The text reproduced below consolidates the different written proposals on raising the specified maximum speed of ALKS up to 130 km/h into a single document. It is based on document UNR157-05-06 (which was derived from the open points list (document UNR157-05-05, column “F”)).

Modifications to the existing text of UN-Regulation No. 157 are marked:

- in **black bold** for new or ~~strikethrough~~ for deleted characters (as proposed in ECE/TRANS/WP29/GRVA/2020/32 (DE)),
- in **red bold** for new or ~~strikethrough~~ for deleted characters (as proposed in UNR157-03-06 (EC)),
- in **blue bold** for new or ~~strikethrough~~ for deleted characters (as proposed in UNR157-06-07 (OICA/CLEPA)) and
- in **green** for new or ~~strikethrough~~ for deleted characters (new proposed amendments by leadership following the discussions and conclusions from 6th SIG meeting).

Comments as points of discussions or agreements are highlighted in yellow.

I. Proposal

Paragraph 2.1., amend to read:

2.1. “*Automated Lane Keeping System (ALKS)*” ~~for low speed application~~ is a system which is activated by the driver and which keeps the vehicle within its lane for travelling speed of ~~60~~ **130** km/h or less by controlling the lateral and longitudinal movements of the vehicle for extended periods without the need for further driver input.

Within this Regulation, ALKS is also referred to as “*the system*”.

Point of discussion: SIG157-03-06 (EC) to include a string stability requirement

*Paragraphs 2.21. and 2.22, i*nsert to read:

2.21. “*Stability of vehicle and driver system*” is the ability of the system composed by the vehicle and the driver, either human or non-human, to recover the initial safe motion after a disturbance.

2.22. “*String stability*” is the capability of the ALKS vehicle to react to a perturbation in the speed profile of the vehicle in front, whose speed profile directly affects the speed profile of the ALKS vehicle, with a perturbation in its speed profile of lower or equal absolute magnitude.

Points of discussion: Add general requirement for ‘anticipatory behaviour and this proposed wording (and position to place in UN R 157)?

*Paragraph 5.1.1.x, i*nsert to read:

5.1.1.x. The system shall demonstrate anticipatory behavior in interaction with other road user(s), in order to ensure stable, low-dynamic longitudinal behavior and risk minimizing behavior when critical situations could become imminent, e.g. with pedestrians or cutting-in vehicles.

Point of discussion: SIG157-03-06 (EC) clarification

Paragraph 5.2.1., amend to read:

5.2.1. The activated system shall keep the vehicle inside its lane of travel and ensure that the vehicle does not cross any lane marking (outer edge of the front tyre to outer edge of the lane marking). The system shall aim to keep the vehicle in a stable lateral ~~position~~ **motion** inside the lane of travel to avoid confusing other road users.

Point of discussion: SIG157-03-06 (EC) clarification

Paragraph 5.2, amend to read:

5.2. Dynamic Driving Task

The fulfilment of the provisions of this paragraph shall be demonstrated by the manufacturer to the technical service during the inspection of the safety approach as part of the assessment to Annex 4 (in particular for conditions not tested under Annex 5) and according to the relevant tests in Annex 5.

Point of discussion: Further consideration in 7th SIG meeting needed to come to agreement regarding the newly proposed amendment by industry (blue text), also taking into account early feedback by some CPs and tentative group agreement from 6th SIG using 60 km/h instead of 100 km/h from 6th meeting into account (green text).

Paragraph 5.2.3.1., amend to read:

5.2.3.1. **Speed**

The manufacturer shall declare the specified maximum speed based on the forward detection range of the system as described in paragraph 7.1.1.

The maximum speed up to which the system is permitted to operate is ~~60~~ **130** km/h.

Specified maximum speeds of more than [60] ~~[100]~~ km/h shall only be permissible if the ALKS is capable of bringing the vehicle to standstill on the hard shoulder during an MRM according to par. X.x.x.

Point of discussion: Decision to be confirmed in 7th SIG meeting, if table can be deleted entirely or if alternatively the table can be kept for speeds up to 60km/h and general requirements apply above 60 km/h (e.g. as set out with red, blue and green text in para. 5.2.3.3. below). Chair proposal is to remove the text in square brackets (delete the table).

Paragraph 5.2.3.3., amend to read:

5.2.3.3. The activated system shall detect the distance to the next vehicle in front as defined in paragraph 7.1.1. and shall adapt the vehicle speed **to adjust a safe following distance** in order to avoid **a** collision.

[While the ALKS vehicle is not at standstill **and operating in speed range up to 60 km/h**, the system shall adapt the speed to adjust the distance to a vehicle in front in the same lane to be equal or greater than the minimum following distance **according to the table below**.

For speeds above 60 km/h the activated system shall comply with minimum following distances in the country of operation as defined in paragraph 5.1.2.]

In case ~~the minimum time gap cannot be respected temporarily because of other road users~~ **this following distance to a vehicle in front is temporarily disrupted** (e.g. vehicle is cutting in, decelerating lead vehicle, etc.), the vehicle shall readjust the ~~minimum~~ following distance at the next available opportunity without any harsh braking unless an emergency manoeuvre would become necessary.

[For speeds up to 60 km/h ~~T~~the minimum following distance shall be calculated using the formula:

$d_{min} = v_{ALKS} * t_{front}$

Where:

d_{min} = the minimum following distance

v_{ALKS} = the present speed of the ALKS vehicle in m/s

t_{front} = minimum time gap in seconds between the ALKS vehicle and a leading vehicle in front as per the table below:

Present speed of the ALKS vehicle		*Minimum time gap*	*Minimum following distance*
(km/h)	(m/s)	(s)	(m)
7.2	2.0	1.0	2.0
10	2.78	1.1	3.1
20	5.56	1.2	6.7
30	8.33	1.3	10.8
40	11.11	1.4	15.6
50	13.89	1.5	20.8
60	16.67	1.6	26.7
~~70~~	~~19.44~~	~~1.7~~	~~33.1~~
~~80~~	~~22.22~~	~~1.8~~	~~40.0~~
~~90~~	~~25.00~~	~~1.9~~	~~47.5~~
~~100~~	~~27.78~~	~~2.0~~	~~55.6~~
~~110~~	~~30.56~~	~~2.0~~	~~61.1~~
~~120~~	~~33.33~~	~~2.0~~	~~66.7~~
~~130~~	~~36.11~~	~~2.0~~	~~72.2~~

For speed values **up to 60 km/h which are** not mentioned in the table, linear interpolation shall be applied.

Notwithstanding the result of the formula above for present speeds below 2 m/s the minimum following distance shall never be less than 2 m.**]**

The requirements of this paragraph are without prejudice to other requirements in this Regulation, most notably paragraphs 5.2.4. and 5.2.5. with subparagraphs.

***Group conclusion and agreement** from 6th SIG meeting is to delete the word 'stationary' from 'stationary road user' and otherwise keep the original text .*

5.2.4. The activated system shall be able to bring the vehicle to a complete stop behind a stationary vehicle, a ~~stationary~~ road user or a blocked lane of travel to avoid a collision. This shall be ensured up to the maximum operational speed of the system.

Point of discussion: Further consideration and agreement needed how to deal with issue of wrong way driver. Chair proposal is to remove the [].

Paragraph 5.2.5. and its subparagraphs, amend to read:

5.2.5. The activated system shall detect the risk of collision in particular with another road user ahead or beside the vehicle, due to a decelerating lead vehicle, a cutting in vehicle~~**, a vehicle proceeding in the opposite direction**~~ or a suddenly appearing obstacle and shall automatically perform appropriate manoeuvres to minimize risks to safety of the vehicle occupants and other road users.

[Additionally the ALKS shall implement strategies to react to a vehicle proceeding in the opposite direction in the ALKS vehicle's lane of travel aiming to mitigate the effects of a potential collision with that vehicle.]

~~For conditions not specified in paragraphs 5.2.4., 5.2.5. or its subparagraphs, this shall be ensured at least to the level at which a competent and careful human driver could minimize the risks. This shall be demonstrated the assessment carried out under Annex 4 and by taking guidance from Appendix 3 to Annex 4.~~

5.2.5.1. The activated system shall avoid a collision with a leading vehicle which decelerates up to its full braking performance provided that there was no undercut **by another vehicle** ~~of the minimum following distance the ALKS vehicle would adjust to a leading vehicle at the present speed due to a cut in manoeuvre of this lead vehicle~~. **This shall be demonstrated in accordance with the test specifications defined in Annex 5.**

Point of discussion: SIG157-03-06 (EC) to merge the two different models in the current ALKS text into a single one (in Appendix 3)

5.2.5.2 The activated system shall avoid a collision with a cutting in vehicle **at least for the conditions for which a competent and attentive human driver supported by state-of-the-art driving assistance or automation systems would also be able to avoid a collision. This shall be demonstrated in accordance with the test specifications defined in Annex 5 of this Regulation and with the performance model defined in Appendix 3 to Annex 4.**

~~(a) Provided the cutting in vehicle maintains its longitudinal speed which is lower than the longitudinal speed of the ALKS vehicle and~~

~~(b) Provided that the lateral movement of the cutting in vehicle has been visible for a time of at least 0.72 seconds before the reference point for *TTCLaneIntrusion* is reached,~~

~~(c) When the distance between the vehicle's front and the cutting in vehicle's rear corresponds to a TTC calculated by the following equation:~~

~~$TTCLaneIntrusion > vrel/(2\cdot 6 m/s^2) + 0.35 s$~~

~~Where:~~

~~Vrel = relative velocity between both vehicles, positive for vehicle being faster than the cutting in vehicle~~

~~TTCLaneIntrusion = The TTC value, when the outside of the tyre of the intruding vehicle's front wheel closest to the lane markings crosses a line 0.3 m beyond the outside edge of the visible lane marking to which the intruding vehicle is being drifted.~~

Paragraph 5.2.5.3., amend to read:

5.2.5.3. The activated system shall avoid a collision with an unobstructed crossing pedestrian in front of the vehicle.

In a scenario with an unobstructed pedestrian crossing with a lateral speed component of not more than 5 km/h where the anticipated impact point is displaced by not more than 0.2 m compared to the vehicle longitudinal center plane, the activated ALKS shall avoid a collision up to ~~the maximum operational speed of the system~~ **60 km/h**.

***Group conclusion and agreement** from 6th SIG meeting is to delete the proposed text below, so para. 5.4.2. remains in its original version (see UN-R 157).*

Paragraph 5.4.2., amend to read:

5.4.2. The initiation of the transition demand shall be such that sufficient time is provided for a safe transition to manual driving.

~~Manufacturers shall declare during type approval that drivers' adjustments in and on the vehicle when the system is active (e.g. for the purpose of engaging in non-driving related activities) do not have negative consequences to a take-over in the manual driving phase.~~

Point of discussion: Decision needed which parameters to be used for forward detection range calculation. In []: DE proposal (based on 5m/s² deceleration) or alternative values from SE/JP (based on 3,7 m/²2).Further text proposal by SE below: underlined.

Paragraph 7.1.1., amend to read:

7.1.1. Forward detection range

The manufacturer shall declare the forward detection range measured from the forward most point of the vehicle. This declared value shall be at least 46 metres **for a specified maximum speed of 60 km/h**.

A specified maximum speed above 60 km/h shall only be declared by the manufacturer, if the declared forward detection range fulfils the corresponding minimum value according the following table:

Specified maximum speed / *km/h*	*Minimum forward detection range /* *m*
0…60	**46**
70	**[50] 60**
80	**[60] 80**
90	**[75] 100**
100	**[90] 120**
110	**[110] 140**
120	**[130] 170**
130	**[150] 200**

For values not mentioned in the table, linear interpolation shall be applied.

It is recognized that the minimum forward detection range cannot be achieved under all conditions. Nevertheless, the system shall implement appropriate strategies (e.g. limited speed in case of bad weather condition) in order to ensure safe operation at all times.

The Technical Service shall verify that the distance at which the vehicle sensing system detects a road user during the relevant test in Annex 5 is equal or greater than the declared value.

Point of discussion: SIG157-03-06 (EC) to introduce a string stability requirement

Paragraph 5.2.7., insert to read:

5.2.7 The stability of the vehicle and driver system is a necessary condition that must be always met, provided that effects of unplanned events disturbing the safe motion are within reasonable limits. This shall be demonstrated in the assessment of the tests carried out in accordance with Annex 4 and 5 of this Regulation

Paragraph 5.2.8., insert to read:

5.2.8 While following another vehicle the ALKS vehicle shall be string stable. This shall be demonstrated in accordance with Annex 5 of this Regulation.

Paragraph 5.3.2., amend to read:

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).

After the evasive manoeuvre the vehicle shall aim at resuming a stable ~~position~~ **motion**.

Point of discussion: SIG157-03-06 (EC) to merge the different models in the current ALKS text.

Annex 4 Appendix 3, amend to read

1. General

1. This document clarifies derivation process to define conditions under which ~~Automated Lane Keeping Systems (~~**the** ALKS~~)~~ **vehicle** shall avoid a collision. Conditions under which ALKS shall avoid a collision are determined by ~~a general simulation program with following attentive human driver~~ **the** performance model and~~[1]~~ related parameters in the traffic critical disturbance scenarios.

2. Traffic critical scenarios

2.1. Traffic disturbance critical scenarios are those which have conditions under which **the** ALKS **vehicle** may not be able to avoid a collision.

2.2. **The** ~~F~~**f**ollowing ~~three are~~ traffic critical scenario**s is considered for the case of the ALKS vehicle**:

(a) Cut-in: the ‘other vehicle’ suddenly merges in front of the ~~‘ego~~ **ALKS** vehicle~~’~~

~~(b) Cut-out: the ‘other vehicle’ suddenly exits the lane of the ‘ego vehicle’~~

~~(c) Deceleration: the ‘other vehicle’ suddenly decelerates in front of the ‘ego vehicle’~~

2.3. ~~Each of these~~ **This** traffic critical scenario~~s~~ can be created using the following parameters/elements:

(a) Road geometry

(b) Other vehicles’ behavior/maneuver

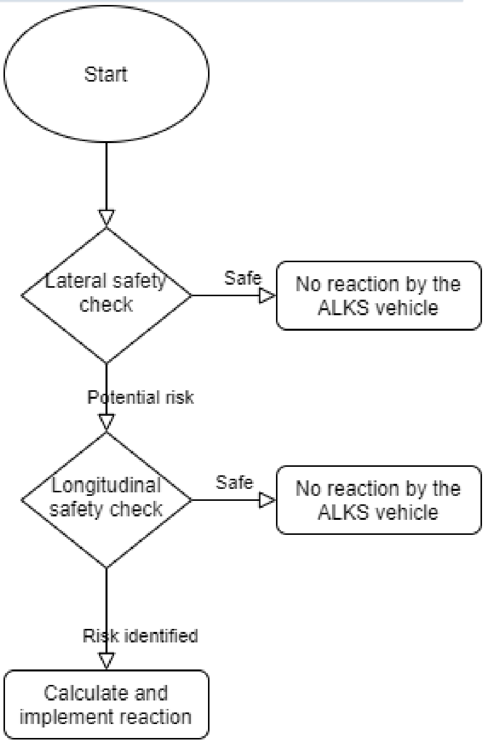
3. Performance model of ALKS **for the cut-in scenario**

3.1. Traffic critical scenarios of ALKS are divided into preventable and unpreventable scenarios. The threshold for preventable/unpreventable is based on the simulated performance of a ~~skilled~~ **competent** and attentive human driver **supported by state-of-the-art driving assistance or automation systems**. It is expected that some of the "unpreventable" scenarios by human standards may actually be preventable by the ALKS system.

3.2. ~~In a low-speed ALKS scenario, the avoidance capability of the driver model is assumed to be only by braking.~~ The driver model is separated into the following three **steps** ~~segments~~: "~~Perception~~ **Lateral Safety Check**"; "**Longitudinal Safety Check** ~~Decision~~"; and, "Reaction". **A Reaction is implemented only if the Lateral and Longitudinal Safety Checks identify a risk of imminent collision**. The following diagram is a visual representation of these **three steps** ~~segments~~:

Figure 1

Flow-chart of the ALKS ~~Skilled human~~ performance model



3.2.1 **The Lateral Safety Check identifies a potential risk of collision if the following conditions hold true:**

a) the rear of the 'other vehicle' is ahead of the front of the ALKS vehicle along the longitudinal direction of motion;

b) the 'other vehicle' is moving towards the ALKS vehicle

c) the longitudinal speed of the ALKS vehicle is greater than the longitudinal speed of the 'other vehicle'

d) the following equation is satisfied

$$\frac{dist_{lat}}{u_{cut-in,lat}} < \frac{dist_{lon}+length_{ego}+length_{cut-in}}{u_{ego,lon}-u_{cut-in,lon}} + 0.1$$

Where

$dist_{lat}$	**instantaneous lateral distance between the two vehicles**
$dist_{lon}$	**instantaneous longitudinal distance between the two vehicles**
$length_{ego}$	**length of the ALKS vehicle**
$length_{cut-in}$	**length of the 'other vehicle'**
$u_{cut-in,lat}$	**instantaneous lateral speed of the 'other vehicle'**
$u_{ego,lon}$	**instantaneous longitudinal speed of the ALKS vehicle**
$u_{cut-in,lon}$	**instantaneous longitudinal speed of the 'other' vehicle.**

3.2.2 The Longitudinal Safety Check requires the assessment of two Fuzzy Surrogate Safety Metrics, the Proactive Fuzzy Surrogate Safety Metric (PFS), and the Critical Fuzzy Surrogate Safety Metric (CFS).

3.2.2.1. The PFS is defined by the following equation:

$$PFS(dist_{lon}) = \begin{cases} 1 & \text{if } 0 < dist_{lon} < d_{unsafe} \\ 0 & \text{if } dist_{lon} > d_{safe} \\ \frac{dist_{lon}-d_{safe}-d_1}{d_{unsafe}-d_{safe}} & \text{if } d_{unsafe} < dist_{lon} < d_{safe} \end{cases}$$

where

d_1	**is the safety distance when the two vehicles reach complete stop**

$$d_{safe} = u_{ego,lon}\tau + \frac{u_{ego,lon}^2}{2b_{ego,comf}} - \frac{u_{cut-in,lon}^2}{2b_{ego,max}} + d_1$$

$$d_{unsafe} = u_{ego,lon}\tau + \frac{u_{ego,lon}^2}{2b_{ego,max}} - \frac{u_{cut-in,lon}^2}{2b_{cut-in,max}}$$

with

τ	**the reaction time of the ALKS vehicle defined as the total time from the moment in which the need for a reaction is identified until it starts to be implemented**
$b_{ego,comf}$	**the comfortable deceleration of the ALKS vehicle**
$b_{ego,max}$	**the maximum deceleration of the ALKS vehicle**
$b_{cut-in,max}$	**the maximum deceleration of the 'other vehicle'**

3.2.2.2 The CFS is defined by the following equation:

$$CFS(dist_{lon}) = \begin{cases} 1 & \text{if } 0 < dist_{lon} < d_{unsafe} \\ 0 & \text{if } dist_{lon} > d_{safe} \\ \frac{dist_{lon}-d_{safe}}{d_{unsafe}-d_{safe}} & \text{if } d_{unsafe} < dist_{lon} < d_{safe} \end{cases}$$

Where

$$d_{safe} = \begin{cases} \frac{(u_{ego,lon} - u_{cut-in,lon})^2}{2a'_{ego}} & \text{if } u_{ego,lon,NEXT} \le u_{cut-in,lon} \\ d_{new} + \frac{(u_{ego,lon,NEXT} - u_{cut-in,lon})^2}{2b_{ego,comf}} & \text{if } u_{ego,lon,NEXT} > u_{cut-in,lon} \end{cases}$$

$$d_{unsafe} = \begin{cases} \frac{(u_{ego,lon} - u_{cut-in,lon})^2}{2a'_{ego}} & \text{if } u_{ego,lon,NEXT} \leq u_{cut-in,lon} \\ d_{new} + \frac{(u_{ego,lon,NEXT} - u_{cut-in,lon})^2}{2b_{ego,max}} & \text{if } u_{ego,lon,NEXT} > u_{cut-in,lon} \end{cases}$$

in which

$$a'_{ego} = max(a_{ego}, -b_{ego,comf})$$

$$u_{ego,lon,NEXT} = u_{ego,lon} + a'_{ego}\tau$$

$$d_{new} = \left(\frac{(u_{ego,lon} + u_{ego,lon,NEXT})}{2} - u_{cut-in,lon}\right)\tau$$

where

a_{ego}	**the instantaneous longitudinal acceleration of the ALKS vehicle**
a'_{ego}	**a modified instantaneous acceleration which assume that ALKS vehicle cannot decelerate by more than** $b_{ego,comf}$
$u_{ego,lon,NEXT}$	**the expected longitudinal speed of the ALKS vehicle after the reaction time assuming constant acceleration**
d_{new}	**the expected longitudinal distance between the ALKS vehicle and the 'other vehicle' after the reaction time**

3.2.2.3. **The Longitudinal Safety Check identifies a potential risk if either PFS or CFS are greater than 0.**

3.2.3. **If a risk is identified the ALKS vehicle is assumed to plan and implement a reaction by decelerating according to the following equation:**

$$b_{reaction} = \begin{cases} CFS \cdot (b_{ego,max} - b_{ego,comf}) + b_{ego,comf} & \text{if } CFS > 0 \\ PFS \cdot b_{ego,comf} & \text{if } CFS = 0 \end{cases}$$

3.3.2.1 **The deceleration is implemented after a time equal to τ when it starts to increase with a constant rate equal to the maximum jerk.**

3.2.4. **In the case the reaction is not able to prevent the vehicle to collide with the cutting-in vehicle, the scenario is classified as unpreventable, otherwise it is classified as preventable.**

3.3. To determine conditions under which **the** ~~Automated Lane Keeping Systems (~~ALKS~~)~~ **vehicle** shall avoid a collision, **the following** performance model factors ~~for these three segments in the following table should be used as the performance model of ALKS considering attentive human drivers' behavior with ADAS~~ **shall be used**.

Table 1

Performance model factors for vehicles

		Factors
Risk perception point	~~Lane change (cutting in, cutting out)~~	~~Deviation of the center of a vehicle over 0.375m from the center of the driving lane~~ ~~(derived from research by Japan)~~ **The time when either PFS or CFS value is not any longer 0**
	~~Deceleration~~	~~Deceleration ratio of preceding vehicle and following distance of ego vehicle~~

~~Risk evaluation time~~	~~0.4 seconds~~ ~~(from research by Japan)~~
~~Time duration from having finished perception until starting deceleration~~	~~0.75 seconds~~ ~~(common data in Japan)~~
Reaction time of the ALKS vehicle	**τ = 0.75 seconds**
Jerking time to full deceleration (road friction 1.0)	0.6 seconds to 0.774~~G~~g (from experiments by NHTSA and Japan)
~~Jerking time to full deceleration (after full wrap of ego vehicle and cut-in vehicle, road friction 1.0)~~	~~0.6 seconds to 0.85G~~ ~~(derived from UN Regulation No. 152 on AEBS)~~
Safety distance when the two vehicles reach complete stop	**d_1 = 2 meters**
Comfortable deceleration of the ALKS vehicle	**$b_{ego,comf}$ = 4 m/s^2**
Maximum deceleration of the ALKS vehicle	**$b_{ego,max}$ = 6 m/s^2**
Maximum deceleration of the 'other vehicle'	**$b_{cut-in,max}$ = 7 m/s^2**

~~3.4. Driver model for the three ALKS scenarios:~~

~~3.4.1. For Cut in scenario:~~

~~The lateral wandering distance the vehicle will normally wander within the lane is 0.375m.~~

~~The perceived boundary for cut-in occurs when the vehicle exceeds the normal lateral wandering distance (possibly prior to actual lane change)~~

~~The distance a. is the perception distance based on the perception time [a]. It defines the lateral distance required to perceive that a vehicle is executing a cut-in manoeuvre a. is obtained from the following formula;~~

~~a.= lateral movement speed x Risk perception time [a] (0.4sec)~~

~~The risk perception time begins when the leading vehicle exceeds the cut-in boundary threshold.~~

~~Max lateral movement speed is real world data in Japan.~~

~~Risk perception time [a] is driving simulator data in Japan.~~

~~2sec* is specified as the maximum Time To Collision (TTC) below which it was concluded that there is a danger of collision in the longitudinal direction.~~

~~Note: TTC = 2.0sec is chosen based on the UN Regulation guidelines on warning signals.~~

~~Figure 2~~

~~**Driver model for thecut-in scenario**~~

~~3.4.2. For Cut out scenario:~~

~~The lateral wandering distance the vehicle will normally wander within the lane is 0.375m.~~

~~The perceived boundary for cut-out occurs when the vehicle exceeds the normal lateral wandering distance (possibly prior to actual lane change)~~

~~The risk perception time [a] is 0.4 seconds #and begins when the leading vehicle exceeds the cut-out boundary threshold.~~

~~The time 2 sec is specified as the maximum Time Head Way (THW) for which it was concluded that there is a danger in longitudinal direction.~~

~~Note: THW = 2.0sec is chosen according to other countries' regulations and guidelines.~~

~~Figure 3~~

~~**Cut in scenario**~~

~~3.4.3. For Deceleration scenario:~~

~~The risk perception time [a] is 0.4 seconds. The risk perception time [a] begins when the leading vehicle exceeds a deceleration threshold 5m/s^2.~~

~~Figure 4~~

~~**Deceleration scenario**~~

4. Parameters

4.1. Parameters below are essential when describing the pattern of the traffic critical scenarios in section 2.1.

4.2. Additional parameters could be added according to the operating environment (e.g. friction rate of the road, road curvature, lighting conditions).

Table 2
Additional parameters

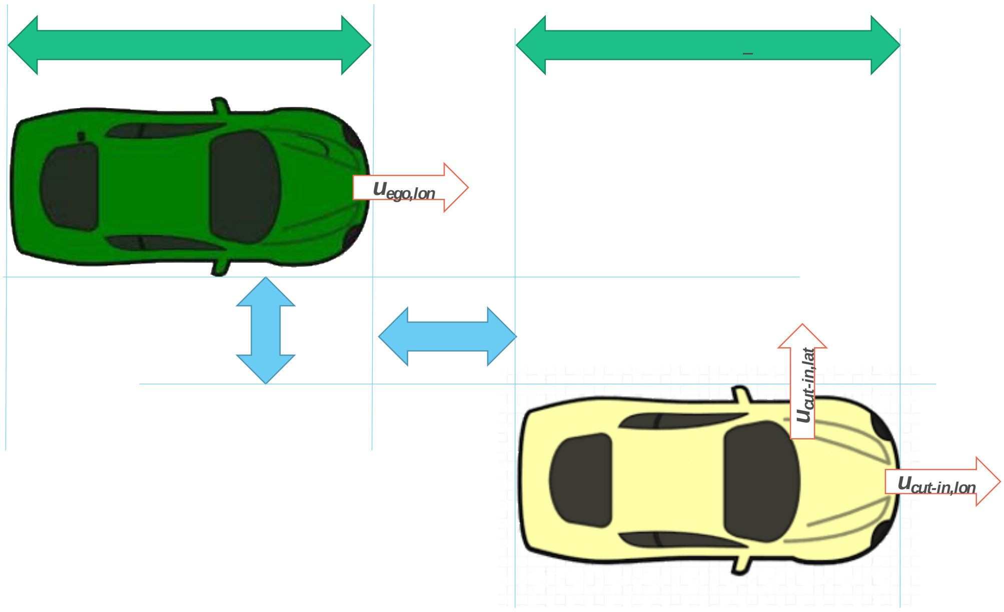
Operating conditions	Roadway	**Number of lanes** = The number of parallel and adjacent lanes in the same direction of travel **Lane Width** = The width of each lane **Roadway grade** = The grade of the roadway in the area of test **Roadway condition** = the condition of the roadway (dry, wet, icy, snow, new, worn) including coefficient of friction **Lane markings** = the type, colour, width, visibility of lane markings
	Environmental conditions	**Lighting conditions** = The amount of light and direction (ie, day, night, sunny, cloudy) **Weather conditions** = The amount, type and intensity of wind, rain, snow etc.
Initial condition	Initial velocity	~~**Ve0**~~ $u_{ego,lon}$ = **ALKS** vehicle
		~~**Vo0**~~ $u_{cut-in,lon}$ = ~~Leading~~ **'Other vehicle'** vehicle in lane or in adjacent lane
		~~**Vf0** = Vehicle in front of leading vehicle in lane~~
	Initial distance	~~**dx0**~~ $dist_{lon}$ = Distance in Longitudinal direction between the front end of the ego vehicle and the rear end of the ~~leading vehicle~~ **'other vehicle'** in ego vehicle's lane or in adjacent lane
		~~**dy0**~~ $dist_{lat}$ = Inside Lateral distance between outside edge line of ego vehicle in parallel to the vehicle's median longitudinal plane within lanes and outside edge line of ~~leading vehicle~~ **'other vehicle'** in parallel to the vehicle's median longitudinal plane in adjacent lines.
		~~**dy0_f** = Inside Lateral distance between outside edge line of leading vehicle in parallel to the vehicle's median longitudinal plane within lanes and outside edge line of vehicle in front of the leading vehicle in parallel to the vehicle's median longitudinal plane in adjacent lines.~~
		~~**dx0_f** = Distance in longitudinal direction between front end of leading vehicle and rear end of vehicle in front of leading vehicle~~
		~~**dfy** = Width of vehicle in front of leading vehicle~~
		~~**doy** = Width of leading vehicle~~
		~~**dox**~~ $length_{cut-in}$ = Length of the ~~leading~~ **'other vehicle'**

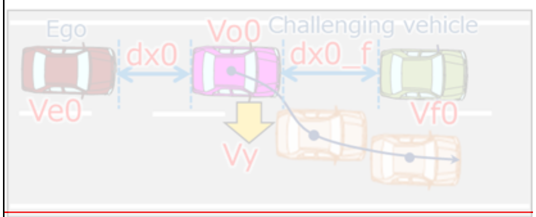
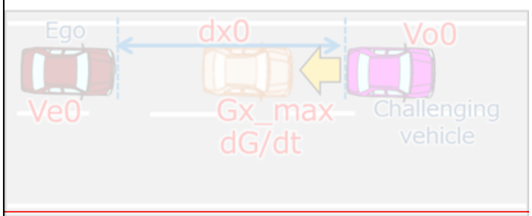
		$length_{ego}$ = Length of the ALKS vehicle
Vehicle motion	Lateral motion	~~Vy~~ $u_{cut-in,lat}$ = ~~leading vehicle~~ **'Other vehicle'** lateral velocity
	~~Deceleration~~	~~Gx_max = Maximum deceleration of the leading vehicle in G~~
		~~dG/dt = Deceleration rate (Jerk) of the leading vehicle~~

4.3. Following ~~are~~ **is the** visual representation~~s~~ of parameters for the ~~three types of~~ **cut in** scenario~~s~~

Figure 5

Visualisation of the cut-in scenario



~~Cut in~~	
~~Cut out~~	
~~Deceleration~~	

5. Reference

Following data sheets are pictorial examples of simulations which determines conditions under which ALKS shall avoid a collision, taking into account the combination of every parameter, *at and below* the maximum permitted ALKS vehicle speed.

5.1. Cut in

Figure 6
Parameters

Initial condition	Initial velocity	Ve0	Ego vehicle velocity
		Ve0-Vo0	Relative velocity
	Initial distance	dy0	Latteral distance[x]
		dx0	Longitudinal distance
Vehicle motion	Lateral motion	Vy	Lateral velocity

[x]Latteral distance
ex) Lane width : 3.5 [m]
Vehicle width:1.9 [m]
Driving in the center of the lane
dy=1.6 [m]

(Data sheets image)

Figure 7
Overview

~~Figure 8~~

~~**For Ve0 = 60 kph**~~

3
Ego vehicle velocity【Ve0】 : 60[kph]
Relative velocity【Ve0-Vo0】 : 30[kph]
[m/sec]
dy0=1.6m
Lateral velocity 【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
60 [m]
Longitudinal distance 【dx0】

4
Ego vehicle velocity【Ve0】 : 60[kph]
Relative velocity【Ve0-Vo0】 : 40[kph]
[m/sec]
dy0=1.6m
Lateral velocity 【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
60 [m]
Longitudinal distance 【dx0】

~~Figure 9~~
~~**For Ve0 = 50 kph**~~

7
Ego vehicle velocity【Ve0】 : 50[kph]
Relative velocity【Ve0-Vo0】 : 30[kph]
[m/sec]
dy0=1.6m
Lateral velocity【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
60 [m]
Longitudinal distance【dx0】

8
Ego vehicle velocity【Ve0】 : 50[kph]
Relative velocity【Ve0-Vo0】 : 40[kph]
[m/sec]
dy0=1.6m
Lateral velocity【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
60 [m]
Longitudinal distance【dx0】

~~Figure 10~~

~~**For Ve0 = 40 kph**~~

~~Figure 11~~
~~**For Ve0 = 30 kph**~~

Figure 12

For Ve0 =20 kph

5.2. Cut out

It is possible to avoid all the deceleration (stop) vehicles ahead of the preceding vehicle cut-out in the following running condition at THW 2.0 sec.

~~Figure 12~~

~~**Parameters**~~

Initial condition	Initial velocity	**Ve0**	Ego vehicle velocity
		Vo0	Leading vehicle velocity[1]
		Vf0	Vehicle in front of leading vehicle[2]
	Initial distance	**dx0**	Longitudinal distance[3]
		dx0_f	Front of lead distance
Vehicle motion	Lateral motion	**Vy**	Lateral velocity

1 Vo0 = Ve0(Same speed as the leading vehicle)
2 Vf0 = 0 (stop vehicle)
3 Follow the leading vehicle in THW=2sec

~~(Data sheets image)~~

Ego vehicle velocity[Ve0] : 40[kph]
Longitudinal distance[dx0] : 22.2[m]
(THW=2.0[sec])
[Vo0]: 40[kph]
[Vf0] : 0[kph]
[m/sec]
Lateral velocity [Vy]
: no collision
: leading vehicles collision
: collision
100[m]
Front of lead distance[dx0_f]

Ego vehicle velocity[Ve0] : 30[kph]
Longitudinal distance[dx0] : 16.6[m]
(THW=2.0[sec])
[Vo0]: 30[kph]
[Vf0] : 0[kph]
[m/sec]
Lateral velocity [Vy]
: no collision
: leading vehicles collision
: collision
100[m]
Front of lead distance[dx0_f]

Ego vehicle velocity[Ve0] : 20[kph]
Longitudinal distance[dx0] : 11.1[m]
(THW=2.0[sec])
[Vo0]: 20[kph]
[Vf0]: 0[kph]
[m/sec]
Lateral velocity [Vy]
: no collision
: leading vehicles collision
: collision
100[m]
Front of lead distance[dx0_f]

Ego vehicle velocity[Ve0] : 10[kph]
Longitudinal distance[dx0] : 5.5[m]
(THW=2.0[sec])
[Vo0]: 10[kph]
[Vf0]: 0[kph]
[m/sec]
Lateral velocity [Vy]
: no collision
: leading vehicles collision
: collision
100[m]
Front of lead distance[dx0_f]

~~5.4. Deceleration~~

~~It is possible to avoid sudden deceleration of -1.0G or less in the follow-up driving situation at THW 2.0sec.~~

~~(Data sheet image)~~

~~(Data sheets image)~~

Point of discussion: SIG157-03-06 (EC) to propose new on road tests

Annex 5, insert to read

4.8 Detect and response to traffic rules and road furniture

4.8.1. These tests shall ensure that the ALKS respects traffic rules, detects and adapts to a variation of permanent and temporary road furniture.

4.8.2. The test shall be executed at least with the list of scenarios below, but based on the ODD of the given system:

(a) Different speed limit signs, so that the ALKS vehicle has to change its speed according to the indicated values;

(b) Signal lights of an ending lane. The signal lights are set above the belonging lanes, and the signal lights of adjacent lanes are kept in green state, while the one of the current lane for the ALKS vehicle is kept red.;

(c) Driving through a tunnel: at least [X]m long section of the road with no sunlight and availability of the positioning system.

(d) Toll station: a section of the motorway with toll station-, speed limit signs and buildings (ticket machines, barriers, etc.).

(e) Temporary modifications: e.g., road maintenance operations indicated by traffic signs, cones and other modifications.

4.8.3. **Each test shall be executed at least:**

(a) Without a lead vehicle;

(b) With a passenger car target as well as a PTW target as the lead vehicle / other vehicle.

4.9. **Avoid braking before a passable object in the lane**

4.9.1. **The test shall demonstrate that the ALKS vehicle is not braking without a reason before a passable object in the lane (e.g., a manhole lid or a small branch).**

4.9.2. **The test shall be executed at least:**

(a) Without a lead vehicle;

(b) With a passenger car target as well as a PTW target as the lead vehicle / other vehicle.

Point of discussion: SIG157-03-06 (EC) to propose a string stability test

4.10. **String stability**

4.10.1. **The tests shall demonstrate that the ALKS is able to achieve string stable operations when following a car target proceeding with a speed lower than the speed the ALKS would maintain in the same situation in the absence of the same target.**

4.10.2. **The tests can be executed with one or more ALKS vehicles proceeding in platoon formation. The maximum number of ALKS vehicles that the test can include is [5].**

4.10.3. **The following conditions shall be ensured for the correct execution of each test:**

4.10.3.1. **The initial speed of the car target shall be lower than the speed limit or of the speed the ALKS would maintain in the same situation, whatever is the minimum.**

4.10.3.2. **The car target shall keep the constant initial speed for a time sufficient to ensure that all the ALKS vehicles are able to maintain the same constant speed. A fluctuation of the speed of the ALKS vehicles within a range of ± [1] m/s from the speed of the car target is allowed. When these conditions are achieved the platoon is in steady state formation and the test can be considered as started.**

4.10.3.4. **Each test shall comprise the deceleration of the car target from steady state platoon formation to achieve a speed reduction of at least [3] m/s. The speed of the car target at the end of the deceleration shall not be lower than [5] m/s. The deceleration adopted by the car target shall be in the range [1-5] m/s^2.**

4.10.3.4. **At the end of the deceleration, the car target shall maintain the new speed for a time sufficient to bring the platoon again in steady state formation according to the previsions of paragraph 4.10.3.2. When this is achieved the test can be considered as concluded.**

4.10.3.5. **At the end of the test the following quantities have to be computed.**

(a) The difference between the maximum and the minimum speed achieved by the car target during the test (L_{target})

(b) The difference between the maximum and the minimum speed achieved by the last ALKS vehicle in the platoon during the test (L_{ALKS})

(c) The ratio between the two differences $L = \frac{L_{ALKS}}{L_{target}}$

4.10.4. The test shall the executed for at least [5] different combinations of initial speed, final speed and deceleration adopted by the car target.

4.10.5. The string stability requirement is considered achieved if for all the tests the value of L is lower than 1.

4.11 Oncoming traffic / Wrong way driver

4.11.1. The test shall demonstrate that ALKS is capable of detecting and reacting to oncoming traffic in an adjacent lane.

4.11.2. The test for oncoming vehicle shall be executed at least:

(a) Without a lead vehicle;

(b) With a passenger car target as well as a PTW target as the lead vehicle / other vehicle

II. Justification
