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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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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 22, *Road vehicles*, Subcommittee SC 33, *Vehicle dynamics and chassis components*.

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

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.

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*

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 kinds of LKAS: 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.

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
$\boldsymbol{T_{\mathrm{TLC}}}$
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

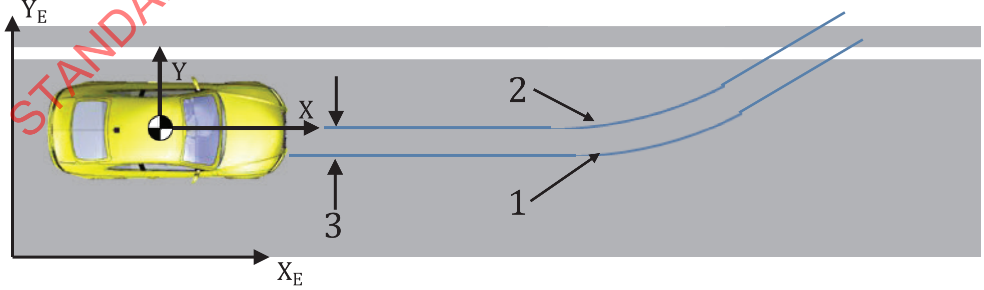
4 Variables

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 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

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.

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

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 position 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.

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.

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.

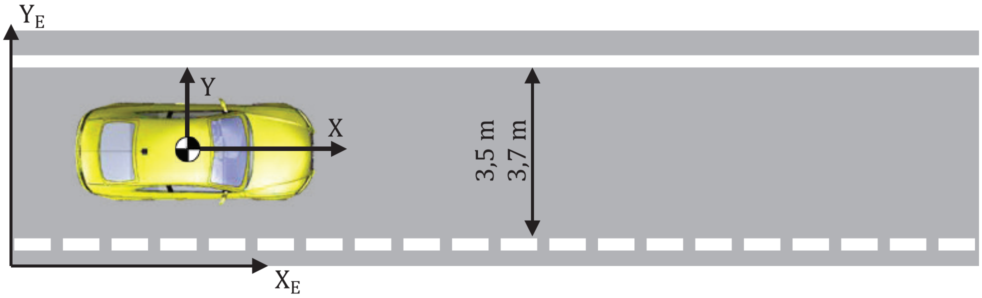


Figure 2 — Lane marking

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 temperature 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.

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

— 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 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.

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.

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.

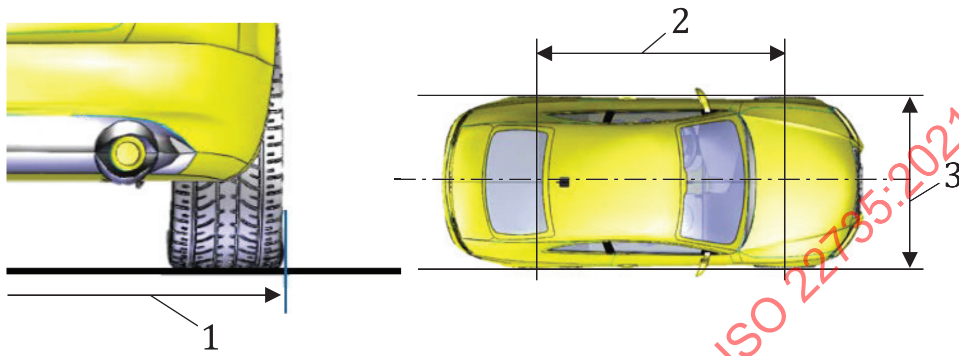
Compare these loads with the "unladen kerb mass".

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.

Vehicle dimensional measurements shall be taken. For the purposes of this test procedure, vehicle dimensions shall be represented by a two-dimensional polygon defined by the lateral and longitudinal dimensions relative to the centroid of the vehicle. The corners of the polygon are defined by the lateral and longitudinal locations where the plane of the outside edge of each tyre touches the road. This plane is defined by running a perpendicular line from the outer most edge of the tyre to the ground at the wheelbase, as illustrated in Figure 3.

The vehicle's wheelbase and the lateral and longitudinal locations shall be measured and recorded.



Key

1 definition of lateral location

2 longitudinal locations

3 lateral locations

Figure 3 — Vehicle dimensional measurements

7 Test procedure

7.1 Pre-test conditioning

7.1.1 General

A new car is used as delivered to the test laboratory however, a car may have been used for other active safety tests.

Drive a maximum of 100 km on a mixture of urban and rural roads with other traffic and roadside furniture to calibrate the sensor system. Avoid harsh acceleration and braking.

7.1.2 Brakes conditioning

If not performed already for other tests, or when the vehicle manufacturer requests, condition the vehicle's brakes in the following manner:

— perform 10 stops from a speed of 56 km/h with an average deceleration of approximately 0,5 g to 0,6 g;

— immediately following the series of 56 km/h stops, perform three additional stops from a speed of 72 km/h, each time applying enough force to the pedal to operate the vehicle's antilock braking system (ABS) for most of each stop;

— immediately following the series of 72 km/h stops, drive the vehicle at a speed of approximately 72 km/h for five minutes to cool the brakes;

— initiation of the first test shall begin within two hours after completion of the brake conditioning.

7.1.3 Tyres conditioning

Condition tyres in the following manner to remove the mould sheen:

- drive around a circle of 30 m in diameter at a speed enough to generate a lateral acceleration of approximately 0,5 g to 0,6 g for three clockwise laps followed by three anticlockwise laps;
- immediately following the circular driving, drive four passes at 56 km/h, performing 10 cycles of a sinusoidal steering input in each pass at a frequency of 1 Hz and amplitude enough to generate a peak lateral acceleration of approximately 0,5 g to 0,6 g;
- make the steering wheel amplitude of the final cycle of the final pass double that of the previous inputs.

In case of instability in the sinusoidal driving, reduce the amplitude of the steering input to an appropriately safe level and continue the four passes.

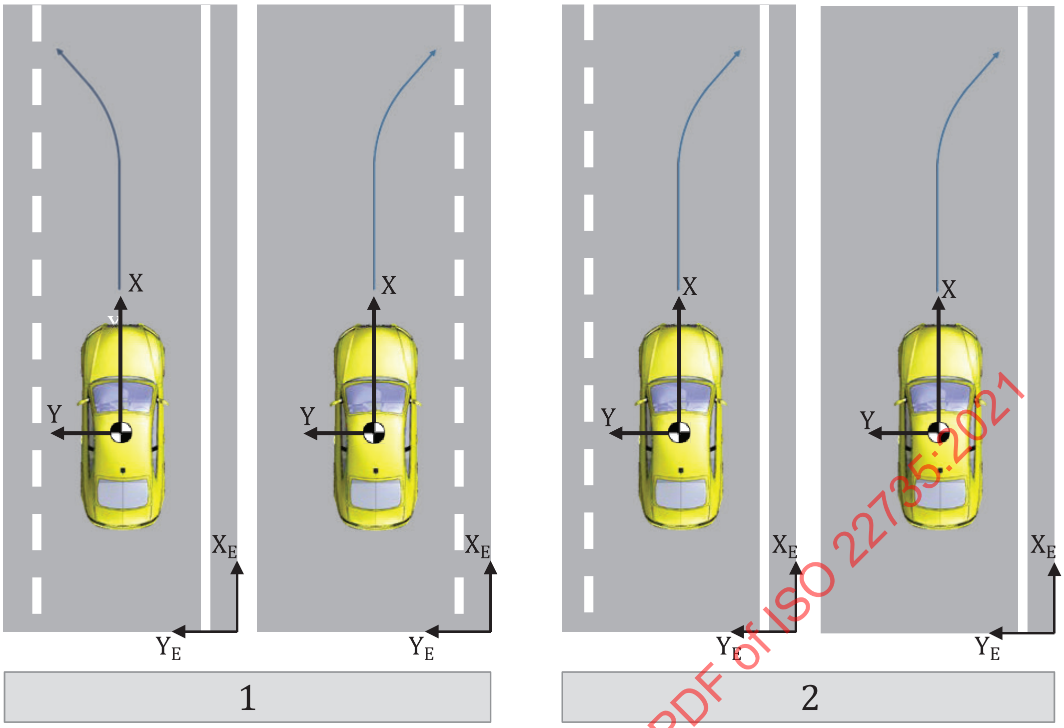
7.1.4 System check

Before any testing begins, perform a maximum of 10 runs, to ensure proper functioning of the system.

7.2 Test scenarios

The performance of the LKAS is assessed in different scenarios that are applicable to the system. Examples of scenarios are given in Figure 4, where solid and dotted lane markings are used as lane boundaries. Including these examples, any other test scenarios along with the number of tests can be selected.

NOTE An example scenario can be performing steering according to Figure 4, which requires four tests. Another example scenario can be performing steering to each dashed and solid line in any direction which requires a minimum of two tests.



Key

1 dashed line

2 solid line

Figure 4 — Test scenarios

For testing purposes, assume an initial straight-line path followed by a fixed radius of 1 200 m followed again by a straight line, hereby known as the test path. Control the VUT with driver inputs or using alternative control systems that can modulate the vehicle controls as necessary to perform the tests.

Tests shall be performed with 0,1 m/s incremental steps within the lateral velocity range of 0,2 m/s to velocity until LKAS fails.

The vehicle manufacturer shall provide information describing the location when the closed loop path and/or speed control shall be ended so as not to interfere with intervention for each test. Otherwise for each lateral velocity, two calibration runs shall be performed in order to determine when the system activates. Compare steering wheel torque, vehicle speed or yaw rate of both runs and determine where there is a notable difference that identifies the location of intervention.

Run 1: complete the required test path with the system turned OFF and measure the control parameter.

Run 2: complete the required test path with the system turned ON and measure the control parameter.

Complete the tests while ending the closed loop control before system activation. In the case of calibration runs, the release of steering control should occur on the test path and no less than 5 m longitudinally before the location of intervention.

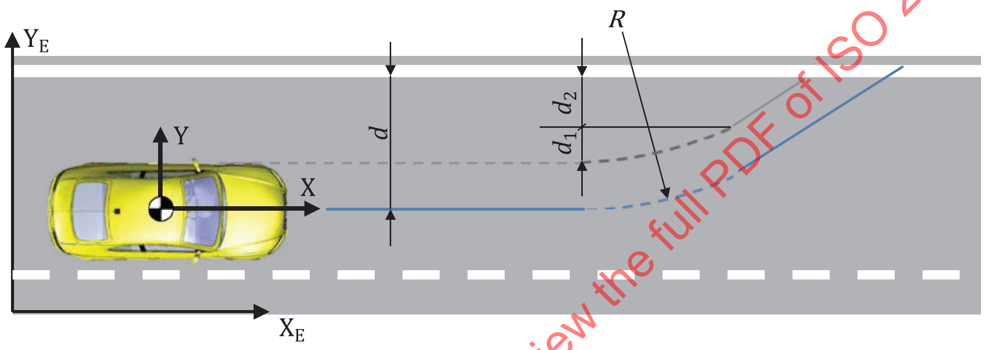
The following parameters should be used to create the test paths.

Table 2 — Test path definition

Lateral velocity [m/s]	Radius of turn [m]	Yaw angle [°]	Lateral distance during curve establishing yaw angle d_1 [m]	Lateral distance travelled during V_{lat} steady-state d_2 [m]
0,2	1 200	0,57	0,06	0,70
0,3		0,86	0,14	0,90
0,4		1,15	0,24	0,80
0,5		1,43	0,38	0,75
0,6		1,72	0,54	0,60
0,7		2,01	0,74	0,60
0,8		2,29	0,96	0,60

NOTE Offset from lane marking (d) = d_1 + d_2 + half of the vehicle width (m).

More than 0,6 m/s lateral velocity test can be performed to validate the system behaviour. In that case, the value of d_2 can be adjusted to ensure correct behaviour and this value should be reported.



Key

R = 1 200 m

Figure 5 — Test road

Before every test run, drive the VUT around a circle of maximum diameter 30 m at a speed less than 10 km/h for one clockwise lap followed by one anticlockwise lap, and then manoeuvre the VUT into position on the test path. If requested by the OEM, an initialisation run may be included before every test run.

For vehicles with an automatic transmission, select D. For vehicles with a manual transmission, select the highest gear where the RPM will be at least 1 500 at the test speed.

Between tests, manoeuvre the VUT at a maximum speed of 50 km/h and avoid riding the brake pedal and harsh acceleration, braking or turning unless strictly necessary to maintain a safe testing environment.

7.3 Test execution

Accelerate the VUT to 72 km/h. If needed for activation of LKAS, change the speed appropriately. The test shall start at T_0 and is valid when all boundary conditions are met between T_0 and T_{LKAS}:

— Speed of VUT 72 ± 1,0 km/h;

— VUT lateral deviation from test path 0 ± 0,05 m;

— Steady-state lane departure lateral velocity ±0,05 m/s;

— Steering wheel velocity ±15,0 °/s.

Steer the vehicle as appropriate to achieve the lateral velocity in a smooth controlled manner and with minimal overshoot.

The subsequent lateral velocity for the next test is incremented with 0,1 m/s. If the test ends because the vehicle has failed to intervene sufficiently it is recommended that the VUT is steered away from the impact, either manually or be reactivating the steering control of the driving robot.

8 Performance metrics

8.1 General

The following metrics can evaluate the performance of a LKAS. Record the time history of the variables in 4.3 and obtain the following characteristic values.

Any line crossing should not be interpreted as a kind of pass/fail criteria.

8.2 Lateral speed of VUT during a test run (V_{latVUT}) and last lateral speed of VUT before line crossing $(V_{latVUT})_{blc}$

For each value of V_{latVUT}, other metrics in the following subclauses are obtained and recorded as shown in Table 3. $(V_{latVUT})_{blc}$ is the maximum lateral speed of VUT before line crossing.

8.3 Lane departure warning activation time during a test run (T_{LDW}) and last lane departure warning activation time before line crossing $(T_{LDW})_{blc}$

For each value of V_{latVUT}, record corresponding T_{LDW} as shown in Table 3, where $(T_{LDW})_{blc}$ is the last T_{LDW} before line crossing.

8.4 LKAS activation time during a test run (T_{LKAS}) and last LKAS activation time before line crossing $(T_{LKAS})_{blc}$

For each value of V_{latVUT}, record corresponding T_{LKAS} as shown in Table 3, where $(T_{LKAS})_{blc}$ is the last T_{LKAS} before line crossing.

8.5 Time to line crossing during a test run (T_{TLC}) and last T_{TLC} before line crossing $(T_{TLC})_{blc}$

For each value of V_{latVUT}, record corresponding T_{TLC} as shown in Table 3, where $(T_{TLC})_{blc}$ is the last T_{TLC} before line crossing. $(T_{TLC})_{blc}$, considered with other metrics such as $(T_{LDW})_{blc}$, and $(T_{LKAS})_{blc}$.

8.6 Distance to line crossing during a test run (D_{TLC}) and last D_{TLC} before line crossing $(D_{TLC})_{blc}$

For each value of V_{latVUT}, record corresponding D_{TLC} as shown in Table 3, where $(D_{TLC})_{blc}$ is the last D_{TLC} before line crossing. $(D_{TLC})_{blc}$, considered with other metrics such as $(T_{LDW})_{blc}$, and $(T_{LKAS})_{blc}$.

8.7 Maximum yaw velocity during a test run $(\dot{\Psi}_{VUT})_{max}$ and last $(\dot{\Psi}_{VUT})_{max}$ before line crossing $(\dot{\Psi}_{VUT})_{max,blc}$

For each value of V_{latVUT}, record corresponding $(\dot{\Psi}_{VUT})_{max}$ as shown in Table 3, where $(\dot{\Psi}_{VUT})_{max,blc}$ is the last $(\dot{\Psi}_{VUT})_{max}$ before line crossing.

8.8 Maximum lateral acceleration during a test run $(A_{latVUT})_{max}$ and last $(A_{latVUT})_{max}$ before line crossing $(A_{latVUT})_{max,blc}$

For each value of V_{latVUT}, record corresponding $(A_{latVUT})_{max}$ as shown in Table 3, where $(A_{latVUT})_{max,blc}$ is the last $(A_{latVUT})_{max}$ before line crossing.

8.9 Maximum steering torque during a test run $(M_{VUT})_{max}$ and last $(M_{VUT})_{max}$ before line crossing $(M_{VUT})_{max,blc}$

For each value of V_{latVUT}, record corresponding $(M_{VUT})_{max}$ as shown in Table 3, where $(M_{VUT})_{max,blc}$ is the last $(M_{VUT})_{max}$ before line crossing.

NOTE $(M_{VUT})_{max}$ is crucial for the driver's ability to override the system.

Test results shall be reported along with all performance metrics in Table 3. Examples of test reports are given in Annex B.

Table 3 — Performance evaluation metrics

V_{latVUT} [m/s]	T_{LDW} [s]	T_{LKAS} [s]	T_{TLC} [s]	D_{TLC} [s]	$(\dot{\Psi}_{VUT})_{max}$ [a] [rad/sec]	$(A_{latVUT})_{max}$ [a] [m/s]	$(M_{VUT})_{max}$ [a, b] [Nm]
0,2							
0,3							
0,4							
0,5							
0,6							
•							
•							
$(V_{latVUT})_{blc}$	$(T_{LDW})_{blc}$	$(T_{LKAS})_{blc}$	$(T_{TLC})_{blc}$	$(D_{TLC})_{blc}$	$(\dot{\Psi}_{VUT})_{max,blc}$	$(A_{latVUT})_{max,blc}$	$(M_{VUT})_{max,blc}$
Line crossing	–	–	–	–	–	–	–

[a] Maximum value during a test run with a given V_{latVUT}.

[b] Since steering torque is not applied by either steering robot or driver during the "Lateral distance travelled during V_{lat} steady state d_2" defined in Table 1, for some LKAS where steering intervention occurs imminent to line crossing, steering torque may not be measurable.

Annex A
(informative)

Road markings

A.1 General

National road markings are specified in ISO 11270. Table A.1 states road markings and patterns of selected countries.

Table A.1 — Road markings and patterns of selected countries

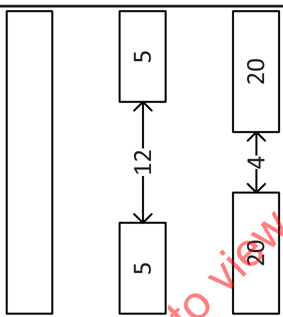
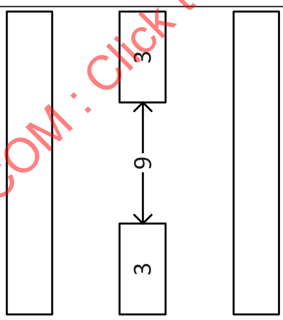
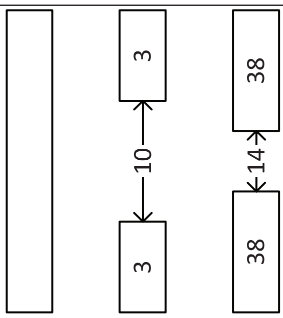
Country	Pattern (m)	Width (cm)		
		Left lane marking	Centre line	Right lane marking
Spain		20	10	20
Sweden		20	10	20
France		22	15	22

Table A.1 *(continued)*

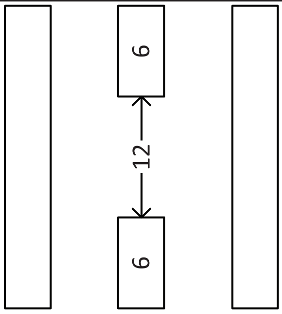
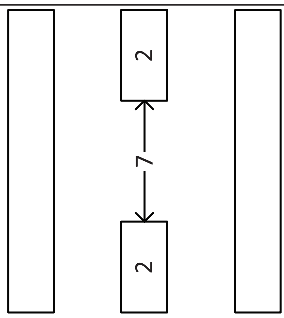
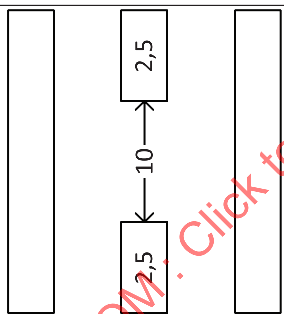
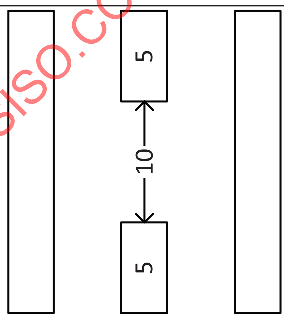
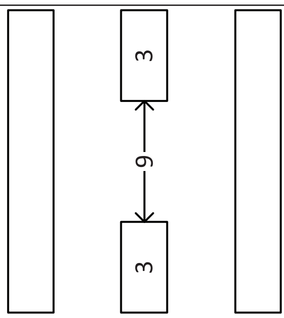
Country	Pattern (m)	Width (cm)		
		Left lane marking	Centre line	Right lane marking
Germany		15	15	30
United Kingdom		20	10	20
Belgium		30	20	30
Denmark		30	15	30
Netherlands		15	10	15

Table A.1 *(continued)*

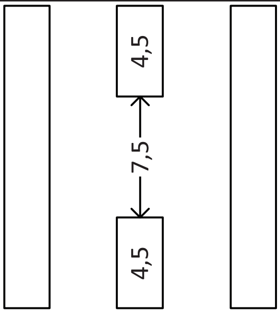
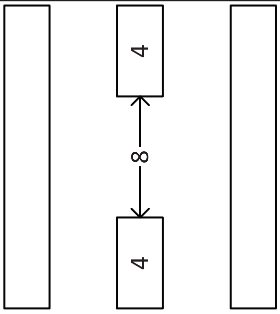
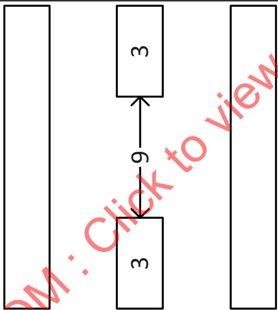
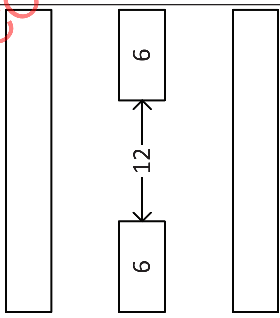
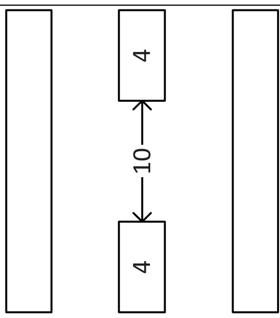
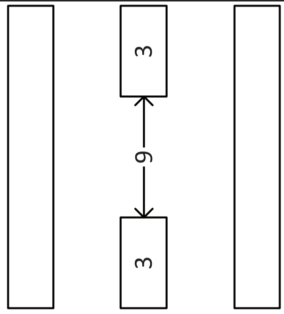
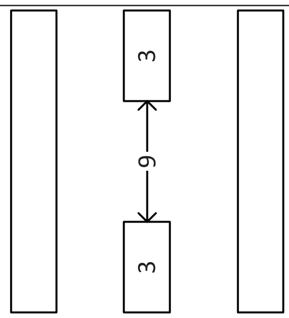
Country	Pattern (m)	Width (cm)		
		Left lane marking	**Centre line**	**Right lane marking**
Italy		15	15	15
Ireland		15	10	15
Greece		12	12	12
Switzerland		20	15	20
Portugal		20	15	20

Table A.1 *(continued)*

Country	Pattern (m)	Width (cm)		
		Left lane marking	Centre line	Right lane marking
Norway		20	15	20
Finland		20	10	20

A.2 China – lane boundary geometry

Lane width should be between 3,0 m to 3,75 m.

Lane boundary width should be 3 100 mm, 150 mm, or 200 mm wide. The interrupted marking lines should be:

— 4 m (segment) + 6 m (void) for the opposite direction;

— for the same direction, 2 m (segment) + 4 m (void) for urban areas;

— 6 m (segment) + 9 m (void) for highways.

NOTE The information about lane boundaries in China is taken from China national standard GB 5768:1999[7].

A.3 Italy – lane boundary geometry

Lane width should be between 2,5 m to 3,75 m for normal lanes and from 2 m to 3,5 m for emergency lanes. However, lanes have been also measured with approximately 4 m.

Lane boundaries should be large from 120 mm (generic), via 150 mm (highway) to 250 mm (borders). Interrupted marking lines should be:

— 3 m (segment) + 3 m (void) for urban areas;

— 3 m (segment) + 4,5 m (void) for extra urban roads;

— 4,5 m (segment) + 7,5 m (void) for highways. In special cases, other markings are possible.

NOTE The data about lane boundary geometry in Italy were taken from the "Manuale della segnaletica stradale permanente"[8].

A.4 Japan – lane boundary geometry

Lane width should be between 2,75 m to 3,5 m for generic lanes and from 3,25 m to 3,75 m for highway lanes.

Lane boundaries should be from 100 mm to 150 mm (borders) to 200 mm (centre) wide.

Lane segments and voids for interrupted marking lines should have the same length (between 3 m to 10 m) for centrelines. For borderlines, painted segments should be within 3 m to 10 m, and 6 m to 20 m for voids.

A.5 United States – lane boundary geometry

Lane width: 2,6 m to 4,2 m.

Lane marker width: 120 mm to 250 mm (250 mm for thick border markers).

Double markers, which indicate "no passing zones" on roads with tow-way traffic have two parallel painted stripes, each 100 mm wide, with approximately 80 mm between them.

Interrupted markers: for dashed markers (with voids between dashes), the mean painted dash length is approximately 4 m (2 m), with a void between dashes of approximately 6 m (2 m).

Other characteristics: pavement marker installation based on California standard plans raised pavement markers can be used in place of painted strips in marking California roads. These markers can be white or yellow, depending on the specific application, following the same logic used to determine whether painted lines are white or yellow.

There are two types of markers: non-reflective circular "dots" and rectangular reflectors.

Dots (D): diameter 100 mm, spherical section with maximum height up to 16 mm above pavement.

Reflectors (R): width 100mm, length (travel direction) 50 mm to 100 mm, height above pavement 10 mm. reflective face shall have an area of at least 1 sq in (6,45 sq cm).

These are used in place of painted lines, which are normally 100 mm wide. Where a double width painted in would be used, two rows of adjacent markers can be used instead.

To represent continuous line (no passing): markers are separated by 1,2 m, arranged in following sequence, repeated continuously: R D D D D D R D D D D D.

Where dashed lines are used, in areas where passing is permitted, or between lanes of multi-lane highways, the painted stripes can be in either of two configurations, each of which has its equivalent in markers:

— painted stripe of length 2,1 m with blank space of 5,2 m repeated continuously, or markers arranged as: R-2,4m–D-1,2m-D-1,2m-D-4,5m-D-1,2m-D-1,2m-D-2,4m-R, also repeated continuously;

— painted stripe of length 3,65 m, separated by space of 11 m, repeated continuously, or markers arranged as: R-5,5m-D-1,2m-D-1,2m-D-1,2m-D-5,5m-R, also repeated continuously.

A.6 Australia – lane boundary geometry

Lane widths 3,5 m desirable, but can range from 2,6 m in turn lanes, 2,8 m on low volume rural roads (with no edge line) and at signalised intersections to 4,5 m on freeway interchange ramps.

Longitudinal lines and their warrants vary between the eight states and territories of Australia. Line widths vary from 80 mm to 200 mm depending on the annual average daily traffic (AADT) and road type and are predominantly white. Yellow lines are used as an edge line in selected locations but are not currently use for dividing/barrier line.

Edge lines (white):

— continuous: 80 mm to 200 mm wide;

— broken: 24 m line, 1 m void with reflector (RRPM) placed in the void.

Two lane pavements between 5,5 m to 6,8 m wide can be treated with edge lines where special circumstances exist, i.e. poor alignment, fog, and similar conditions.

If lane widths are narrow, the kerb can be painted instead of an edge line or outline (adjacent a median).

Edge lines (yellow):

— continuous: 80 mm to 200 mm wide no stopping zones/clearways or in areas subject to snow;

— broken: 9 m line, 1 m gap in areas subject to snow;

— broken: 600 mm stripe and 900 mm gap in yellow for restricted parking;

— broken: 3 m line, 3 m gap for part time clearways.

Broken or interrupted markings:

— continuity lines: 1 m line, 3 m void;

— turn lines: 600 mm stripe, 600 mm void;

— special purpose: 9 m line, 3 m void;

— lane lines: 3 m line, 9 m void;

— dividing lines: 3 m line and 9 m void (most common), 9 m line and 3 m void, 6 m line and 6 m void.

Barrier lines:

— double two-way: two parallel continuous white lines;

— double one-way: one continuous line parallel to a dividing line 3 m line, 9 m void.

Raised reflective pavement markers (RRPMs) are used as part of a simulated lane line (see below) and to augment longitudinal lines. RRPMs can be placed in the void between lines and dividing lines, the void in broken edge lines or either side of a continuous edge line depending on the width of the sealed shoulder.

Simulated lane line-RRPMs and non-reflective raised pavement markers (NRPMN) are used as an alternative to the 3 m painted line and 9 m void in the order RRPM NRPM NRPM NRPM, 9 m void (and repeat).

The data in this subclause are taken from the following sources:

— Australian standard 1742.2:2009[9],

— AUSTROADS Guide to Traffic Management[10],

— AUSTROADS Guide to Road Design Part 3: Geometric Design[11],

— various state published pavement marking standards (e.g. RMS-NSW, VicRoads, Qld Main Roads, SADTI).

A.7 Netherlands – lane boundary geometry

Road markings are:

— length markings;

