General Safety Regulation - Technical study to assess and develop performance requirements and test protocols for various measures implementing the new General Safety Regulation, for accident avoidance and vehicle occupant, pedestrian and cyclist protection in case of collisions

Emergency Lane Keeping System (ELKS) Interim Report:
Detailed development of requirements and tests

Written by Mervyn Edwards
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Directorate C — Industrial Transformation and Advanced Value Chains
Unit C.4 — Automotive and Mobility Industries

E-mail: GROW-C4@ec.europa.eu

European Commission
B-1049 Brussels

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Table of Contents

Executive Summary

Emergency Lane Keeping System (ELKS) means a system assisting the driver in keeping a safe position of the vehicle with respect to the lane or road boundary, at least when a lane departure occurs or is about to occur and a collision may be imminent.

The revised General Safety Regulation (EU) 2019/2144 has entered into force and will help ensure the deployment of new advanced safety features with high potential of saving lives on EU roads. One of a package of measures to be implemented within this revision is the mandatory fitment of emergency lane keeping system ELKS to cars and vans.

The objective of the ELKS work package was to develop draft technical annexes setting out requirements and test procedures for secondary type approval legislation to mandate fitment of ELKS to M_1 and N_1 category vehicles. This work package was divided into the following tasks:

- Task 1: Review and scope contents of draft technical annexes
- Task 2: Detailed development of requirements and tests
- Task 3: Consultations / liaison
- Task 4: Reporting, meetings and ad-hoc support

The work was performed in two stages. In the first stage, literature review and bi-lateral consultations with seven organisations were undertaken to develop a high-level proposal for the contents of the ELKS regulation. The second stage of the work developed the draft technical annexes taking into account comments from stakeholders on the first stage report and using bi-lateral consultations with key stakeholders, including ACEA and CLEPA.

This report details the draft technical annexes developed including requirements, test procedures and associated performance limits, the thinking behind their development, and, where appropriate, justification for the text content, in particular suggested performance limits.

1 Introduction

TRL are providing support to the European Commission to develop the General Safety Regulation (GSR), specifically to develop input for the secondary legislation of Regulation (EU) 2019/2144 for the following vehicle safety measures:

- AEB: Advanced Emergency Braking (light duty, vehicles and pedestrians/cyclists)
- DDR: Driver Drowsiness and Attention Monitoring, Driver Readiness Monitoring for Automated Driving & Advanced Distraction Recognition
- EDR: Event Data Recorder
- FFW: Frontal Full-Width Impact
- HED: Pedestrian and Cyclist Enlarged Head Impact Zone
- ISA: Intelligent Speed Assistance
- ELKS: Emergency Lane Keeping System
- REV: Reversing Safety
- TPM: Tyre Pressure Monitoring (heavy duty)
- VIS: Direct Vision & Pedestrian and Cyclist Detection (heavy duty)

This report is related to Emergency Lane Keeping Systems (ELKS). ELKS means a system assisting the driver in keeping a safe position of the vehicle with respect to the lane or road boundary, at least when a lane departure occurs or is about to occur and a collision may be imminent.

The objective of the ELKS work package was to develop draft technical annexes setting out suggested performance based requirements and test procedures for secondary type approval legislation as regards fitment of ELKS to vehicles of categories M_1 and N_1.

This work package was divided into the following tasks:

- Task 1: Review and scope contents of draft technical annexes
- Task 2: Detailed development of requirements and tests
- Task 3: Consultations / liaison
- Task 4: Reporting, meetings and ad-hoc support

The work was performed in two stages. In the first stage, literature review and bi-lateral consultations with seven organisations were undertaken to develop a high-level proposal for the contents of the ELKS regulation. The organisations consulted included vehicle manufacturers (OEMs), suppliers, consumer testing type organisations, technical services and by extension national authorities. The high-level proposal and relevant supporting information were documented in a report (Edwards *et al.* 2019) which was circulated to stakeholders for comment.

Following this, the second stage of the work further developed the draft technical annexes taking into account comments from stakeholders on the report mentioned above and using bi-lateral consultations with key stakeholders, including ACEA and CLEPA.

This report is divided into three sections. The first section describes the principles, approach, and baseline requirements which formed the basis on which to develop the requirements and tests and write the draft regulatory text. The second section describes the draft regulatory text, including the thinking behind it, and, where appropriate, justification for the text content, in particular suggested performance limits. The third and final section describes the way forward.

2 Principles, Approach and Baseline Requirements

The first two parts of this section outline the principles and approach followed to develop the ELKS regulation. The third part describes the development of the baseline requirements which were changed to overcome problems that arose during detailed development of requirements and tests.

2.1 Principles

The principles followed to develop the ELKS regulation are listed below in terms of general ones and those specific to ELKS. These were derived from the insights acquired from consultation with the Commission and expert stakeholders.

- General
    - The regulation developed should not be design restrictive and hence should be performance-based, as far as possible
    - Given the timescales intended for its implementation, the regulation developed should ensure an acceptable minimum level of performance that can be delivered using readily available current technology
- ELKS
    - ELKS is an active safety system to **assist** the driver and therefore the driver should have control of the vehicle at all times and the ELKS should:
        - Assist the driver to keep the vehicle from leaving the lane in the case of driver unintentional manoeuvres
        - Only be required to become active when the vehicle is about to unintentionally leave its lane of travel and a collision may occur
        - Not annoy the driver with unnecessary interventions such that the option is taken to switch it off leading to the loss of potential benefit

2.2 Approach

The overall approach followed to develop the regulatory proposal was that it should:

- Adhere to the requirements laid out in the Regulation (EU) 2019/2144 (EP 2019).
- Align with and not be in conflict with requirements mandated by UN Regulation No. 79 (UNECE 2018)
- Follow the principles outlined above

2.2.1 Main relevant requirements of Regulation (EU) 2019/2144

The definition of ELKS is given as:

> *ELKS means a system that assists the driver in keeping a safe position of the vehicle with respect to the lane or road boundary, at least when a lane departure occurs or is about to occur and a collision may be imminent.*

'Assisting' is understood to mean either an intervention to guide the vehicle leaving the lane back into the lane OR a warning to the driver to intervene and do this.

Specific requirements for ELKS are detailed in Article 7 (EP 2019). These include:

- Only possible to switch off ELKS by itself and by a sequence of actions to be carried out by the driver
    - *Article 7:4(a) It shall only be possible to switch off systems [ELKS] one at a time by a sequence of actions to be carried out by the driver*
- ELKS switched ON by default with each activation of the vehicle master control switch (i.e. ignition switch for vehicles with conventionally fuelled engines).

- *Article 7:4(b) the systems shall be in normal operation mode upon each activation of the vehicle master control switch*

- ELKS audible warnings shall be easy to suppress, but it should not be possible to suppress other system functions easily at the same time
  - *Article 7:4(c) it shall be possible to easily suppress audible warnings, but such action shall not at the same time suppress system functions other than audible warnings;*
- ELKS intervention can be overridden by driver
  - *Article 7:4(d) it shall be possible for the driver to override such systems*

2.2.2 Relationship with UN Regulation No. 79

UN Regulation No. 79 revision 4 (UNECE 2018) contains requirements for three control functions that are relevant to ELKS. These are:

- Corrective Steering Function (CSF) type (c) which is defined as a control function which, for a limited duration, changes the steering angle of one or more wheels in order to correct lane departure (e.g. to avoid crossing lane markings, leaving the road).
- Automatically Commanded Steering Function (ACSF) category B1 which is defined as a control function which actuates the steering system in order to assist the driver in keeping the vehicle in the lane by influencing the lateral movement of the vehicle.
- Emergency Steering Function (ESF) type a(ii) which is defined as a control function which can automatically detect a potential collision and, for a limited duration, automatically activate the vehicle steering system with the purpose of avoiding or mitigating a collision with another vehicle driving (note that the vehicle may be driving in the same or opposite direction as the subject vehicle) in an adjacent lane into the path of which the subject vehicle is drifting.

Consultation with stakeholders and analysis of these functions revealed that, in general, the aim of the CSF type (c) function is to protect the inattentive driver by providing a corrective steering action for a limited duration and similarly for ESF type a(ii) function the aim is to protect the inattentive driver but also to reduce system interference for the attentive driver for crossing dashed lane markings when it is safe to do so.

In contrast, in general, the aim of the ACSF B1 function is to provide more comfortable driving by providing continuous lateral support within specified limits, for example when the system can clearly determine the course of the lane ahead. Regulation 79 mandates that an ACSF B1 function can be switched off by a single action by the driver and will automatically deactivate if the driver is not holding the steering wheel and doesn't react to the warning given. Based on this, it was concluded that the ACSF B1 function is not the best option for definition of the ELKS mainly because the ELKS should support the driver only in case of unintentional lane crossing , be switched on by default and switched off only by a sequence of actions by the driver.

On this basis it was proposed that the appropriate functions for definition of the ELKS are CSF type (c) and ESF type a(ii) ones. The ELKS requirements will have to be compatible with an ACSF B1 function that could be proposed on top of the ELKS function. Based on the principle that the ELKS regulation to be developed should deliver an acceptable minimum level of performance (see Section 2.1) it is proposed that an ESF type a(iii) function (which is defined as a control function which can detect a potential collision and, for a limited duration, activate the steering system with the purpose to avoid or mitigate a collision with another vehicle into the lane of which the driver initiates a lane change manoeuvre) should not be included to ensure an unreasonable burden is not put on the manufacturer. Also, on this basis, it was proposed that the ESF type a(ii) function should be optional, i.e. its fitment is not mandated, but it should be tested if fitted.

Another important consideration regarding the relationship of the ELKS regulation with Regulation 79 is that the scope of Regulation 79 appears not to include systems that use differential braking for directional control. Because one of the principles is that the ELKS regulation should not be design restrictive and differential braking type systems are likely to be in use in the timescales for implementation of the ELKS regulation, it was proposed that the ELKS regulation is written in a manner to accommodate these types of system.

It was decided to solve this problem by transposing (or referencing) the relevant parts of Regulation 79 into a European Union ELKS regulation and making appropriate adjustments where there is reference to the use of steering to provide directional control. The first part of this process involved redefining Corrective Steering Function and Emergency Steering Function as follows:

> "*Corrective Directional Control Function (CDCF)*" means a control function within an electronic control system whereby, for a limited duration, changes to the steering angle of one or more wheels and/or braking of individual wheels may result from the automatic evaluation of signals initiated on-board the vehicle, in order to correct lane departure, e.g. to avoid crossing lane markings, leaving the road.
>
> *"Emergency Directional Control Function (EDCF)"* means a control function which can automatically detect a potential collision and automatically activate the vehicle steering system and/or individual wheel braking for a limited duration, to change the direction of the vehicle with the purpose of avoiding or mitigating a collision, with another vehicle driving* in an adjacent lane into which path the subject vehicle is drifting.
>
> *Note: vehicle may be driving in opposite direction.

Currently, differential braking type systems are subject to the requirements of UN Regulation No. 13H, specifically the requirements of Annex 8 which shall be applied to the safety aspects of all complex electronic vehicle control systems, (including those defined in an independent regulation), which provide or form part of the control transmission of the braking function, and including those which utilize the braking system(s) for automatically commanded braking or selective braking. The purpose of these requirements is to show that, with the differential braking system fitted, the overall braking system still respects under normal and fault conditions, all the appropriate performance requirements specified within Regulation 13H. The author believes that this is sufficient and further modification of the braking regulations is not necessary, provided the approach proposed above is followed.

2.2.3 Technology considerations

One of the principles established above was that the regulation developed should ensure an acceptable minimum level of performance that can be delivered using readily available current technology.

From consultation with expert stakeholders it was concluded that the current readily available technology was not capable of detecting plain road edges reliably enough. On this basis, it was proposed that the systems mandated should be capable of detecting the following lane edges / scenarios:

- Solid lane markings
- Dashed lane markings
- Solid or dashed lane markings adjacent to road edges

for all lane markings as defined in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'.

Also, the regulation developed should not restrict the placing on the market of improved ELKS such as those which can detect road edges without lane markings adjacent to them and / or those fitted with systems to detect potential collisions and avoid them.

2.3 Baseline requirements

Taking the approach described above into account and through consultation with stakeholders the following top-level objectives were derived to guide the development of the baseline requirements:

- Prevent lane departure toward another lane
- Prevent lane departure towards a road edge
- Keep driver annoyance to a minimum in order to avoid deactivation by the driver resulting in loss of all potential ELKS benefit

Using these objectives and building on the information above, initial baseline requirements for ELKS consisting of the following two options were proposed:

Option A:

Mandate fitment of a Corrective Directional Control Function (CDCF) to prevent crossing of solid and dashed lane markings unless a driver intentional manoeuvre is detected.

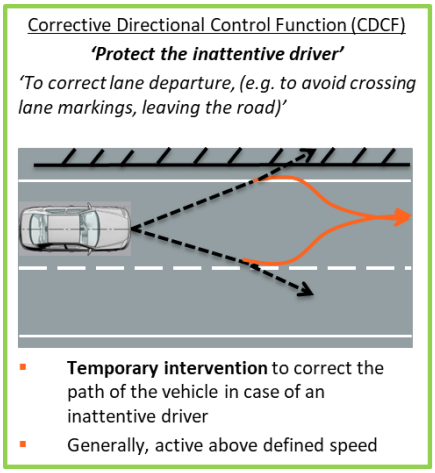


Figure 1: Option A: CDCF fitted to prevent 'unintended' crossing of solid and dashed lane markings

Option B:

Optionally, to help reduce driver annoyance, permit deactivation of CDCF for dashed lane markings provided vehicle fitted with an Emergency Corrective Directional Control Function (CDCF) to avoid a collision with a vehicle driving in an adjacent lane.

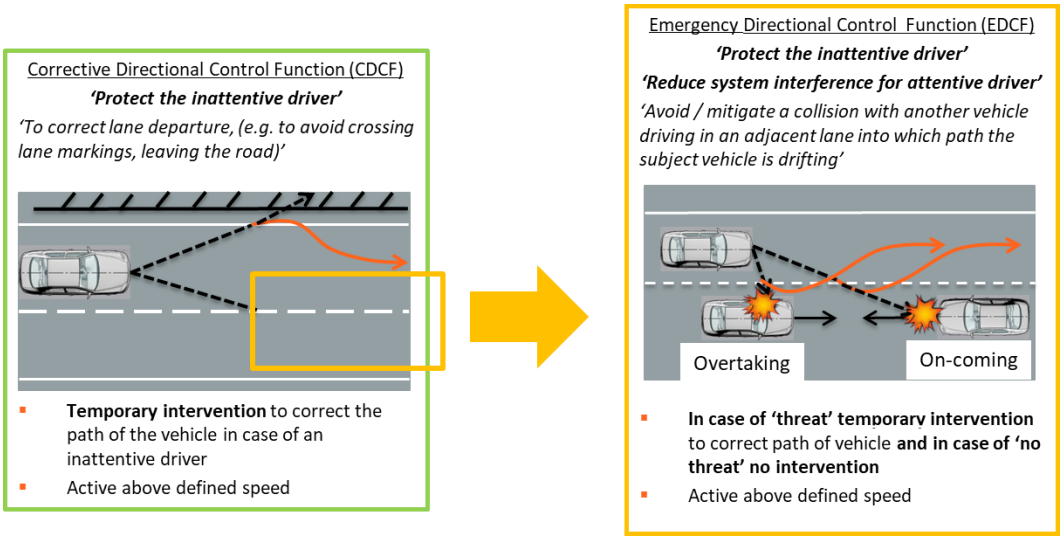


Figure 2: Option B: Crossing of dashed lane markings into adjacent lane permitted provided EDCF fitted to avoid a collision with a vehicle driving in an adjacent lane

Unfortunately, during the drafting of the detailed text a number of problems were found with these baseline requirements. The problems found included:

- Definition of the performance requirements and test procedure for an Emergency Directional Control Function (EDCF).

  Initially, it was thought that the requirements and test procedure for this function could be based on the Euro NCAP procedure for this type of function. However, to represent the threat (oncoming or overtaking vehicle), the Euro NCAP procedure uses a Global Vehicle Target (GVT) which represents a car. ISO are currently developing an appropriate standard for this 'car GVT' which is expected to be complete sometime in 2020 (ISO/CD 19206-3). However, EDCF should detect threats other than cars, such as motorcycles and no vehicle targets which represent motorcycles currently exist. This causes a problem for the introduction of an appropriate test procedure into regulation.

- How to deal with dashed lane markings next to road edges for an EDCF.

  If an EDCF is fitted which allows crossing of dashed lane markings, because readily available current technology cannot detect road edges reliably (see Section 2.2.3 above) and hence distinguish that a dashed lane marking is next to a road edge a problem arises for countries, such as Sweden and France, which have dashed lane markings next to road edges. The problem is that departure over dashed lane marking next to a road edge may be permitted without intervention. Two potential solutions for this problem were discussed:

  - Allow deactivation of lane keep intervention for dashed lane markings on driver side of vehicle only
  - Fit road edge detection and do not permit deactivation of lane keep intervention for road edges, even if there are dashed lane markings next to them.

  But neither of these were preferred by stakeholders.

To help resolve these challenges, stakeholders proposed new baseline requirements which can be summarised as follows:

- In the case of unintended lane departure:
  - Mandate an intervention for crossing solid lane markings

- Mandate a warning for crossing solid or dashed lane markings, regardless of whether or not there is a threat or road edge

Implementation of these baseline requirements would result in the responses to lane markings and road edges as summarised in Figure 3 below.

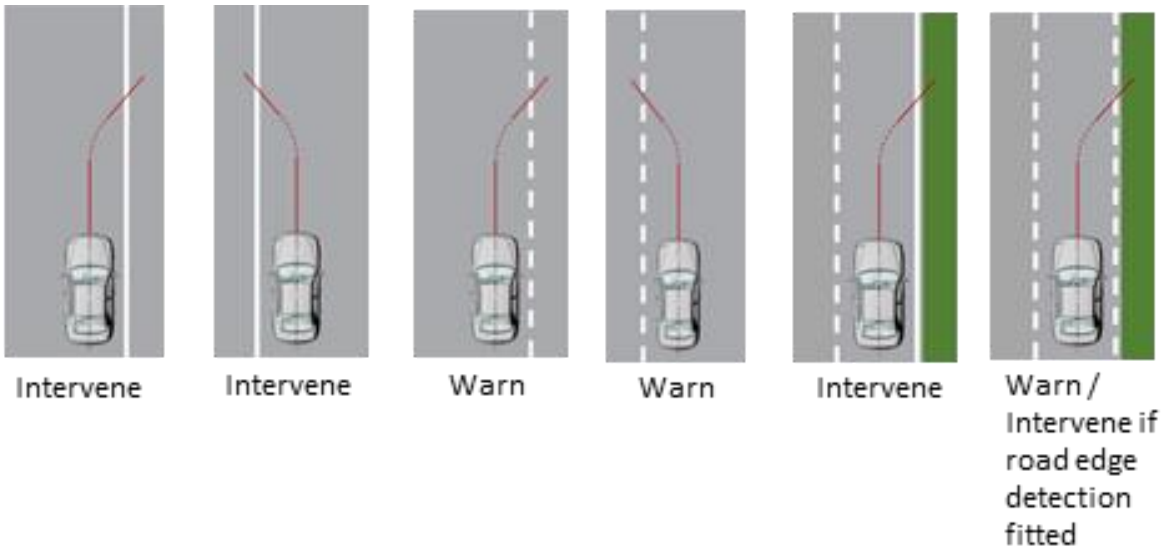


Figure 3: Response of ELKS to lane markings and road edge scenarios assuming implementation of new baseline requirements proposed by stakeholders

The main advantages of these new baseline requirements were that they should help simplify the proposed ELKS regulation greatly and side-step problems caused by the readiness of currently available technology, namely the need to define requirements for EDCF and / or provisions for road edge detection, both of which were proving problematic to resolve.

However, a potential disadvantage was that they may result in a reduction of the effectiveness of the ELKS mandated because only a warning is given to the driver (compared to an intervention supplemented with a warning) for two collision scenarios which contain a large proportion of the target population (Euro NCAP 2016), namely:

- Crossing dashed lane marking into oncoming traffic
- Crossing lane marking next to road boundary into obstacle (note that there are dashed lane markings next to road boundaries in some EU member states, e.g. Sweden and France)

To estimate the magnitude of this potential disadvantage the following two items were considered:

- The effectiveness of a Lane Departure Warning System (LDWS) compared to a Corrective Directional Control Function (CDCF)
- In terms of driver annoyance, whether or not unjustified warnings would be less likely to lead to a driver switching the system off compared to unjustified lane keep interventions

The author could not find any relevant information in the literature to be able to compare the effectiveness of a LDWS to a CDCF. Indeed, for this reason the underlying effectiveness data used for the ELKS measure for the General Safety Regulation Impact Assessment (EC 2018) were LDWS effectiveness data from Sternlund et al. (2017) and Cicchino (2018). Both these studies were based on real-world accident data and used methods which compared the accident exposure of cars with and without LDWS fitted to

derive effectiveness values. The effectiveness values applied for the Impact Assessment for the target population of:

'*casualties in head-on and single-vehicle crashes on roads with speed limits between 70 km/h and 120 km/h (40 mph and 70 mph) and dry or wet road surfaces (i.e. not covered by ice or snow)'*

were 53% for fatalities and 38.5% for seriously and slightly injured. These results show that the effectiveness of a LDWS is reasonably high and assuming that the effectiveness of a CDCF system is higher, the gap is not likely to be that great because there is not that much head room.

From their customer feedback vehicle manufacturers indicated that unjustified warnings were less likely to lead to a driver switching the system off compared to unjustified lane keep interventions.

In conclusion, the magnitude of the potential disadvantage of the new baseline requirements cannot be estimated accurately. However, disadvantages to the benefit caused by a reduction in effectiveness due to the fitment of an LDWS instead of an CDCF should, to some extent, be offset by drivers being less likely to switch the system off. Also, because the GSR Impact Assessment was based on data for LDWS, the new baseline requirements can deliver the benefit predicted by it.

In summary, it is proposed to implement the new baseline requirements:

- In the case of unintended lane departure:
    - Mandate an intervention for crossing solid lane markings
    - Mandate a warning for crossing solid or dashed lane markings, regardless of whether or not there is a threat or road edge

as the starting point for detailed development of requirements and tests for the ELKS regulation on the following basis:

- They fulfil the principles and follow the overall approach originally proposed above
- They overcome problems with the requirements proposed previously, namely setting appropriate performance requirements for an EDCF caused by the readiness of currently available technology
- They should enforce systems which have reasonably high effectiveness values which can deliver the benefit predicted in the GSR Impact Assessment

3 Detailed Development of Performance Requirements and associated Tests

To develop the draft technical annexes, an iterative process involving bi-lateral consultations with key stakeholders, including ACEA and CLEPA, was undertaken. This entailed cycles in which:

- TRL drafted text which was circulated to key stakeholders
- Draft text was discussed with stakeholders in internet-based meetings and suggested changes and comments noted
- TRL considered suggested changes and comments, and updated the text where appropriate

The approach followed to develop the requirements and tests was as detailed in Section 2 above. Additional points to note are:

- The layout of the draft text was based on that used in draft UN Regulation No. 152 for Advanced Emergency Braking System (AEBS) for M_1 and N_1 vehicles (UNECE 2019), i.e.:
    - Requirements were divided into 'General' and 'Specific' sections.
    - Test requirements were written as separate sections.
    - To enable clarity for potential future market surveillance activities, performance requirements for functions and, if applicable, conditions under which these requirements should be met, were written in the specific requirements section.
- The content and style of draft text was written to be suitable for inclusion within an EU regulation.
- Requirements for the Lane Departure Warning System (LDWS) were based on those in UN Regulation No. 130.
- Requirements for the Corrective Directional Control Function (CDCF) were based on those in UN Regulation No. 79 for a Corrective Steering Function (CSF) type (c) and lane keep requirements developed within this project.

The sections below describe the thinking and, if appropriate, justification for the draft text content, including suggested performance limits, for each of the draft text sections.

3.1 Scope

The scope is defined in Regulation (EU) 2019/2144 Article 7.3 and is:

> *Vehicles of category M_1 and N_1 shall also be equipped with an Emergency Lane-Keeping System.*

Article 16 and Annex II detail the implementation dates for the regulation.

For fitment of ELKS, these are:

- For new vehicle types, the date of application of the regulation.
- For new vehicles, 24 months after the date of application of the regulation.

It should be noted that for vehicles with hydraulic power assisted steering systems the implementation dates for fitment of ELKS are later. These vehicles, however, shall be fitted with a lane departure warning system (LDWS) instead.

- For new vehicle types with hydraulic power assisted steering systems:
    - ELKS fitted: 24 months after the date of application of the regulation

    - LDWS fitted: for the period from the date of application of the regulation to 24 months later
- For new vehicles with hydraulic power assisted steering systems:
    - ELKS fitted: 48 months after the date of application of the regulation
    - LDWS fitted: for the period from 24 months after the date of application of the regulation to 24 months later

Currently, the date of application of the regulation is expected to be in July2022.

It should be noted that ACEA have raised a concern about meeting the currently proposed schedule for implementation of the regulation because its implementation will entail many changes for vehicles that have not been designed to be ready to incorporate them. These concerns are greater for some vehicle types such as Light Commercial Vehicles (LCVs) which have long life cycles. To help solve this problem they propose that the implementation date for new vehicles is extended. They suggest that one way to do this could be to define the new vehicles application date on the basis of a 'Start of Production' date to allow vehicles to be produced and sold for a given number of years.

ACEA comment:

> *Due to the tight schedule for GSR ELKS regulation 2022 new-types dates, in combination with that the GSR2 regulation is very heavy and implies a lot of changes on cars that have not been designed for these constraints. The All-types application should be extended beyond 2024. A differentiated transition period for certain vehicles e.g. LCV with long life cycles or technologies that might not fully be applicable to the coming regulation e.g. differential braking systems, might also be needed.*
>
> *One possible solution could be to define minimum Start of Production (SOP) date for All Types rule --> e.g. If vehicle was type approved after ~~before~~ 2014 the all types rule is extended to 2026 or does not apply.*

3.2 Definitions

Definitions were drafted as required to ensure that the meaning of the draft text was clear and unambiguous. Where possible, to help ensure consistency, they were based on definitions from other regulations and standards, for example:

- The Emergency Lane Keeping System (ELKS) definition was copied from Regulation (EU) 2019/2144.
- The lane keeping function definition 'Corrective Directional Control Function CDCF)' was based on the definition of a Corrective Steering Function (CSF) type (c) in UN Regulation No. 79 – see Section 2.2.2.
- The lane departure warning system (LDWS) definition was copied from Regulation (EU) 2019/2144. This definition is nearly the same as the one in UN Regulation No. 130.

It should be noted that a vehicle type definition has been included but it is not known whether or not it will be needed, because it is not known exactly how the Commission will incorporate the draft text written into the final EU regulation. However, it can be deleted easily if it is not needed.

Draft text

0.10	*"Emergency Lane Keeping System (ELKS)"* means a system that assists the driver in keeping a safe position of the vehicle with respect to the lane or road boundary, at least when a lane departure occurs or is about to occur and a collision may be imminent.
0.11	*"Vehicle master control switch"* means the device by which the vehicle's on-board electronics system is brought, from being switched off, as in the case where a vehicle is parked without the driver being present, to normal operation mode.
0.12	*"Corrective Directional Control Function (CDCF)"* means a control function within an electronic control system whereby, for a limited duration, changes to the steering angle of one or more wheels and/or braking of individual wheels may result from the automatic evaluation of signals initiated on-board the vehicle optionally enriched by data provided off-board the vehicle, in order to correct lane departure, e.g. to avoid crossing lane markings, leaving the road.
0.13	*"Lane Departure Warning System (LDWS)"* means a system to warn the driver that the vehicle is drifting out of its travel lane.
[0.14]	["*Vehicle Type with Regard to its Emergency Lane Keeping System*" means a category of vehicles which do not differ in such essential aspects as: (a) Vehicle features which significantly influence the performances of the Emergency Lane Keeping System; (b) The type and design of the Emergency Lane Keeping System.]
0.15	"*Subject Vehicle*" means the vehicle being tested.
0.16	*"Distance to Lane Marking (DTLM)"* means the remaining lateral distance (perpendicular to the lane marking) between the inner side of the lane marking and most outer edge of the tyre before the subject vehicle crosses the inner side of the lane marking.
0.17	"*Common Space*" means an area on which two or more information functions (e.g. symbol) may be displayed, but not simultaneously.
0.18	"*Self-Check*" means an integrated function that checks for a system failure on a continuous basis at least while the system is active.
0.19	*"Dry road"* means a road with a nominal peak braking coefficient of 0.9.
0.20	*"Flat road"* means a road with a slope less than 1% in the longitudinal direction and for the lateral direction, less than 2% for half a lane width either side of the centreline and less than 3% for the outer half of the lane.

3.3 Requirements

The requirements section was divided into 'general requirements' and 'specific requirements' to follow the layout typically used for regulations.

3.3.1 General Requirements

The main part of the General Requirements section defines that an ELKS shall comprise a LDWS and a CDCF (see Section 2.3 'baseline requirements') and directs the reader to what specific requirements this system and function shall meet.

A general requirement was added to emphasize the importance that the system should be designed to minimise driver annoyance to help ensure it is not switched off so that the benefits it offers can be realised.

General requirements that are normally included in UN regulations such as Electromagnetic Compatibility (EMC) of the system by reference to the relevant regulation (UN Regulation No. 10) were not included in the draft text. This was because the author understands that the ELKS regulation will be implemented as an EU Regulation and hence requirements such as EMC will be included implicitly as part of the General Safety Regulation which will sit above the ELKS regulation.

Draft text

1	General requirements
1.1	An ELKS shall comprise a LDWS and a CDCF
1.1.1	The LDWS shall meet the requirements of paragraphs 2.1 to 2.4 and paragraph 2.5.
1.1.2	The CDCF shall meet the requirements of paragraphs 2.1 to 2.4 and paragraph 2.6.
1.2	ELKS lane departure warnings and interventions Subject to specific requirements below the system shall be designed to minimise warnings and interventions for driver intended manoeuvres.

3.3.2 Specific Requirements

The specific requirements were divided into the following three main parts:

- Failure warning, deactivation, suppression and Periodic Technical Inspection (PTI), the first three of which are related to the Human Machine Interface (HMI)
- Lane Departure Warning System (LDWS)
- Lane keep system - Corrective Directional Control Function (CDCF)

3.3.2.1 Failure warning, deactivation, suppression and PTI

In terms of approach, the information that should be provided to the driver related to the ELKS status was discussed with stakeholders. From these discussions it was agreed that the ELKS should be envisaged as an active system which is works in the background and supplies assistance to the driver when needed. Advanced Emergency Braking Systems (AEBS) and Electronic Stability Control (ESC) are examples of this type of system. Therefore, it was agreed that the driver should be informed if the ELKS cannot provide the support regulated, but the driver should not be informed if the ELKS cannot detect the lane markings because, for example, they are worn. This is because this could lead to supplying the driver with too much information and possibly distracting him from the driving task which would negate the primary purpose of the ELK assistance system.

<u>Failure warning</u>

Following a similar approach to other regulations (e.g. UN Regulations No. 130 and 152 draft) text was drafted to require a constant optical failure warning signal for electrically detectable failures and non-electrical failures such as sensor mis-alignment. It should be noted that non-electrical failures do not include periods when the sensor may be blinded by the sun and/or lane markings are not detected. This warning signal can also be used to indicate when the system is deactivated. In other regulations this signal is often mandated to be yellow. However, at the suggestion of a stakeholder this requirement was dropped because systems which use other colours may already be in use, i.e. fitted to vehicles.

Because the ELKS comprises a lane departure warning system (LDWS) and a lane keep system (CDCF) system, it is possible that the CDCF could fail but the LDWS could still be functional, if for example, there was a CDCF failure related to the steering system. In this

case one would want the LDWS to remain active to provide assistance to the driver. To permit this, for the case that LDWS lane departure optical warning is provided by flashing the failure warning signal, the text was drafted appropriately.

Draft text

2.1	ELKS failure warning A warning shall be provided when there is a failure in the ELKS that prevents the requirements of this Regulation of being met.
2.1.1	The warning shall be a constant optical warning signal. This warning signal may be interrupted by an optical warning according to paragraphs 2.5.3.1 or 2.6.5.1, if the ELKS is only partially* affected by the failure. *Note: ELKS partial failures are failures of the CDCF only or the LDWS only.
2.1.1.1	There shall not be an appreciable time interval between each ELKS self-check, and subsequently there shall not be a delay in illuminating the warning signal, in the case of an electrically detectable failure.
2.1.1.2	Upon detection of any non-electrical failure condition (e.g. sensor misalignment), the warning signal as defined in paragraph 2.1.1 shall be activated.
2.1.2	If the vehicle is equipped with a means to deactivate the ELKS a warning shall be given when the system is deactivated according to paragraph 2.2. This shall be a constant optical warning signal. The warning signal specified in paragraph 2.1.1 above may be used for this purpose.

<u>Deactivation</u>

From learnings from discussions with stakeholders it is proposed that manual deactivation of the ELKS whilst driving should be permitted. This was because situations can occur while driving which will trigger repeated ELKS interventions, e.g. on a narrow country road or in roadworks. Therefore, deactivation of the system should be permitted while driving. If it is not provided, the repeated interventions will likely annoy the driver which could cause customer acceptance problems. Also, the driver could likely choose to switch the ELKS off at the beginning of the trip, thus negating any possible benefit from it. Further discussions revealed support for a Euro NCAP-type approach that permits deactivation while driving but not by a simple single action of the driver as for an ACSF B1 system (i.e. a lane positioning comfort type system). An example of such a solution is a switch which requires two presses or a long press to deactivate and a single press to reactivate.

Regulation (EU) 2019/2144 requires (see Section 2.2.1):

- *It shall be possible to switch off systems [ELKS] only one at a time by a sequence of actions to be carried out by the driver*
- *The systems [ELKS] shall be in normal operation mode upon each activation of the vehicle master control switch*

It is assumed that a 'long press' of a button would be considered a sequence of actions, i.e. press and hold.

Text was drafted to permit fitment of a means to manually deactivate the ELKS and its reinstatement upon each activation of the vehicle master control switch. However, a stakeholder requested that the text related to the reinstatement be modified by adding the part in square brackets, see below:

> *The ELKS function shall be automatically and fully reinstated upon each activation of the vehicle master control switch, [at least provided the driver door is opened in-between].*

The reason given for this was to cover situations when the driver has not completed a journey and has for example switched their car off at traffic lights or in a traffic jam to save fuel or indeed has stalled the car. Reinstatement of the ELKS in these situations will likely increase customer annoyance. The Commission should decide whether or not this proposed modification should be included in the draft text because the author was unable to make a definite recommendation.

Text was drafted to permit automatic deactivation of the ELKS, either partially or fully, in situations such as off-road use, being towed, when towing a trailer, etc. Partial deactivation was permitted for situations such as towing a trailer when it may be necessary to deactivate the lane keep capability but not the lane departure warning.

Text was also drafted to mandate a constant optical warning signal to inform the driver if the ELKS has been deactivated. In the case that the ELKS may not be fully deactivated, for example CDCF deactivated but LDWS not, text added to allow interruption of the signal so, for example, if desired for the LDWS it can be utilised as an optical warning signal.

Draft Text

2.2	ELKS deactivation
2.2.1	Manual deactivation When a vehicle is equipped with a means to manually deactivate the ELKS function, either partially or fully, the following conditions shall apply as appropriate:
2.2.1.1	The ELKS function shall be automatically and fully reinstated upon each activation of the vehicle master control switch, [*at least provided the driver door is opened in-between*].
2.2.1.2	The ELKS control shall be designed a in such a way that manual deactivation shall not be possible with less than two deliberate actions, e.g. press and hold on a button, or select and confirm on menu option.
2.2.1.3	The manual deactivation capability shall be tested in accordance with the relevant vehicle test(s) specified in paragraph 3 to this Regulation.
2.2.2	Automatic deactivation If the vehicle is equipped with a means to automatically deactivate the ELKS function, either partially or fully, for instance in situations such as off-road use, being towed, a trailer being hitched to the vehicle or the ESC being deactivated the following conditions shall apply as appropriate:
2.2.2.1	The vehicle manufacturer shall provide a list of situations and corresponding criteria where the ELKS function is automatically deactivated to the technical service at the time of type approval and it shall be annexed to the test report.
2.2.2.2	The ELKS function shall be automatically and fully reactivated as soon as the conditions that led to the automatic deactivation are not present anymore.
2.2.3	A constant optical warning signal shall inform the driver that the ELKS function has been deactivated. The failure warning signal specified in paragraph 2.1.1 may be used for this purpose. This warning signal may be interrupted by an optical warning according to paragraphs 2.5.3.1 or 2.6.5.1, if the ELKS is only partially deactivated.

Author's Note:

A stakeholder proposed to change section 2.2.3 to the following:

'A constant optical warning signal shall inform the driver that the ELKS function has been ***fully*** *deactivated. The failure warning signal specified in paragraph 2.1.1 above may be used for this purpose.* ***If the ELKS is partially deactivated, the system shall give an information to the driver.'***

The intention and effect of this proposed change were not made clear, so it was decided that the draft text should not be changed at this stage. Open questions included:

- Why is the change necessary?
- What information would be given to the driver?

However, modification of the draft text could be considered at a later stage following further consultation.

Suppression

To help reduce driver annoyance, draft text was written to permit automatic suppression of the ELKS for driver intended manoeuvres. Ideally the ELKS should only intervene in the case of driver unintended manoeuvres. Driver intended manoeuvres can be detected:

- By sign of driver activity, for example
    - Active turn indicator or
    - Active input to brake or accelerator control or
    - Driver input to the steering control, for example steering wheel torque above a threshold
- OR by dynamic of vehicle manoeuvre or lane geometry, for example
    - Lateral departure velocity above given value, or
    - Tight curve, e.g. curve radius below threshold or
    - Lane is very narrow, e.g. width below threshold
- OR by a combination of the factors above

Detecting whether a driver manoeuvre is intentional or unintentional with a degree of certainty is difficult and therefore there are many manoeuvres for which it is unknown (Figure 4). For these manoeuvres, by default the LDWS and CDCF are activated in case driver assistance is needed. In the case that driver assistance is not needed the LDWS warning still occurs and the CDCF lane keep intervention can be overridden by driver steering input, but this interference will likely annoy the driver. Because of this, to minimise driver annoyance, system designers may be encouraged to set low limits for parameters to suppress the ELKS, such as lateral departure velocity, to reduce driver annoyance at the expense of not activating for some unintentional manoeuvres, thus reducing the effectiveness of the ELKS.

Manoeuvre	Unintentional	Unintentional / Intentional	Intentional
Detection (Unintentional / Intentional)	Yes	No	Yes
Frequency	Low	High	Medium / High
ELKS Action	Intervene, keep in lane (solid) / Warn (dashed)	Intervene, keep in lane (solid) / Warn (dashed) OR Limit intervention by driver override (solid) Warn (dashed)	Stop intervention / warning by automatic system suppression

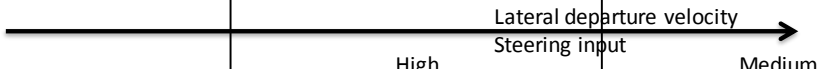


Figure 4: Summary of suggested approach in relation to ELK system action for solid and dashed lane markings with respect to whether or not the driver manoeuvre was detected as unintentional or intentional

To counter this tendency, a requirement was written that the technical service assess the system for detection of likely intended manoeuvres and check that any unintended manoeuvres within the scope of the lane keep test parameters, in particular the lateral departure velocity, are not suppressed. In addition, this issue was kept in mind when setting lane keep test parameters, in particular lateral departure velocity.

Requirements for assessment of the system for detection of likely intended driver manoeuvres by the technical service were also written.

In addition, draft text was written to permit automatic suppression of the ELKS when other steering functions, (e.g. ACSF, ESF or ALKS), are controlling the lateral movement of the vehicle.

Draft Text

2.3	Automatic suppression
2.3.1	For driver intended manoeuvres As part of the CEL Annex requirements, the manufacturer shall provide a documentation package which gives access to the basic design and logic of the system for detection of likely driver intended manoeuvres and automatic suppression of the ELKS. This package shall include a list of parameters detected and a basic description of the method used to decide that the system should be suppressed, including limit values where possible. For both the CDCF and LDWS, the technical service shall assess the documentation package to show that driver unintentional manoeuvres, within the scope of the lane keep test parameters (in particular lateral departure velocity), will not result in automatic suppression of the system.
2.3.2	Automatic suppression of the ELKS is permitted in situations when other assistive or automated steering functions, (e.g. ACSF, ESF or ALKS), are controlling the lateral movement of the vehicle.

Periodic Technical Inspection (PTI)

Provisions for PTI were drafted based closely on those in the draft UN Regulation No. 152 for Advanced Emergency Braking Systems (AEBS).

Draft Text

2.4	Provisions for the Periodic Technical Inspection
2.4.1	At a Periodic Technical Inspection, it shall be possible to confirm the correct operational status of the ELKS by a visible observation of the failure warning

	signal status following a "power-ON" and any bulb check. In the case of the failure warning signal being in a common space, the common space must be observed to be functional prior to the failure warning signal status check.
2.4.2	At the time of type approval, the means to protect against simple unauthorised modification of the operation of the failure warning signal chosen by the manufacturer shall be confidentially outlined. Alternatively, this protection requirement is fulfilled when a secondary means of checking the correct operational status of the ELKS is available.

3.3.2.2 Lane Departure Warning System (LDWS)

The approach taken to develop the requirements for the LDWS and write the draft text consisted of the following steps:

- Start with requirements for LDWS within UN Regulation No. 130
- Adjust these to align with the requirements for the CDCF component of the ELKS and transform into required format, e.g. write performance requirements and conditions under which they should be met within specific requirements section

It was necessary to align the requirements for parameters such as the operational speed range and lateral departure velocity with those for the ELKS CDCF component to allow that the ELKS as a whole can appear as a single coherent system to the driver; for example to allow system suppression to occur in a logical manner and to allow warnings to occur before interventions when crossing solid lane markings unintentionally. Further detail for why the CDCF parameter ranges were proposed can be found in Section 3.3.2.3.

The LDWS operational speed range in Regulation 130 is 'above 60 km/h'. The operational speed range for the CDCF is proposed to be 70 km/h to 130 km/h, but when reducing speed from above 70 km/h operate until speed less than 65 km/h – see Section 3.3.2.3. To align a speed range of 65 km/h to 130 km/h was recommended for LDWS.

The LDWS lateral departure velocity operational range in Regulation 130 is 0.1 m/s to 0.8 m/s. The operational range proposed for the CDCF is 0.2 m/s to 0.5 m/s. To align a lateral departure velocity range of 0.1 m/s to 0.5 m/s was recommended for LDWS.

The LDWS maximum crossing of lane marking before warning in Regulation 130 is before the outside of the vehicle's front tyre is 0.3 m beyond the lane marking outer edge. The operational range proposed for the CDCF is before the outside of the vehicle's front tyre is 0.3 m beyond the lane marking inner edge. To align the CDCF requirement was chosen which references the lane marking inner edge.

The conditions in which the requirements shall be met were also aligned with the CDCF ones where relevant, i.e. the surface, the lane markings and their condition and the weather conditions such as illumination and fog.

The requirements for the LDWS warning indication were copied from Regulation 130. Therefore, the top-level requirements proposed were:

The lane departure warning shall be noticeable by the driver and be provided by:

(a) At least two warning means out of optical, acoustic and haptic, or

(b) One warning means out of haptic and acoustic, with spatial indication about the direction of unintended drift of the vehicle.

It was also proposed that a CDCF intervention should be considered a haptic warning to allow better integration of the LDWS and CDCF ELKS components.

In addition, to comply with the Article 7: 4(c) requirements in Regulation (EU) 2019/2144, namely:

'It shall be possible to easily suppress audible warnings, but such action shall not at the same time suppress system functions other than audible warnings'

an option for the driver to temporarily suppress the audible warning for the duration of the vehicle master control switch cycle was included provided that the remaining warning is still noticeable by the driver

The author is unsure whether or not it is appropriate to include this requirement because it may be superfluous because practically if a manufacturer was concerned about annoying the driver with audible warnings, they would likely choose to fit a system with optical and/or haptic warnings. For this reason, this requirement is included in square brackets. The Commission should decide whether or not to include it.

Draft Text

2.5	LDWS requirements
2.5.1	Speed range The LDWS shall be active at least within the vehicle speed range between [65 km/h] and the lower of [130 km/h] or maximum vehicle speed and at all vehicle load conditions, unless deactivated as per paragraph 2.2.
2.5.2	Lane departure warning In the absence of conditions leading to deactivation or suppression of the system according to paragraphs 2.2 and 2.3, when operated within the prescribed speed range according to paragraph 2.5.1, the LDWS shall be able to warn the driver as specified in paragraph 2.5.3 at the latest if the vehicle crosses over a visible lane marking for the lane in which it is running by more than a DTLM of [-0.3 m]: (a) for lateral departure velocities in the range of the [0.1 m/s] to [0.5 m/s] (b) on straight, flat and dry roads (c) for lane markings in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification' (d) with the markings being in good condition and of a material conforming to the standard for visible markings of that contracting party (e) in all illumination conditions without direct blinding sunlight and low beam head lamps if necessary (f) in absence of weather conditions affecting the visibility of lane markings (e.g. no fog) It is recognised that the performance required may not be fully achieved in other conditions than those listed above. However, the system shall not unreasonably switch the control strategy in these other conditions. The lane departure warning capability shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 3.
2.5.3	LDWS warning indication
2.5.3.1	The lane departure warning referred to in paragraph 2.5.2 above shall be noticeable by the driver and be provided by: (a) at least two warning means out of optical, acoustic and haptic, or (b) one warning means out of haptic and acoustic, with spatial indication about the direction of unintended drift of the vehicle. [The manufacturer may offer means for the driver to temporarily suppress an audible warning for the duration of the vehicle master control switch

	cycle provided that the remaining warning is still noticeable by the driver.]
2.5.3.1.1	Where an optical signal is used for the lane departure warning, it may use the failure warning signal as specified in paragraph 2.1.1 in a flashing mode.
2.5.3.1.2	When there is a lane keep intervention by the CDCF, this shall be considered a haptic warning according to paragraph 2.5.3.1.
2.5.3.2	The LDWS optical warning signals shall be activated following a vehicle master control switch "power-ON". This requirement does not apply to warning signals shown in a common space.
2.5.3.3	The LDWS optical warning signals shall be visible even by daylight; the satisfactory condition of the signals must be easily verifiable by the driver from the driver's seat.
2.5.3.4	The optical warning signal shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 3.

3.3.2.3 Corrective Directional Control Function (CDCF)

The approach taken to develop the requirements for the CDCF and write the draft text was to:

- Start with the requirements in UN Regulation No. 79 for a Corrective Steering Function (CSF) type (c) to correct lane departure
- Modify so that differential braking type systems can also be allowed.
- Add requirements for lane keep capability for crossing of solid lane markings

Lane Keep

Three main questions to answer to develop the requirements were:

- What the operational speed range of the function should be?
- What range of lateral departure velocities should the vehicle be kept in lane for?
- How far should a vehicle be allowed to cross a solid lane marking?

To answer the first question the following were considered in conjunction with stakeholder consultation:

- Speed limits of European roads – see Appendix A
- Operational speed ranges of current systems reported by Euro NCAP – see Appendix B

The data for the European road speed limits shows that the speed limit for urban roads is generally 50 km/h, for non-urban roads generally 90 km/h but ranges from 70 km/h to 100 km/h, and for motorways often 130 km/h but ranges from 80 km/h to 140 km/h (or unrestricted in Germany).

The data for the operational speed ranges of current systems shows that the minimum operational speed is usually 60 or 65 km/h with a small number of systems operating from a lower speed of 50 km/h. The maximum operational speed is generally quite high and much above 130 km/h and appears to be somewhat related to the maximum speed of the vehicle.

Based on these data a minimum operational speed range for ELKS of 65 km/h to 130 km/h was suggested on the basis that current systems should meet this requirement and that the system would be active on non-urban roads and motorways but not on urban roads where interventions for intended manoeuvres may be more likely.

In consultation with stakeholders the following issues were raised and discussed:

- In general, **the target population for ELKS is collisions that occur on inter-urban roads at higher speeds, the majority at 70 km/h plus** (Euro NCAP 2016).
- Safety margins are needed to ensure that it is guaranteed that the requirement is met.
- Driving below 70 km/h occurs in urban environments with unclear lane markings and thus a high potential for driver annoyance. Also speeds often fluctuate between 40 km/h and 65 km/h. If lower end of speed range was 65 km/h, which could actually be 60 km/h when taking safety margin into account, this could cause much driver annoyance as the system would switch on and off as the vehicle speed changed from 40 km/h to 65 km/h.

After discussion the following performance requirements were proposed:

- Active at least within the vehicle speed range between [70 km/h] and the lower of [130 km/h] or maximum vehicle speed
- In the case that the vehicle reduces its speed from above [70 km/h] to below [70 km/h], the system shall be active at least until the vehicle speed reduces below [65 km/h].

To answer the second question about the minimum range of lateral departure velocities that the system should operate for, the following was considered:

- Stakeholder discussion revealed that high lateral departure velocities (circa 0.6 m/s and above) are usually indicative of driver intended manoeuvres and manufacturers sometimes use this parameter as an indicator to identify intended manoeuvres. Designers may be encouraged to set low limits for this parameter to help minimise driver annoyance. Therefore, ideally, the test range should be set to discourage this. In their assessment for unintentional manoeuvres Euro NCAP test for a lateral departure range of 0.2 m/s to 0.5 m/s (Euro NCAP 2019).
- Results from Euro NCAP assessments of current ELK systems show that they achieved full points for the lateral velocity departure range of 0.2 m/s to 0.5 m/s provided they worked for that scenario (Euro NCAP 2019 – 2). However, it should be noted that all tests were conducted with a test velocity of 72 km/h.
- A simple relationship was developed between lateral departure velocity and lateral acceleration and bend radius – see Appendix C. This relationship shows that a lateral departure velocity of 0.5 m/s equates to keeping a vehicle in its lane in a bend of radius 400 m at a speed of 72 km/h and a bend of radius 772 m at a speed of 100 km/h.

  Note that ideally this relationship should be confirmed through testing using real systems and vehicles.

Lateral departure velocity (m/s)	Average lateral acceleration (m/s^2)	Radius of bend (m)
0.2	0.40	1000
0.3	0.60	667
0.4	0.80	500
0.5	1.00	400
0.6	1.20	333
0.7	1.40	286
1	2.00	200

Test speed 72 km/h

Lateral departure velocity (m/s)	Average lateral acceleration (m/s^2)	Radius of bend (m)
0.2	0.40	1929
0.3	0.60	1286
0.4	0.80	965
0.5	1.00	772
0.6	1.20	643
0.7	1.40	551
1	2.00	386

Test speed 100 km/h

Figure 5: Relationship between lateral departure velocity, lateral accelerations and bend radii for test speeds of 72 km/h and 100 km/h

- On UK motorways bends have radii in region of 1000–2000 m, on other major roads often in region of 300–500 m, so a 0.5 m/s value for the upper range of a requirement for lateral departure velocity appears reasonable.

Stakeholders, suggested that the lateral departure velocity requirement for higher speeds should be reduced and the following was proposed:

- Vehicle should be kept in lane for lateral departure velocities in the range of the 0.2 m/s to 0.5 m/s for vehicle speeds up 100 km/h and for lateral departure velocities in the range of 0.2 m/s to 0.3 m/s for vehicle speeds greater than 100 km/h.

The main reason for selecting 100 km/h was related to the speed limits on inter-urban roads and motorways and their typical bend radii. The speed limits on inter-urban roads and motorways in Europe are 100 km/h or less and 140 km/h or less, respectively – see Appendix A. Bend radii are tighter on inter-urban roads than motorways and hence greater lane keeping capability is needed for these roads.

To answer the third question about how far a vehicle should be allowed to cross a solid lane marking, the value used in the Euro NCAP assessment of a Distance to Lane Marking (DTLM) of [-0.3m] was effectively adopted (Euro NCAP 2019). This value was set based on consideration of lane departure over a solid marking and a road edge. For a road edge Euro NCAP permits departure over the edge of 0.1 m based upon the logic that this means that about half the tyre width will still be on the road, thus reasonable control of the vehicle should still be possible. The inside of a lane marking is typically 0.2 m or greater from the road edge, so to ensure reasonable control of the vehicle in the situation of crossing a solid lane marking next to a road edge, a DTLM value of [-0.1 m – 0.2 m = -0.3 m] was chosen.

The conditions in which the lane keep requirements should be met were developed based on consideration of detection of the lane markings and potential effects of environmental conditions on vehicle dynamics. For detection of lane markings, they should be in line with one of those described in the Commission Regulation (EU) No. 351/2012, in good condition and visibility should be good. Performance at night time with head lamps if necessary was added For potential effects on vehicle dynamics the road surface should be straight, flat, and dry and weather conditions good, e.g. no storm, not below 5°C.

Draft Text

<table>
<tr><td>2.6</td><td>CDCF performance requirements</td></tr>
<tr><td>2.6.1</td><td>Speed range

The CDCF shall be active at least within the vehicle speed range between [70 km/h] and the lower of [130 km/h] or maximum vehicle speed and at all vehicle load conditions, unless deactivated as per paragraph 2.2.

However, in the case that the vehicle reduces its speed from above [70 km/h] to below [70 km/h], the system shall be active at least until the vehicle speed reduces below [65 km/h].</td></tr>
<tr><td>2.6.2</td><td>Lane keep

In the absence of conditions leading to deactivation or suppression of the system according to paragraphs 2.2 and 2.3, the CDCF shall be able to prevent lane departure by crossing of visible lane markings in the scenarios shown in the following table by more than a DTLM of [-0.3 m]:

(a) for lateral departure velocities in the range of the [0.2 m/s] to [0.5 m/s] for vehicle speeds up [100 km/h] and for lateral departure velocities in the range of [0.2 m/s] to [0.3 m/s] for vehicle speeds greater than [100 km/h].

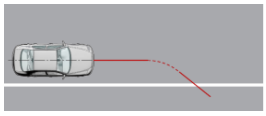
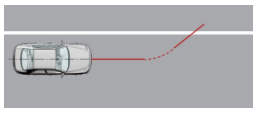
(b) on straight, flat and dry roads

(c) for lane markings in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix ‘Visible lane marking identification’

(d) with the markings being in good condition and of a material conforming to the standard for visible markings of that contracting party

(e) in all illumination conditions without direct blinding sunlight and low beam head lamps if necessary

(f) in absence of weather conditions affecting the dynamic performance of the vehicle (e.g. no storm, not below 5°C) or the visibility of lane markings (e.g. no fog)

<table>
<tr><td>No.</td><td>Scenario Description</td></tr>
<tr><td>1.</td><td>Solid line – Departure to right side of vehicle.
  </td></tr>
<tr><td>2</td><td>Solid line – Departure to left side of vehicle.
  </td></tr>
</table>

It is recognised that the performances required for the scenarios in this table may not be fully achieved in other conditions than those listed above. However, the system shall not unreasonably switch the control strategy in these other conditions.

This shall be demonstrated in accordance with Annex 6 of UN Regulation No. 79 for steering based systems or Annex 8 of UN Regulation No. 13-H for non-steering based systems.

The lane keep capability shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 4.</td></tr>
</table>

Driver Steering Override

The approach taken to develop the requirements for this item was:

- Base on UN Regulation No. 79
- Add requirements for non-steering based CDCF, e.g. differential braking type ones

Regulation 79 requires that:

> *'The steering control effort necessary to override the directional control provided by the system shall not exceed 50 N in the whole range of CSF operations.'*

Consultation with expert stakeholders revealed that the typical override force measured for current 'steering based' lane support systems was about 4 Nm or slightly less, which assuming a steering wheel rim diameter of 0.35 m equates to about 23 N (Euro NCAP 2019 - 2). This is about half the maximum mandated by Regulation 79.

In response to this, a proposal to set a more stringent override force limit for ELKS was discussed with vehicle manufacturers and other stakeholders. After much discussion it was recommended that the current Regulation 79 override force limit should be adhered to because:

- Harmonisation with Regulation 79 offers advantages such as keeping the regulation straight forward. Also, the current Regulation 79 limit was set following much debate and careful consideration by the UNECE ACSF informal working group taking into account safety issues and potential future systems; for example, future emergency steer type functions may require override force limits higher than those typically used for current lane keep functions.
- Vehicle manufacturers have to allow a considerable safety margin to ensure performance requirements are met for all situations and configurations. Examples of influencing factors that drive the need for a safety factor are:
    - Vehicle design-dependent friction between steering wheel and torque sensor
    - Production tolerances
    - Measurement tolerances

Also, whilst test driving a current car being assessed by Euro NCAP, the author noted a potential problem with how the steering override can be implemented. For a particular vehicle, once the override torque of about 4 Nm was reached, the torque required to turn the steering wheel dropped almost instantaneously to a very low value. This could cause control issues, especially if the torque to override the function was higher. In response to this issue, following discussion with stakeholders, a proposal to add the following requirement to the Regulation 79 requirement was recommended:

> *'Significant loss of steering support once overridden shall not happen suddenly.'*

Non-steering-based ELK systems, such as differential braking type ones, require steering input in the opposite direction to which they are directing the vehicle to override them. As a result of consultation with stakeholders, for non-steering based ELKS, a proposal to limit the steering input to 25 degrees to override was recommended.

Non-steering-based systems by their design act indirectly on the steering system rather than directly. Because of this, steering force magnitudes are those as for 'normal' steering which practically are below 50 N for M_1 and N_1 vehicles. On this basis and to reduce the regulatory burden, vehicle manufacturer stakeholders recommended that non-steering-based ELKS should have to meet the steering input limit requirement only and not the force requirements. The author found it difficult to make a recommendation whether or not to include the steering override force requirements for non-steering-based systems and thus defaulted to the 'safe' option to include them.

The choice of the word 'Additionally' or 'Alternatively' in the draft text below includes or does not include the force requirements, respectively. The Commission should decide which option to choose.

Draft Text

2.6.3	Steering override
2.6.3.1	The steering control effort necessary to override the directional control provided by the system shall not exceed 50 N. Significant loss of steering support once overridden shall not happen suddenly.
2.6.3.2	[Additionally / Alternatively], for CDCF systems which do not act on the steering itself (e.g. differential braking type CDCF), the steering input shall not exceed [25] degrees.
2.6.3.3	The steering override control effort shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 4.

Warning Indication

The approach taken to develop the requirements for this item was:

- Base on UN Regulation No. 79

The warning indication requirements for Corrective Steering Function (CSF) in Regulation 79 were copied and pasted into the draft text. An option for the driver to temporarily suppress the audible warning for the duration of the vehicle master control switch cycle was added to comply with the Article 7: 4(c) requirements in Regulation (EU) 2019/2144, namely:

'It shall be possible to easily suppress audible warnings, but such action shall not at the same time suppress system functions other than audible warnings'

Draft Text

2.6.4	CDCF warning indication
2.6.4.1	Every CDCF intervention shall immediately be indicated to the driver by an optical warning signal which is displayed for at least 1 s or as long as the intervention exists, whichever is longer. The optical signal may be the flashing of the failure warning signal specified in paragraph 2.1.1.
2.6.4.1.1	In the case of an intervention longer than 10 seconds an acoustic warning signal shall be provided until the end of the intervention. The manufacturer may offer means for the driver to temporarily suppress the audible warning for the duration of the vehicle master control switch cycle.
2.6.4.1.2	In the case of two or more consecutive interventions within a rolling interval of 180 seconds and in the absence of a steering input by the driver during the intervention, an acoustic warning signal shall be provided by the system during the second and any further intervention within a rolling interval of 180 seconds. Starting with the third intervention (and subsequent interventions) the acoustic warning signal shall continue for at least 10 seconds longer than the previous warning signal.
2.6.4.2	The requirements in paragraphs 2.6.4.1.1 and 2.6.4.1.2 shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 4.

3.3.3 Test procedures

3.3.3.1 Lane Departure Warning System (LDWS)

The approach taken to develop the requirements for this item was:

- Base on UN Regulation No. 130 / Regulation (EU) 351/2012
- Write in style of draft UN Regulation No. 152 on AEBS (UNECE 2019)

Points to note were:

- Tests were included for:
  - Optical warning signal
  - Lane departure warning signal
  - Manual deactivation test for warning signal and default on with activation of the master control switch
- A test for failure detection contained in Regulation 130 was not included in the test procedures for the LDWS. This is because, effectively, it will be covered by tests within the CEL annex for the CDCF which will have many components in common with the LDWS.
- Tolerances for testing were kept the same as for Regulation 130 / Regulation (EU) 351/2012 which means that the tests can be performed with a driver and a driving robot is not necessary.
- Performance requirements and test conditions were aligned with those in the performance requirements section which in turn were aligned with those for the CDCF.

Draft Text

3	Test requirements for LDWS
3.1	General provisions Vehicles fitted with LDWS shall fulfil the appropriate test requirements of this paragraph.
3.2	Testing conditions The tests shall be performed: • On a flat and dry asphalt or concrete road type surface, which may 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 centre of the test lane and with a longitudinal distance of 30 m ahead of the subject vehicle from the point after the test is complete • In all illumination conditions without direct blinding sunlight and low beam head lamps if necessary • In ambient air temperatures between [5°C and 45°C]. • In the absence of weather conditions affecting the visibility of lane markings, e.g. fog At the manufacturer's discretion and with the agreement of the Technical Service the tests may be performed under conditions deviating from what is described above (e.g. at lower ambient air temperatures).
3.2.1	Lane markings The lane markings on the road used for the tests shall be in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. The markings shall be in good condition and of a material conforming to the standard for visible lane markings. The lane-marking layout used for the tests shall be recorded in

	the test report. The width of the lane shall be a minimum of 3.5 m for the purpose of the tests of this paragraph. The vehicle manufacturer shall demonstrate, through the use of documentation, compliance with all other lane markings identified in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. Any of such documentation shall be appended to the test report.
3.2.2	Subject vehicle conditions
3.2.2.1	Test mass The subject vehicle shall be tested in a load condition agreed between the manufacturer and the Technical Service. No load alteration shall be made once the test procedure has begun. The vehicle manufacturer shall demonstrate, through the use of documentation, that the system works at all load conditions.
3.2.2.2	The subject vehicle shall be tested at the tyre pressures recommended by the vehicle manufacturer.
3.2.2.3	Where the LDWS is equipped with a user-adjustable warning threshold, the tests specified in paragraph 3.3 shall be performed with the warning threshold set at its maximum lane departure setting. No alteration shall be made once the test procedure has begun.
3.2.2.4	Pre-test conditioning If requested by the vehicle manufacturer the vehicle can be driven a maximum of 100 km on a mixture of urban and rural roads with other traffic and roadside furniture to calibrate the sensor system.
3.3	Test procedures
3.3.1	Optical warning signal verification test With the vehicle stationary, check that the optical warning signal(s) comply with the requirements of paragraph 2.5.3.2.
3.3.2	Lane departure warning test
3.3.2.1	Drive the vehicle at a speed of [70 km/h +/- 3 km/h] into the centre of the test lane in a smooth manner so that the attitude of the vehicle is stable. Maintaining the prescribed speed, gently drift the vehicle, either to the left or the right, with a lateral departure velocity of between [0.1] and [0.5 m/s] so that the vehicle crosses the lane marking. Repeat the test at a different rate of departure within the range [0.1] and [0.5 m/s]. Repeat the above tests drifting in the opposite direction.
3.3.2.2	The test requirements are fulfilled if the LDWS provides the lane departure warning indication mentioned in paragraph 2.5.3.1 above at the latest when the DLTM is [-0.3 m].
3.3.2.3	In addition, the vehicle manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements for the whole speed range and lateral departure velocity range are fulfilled. This may be achieved on the basis of appropriate documentation appended to the test report.
3.3.3	Manual deactivation test
3.3.3.1	If the vehicle is equipped with means to manually deactivate the ELKS (LDWS), turn the vehicle master control switch to the "Power ON" position and deactivate the ELKS (LDWS). The warning signal specified in paragraph 2.2.3 shall be activated.

	Turn the master control switch to the "Power OFF" position [and open driver's door]. Turn the vehicle master control switch to the "Power ON" position and verify that the previously activated warning signal is not reactivated, thereby indicating that the ELKS (LDWS) has been reinstated as specified in paragraph 2.2.1.1.

3.3.3.2 Corrective Directional Control Function (CDCF)

The approach taken to develop the requirements for this item was:

- Base on UN Regulation No. 79 test requirements for Corrective Steering Function (CSF) for lane departure (type (c))
- Adjust to allow testing of non-steering-based CDCF, e.g. different steering override requirements
- Add lane keep test requirements
- Write in style of draft UN Regulation No. 152 on AEBS (UNECE 2019)

A main question which had to be resolved to write the procedure was:

- What type of lane keep test procedure should be used?

Using literature review, two candidate test procedures currently in use that could be adapted to assess the lane detection and lane keeping capability of the CDCF were identified, namely the lane keep test procedure used in the current Euro NCAP lane support systems assessment (Euro NCAP 2019) and the lane keeping functional test used in Regulation 79 for the assessment of the lane keeping capability of ACSF category B1 systems.

Euro NCAP lane keep test procedure

In this procedure the vehicle is driven using a steering robot in a straight lane with defined road makings and / or a road edge as required. A steering input is applied to give the vehicle a specified yaw and lateral departure velocity. Following this, steering effort is removed so that the vehicle starts to leave the lane with the lateral velocity specified and the steering oriented in the straight ahead position as illustrated in Figure 6.

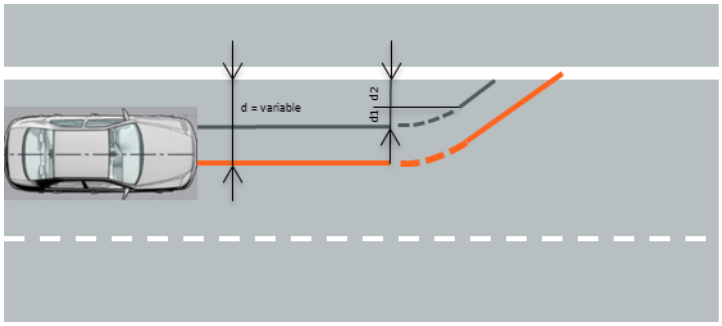


Figure 6: Euro NCAP lane keep test procedure, note driving on left hand side of road as in UK. Source Euro NCAP

As the vehicle starts to get close to the lane markings and / or road edge, the lane keep system should activate and keep the vehicle in the lane.

UN Regulation No. 79 ACSF Cat B1 lane keep test procedure

In this procedure the vehicle is driven without any force applied by the driver on the steering control (e.g. by removing the hands from the steering control) with a given constant speed into a bend with a given radius with lane markings at each side (Figure 7).

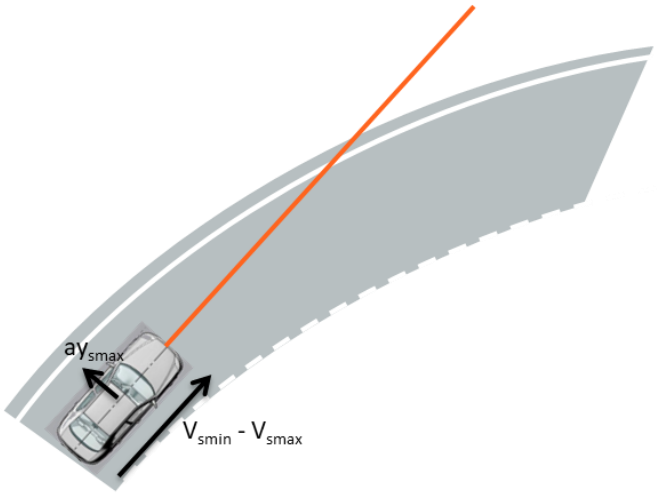


Figure 7: UN Regulation No. 79 ACSF Cat B1 lane keep test procedure

As the vehicle starts to get close to the lane markings and / or road edge, the lane keep system should activate and keep the vehicle in the lane.

The advantages and disadvantages of each of the procedures are as follows:

- Euro NCAP type procedure:

  Advantages are that it is a tried and tested procedure that is fit for purpose without any major alterations and is generally accepted by stakeholders.

  Disadvantages are that is that it does not align with current test procedures used in Regulation 79.

- UN Regulation No. 79 ACSF B1 type procedure:

  Advantages are that it is a test procedure currently used within regulation, so test services are somewhat familiar with it, although some stakeholders mentioned that there are ongoing problems with its implementation currently.

  Disadvantages are that it would require modification to be fit to test the CDCF envisaged. Modifications envisaged are that the vehicle would be driven in the lane at a specified speed around a bend of a specified radius, the steering force would be released which would cause the vehicle to start to drive out of the lane due to the steering self-centring. Requirements could be set for the CDCF to intervene and keep the vehicle in the lane for specified lateral accelerations. The lateral accelerations could be varied by changing the vehicle speed and / or bend radius. Stakeholders have mentioned that it can be difficult to find test facilities which have bends with the radii needed to perform these tests.

Based on these advantages and disadvantages it was proposed that a Euro NCAP type procedure should be used. Another reason for this proposal was because it is the more appropriate procedure for assessment of a system which provides a temporary intervention to correct lane departure (rather than long-lasting steering support), which the CDCF is intended to do.

Other points to note were:

- Lane keep test: Lane markings – For the lane keep test with single solid lane markings, to help ensure minimal influence from other lane markings on the test

result it was proposed that the solid lane marking shall be a minimum of 7 m distance from any other lane markings. This was estimated as follows:

- From the Euro NCAP Lane Support Systems test protocol (Euro NCAP 2019)

  d = d1 + d2

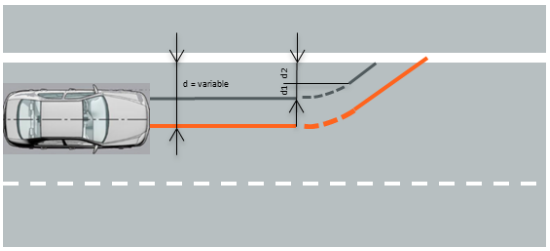
  For lateral departure of 0.5 m/s (largest velocity to be tested),

  d1 = 0.75 m

  If allow about 3 sec free drift as recommended by stakeholders

  d2 = 3 *0.5 m/s = 1.5 m

  Therefore d = d1 + d2 = 0.75 + 1.5 = 2.25m.



  Typical car width = 1.8 m

  Need to be at least same distance from another lane marking compared to one being tested

  Therefore, distance to other lane marking = 2.25*2 + 1.8 m = 6.3 m

  Ideally, need a little more than this, otherwise other lane marking could help detection of marking being tested.

  Typical two-lane road width =3.5 *2 m.

  Therefore, on basis that central lane marking in two lane road on a test track could be removed, pragmatically choose minimum of 7 m.

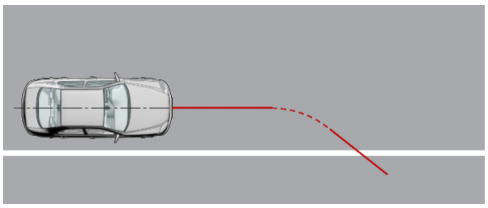
- Lane keep test: tolerances and driving robot – The tight tolerances defined for parameters such as the test speed and lateral departure velocities in the Euro NCAP test procedure dictate that a driving robot must be used for testing; a test driver would not be able to achieve the tolerances required. Based on familiarity of the test being performed with a driving robot and the requirement to test at the minimum and maximum lateral departure velocities which a driver could not do, it was proposed to keep the tight tolerances for the test parameters for the test.
- Steering Override test: Compared to Regulation 79, additional requirements were included for testing of non-steering-based systems.

Draft Text

4	Test requirements for CDCF
4.1	General provisions Vehicles fitted with CDCF shall fulfil the appropriate test requirements of this paragraph.
4.2	Testing conditions The tests shall be performed: • On a flat and dry asphalt or concrete road type surface, which may 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 centre of the test lane and with a longitudinal distance of

	30 m ahead of the subject vehicle from the point after the test is complete. • In all illumination conditions without direct blinding sunlight and low beam head lamps if necessary. • In ambient air temperatures between [5°C and 45°C]. • In the absence of weather conditions of weather conditions affecting the dynamic performance of the vehicle (e.g. no storm, not below 5°C) or the visibility of lane markings (e.g. fog). At the manufacturer's discretion and with the agreement of the Technical Service the tests may be performed under conditions deviating from what is described above (e.g. at lower ambient air temperatures).
4.2.1	Lane markings The solid lane marking on the road used for the tests shall be in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. The marking shall be in good condition and of a material conforming to the standard for visible lane markings. The lane-marking used for the tests shall be recorded in the test report. The solid lane marking shall be a minimum of [7 m] distance from any other lane markings, for the purpose of the tests of this paragraph. The vehicle manufacturer shall demonstrate, through the use of documentation, compliance with all other solid lane markings identified in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. Any of such documentation shall be appended to the test report.
4.2.2	Subject vehicle conditions
4.2.2.1	Test mass The subject vehicle shall be tested in a load condition agreed between the manufacturer and the Technical Service. No load alteration shall be made once the test procedure has begun. The vehicle manufacturer shall demonstrate, through the use of documentation, that the system works at all load conditions.
4.2.2.2	The subject vehicle shall be tested at the tyre pressures recommended by the vehicle manufacturer.
4.2.2.3	Where the CDCF is equipped with a user-adjustable timing threshold, the test specified in point 4.3.3 shall be performed with the timing threshold set at its latest setting for system intervention. No alteration shall be made once the test procedure has begun.
4.2.2.4	Pre-test conditioning If requested by the vehicle manufacturer the vehicle can be driven a maximum of 100 km on a mixture of urban and rural roads with other traffic and roadside furniture to calibrate the sensor system.
4.3	Test procedures
4.3.1	Warning indication test
4.3.1.1	The subject vehicle shall be driven with an activated CDCF on a road with solid lane markings on at least one side of the lane. The test conditions and the subject vehicle test speed shall be within the operating range of the system. During the test, the duration of the CDCF interventions and of the optical and acoustic warning signals shall be recorded.

	In the case of paragraph 2.6.5.1.1 of this Regulation, the subject vehicle shall be driven such that it attempts to leave the lane and causes CDCF intervention to be maintained for a period longer than 10 seconds. If such a test cannot be practically achieved due to e.g. the limitations of the test facilities, with the consent of the Type Approval Authority this requirement may be fulfilled through the use of documentation. The test requirements are fulfilled if: (a) The acoustic warning is provided no later than 10 s after the beginning of the intervention. In the case of paragraph 2.6.5.1.2 of this Regulation, the subject vehicle shall be driven such that it attempts to leave the lane and causes at least three interventions of the system within a rolling interval of 180 seconds. The test requirements are fulfilled if: (a) An optical warning signal is provided for each intervention, as long as the intervention exists, and (b) An acoustic warning signal is provided at the second and third intervention, and (c) The acoustic warning signal at the third intervention is at least 10 s longer than the one at the second intervention.
4.3.1.2	In addition, the manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements defined in paragraphs 2.6.5.1.1 and 2.6.5.1.2 are fulfilled in the whole range of CDCF operation. This may be achieved on the basis of appropriate documentation appended to the test report.
4.3.2	Steering override test
4.3.2.1	The subject vehicle shall be driven with an activated CDCF on a road with solid lane markings on each side of the lane. The test conditions and the subject vehicle test speed shall be within the operating range of the system. The vehicle shall be driven such that it attempts to leave the lane and causes CDCF intervention. During the intervention, the driver shall apply the steering control effort necessary to override the intervention. The force and steering input applied by the driver on the steering control to override the intervention shall be recorded. The test requirements are fulfilled if: (a) The force applied by the driver on the steering control to override the intervention does not exceed 50 N, and (b) Significant loss of steering support once overridden does not happen suddenly. (c) [Additionally / alternatively], for ELK systems which do not act on the steering itself (e.g. differential braking type CDCF), the steering input does not exceed [25] degrees.
4.3.2.2	In addition, the manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements defined in paragraph 2.6.4 are fulfilled in the whole range of CDCF operation. This may be achieved on the basis of appropriate documentation appended to the test report.
4.3.3	Lane keep test
4.3.3.1	The CDCF shall be tested for each test scenario described in paragraph 2.6.

4.3.3.1.1	Tests for all scenarios shall be performed with lateral velocities of [0.2 m/s and 0.5 m/s].
4.3.3.1.2	A test path shall be driven which consists of an initial straight path parallel to the solid lane marking being tested, followed by a fixed radius curve to apply a known lateral velocity and yaw to the subject vehicle, followed again by a straight path without any force applied on the steering control (e.g. by removing the hands from the steering control). 
4.3.3.1.3	The subject vehicle speed during the test up to the point of system intervention shall be [72 km/h +/- 1] km/h. The curve of fixed radius driven to apply the lateral velocity required shall have a radius of 1200 m or more. The lateral velocity required shall be achieved to a tolerance of [+/- 0.05 m/s]. The vehicle manufacturer shall provide information describing the radius of the curve to be driven and the location when the closed loop path and/or speed control shall be ended so as not to interfere with the system intervention for each test.
4.3.3.2	The test requirements are fulfilled if the subject vehicle does not cross the lane marking by a DTLM of more than [-0.3 m].
4.3.3.3	In addition, the vehicle manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements for the whole speed range and lateral departure velocity range are fulfilled. This may be achieved on the basis of appropriate documentation appended to the test report.

4 Way Forward

The next steps for the ELKS regulation are:

- Drafting of the EU regulatory proposal and consultation process by the Commission:
    - It is planned that in particular the Motor Vehicle Working Group (MVWG) meetings to take place in 2020 will be used for this purpose.

      Note: There is a call for applications for those who wish to attend the meeting (and are eligible to attend): https://ec.europa.eu/growth/content/continuously-open-call-applications-working-group-motor-vehicles_en
- Application of regulation

  Following the publication of Regulation (EU) 2019/ 2144 the date of application of the General Safety Regulation is currently expected to be from 5 July 2022.
- Review and potential update of regulation

  Article 14 'Review and reporting' of the European Parliament draft resolution states that:

  By ... [five years after the date of application of this Regulation] and every five years thereafter, the Commission shall submit an evaluation report to the European Parliament and to the Council on the achievements of the safety measures and systems, including their penetration rates and convenience for the user. The Commission shall investigate whether those safety measures and systems act as intended by this Regulation. Where appropriate, that report shall be accompanied by recommendations, including a legislative proposal to amend the requirements concerning general safety and the protection and safety of vehicle occupants and vulnerable road users, in order to further reduce or to eliminate accidents and injuries in road transport.

  With regard to the progression of technology, it is recommended that the following should be considered as part of this review:
    - Mandatory fitment of ELKS which can detect road edges
    - Mandatory fitment of ELKS with threat detection for oncoming and overtaking vehicles
    - Review of CDCF lateral departure velocity performance requirements

5 Acknowledgements

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6 References

Cicchino J (2018). Effects of lane departure warning on police-reported crash rates. Journal of Safety Research, 66 2018 pp61-70.

EC (2018). Commission Staff Working Document, Impact Assessment accompanying the document 'proposal for a Regulation on …. as regards their general safety. Accessed Dec 2019, Retrieved from: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2018:0190:FIN:EN:PDF

Edwards M, Appleby J, and Guy I (2019). General Safety Regulation - Technical study to assess and develop performance requirements and test protocols for various measures implementing the new General Safety Regulation, for accident avoidance and vehicle occupant, pedestrian and cyclist protection in case of collisions: Emergency Lane Keeping System (ELKS) Interim Report: Review and Scope Requirements. TRL Client Report CPR2684.

Euro NCAP (2016). Lane Support Systems (LSS) assessment procedure development – Accident Analysis GIDAS and VOIESUR data. Private communication July 2019.

Euro NCAP (2019). Euro NCAP Test protocol – Lane support systems, version 2.0.2. Accessed Nov 2019, Retrieved from: https://cdn.euroncap.com/media/41770/euro-ncap-lss-test-protocol-v202.201811091311328900.pdf.

Euro NCAP (2019 - 2). Private communication with Euro NCAP secretariat.

European Parliament (EP) (2019). Regulation (EU) 2019/2144 of the European Parliament and of the Council of 27 November 2019. Official Journal of the European Union L 325/1 16/12/2019. Accessed Dec 2019, Retrieved from: https://eur-lex.europa.eu/eli/reg/2019/2144/oj

Sternlund S, Strandroth J, Rizzi M, Lie A and Tingvall C (2017). The effectiveness of lane departure warning systems – A reduction in real-world passenger car injury crashes. Traffic Injury Prevention, 2017, Vol 18, No 2, pp225-229.

UNECE (2018). Uniform provisions concerning the approval of vehicles with regard to steering equipment, revision 4, Nov 2018. Accessed Nov 2019, Retrieved from: https://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2018/R079r4e.pdf

UNECE (2019). Proposal – UN Regulation No. [152]. Uniform provisions concerning the approval of motor vehicles with regard to the Advanced Emergency Braking System (AEBS) for M1 and N1 vehicles. July 2019. Accessed Nov 2019, Retrieved from: https://www.unece.org/trans/main/wp29/wp29wgs/wp29grva/grva2019.html

7 Appendix A: Speed limits of European Roads by Country

For passenger cars and vans; from:
https://ec.europa.eu/transport/road_safety/going_abroad/spain/speed_limits_en.htm

Country	Urban Road (km/h)	Non-Urban (km/h)	Motor- / Expressways (km/h)	Comments
Austria	50	100	130	
Belgium	50	70 Flemish Region 90 Other areas	120	20 km/h in residential areas, 30 km/h near schools and in streets with cycle paths
Bulgaria	50	90	120 - 140	
Croatia	50	90	130	
Cyprus	50	80	100	30 km/h for Pedestrian Zones
Czech Republic	50	90	110 - 130	80 km/h in built-up areas
Denmark	50	80	130	
Estonia	50	90	90	Motorways/Expressways; Summer time speed limit - 110 km/h
Finland	50	80	80 - 120	Motorways/Expressways: Always displayed by traffic signs (80 km/h, 100 km/h, 120 km/h); Vans 80 km/h or 100 km/h
France	50	80 (some are 90)	110 - 130	Motorways/Expressways: 100 km/h in rainy/wet conditions, 50 km/h if the visibility is less than 50 m
Germany	50	100	130	Motorways/Expressways: Generally unlimited with 130 km/h recommended speed
Greece	50	90	110 - 130	
Hungary	50	90	110 - 130	
Ireland	50	80 and 100	120	
Italy	50	90 [km/h]	130	
Latvia	50	90 (80 for gravel roads)	-	

Liechtenstein	50	80	-	
Lithuania	50	70, 90 asphalt and concrete roads (80 for less than 2 years of experience)	110 - 130	Motorway: 130 km/h from April to October; 110 km/h from November to March. For drivers with under 2 years of driving experience – 100 km/h. Highway: 120 km/h from April to October; 110 km/h from November to March. For drivers with under 2 years of driving experience – 90 km/h.
Luxembourg	50	90	130 (110 in the rain)	
Malta	50	80	80	
Netherlands	50	80	100 - 130	
Norway	50	80 [km/h]	100	
Poland	50 (5 am - 11pm), 60 (11pm - 5am)	90	110 - 140 100 on single carriageway expressway	20 in residential areas
Portugal	50	90	100 - 120	
Romania	50	90 and 100	130	
Slovakia	50	90	130 (90 in built-up areas)	
Slovenia	50	90	110 - 130	For urban roads 30 km/h in speed limit zones; 10 km/h in pedestrian zones where traffic is allowed
Spain	50	80 for vans and light lorries, 90 for passenger cars, pick-ups and multi-purpose vehicles	90 for vans and light lorries, 100 for multi-purpose vehicles, 120 for passenger cars and pick-ups	
Sweden	50	70	110	
Switzerland	50	80	100 - 120	
United Kingdom	48	96	112	

8 Appendix B: Operational speed ranges of current ELK systems reported by Euro NCAP

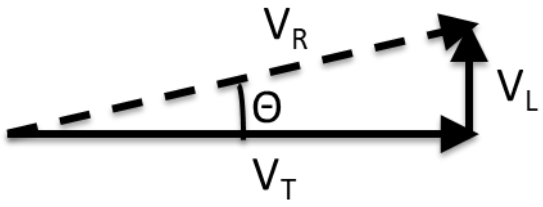
Note: Data extracted from vehicle handbook or provided to Euro NCAP by manufacturer.

Vehicle Category	Year Tested	Default ON	Min Speed	Max Speed
Supermini	2019	YES	65	250
Executive	2018	YES	65	250
Large off-road	2019	YES	65	250
Small off-road	2018	YES	65	250
Small MPV	2018	YES	60	180
Small off-road	2019	YES	65	180
Small off-road	2019	YES	65	180
Large off-road	2018	YES	60	130
Large off-road	2018	YES	60	180
Executive	2018	YES	50	180
Small family car	2019	YES	60	200
Small off-road	2019	YES	50	180
Small family car	2018	YES	60	200
Small MPV	2019	YES	60	200
Small family car	2019	YES	60	200
Small off-road	2019	YES	60	200
Large off-road	2019	YES	60	200
Large off-road	2019	YES	60	200
Small MPV	2018	YES	60	180
Large family car	2018	YES	60	180
Small MPV	2018	YES	60	180
Small off-road	2019	YES	30	140
Large off-road	2019	YES	60	250
Small off-road	2019	YES	60	250
Small family car	2019	YES	60	250
Supermini	2018	YES	55	200
Large family car	2019	YES	40	145
Small off-road	2018	YES	65	250
Small MPV	2019	YES	60	200
Large off-road	2018	YES	60	180

9 Appendix C: Derivation of relationship between lateral velocity, acceleration and bend radius

Derivation:

Assume test speed (V_T) >>> lateral velocity (V_L), then $V_T \approx V_R$ (1)

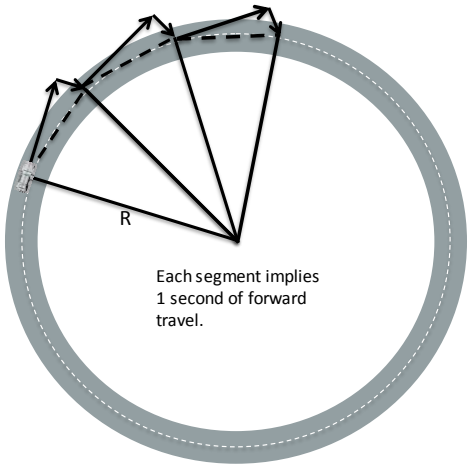


For time duration of 1 second:

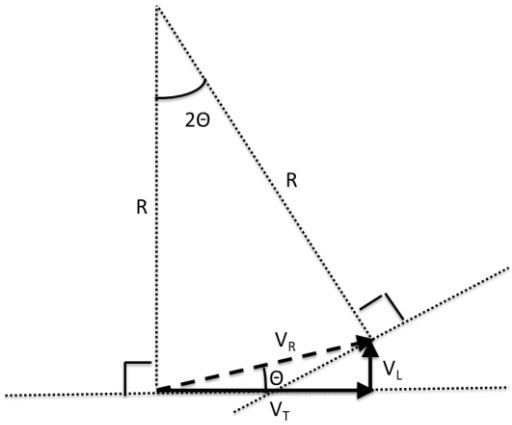
$\Theta = \tan^{-1}(V_L/V_T) \approx V_L/V_T$ in radians for small angles (2)

Assume re-input of lateral drift velocity every second, i.e. constant lateral acceleration

If continue like this will eventually travel around in a circle:



However, geometry means that in 1 second will travel 2Θ radians:



Circle consists of 2π radians

Therefore, time to travel a circle = $2\pi/2\dot{\Theta}$ seconds = $\pi/\dot{\Theta}$ seconds (3)

Circumference of circle travelled = velocity * time to travel a circle

$= V_R * \pi / \dot{\Theta}$ (4)

Circumference of circle = $2\pi R$

Solve for R: $R = V_R / 2\dot{\Theta}$ (5)

Lateral acceleration $= V_R^2/R$ (6)

Substitute for R from (5) $= 2V_R \dot{\Theta}$

Substitute for Θ from (2) $\approx 2V_R*(V_L/ V_T) \approx 2V_L$ for short (1 second) time duration ..note from (1) $V_T \approx V_R$

i.e. lateral acceleration ≈ 2*(lateral velocity) for short time duration / constant lateral acceleration

and $R \approx V_R^2/$(lateral acceleration) for short time duration / constant lateral acceleration

10 Appendix D: Draft performance requirements and tests

10.1 Definitions

0.10	*"Emergency Lane Keeping System (ELKS)"* means a system that assists the driver in keeping a safe position of the vehicle with respect to the lane or road boundary, at least when a lane departure occurs or is about to occur and a collision may be imminent.
0.11	*"Vehicle master control switch"* means the device by which the vehicle's on-board electronics system is brought, from being switched off, as in the case where a vehicle is parked without the driver being present, to normal operation mode.
0.12	*"Corrective Directional Control Function (CDCF)"* means a control function within an electronic control system whereby, for a limited duration, changes to the steering angle of one or more wheels and/or braking of individual wheels may result from the automatic evaluation of signals initiated on-board the vehicle optionally enriched by data provided off-board the vehicle, in order to correct lane departure, e.g. to avoid crossing lane markings, leaving the road.
0.13	*"Lane Departure Warning System (LDWS)"* means a system to warn the driver that the vehicle is drifting out of its travel lane.
0.14	"*Vehicle Type with Regard to its Emergency Lane Keeping System*" means a category of vehicles which do not differ in such essential aspects as: (a) Vehicle features which significantly influence the performances of the Emergency Lane Keeping System; (b) The type and design of the Emergency Lane Keeping System.
0.15	"*Subject Vehicle*" means the vehicle being tested.
0.16	*"Distance to Lane Marking (DTLM)"* means the remaining lateral distance (perpendicular to the lane marking) between the inner side of the lane marking and most outer edge of the tyre before the subject vehicle crosses the inner side of the lane marking.
0.17	"*Common Space*" means an area on which two or more information functions (e.g. symbol) may be displayed, but not simultaneously.
0.18	"*Self-Check*" means an integrated function that checks for a system failure on a continuous basis at least while the system is active.
0.19	*"Dry road"* means a road with a nominal peak braking coefficient of 0.9.
0.20	*"Flat road"* means a road with a slope less than 1% in the longitudinal direction and for the lateral direction, less than 2% for half a lane width either side of the centreline and less than 3% for the outer half of the lane.

10.2 Requirements

1	General requirements
1.1	An ELKS shall comprise a LDWS and a CDCF
1.1.1	The LDWS shall meet the requirements of paragraphs of 2.1 to 2.4 and paragraph 2.5.
1.1.2	The CDCF shall meet the requirements of paragraphs of 2.1 to 2.4 and paragraph 2.6.
1.2	ELKS lane departure warnings and interventions Subject to specific requirements below the system shall be designed to minimise warnings and interventions for driver intended manoeuvres.
2	Specific requirements
2.1	ELKS failure warning A warning shall be provided when there is a failure in the ELKS that prevents the requirements of this Regulation of being met.
2.1.1	The warning shall be a constant optical warning signal. This warning signal may be interrupted by an optical warning according to paragraphs 2.5.3.1 or 2.6.5.1, if the ELKS is only partially* affected by the failure. *Note: ELKS partial failures are failures of the CDCF only or the LDWS only.
2.1.1.1	There shall not be an appreciable time interval between each ELKS self-check, and subsequently there shall not be a delay in illuminating the warning signal, in the case of an electrically detectable failure.
2.1.1.2	Upon detection of any non-electrical failure condition (e.g. sensor misalignment), the warning signal as defined in paragraph 2.1.1 shall be activated.
2.1.2	If the vehicle is equipped with a means to deactivate the ELKS a warning shall be given when the system is deactivated according to paragraph 2.2. This shall be a constant optical warning signal. The warning signal specified in paragraph 2.1.1 above may be used for this purpose.
2.2	ELKS deactivation
2.2.1	Manual deactivation When a vehicle is equipped with a means to manually deactivate the ELKS function, either partially or fully, the following conditions shall apply as appropriate:
2.2.1.1	The ELKS function shall be automatically and fully reinstated upon each activation of the vehicle master control switch, [at least provided the driver door is opened in-between].
2.2.1.2	The ELKS control shall be designed a in such a way that manual deactivation shall not be possible with less than two deliberate actions, e.g. press and hold on a button, or select and confirm on menu option.
2.2.1.3	The manual deactivation capability shall be tested in accordance with the relevant vehicle test(s) specified in paragraph 3 to this Regulation.
2.2.2	Automatic deactivation If the vehicle is equipped with a means to automatically deactivate the ELKS function, either partially or fully, for instance in situations such as off-road

	use, being towed, a trailer being hitched to the vehicle or the ESC being deactivated the following conditions shall apply as appropriate:
2.2.2.1	The vehicle manufacturer shall provide a list of situations and corresponding criteria where the ELKS function is automatically deactivated to the technical service at the time of type approval and it shall be annexed to the test report.
2.2.2.2	The ELKS function shall be automatically and fully reactivated as soon as the conditions that led to the automatic deactivation are not present anymore.
2.2.3	A constant optical warning signal shall inform the driver that the ELKS function has been deactivated. The failure warning signal specified in paragraph 2.1.1 above may be used for this purpose. This warning signal may be interrupted by an optical warning according to paragraphs 2.5.3.1 or 2.6.5.1, if the ELKS is only partially deactivated.
2.3	Automatic suppression
2.3.1	For driver intended manoeuvres As part of the CEL Annex requirements, the manufacturer shall provide a documentation package which gives access to the basic design and logic of the system for detection of likely driver intended manoeuvres and automatic suppression of the ELKS. This package shall include a list of parameters detected and a basic description of the method used to decide that the system should be suppressed, including limit values where possible. For both the CDCF and LDWS, the technical service shall assess the documentation package to show that driver unintentional manoeuvres, within the scope of the lane keep test parameters (in particular lateral departure velocity), will not result in automatic suppression of the system.
2.3.2	Automatic suppression of the ELKS is permitted in situations when other assistive or automated steering functions, (e.g. ACSF, ESF or ALKS), are controlling the lateral movement of the vehicle.
2.4	Provisions for the Periodic Technical Inspection
2.4.1	At a Periodic Technical Inspection, it shall be possible to confirm the correct operational status of the ELKS by a visible observation of the failure warning signal status following a "power-ON" and any bulb check. In the case of the failure warning signal being in a common space, the common space must be observed to be functional prior to the failure warning signal status check.
2.4.2	At the time of type approval, the means to protect against simple unauthorised modification of the operation of the failure warning signal chosen by the manufacturer shall be confidentially outlined. Alternatively, this protection requirement is fulfilled when a secondary means of checking the correct operational status of the ELKS is available.
2.5	LDWS requirements
2.5.1	Speed range The LDWS shall be active at least within the vehicle speed range between [65 km/h] and the lower of [130 km/h] or maximum vehicle speed and at all vehicle load conditions, unless deactivated as per paragraph 2.2.
2.5.2	Lane departure warning In the absence of conditions leading to deactivation or suppression of the

	system according to paragraphs 2.2 and 2.3, when operated within the prescribed speed range according to 2.5.1, the LDWS shall be able to warn the driver as specified in paragraph 2.5.3 at the latest if the vehicle crosses over a visible lane marking for the lane in which it is running by more than a DTLM of [-0.3 m]: (a) for lateral departure velocities in the range of the [0.1 m/s] to [0.5 m/s] (b) on straight, flat and dry roads (c) for lane markings in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification' and other markings expected on EU roads. (d) with the markings being in good condition and of a material conforming to the standard for visible markings of that contracting party. (e) in all illumination conditions without direct blinding sunlight and low beam head lamps if necessary (f) in absence of weather conditions affecting the visibility of lane markings (e.g. no fog) It is recognised that the performance required may not be fully achieved in other conditions than those listed above. However, the system shall not unreasonably switch the control strategy in these other conditions. The lane departure warning capability shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 3.
2.5.3	LDWS warning indication
2.5.3.1	The lane departure warning referred to in paragraph 2.5.2 shall be noticeable by the driver and be provided by: (a) at least two warning means out of optical, acoustic and haptic, or (b) one warning means out of haptic and acoustic, with spatial indication about the direction of unintended drift of the vehicle.
2.5.3.1.1	Where an optical signal is used for the lane departure warning, it may use the failure warning signal as specified in paragraph 2.1.1 above in a flashing mode.
2.5.3.1.2	When there is a lane keep intervention by the CDCF, this shall be considered a haptic warning according to paragraph 2.5.3.1.
2.5.3.2	The LDWS optical warning signals shall be activated following a vehicle master control switch "power-ON". This requirement does not apply to warning signals shown in a common space.
2.5.3.3	The LDWS optical warning signals shall be visible even by daylight; the satisfactory condition of the signals must be easily verifiable by the driver from the driver's seat.
2.5.3.4	The optical warning signal shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 3.

2.6	CDCF performance requirements
2.6.1	Speed range The CDCF shall be active at least within the vehicle speed range between [70 km/h] and the lower of [130 km/h] or maximum vehicle speed and at all vehicle load conditions, unless deactivated as per paragraph 2.2.

<table>
<tr><td></td><td>However, in the case that the vehicle reduces its speed from above [70 km/h] to below [70 km/h], the system shall be active at least until the vehicle speed reduces below [65 km/h].</td></tr>
<tr><td>2.6.2</td><td>Lane keep

In the absence of conditions leading to deactivation or suppression of the system according to paragraphs 2.2 and 2.3, the CDCF shall be able to prevent lane departure by crossing of visible lane markings in the scenarios shown in the following table by more than a DTLM of [-0.3 m]:

(a) for lateral departure velocities in the range of the [0.2 m/s] to [0.5 m/s] for vehicle speeds up [100 km/h] and for lateral departure velocities in the range of [0.2 m/s] to [0.3 m/s] for vehicle speeds greater than [100 km/h].

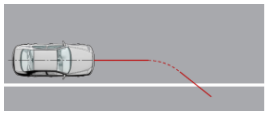
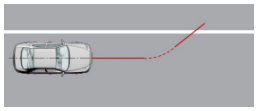
(b) on straight, flat and dry roads

(c) for lane markings in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix ‘Visible lane marking identification’.

(d) with the markings being in good condition and of a material conforming to the standard for visible markings of that contracting party.

(e) in all illumination conditions without direct blinding sunlight and low beam head lamps if necessary

(f) in absence of weather conditions affecting the dynamic performance of the vehicle (e.g. no storm, not below 5°C) or the visibility of lane markings (e.g. no fog)

<table><tr><td>No.</td><td>Scenario Description</td></tr><tr><td>1.</td><td>Solid line – Departure to right side of vehicle.
  </td></tr><tr><td>2</td><td>Solid line – Departure to left side of vehicle.
  </td></tr></table>
It is recognised that the performances required for the scenarios in this table may not be fully achieved in other conditions than those listed above. However, the system shall not unreasonably switch the control strategy in these other conditions.

This shall be demonstrated in accordance with Annex 6 of UN Regulation No. 79 for steering based systems or Annex 8 of UN Regulation No. 13-H for non-steering based systems.

The lane keep capability shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 4.</td></tr>
<tr><td>2.6.3</td><td>Steering override</td></tr>
<tr><td>2.6.3.1</td><td>The steering control effort necessary to override the directional control provided by the system shall not exceed 50 N. Significant loss of steering support once overridden shall not happen suddenly.</td></tr>
<tr><td>2.6.3.2</td><td>[Additionally / Alternatively], for CDCF systems which do not act on the</td></tr>
</table>

	steering itself (e.g. differential braking type CDCF), the steering input shall not exceed [25] degrees.
2.6.3.3	The steering override control effort shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 4.
2.6.4	CDCF warning indication
2.6.4.1	Every CDCF intervention shall immediately be indicated to the driver by an optical warning signal which is displayed for at least 1 s or as long as the intervention exists, whichever is longer. The optical signal may be the flashing of the failure warning signal specified in paragraph 2.1.1
2.6.4.1.1	In the case of an intervention longer than 10 seconds an acoustic warning signal shall be provided until the end of the intervention. The manufacturer may offer means for the driver to temporarily suppress the audible warning for the duration of the vehicle master control switch cycle.
2.6.4.1.2	In the case of two or more consecutive interventions within a rolling interval of 180 seconds and in the absence of a steering input by the driver during the intervention, an acoustic warning signal shall be provided by the system during the second and any further intervention within a rolling interval of 180 seconds. Starting with the third intervention (and subsequent interventions) the acoustic warning signal shall continue for at least 10 seconds longer than the previous warning signal.
2.6.4.2	The requirements in paragraphs 2.6.4.1.1 and 2.6.4.1.2 shall be demonstrated in accordance with the relevant vehicle test(s) specified in paragraph 4.

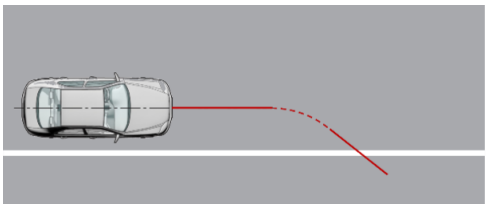
3	Test requirements for LDWS
3.1	General provisions Vehicles fitted with LDWS shall fulfil the appropriate tests requirements of this paragraph
3.2	Testing conditions The tests shall be performed: • On a flat and dry asphalt or concrete road type surface, which may not contain any irregularities (e.g. large dips or cracks, manhole covers or reflective studs) within a lateral distance of 3.0m to either side of the centre of the test lane and with a longitudinal distance of 30m ahead of the subject vehicle from the point after the test is complete. • In all illumination conditions without direct blinding sunlight and low beam head lamps if necessary. • In ambient air temperatures between [5°C and 45°C]. • In the absence of weather conditions affecting the visibility of lane markings, e.g. fog At the manufacturer's discretion and with the agreement of the Technical Service the tests may be performed under conditions deviating from what is described above (e.g. at lower ambient air temperatures).
3.2.1	Lane markings The lane markings on the road used for the tests shall be in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. The markings shall be in good condition and of a material conforming to the standard for visible lane markings. The lane-marking layout used for the tests shall be recorded in

	the test report. The width of the lane shall be a minimum of 3.5 m for the purpose of the tests of this paragraph. The vehicle manufacturer shall demonstrate, through the use of documentation, compliance with all other lane markings identified in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. Any of such documentation shall be appended to the test report.
3.2.2	Subject vehicle conditions
3.2.2.1	Test mass The subject vehicle shall be tested in a load condition agreed between the manufacturer and the Technical Service. No load alteration shall be made once the test procedure has begun. The vehicle manufacturer shall demonstrate, through the use of documentation, that the system works at all load conditions.
3.2.2.2	The subject vehicle shall be tested at the tyre pressures recommended by the vehicle manufacturer.
3.2.2.3	Where the LDWS is equipped with a user-adjustable warning threshold, the tests specified in paragraph 3.3 shall be performed with the warning threshold set at its maximum lane departure setting. No alteration shall be made once the test procedure has begun.
3.2.2.4	Pre-test conditioning If requested by the vehicle manufacturer the vehicle can be driven a maximum of 100 km on a mixture of urban and rural roads with other traffic and roadside furniture to calibrate the sensor system.
3.3	Test procedures
3.3.1	Optical warning signal verification test With the vehicle stationary check that the optical warning signal(s) comply with the requirements of paragraph 2.5.3.2.
3.3.2	Lane departure warning test
3.3.2.1	Drive the vehicle at a speed of [70 km/h +/- 3 km/h] into the centre of the test lane in a smooth manner so that the attitude of the vehicle is stable. Maintaining the prescribed speed, gently drift the vehicle, either to the left or the right, with a lateral departure velocity of between [0.1] and [0.5 m/s] so that the vehicle crosses the lane marking. Repeat the test at a different rate of departure within the range [0.1] and [0.5 m/s]. Repeat the above tests drifting in the opposite direction.
3.3.2.2	The test requirements are fulfilled if the LDWS provides the lane departure warning indication mentioned in paragraph 2.5.3.1 above at the latest when the DLTM is [-0.3 m].
3.3.2.3	In addition, the vehicle manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements for the whole speed range and lateral departure velocity range are fulfilled. This may be achieved on the basis of appropriate documentation appended to the test report.
3.3.3	Manual deactivation test
3.3.3.1	If the vehicle is equipped with means to manually deactivate the ELKS (LDWS), turn the vehicle master control switch to the "Power ON" position and deactivate the ELKS (LDWS). The warning signal specified in paragraph 2.2.3 shall be activated.

	Turn the master control switch to the "Power OFF" position [and open driver's door]. Turn the vehicle master control switch to the "Power ON" position and verify that the previously activated warning signal is not reactivated, thereby indicating that the ELKS (LDWS) has been reinstated as specified in paragraph 2.2.1.1.

4	Test requirements for CDCF
4.1	General provisions Vehicles fitted with CDCF shall fulfil the appropriate tests requirements of this paragraph
4.2	Testing conditions The tests shall be performed: • On a flat and dry asphalt or concrete road type surface, which may 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 centre of the test lane and with a longitudinal distance of 30m ahead of the subject vehicle from the point after the test is complete. • In all illumination conditions without direct blinding sunlight and low beam head lamps if necessary. • In ambient air temperatures between [5°C and 45°C]. • In the absence of weather conditions of weather conditions affecting the dynamic performance of the vehicle (e.g. no storm, not below 5°C) or the visibility of lane markings (e.g. fog). At the manufacturer's discretion and with the agreement of the Technical Service the tests may be performed under conditions deviating from what is described above (e.g. at lower ambient air temperatures).
4.2.1	Lane markings The solid lane marking on the road used for the tests shall be in line with one of those described in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. The marking shall be in good condition and of a material conforming to the standard for visible lane markings. The lane-marking used for the tests shall be recorded in the test report. The solid lane marking shall be a minimum of [7 m] distance from any other lane markings, for the purpose of the tests of this paragraph. The vehicle manufacturer shall demonstrate, through the use of documentation, compliance with all other solid lane markings identified in Commission Regulation (EU) No. 351/2012 Annex II, Appendix 'Visible lane marking identification'. Any of such documentation shall be appended to the test report.
4.2.2	Subject vehicle conditions
4.2.2.1	Test mass The subject vehicle shall be tested in a load condition agreed between the manufacturer and the Technical Service. No load alteration shall be made once the test procedure has begun. The vehicle manufacturer shall demonstrate, through the use of documentation, that the system works at all load conditions.
4.2.2.2	The subject vehicle shall be tested at the tyre pressures recommended by the vehicle manufacturer.

4.2.2.3	Where the CDCF is equipped with a user-adjustable timing threshold, the test specified in point 4.3.3 shall be performed with the timing threshold set at its latest setting for system intervention. No alteration shall be made once the test procedure has begun.
4.2.2.4	Pre-test conditioning If requested by the vehicle manufacturer the vehicle can be driven a maximum of 100 km on a mixture of urban and rural roads with other traffic and roadside furniture to calibrate the sensor system.
4.3	Tests procedures
4.3.1	Warning Indication test
4.3.1.1	The subject vehicle shall be driven with an activated CDCF on a road with solid lane markings on at least one side of the lane. The test conditions and the subject vehicle test speed shall be within the operating range of the system. During the test, the duration of the CDCF interventions and of the optical and acoustic warning signals shall be recorded. In the case of paragraph 2.6.5.1.1 of this Regulation, the subject vehicle shall be driven such that it attempts to leave the lane and causes CDCF intervention to be maintained for a period longer than 10 seconds. If such a test cannot be practically achieved due to e.g. the limitations of the test facilities, with the consent of the Type Approval Authority this requirement may be fulfilled through the use of documentation. The test requirements are fulfilled if: (b) The acoustic warning is provided no later than 10 s after the beginning of the intervention. In the case of paragraph 2.6.5.1.2 of this Regulation, the subject vehicle shall be driven such that it attempts to leave the lane and causes at least three interventions of the system within a rolling interval of 180 seconds. The test requirements are fulfilled if: (a) An optical warning signal is provided for each intervention, as long as the intervention exists, and (b) An acoustic warning signal is provided at the second and third intervention, and (c) The acoustic warning signal at the third intervention is at least 10 s longer than the one at the second intervention.
4.3.1.2	In addition, the manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements defined in paragraphs 2.6.5.1.1 and 2.6.5.1.2 are fulfilled in the whole range of CDCF operation. This may be achieved on the basis of appropriate documentation appended to the test report.
4.3.2	Steering override test
4.3.2.1	The subject vehicle shall be driven with an activated CDCF on a road with solid lane markings on each side of the lane. The test conditions and the subject vehicle test speed shall be within the operating range of the system. The vehicle shall be driven such that it attempts to leave the lane and causes CDCF intervention. During the intervention, the driver shall apply the steering control effort necessary to override the intervention.

	The force and steering input applied by the driver on the steering control to override the intervention shall be recorded. The test requirements are fulfilled if: (d) The force applied by the driver on the steering control to override the intervention does not exceed 50 N, and (e) Significant loss of steering support once overridden does not happen suddenly. (f) [Additionally / alternatively], for ELK systems which do not act on the steering itself (e.g. differential braking type CDCF), the steering input does not exceed [25] degrees.
4.3.2.2	In addition, the manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements defined in paragraph 2.6.4 are fulfilled in the whole range of CDCF operation. This may be achieved on the basis of appropriate documentation appended to the test report.
4.3.3	Lane keep test
4.3.3.1	The CDCF shall be tested for test scenarios No 1 and No 2 described in paragraph 2.6.2.
4.3.3.1.1	Tests for all scenarios shall be performed with lateral velocities of [0.2 m/s and 0.5 m/s].
4.3.3.1.2	A test path shall be driven which consists of an initial straight path parallel to the solid lane marking being tested, followed by a fixed radius curve to apply a known lateral velocity and yaw to the subject vehicle, followed again by a straight path without any force applied on the steering control (e.g. by removing the hands from the steering control). 
4.3.3.2.1	The subject vehicle speed during the test up to the point of system intervention shall be [72 km/h +/- 1] km/h. The curve of fixed radius driven to apply the lateral velocity required shall have a radius 1200 m or more. The lateral velocity required shall be achieved to a tolerance of [+/- 0.05 m/s]. The vehicle manufacturer shall provide information describing the radius of the curve to be driven and the location when the closed loop path and/or speed control shall be ended so as not to interfere with the system intervention for each test.
4.3.3.2	The test requirements are fulfilled if the subject vehicle does not cross the lane marking by a DTLM of more than [-0.3 m].
4.3.3.3	In addition, the vehicle manufacturer shall demonstrate to the satisfaction of the Technical Service that the requirements for the whole speed range and lateral departure velocity range are fulfilled. This may be achieved on the basis of appropriate documentation appended to the test report.

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