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Intelligent transport systems — Collision evasive lateral manoeuvre systems (CELM) — Requirements and test procedures

Systèmes de transport intelligents — Systèmes de manœuvre latérale d'évitement de collision (CELM) — Exigences et procédures d'essai

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Foreword

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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).

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For an explanation of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 204, *Intelligent transport systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Reducing traffic fatalities, injuries and property damage caused by driver carelessness or unexpected events is a global challenge.

To address this situation, automatic emergency braking (AEB) systems were introduced to mitigate crash consequences through automatic deceleration by braking of the vehicle.

NOTE ISO 22839 and ISO 19237 are examples of related International Standards defining the minimum performance requirements of such systems. The ISO 22733 series defines test procedures to evaluate the performance level of such systems.

These AEB systems work effectively when there is a high probability of a collision, but their operation can be limited, or they can potentially not work at all, when there is a low probability of a collision (e.g. when the degree of overlap to the object is small). However, even in such scenarios, there are cases where a collision can be avoided by system support, i.e. by a small amount of lateral movement.

This document defines functional requirements, minimum performance requirements and test procedures to verify these requirements for collision avoidance systems using lateral movement of the vehicle. The aim of this system is to avoid collisions occurring in the subject vehicle's travelling direction.

Intelligent transport systems — Collision evasive lateral manoeuvre systems (CELM) — Requirements and test procedures

1 Scope

This document specifies basic control strategies, minimum functional requirements, basic driver interface elements, and test procedures for verifying the system requirements for collision evasive lateral manoeuvre systems (CELM).

A CELM is a safety system aimed at supporting the driver's vehicle operation by avoiding collisions with objects in the forward path of the vehicle. When a collision is predicted, the CELM controls lateral movement of the vehicle by generating yaw moment.

The lateral control manoeuvres can be performed automatically by CELM or can be initiated by the driver and supported by CELM.

Specific methods for object detection and other environmental perception technologies are not described in this document.

This document applies to light vehicles[1] and heavy trucks.[1] Vehicles equipped with trailers are not within the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

FMVSS 105, *Hydraulic and Electric Brake Systems*

ISO 19206-2, *Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 2: Requirements for pedestrian targets*

ISO 19206-3, *Road vehicles — Test devices for target vehicles, vulnerable road users and other objects, for assessment of active safety functions — Part 3: Requirements for passenger vehicle 3D targets*

3 Terms and definitions

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

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

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

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

3.1
subject vehicle
SV
vehicle equipped with a collision evasive lateral manoeuvre system (CELM)

3.2
object
obstacle that could represent a hazard if hit by the subject vehicle

3.3
lane marking
delineator, marking or Botts' dot intentionally placed on the borderline of the lane

3.4
lane boundary
outer edge of the lane marking

Note 1 to entry: See 3.3.

3.5
system failure
inability of a system or system component to perform a required function within specified limits, which is caused by mechanical or electronic malfunction

3.6
SV direction
direction of travel of SV used to predict a collision

3.7
time to collision
TTC
time that it will take a subject vehicle to collide with an object assuming constant relative velocity

3.8
critical approach
driving situation which leads to an imminent collision if no driver or system prevention reaction occurs

4 Symbols and abbreviated terms

4.1 Symbols

Symbols used in this document and their meanings are described in Table 1.

Table 1 — Symbols and meanings

Symbol	Meaning	Unit
V_{SV}	Speed of the SV.	m/s
V_{min}	Minimum SV speed for CELM operation.	m/s
V_{max}	Maximum SV speed for CELM operation.	m/s
V_{svL}	The mean of lateral speed of the SV orthogonal to the lane markings, i.e. the y-axis component of vehicle motion when traveling parallel to the lane markings (see 9.3.3.3 for details).	m/s

Table 1 *(continued)*

Symbol	Meaning	Unit
L_d	Lateral distance between the outermost edge of the object and the extension of the side of the SV closest to the object when measured parallel to the SV (i.e. point at which the distance becomes minimum). A positive value refers to a situation where an overlap exists between the SV and object. A negative value refers to a situation where an overlap does not exist between the SV and object. See 7.2.2 for details.	m
L_{d_inner}	Distance between the edge of an object and the inner edge of lane marking, when the object is located inside the ego lane of the SV.	m
L_{d_outer}	Distance between the edge of an object and the outer edge of lane marking, when the object is located outside the ego lane of the SV.	m
L_{ofst_min}	Minimum amount of lateral offset to which the system is designed to respond.	m
L_{ofst_max}	Maximum amount of lateral offset to which the system is designed to respond.	m
x_{c_min}	Minimum longitudinal distance for which the angle between the SV and an object must be constant when the SV approaches a test target.	m

4.2 Abbreviated terms

AEB automatic emergency braking

CELM collision evasive lateral manoeuvre system

LDP lane departure prevention

TTC time to collision

GNSS Global Navigation Satellite System

5 System overview

5.1 General

The CELM detects objects in the front area in the current SV direction of travel.

The CELM determines objects as hazardous if they are predicted to be in the driving path of the SV and a collision with the object is imminent.

The CELM activates actuators (e.g. steering, brake) to generate yaw moment in an attempt to avoid a collision.

The CELM controls or supports the lateral movement of the SV in the direction which avoids the collision in the best manner or which has been chosen by the driver.

The CELM may operate under conditions where AEB systems are activated.

5.2 Classification

CELMs are classified into two types as shown in Table 2.

Table 2 — Type classification

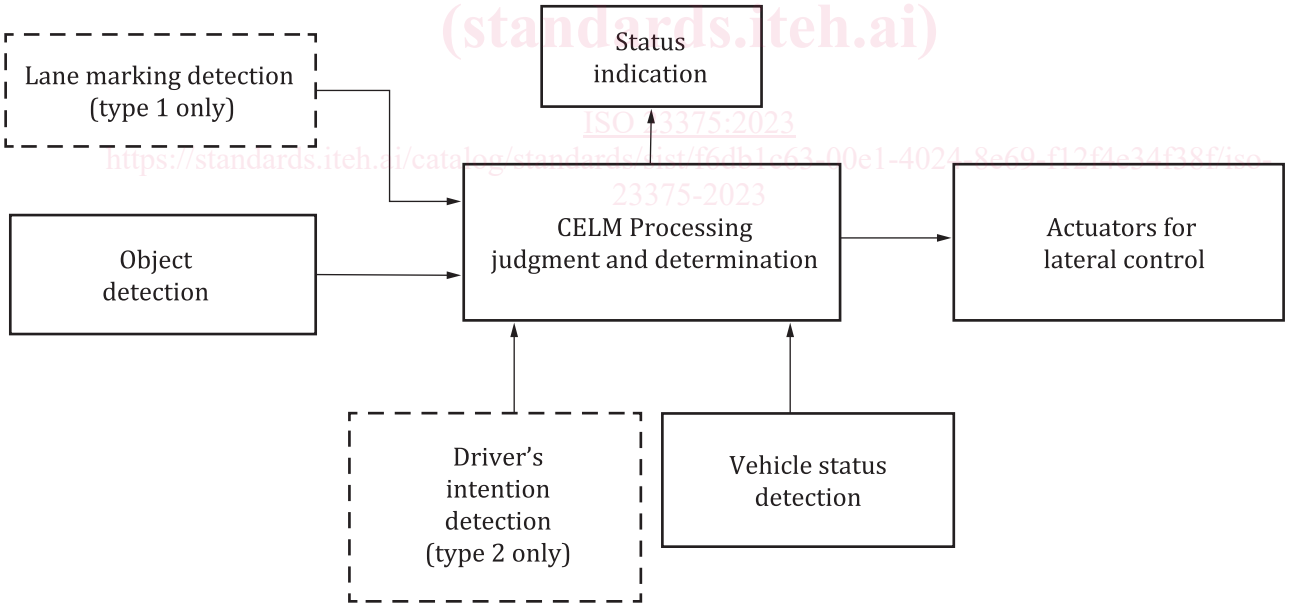
Types	Initiation	Description
Type 1	Automatic	— The evasive manoeuvre is performed automatically by the system (See Clause 7 for details). — Amount of lateral movement is restricted.
Type 2	Driver trigger	— The driver performs the evasive manoeuvre. The system supports the driver (See Clause 8 for details). — No restriction on the amount of lateral movement.

6 General functional requirements

6.1 Functional elements

The CELM shall be designed taking into consideration the functional elements shown in Figure 1.

Output to the brake actuator (e.g. activation of AEB systems) can potentially improve avoidance performance. However, the implementation methods for such a combination are not described in this document.



Key

common elements for both types

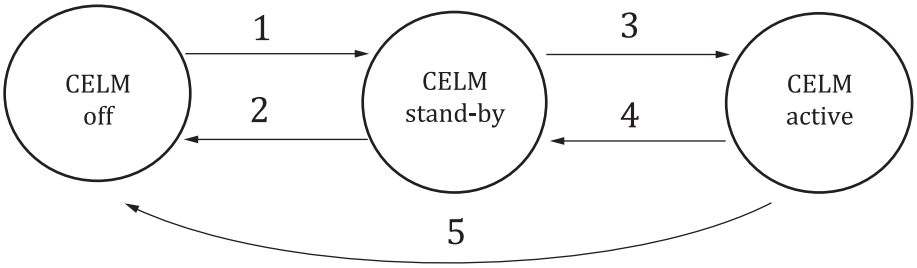
type specific elements

Figure 1 — Functional elements

6.2 State transition

A CELM shall operate according to the state transition diagram shown in Figure 2. Specific implementation beyond what is illustrated in Figure 2 is left up to the manufacturer.

The transition diagram in Figure 2 is applicable to both Type 1 and 2 systems. However, conditions for transition 3 and 4 are different.



Key

1 Ignition on
and no system failure
and CELM is switched on (optionally)

2 System failure
or ignition off
or CELM is switched off (optionally)

3 Type 1
— critical approach is predicted
— and $V_{min} \leq V_{sv} \leq V_{max}$
— and other criteria specified by manufacturer (optionally)

Type 2
— system predicts a critical approach to an object
— and the driver initiates an evasive manoeuvre
— and $V_{min} \leq V_{sv} \leq V_{max}$
— and other criteria specified by manufacturer (optionally)

4 Driver override condition satisfied
or evasive manoeuvre is completed

5 System failure
or ignition off
or CELM is switched off (optionally)

Figure 2 — State transition diagram

6.2.1 Definition of states

6.2.1.1 CELM off state

State in which the CELM is not ready for activation.

6.2.1.2 CELM stand-by state

State in which the system is ready for activation.

6.2.1.3 CELM active state

State in which the system is activated. Operating conditions and requirements defined in Clause 7 (for Type 1) or Clause 8 (for Type 2) and manufacturer-defined collision prediction conditions and minimum functional requirements shall be satisfied.

6.2.2 Transition conditions

6.2.2.1 Transition from CELM off to CELM stand-by (key element 1 of Figure 2)

The system shall transition from CELM off state to CELM stand-by state with the conditions of ignition on and no system failure. If the system is equipped with a CELM on/off switch, it shall transition from

CELM off state to CELM stand-by state with the conditions of ignition on, no system failure, and the system has not been deactivated by the driver.

6.2.2.2 Transition from CELM stand-by to CELM off (key element 2 of Figure 2)

The system shall transition from CELM stand-by state to CELM off state with the conditions of system failure or ignition off. If the system is equipped with a CELM on/off switch, it shall transition from CELM stand-by state to CELM off state when the driver deactivates CELM with the switch.

6.2.2.3 Transition from CELM stand-by to CELM active (key element 3 of Figure 2)

6.2.2.3.1 Type 1 systems

The system shall transition from CELM stand-by to CELM active state when the system predicts a collision, no driver avoidance operation is detected, and operating conditions and requirements defined in Clause 7 are satisfied.

NOTE See Annex A for examples of use cases of Type 1 systems.

6.2.2.3.2 Type 2 systems

The system shall transition from CELM stand-by to CELM active state when the system predicts a critical approach, the driver initiates an evasive manoeuvre, and operating conditions and requirements defined in Clause 8 are satisfied.

6.2.2.4 Transition from CELM active to CELM stand-by state (key element 4 of Figure 2)

The system shall transition from CELM active state to CELM stand-by state when the evasive manoeuvre is completed, or the driver overrides the system.

6.2.2.5 Transition from CELM active to CELM off (key element 5 of Figure 2)

The system shall transition from CELM active state to CELM off state with the conditions of system failure or ignition off. If the system is equipped with a CELM on/off switch, it shall transition from CELM active state to CELM off state. It is recommended for the transition to result in a gradual change of the yaw moment control.

6.3 Response to failure during CELM active state

Occurrence of a system failure during CELM active state should not result in conditions uncontrollable by the driver. Yaw moment control should fade out gradually.

6.4 Status indication

6.4.1 Active state

The system shall provide information to the driver when the system is in active state.

If the vehicle is equipped with AEB and/or lane departure prevention (LDP) systems, the display device may be commonly used to indicate the active state of multiple systems.

The driver shall be provided with an indication of active state. Specific implementation of the indication is left to the manufacturer.