Date: **2017-05-05**	**ISO/TC 22 "**Road Vehicles"
Your contact: *Valérie MAUPIN* *Direct line : + 33 (0)9.72.58.77.89* *valerie.maupin@bn-auto.com*	Doc. Number: **N 3659**

NWIP on "*Road Vehicles – Test method to evaluate the performance of lane-keeping assistance systems" (ISO/NP 22735).*

COMMENTS/ DECISIONS	Please find here attached a NWIP on "*Road Vehicles Test method to evaluate the performance of lane-keeping assistance systems ".(ISO/NP 22735)* If approved, this NWIP will be allocated to ISO/TC 22 SC33 WG3
EXPECTED ACTION	**For vote through the CIB before 2017-07-05.**
SOURCE	COREE

Form 4: New Work Item Proposal

Circulation date: 2017-05-05 Closing date for voting: 2017-07-05	Reference number: ISO/NP 22735 (to be given by Central Secretariat) ISO/TC 22 **N 3659**
Proposer (e.g. ISO member body or A liaison organization) KATS	
Secretariat AFNOR	

A proposal for a new work item within the scope of an existing committee shall be submitted to the secretariat of that committee with a copy to the Central Secretariat and, in the case of a subcommittee, a copy to the secretariat of the parent technical committee. Proposals not within the scope of an existing committee shall be submitted to the secretariat of the ISO Technical Management Board.

The proposer of a new work item may be a member body of ISO, the secretariat itself, another technical committee or subcommittee, an organization in liaison, the Technical Management Board or one of the advisory groups, or the Secretary-General.

The proposal will be circulated to the P-members of the technical committee or subcommittee for voting, and to the O-members for information.

☒ The proposer has considered the guidance given in the Annex C during the preparation of the NWIP.

Proposal (to be completed by the proposer)

Title of the proposed deliverable.

English title:

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

French title:

Véhicules routiers -- Méthode d'essai pour évaluer les performances des systèmes d'assistance de maintien de voie

(In the case of an amendment, revision or a new part of an existing document, show the reference number and current title)

Scope of the proposed deliverable.

This international standard specifies test methods to evaluate the behaviour of a vehicle equipped with LKAS (Lane Keeping Assistance System) whose purpose is to keep the vehicle within a lane at different driving situations. For this purpose relevant vehicle dynamic variables that are useful to assess the behaviour of a vehicle with LKAS and their measurement methods are defined.

This proposal is to move forward to CD stage for 2 preliminary work items studied at TC22/SC33/WG3 to evaluate performance of AEB(autonomous emergency braking) and LKAS(Lane keeping Assistance System), which are major safety enhancing components, as well as critical technology for achieving autonomous driving;

ISO/PWI 20351 Road vehicles -- Test method to evaluate the performance of autonomous braking systems

ISO/PWI 20352: Road vehicles —Test method to evaluate the performance of lane-keeping assistance systems

Purpose and justification of the proposal*

The main function of a Lane Keeping Assistance System (LKAS) is to support the driver in keeping the vehicle within the current lane in different driving situations. This function is essential for autonomous driving as well as enhancing safety of vehicle.

Currently different types of LKAS's are actively developed worldwide, and adoption to the vehicle is increasing rapidly.

However, up to now, there has been no standard to practically evaluate dynamic performance of LKAS including the behaviour of vehicle equipped with it. This standard 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

Consider the following: Is there a verified market need for the proposal? What problem does this standard solve? What value will the document bring to end-users? See Annex C of the ISO/IEC Directives part 1 for more information. See the following guidance on justification statements on ISO Connect:
https://connect.iso.org/pages/viewpage.action?pageId=27590861

Preparatory work (at a minimum an outline should be included with the proposal)

☒ A draft is attached ☐ An outline is attached ☐ An existing document to serve as initial basis

The proposer or the proposer's organization is prepared to undertake the preparatory work required:

☒ Yes ☐ No

If a draft is attached to this proposal:

Please select from one of the following options (note that if no option is selected, the default will be the first option):

☐ Draft document will be registered as new project in the committee's work programme (stage 20.00)

☒ Draft document can be registered as a Working Draft (WD – stage 20.20)

☐ Draft document can be registered as a Committee Draft (CD – stage 30.00)

☐ Draft document can be registered as a Draft International Standard (DIS – stage 40.00)

Is this a Management Systems Standard (MSS)?

☐ Yes ☒ No

NOTE: if Yes, the NWIP along with the Justification study (see Annex SL of the Consolidated ISO Supplement) must be sent to the MSS Task Force secretariat (tmb@iso.org) for approval before the NWIP ballot can be launched.

Indication(s) of the preferred type to be produced under the proposal.

☒ International Standard ☐ Technical Specification

☐ Publicly Available Specification ☐ Technical Report

Proposed development track

☐ 1 (24 months) ☐ 2 (36 months - default) ☒ 3 (48 months)

Note: Good project management is essential to meeting deadlines. A committee may be granted only one extension of up to 9 months for the total project duration (to be approved by the ISO/TMB).

Known patented items (see ISO/IEC Directives, Part 1 for important guidance)

☐ Yes ☒ No

If "Yes", provide full information as annex

Co-ordination of work: To the best of your knowledge, has this or a similar proposal been submitted to another standards development organization?

☐ Yes ☒ No

If "Yes", please specify which one(s):

A statement from the proposer as to how the proposed work may relate to or impact on existing work, especially existing ISO and IEC deliverables.
The proposer should explain how the work differs from apparently similar work, or explain how duplication and conflict will be minimized.

New work item, no influence on current project

A listing of relevant existing documents at the international, regional and national levels.

ISO 11270 Intelligent transport systems — Lane keeping assistance systems(LKAS) -- Performance requirements and test procedures

Please fill out the relevant parts of the table below to identify relevant affected stakeholder categories and how they will each benefit from or be impacted by the proposed deliverable(s).

	Benefits/impacts	Examples of organizations / companies to be contacted

Industry and commerce large industry	Car manufacturers and suppliers can establish standardized test method to measure performance of LKAS and vehicle equipped with it.	
Industry and commerce SMEs		
Government		
Consumers		
Labour		
Academic and research bodies		
Standards application businesses		
Non-governmental organizations		
Other (please specify)		

Liaisons: A listing of relevant external international organizations or internal parties (other ISO and/or IEC committees) to be engaged as liaisons in the development of the deliverable(s).	**Joint/parallel work:** **Possible joint/parallel work with:** ☐ IEC (please specify committee ID) ☐ CEN (please specify committee ID) ☐ Other (please specify)

A listing of relevant countries which are not already P-members of the committee. Note: The committee secretary shall distribute this NWIP to the countries listed above to see if they wish to participate in this work

Proposed Project Leader (name and e-mail address) Dr. Taeoh Tak totak@kangwon.ac.kr	**Name of the Proposer** (include contact information) Dr. Taeoh Tak totak@kangwon.ac.kr

This proposal will be developed by:

☐ An existing Working Group:

☐ A new Working Group:

(Note: establishment of a new WG must be approved by committee resolution)

☐ The TC/SC directly

☒ To be determined: ISO/TC 22 SC33 WG3

Supplementary information relating to the proposal

☒ This proposal relates to a new ISO document

☐ This proposal relates to the adoption as an active project of an item currently registered as a Preliminary Work Item

☐ This proposal relates to the re-establishment of a cancelled project as an active project

Other:

☐ Annex(es) are included with this proposal (give details)

Additional information/question(s)

ISO/TC 22/SC 33/WG3 N

Date: 2017-03-22

Secretariat: AFNOR

Road vehicles — Performances evaluation of lane-keeping assistance systems — Requirements and test methodsRoad vehicles — Performances evaluation of lane-keeping assistance systems — Requirements and test methods

Élément introductif — Élément central — Élément complémentaire

Warning

This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Document type: International Standard
Document subtype:
Document stage:
Document language: E

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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 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO t.b.d. was prepared by technical Committee ISO/TC 22, *Road Vehicles*, Subcommittee SC 33,

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 standard 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 — Performances evaluation of lane-keeping assistance systems — Requirements and test methods

1 Scope

This international standard specifies test methods to evaluate the behaviour of a vehicle equipped with LKAS (Lane Keeping Assistance System) whose purpose is to keep the vehicle within a lane at different driving situations. For this purpose relevant vehicle dynamic variables that are useful to assess the behaviour of a vehicle with LKAS and their measurement methods are defined.

A system requiring a driver intervention is excluded from the scope

This standard applies to the vehicles of M1 category

2 Normative references

The following standards contain provisions, which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 8855:2011, *Road vehicles - Vehicle dynamics and road holding ability – Vocabulary.*

ISO 15037-1:2006, *Road vehicles – Vehicle dynamics test methods – Part 1: General conditions for passenger cars.*

ISO 11270:2014, Intelligent transport system – Lane keeping assistance systems (LKAS) – Performance requirements and test procedures.

ISO 20531 :20xx, Road vehicles -- Test method to evaluate the performance of autonomous emergency braking systems -- Part 1 : car to car

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 8855 and the general conditions given in ISO 15037-1 shall apply.

3.1 Peak braking coefficient (PBC)

The measure of tyre to road surface friction based on the maximum deceleration of a rolling tyre, measured using the American Society for Testing and Materials (ASTM) E1136-10 (2010) standard reference test tyre, in accordance with ASTM Method E 1337-90 (reapproved 1996), at a speed of 64.4km/h, without water delivery. Alternatively, the method as specified in UNECE R13-H.

3.2 Lane keeping assist 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 or road edge of the current travel lane.

3.3 Vehicle width

The widest point of the vehicle ignoring the rear-view mirrors, side marker lamps, tyre pressure indicators, direction indicator lamps, position lamps, flexible mud-guards and the deflected part of the tyre side-walls immediately above the point of contact with the ground.

3.4 Vehicle under test (VUT)

The vehicle tested according to this protocol with a Lane Keep Assist and/or Lane Departure Warning system.

3.5 Time to line crossing (TTLC)

The remaining time before the VUT crosses the line or road edge, assuming that the VUT would continue to travel with the same lateral velocity towards the lane marking.

3.6 Distance to line crossing (DTLC)

The remaining lateral distance (perpendicular to the line or road edge) between the inner side of the lane marking or road edge and most outer edge of the tyre, before the VUT crosses the line or road edge, assuming that the VUT would continue to travel with the same lateral velocity towards the lane marking or road edge

4 Variables

4.1 Coordinate system

The reference system specified in ISO 8855:1991 shall apply.

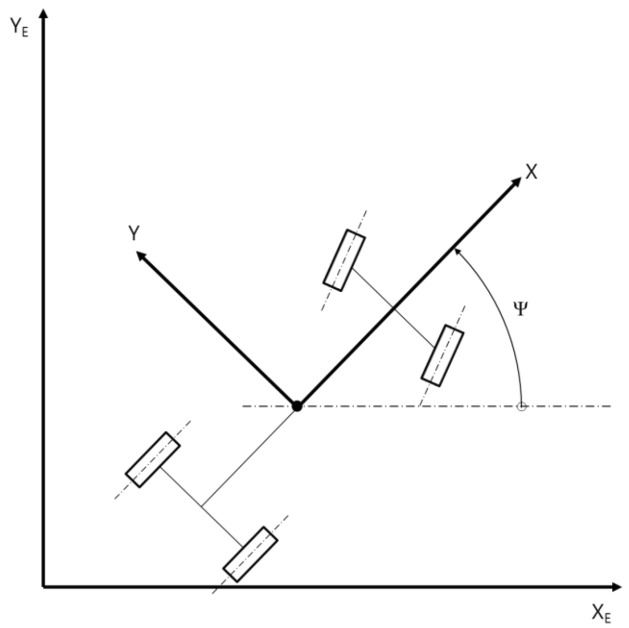

Figure 1. Coordinate system

4.2 Lateral offset

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 the figure below. This measure applies during both the straight line approach and the curve that establishes the lane departure.

Lateral Deviation from Path = Y_{VUT} error

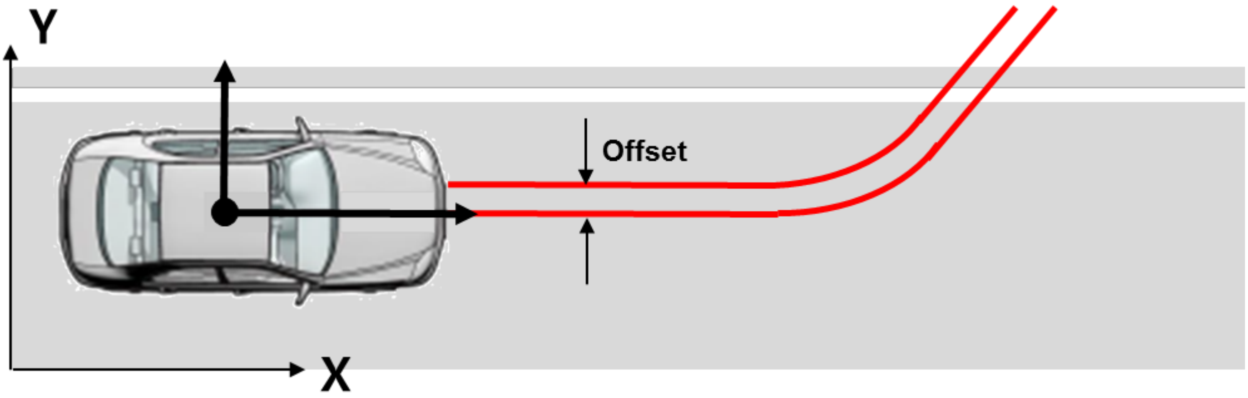

Figure 2. Definition of lateral offset

4.3 Variables to be measured (to be discussed and determined)

- Time	**T**
○ T_0, time when manoeuvre starts with 2 seconds of straight path	$\mathbf{T}_0$
○ T_{LKAS}, time when LKAS activates	$\mathbf{T}_{LKAS}$
○ $T_{crossing}$, time where VUT crosses the line or road edge	$\mathbf{T}_{crossing}$
- Position of the VUT during the entire test	$\mathbf{X}_{VUT}$, $\mathbf{Y}_{VUT}$
- Speed of the VUT during the entire test	$\mathbf{Vlong}_{VUT,,}$
	$\mathbf{Vlat}_{VUT}$
○ Speed when VUT crosses the line or road edge	$\mathbf{V}_{crossing}$
- Yaw velocity of the VUT during the entire test	$\dot{\Psi}_{VUT}$
- Steering wheel velocity of the VUT during the entire test	$\mathbf{\Omega}_{VUT}$
- Steering wheel torque of the VUT during the entire test	$\mathbf{M}_{VUT}$
- Lateral Acceleration of the VUT during the entire test	$\mathbf{Alat}_{VUT}$
- Lateral Jerk of the VUT during the entire test	$\dot{\mathbf{A}}\mathbf{lat}_{VUT}$

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

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 0.1km/h;
- lateral and longitudinal position to 0.03m;
- heading angle to 0.1°;
- yaw rate to 0.1°/s;
- longitudinal acceleration to 0.1m/s2;
- steering wheel velocity to 1.0°/s.

5.2 Transducer installation

The requirements of ISO 15037-1, Paragraph 4.2 shall apply. In addition, it must 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 manufacturers' 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 10Hz
- Yaw rate with a 12-pole phaseless Butterworth filter with a cut off frequency of 10Hz
- Force with a 12-pole phaseless Butterworth filter with a cut off frequency of 10 Hz.

6 Test conditions

The test conditions shall be in accordance with ISO 15037-1 Clause 5, unless otherwise specified below.

6.1 Test data

General data on the test vehicle and test conditions shall be recorded as specified in clause 5.4.1 of ISO 15037-1:

6.2 Test track

6.2.1 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 3.0m to either side of the test line(s) and with a longitudinal distance of 30m ahead of the VUT from the point after the test is complete.

6.2.2 Line Marking and Road Edge

The tests described in this Standard require use of two different types of lane markings conforming to one of the lane markings as defined in UNECE Regulation 130 to mark a lane with a width of 3.5 to 3.7m and a road edge:

- Dashed line with a width between 0.10 and 0.25m
- Solid line with a width between 0.10 and 0.25m
- Road Edge consisting of grass and/or gravel

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

Lane markings for different nations are listed in Annex A.

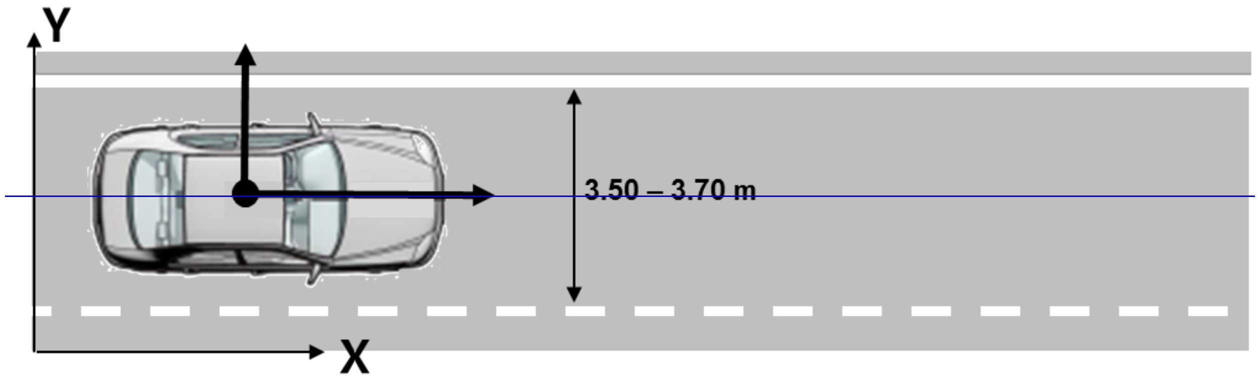

Figure 3. Lane marking

6.3 Environmental conditions

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

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

Natural ambient illumination shall be homogenous in the test area and in excess of 2000 lux 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 minutes:

- Ambient temperature in °C;
- Track Temperature in °C;
- Wind speed and direction in m/s;
- Ambient illumination in Lux.

6.4 Test vehicle

6.4.1 General condition

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

6.4.2 LKAS settings

Set any driver configurable elements of the system to the middle setting or midpoint and then next latest setting similar to the examples shown in Figure 4.

Setting 1 **Setting 2**

Early Setting 1 **Setting 2** Setting 3 Late

Setting 1 Setting 2 **Setting 3** Setting 4

Figure 4: System setting for testing

The test procedure can be repeated for different settings if needed,

6.4.3 Tyres

Generally, all measurements shall be conducted with summer tyres mounted.

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 8.1.2. 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 kPa1) for pressures up to 250 kPa and ±2 % for pressure above 250 kPa.

6.4.4 Wheel Alignment Measurement

The vehicle should be subject to a vehicle (in-line) geometry check to record the wheel alignment set by the OEM. This should be done with 'unladen kerb mass' specified in 6.4.5

6.4.5 Loading conditions

The fuel tank shall be full 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

6.5 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 200kg. 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 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 using the standard SAE coordinate system. The corners of the polygon are defined by the lateral and longitudinal locations where the plane of the outside edge of each tyre makes contact with 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 5.

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

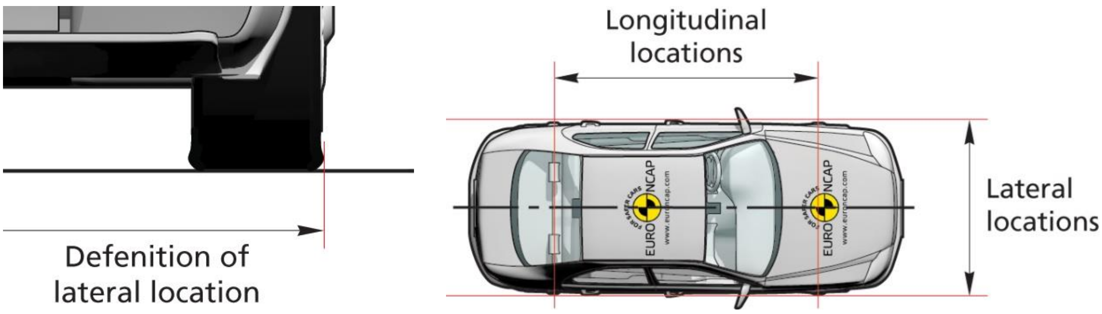

Figure 5: Vehicle dimensional measurements

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 Euro NCAP active safety tests

Drive a maximum of 100km 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 ten stops from a speed of 56km/h with an average deceleration of approximately 0.5 to 0.6g.
- Immediately following the series of 56km/h stops, perform three additional stops from a speed of 72km/h, each time applying sufficient force to the pedal to operate the vehicle’s antilock braking system (ABS) for the majority of each stop.
- Immediately following the series of 72km/h stops, drive the vehicle at a speed of approximately 72km/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 30m in diameter at a speed sufficient to generate a lateral acceleration of approximately 0.5 to 0.6g for three clockwise laps followed by three anticlockwise laps.
- Immediately following the circular driving, drive four passes at 56km/h, performing ten cycles of a sinusoidal steering input in each pass at a frequency of 1Hz and amplitude sufficient to generate a peak lateral acceleration of approximately 0.5 to 0.6g.
- 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 ten 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

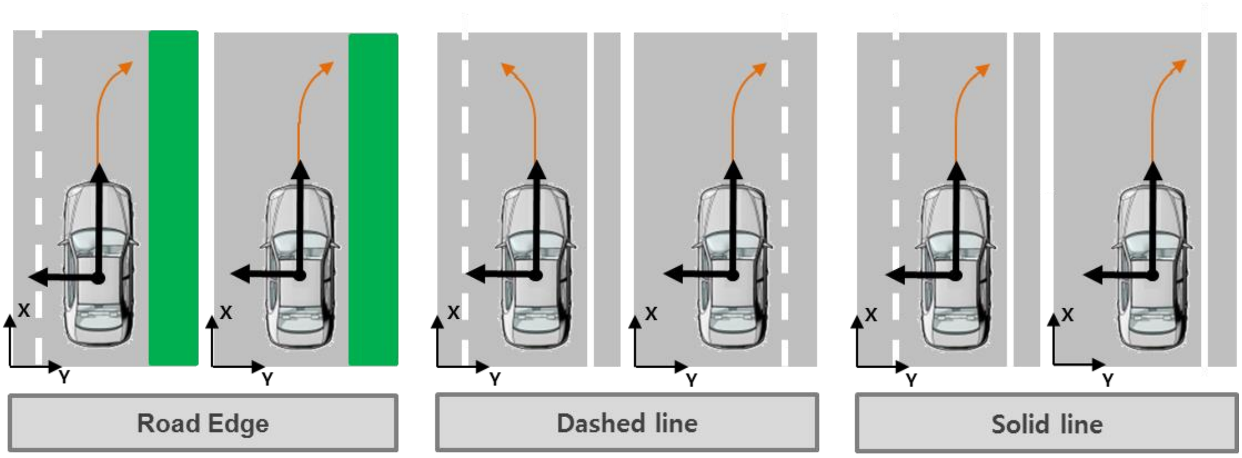

Figure 6. Test scinarios

For testing purposes, assume an initial straight line path followed by a fixed radius of 1200m 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 0.2 m/s incremental steps within the lateral velocity range of 0.2 to 1.0m/s for both left and right hand side departures. For lateral velocities of 0.6m/s and greater, continue testing as long as the system continues to intervene.

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 5m longitudinally before the location of intervention.

The following parameters should be used to create the test paths

Table 1. Test path definition

Lateral velocity [m/s]	Radius of Turn [m]	Yaw Angle [°]	Lateral deviation during curve establishing yaw angle [m]	Lateral distance travelled during Vlat steady state [m]	Lateral Offset [m]
0.2	1200	0.57	0.06	0.70	*d=d1*
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	0.53	
0.8		2.29	0.96	0.40	
0.9		2.58	1.22	0.23	
1.0		2.86	1.50	0.00	

Where the offset from lane marking (d1):

d1 = Lateral distance travelled during Vlat steady state (m)
+ Lateral deviation during curve establishing yaw angle (m)
+ Half of the vehicle width (m)

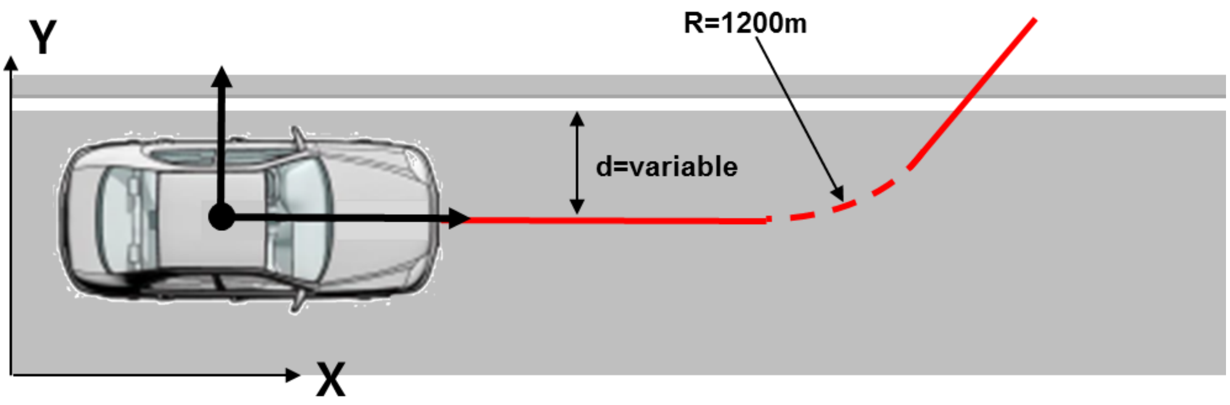

Figure 7. Test road

7.3 Test conduct

Before every test run, drive the VUT around a circle of maximum diameter 30m at a speed less than 10km/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 1500 at the test speed.

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

7.4 Test execution

Accelerate the VUT to 72 km/h.

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 (GPS-speed) 72 ± 1.0km/h
- VUT Lateral deviation from test path 0 ± 0.05m
- Steady state lane departure lateral velocity ± 0.05m/s
- Steering wheel velocity ± 15.0°/s
- Lateral acceleration of VUT ± 0.15m/s^2

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

The end of test is considered as when one of the following occurs:

- The LKAS fails to maintain the VUT within the permitted lane departure distance.
- The LKAS intervenes to maintain the VUT within permitted lane departure distance, such that a maximum lateral position is achieved that subsequently diminishes causing the VUT to turn back towards the lane.

The test is considered complete 2 seconds after one of the above occurs.

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.

The subsequent lateral velocity for the next test is incremented with 0.1m/s.

Annex A
(informative)
Road Markings

A.1 General

For the application of national road marking, refer to Annex B of ISO 11270:2014.

PATTERN			COUNTRY	WIDTH		
Left edge Lane marking	**Centre line**	**Right edge Lane marking**		**Left edge Lane marking**	**Centre line**	**Right edge Lane marking**
	5m 12m	20m 4m	**SPAIN**	20cm	10cm	20cm
	3m 9m		**SWEDEN**	20cm	10cm	20cm
	3m 10m	38m 14m	**FRANCE**	22.5cm	15cm	22.5cm
	6m 12m		**GERMANY**	15cm	15cm	30cm
	2m 7m		**UNITED KINGDOM**	20cm	10cm	20cm

PATTERN			COUNTRY	WIDTH		
Left edge Lane marking	Centre line	Rigth edge Lane marking		Left edge Lane marking	Centre line	Right edge Lane marking
	2.5m 10m		**BELGIUM**	30cm	20cm	30cm
	5m 10m		**DENMARK**	30cm	15cm	30cm
	3m 9m		**THE NETHERLANDS**	15cm	10cm	15cm
	4.5m 7.5m		**ITALY**	15cm	15cm	15cm
	4m 8m		**IRELAND**	15cm	10cm	15cm

PATTERN			COUNTRY	WIDTH		
Left edge Lane marking	**Centre line**	**Rigth edge Lane marking**		**Left edge Lane marking**	**Centre line**	**Right edge Lane marking**
	3m 9m		**GREECE**	12cm	12cm	12cm
	6m 12m		**SWITZERLAND**	20cm	15cm	20cm
	4m 10m		**PORTUGAL**	20cm	15cm	20cm
	3m 9m		**NORWAY**	20cm	15cm	20cm
	3m 9m		**FINLAND**	20cm	10cm	20cm

A.2 CHINA – Lane boundary geometry

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

Lane boundary width should be3 100mm, 150mm, or 200mm wide

Interrupted marking lines should be:

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

- For same direction, 2m (segment) + 4m (void) for urban areas

- 6m (segment) + 9m (void) for highway.

Note the information about lane boundaries in china is taken from china national standard GB 5768:1999

A.3 ITALY – Lane boundary geometry

This is the information we have regarding lane boundary regulations in Italy.

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

Lane boundaries should be large from 120 mm (generic) to 150mm (highway) to 250 mm (borders)

Interrupted marking lines should be:

- 3m (segment) + 3m (void) for urban areas;
- 3m (segment) + 4,5m (void) for extra urban roads;
- 4,5m (segment) + 7.5m (void) for highways.

In special cases, other markings are possible.

The data about lane boundary geometry in Italy were taken from the “Manuale della segnaletica stradale” ,ACINNOVA.

A.4 JAPAN – Lane boundary geometry

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

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

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

A.5 USA – Road markings in the USA

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

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

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

Interrupted markers:

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

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 100mm, spherical section with maximum height up to 16mm above pavement.

Reflectors (R): width 100mm,length (travel direction) 50mm to 100mm, height above pavement 10mm. reflective face shall have an area of at least 1 sq in (6.45sq cm).

These are used in place of painted lines, which are normally 100mm 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 1,2m, 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 2,1m with blank space of 5,2m repeated continuously, or markers arranged a s: 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 3,65m, separated by space of 11m, repeated continuously, or markers arrang ed 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-3,5m desirable, but can range from 2,6m in turn lanes, 2,8m on low volume rural roads (with no edge line) and at signallised intersections to 4,5m on freeway interchange ramps

Longitudinal lines and their warrants vary between the eight states and territories of Australia Line widths vary from 80mm to 200mm 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 5,5m to 6,8m 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: 80mm to 200mm wide no stopping zones/clearways or in areas subject to snow

- broken: 9m line, 1 m gap in areas subject to snow
- broken: 600mm stripe and 900mm gap in yellow for restricted parking
- broken: 3m line, 3m gap for part time clearways

Broken or Interrupted markings

- Continuity lines: 1m line, 3m void
- Turn lines: 600mm stripe, 600mm void
- Special purpose: 9m line, 3m void
- Lane lines: 3m line, 9m void
- Dividing lines: 3m line and 9m void (most common), 9m line and 3m void, 6m line and 6m 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)-used as part of a simulated lane line (see below) and to augment longitudinal lines. RRPM's 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-RRPMsand Non-reflective Raised Pavement Markers(NRPMN) used as an alternative to the 3m painted line and 9m void in the order RRPM NRPM NRPM NRPM, 9m void(and repeat).

Sources:

Australian standard 1742.2~2009 Manual of Uniform Traffic control Devices Part 2: Traffic Control devices for general use

AUSTROADs Guide to Traffic Management Part 10: Traffic control Devices and Communication Devices

AusTROADs Guide to Road Design Part 3: Geometric Design

Various state published pavement marking standards(eg RMS-NSW, VicRoads, Qld Main Roads, SADTI)

A.7 NETHERLANDS – Road markings in the Netherlands

Road markings are:

- Length markings
- Cross markings
- Other markings
    - arrow markings
    - expel markings

- angle markings
- symbols and traffic markings

The traffic area (carriageway and traffic lanes) is bounded by length markings which generally trends parallel to the axis of the road. Length markings can occur as a uninterrupted or interrupted (broken) line and can be divided into edge lines and centre or separation lines. Dependent on the position of the marking, the width of the line differs. For interrupted lines, the length of segments and voids depends on the meaning of the marking. For a centerline, a combination of an uninterrupted and/or broken line (spaced out equal to the width of line) is possible.

The requirements for the marking width and the lane width can be spilt up in two: freeways and non-freeways.

Freeways or motor ways

- 120 km/h-roads:
  - lane width (separation lines included and edge lines excluded): 3,50m
  - edge line 0,20m width
  - separation line 0,15 m width

In special other lane widths are possible.

Rural roads (non-freeways)

- 60km/h-roads
  - lane width (markings excluded):2,75m
  - width of edge line and centre of separation line:0,10 m
- 80km/h-roads:
  - lane width (markings excluded):3,10 m
  - edge line 0,15 m wide
  - centre of separation line 0,10 m wide
- 100km/h-roads:
  - lane width (markings excluded):3,25 m
  - edge line 0,15 m wide
  - centre of separation line 0,10 m wide

In special cases other lane widths are possible

A.8 CNADA – Highway markings

The following information on pavement markings was taken from the Manual of Uniform Traffic control devices for Canada (1998):

- Normal width line is 100 mm to 150 mm wide.
- Wide line is nearly twice the width of a normal line
- Double line consists of two normal line
- Dashed line is formed by shorter segments and gaps in the ratio of 1:1. These are typically 0,5 m to 3,0m each

Lane lines are broken white lines normally with segments and gaps in a 1:2 ratio. A recommended pattern is 3,0 m line segments with 6,0 m gaps. On high speed roads such as freeways, a segment to gap ratio of 1:3 (3,0 m segment, 9,0 m gap) can be used.

Lane lines are broken white defined by lane lines normally should not be less than 3,1 m, but widths as narrow as 2,8 m have been used. Widths should increase on sharply curved sections of urban streets.

Pavement edge lines are continuous solid lines placed on the pavement of the travelled lane as close as practicable to the travelled lane. A white line is used to the right and a yellow line is used to the left of the travelled land.

The following information on lane width guidelines was taken from the Canadian Geometric Design Guide (1999).

- Width for two-lane rural roads(<=80 km/h)3,0 m to 3,7 m, and (>80 km/h) 3,3 m to 3,7m;
- Multilane rural roadways((<=100 km/h) 3,5 m to 3,7 m, and (>=100km/h) 3.7 m;
- Urban freeways, major arterials, and industrial/ commercial collector roadways 3,7 m;
- Minor arterials, residential collectors, and local industrial/ commercial roadway.

Local residential roadways 3,0 m to 3,7 m

A.9 KOREA – Lane width and road markings

Lane width: 2,75 m-3,50 m.

Lane marker width should be from 1oo mm to 150 mm wide for both borders and centre.

Lane segments and voids interrupted lines between 3 m to 10 m. The guidelines include for

- urban collectors and arterials 3 m painted, 5 m void,
- rural arterials: 5 m painted, 8 m void, and
- freeways and expressways: 10 m painted and 10 m void.