INTERNATIONAL STANDARD

ISO 17361

Second edition
2017-06

Intelligent transport systems — Lane departure warning systems — Performance requirements and test procedures

Systèmes intelligents de transport — Systèmes d'avertissement de départ de ruelle — Exigences de performance et méthodes d'essai

Reference number
ISO 17361:2017(E)

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

This second edition cancels and replaces the first edition (ISO 17361:2007), of which it constitutes a minor revision with the following modifications:

— Clause 2 has been updated;

— Annex A has been deleted;

— reference to Annex A has been changed to ISO 11270 in 3.2;

— inequality signs have been updated to Unicode.

Introduction

Lane departure warning systems (LDWSs) are based on fundamental traffic rules. The main focus of an LDWS is to help the driver keep the vehicle in the lane on highways and highway-like roads. Accordingly, a warning is issued to alert the driver in case of lane departure caused by, for example, inattention. LDWSs are not intended to issue warnings with respect to collisions with other vehicles or to control vehicle motions.

Intelligent transport systems — Lane departure warning systems — Performance requirements and test procedures

1 Scope

This document specifies the definition of the system, classification, functions, human-machine interface (HMI) and test methods for lane departure warning systems. These are in-vehicle systems that can warn the driver of a lane departure on highways and highway-like roads. The subject system, which may utilize optical, electromagnetic, GPS or other sensor technologies, issues a warning consistent with the visible lane markings. The issuance of warnings at roadway sections having temporary or irregular lane markings (such as roadwork zones) is not within the scope of this document. This document applies to passenger cars, commercial vehicles and buses. The system will not take any automatic action to prevent possible lane departures. Responsibility for the safe operation of the vehicle remains with the driver.

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
lane
area of roadway that a vehicle would be expected to travel along in the absence of any obstruction without the driver's desire to change the path of travel

3.2
visible lane marking
delineators intentionally placed on the borderline of the *lane* (3.1) that are directly visible by the driver while driving (i.e. not covered by snow, etc.)

Note 1 to entry: ISO 11270:2014, Annex B gives country-specific visible lane-marking definitions.

3.3
incidental visible road feature
visible patterns on the road surface that were not explicitly intended to delineate the boundaries of the *lane* (3.1) but which are indicative of the position of the lane

Note 1 to entry: These include such features as pavement seams or edges, kerbs, and tracks or ruts left by previous vehicles.

3.4
lane boundary
borderline of the *lane* (3.1), situated at the centre of a *visible lane marking* (3.2) or, in the absence of a visible lane marking, determined by *incidental visible road features* (3.3) or other means such as GPS, magnetic nails, etc.

3.5
default lane width
predetermined width given to a *lane* (3.1) when a *visible lane marking* (3.2) exists only on one side of the lane and no other lane boundaries are detected by the system

3.6
departure
situation in which the outside of one of the front wheels of a vehicle or of the leading part of an articulated vehicle (or, in the case of a three-wheeled vehicle, the outside of one of the wheels on the axle with the widest track) is crossing a specified line

3.7
lane departure
point of *departure* (3.6) across the *lane boundary* (3.4)

3.8
rate of departure
V
subject vehicle's approach velocity at a right angle to the *lane boundary* (3.4) at the *warning issue point* (3.10)

3.9
time to line crossing
TTLC
calculated time to *lane departure* (3.7)

EXAMPLE The simplest method of calculating TTLC is to divide the lateral distance, *D*, between the predetermined part of the vehicle and the *lane boundary* (3.4) by the *rate of departure*, *V*, (3.8) of the vehicle relative to the *lane* (3.1).

3.10
warning issue point
measured location and time at which a warning starts to be issued

3.11
warning threshold
location where the warning is issued on the road, which corresponds to a warning trigger point set in the system

Note 1 to entry: In the case of *TTLC* (3.9), the warning threshold shifts depending on the *rate of departure* (3.8).

Note 2 to entry: The warning threshold is placed within the *warning threshold placement zone* (3.12) (see Figure 1).

3.12
warning threshold placement zone
zone between the earliest and the *latest warning lines* (3.17) within which the *warning threshold* (3.11) is placed

Note 1 to entry: There is one warning threshold placement zone around the left *lane boundary* (3.4) and one around the right lane boundary (see Figure 1).

3.13
warning condition
condition in which *departure* (3.6) across the *warning threshold* (3.11) occurs

Note 1 to entry: See Figure 2.

3.14
repeatability
ability of a certain percentage of warnings issued by the system to consistently fall within a given range

3.15
false alarm
alarm that is issued when the *warning conditions* (3.13) have not been fulfilled

3.16
earliest warning line
innermost limit of the *warning threshold* (3.11)

3.17
latest warning line
outermost limit of the *warning threshold* (3.11)

3.18
no warning zone
zone between the two *earliest warning lines* (3.16)

3.19
suppression request
driver request or system feature intended to prevent a *lane departure warning* (3.20) if an intended *lane departure* (3.7) is detected

3.20
lane departure warning
warning given to the driver in accordance with the lane departure warning condition in the absence of *suppression requests* (3.19)

3.21
system incapable
state of the system in which it is unable to warn the driver of a *lane departure* (3.7) due to temporary conditions

3.22
status indication
indication of system status

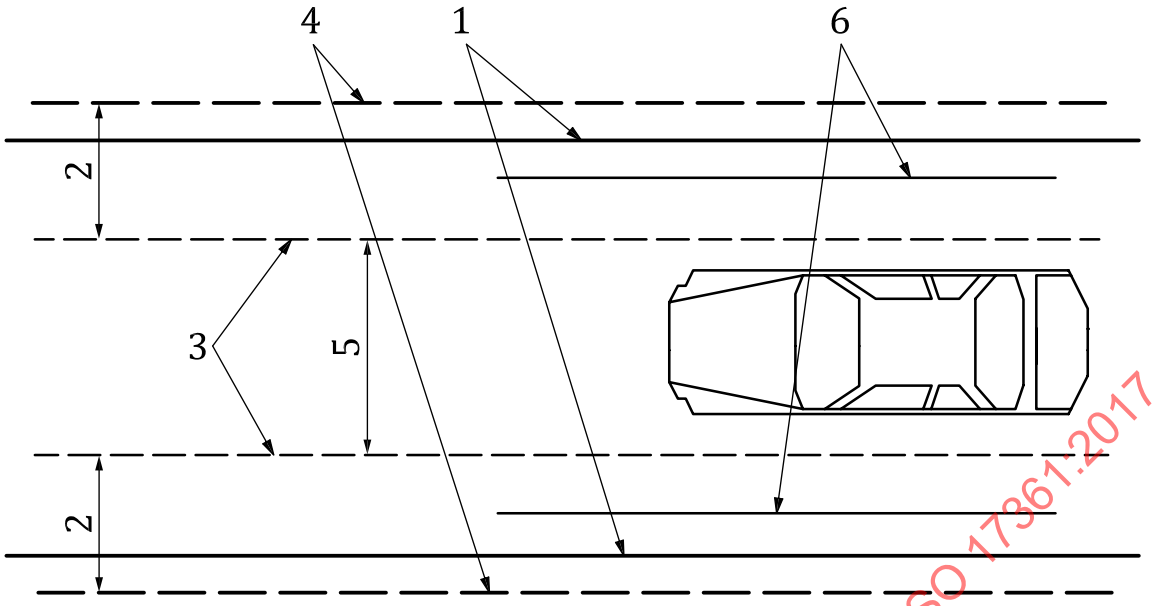
EXAMPLE On/off, failure and incapable.

3.23
haptic warning
warning that stimulates the driver's sense of touch, vibration, force and motion

EXAMPLE Steering wheel motion, steering wheel vibration, seat vibration and pedal vibration.

3.24
curve cutting
act of driving to the inner side of a curve, which can lead to an intentional *lane departure* (3.7)

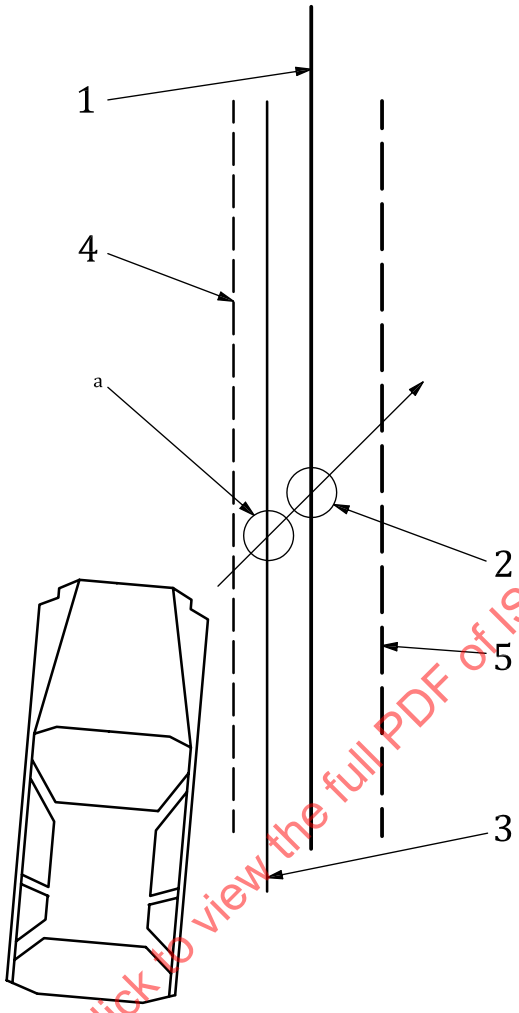
3.25
visibility
distance at which the illuminance of a non-diffusive beam of white light with a colour temperature of 2 700 K is decreased to 5 % of its original light source illuminance



Key

1 lane boundary (see 3.4)
2 warning threshold placement zone (see 3.12)
3 earliest warning line (see 3.16)
4 latest warning line (see 3.17)
5 no warning zone (see 3.18)
6 warning threshold (for reference only) (see 3.11)

Figure 1 — Concept of warning thresholds and warning threshold placement zones



Key

1 lane boundary (see 3.4)
2 lane departure (see 3.7)
3 warning threshold (see 3.11)
4 earliest warning line (see 3.16)
5 latest warning line (see 3.17)
a When warning condition is fulfilled here and there is no suppression request, a lane departure warning is issued.

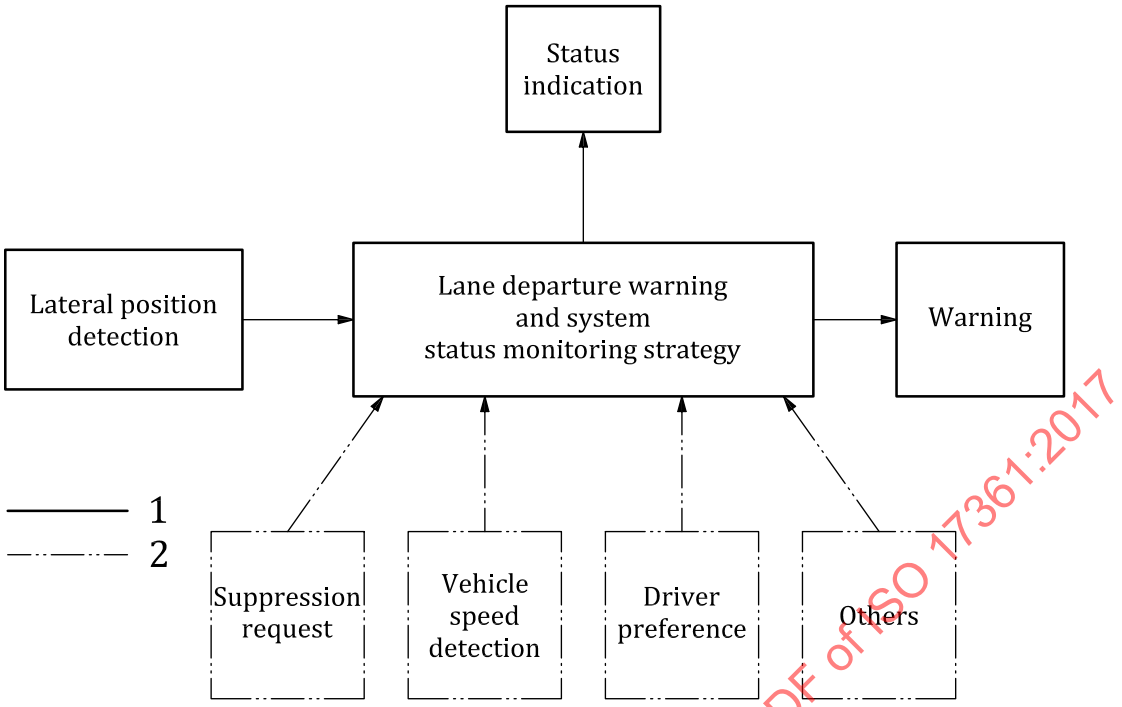
Figure 2 — Warning issue definitions

4 Specifications and requirements

4.1 System functions

The functional elements of a lane departure warning system shall be in accordance with Figure 3.

The suppression request, vehicle speed detection, driver preference and other additional functional elements are optional.



Key

1 minimum requirement

2 optional function

Figure 3 — Functional elements

4.2 System classification

Lane departure warning systems are classified as shown in Table 1. They shall be able to give warning under at least one of the curvature conditions in Table 1.

Table 1 — Classification types

Parameter	Class	
	I	II
Radius of curvature	≥500 m	≥250 m
Vehicle speed	≥20 m/s	≥17 m/s

4.3 Requirements

4.3.1 Basic requirements

The system shall perform the following functions, at the minimum.

a) Monitor system status for system failure, system incapable and system on/off (if switch is installed) conditions.

b) Indicate system status to the driver.

c) Detect the lateral position of the subject vehicle relative to the lane boundary.

d) Determine if the warning condition is fulfilled.

e) Warn the driver.

4.3.2 Operational requirements

The following operational requirements apply.

a) The system shall warn the driver when the warning condition is fulfilled.

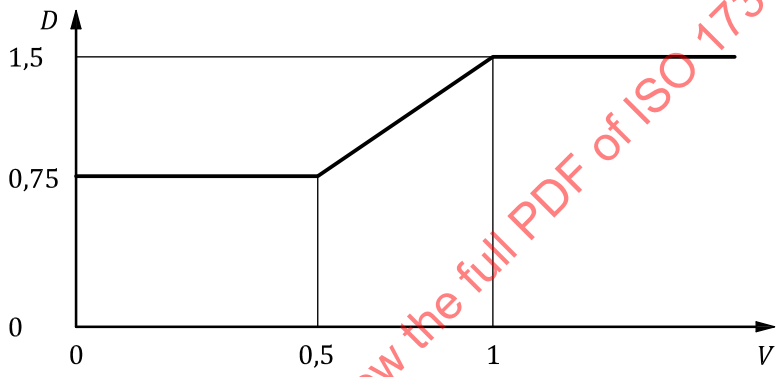
b) The latest warning line is located 0,3 m outside of the lane boundary for passenger cars and 1 m outside of the lane boundary for trucks and buses.

c) The earliest warning line is located as specified in Figure 4 and Table 2.

d) The warning shall be consistently produced around the warning threshold as verified in 5.5.2.

e) False alarms shall be minimized as verified in 5.5.2.

f) A Class I system shall be operable at speeds equal to or above 20 m/s and a Class II system shall be operable at speeds equal to or above 17 m/s. The system may operate at lower vehicle speeds.



Key

D maximum distance inside the lane boundary (m)

V rate of departure (m/s)

Figure 4 — Location of earliest warning line

Table 2 — Location of earliest warning line

Rate of departure, *V* m/s	**Maximum distance inside the lane boundary** m
$0 < V \leq 0,5$	0,75
$0,5 < V \leq 1,0$	$1,5 \times V$[a]
$1,0 < V$	1,5
[a] TTLC multiplied by rate of departure. See 3.9.	

4.3.3 Human interface requirements

The following human interface requirements apply.

a) Warning presentation.

— An easily perceivable haptic and/or audible warning shall be provided.

b) Interference with other warnings.

— Even when a vehicle is equipped with LDWS along with other warning systems such as forward vehicle collision warning system (FVCWS) , the warning shall be clearly distinguishable to the driver by a haptic, audible or visual modality, or any combination thereof.

c) Indication of the system status.

— The system status shall be indicated to the driver.

— The system status indication shall be easy to understand for the driver.

— If a failure is detected during system start-up or operation, or a system incapable is detected during operation, the driver shall be informed.

— Any symbol used to notify the driver shall be a standard symbol. For example, if a symbol is used to indicate that a system incapable condition exists, the symbol shall be the standard symbol for that message.

d) The owner's manual shall describe the minimum vehicle speed at which the system operates and the conditions for a system incapable.

4.4 Optional functions

The following are optional functions of lane departure warning systems.

a) The system may be fitted with a system on/off control that can be operated by the driver at all times.

b) The system may detect the suppression request to minimize nuisance warnings. The suppression request is issued, for example, if the driver operates a turn signal, is braking or is engaged in other high-priority manoeuvres such as crash avoidance manoeuvres.

c) The system may give an indication to the driver when warnings are suppressed.

d) Subject vehicle speed can be optionally detected for uses including suppression of warnings below the speeds identified in 4.3.2 f).

e) On roadways that contain only one lane marking, the system may use a default lane width to establish a virtual lane marking on the opposite side from the visible lane marking to issue warnings, or system incapable may be reported to the driver.

f) The warning threshold may be adjustable within the warning threshold placement zone.

g) While driving in a curve, the system may move the warning threshold farther out, allowing for curve cutting behaviour; but the warning threshold shall never be moved beyond the latest warning line.

h) When only haptic and/or audible warnings are used, the warnings may be designed to indicate the direction of the departure (position of sound source, direction of movement, etc.). If the haptic and/or audible warnings are not designed to indicate the direction, a visual cue may be used to supplement the warning.

i) The system may suppress additional warnings to avoid multiple nuisance warnings.

5 Test method

5.1 Test environment conditions

The following requirements apply.

a) The test location shall be on a flat, dry asphalt or concrete surface.

b) The temperature range shall be 10 °C ± 30 °C.

c) Visible lane markings of the test location shall be in good condition in accordance with the nationally defined visible lane markings. Also, they shall be marked in accordance with applicable standards for lane-marking design and materials.

d) The horizontal visibility range shall be greater than 1 km.

5.2 Test course conditions

The test course shall be set to within ±10 % of the minimum radius of curvature specified in Table 1 for the relevant class. The course shall be of sufficient length in order to maintain a minimum vehicle speed (17 m/s for Class I, 20 m/s for Class II) to allow drifting out of the lane at a rate of departure of 0 m/s < V ≤ 0,8 m/s.

5.3 Test vehicle conditions

The test vehicle mass shall be between complete vehicle kerb mass plus driver and test equipment (combined mass of driver and test equipment shall not exceed 150 kg) and maximum authorized total mass (see ISO 15037). No alterations shall be made once the test procedure has begun.

NOTE 1 Complete vehicle kerb mass includes lubricants, coolant, washer fluid, fuel, spare wheel, fire extinguisher, standard spare parts, chocks and standard tool-kit.

NOTE 2 Maximum authorized total mass is determined as a maximum by the administrative authority.

5.4 Test system installation and configuration

The LDWS shall be installed and configured in accordance with the instructions provided by the manufacturer. For tests of the LDWS with a user-adjustable warning threshold, each test shall be performed twice: once with the warning threshold set at its earliest setting and once with the warning threshold set at its latest setting. No alterations to the system shall be made once the test procedure has begun.

5.5 Test procedure

5.5.1 Parameters recoverable from data record

The following parameters are recoverable from a data record:

a) warning issue point;

b) rate of departure;

c) vehicle speed.

All warnings that occur during the test shall be recorded. The data shall be recovered by a device other than the system. The precision of the test device shall be noted in the test report.

5.5.2 Procedure

5.5.2.1 General

Three types of test shall be carried out:

— a test for warning generation in a curve according to curve classification (warning generation test);

— a test for repeatability on a straight course (repeatability test);

— a test for false alarms (false alarm test).

5.5.2.2 Warning generation test

The start location within the lane shall be in approximately the centre of the lane.

After the vehicle has entered the course and is smoothly tracking it so that the posture of the vehicle is stable, the vehicle shall gently drift off inside and outside of the course while taking a curve according to curve classification at a speed of 20 m/s to 22 m/s for Class I and 17 m/s to 19 m/s for Class II. The vehicle shall depart once to both the right and left sides for both ranges of rate of departure (0 m/s to 0,4 m/s and 0,4 m/s to 0,8 m/s) on a curve to the right and a curve to the left, for a total of eight departures as shown in Table 3 and Figure 5.

Table 3 — Warning generation test

Rate of departure	Right curve		Left curve	
	Left departure	Right departure	Left departure	Right departure
0 to 0,4 m/s	one trial	one trial	one trial	one trial
0,4 m/s to 0,8 m/s	one trial	one trial	one trial	one trial

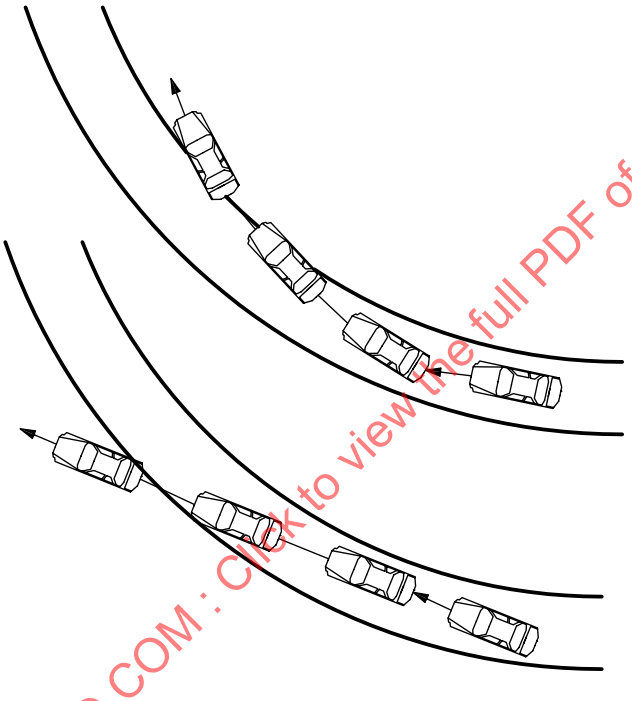


Figure 5 — Method of conducting warning generation test

5.5.2.3 Repeatability test

The repeatability test shall be conducted on a segment of straight road. The vehicle will travel straight along the segment of straight road at a speed of 20 m/s to 22 m/s for Class I and 17 m/s to 19 m/s for Class II. When travelling straight along the segment of straight road, the vehicle may travel either in the centre of the lane or along the lane marking opposite the lane marking that will be crossed at the time of lane departure. For example, when lane departure is carried out to the right, the vehicle may be driven along the left-hand lane marking and vice versa, as shown in Figure 6. While maintaining the designated speed according to the relevant class with the vehicle smoothly tracking the course so that its posture is stable, the vehicle shall be steered so as to gently depart from the lane at a rate of departure of 0,1 m/s < (V_1 ± 0,05) ≤ 0,3 m/s for eight tests [four to the left (Group 1) and four to the right (Group 2)], and at a rate of departure of 0,6 m/s < (V_2 ± 0,05) ≤ 0,8 m/s for another eight tests [four to the left (Group 3) and four to the right (Group 4)], such that a total of 16 tests are conducted. V_1 and V_2 are selected by the manufacturer. The tester shall conduct lane departure trials until four trials are achieved within each group according to the rate-of-departure tolerance given in Table 4.