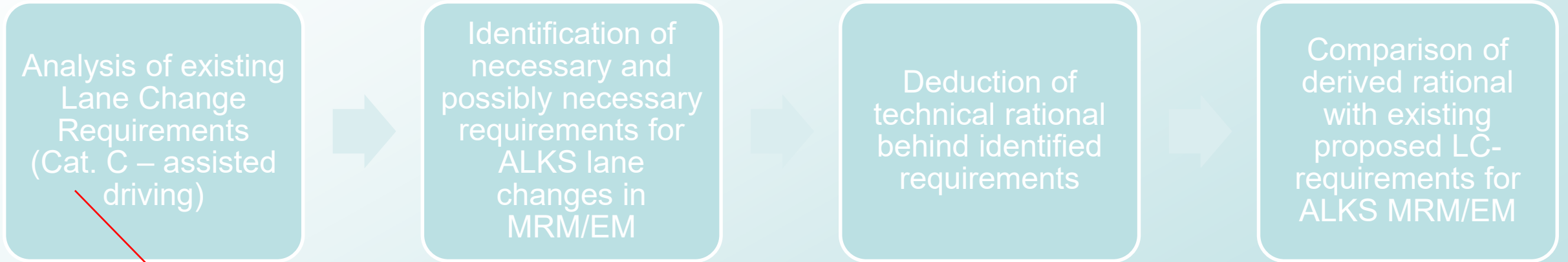


Analysis of necessary and proposed requirements for lane changes in ALKS Minimal Risk or Emergency Maneuvers



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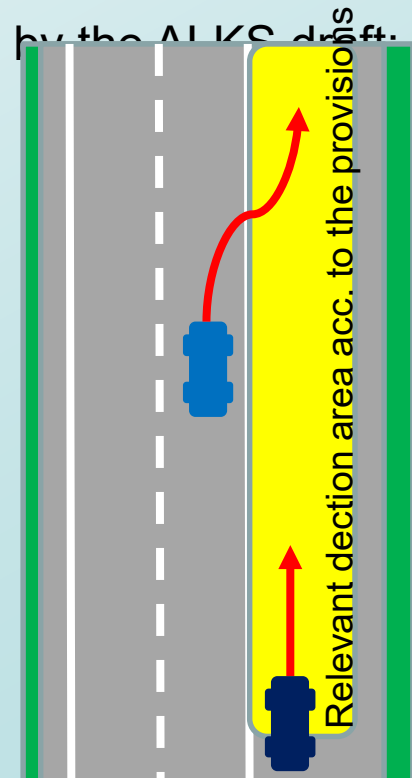
Microsoft Excel
Worksheet



Is there anything missing from the proposed ALKS MRM Lane Change provisions compared to ACSF Cat. C?

- When comparing lane change provisions of ACSF Cat. C and those drafted for ALKS during an MRM or when crossing lane markings during an EM, all applicable, safety relevant provisions are addressed.
- Example of safety relevant provisions that are (directly or indirectly) reflected by the ALKS draft provisions:
 - Suppression criteria
 - Definition of a Critical situation
 - Sensor Range
 - Indication to other road users
- **Example of sensor range and critical situation, according to ALKS draft:**

Such lane changes are deemed critical either if there is a **risk of a collision with another road user in the target lane**, or if an **approaching vehicle in the target lane would have to decelerate at a higher level than $3m/s^2$** , 0.4 s 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 s.”





Rational for requirements identified as necessary with regards to ALKS MRM/EM.

The lane change procedure shall be suppressed automatically by the system when at least one of the following situations occurs before the lane change manoeuvre has started:

- (a) The system detects a critical situation (as defined in paragraph 5.6.4.7.);
- (b) The system is overridden or switched off by the driver;
- (f) The lane change manoeuvre has not commenced within 5.0 seconds following the deliberate action of the driver described in paragraph 5.6.4.6.2.;
- (g) The lateral movement described in paragraph 5.6.4.6.4. is not continuous.
- (c) The system reaches its boundaries (e.g. lane markings are no longer detected);
- (d) The system has detected that the driver is not holding the steering control at the start of the lane change manoeuvre;
- (e) The direction indicator lamps are manually deactivated by the driver;

No LC in critical situations, beyond system boundaries or when overridden

A situation is deemed to be critical when, at the time a lane change manoeuvre starts, an approaching vehicle in the target lane would have to decelerate at a higher level than 3m/s^2 , 0.4 seconds after the lane change manoeuvre has started, to ensure the distance between the two vehicles is never less than that which the lane change vehicle travels in 1 second.

The resulting critical distance at the start of the lane change manoeuvre shall be calculated using the following formula:

$$S_{\text{critical}} = (v_{\text{rear}} - v_{\text{ACSF}}) * t_B + (v_{\text{rear}} - v_{\text{ACSF}})^2 / (2 * a) + v_{\text{ACSF}} * t_G$$

Definition of possible gaps needed

The ACSF of Category C shall be able to detect vehicles approaching from the rear in an adjacent lane up to a distance S_{rear} as specified below:

The minimum distance S_{rear} shall be declared by the vehicle manufacturer. The declared value shall not be less than 55 m.

The declared distance shall be tested according to the relevant test in Annex 8 using a two-wheeled motor vehicle of Category L31 as the approaching vehicle.

The minimum operation speed V_{min} , down to which the ACSF of Category C is permitted to perform a lane change manoeuvre, shall be calculated with minimum distance S_{rear} using the following formula: $V_{\text{min}} = \sqrt{a * (t_B - t_G) + v_{\text{app}} - \sqrt{a^2 * (t_B - t_G)^2 - 2a(v_{\text{app}} * t_G - s_{\text{rear}})}}$

rear sensorrange must be apt to allow LC

If the vehicle is operated in a country with a general maximum speed limit below 130 km/h, this speed limit may be used as an alternative for V_{app} in the above formula to calculate the minimum operation speed V_{min} . In this case the vehicle shall be equipped with a means to detect the country of the operation and shall have information available on the general maximum speed limit of this country.

Notwithstanding the requirements above in this paragraph, the ACSF of Category C is permitted to perform a lane change manoeuvre at speeds lower than the calculated V_{min} provided that the following conditions are met:

- (a) The system has detected another vehicle in the adjacent lane into which the lane change is planned at a distance lower than S_{rear} ; and
- (b) The situation is not deemed to be critical according to paragraph 5.6.4.7. (e.g. at low speed differences and $V_{\text{app}} < 130 \text{ km/h}$);
- (c) The declared value S_{rear} is greater than the calculated value S_{critical} from paragraph 5.6.4.7. above.

Shorter gaps possible in dense traffic or when fast overtakes not rational

The vehicle system detection area on ground level shall be at minimum as shown in the figure below.

rear sensorrange must be apt to allow LC

① Rational for requirements identified as possibly necessary with regards to ALKS MRM/EM.

The lateral acceleration induced by the system during the lane change manoeuvre:

- (a) Shall not exceed 1 m/s^2 in addition to the lateral acceleration generated by the lane curvature, and
 - (b) Shall not cause the total vehicle lateral acceleration to exceed the maximum values indicated in tables of paragraph 5.6.2.1.3. above.
- The moving average over half a second of the lateral jerk generated by the system shall not exceed 5 m/s^3 .

No harsh maneuvers – could be needed due to criticality of situation, e.g. EM

When the lane change procedure is ongoing an optical signal shall be provided to the driver.

Signalling of LC to driver in MRM, not in EM due to possible false reaction

The lateral movement of the vehicle towards the intended lane shall not start earlier than 1 second after the start of the lane change procedure. Additionally, the lateral movement to approach the lane marking and the lateral movement necessary to complete the lane change manoeuvre, shall be completed as one continuous movement.

The lane change manoeuvre shall not be initiated before a period of 3.0 seconds and not later than 5.0 seconds after the deliberate action of the driver described in paragraph 5.6.4.6.2. above.

Indication to other road users should start well ahead movement – not feasible for EM

The lane change manoeuvre shall be completed in less than:

- (a) 5 seconds for M1, N1 vehicle categories;
- (b) 10 seconds for M2, M3, N2, N3 vehicle categories.

When movement has started, LC should be completed timely

The direction indicator shall remain active throughout the whole period of the lane change manoeuvre and shall be deactivated by the system no later than 0.5 seconds after the resumption of ACSF of Category B1 lane keeping function as described in paragraph 5.6.4.6.6. above.

Indication to other road users of maneuver – coupling with hazard warning lamps could make sense



Comparison of derived rational with proposed requirements.

Requirement	Provisions MRM	Provisions EM
No harsh maneuvers – could be needed due to criticality of situation, e.g. EM	The system's safety strategies shall be demonstrated and proved by the manufacturer to the satisfaction of the Technical Service.]	
Signalling of LC to driver in MRM, not in EM due to possible false reaction		
Indication to other road users should start well ahead movement – not feasible for EM	Any lane change shall be indicated to other road users according to traffic law and the signal to activate the hazard warning lights may be suppressed during the lane change manoeuvre.	
When movement has started, LC should be completed timely	The system's safety strategies shall be demonstrated and proved by the manufacturer to the satisfaction of the Technical Service.]	
Indication to other road users of maneuver – coupling with hazard warning lamps could make sense	Any lane change shall be indicated to other road users according to traffic law and the signal to activate the hazard warning lights may be suppressed during the lane change manoeuvre.	
No LC in critical situations, beyond system boundaries or when overridden	In case the ALKS is capable of performing lane change manoeuvres during the MRM, including to the hard shoulder, this shall only be permitted if the situation is not critical.	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) [unless the system is capable of confirming and has confirmed that no critical situation would result from this manoeuvre].
Definition of possible gaps needed	Such lane changes are deemed critical either if there is a risk of a collision with another road user in the target lane, or if an approaching vehicle in the target lane would have to decelerate at a higher level than 3m/s^2 , 0.4 s 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 s.	The situation is deemed critical either if there is a risk of a collision with another road user in the evasive path, or if a vehicle approaching from the rear in the evasive lane [with the allowed or advised maximum speed] would be forced to decelerate at a higher level than $[3] \text{m/s}^2$, 0.4 s 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 s.]
rear sensor range must be apt to allow LC	The system's safety strategies shall be demonstrated and proved by the manufacturer to the satisfaction of the Technical Service.]	[The system shall demonstrate its capabilities to assess the criticality of an evasive manoeuvre crossing lane markings according to the relevant test in Annex X.]
Shorter gaps possible in dense traffic or when fast overtakes not rational		