Submitted by Japan UNR157-08-06
Based on document UNR157-08-03 submitted by the leadership of SIG UNR157

The text reproduced below reflects the state of play of the discussion of the SIG UNR157 up to its 7th meeting on raising the specified maximum speed of ALKS up to 130 km/h. It is based on ECE/TRANS/WP.29/GRVA/2020/32 (DE) and subsequent amendments received on this proposal.

Modifications to the existing text of UN-Regulation No. 157 (incl. suppl. 02 to 00 series) are marked in **black bold** for new or ~~strikethrough~~ for deleted characters.

Comments:
- Agreements and group conclusions after 7th SIG: highlighted in *grey*.
- Open points of discussions after 7th SIG: highlighted in *yellow*. In particular: ***Homework***

Modifications to the existing text of UNR157-08-03 are marked in **blue bold** for new or ~~strikethrough~~ for deleted characters.

I. Proposal

Group conclusion on para. 2.1: agreed.

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 on 2.21. and 2.22: Stability and string stability definitions (As proposed by JRC/EC in UNR157-03-06), to be confirmed together with string stability requirements.

→Japan proposal: The MRMLC function is indispensable for speed increase.

Paragraphs 2.21.-2.27. ,2.31. and 2.32, insert 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.]

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

2.24. "*Beside the road*" means the area of road surface beyond the boundaries of the carriageway which is not a hard shoulder or emergency refuge area.

2.25. "*Target lane*" is the lane into which the ALKS vehicle intends to manoeuvre. The target lane can be a regular lane of travel, ~~an enter lane, an exit lane~~ or a hard shoulder, emergency refuge area or beside the road.

2.26. "*Target stop area*" means a potential stopping area (e.g. emergency lane, hard shoulder, emergency refuge area, beside the road, ~~slowest lane of traffic, own lane of travel~~).

2.27. A "*MRM Lane Change*" is a lane change performed by the ALKS during a minimum risk manoeuvre.

2.28. A "*Minimum Risk Manoeuvre Lane Change Procedure (MRMLCP)*" starts when the direction indicator lamps are activated and ends when the

Commented [1]: Delete"slowest lane of traffic, own lane of travel" because MRMLC does not stop the vehicle at these places. Added "emergency refuge area"

hazard warning ~~lamps~~ lights are activated by the system. It comprises the following operations in the given order:

(a) Activation of the direction indicator lamps;

(b) Temporary suspension of the mandatory lane keeping functionality of the ALKS;

(c) Lateral movement of the vehicle towards the lane boundary;

(d) Lane Change Manoeuvre towards the target stop area in the target lane;

(e) ~~Stop~~ Standstill of the vehicle when it arrives at the target stop area.

(f) Deactivation of direction indicator lamps and activation of hazard warning lights.

2.29. A "*Minimum Risk Lane Change Manoeuvre (MRLCM)*" is part of the ~~Lane Change Procedure (~~MRMLCP~~)~~ defined in 2.28.;

(a) Starts when the outside edge of the tyre tread of the vehicle's front wheel closest to the lane markings crosses the outside edge of the lane marking to which the vehicle is being manoeuvred and

(b) Ends when the all rear wheels of the vehicle have fully crossed the lane marking [or combination]~~(except for the case of evasive lane change).~~

Commented [2]: What does this word mean?

Group conclusion on 5.1.1.1.: agreed.

Paragraph 5.1.1.1, insert to read:

5.1.1.1. 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.

Group conclusion on 5.2.1: Proposal (change 'position' into 'motion') agreed. Point of discussion: Introducing provisions by the leadership of "smooth driving" and "string stability" from JRC/EC proposal (UNR157-03-06, new para. 5.2.7. and 5.2.8.) which are detailed further below. Are they appropriately worded by leadership (green text) and well-placed?

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 [**drive smoothly],** aim**ing** to keep the vehicle in a stable lateral [**and longitudinal]** ~~position~~ **motion** inside the lane of travel to avoid confusing other road users [**or requiring them to take unnecessary avoiding action**.]

Group conclusion on paragraph 5.2.: No change to 5.2. needed as already covered in WP.29/2021/17.

~~*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 on 5.2.3.1.: The group agreed the max speed of 60 km/h instead of originally proposed 100 km/h by industry for systems with no lane change capability during MRM. New text in [] proposed by industry to allow systems to operate at higher speeds without lane change capability during MRM in very limited circumstances.

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 60km/h shall only be permissible if the ALKS is capable of bringing the vehicle to standstill ~~on~~ in the ~~hard shoulder~~ target stop area during an MRM according to paragraph ~~X.x.x.~~ 5.5.7. and its subparagraphs.

Commented [3]: Japan do supports this option. In smooth traffic, stopping in the regular lane causes high collision risk with following other vehicle. See other Japanese document.

~~**[Operational speeds of more than [60 km/h] are permitted either**~~

~~**- up to [90]km/h exclusively in the slowest lane of travel, provided there is surrounding traffic travelling at a similar speed (e.g. dense traffic or following a lead vehicle) or**~~

~~**- in all lanes of travel, if the ALKS is capable of changing lanes to bring the vehicle to a standstill outside of the regular lanes of travel during an MRM according to para. Xxx.**~~

~~**Systems that operate above 60 km/h up to [90]km/h without lane change capability shall implement strategies to minimize the risk of stopping in lane to the vehicle occupants and other road users, e.g. adapted deceleration strategy, operation only under good visibility.]**~~

Group conclusion on 5.2.3.3.: Agreed to keep table only up to 60 km/h. Values based on braking capabilities. For speeds above 60 km/h, the text refers to traffic rules.

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

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 on 5.2.4.: Agreed to keep para. 5.2.4. in its original version → no change

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.

Group conclusion: New text in bold in 5.2.5. on a vehicle proceeding in opposite direction agreed and moved to 5.2.8.by the leadership → Group needs to confirm that new location of para. 5.2.8. is OK (reworded slightly to fit with existing text).

~~*Paragraph 5.2.5.*, 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 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.**~~

Insert new paragraph 5.2.8., to read:

[5.2.8. In the situation where a vehicle is proceeding in the opposite direction in the ALKS vehicle's lane of travel, the ALKS shall implement strategies to react to the vehicle with the aim of mitigating the effects of a potential collision.]

Group conclusion: Para. 5.2.5.1. remains in its original version, since table for minimum following distance in para. 5.2.3.3. unchanged for ALKS up to 60 km/h → no change!

~~*Paragraph 5.2.5.1.*, amend to read:~~

~~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 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.~~

Group conclusion: Para. 5.2.5.2. to remain in its original version → no change! Proposed model by JRC/EC to be incorporated as guidance in Appendix 3 for the time being in addition to existing driver model.

5.2.5.2 The activated system shall avoid a collision with a cutting in vehicle

(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:

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

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.

Point of discussion on 5.2.5.3.: Tentative group conclusion to agree on proposal for para. 5.2.5.3. ***Homework****: UK to check if better wording can be found on deceleration above 60 km/h.*

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**.

[At higher speeds, upon detection of pedestrians crossing the carriageway the ALKS shall implement strategies to reduce the potential for a collision.]

Points of discussion for 5.2.7.: Group tentatively agreed at the 7th meeting to include JRC/EC fuzzy logic model in UN-R 157-Annex 3 in addition to existing model. Group to confirm that the text below reflects the agreement.

Paragraph 5.2.7., amend to read:

5.2.7. For conditions not specified in paragraphs 5.2.4., 5.2.5. or its subparagraphs, the performance of the system shall be ensured at least to the level at which a competent and careful human driver could minimize the risks. The attentive human driver performance model**s** and related parameters in ~~the~~ traffic critical disturbance scenarios ~~from~~ **in** Annex 3 may be taken as guidance. The capabilities of the system shall be demonstrated in the assessment carried out under Annex 4.

Point of discussion on 5.2.9. and 5.2.10: Agreement to include some aspects of proposals from JRC/EC (UNR157-03-06) on "string stability" as general requirements. Leadership to prepare proposal. → Group needs to review proposal by leadership.

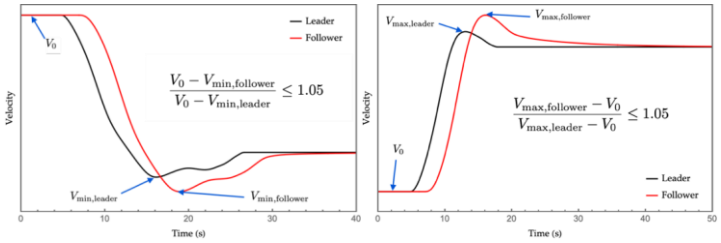
Paragraph 5.2.9., insert to read:

~~[5.2.9. 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 5.2.10., insert to read:

~~[5.2.10 While following another vehicle the ALKS vehicle shall aim to be string stable.~~

~~In particular, when following another vehicle at constant speed and at a distance such that the speed profile of the ALKS vehicle is influenced by the speed profile of the vehicle in front, the ALKS vehicle shall aim to respond to a perturbation in the speed of the vehicle in front with a perturbation in its speed profile by at most a 5% increase in the maximum difference in speed compared to the vehicle in front before reaching a new equilibrium velocity following the visual examples reported in the following figures.~~



~~In addition, in the case when there is more than one ALKS vehicle in a chain following a vehicle under the conditions described in the previous paragraph, they shall aim to avoid further amplifying the perturbation caused by the lead vehicle from one vehicle to the next. The provisions included in this paragraph shall be demonstrated in accordance with Annex 4 of this Regulation.]~~

Group conclusion for 5.3.2: Proposal. agreed.

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**.

Group conclusion: Para. 5.4.2. to remain in its original version. → no change!

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.

Point of discussion 5.4.2.4.: Text from JRC/EC (UNR157-03-06) to be confirmed (Reminder: definition for 'regular LCP' might need to be introduced, if inserted here as (new) term.)

→This paragraph is required for all LCPs.

Paragraph 5.4.2.4., insert to read:

5.4.2.4. In case the ALKS is capable to perform ~~[a regular]~~LCP, it shall be aimed that ~~[a regular]~~ LCP is not part of the transition phase, meaning that the transition demand is not given shortly before or during a LCP.

Japan proposal: The MRMLC function is indispensable for speed increase.

Paragraph 5.5.1.., amend to read:

5.5.1. During the minimum risk manoeuvre the vehicle shall be slowed down ~~inside the lane or, in case the lane markings are not visible, remain on an appropriate trajectory taking into account surrounding traffic and road infrastructure~~, with an aim of achieving a deceleration demand not greater than 4.0 m/s².

Higher deceleration demand values are permissible for very short durations, e.g. as haptic warning to stimulate the driver's attention, or in case of a severe ALKS or severe vehicle failure. **[The ALKS shall either:**

(a) Keep the vehicle inside the lane, or in case the lane markings are not visible, remain on an appropriate trajectory taking into account surrounding traffic and road infrastructure; or,

(b) Bring the vehicle to a safe stop outside of its lane of travel, when:

(i) ALKS is capable of performing a lane change according to paragraph 5.~~2.7.6.~~5.7. and its subparagraphs; and

(ii) A lane change can be safely performed under the current conditions to bring the vehicle to a safe stop outside its lane of travel.]

Additionally, the signal to activate the hazard warning lights shall be generated with the start of the minimum risk manoeuvre.

~~[If a lane change procedure is performed during the minimal risk manoeuvre, the signal to activate the hazard warning lights shall be generated again once the vehicle has reached its target lane.]~~

Commented [4]: Provide in paragraph 5.5.7.7and 5.5.7.8.

Paragraph 5.5.7.-5.5.7.12.9., insert to read:

5.5.7. Minimum Risk manoeuvre Lane Change Procedure (MRMLCP)

The requirements of this paragraph and its subparagraphs apply to the system, if fitted to perform a MRMLCP.

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 3,~~ Annex 4 and according to the relevant tests in Annex 5.

5.5.7.1. A MRMLCP shall not cause an unreasonable risk to safety of the vehicle occupants and other road users. MRMLCPs shall only be performed in an uncritical way as described in paragraphs 5.5.7.1.1. and 5.5.7.1.2.

5.5.7.1.1. The intervention shall not cause a collision with another vehicle or road user in the predicted path of the vehicle during a lane change.

5.5.7.1.2. A lane change procedure shall be predictable and manageable for other road users.

5.5.7.2. A MRMLCP shall be completed without undue delay.

Commented [5]: Described the same elements as 5.2.6 to 5.2.6.2 as elements common to LCP.

5.5.7.3. The system may perform a single or multiple lane change(s) across to the target stop area in accordance with national traffic rules.

~~5.2.6.5.2. Lane Change Procedure: Additional specific requirements during an MRM~~

5.~~5.~~7.4. ~~Lane changes during a~~ A MRMLCP shall be made only if under the traffic situation these lane changes can be considered to minimize the risk to safety of the vehicle occupants and other road users.

5.5.7.5. **Before initiating a MRMLCP ~~a lane change procedure~~, the system shall, if deemed appropriate, reduce the vehicle speed to minimize the risk related to that lane change (e.g. by adapting the speed of the vehicle to that of other vehicles in the target lane).**

~~5.2.6.5.2.3~~5.7.6.. A lane change procedure shall not start within the first 5s following the start of the MRM intervention.

~~[~~5.5.7.7.~~5.2.3.~~ In case the vehicle ~~target stop area~~ cannot ~~be~~ reach~~ed~~ the target stop area in an uncritical way, the system may ~~shall~~ aim to stop ~~keep~~ the vehicle within its current lane of travel ~~while the vehicle is stopping~~.~~]~~

5.5.7.8. The system shall generate the signal to activate and deactivate the direction indicator signal. The direction indicator shall remain active throughout the lane change and shall be deactivated by the system in a timely the vehicle is arrive at the target stop area.

5.5.7.9. The system shall generate the hazard warning lights to activate. The hazard warning lights shall remain active throughout stay in the target stop area.

5.5.7.10. The activated system may undertake a MRMLCP only if all of the following ~~requirements~~ conditions are fulfilled:

(a) The vehicle is equipped with a sensing system capable of fulfilling the front, side and rearward detection range requirements as defined in paragraph 7.1., [7.1.1.1. and 7.1.2.1.] and subparagraph 7.1.3.;

(b) All system self-checks, as defined in paragraph 5.1.6. is positively confirmed;

(c) A gap allowing a MRLCM is already present or expected to open up shortly.

(d) The target lane is a hard shoulder, emergency refuge area or beside the road.

5.5.7.11.~~2.6.6.4~~ Minimum Risk Lane change manoeuvre~~: Additional specific requirements in~~ (MRLCM)

5.5.7.11.1. The lateral movement to approach the lane marking in the starting lane and the lateral movement necessary to complete the MRLCM shall aim to be one continuous movement. [During the lane change manoeuvre, the system shall aim to avoid a lateral acceleration of more than 1 m/s^2 in addition to the lateral acceleration generated by the lane curvature.]

[The MRLCM shall not be initiated before a period of 3.0 seconds after activation of the direction indicator lamps.]

5.5.7.11.2. The MRLCM may be abandoned before being completed if the situation requires it. In this case the MRLCM shall be completed by steering the ALKS vehicle back into the starting lane if traffic conditions allow it.

The ALKS vehicle shall be in a single lane of travel at the end of the MRLCM.

5.5.7.11.3. When several consecutive lane changes are performed, the direction indicator may remain active throughout these lane changes while the lateral behaviour shall ensure that each lane change manoeuvre can be perceived as an individual manoeuvre by following traffic.

5.5.7.11.4.~~1.6.6.4.1.~~ A ~~lane change manoeuvre during~~ MR~~M~~LCM shall be indicated in advance to other road users by activating the appropriate direction indicator lamps instead of the hazard warning lights.

5.5.7.11.5.~~5.1.6.6.4.2.~~ Once the lane change manoeuvre is completed the direction indicator lamps shall be deactivated in a timely manner, and the hazard warning lights shall become active again.

Commented [6]: This provision should not be removed.because it is intended to safely carry out lane changes by informing other road users that it is an MRM and asking for their cooperation.

Commented [7]: Described the same elements as elements of RLCP

5.5.7.11.6.~~5.1.6.6.4.3.~~ Upon termination of the MRLCM the ALKS shall aim to bring the vehicle in a position that reduces the risk to the vehicle occupants and other road users.

5.5.7.11.7.~~5.1.6.6.4.4~~ ~~The following additional requirements are to be fulfilled~~ When bringing the vehicle to a safe stop beside the road, the vehicle may come to a standstill on the lane mark beside the road.

~~**5.2.6.9.4.4.1. All provisions of paragraph 5.2.6. shall be applied except [5.2.6.5.1 item a].**~~

~~**[5.2.6.6.4.5. In addition to the provisions of paragraph 5.1.6.6.4.1, an acoustic warning may be given as warning to other road users unless traffic rules in the country prohibits using an acoustic warning.]** <JP comment: need to clarify because this paragraph mainly for the purpose of avoiding collision with pedestrian/cyclist> Industry propose to delete since pedestrians/cyclists are not expected in the ALKS ODD.~~

~~**5.2.6.6.4.6. When bringing the vehicle to a stop beside the road the vehicle speed shall not exceed 10 km/h.]** <JP comment: need to clarify because this paragraph mainly for the purpose of avoiding collision with pedestrian/cyclist> Industry propose to delete since pedestrians/cyclists are not expected in the ALKS ODD.~~

5.5.7.12.~~2.6.7.3.~~ Assessment of the target lane for an MRM lane change

5.5.7.12.1. A MRMLCP shall only be initiated if [the ALKS vehicle would be able to keep a safe distance from a lead vehicle or any other obstacle in the target lane according with the provisions of paragraph 5.2.3.3. and if] an approaching vehicle in the target lane is not forced to unmanageably decelerate due to the lane change of the ALKS vehicle.

5.5.7.12.2.~~2.6.7.3.1.~~ When there is an approaching vehicle

~~An approaching vehicle in the target lane should not have to~~ The ALKS vehicle shall not make an approaching vehicle in the target lane decelerate at a higher level than A m/s², B seconds after the ALKS vehicle starts crossing a lane marking, to ensure the distance between the two vehicles is never less than that which the lane change vehicle travels in C seconds.

With:

(a) A equal to 3.7 m/s²

(b) B equal to:

(i) 0.0 second, if during a minimal risk manoeuvre the lateral movement of the ALKS vehicle continued for at least 1 second while the vehicle had not yet crossed the lane marking and the direction indicator had been active for at least 3.0 seconds prior to crossing of the lane markings while a vehicle approaching from the rear was detected by the sensing system;

(ii) 0.4 seconds after the ALKS vehicle has crossed the lane marking, provided there was at least 1.0 s lateral movement of the ALKS vehicle within the starting lane in principle visible to an approaching vehicle from the rear without an obstruction before the MRLCM starts; or

(iii) 1.4 seconds after the ALKS vehicle has crossed the lane marking, provided there was not at least 1.0 s lateral movement of the ALKS vehicle within the starting lane in principle visible to an approaching vehicle from the rear before the MRLCM starts.

(c) C equal to:

Commented [8]: Japan agrees to delete these 2 paragraphes because these are dedicated to the situation with pedestrian and cyclists.

(i) 0.5 second, if the lane change is performed towards a lane intended for slower traffic or towards the hard shoulder during a minimal risk manoeuvre;

(ii) 1.0 second for all other conditions.

5.5.7.12.3.~~.2.6.7.4.~~ Determination of whether a situation is critical shall consider any deceleration or acceleration of the ALKS vehicle ~~after it has crossed the lane marking~~.

5.5.7.12.4.~~2.6.7.3.2.~~ When there is no vehicle detected

If no approaching vehicle is detected by the system in the target lane, the minimum gap to the rear shall be calculated under the assumption that:

(a) the approaching vehicle in the target lane is at a distance from the ALKS vehicle equal to rearward detection ~~distance~~ range and

(b) the approaching vehicle in the target lane is travelling [with the allowed maximum speed or 130km/h whichever is lower] and

(c) the approaching vehicle on a hard shoulder is travelling [at a maximum speed of 80 km/h and a maximum speed difference to the ALKS vehicle at the start of the MRLCM of 40 km/h].

5.5.7.12.5.~~2.6.7.3.3.~~ When there is an equally fast or slower moving vehicle

At the beginning of the MRLCM , the distance between the rear of the ALKS vehicle and the front of a vehicle following behind in the target lane at equal or lower longitudinal speed shall never be less than the speed which the following vehicle in target lane travels in 0.7s.

5.5.7.12.6.~~.2.6.7.5.~~ For the duration of the ~~lane change manoeuvre~~MRMLCP, the lane change vehicle shall observe the minimum following distance requirements in accordance with 5.2.3.3 for any lead vehicle(s) or road user(s) in the target lane of travel or the initial lane of travel.

The strategy shall be clearly documented to ensure that this requirement is met, whilst ensuring that all lane changes can be completed and forward collisions avoided.

5.5.7.12.7.~~2.6.7.6.~~ 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.]

5.5.7.12.8.~~.2.6.7.7.~~ In case the ALKS decelerates the vehicle during a ~~lane change procedure~~MRMLCP, this deceleration shall be factored in when assessing the distance to a vehicle approaching from the rear, and the deceleration shall ~~[~~not exceed 2m/s^2, except for the purpose of avoiding or mitigating the risk of an imminent collision ~~/ be manageable for the vehicle approaching from the rear]~~.

How the provisions of this paragraph are implemented in the system design shall be demonstrated to the Technical Service during type approval.

5.5.7.12.9.~~2.6.7.8.~~ Where there is not sufficient headway time for the vehicle behind at the end of the ~~lane change procedure~~MRMLCP, the ALKS shall not increase the rate of deceleration for ~~[~~at least 2 seconds ~~/ a certain period of time]~~ after the completion of the ~~lane change procedure~~MRMLCP except for the purpose of avoiding or mitigating the risk of an imminent collision.

Commented [9]: It is no relation,after or not.

Commented [10]: We would like to know the background of this condition.

Commented [11]: This explanations is given in UNR157-08-XX(Japanese Study on Lane Changes during MRM.)

How the provisions of this paragraph are implemented in the system design shall be demonstrated to the Technical Service during type approval.

Paragraph 6.4.1.., amend to read:

6.4.1. The following information shall be indicated to the driver:

(a) The system status as defined in paragraph 6.4.2.

(b) Any failure affecting the operation of the system with at least an optical signal unless the system is deactivated (off mode),

(c) Transition demand by at least an optical and in addition an acoustic and/or haptic warning signal.

At the latest 4 s after the initiation of the transition demand, the transition demand shall:

(i) Contain a constant or intermittent haptic warning unless the vehicle is at standstill; and

(ii) Be escalated and remain escalated until the transition demand ends.

(d) Minimum risk manoeuvre by at least an optical signal and in addition an acoustic and/or a haptic warning signal and

(e) Emergency manoeuvre by an optical signal

[(f) A LCP, if the ALKS is capable of performing a LCP, by at least an optical signal.]

The optical signals above shall be adequate in size and contrast. The acoustic signals above shall be loud and clear.

Paragraph 7.1.., amend to read:

7.1. Sensing requirements

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 and according to the relevant tests in Annex 5.

The ALKS vehicle shall be equipped with a sensing system such that, it can at least determine the driving environment (e.g. road geometry ahead, lane markings) and the traffic dynamics:

(a) 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 forward detection range;

(b) Along the full length of the vehicle and up to the limit of the lateral detection range.

[(c) Across the full width of its own traffic lane, the full width of the traffic lanes immediately to its left and to its right, the full width of the lane next to the target lane, up to the limit of the forward, side and rearward detection range, if fitted to perform a LCP.]

The requirements of this paragraph are without prejudice to other requirements in this Regulation, most notably paragraph 5.1.1.

Group conclusion on 7.1.1.: Proposal. agreed (based on 5 m/s2 deceleration)

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**
80	**60**
90	**75**
100	**90**
110	**110**
120	**130**
130	**150**

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.

Paragraph 7.1.1.1.., insert to read:

[7.1.1.1. The requirements of this paragraph apply to the system, if the ALKS is capable to perform a LCP.

The manufacturer shall declare the forward detection range measured from the most forward point of the vehicle. This declared range shall be sufficient to cover at least the target lane and the lane next to the target lane.

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.]

Paragraph 7.1.2.1.and 7.1.3., insert to read:

[7.1.2.1. The requirements of this paragraph apply to the system, if the ALKS is capable to perform a LCP.

The manufacturer shall declare the lateral detection range. This declared range shall be sufficient to cover at least the target lane and the lane next to the target lane.

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.]

[7.1.3. Rearward detection range

The requirements of this paragraph apply to the system, if the ALKS is capable to perform a LCP.

The manufacturer shall declare the rear detection range measured from the most rearward point of the vehicle. This declared range shall be sufficient to cover at least the target lane and the lane next to the target lane.

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.]

The following items are shifted one by one.

Points of discussion for Annex 3: Proposal by leadership to implement the tentative group decision from 7th SIG to embrace the JRC/EC model in Annex 3 as guidance (largely transferred from JRC/EC proposal UNR157-03-06)). ***Group needs to confirm, if this proposal is acceptable.***

Annex 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~~ **two possible** performance model**s** 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. Following three are traffic critical scenario:

(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 **ALKS vehicle** ~~'ego vehicle'~~

(c) Deceleration: the 'other vehicle' suddenly decelerates in front of the **ALKS vehicle** ~~'ego vehicle'~~

2.3. Each of these traffic critical scenarios can be created using the following parameters/elements:

(a) Road geometry

(b) Other vehicles' behavior/maneuver

3. Performance models of ALKS

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~~ ~~**careful**~~ **competent** and ~~**competent**~~ **careful** ~~attentive~~ human driver. It is expected that some of the "unpreventable" scenarios by human standards may actually be preventable by the ALKS system.

Commented [12]: To be in line with discription in 5.2.7

3.2. **For the purpose of determining whether a traffic critical scenario is preventable or unpreventable, the following two performance models can be used.**

3.3 **“Performance model 1”**

3.3.1. **In the first performance model,** the avoidance capability of the driver model is assumed to be only by braking. The driver model is separated into the following three segments: "Perception"; "Decision"; and, "Reaction". The ~~following~~ diagram **in Figure 1** is a visual representation of these segments.~~:~~

3.3.1.1. To determine conditions under which Automated Lane Keeping Systems (ALKS) shall avoid a collision, performance model factors for these three segments in ~~the following~~ **Table 1** ~~table~~ should be used as the performance model of ALKS considering attentive human drivers’ behavior with ADAS.

Figure 1
~~Skilled~~ ~~Careful~~ Competent and ~~competent~~ careful human performance model

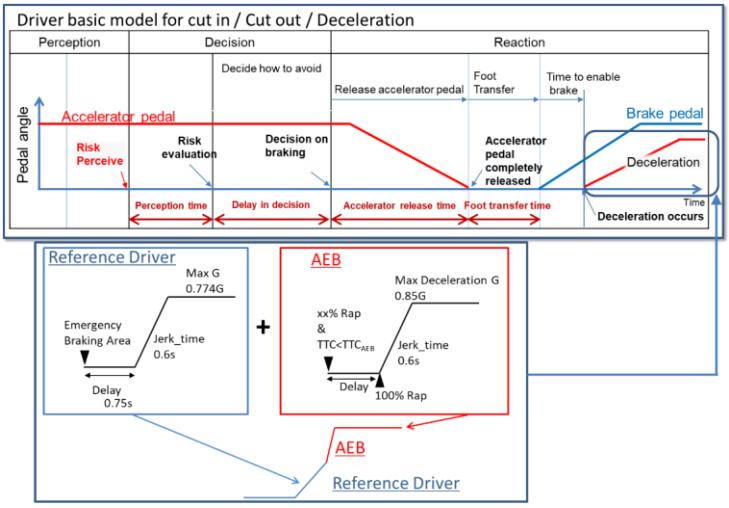


Table 1
Performance model factors for vehicles

		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)~~
	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)~~
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 0.85~~G~~g ~~(derived from UN Regulation No. 152 on AEBS)~~

3.3.2. Driver model for the three ALKS scenarios:

3.3.2.1. 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)

Commented [13]: To be in line with discription in 5.2.7

Commented [14]: This is international regulation, so origin of data and specific coutry name is not necessary. Same in other paragraph.

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.

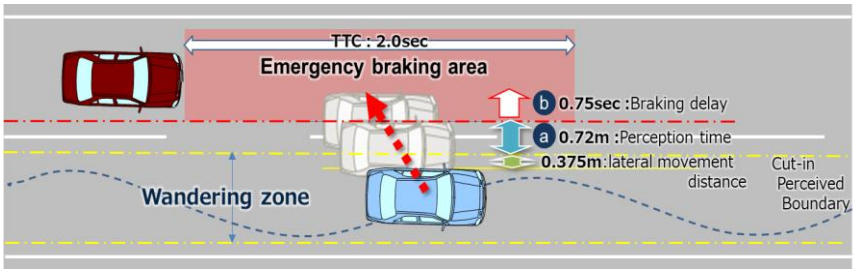
~~Max lateral movement speed is real world data in Japan.~~

~~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 the cut-in scenario



3.3.2.2. For Cut out scenario:

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

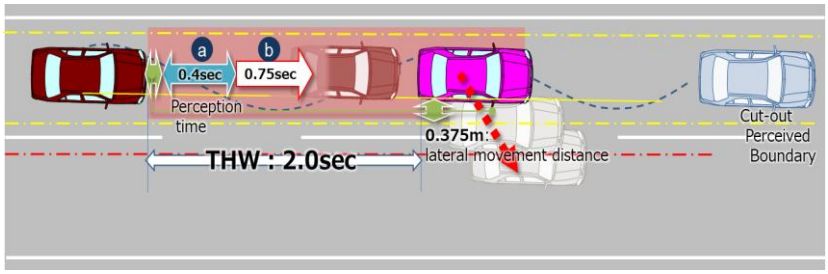
The perceived boundary for cut-out occurs when the vehicle exceeds the normal lateral wandering distance (possibly prior to actual lane change)

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.~~

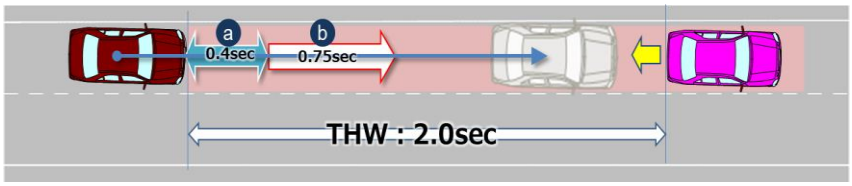
Figure 3
Cut in scenario



3.3.2.3. 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~~

3.3.3. Parameters

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

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

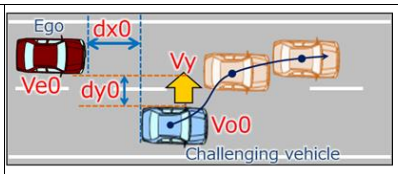
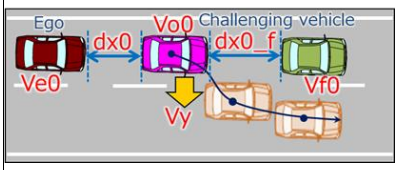
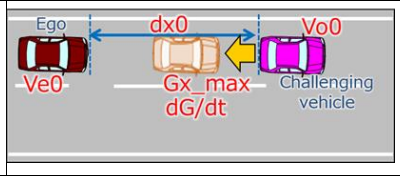
Table 2
Additional parameters

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 (i.e., day, night, sunny, cloudy) **Weather conditions** = The amount, type and intensity of wind, rain, snow etc.
Initial condition	Initial velocity	**Ve0** = Ego vehicle
		Vo0 = Leading vehicle in lane or in adjacent lane
		Vf0 = Vehicle in front of leading vehicle in lane
	Initial distance	**dx0** = Distance in Longitudinal direction between the front end of the ego vehicle and the rear end of the leading vehicle in ego vehicle's lane or in adjacent lane
		dy0 = 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 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 of the leading vehicle
Vehicle motion	Lateral motion	**Vy** =Leading vehicle lateral velocity
	Deceleration	**Gx_max** = Maximum deceleration of the leading vehicle in G
		dG/dt = Deceleration rate (Jerk) of the leading vehicle

3.3.3.3. Following are visual representations of parameters for the three types of scenarios

Figure 5
Visualisation

Cut in	
Cut out	
Deceleration	

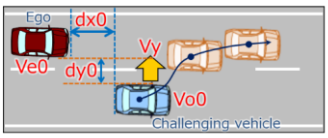
~~5~~. **3.3.4** **Reference**

Following data sheets are pictorial examples of simulations which determines conditions under which ALKS **travelling at a speed up to 60 km**/h shall avoid a collision**,** taking into account the combination of every parameter, *at and below* the maximum permitted ALKS vehicle speed.

~~5.1~~. **3.3.4.1.** Cut in

Commented [15]: Japan can accept to delete this section because these are just up to 60kph and just refference. If SIG requests, Japan can make similar figures up to 130kph.

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

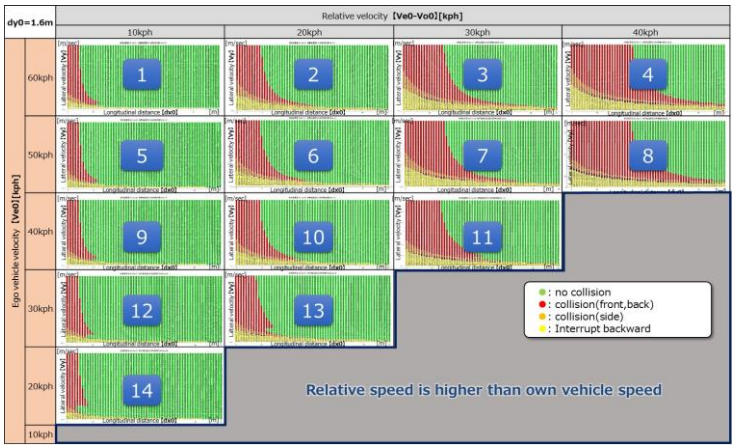
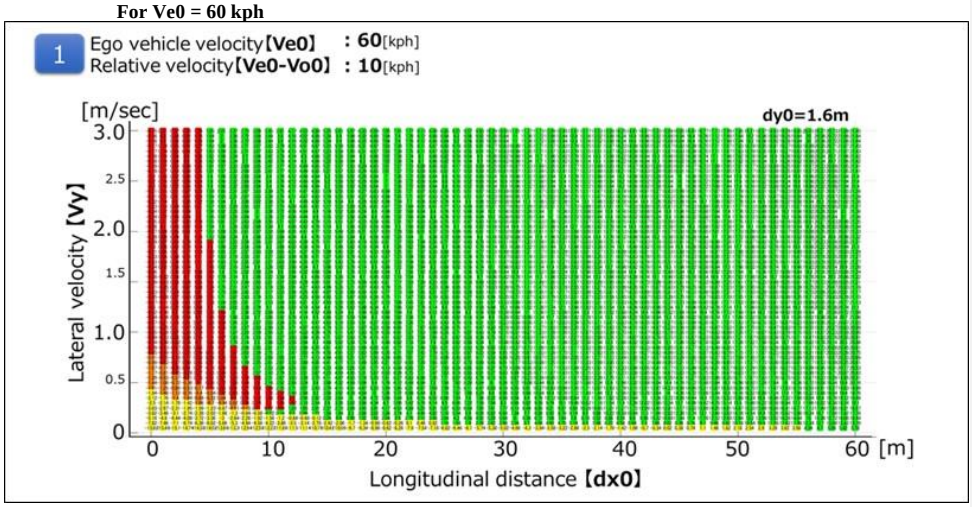
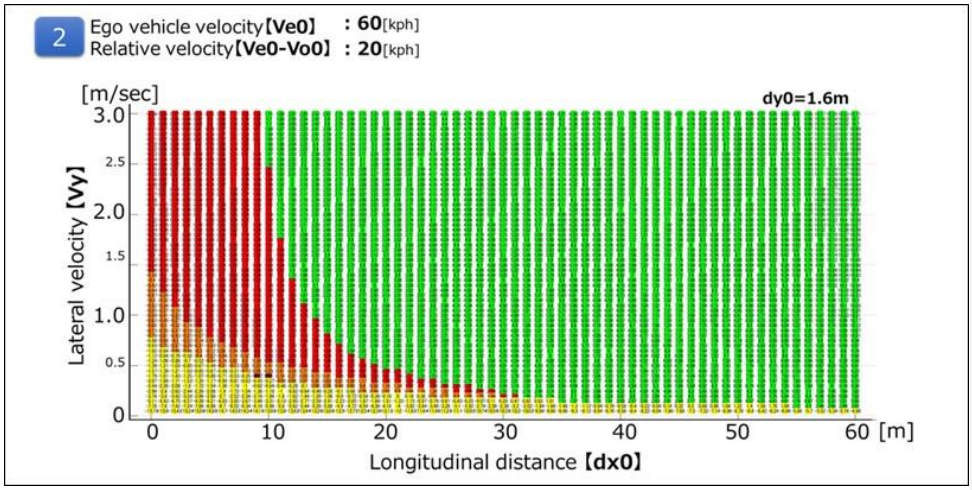
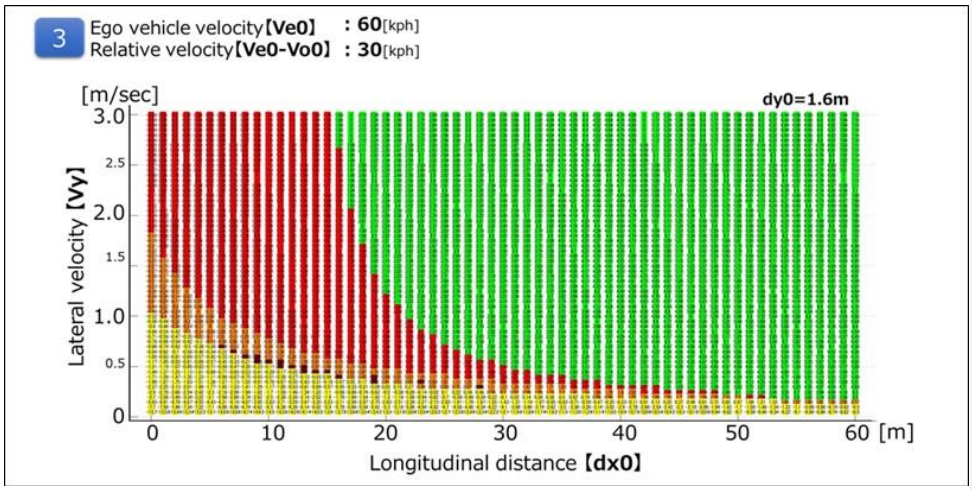


Figure 8
For Ve0 = 60 kph






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】

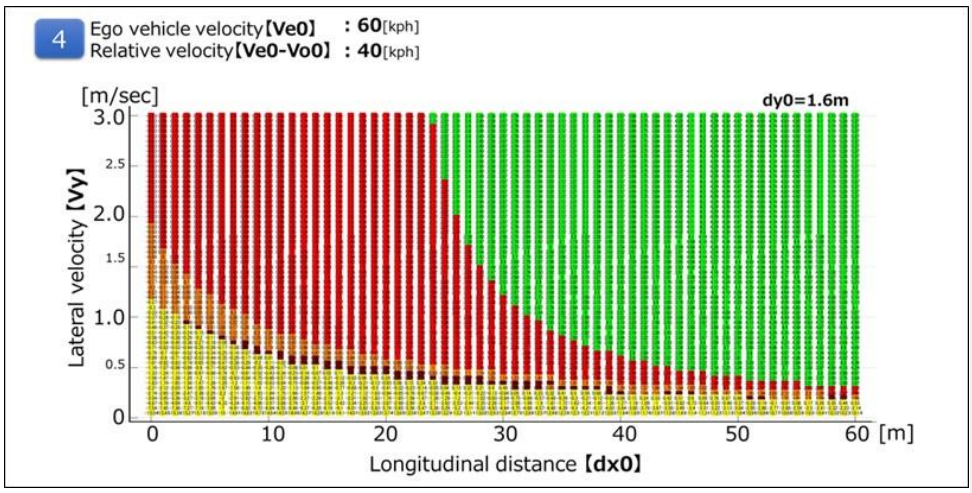
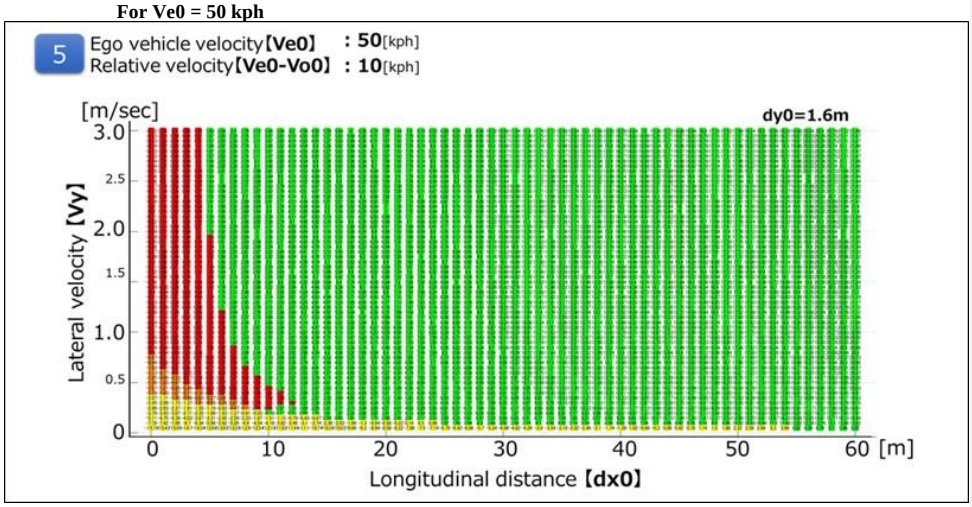
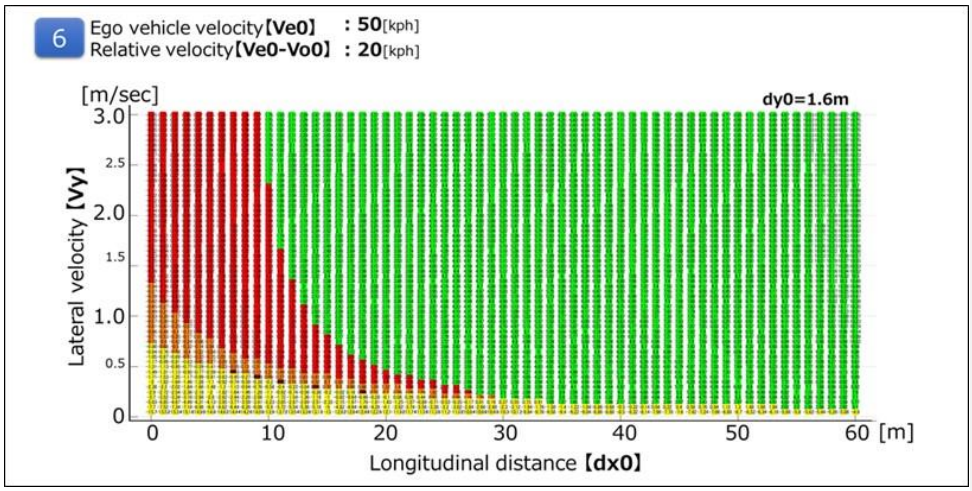
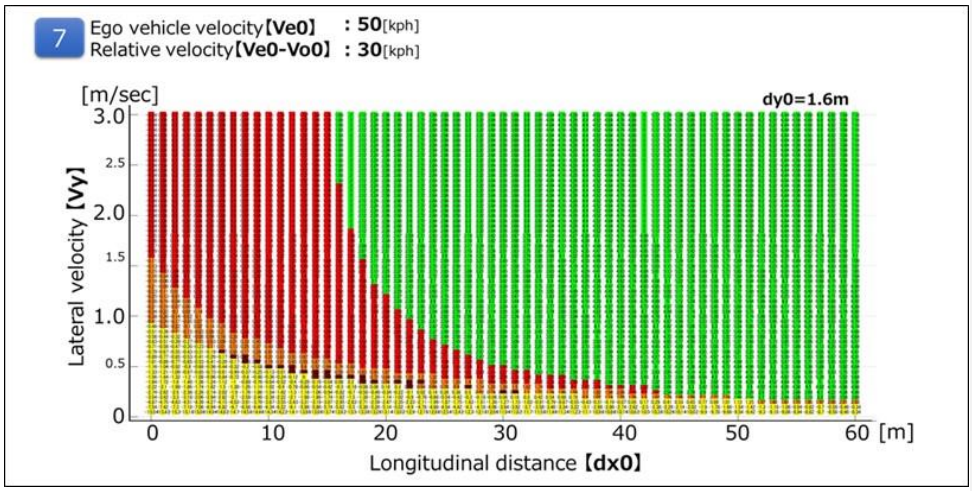

4
Ego vehicle velocity【Ve0】 : 60[kph]
Relative velocity【Ve0-Vo0】 : 40[kph]
[m/sec]
dy0=1.6m
Lateral velocity【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
60 [m]
Longitudinal distance【dx0】

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】

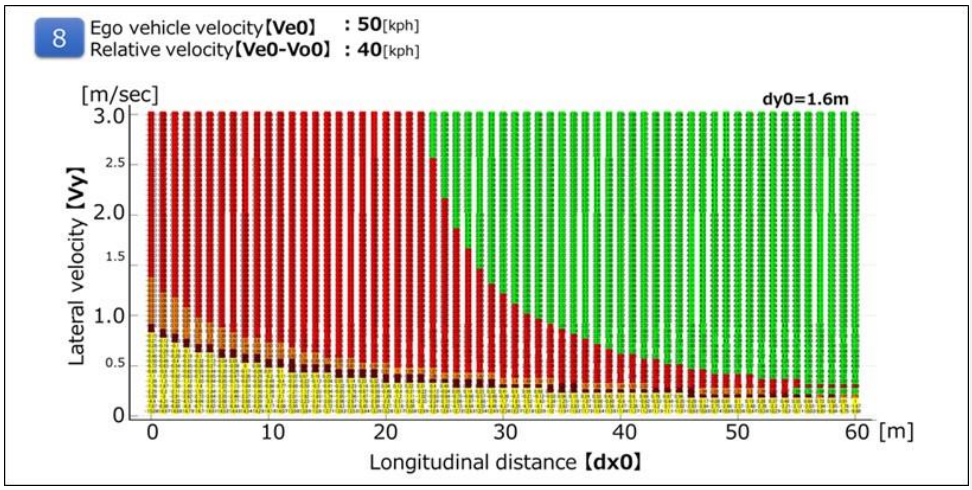
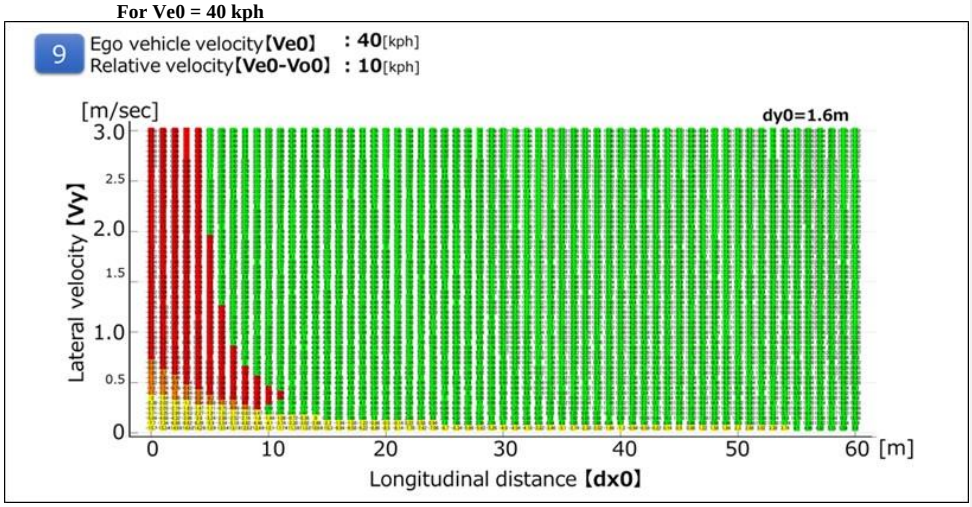
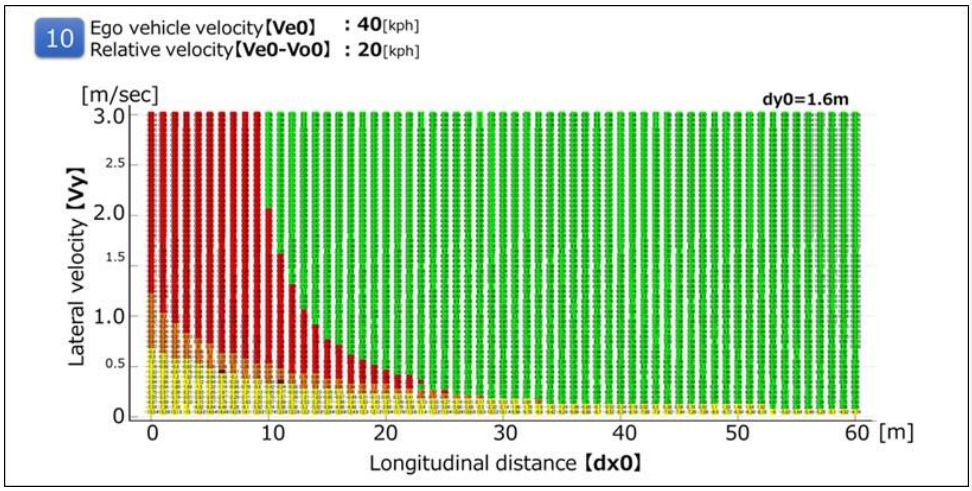

8
Ego vehicle velocity【Ve0】 : 50[kph]
Relative velocity【Ve0-Vo0】 : 40[kph]
[m/sec]
dy0=1.6m
Lateral velocity【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
0
10
20
30
40
50
60 [m]
Longitudinal distance【dx0】

Figure 10
For Ve0 = 40 kph





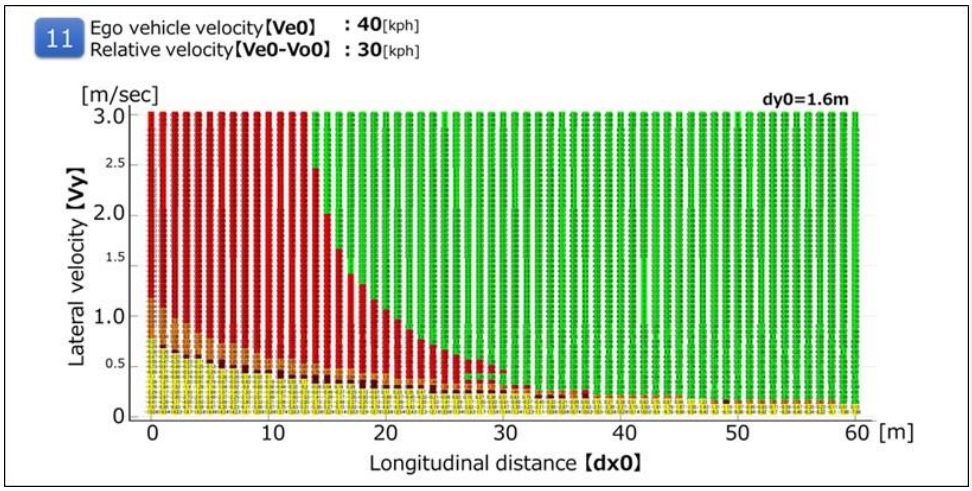
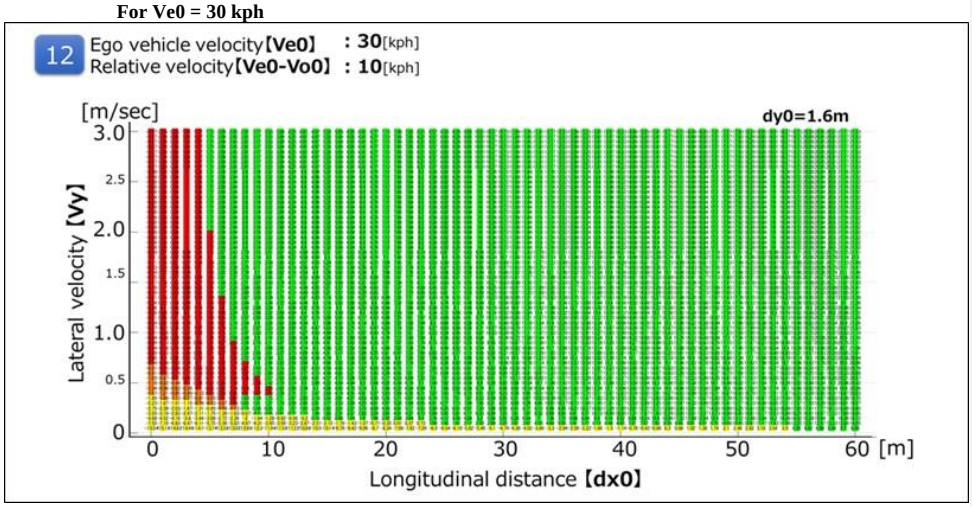


Figure 11
For Ve0 = 30 kph



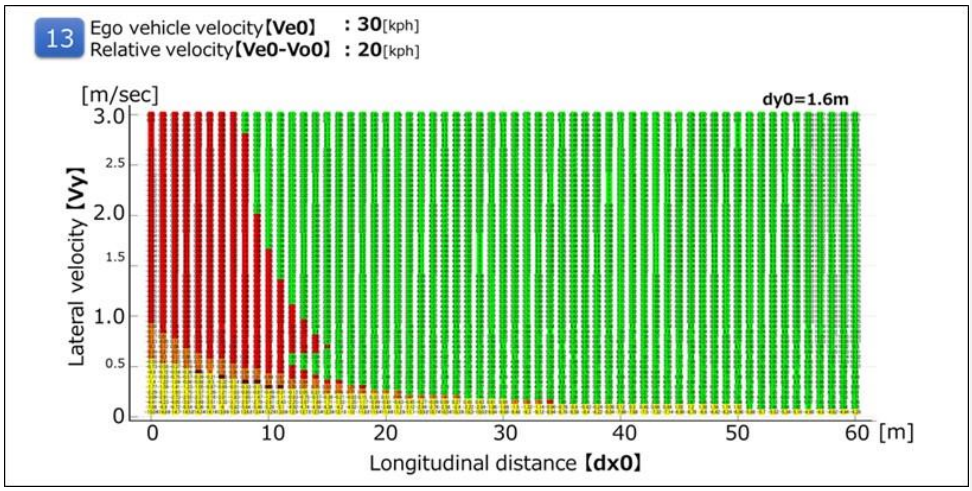
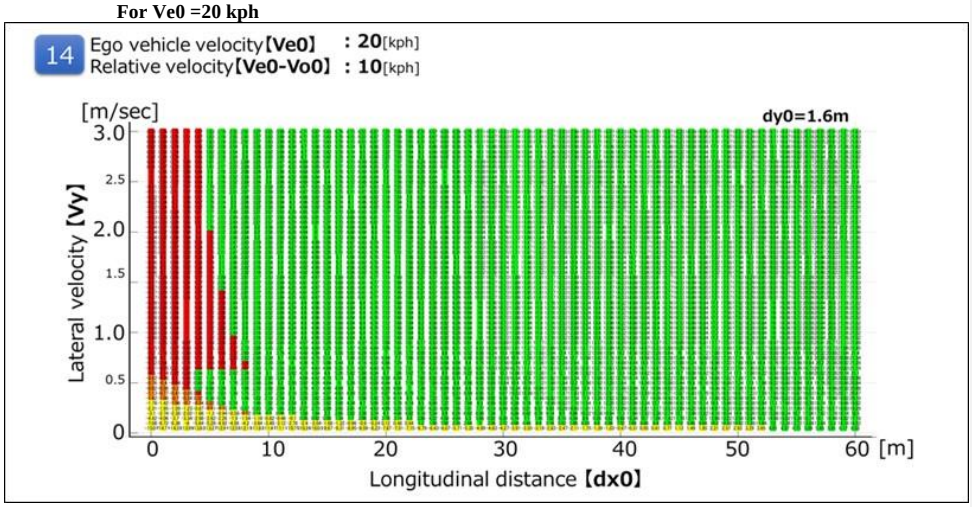


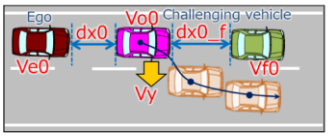
Figure 12
For Ve0 =20 kph



~~5.2.~~ 3.3.4.2. 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.

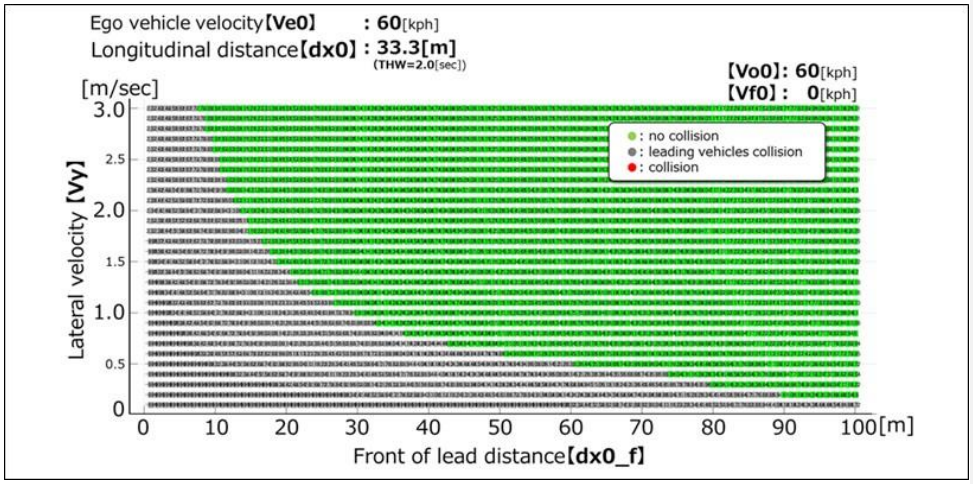
Figure 12
Parameters

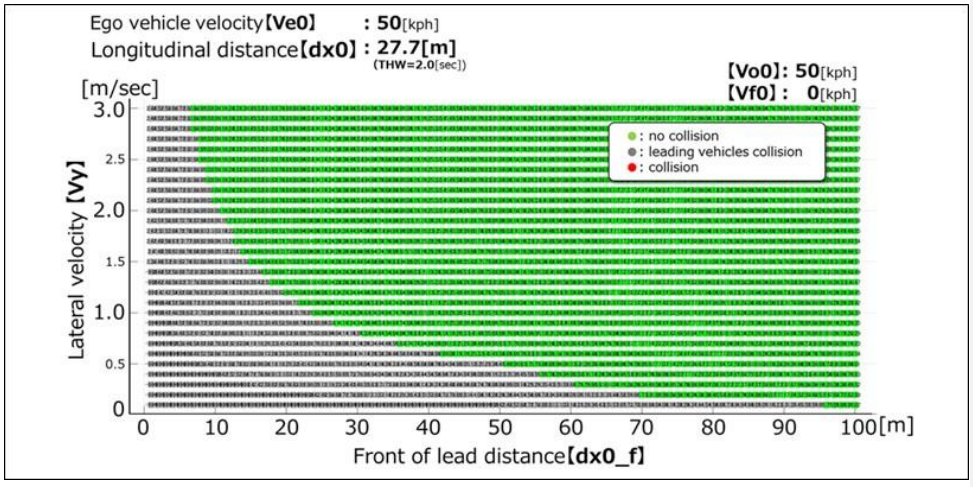


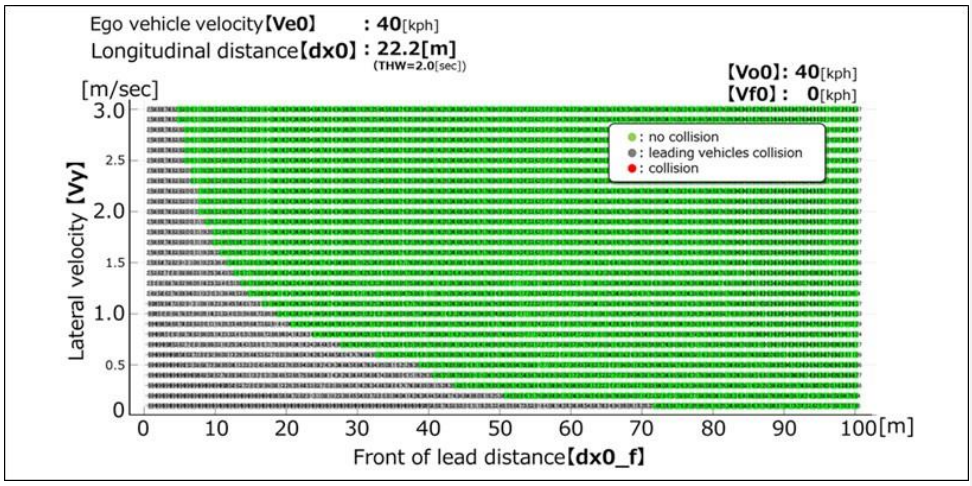
Initial condition	Initial velocity	**Ve0**	Ego vehicle velocity
		Vo0	Leading vehicle velocity[1]
		Vf0	Vehicle in front of leading vehicle[2]
	Initial distance	**dx0**	Longitudinal distance[3]
		dx0_f	Front of lead distance
Vehicle motion	Lateral motion	**Vy**	Lateral velocity

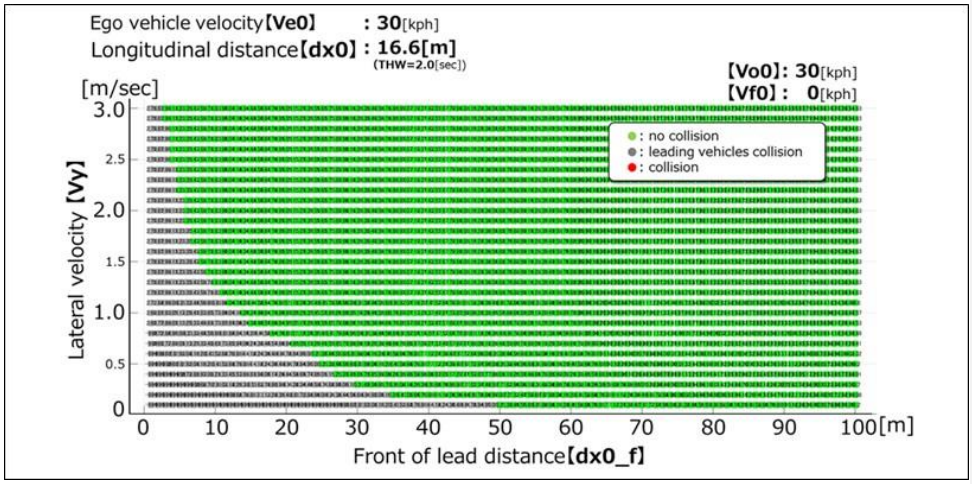
1 Vo0 = Ve0(Same speed as the leading vehicle)
2 Vf0 = 0 (stop vehicle)
3 Follow the leading vehicle in THW=2sec

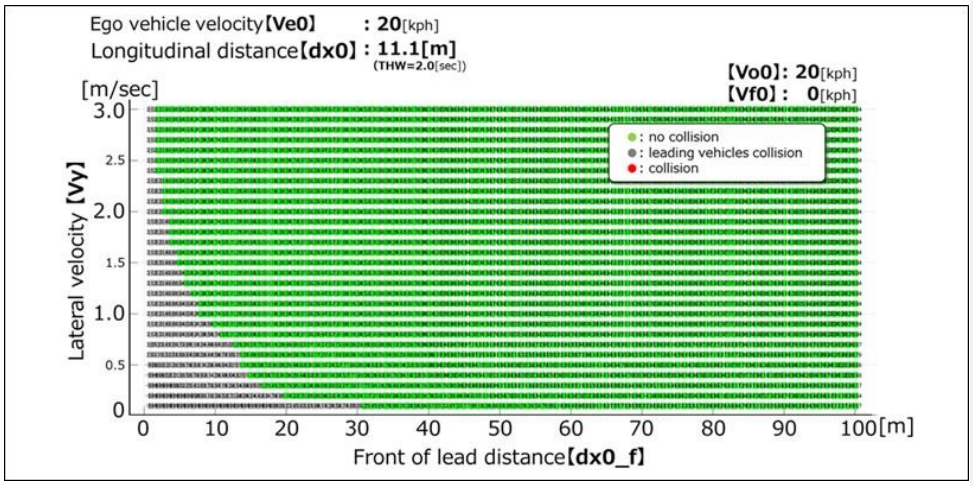
(Data sheets image)

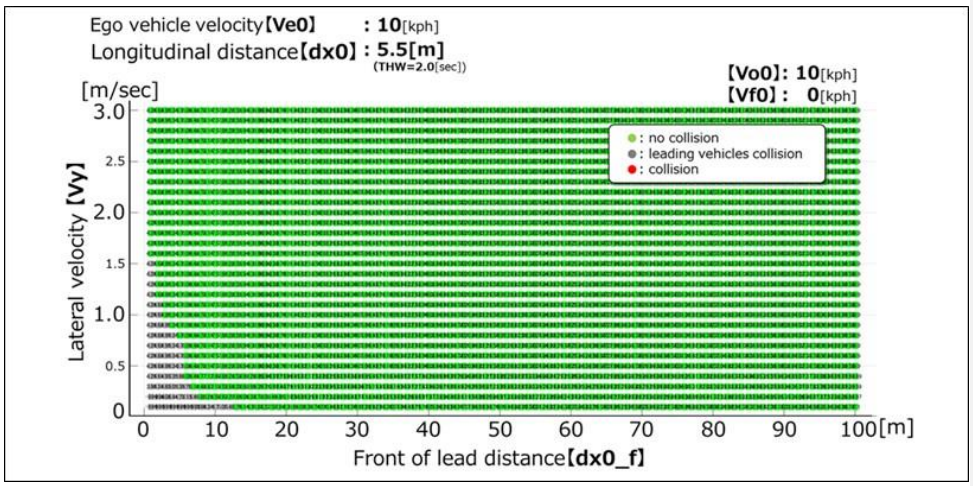





Ego vehicle velocity【Ve0】 : 40[kph]
Longitudinal distance【dx0】: 22.2[m]
(THW=2.0[sec])
【Vo0】: 40[kph]
【Vf0】: 0[kph]
[m/sec]
Lateral velocity【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
: no collision
: leading vehicles collision
: collision
0 10 20 30 40 50 60 70 80 90 100[m]
Front of lead distance【dx0_f】


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】
3.0
2.5
2.0
1.5
1.0
0.5
0
: no collision
: leading vehicles collision
: collision
0 10 20 30 40 50 60 70 80 90 100[m]
Front of lead distance【dx0_f】

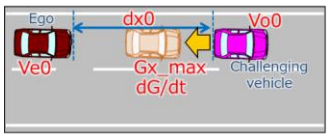

Ego vehicle velocity【Ve0】 : 20[kph]
Longitudinal distance【dx0】 : 11.1[m]
(THW=2.0[sec])
【Vo0】: 20[kph]
【Vf0】: 0[kph]
[m/sec]
Lateral velocity【Vy】
3.0
2.5
2.0
1.5
1.0
0.5
0
: no collision
: leading vehicles collision
: collision
0 10 20 30 40 50 60 70 80 90 100[m]
Front of lead distance【dx0_f】


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】
3.0
2.5
2.0
1.5
1.0
0.5
0
: no collision
: leading vehicles collision
: collision
0 10 20 30 40 50 60 70 80 90 100[m]
Front of lead distance【dx0_f】

~~5.4.~~ **3.3.4.3.** Deceleration

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

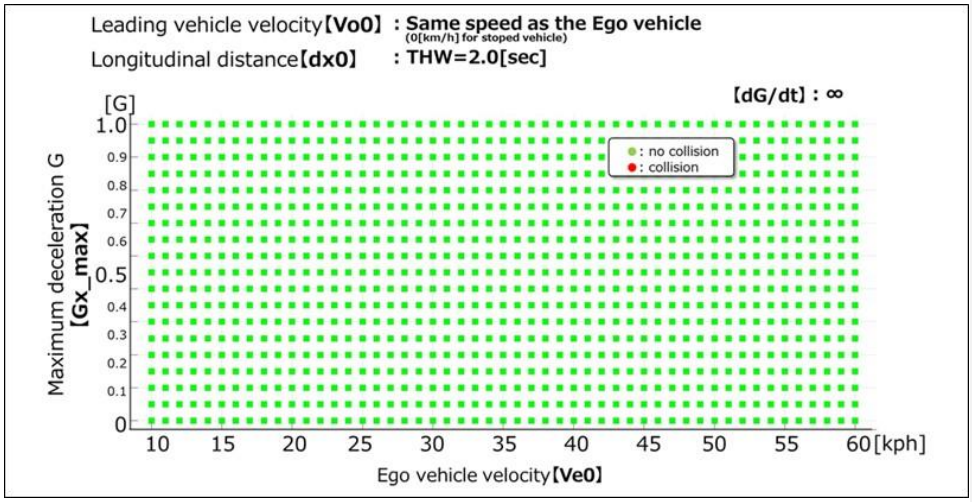
(Data sheet image)



Initial condition	Initial velocity	**Ve0**	Ego vehicle velocity
		Vo0	Leading vehicle velocity[1]
	Initial distance	**dx0**	Longitudinal distance[2]
Vehicle motion	Deceleration	**Gx_max**	Maximum deceleration G
		dG/dt	Deceleration rate[3]

1 Vo0 = Ve0(Same speed as the leading vehicle) 0[km/h] for a stopped vehicle
2 Follow the leading vehicle in THW=2sec
3 The most severe conditions ∞

(Data sheets image)

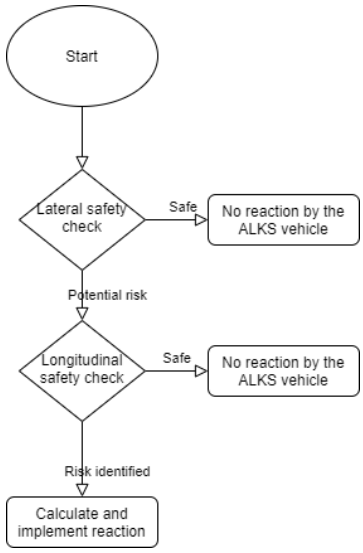


3.4 ““Performance model 2”

3.4.1. In the second performance model, it is assumed that the driver can anticipate the risk of a collision and apply proportionate braking.~~apply proportionate braking actions in order to anticipate the risk of collision.~~ In this case, the performance model considers the following three actions performed by the competent and careful human driver: "Lateral Safety Check"; "Longitudinal Safety Check"; and, "Reaction". A Reaction is implemented only if the Lateral and Longitudinal Safety Checks identify a risk of imminent collision. The diagram reported in Figure 2 provides a visual representation of the decision flow followed by the driver in the second performance model for the case of the cut-in traffic critical scenario.

Commented [16]: This amemdment is to just for clarilication.

Figure 6
Flow-chart of the second ALKS performance model for the case of the cut in traffic critical scenario



3.4.2. Cut-in traffic critical scenario.

3.4.2.1. 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.**

3.4.2.2. **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).**

3.4.2.2.1. **The PFS is defined by the following equation:**

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'**

3.4.2.2.2. **The CFS is defined by the following equation:**

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

Where

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

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

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 change in distance between the ALKS vehicle and the 'other vehicle' after the reaction time**

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

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

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

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

3.4.2.4. **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.**

3.4.3. **Cut-out traffic critical scenario.**

In case of a cut-out, the model follows the same flow chart described in 3.2.2.1. for the cut-in scenario, with three changes:

a) The Lateral Safety check is ignored, as the ALKS vehicle and the static object are already in the same lane.

b) The Longitudinal Safety check is evaluated as in paragraph 3.2.2.1.2. with the state parameters being calculated for the static object instead of the cutting in vehicle.

c) The ALKS vehicle is assumed not to be able to start the reaction time before the cutting out vehicle's centre is outside the wandering zone of 0.375 m from the centre of the lane.

3.4.4. **Deceleration traffic critical scenario**

In case of a sudden deceleration of the preceding vehicle, the model follows the same flow chart described in 3.2.2.1. for the cut-in scenario, with two changes:

a) The Lateral Safety check is ignored, as the ALKS vehicle and the preceding vehicle are already in the same lane.

b) The Longitudinal Safety check is evaluated as in 3.2.2.1.2. with the state parameters being calculated for the preceding vehicle instead of the cutting in vehicle.

3.4.5. **A software implementation of the second performance model applied to the three traffic critical scenarios described in paragraph 2.2. of the present appendix is openly available at the following url: [link to be provided as soon as the software is published]. For any request of support to its use the following email address can be used: JRC-SMART-MOBILITY@ec.europa.eu**

3.4.6. **To determine conditions under which the ALKS vehicle shall avoid a collision, the following performance model factors shall be used.**

Table 3
Performance model factors for vehicles

	Factor
Risk perception point	**The time when either PFS or CFS value is not any longer 0**
	In the case of cut-out the ALKS vehicle reaction time cannot start before the cutting out vehicle's centre is outside the wandering zone of 0.375 m from the centre of the lane
Reaction time of the ALKS vehicle	**τ = 0.75 seconds**
Jerking (road friction 1.0)	**12.65 m/s^3**
Safety distance when the two vehicles reach complete stop	**d_1 = 2 meters**

Comfortable deceleration of the ALKS vehicle	$b_{ego,comf} = 4$ **m/s²**
Maximum deceleration of the ALKS vehicle	$b_{ego,max} = 6$ **m/s²**
Maximum deceleration of the 'other vehicle'	$b_{cut-in,max} = 7$ **m/s²**

]

Japan proposal: The MRMLC function is indispensable for speed increase.

Annex 5, paragraphs 4.6.1.amend to read:

4.6.1. The test shall demonstrate that the ALKS is capable of detecting another road user within the forward detection area up to the declared forward detection range and a vehicle beside within the lateral detection area up to at least the full width of the adjacent lane. **[If the ALKS is capable of performing lane changes, it shall additionally demonstrate that the ALKS is capable of detecting another vehicle within the front, side and rearward detection range at least the target lane and the lane next to the target lane.]**

Annex 5, paragraphs 4.6.2.1.- 4.7.2..insert to read:

[4.6.2.1 The requirements of this paragraph apply to the system, if the ALKS is capable ~~to~~of performing a LCP.

The test for the forward detection range shall be executed at least:

(a) When approaching a motorcycle positioned at the outer edge of each target lane and the lane next to the target lane;

(b) When approaching a stationary pedestrian positioned at the outer edge of each target lane and the lane next to the target lane;]

[4.6.3.1 The requirements of this paragraph apply to the system, if the ALKS is capable ~~to~~of performing a LCP.

The test for the lateral detection range shall be executed at least:

(a) With a motorcycle target approaching the ALKS vehicle from the left target lane and the lane next to the target lane;

(b) With a motorcycle target approaching the ALKS vehicle from the right target lane and the lane next to the target lane.

4.6.4. The test for the rear detection range shall be executed at least:

(a) With a motorcycle approaching the ALKS from the rear in the left ~~adjacent lane~~ target lane and the lane next to the target lane;

(b) With a motorcycle approaching the ALKS from the rear in the right ~~adjacent lane~~ target lane and the lane next to the target lane.]

[4.7. Lane changing

Lane Change tests (only required if the ALKS is capable of performing lane changes either during an MRM~~, emergency situations or during regular operation~~)

The tests shall demonstrate that the ALKS does not cause an unreasonable risk to safety of the vehicle occupants and other road users during a Lane Change Procedure (LCP), is capable of correctly performing lane changes and is able to assess the criticality of the situation before starting the LCM.

4.7.1. The test shall be executed at least:

(a) With different vehicles, including a motorcycle approaching from the rear;

~~(b) In a scenario where a LCM in regular operation is possible and executed;~~

~~(c) In a scenario where the LCM in regular operation is not possible due to a vehicle approaching from the rear~~;

(~~d~~b) With an equally fast vehicle following behind in the adjacent lane at a distance of less than that which the following vehicle travels in 1.0 second preventing a lane change;

(ec) With a vehicle driving beside in the adjacent lane preventing a lane change;

(~~f~~d) In a scenario where a LCM during a minimal risk manoeuvre is possible and executed.

4.7.2. The following on road-tests shall be executed. but based on the ODD of the given system:

(a) With the ALKS vehicle performing lane change in the adjacent (target) lane;

(b) Merging at motorway entry;

(c) Merging at lane end;

(d) Merging into an occupied lane.]

Points of discussion for Annex 5: Group agreement needed how to deal with the following two new on-road tests proposed by JRC/EC (UNR157-03-06). ***Can the 3 tests be added to UN-R 157?***

Annex 5, paragraphs 4.7. and 4.8., insert to read:

[4.~~7~~8. Detect and response to traffic rules and road furniture

4.~~7~~8.1. These tests shall ensure that the ALKS ~~respects~~ complies with traffic rules, detects and adapts to a variation of permanent and temporary road furniture.

4.~~7~~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.~~7~~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.~~8~~9. Avoid braking before a passable object in the lane

4.~~8~~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.~~8~~9.2. The test shall be executed at least:

Commented [17]: This paragraph should be moved on paragraph 5.4.because it is real world test.

Commented [18]: What can be done in the truck test and the real world test should be organized and described.

Commented [19]: Traffic rules is what to be complied with, not only what to be respected. “respect” is ambiguous word as regulation.

(a) Without a lead vehicle;

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

Annex 5, paragraph 4.9., insert to read:

[4.910. Oncoming traffic / Wrong way driver

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

4.910.2. 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]

Commented [20]: We would like to know the background of this condition.
Is this correct ?

II. Justification