Submitted by Japan

Informal Document - ACSF-22-08

~~Base document for ALKS for low speed application~~

This document is modified from ACSF-22-03.

Modifications are written in red and deletions are marked by "~~strike though~~"

~~All the paragraphs in this document are picked up from the related paragraphs of the functional requirements of ACSF-21-03r1 in order to respect the discussion of the 2nd session of GRVA.~~

~~Some of the reminder in the 21st session are reflected, and the scope (definition) of the system to be considered (blue) is added.~~

~~In case of two options (remaining from ACSF-20-04):~~
~~**A** = ACSF-19-09 and **B** = ACSF-19-03.~~

~~Reminders and remarks in *green*.~~

Proposal for Technical Requirements for an Automated Lane Keeping System

*** S P E C I F I C R E Q U I R E M E N T S ***

2.1 Scope

The following set of requirements applies to "Automated Lane Keeping System (ALKS) for low speed application" **for categories M1 and N1**[t1], a system which is initiated/activated by the driver and which keeps the vehicle within its lane by influencing the lateral movement of the vehicle and controls the longitudinal movement of the vehicle for extended periods without further driver command/confirmation at **~~the~~ low** speed **~~of [60] km/h or below~~**[t2] under the condition when **the ego vehicle is** following a **~~frontal~~ leading** vehicle **within the same lane**[t3].

~~**2.1.1. This system applies to vehicles of categories M1.**~~[t4]

2.2. Definitions

2.2.1 "*Transition demand*" is a logical and intuitive procedure to transfer the dynamic driving task from automated control by the system to human driver control. This request given from the system to the human driver indicates the transition phase.

2.2.2. "*Transition phase*" means the duration of the transition demand.

2.2.3. "*Planed event*" is a situation which is known ~~[~~in advance~~]~~, e.g. at the time of activation such as a journey point (e.g. exit of a highway) etc. and which requires a transition demand.

2.2.4. "*Unplaned event*" is a situation which is unknown ~~[~~in advance~~]~~, but assumed as very likely in happening, e.g. [road construction, inclement weather,

approaching emergency vehicle, missing lane marking, load falling from truck (collision)] and which requires a transition demand.

2.2.5. "*Imminent danger*" describes a situation or an event which leads to a collision of the vehicle with another road user or an obstacle unless an emergency manoeuvre is executed.

2.2.6. "*Minimum risk manoeuvre*" means a procedure aimed at minimizing risks in traffic, which is automatically performed by the system after a transition demand.

2.2.7. "*Emergency Manoeuvre*" is a manoeuvre performed by the system in case of a sudden un*planne*d event in which the vehicle is in imminent danger of a collision [and in case of insufficient lead time to transition the control back to the driver,] with the purpose of avoiding or mitigating a collision.

2.2.8. "**Maximum** *Operational speed*" is the maximum vehicle speed at which the system may be active and shall be determined by ~~the capability of the system's visualisation technology.~~ **the detection range.**[t5]

2.2.9. *"Detection range"* ~~**of the visualisation system**~~ is the distance at which the system can reliably ~~**recognise**~~ **detect** a target and generate an appropriate control signal.

~~[2.2.10. "*Operating range*" shall be determined from the value of the verified detection range after taking account of the deterioration of components of the visualisation system due to time and usage throughout the normal life of a vehicle.]~~

~~[2.2.11. "*Normal life*" of a vehicle is understood to be [10] years or [160 000] kilometres.~~

2.4. Activation and deactivation

2.4.1. The vehicle shall be equipped with means for the driver to activate (active mode) and deactivate (off mode) the system.

2.4.2. The default status of the system shall be in off mode at the initiation of each new engine start/run cycle. This requirement does not apply when a new engine start/run cycle is performed automatically, e.g. by the operation of a stop/start system.

2.4.3. The system shall be active only after a deliberate action by the driver.

The activation of the system shall be possible only if:

- The driver is present in the driver seat and the seatbelt is fastened,
- the driver is ~~**detected to ready**~~ **available** to take over ~~**control**~~ **the driving task** on request,[t6]
- all functions needed for the operation are working properly and
- the vehicle is on roads where pedestrians and cyclists are prohibited ~~**and which, by design, are equipped with a physical separation that divides the traffic moving in opposite directions.**~~,[t7]
- **a vehicle is detected in front in the same lane within $s_{front\text{-}ALKS}$**[t8]**,**

- **a vehicle further than or equal to $s_{front\text{-}ALKS}$ in front has been detected in the same trip.**

2.4.4. It shall be possible to deactivate (off-mode) the system at any time by a single deliberate action of the driver using the same control as indicated in paragraph 2.4.3 above. **Following this action, the system shall only become active again as a result of a deliberate action by the driver.**[t9]

[2.4.5.A The system shall be deactivated automatically when the driver has taken over manual control.

2.4.5. B The system shall terminate the control function be deactivated automatically when the driver has taken over manual control following a transition demand.

Reminder: Definition for "manual control" needed, to explain what driver took over manual control means?

2.4.5.1. Any input of the driver shall have priority over the control functions of the system. A steering input of the driver shall deactivate the system. The steering control effort necessary to deactivate the system shall not exceed 50 N.

2.4.5.2. The system design shall include protection against unintentional deactivation input by a driver input on the system controls.

2.4.5.3. An acceleration demand by the driver shall deactivate the system only if the driver is holding the steering control.

2.4.6.5.3. A braking demand by the driver shall have priority over the longitudinal control function of the system and shall generate transition demand. A return to the set speed of the system shall only be possible following a deliberate action by the driver using the same control as indicated in paragraph 2.4.3. above.

2.4.7.A An acceleration demand by the driver may have priority over the longitudinal control of the system. However, such a demand shall not cause the speed of the vehicle to exceed the operational speed as determined in accordance with this regulation. Following the release of the accelerator control, and in the absence of a deactivation, the speed of the vehicle shall return automatically to the set speed of the system.

2.4.7.B Driver action on the accelerator control may override the longitudinal control of the system. In case the driver is not holding the steering control during this override, the system shall initiate a transition demand or a hands-on warning as specified in paragraph 2.8.][t10]

2.5. Dynamic Driving Task and Headway Control

~~*Reminder: Definition for "dynamic driving task" needed?*~~

2.5.1. The activated system shall cope with all dynamic driving tasks and with any situation or shall otherwise transition the control back to the driver offering sufficient lead time.

Any type of situation in which the vehicle will generate a transition demand to the driver shall be declared by the vehicle manufacturer and explained by documentation.

2.5.2. The activated system shall keep the vehicle inside its lane of travel and ensure that the vehicle does not cross any lane marking. The system shall aim to keep

the vehicle in a stable lateral position inside the lane of travel to avoid confusing other road users.

2.5.3. The activated system shall detect a vehicle driving beside and if necessary adjust speed and/or the lateral position of the vehicle within its lane as appropriate.

2.5.4. The activated system shall control the longitudinal speed of the vehicle.

2.5.4.1. The activated system shall adapt the vehicle speed to infrastructural and environmental conditions (e.g. narrow curve radii, inclement weather).

2.5.4.2 The activated system shall detect the distance to another road user in front.

It 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 safety distance calculated using the formula:

$$S = \mathbf{max}(v_{ALKS} * t_{front}, d_{front})$$

Where:

v_{ALKS} = the actual speed of the **ALKS** vehicle in [m/s];

t_{front} = time gap of [2] seconds between the **ALKS** vehicle and the leading vehicle in front.[t11]

d_{front} = minimum distance gap of [2] meter between the ALKS vehicle and the leading vehicle in front.

The above shall also be ensured for lead vehicles slowing down or cutting-in **except the imminent danger situation.**

~~***Reminder: Homework Industry, take Korean proposal ACSF-20-08 with appropriate deceleration rate into account.***~~

2.5.4.3. Maximum operational speed and lead vehicle detection

The manufacturer shall declare the maximum operational speed up to which the system will operate. This declared speed shall be less or equal to [60] km/h.

The system shall detect vehicles driving in front in the same lane up to a distance of $s_{front\text{-}ALKS}$ as specified below.

$$s_{front\text{-}ALKS} = v_{max\text{-}ALKS} * v_{max\text{-}ALKS}/2/ a_{ALKS} - v_{max\text{-}ALKS} * t_{system}$$ [t12]

Where:

a_{ALKS} = [3,7] m/s² = feasible deceleration under wet conditions ;

$s_{front\text{-}ALKS}$ = Detection range in meter.

$v_{max\text{-}ALKS}$ = Maximal operational speed of the system declared by the manufacturer.

t_{system} = System delay [0.5] seconds until deceleration level is reached.

The fulfilment of the provisions of paragraph 2.5.4.3 shall be demonstrated to the technical service and tested according to the relevant tests by using a two-wheeled motor vehicle of Category L3 as the leading vehicle in Annex [X].

2.5.5. The activated system shall be able to bring the vehicle to a complete stop behind a stationary vehicle blocking its lane of travel. This shall be ensured up to the maximum operational speed of the system, as defined in paragraph **2.5.4.3.**

2.5.6. The activated system shall detect the risk of an imminent collision e.g. [with another road user ahead or beside the vehicle,] due to a decelerating lead vehicle, a cutting in vehicle or a suddenly appearing obstacle after a lane change of a leading vehicle and shall automatically perform an appropriate emergency manoeuver as specified in paragraph 2.10.

[2.5.7. Field of view

The field of view of the detection system shall be such that it can determine the driving environment and the traffic dynamics across its own traffic lane, the traffic lane immediately to its left and to its right, and at the limit of the operating range.][t13]

~~**2.5.8. Detection range** *(remark: UK and Canada will propose new wording)*~~[t14]

~~***Principle: The detection range shall be declared by the vehicle manufacturer including the deterioration factor and the environmental factor as well as installation influences which shall be all verified by the Technical Service.***~~

~~**The detection range shall be declared by the vehicle manufacturer which shall be verified by the Technical Service.**~~

~~**This value shall be recorded during the relevant test in Annex [X] using a two-wheeled motor vehicle of category L3 as the vehicle in front**~~

~~**[2.5.9. Operating range** *(remark: UK and Canada will propose new wording)*~~

~~**The operating range of the detection system shall be determined by the application of the deterioration factor and the environmental factor to the value for the verified detection range. This value shall be rounded down to the nearest whole number.**~~

~~**2.5.9.1. A time based deterioration factor shall be applied to the detection range value.**~~

~~**The manufacturer provide evidence to demonstrate a level of deterioration. This shall be subject to agreement with the Technical Service.**~~

~~**2.5.9.2. The detection range shall be further qualified to take account of performance limitations resulting from environmental conditions, e.g. rain.**~~

~~**An environmental factor shall be applied to the detection range value.**~~

~~**The manufacturer provide evidence to demonstrate a lower impact of environmental factors on the performance of the system, e.g. the system**~~

~~may transition back to the driver when rain is detected. This information shall be subject to verification by the Technical Service.~~

~~2.5.9.3. Where the manufacturer provides deterioration factors for normal life and environmental conditions, the Technical Service shall append details of the assessment procedures to the test report. These details shall be sufficient for replication of the assessment during in-service compliance/market surveillance testing.]~~

~~2.5.10.A Operational speed~~

~~[The operational speed shall not exceed the speed at which the detection system can identify a foreseeable critical situation (e.g. slow, slowing or stationary traffic, lane obstruction etc.) within its field of view and, based upon that identification, cause the vehicle to be brought to a halt behind the hazard automatically with a deceleration rate not exceeding a_{ALKS}.]~~

~~The required operation range $S_{front,}$ shall be calculated using the formula below:~~

$$V_{max-B2} = +\sqrt{2 * a_{ACSF} * (s_{front-B2} - (v_{max-B2} * t_{System}))}$$

$$\Rightarrow$$

$$V_{max-B2} = -a_{ACSF} * t_{System} + \sqrt{(a_{ACSF} * t_{System})^2 + 2a_{ACSF} * s_{front-B2}}$$

~~Where:~~

~~a_{ALKS} = [3.7] m/s² = feasible deceleration under wet conditions~~

~~s_{front} = Operating range [m]~~

~~v_{max} = Resulting maximum operation speed of the system~~

~~t_{system} = System delay [of 0.5s] until deceleration level is reached~~

~~2.5. 10.B Maximum operational speed and lead vehicle detection~~

~~The system shall detect vehicles driving in front in the same lane up to a distance of $S_{front\ ALKS}$ as specified below.~~

~~The distance $S_{front\ ALKS}$ shall be declared by the manufacturer. This value shall not be less than [46] m and shall be less or equal than that value to be recorded during the relevant test described in Annex [X] using a two wheeled motor vehicle of category L3 as the leading vehicle.~~

~~The maximum speed $v_{max\ B2}$ of the system up to which the system is permitted to operate shall be calculated with the distance $S_{front\ ALKS}$ using the formula below:~~

$$V_{max-B2} = -a_{ALKS} * t_{System} + \sqrt{(a_{ALKS} * t_{System})^2 + 2a_{ALKS} * s_{front\_ALKS}}$$

~~Where:~~

~~a_{ALKS} = [3,7] m/s² = feasible deceleration under wet conditions[1];~~

~~$s_{front\ ALKS}$ = Distance in [m] declared by the manufacturer.~~

~~$v_{max\ ALKS}$ = Resulting maximal operational speed of the system~~

~~t_{system} = System delay [0.5] seconds until deceleration level is reached.~~

~~The manufacturer shall declare the speed up to which the system will operate. This declared speed shall be less or equal to the value calculated by the formula above.~~

~~2.5.11 The fulfilment of the provisions of paragraph 2.5. and its subparagraphs shall be demonstrated to the technical service and tested according to the relevant tests in Annex [X].~~

2.6. Driver Availability Recognition System

The activated system shall comprise a driver availability recognition system.

The driver availability recognition system shall detect that the driver is present in the driver seat, the safety belt of the driver is fastened and that the driver is available to take over the driving task.

2.6.1. Driver not present in the driver seat

Whenever the driver is detected not to be present in the driver seat or the safety belt of the driver is detected not to be fastened, the system shall provide a distinctive acoustic warning.

When the driver is not detected in the seat for a period of more than [1] second a transition demand shall be initiated according to paragraph 2.7.4.

When the safety belt is not fastened ~~for a period of more than [3] second~~[なし15]~~s~~ a transition demand shall be initiated according to paragraph 2.7.4.

2.6.2. Driver not available to take over the driving task

The system shall detect if the driver is available to take over the driving task by permanently evaluating that the driver is awake. The manufacturer shall declare appropriate means to detect that the driver is awake to the technical service ~~**and the type approval authority**~~[t16].

The driver's awareness shall be detected by the use of at least two independent ~~**means**~~ **features**[t17].

[1] ~~Unless a higher value is declared by the manufacturer and verified during type approval to the satisfaction of and in agreement with the technical service.~~

When the driver does not show any activity for a period [180] seconds the system shall provide a distinctive warning until appropriate actions of the driver are detected or until a transition demand is initiated.

When the system does not detect appropriate actions from the driver during the distinctive warning for a period of more than [15 s] a transition demand shall be initiated according to paragraph 2.7.4.

2.7. Transition Demand and System Operation during Transition

2.7.1. The activated system shall recognise situations in which it needs to transition the control back to the driver.

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

2.7.2.1. In case of a planned event, a transition demand shall be given latest [15] seconds before the event occurs.

2.7.2.2. In case of an unplanned event, a transition demand shall be given upon detection.

2.7.2.3 In case of any failure of the system or of any function needed for the operation, the system shall immediately initiate a transition demand upon detection.

[In addition, notwithstanding paragraph 2.7.4, a minimum risk manoeuvre may be immediately initiated depending on the criticality of the failure.]

Remark: *ACSF-20-06r1: (Industry homework) delete or consider examples where MRM should be initiated immediately. (electrical failure, including a failure of the electrical energy storage system -> severe system failure)*

2.7.3. During the transition phase the system shall continue to operate. The system may reduce the speed of the vehicle to ensure its safe operation but shall not bring it to standstill unless required by the situation (e.g. due to vehicles or obstacles obstructing the path of the vehicle).

Once in standstill the vehicle [may / shall] remain in this condition and shall activate the hazard warning lights if the driver has not taken over latest [4] s after the standstill.

2.7.4. A transition demand shall only be terminated once the system has detected the driver has taken over manual control or a minimum risk manoeuvre has started.

2.7.4.1. In case the driver is not responding to a transition demand by taking over manual control, a minimum risk manoeuvre shall be started automatically, earliest [10 s] after the start of the transition demand.

2.7.5. The transition demand shall consist at least of an optical and in addition an acoustic and/or haptic warning signal. Latest [4] seconds after the initiation of

the transition demand, the warning shall be escalated ~~and shall contain a haptic warning~~[t18].

2.7.6. The system shall be deactivated at the end of any transition phase, unless a minimum risk manoeuvre needs to be performed.

2.8. Information to the driver

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

- the system status “active” by at least an optical signal~~, [containing an unique indication [with a green steering wheel with an additional “A”].]~~[t19]
- any failure of the system with at least an optical signal unless the system is manually deactivated (off mode),
- transition demand as specified in paragraph 2.7.
- minimum risk manoeuvre by an optical signal and either an acoustic or a haptic signal and
- emergency manoeuvre by an optical signal and either an acoustic or a haptic signal.

2.8.2. During the transition phase and the minimum risk manoeuver, the system shall instruct the driver in an intuitive and unambiguous way to take over manual control of the vehicle. ~~The instruction shall include a pictorial information showing hands and the steering control and may be accompanied by additional explanatory text or warning symbols, as shown in the example below.~~[t20]

Example 1.

Example 2.

~~[2.8.2.1. To visually emphasize and escalate the optical warning symbol a yellow steering control with moving hands shall be used during the transition phase.]~~[t21]

[2.8.2.2. With the start of the minimum risk manoeuvre, the given signal shall change its characteristics ~~to a red flashing steering control with moving hands~~ [t22]to emphasize the urgency of an action through the driver.]

2.9. Minimum Risk Manoeuvre (as risk mitigation strategy)

2.9.1. 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 a deceleration not greater than [4] m/s². Higher deceleration values are

permissible for very short durations, e.g. as haptic warning to stimulate the driver's attention, or in case of a severe system failure. Additionally, the hazard warning lights shall be activated not later than [4] seconds after the start of the minimum risk manoeuvre.

2.9.2. In case the driver does not take over manual control during a minimum risk manoeuvre, the system shall bring the vehicle to standstill~~2.9.3. The vehicle shall perform lane changes [across regular driving lanes] to the hard shoulder only if the situation is not critical. Such lane changes are deemed critical if an approaching vehicle in the target lane would have to decelerate at a higher level than 3m/s², 0.4 seconds after the ALKS vehicle has crossed the lane marking, to ensure the distance between the two vehicles is never less than that which the ALKS vehicle travels in 1 second.~~

~~In case of a low speed system [traffic jam pilot] which cannot assess the criticality of a lane change, the vehicle shall be brought to standstill~~ in its lane of travel.

~~2.9.3.2. In case of a high speed system [highway pilot] which cannot assess the criticality of a lane change, the system shall only be activated in the slowest lane and the vehicle shall be brought to standstill in its lane of travel.~~[t23]

2.9.4. A minimum risk manoeuvre shall only be terminated once the system has detected the driver has taken over manual control of the vehicle or the system has brought the vehicle to a standstill.

2.9.5. The system shall be deactivated at the end of any minimum risk manoeuvre.

The hazard warning lights shall remain activated [unless deactivated manually] and the vehicle shall not move away after standstill without manual input.

2.9.6. Reactivation of the system after the end of any minimum risk manoeuver shall only be possible after a new engine run cycle.

2.10. Emergency Manoeuvre (as collision ~~avoidance~~ mitigation[t24] **strategy)**

2.10.1. Only if the activated system has detected that the vehicle is in ~~unplanned,~~[t25] imminent danger to collide with e.g. another road user ahead or beside the vehicle and in case of insufficient lead time to transition the control back to the driver, an emergency manoeuvre shall be initiated automatically.

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

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]

~~*Remark: ACSF-20-06r1: Homework: define "detect" (sensors) and add test procedure as annex*~~

2.10.3. An emergency manoeuvre shall be terminated as soon as the collision risk disappeared [or the driver took over manual control of the vehicle].

~~2.10.3.1. In case an emergency manoeuvre has not led to a complete standstill of the vehicle, t~~The system shall remain activated and initiate a transition demand.

~~2.10.3.2. In case an emergency manoeuvre has led to a complete standstill of the vehicle, the system shall be deactivated automatically.~~[t26]

When coming to standstill the hazard warning lights shall be activated and the vehicle shall not move away without manual input.

2.11. System information data

~~2.11.1.~~[t27] The following data shall be provided, together with the documentation package required in Annex [X] of this UN Regulation, to the Technical Service at the time of type approval.

2.11.2. A list of situations in which the vehicle may generate a transition demand to the driver.

2.11.3. Information about how the system detects that the driver is available to take over the control.

2.11.4. The means to monitor the driving environment.

2.11.5. The means to activate, override and to suppress or cancel the system (as relevant).

2.11.6. Information about how the failure warning signal status and the confirmation of the valid software version related system performance can be checked via the use of an electronic communication interface.*

* This paragraph shall be reviewed once the Task Force on Cyber Security and Over the Air issues (TF CS/OTA) reporting to the World Forum for the Harmonization of Vehicle Regulations (WP.29) Informal Working Group on Intelligent Transport Systems / Automated Driving has finalized its work on measures for software identification and, if necessary, amended accordingly.

~~2.11.8. Information on the sensor range over lifetime. The sensor range shall be specified in such way that any influence on deterioration of the sensor shall not affect the fulfilment of paragraphs 2.5.6. and 2.5.10. of this Annex.~~[t28]

2.11.9. **The safe operation of the system f**~~F~~or driving situations not covered by the tests of Annex [4]~~, the safe operation of the system shall be demonstrated by the vehicle manufacturer on the base of Annex X of this Regulation.~~[t29]

~~2.11.10 Installation~~[t30]

~~The manufacturer shall provide information regarding the installation options that will be employed for the individual components that comprise the visualisation system. These options shall include, but are not limited to, the location of the component in/on the vehicle, the material(s) surrounding the component, the dimensioning and geometry of the material surrounding the component, and the surface finish of the materials surrounding the component, once installed in the vehicle. The information shall also include installation specifications that are critical to the system's performance, e.g. tolerances on installation angle.~~

~~Changes to the individual components of the visualisation system, or the installation options, shall be notified to the Type Approval Authority and be subject to further assessment.~~

* * * TESTS * * *

The width of a traffic lane shall be considered to be [3.65]m.

Lane Keeping Functionality Test:

- approach curve with narrow (minimum) radius with the maximum operational speed
- swerving test: stable lateral position in straight lane
- driver availability test: detecting that the driver is not available to take-over the control

Following Distance Test:

- approach a slower lead vehicle which is on constant speed
- follow a leading vehicle which starts slightly decelerating

~~**Blocked Lane Test:**~~

- ~~**approach a stationary target in the lane of travel with the maximum operational speed**~~[t31]

Deceleration Tests

- Lead vehicle performs an emergency braking
- Cutting in vehicle
- Deceleration during minimal risk manoeuvre is below [4m/s²]
- Maximum deceleration during emergency manoeuvre (inclusive full braking performance manually by the driver as a reference)

Maximum Operational Speed Test

- Sensor performance test
- Maximum speed test (with ~~**and without**~~ leading vehicle)

DETAILS TO BE DEFINED ONCE THE REQUIREMENTS ARE AGREED