous conditions. Detecting hazardous conditions may require measurement value of time course, other measurement values, and/or other information. These are included in the detection functional block time factor.

The detection functional block time factor includes detection time.

EXAMPLE If the area or length of the hazardous condition is expanding or moving, the hazardous conditions should be detected after a regular interval.

4.5.3 Assessment functional block time factor

The assessment functional block time factor is the time required to assess the situation and issue a hazard notification.

The assessment functional block time factor includes the following times.

— Situation assessment time. Situation assessment time is the time required to assess a situation based on detection information.

— Notification assessment time. Notification assessment time is the time required to assess the function and the content of a hazard notification based on situation assessment. It assesses whether a notification is needed or not, which notification is suitable, a warning or awareness message, etc.

NOTE In “situation assessment time”, the situation is recognized, then whether a driver needs a notification and what kind of notification is suitable are determined in “notification assessment time”.

4.5.4 HMI functional block time factor

The HMI functional block time is the delay time from receiving a notification to its presentation to the driver.

The HMI functional block time factor includes the following times.

— Processing time to prepare information. The Processing time to prepare information is the time needed to prepare information to notify the driver of a hazard notification reflected in judgment of priority.

— Presentation time. The Presentation time is the time needed to render a hazard notification to the driver.

4.5.5 Communication functional block time factor

The communication functional block time factor is the time needed to transmit and process messages to a vehicle from outside the vehicle (e.g. from infrastructure or other vehicles).

The communication functional block time factor includes communication time.

4.5.6 Time factor after hazard notification

In the situation after the driver acknowledges a hazard notification, the driver responds and performs a vehicle controlling manoeuvre. Then, the vehicle can begin to avoid a hazard situation.

Time factor after hazard notification includes the following times.

— Driver reaction time. The driver reaction time is the time during which the driver reacts to a hazard notification.

  It includes the following times:

  — time needed for the driver to understand the contents of a hazard notification;

  — time needed for a driver to assess how to avoid a hazardous condition;

  — time needed for a driver to initiate vehicle control.

  NOTE Driver reaction time and presentation time may overlap. For example, in case a hazard notification has not finished being relayed, a driver may determine how to control the vehicle.

— Vehicle state variation time, until vehicle has reached a safe state. Vehicle state variation time is the time in which the vehicle is manoeuvred by the driver through braking, steering, or any other action, until it has reached a safe state.

5 Requirements for external hazard detection and notification systems

5.1 Principle

Hazard notifications notified by external hazard detection and notification systems shall be provided to a driver before the vehicle encounters hazardous situations so that the vehicle can avoid them with information that shall inform a driver about hazardous situations comprehensibly.

Even if they do not allow the driver to completely avoid the hazard in all cases, they shall still be provided to a driver. They will help reduce the risk of hazards.

Therefore, external hazard detection and notification systems shall be designed to consider the time for systems to process, driver reaction, and vehicle state variation. Then, they shall support vehicle operations by the driver to avoid hazardous situations.

This system just supports a driver and the driver should take responsibility for the operations consistently.

5.2 Particulars

5.2.1 General

This subclause describes particular requirements for information, timing, and distance to meet the requirements described in 5.1.

5.2.2 Detection information

5.2.2.1 General

The detection information is provided from the detection functional block to the assessment functional block to assess hazardous conditions. It includes information on hazardous conditions outside the subject vehicle.

The detection information on hazardous conditions should contain information items that enable a driver to judge the following content:

a) types of hazardous condition and existence;

b) conditions of hazard;

c) time until encountering hazardous conditions and/or distance to hazardous conditions.

NOTE What and how hazardous conditions should be detected are not specified in this document.

5.2.2.2 Types of hazardous condition and existence

Existence of hazardous conditions and their types should be judged.

EXAMPLE 1 "Types of hazardous condition" include obstacles, red signal, and rear-end collisions.

EXAMPLE 2 Specific types of hazardous condition may not be contained in the detection information when the subject vehicle is approaching a stationary vehicle and the driver has no other choice but to brake hard.

5.2.2.3 State variation of hazardous conditions

Temporal and/or spatial changes of hazardous conditions should be judged. It means change of state, for example, increasing/decreasing, extension/reduction, disappearing/ appearing, reducing/increasing, etc. They may assist judgments for hazard notifications and actions of the driver.

5.2.2.4 Time until encountering hazardous conditions and/or distance to hazardous conditions

Time until encountering hazardous conditions and/or distance from hazardous conditions should be distinguished using detection information.

5.2.2.4.1 Distance to hazardous conditions

Distance to hazardous conditions should be judged.

Methods for judging the distance to hazardous conditions may be as follows:

— detecting from difference between absolute coordinate value between coordinate of subject vehicle and hazardous conditions;

— detecting absolute distance from driver's own vehicle to hazardous conditions.

5.2.2.4.2 Time until encountering hazardous conditions

Time until encountering hazardous conditions should be judged.

On this occasion, driving states (including speed, acceleration, direction, etc.) of subject vehicle and states of hazardous condition should be considered.

EXAMPLE If the position of intended hazardous condition is moving, its speed and direction must be considered.

5.2.3 Assessment information

Assessment information should include matters that should be recognized by a driver for hazard notification. It may be assessed from multiple detection information.

If there are multiple hazard notifications or other information provision, it should keep priority information for prioritized notification as much as possible.

NOTE The method and criteria to judge priority can be modified with the characteristics of vehicle and/or driver, surrounding environment, etc.

EXAMPLE When vehicle goes through a red light:

— there is a standing vehicle in front of the vehicle: which warning is better, red light or standing vehicle?

— the vehicle is slowing down: warning is needed or not?

When there are multiple hazards at the same time, the most important thing is to attract the driver's attention so that he/she can react safely. Therefore, the systems have to assess hazardous conditions and inform the applicable notification to the driver.

5.2.4 Notification information

Notification information includes warning and awareness message.

Warning shall urge the driver to perform an immediate avoidance action to avoid potentially hazardous situations.

Awareness message shall inform the driver about a high-potential risk if the vehicle is maintained in its current state and about the need to carry out a corrective action in the short-term.

In any hazard notification, information on hazardous situations should be included except if giving too much information could delay the response of the driver.

NOTE In case a standing vehicle is imminent and the driver has no other choice but to brake hard, details of hazardous conditions may not be provided. This may delay the driver's response if he/she is given too much information.

Contents of warning and awareness message presentation and/or urgency should be different.

This document does not specify concrete presentation method and content on HMI. But, those designing HMI of external hazard detection and notification systems should refer to Reference [3] and Reference [17].

5.2.5 Timing of hazard notification

5.2.5.1 Basis

External hazard detection and notification systems detect hazardous conditions, assess hazardous situations, and if needed, notify the driver of a hazard (see T_{ns} on Figure 2). Upon receiving a hazard notification, a driver controls the subject vehicle, and then the vehicle state is changed to avoid a hazardous condition (see T_{os} on Figure 2).

Therefore, hazard notification shall be notified before the time needed for external hazard detection and notification systems process, driver reaction, and vehicle state variation before the vehicle encounters a hazardous situation.

NOTE 1 The timing and the distance for hazard notification are mutually related. See 5.2.6.

Time from start of detecting hazardous condition to encountering hazardous situation should be longer than time expressed by Formula (1):

$$T_{hs} = T_{ns} + T_{os} \tag{1}$$

where

T_{hs} is the time range from onset of hazardous condition detection by external hazard detection and notification systems until the time avoidance is completed;

T_{ns} is the processing time in external hazard detection and notification systems;

T_{os} is the time from hazard notification until avoidance.

NOTE 2 In case a driver recognizes a hazard notification before its rendering is finished, the beginning of T_{os} may overlap with the ending of T_{ns}.

EXAMPLE 1 An example of timing is shown in Figure 2 for the case of a vehicle stopping to avoid danger.

If there is not enough time from onset of detecting hazardous conditions until encountering hazardous situations, hazard notification should be carried out.

EXAMPLE 2 If the timing of hazard notification is delayed and the time until avoidance is shorter than T_{os} (time from hazard notification until avoidance; see Figure 2).

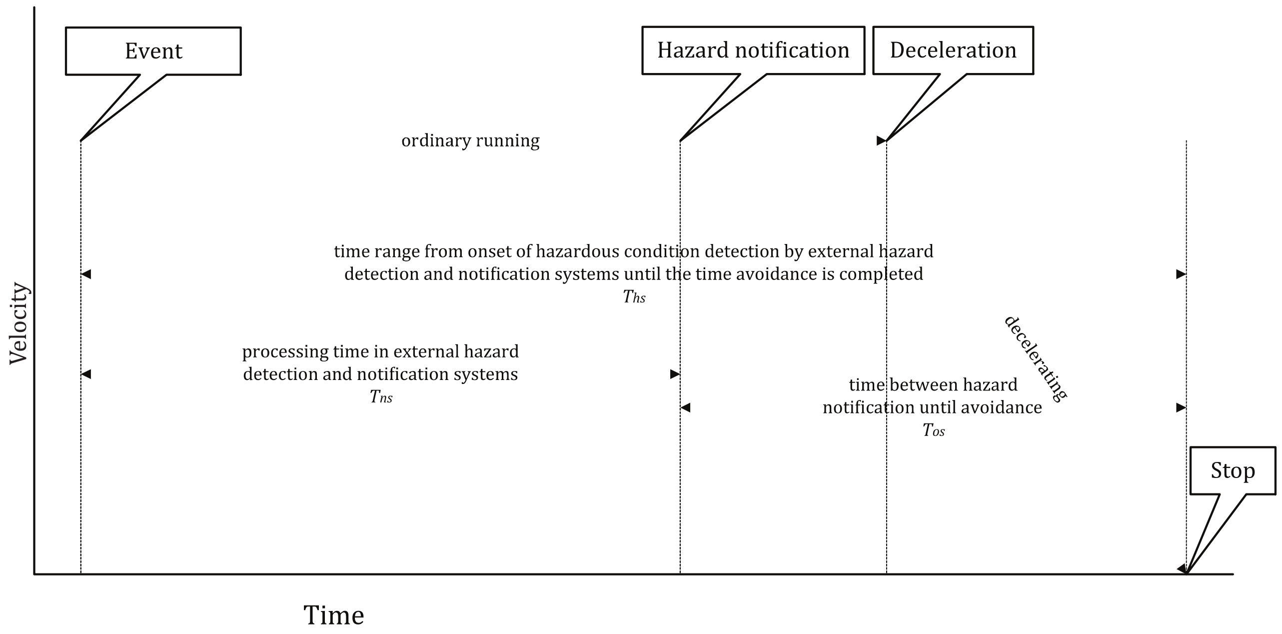


Figure 2 — Example of timing (in case of vehicle stopping to avoid danger)

5.2.5.2 Time required for processing

Processing time is from start of detecting hazardous conditions until presentation of hazard notification. It includes time to do the following.

— Hazardous condition is detected by systems.

— Systems assess hazardous situation.

— Systems assess to give driver notice or not.

— Systems prepare information to notify driver.

— Notification messages are presented to driver via HMI.

— Communication messages are transmitted between functional blocks if needed.

NOTE Depending on function layout, communication (e.g. V-I, V-V, OBU BUS, etc.) between functional blocks may be necessary.

Time is expressed by Formula (2):

$$T_{ns} = T_{dt} + T_{as} + T_{an} + T_{pp} + T_{pz} + T_{tr} \quad (2)$$

where

T_{ns} is the time until processing by external hazard detection and notification systems;

T_{dt} is the detection time;

T_{as} is the situation assessment time;

T_{an} is the notification assessment time;

T_{pp} is the provision processing time;

T_{pz} is the presentation time;

T_{tr} is the communication time.

5.2.5.3 Time required for avoidance

After hazard notification, avoidance is successful due to driver reaction and changing state of vehicle. Time required for avoidance includes time to do the following.

— The driver finds and receives notification and takes necessary action;

— The state of the vehicle changes to one that is safe, following actions of the driver.

Time is expressed by Formula (3):

$$T_{os} = T_{rh} + T_{rv} \quad (3)$$

where

T_{os} is the time from hazard notification until avoidance;

T_{rh} is the driver reaction time;

T_{rv} is the time during which the state of vehicle changes.

NOTE 1 Vehicle state variation time, T_{rv}, is time to change state of vehicle from (potential) hazardous situation to safe situation. There are many cases of a hazardous situation being changed by stopping, accelerating, decelerating, changing lane, etc.

NOTE 2 Warning is urgent hazard notification. So, it is expected that driver reaction time will be reduced and time to change state of vehicle also changes with emergency braking.

5.2.6 Distance of hazard notification

5.2.6.1 General

External hazard detection and notification systems detect hazardous conditions, assess hazardous situations, and if needed, notify the driver of the hazard (see T_{ns} on Figure 2). Upon receiving hazard notification, the driver controls the vehicle and state of the vehicle is changed to avoid a hazardous condition (see T_{os} on Figure 2).

Therefore, the driver should be notified at a distance before the hazardous condition is reached, which is long enough to allow information processing, notification, driver reaction, and change of vehicle state.

NOTE Timing and distance of hazard notification are related. See 5.2.5.

Distance from point where systems start to detect hazardous conditions to point where systems encounter hazardous situation should be longer than distance as expressed by Formula (4):

$$L_{hs} = L_{ns} + L_{os} \quad (4)$$

where

- L_{hs} is the distance travelled from detection of external hazard and notification systems until avoidance action is completed;
- L_{ns} is the travel distance during processing in external hazard detection and notification systems;
- L_{os} is the travel distance from hazard notification until avoidance.

If there is not enough distance from detection of hazardous condition until encountering hazardous situation, the hazard should be notified. This reduces the hazard.

EXAMPLE If the timing of the hazard notification is delayed and distance travelled until avoidance is shorter than L_{os} (travel distance after hazard notification to avoidance; see Figure 2), hazard notification should still be presented to the driver.

5.2.6.2 Distance travelled during processing

Distance travelled while processing external hazard detection and notification systems depends on velocity of vehicle and time from detecting hazardous condition until presenting hazard notification.

Distance travelled while processing external hazard detection and notification systems is expressed by Formula (5):

$$L_{ns} = V_0 \times T_{ns} \tag{5}$$

where

- L_{ns} is the distance travelled while processing in external hazard detection and notification systems;
- V_0 is the initial velocity of vehicle (it is assumed to be constant and may be relative velocity);
- T_{ns} is the time required for processing in external hazard detection and notification systems.

5.2.6.3 Distance required for avoidance

5.2.6.3.1 Basis

After hazard notification, avoidance is successful due to driver reaction and changing vehicle state. Before the driver takes action, the vehicle travels as before. After action is taken, the vehicle transitions to a safe state.

NOTE 1 A safe state may include stopped, reduced speed, and change of lane.

Distance travelled is expressed by Formula (6):

$$L_{os} = L_{rh} + L_{rv} \tag{6}$$

where

- L_{os} is the distance travelled from hazard notification until avoidance;
- L_{rh} is the distance travelled during driver reaction time;
- L_{rv} is the distance travelled until state of vehicle is changed.

NOTE 2 A warning is an urgent hazard notification. So, it is expected that driver reaction time will be reduced and state of vehicle state will be changed by emergency braking time.

5.2.6.3.2 Example of distance calculation

5.2.6.3.2.1 Example of avoidance behaviour using braking (forward avoidance)

After hazard notification, avoidance becomes successful due to driver reaction and change of vehicle state.

Its travel distance is expressed by Formula (7):

$$L_{os} = (V_0 \times T_{rh}) + \frac{(V_0{}^2 - V_s{}^2)}{2\alpha} \tag{7}$$

where

L_{os} is the distance travelled from hazard notification until avoidance;

V_0 is the initial velocity of vehicle (it is assumed to be constant and may be relative velocity);

V_s is the target velocity for avoidance (it may be relative velocity);

T_{rh} is the driver reaction time;

α is the acceleration for avoidance (it is assumed to be constant and may be relative acceleration).

Distance after hazard notification is shown in Figure 3.

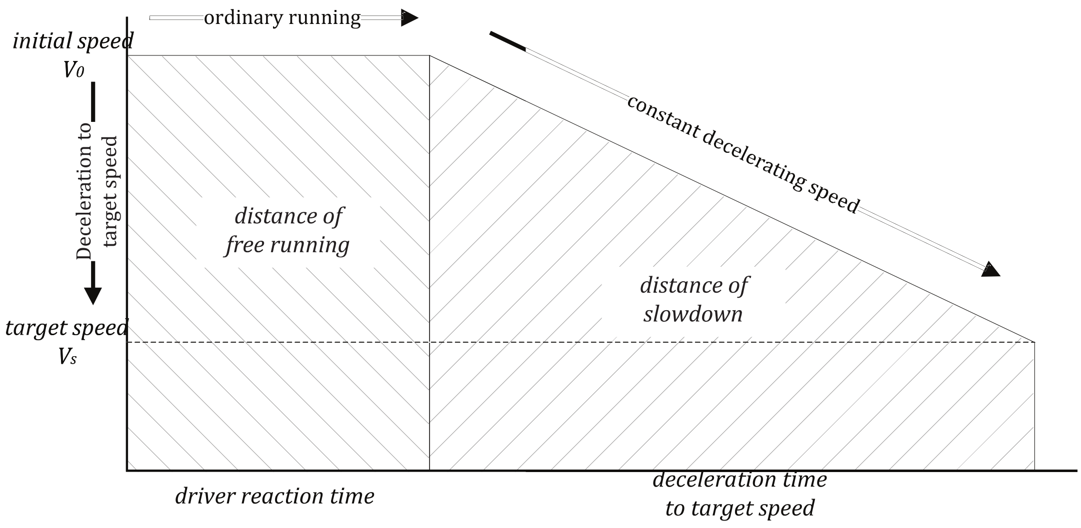


Figure 3 — Distance after hazard notification (forward avoidance)

5.2.6.3.2.2 Example of avoidance behaviour steering (lateral avoidance)

After hazard notification, avoidance becomes successful due to driver reaction and change of vehicle state.

Distance travelled is expressed by Formula (8):

$$L_{os} = (V_0 \times T_{rh}) + V_0 \times \left(2 \times \sqrt{\frac{w}{\beta}}\right) \tag{8}$$

where

L_{os} is the distance travelled from hazard notification until avoidance;

V_0 is the initial speed of vehicle (it is assumed to be constant and may be relative velocity);

T_{rh} is the driver reaction time;

β is the lateral acceleration for avoidance (it is assumed to be constant and may be relative acceleration);

w is the lateral distance of avoidance action.

NOTE In case the vehicle moves laterally with acceleration + and deceleration −.

Distance after hazard notification is shown in Figure 4.

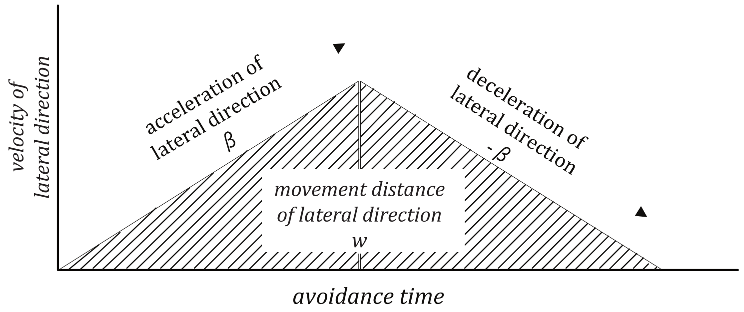


Figure 4 — Distance after hazard notification (lateral avoidance)

6 Non-functional requirements

6.1 General

Other requirements not contained among functional requirements in Clause 5 are described as non-functional requirements in this subclause.

6.2 Consistency

When hazard notifications are performed by two or more methods in the same systems, they should not be in conflict.

Even if hazard notifications are performed by different systems, it is desirable to consider that it does not cause a conflict. Moreover, it is desirable to adjust a term or an expression so that a driver cannot be confused by term, image, or sound used.

6.3 Priority

Multiple hazard notifications within a short time should be assigned from the highest risk. Furthermore, hazard notifications require care so that they are easy for a driver to understand.

In case there are several different hazardous situations within a short time, e.g. time to collision (TTC) or time to event (TTE) is short, critical hazardous situations should take precedence.

To prioritize hazard notifications, “IV. Statement of principles, F. Multiple warnings should be prioritized” in Reference [17] should be referred to as a guide.

6.4 Security

Security, when designing and implementing external hazard detection and notification systems, shall be based on the results of a threat analysis. In addition, proper countermeasures for vulnerability issues that are found during operation of systems should be adopted.

NOTE Some security-related standards are listed in Reference [18]. The methodology of the threat analysis is furnished in Reference [12] and additional information of mechanisms for secure and privacy-preserving communication in ITS environments is shown in Reference [11].

6.5 Quality

The quality of information such as accuracy, freshness, and confidence should be considered when hazard notifications are processed.

Even if errors arise, notifications are to be carried out safely based on quality of information. Moreover, it is desirable to use information on quality if needed and to optimize influence.

NOTE In Reference [1], probe data with confidence information are defined. These are as follows: sensing information (e.g. latitude, longitude and altitude), environment information (e.g. temperature), and vehicle information (e.g. speed, acceleration, direction, yaw rate). The confidence of each item is presented as real or integer type.

Processes or methods to evaluate level of quality might be defined individually in other International Standards and/or documents.

6.6 Integration

In case multiple hazard notifications are integrated and provided to a driver, misunderstandings, confusion, or conflicts among notifications should be eliminated.

To integrate hazard notifications, Reference [3] should be referred to as a guide.

Annex A
(informative)

Consideration of timing and distance of hazard notification (case study)

A.1 General

The timing and point for implementing a hazard notification differs according to device, communication, quantity, presentation method, etc.

Here, according to an example of services considered, the timing and point of hazard notification are illustrated. The illustrated hazard notifications are as follows:

— support for preventing collisions with forward obstacles;

— support for preventing lateral collisions.

A.2 Support for preventing collisions with forward obstacles (I-V cooperative type)

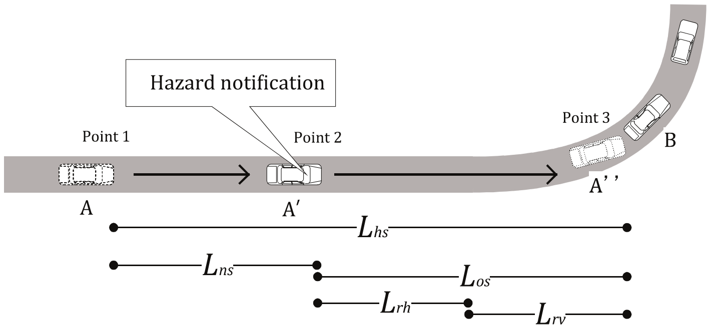
This is a service by which the driver of a vehicle is issued with a hazard notification of a forward stopped vehicle. See Figure A.1.

— When vehicle “A” proceeds to point “1”, the infrastructure detects forward stopped vehicle “B”.

— The infrastructure determines to implement hazard notification and communicates information to vehicle “A”.

— The driver of vehicle “A” is issued with a hazard notification at point “2”.

— The driver brakes and the vehicle stops at point “3” with no rear-end collision occurring.



NOTE Letter symbols are shown in 5.2.6.

Figure A.1 — Support for preventing collisions with forward obstacles

Examples of values are as follows.

— Initial speed is 80 km/h.

— Target speed is 0 km/h (stopped).

— Deceleration is 2,0 m/s^2 (normal deceleration).

— Detection time is 0,2 s (including assessment time).

— Communication time is 0,1 s.

— Processing time of on-board unit is 1 s.

— Presentation time and driver reaction time is 5 s.

Estimated results are shown in Table A.1.

Table A.1 — Support for preventing collisions with forward obstacles

Items			Estimated time			Items			Estimated distance		
T_{hs}	T_{ns}	T_{dt}	17,3 s	1,3 s	0,2 s	L_{hs}	L_{ns}	L_{dt}	291 m	68 m	44 m
		T_{as}						L_{as}			
		T_{an}						L_{an}			
		T_{tr}			0,1 s			L_{tr}			2 m
		T_{pp}			1,0 s			L_{pp}			22 m
		T_{pz}			5,0 s			L_{pz}			110 m
	T_{os}	T_{rh}		16,0 s			L_{os}	L_{rh}		231 m	
		T_{rv}			11,1 s			L_{rv}			121 m
NOTE Letter symbols are shown in 5.2.5 and 5.2.6.											

A.3 Support for preventing lateral collisions (V-V cooperative type)

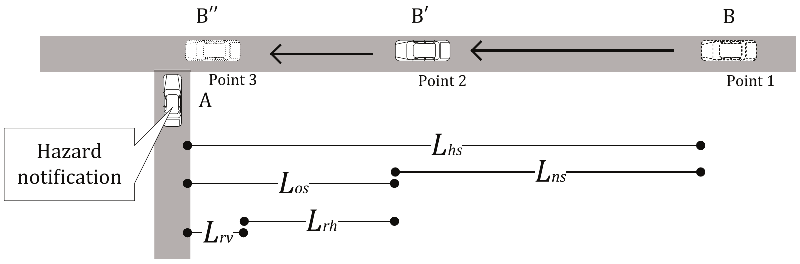
This is a service in which the driver of a vehicle stopped at an intersection issues a hazard notification for an approaching vehicle. See Figure A.2.

— Vehicle “A” stops short of an intersection and receives information that is transmitted from approaching vehicle “B” at point “1”.

— Vehicle “A” assesses a potential hazard notification if vehicle “A” enters the intersection and collides with vehicle “B” at point “3”.

— The driver of vehicle “A” is issued with a hazard notification when vehicle “B” is located at point “2”.

— The driver continues braking and stops short of the intersection and avoids a collision.



NOTE Letter symbols are shown in 5.2.6.

Figure A.2 — Support for preventing lateral collisions

Examples of values are as follows.

— Initial speed is 0 km/h.

— Target speed is 0 km/h (stopped).

— Approaching vehicle speed is 70 km/h.

— Deceleration is 0 m/s[2] (stopped).

— Detection and communication time is 0,1 s.

— Assessment time is 0,3 s.

— Presentation time and driver reaction time is 0,8 s.

Estimated results are shown in Table A.2.

Table A.2 — Support for preventing lateral collisions

<table>
<tr><th colspan="3">Items</th><th colspan="3">Estimated time</th><th colspan="3">Items</th><th colspan="3">Estimated distance</th></tr>
<tr><td rowspan="8">T_{hs}</td><td rowspan="6">T_{ns}</td><td>T_{dt}</td><td rowspan="8">1,2 s</td><td rowspan="6">0,4 s</td><td rowspan="2">0,1 s</td><td rowspan="8">L_{hs}</td><td rowspan="6">L_{ns}</td><td>L_{dt}</td><td rowspan="8">24 m</td><td rowspan="6">8 m</td><td rowspan="2">2 m</td></tr>
<tr><td>T_{tr}</td><td>L_{tr}</td></tr>
<tr><td>T_{as}</td><td rowspan="3">0,3 s</td><td>L_{as}</td><td rowspan="3">6 m</td></tr>
<tr><td>T_{an}</td><td>L_{an}</td></tr>
<tr><td>T_{pp}</td><td>L_{pp}</td></tr>
<tr><td>T_{pz}</td><td rowspan="2">0,8 s</td><td>L_{pz}</td><td rowspan="2">16 m</td></tr>
<tr><td rowspan="2">T_{os}</td><td>T_{rh}</td><td rowspan="2">0,8 s</td><td rowspan="2">L_{os}</td><td>L_{rh}</td><td rowspan="2">16 m</td></tr>
<tr><td>T_{rv}</td><td>—</td><td>L_{rv}</td><td>—</td></tr>
<tr><td colspan="12">NOTE Letter symbols are shown in 5.2.5 and 5.2.6.</td></tr>
</table>

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