Submitted by the experts from the United Kingdom

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Agenda item 2

Proposal for additional requirements to the ALKS Regulation (GRVA-06-02)

This document outlines the UK's latest proposals to permit a lane change function during a minimum risk manoeuvre or emergency manoeuvre as part of the forthcoming ALKS Regulation. Further work is needed to develop the text and so the UK is proposing establishing a group of interested experts to continue this work beyond the 6th session of GRVA. Any interested parties are invited to contact the UK if they wish to be involved in this work.

I. Proposal

Insert new definitions:

"2.21. **"Starting lane" is the lane out of which the ALKS vehicle intends to manoeuvre.**

2.22. **"Target lane" is the lane into which the ALKS vehicle intends to manoeuvre.**

2.23. **"Lane change" is the lateral movement of the ALKS vehicle from the normal driving position in the starting lane to the normal driving position in the target lane, with the intention of maintaining a normal driving position in the target lane.**

2.24. **"Lane excursion" is the lateral movement of the ALKS vehicle from the normal driving position in the starting lane, partly into the target lane before moving back into the normal driving position for the starting lane e.g. to avoid an obstacle in the starting lane.**

2.25. **"Start of lane the change manoeuvre" is defined by the point at which the ALKS vehicle first crosses the lane marking denoting the boundary between the starting lane and the target lane.**

2.26. **"Completion of the lane change manoeuvre" is defined by the point at which the ALKS vehicle has fully crossed into the target lane.**

2.27. **"Start of the lane excursion manoeuvre" is defined by the point at which the ALKS vehicle first crosses the lane marking denoting the boundary between the starting lane and the target lane.**

2.28. **"Completion of the lane excursion manoeuvre" is defined by the point at which the ALKS vehicle has fully crossed back into the starting lane.**

2.29. **"Lead vehicle" is the vehicle immediately in front of the ALKS vehicle. There could be a lead vehicle in either the starting lane, or the target lane, or both.**

Insert new performance requirements during an MRM:

5.5.3. **Lane changes**

The requirements of this paragraph and its subparagraphs apply to systems designed to undertake a lane change manoeuvre during a minimum risk manoeuvre.

The system shall ensure that the lane change manoeuvre does not result in a collision with an obstacle blocking the lane or another road user either

in the starting lane or the target lane during a lane change manoeuvre (whether completed or aborted).

The system may only undertake a lane change manoeuvre if the following requirements are fulfilled:

a) The vehicle is equipped with a sensing system capable of fulfilling the minimum rear detection area requirements (as per 5.5.3.1);
b) The system has detected, at least once, a moving object at a distance greater than the minimum rear detection range declared by the manufacturer (as per 5.5.3.1) for the current engine start/run cycle;
c) The target lane is unoccupied in the area adjacent to the vehicle at the start of the lane change;
d) The system has detected, at least once, an object at a distance greater than the lateral detection range declared by the manufacturer (as per 7.1.2.) for the current engine start/run cycle;
e) The situation is deemed not to be critical (as per 5.5.3.2);
f) The forward distance criteria are fulfilled (as per 5.5.3.4).

The direction indicator shall be active for at least 3.0 seconds prior to the start of the lane change manoeuvre and remain active throughout the whole period of the lane change manoeuvre.

The system shall generate the signal to deactivate the indicator signal and resume the signal to activate the hazard warning lights upon completion of the lane change manoeuvre.

The lateral acceleration during the lane change shall be determined taking into account factors such as available friction afforded by the road surface and traffic conditions (traffic density, traffic flow rate etc). As a general principle, or in the absence of the ability of the system to account for such factors, then the lateral acceleration shall not exceed [1 m/s²] in addition to the lateral acceleration generated by the lane curvature. The manoeuvre shall not cause traction to be broken between the tyres and the road surface.

The fulfilment of the provisions of this paragraph and its subparagraphs shall be demonstrated by the manufacturer to the satisfaction of the technical services during the assessment of Annex 4 and according to the relevant tests in Annex 5.

5.5.3.1. Minimum rear detection area

The minimum rear detection area, throughout the lifetime of the system, shall be such that the system can determine traffic dynamics across the full width of its own traffic lane, the full width of the traffic lanes immediately to its left and to its right, up to the limit of the rear detection range.

The minimum rear detection range throughout the lifetime of the system, S_{rear}, shall be declared by the vehicle manufacturer. The rear detection sensors shall be subjected to self-checks.

The Technical Service shall verify that the distance at which the vehicle sensing system detects a vehicle during the relevant test in Annex 5 is equal to or greater than the manufacturer's declared value for the minimum rear detection range. The test shall be conducted using a two-wheeled motor vehicle of category L3 as the approaching vehicle.

5.5.3.2. **Lane changes are deemed critical either if there is a risk of a collision with another vehicle in the target lane, or if an approaching vehicle in the target lane would have to decelerate at a higher level than 3m/s², 0.4 seconds after the ALKS vehicle has crossed the lane marking, to ensure the distance between the two vehicles is never less than that which the ALKS vehicle travels in 1 second.**

For instances when the ALKS vehicle is travelling at a speed lower than a detected approaching vehicle in the target lane the critical distance at the start of the lane change manoeuvre shall be calculated using the following formula:

$$S_{critical} = (v_{rear} - v_{ALKS}) * t_B + \frac{(v_{rear} - v_{ALKS})^2}{(2 * a)} + v_{ALKS} * t_G$$

Where:

v_{rear} is The actual speed of the approaching vehicle in meters per second, if no vehicle has been detected a value of 36.1m/s (130 km/h) shall be used

v_{ALKS} is The present speed of the ALKS vehicle

a = 3 m/s² (Deceleration of the approaching vehicle)

t_B = 0.4 s (Time after the start of the lane change manoeuvre at which the deceleration of the approaching vehicle starts)

t_G = 1.0s (Remaining gap of the vehicles after the deceleration of the approaching vehicle).

For instances when the ALKS vehicle is travelling at a speed faster than or equal to a rearward vehicle in the target lane, the critical distance shall be calculated as:

$$S_{critical} = v_{ALKS} * t_G$$

For instances when the ALKS vehicle has not detected an approaching vehicle in the target lane, $S_{critical}$ shall be calculated with v_{rear} equal to 36.1m/s (130km/h). In this case a lane change shall only be acceptable if S_{rear} is greater than the calculated $S_{critical}$ for the given v_{ALKS}.

If the vehicle is operated in a country with a general maximum speed limit below 130 km/h, this speed limit may be used as an alternative for v_{rear} in the above formula to calculate the critical distance, $S_{critical}$. In this case, the vehicle shall be equipped with a means to detect the country of operation and shall have information available on the general maximum speed limit of this country. The approach for achieving this shall be declared and shall be part of the type approval documentation.

If the manufacturer considers additional influencing parameters when identifying the critical situation (e.g. acceleration of the ego-vehicle and/or deceleration of the approaching vehicle), the formula may be modified, and the modification shall be declared to and assessed by the

Technical Service. The modified formula must still ensure that an approaching vehicle would not have to decelerate at a higher level than 3m/s², 0.4 seconds after the lane change manoeuvre has started, to ensure the distance between the two vehicles is never less than that which the lane change vehicle travels in 1 second. The modified formula used by the manufacturer to identify the critical situation shall be part of the type approval documentation.

5.5.3.3. Forward distance criteria

The system shall be able to complete the lane change manoeuvre and bring the ALKS vehicle to a complete stop 2m behind a decelerating or stationary road user or object with a deceleration of no greater than [4] m/s².

At no point during the lane change manoeuvre shall the distance to the lead vehicle or road user be less than [2] m.

There are two distinct cases to be considered. In the first case, the ALKS vehicle detects another road user or obstacle in the target lane. In the second case, the lane appears to be unoccupied (insofar as there are no obstacles or other road users located within the target lane within the forward detection range of the ALKS vehicle).

5.5.3.3.1. Obstacle or other road user detected to the front occupying the target lane

At the start of the lane change procedure, the distance, D, between the ALKS vehicle and the obstacle or other road user occupying the target lane shall be the greater of [2] m or the distance given by the equation below.

$$D \geq t_{manoeuvre} V_{ALKS} + \frac{V_{ALKS}^2}{2a_{ALKS}} - \frac{V_{lead}^2}{2a_{lead}} + V_{ALKS}\tau_{system} + 2$$

Where:
$t_{manoeuvre}$ is the time required to complete the lane change manoeuvre, after crossing the lane. This value shall be taken as [3]s;
V_{ALKS} is the forward speed of the ALKS vehicle in m/s;
V_{lead} is the forward speed of the lead vehicle in the target lane in m/s;
a_{ALKS} is a feasible deceleration under the prevailing conditions of the ALKS vehicle. This value shall be taken as [4] m/s²;
a_{lead} is the feasible maximum deceleration of the lead vehicle in the target lane in m/s² and is equal to [4] m/s².
τ_{system} is the system delay of [0.5]s until deceleration level is reached.

At the request of the manufacturer, and with the approval of the Technical Service, an alternative value for the system time delay, τ_{system}, may be declared and used.

If the system detects the risk of a multi-car collision, resulting in a sudden deceleration of the lead vehicle in the target lane, then the value of a_{lead} shall be assumed to be ∞.

5.5.3.3.2. No obstacle or other road user is detected to the front in the target lane

In the case that, in the target lane, no obstacle or road user is present within the forward detection range, the speed of the ALKS vehicle, prior to beginning the lane change manoeuvre, shall be such that the lane change manoeuvre can complete and the vehicle can be brought to a complete stop, within a distance equal to the forward detection range less 2m. In this case, the following condition must be satisfied:

$$D_{detection} \geq t_{manoeuvre} V_{ALKS} + \frac{V_{ALKS}^2}{2a_{ALKS}} + V_{ALKS}\tau_{system} + 2$$

Where:
$t_{manoeuvre}$ is the time required to complete the lane change manoeuvre, after lane crossing;
V_{ALKS} is the forward speed of the ALKS vehicle in m/s;
a_{ALKS} is the feasible deceleration under the prevailing conditions of the ALKS vehicle. This value shall be taken as [4] m/s²;
τ_{system} is the system delay of [0.5]s until deceleration level is reached.

At the request of the manufacturer, and with the approval of the Technical Service, an alternative value for the system time delay, τ_{system}, may be declared and used.

Amend paragraph 6.2.5.2., to read:

6.2.5.2. Deactivation during an ongoing transition demand or an ongoing minimum risk manoeuvre

If a transition demand or a minimum risk manoeuvre is on-going, the system shall only be deactivated

- as defined in paragraph 6.2.5.1. or
- upon detection that the driver has taken hold of the steering control as a response to the transition demand or the minimum risk manoeuvre and provided the system confirms the driver is attentive as defined in paragraph 6.3.1.1. **[In the event of a lane change during a minimum risk manoeuvre, deactivation may be delayed until completion of the lane change manoeuvre.]**

Amend paragraph 5.3.2. to permit lane excursion during an emergency manoeuvre:

5.3.2. This manoeuvre shall decelerate the vehicle up to its full braking performance if necessary and/or may perform an automatic evasive manoeuvre, when appropriate.

If failures are affecting the braking or steering performance of the system, the manoeuvre shall be carried out with consideration for the remaining performance.

~~During the evasive manoeuvre the ALKS vehicle shall not cross the lane marking (outer edge of the front tyre to outer edge of the lane marking).~~

During an evasive manoeuvre, the vehicle may cross the lane marking (outer edge of the front tyre to outer edge of the lane marking) by up to a maximum of [0.X] m, provided that all of the following conditions are satisfied:

a) The collision cannot be avoided by braking at up to [6]m/s^2
b) The conditions of 5.5.3 a) and b) (inclusive)
c) The situation is deemed to be not critical as per 5.3.2.1
d) The ALKS vehicle can complete the lane excursion manoeuvre without colliding with another road user or obstacle in the target lane;
e) A signal to activate the hazard warning lights is generated at the start of the evasive manoeuvre, followed by a signal to deactivate the hazard warning lights upon completion of the evasive manoeuvre.

After the evasive manoeuvre has completed the vehicle shall aim at resuming a stable position.

Annex 5 tests

(To be developed.)

II. Justification

Permitting lane changes under certain conditions provides the vehicle with further options to reach a minimal risk condition.