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Road vehicles — Test method to evaluate the performance of lane-keeping assistance systems

Véhicules routiers — Méthode d'essai pour évaluer la performance des systèmes d'aide au maintien de la trajectoire

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics and chassis components*.

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Introduction

The main function of a lane keeping assistance system (LKAS) is to support the driver in keeping the vehicle within the current lane. LKAS acquires information on the position of the vehicle within the lane and, when required, sends commands to actuators to influence the lateral movement of the vehicle, and in turn provides status information to the driver.

This document is intended to assess the complete performance of an LKAS fitted in a road vehicle:

— the capacity to keep the vehicle within the current lane during other situations not described in this test method (more complex scenarios, other weather conditions);

— the capacity to avoid undesired lane change.

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Road vehicles — Test method to evaluate the performance of lane-keeping assistance systems

1 Scope

This document specifies test methods and performance metrics to evaluate the behaviour of a vehicle equipped with lane keeping assistance system (LKAS, see 3.2).

For this purpose, variables relevant to vehicle dynamics as well as controllability of a vehicle with LKAS and their measurement methods are defined.

A system requiring a driver intervention is excluded from the scope. This document applies to the vehicles of M1 category.

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.

ISO 8855, *Road vehicles — Vehicle dynamics and road-holding ability — Vocabulary*

ISO 15037-1:2019, *Road vehicles — Vehicle dynamics test methods — Part 1: General conditions for passenger cars*

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3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 8855, ISO 15037-1 and the following apply.

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

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

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

3.1
distance to line crossing
DTLC
remaining lateral distance (perpendicular to the line) between the inner side of the lane marking and most outer edge of the tyre, before the *vehicle under test (VUT)* (3.5) crosses the line, assuming that the VUT would continue to travel with the same lateral velocity towards the lane marking

3.2
lane keeping assistance system
LKAS
heading correction system that is applied automatically by the vehicle in response to the detection of the vehicle that is about to drift beyond a delineated edge line of the current travel lane

Note 1 to entry: There are two kind of LKAS systems: lane centring LKAS where steering intervention is constantly occurring to keep the vehicle running along the centreline of lane and lane departure prevention LKAS where steering intervention only occurs when the vehicle is imminent to cross the lane boundary. Different performance metrics can be applied for each system.

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3.3
peak braking coefficient
PBC
measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre

Note 1 to entry: Measured by using the American Society for Testing and Materials (ASTM) E1136–10 (2010) standard reference test tyre, in accordance with ASTM Method E 1337–90 (1996), at a speed of 64,4 km/h, without water delivery.

Note 2 to entry: Alternatively, the method as specified in UNECE R13-H.

3.4
time to line crossing
T_{TLC}
remaining time before the *vehicle under test (VUT)* (3.5) crosses the line, assuming that the VUT continues to travel with the same lateral velocity towards the lane marking

3.5
vehicle under test
VUT
vehicle tested according to this document with a lane keeping assistance system

3.6
vehicle width
widest point of the vehicle ignoring the rear-view mirrors, side marker lamps, tyre pressure indicators, direction indicator lamps, position lamps, flexible mudguards and the deflected part of the tyre sidewalls immediately above the point of contact with the ground

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4 Variables

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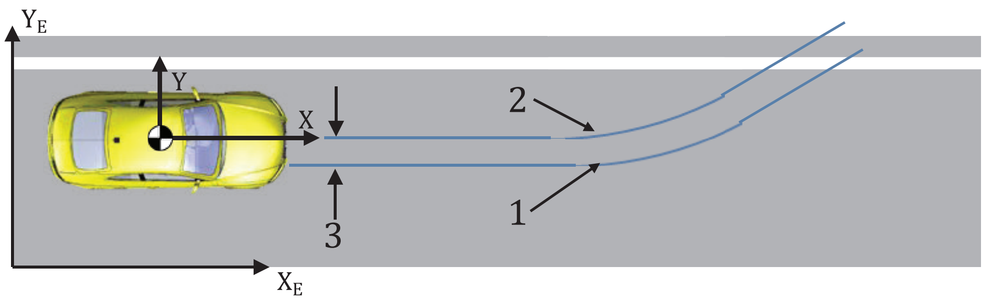
4.1 Coordinate systems

The road fixed reference system X_E-Y_E-Z_E, as shown in Figure 1, is fixed to the lane, and the vehicle fixed reference system X-Y-Z 1 is fixed to the centre of gravity (CG) of VUT.

4.2 Lateral deviation from path (Y_{VUT} error)

The lateral deviation from path is determined as the lateral distance between the centre of the front of the VUT when measured in parallel to the intended path as shown in Figure 1. This measure applies during both the straight-line approach and the curve that establishes the lane departure.



Key
1 intended path
2 actual path
3 lateral deviation from path

Figure 1 — Definition of lateral deviation from path

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4.3 Variables to be measured

Variables that shall be measured are listed in Table 1 along with notations.

Table 1 — Measured variables

Variable		Symbol
Time	Time when manoeuvre starts with 2 s of straight path	T_0
	Time when LKAS activates	T_{LKAS}
	Time when lane departure warning is issued	T_{LDW}
	Time when VUT crosses the line	$T_{crossing}$
Position	Position of the VUT during the entire test	X_{VUT}, Y_{VUT}
Speed and angular velocity	Longitudinal and lateral speed of the VUT during the entire test	$V_{longVUT}$, V_{latVUT}
	Speed when VUT crosses the line	$V_{crossing}$
	Yaw velocity of the VUT during the entire test	$\dot{\Psi}_{VUT}$
Steering wheel motion	Steering wheel velocity of the VUT during the entire test	$\dot{\Omega}_{VUT}$
	Steering wheel torque of the VUT during the entire test[a]	M_{VUT}
Lateral acceleration and jerk	Lateral acceleration of the VUT during the entire test	A_{latVUT}
	Lateral jerk of the VUT during the entire test [b]	$\dot{A}_{latVUT}$

[a] Steering wheel torque characterizes the beginning of the intervention by LKAS and determines driver's overriding capability to LKAS function.

[b] Lateral jerk is the measure of smoothness of lateral movement. Too high jerk prevents driver from correcting path when needed.

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Variables shall be sampled and recorded at a frequency of at least 100 Hz.

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5 Measuring equipment

5.1 General

VUT shall be equipped with data measurement and acquisition system to sample and record data with an accuracy of at least:

— longitudinal speed to 0,1 km/h;

— lateral and longitudinal position to 0,03 m;

— heading angle to 0,1°;

— yaw rate to 0,1°/s;

— longitudinal acceleration to 0,1 m/s^2;

— steering wheel velocity to 1,0°/s.

5.2 Transducer installation

The requirements of ISO 15037-1:2019, 5.2 shall apply. In addition, it shall be ensured that transient vehicle pitch changes do not adversely affect the measurement of the velocity and distance variables for the chosen transducer system.

5.3 Calibration

All transducers shall be calibrated according to the manufacturer instructions. In some cases, calibration may be performed immediately before testing.

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If parts of the measuring system used can be adjusted such calibration shall be performed immediately before the beginning of the tests.

5.4 Data processing

Filter the measured data as follows:

— position and speed are not filtered and are used in their raw state;

— acceleration with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz;

— yaw rate with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz;

— force with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz.

6 Test conditions

6.1 General

The test conditions shall be in accordance with ISO 15037-1:2019, Clause 6, unless otherwise specified below.

6.2 Test data

General data on the test vehicle and test conditions shall be recorded as specified in ISO 15037-1:2019, 6.4.1.

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6.3 Test track

6.3.1 General

All tests shall be carried out on a smooth, clean, dry and uniform paved road surface.

Conduct tests on a dry (no visible moisture on the surface), uniform, solid-paved surface with a consistent slope between level and 1 %. The test surface shall have a minimal peak braking coefficient (PBC) of 0,9.

The surface shall be paved and should not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) within a lateral distance of 3,0 m to either side of the test line(s) and with a longitudinal distance of 30 m ahead of the VUT from the point after the test is complete.

6.3.2 Lane marking

The tests described in this document shall use two different types of lane markings conforming to the individual lane markings (width, length of segment or void) to mark a lane with a width of 3,5 m to 3,7 m:

— dashed line with a width between 0,10 m and 0,25 m;

— solid line with a width between 0,10 m and 0,25 m.

The lane markings should be sufficiently long to ensure that there is at least 20 m of marking remaining ahead of the vehicle after the test is complete.

Lane markings for different nations are listed in Annex A.

Some proving grounds have different lane markings. In that case, difficulties to recognizing the lane should be equivalent to the lane marking.

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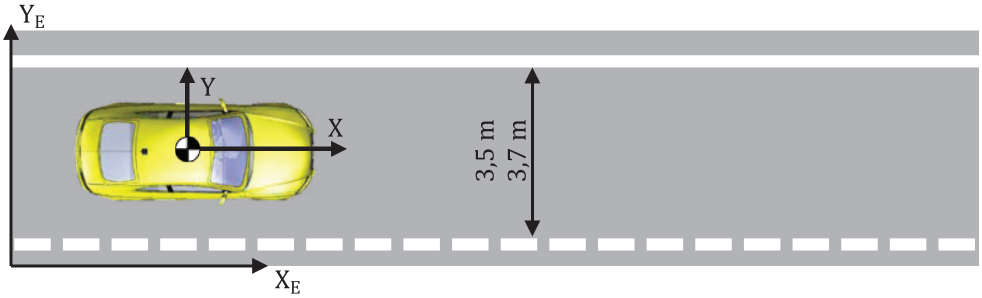

Figure 2 — Lane marking

6.4 Environmental conditions

Conduct tests in dry conditions with ambient temperature above 5 °C and below 40 °C.

For some proving ground where the low limit of ambient of 5 °C is difficult to achieve, lower value can be adopted. However, in that case, the lower limit values shall be reported.

No precipitation shall be falling and horizontal visibility at ground level shall be greater than 1 km. Wind speeds shall be below 10 m/s to minimize VUT disturbance.

Natural ambient illumination shall be homogenous in the test area and in excess of 2 000 lx for daylight testing with no strong shadows cast across the test area other than those caused by the VUT. Ensure testing is not performed driving towards, or away from the sun when there is direct sunlight.

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Measure and record the following parameters preferably at the commencement of every single test or at least every 30 min:

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— ambient temperature in °C;

— wind speed and direction in m/s;

— ambient illumination in lx.

6.5 Test vehicle

6.5.1 General condition

The test vehicle condition shall be in accordance with the vehicle manufacturer specifications, particularly with respect to the wheel alignments, power train (e.g. differentials and locks) configuration and tyre fitment.

6.5.2 LKAS settings

If different settings are available, the chosen setting shall be kept during the complete test procedure. The test procedure can be repeated for different settings if needed.

NOTE The aim of this document is to measure performance of a vehicle equipped with LKAS. It is not intended to compare performance of different vehicles, such as Euro NCAP procedure.

6.5.3 Tyres

Generally, all measurements shall be conducted with original fitment tyres mounted. If several types of tyres are available, the types of tyres shall be reported.

For a general tyre condition, new tyres shall be fitted on the test vehicle according to the manufacturer's specifications. If not specified otherwise by the tyre manufacturer, they shall be run-in according to the

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tyre conditioning procedure specified in 7.1.3. After running-in maintain the run-in tyres in the same position on the vehicle for the duration of the testing

Tyres shall have a tread depth of at least 90 % of the original value across the whole breadth of the tread and around the whole circumference of the tyre.

Tyres shall be manufactured not more than one year before the test. The date of manufacturing shall be noted in the presentation of test conditions.

Tyres shall be inflated to the pressure as specified by the vehicle manufacturer for the test vehicle configuration. The tolerance for setting the cold inflation pressure is ±5 kPa for pressures up to 250 kPa and ±2 % for pressure above 250 kPa.

6.5.4 Wheel alignment measurement

The vehicle should be subject to a vehicle (in-line) geometry check to record the wheel alignment set by the vehicle manufacturer. This should be done with "unladen kerb mass" specified in 6.5.5.

6.5.5 Loading conditions

The fuel tank shall be filled up and, in the course of the measurement sequence, the indicated fuel level should not drop below "half-full".

Check the oil level and top up to its maximum level if necessary. Similarly, top up the levels of all other fluids to their maximum levels if necessary.

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Measure the front and rear axle masses and determine the total mass of the vehicle. Record this mass in the test details.

Calculate the required ballast mass, by subtracting the mass of the test driver and test equipment so that the test mass is the "unladen kerb mass" as specified by vehicle manufacturer plus 200 kg.

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The weight distribution in a ready-for-measurement condition shall be adjusted according to the axle load distribution specified by the vehicle manufacturer for a ready-to-drive (kerb) condition.

If the vehicle is to be tested in any other load condition (for example, GVM) then the additional payload shall be evenly distributed such that cross-axle variations do not exceed 50 kg.

6.6 Vehicle preparation

Fit the on-board test equipment and instrumentation in the vehicle. Also fit any associated cables, cabling boxes and power sources.

Place weights with a mass of the ballast mass. Any items added should be securely attached to the car. With the driver in the vehicle, weigh the front and rear axle loads of the vehicle.

Compare these loads with the "unladen kerb mass".

The total vehicle mass shall be within ±1 % of the sum of the unladen kerb mass, plus 200 kg. The front/rear axle load distribution needs to be within 5 % of the front/rear axle load distribution of the original unladen kerb mass plus full fuel load. If the vehicle differs from the requirements given in this paragraph, items may be removed or added to the vehicle which has no influence on its performance. Any items added to increase the vehicle mass should be securely attached to the car.

Repeat weighing the front and rear axle load and comparison until the front and rear axle loads and the total vehicle mass are within the limits set in the above paragraph. Care should to be taken when adding or removing weight in order to approximate the original vehicle inertial properties as close as possible. Record the final axle loads in the test details. Record the axle weights of the VUT in the "as tested" condition.

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