

## Situations that a B2/ALKS highway system may encounter

### **Purpose and key messages of this document:**

This document aims at providing a better understanding of a B2/ALKS system's possible operational restrictions and ability to safely transfer control back to the driver. It contains examples of different possible detection and coping strategies which do not necessarily have to be implemented in that fashion. They are merely chosen as examples for illustration and don't mean, that there cannot be other, equally effective strategies.

A lot of the common, frequently occurring driving situations will in general be handled by the B2/ALKS system during regular operation. Some situations though, most of them occurring at a low frequency, might require a transition demand for good reason. A lot of these situations could be known well in advance, so a transition could be handled with plenty of lead time, or system activation not even be offered to the driver if the remaining time of operation was judged too short. Furthermore, even those conditions that may occur unexpectedly will not keep the B2/ALKS system away from safely transferring the control back to the driver.

Since this Regulation aims at defining what a safe transition procedure looks like, Industry does not see the need to limit the situations in which a transition demand is allowed to be given.

## **1. Conditions and situations that will generally\* be handled by the B2/ALKS system during regular operation without the need for transitioning:**

\*while those situations normally don't require a transition demand, a transition demand might still be given in special occasions

### **Environmental conditions**

- Different overcast conditions (sunshine, clouds)
- Wind in general, strong wind gusts might require a transition demand

### **Road Conditions**

- changing lane width above the minimum width
- changing lane markings
- changing lane marking visibility (while markings still exist)
- light lane ruts or potholes

### **Driving scenarios in non-critical regular traffic**

- regular lane keeping while performing speed- and distance control
- cutting-out lead vehicle
- cutting-in vehicle with an uncritical distance to the B2/ALKS system vehicle
- decelerating lead vehicle
- accelerating lead vehicle
- vehicles on an enter-lane
- vehicles on an exit-lane
- changing speed limits

**2. Conditions that might require a transition demand, but will, if a transition demand is needed, often result in a planned transition or transition with low criticality:**

Different sources and types of information could be used for Lane Keeping:

- Sensor based lane marking detection (cameras, lidar sensors, ...)
- Map data
- Road course information (guardrail, infrastructural separation, road edge, other general road furniture)
- Course of other vehicles driving ahead and beside

<b>Cat.</b>	<b>Condition</b>	<b>Reason for a possible need for transition</b>	<b>Examples of different Detection possibilities</b>	<b>Examples of different Safety strategies during transition</b>
<b>Road geometry &amp; infrastructure</b>	Too narrow lane	<ul style="list-style-type: none"> <li>- risk of other vehicles protruding into the B2/ALKS vehicle's lane increases</li> <li>- object-lane assignment at higher distances becomes more challenging</li> <li>- too little room in case an evasive maneuver is required</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Optical lane detection (camera, lidar, ...)</li> </ul>	No imminent danger, therefore no need for special safety strategy in order to ensure lane keeping during transition.
	Missing lane markings on either or both sides of the lane	<ul style="list-style-type: none"> <li>- Missing (redundancy for) lane course estimation</li> </ul>	<ul style="list-style-type: none"> <li>- Optical lane detection</li> <li>- Map data</li> <li>- Car 2 Car / Backend data</li> </ul>	Use remaining information for lane estimation: <ul style="list-style-type: none"> <li>- Map data</li> <li>- Guardrail or road edge</li> <li>- Other vehicles around</li> </ul>
	Missing infrastructural separation	<ul style="list-style-type: none"> <li>- Increased risk of a potential collision with oncoming traffic</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Object detection</li> <li>- Road signs</li> </ul>	No imminent danger, therefore no need for special safety strategy in order to ensure lane keeping during transition.
	Opening and closing neighboring lanes	<ul style="list-style-type: none"> <li>- Possibly unclear lane course (e.g. merge into a new lane or one lane merging into the other)</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Optical lane detection</li> <li>- Lane ending sign recognition</li> <li>- Other vehicles around</li> </ul>	<ol style="list-style-type: none"> <li>1. Initiate a planned transition early enough.</li> <li>2. Make a general assumption on lane merge behavior.</li> <li>3. Follow behavior of other vehicles.</li> </ol>

	Closing ego lane	<ul style="list-style-type: none"> <li>- Necessary lane change</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Optical lane detection</li> <li>- Lane ending sign recognition</li> </ul>	<ol style="list-style-type: none"> <li>1. Initiate a planned transition early enough.</li> <li>2. Ensure collision avoidance with any relevant obstacles in the ego lane.</li> </ol>
	Tunnels	<ul style="list-style-type: none"> <li>- Sensor performance affected</li> <li>- Missing GPS/Backend connection (if used)</li> <li>- Usually more narrow lanes and missing hard shoulder</li> <li>- Sometimes poor lighting</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Sensor-based tunnel detection</li> <li>- Tunnel signs</li> </ul>	No imminent danger, therefore no need for special safety strategy in order to ensure lane keeping during transition.
	Stationary infrastructure marked with traffic lights (e.g. movable bridges)	<ul style="list-style-type: none"> <li>- Traffic light detection could be challenging</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Traffic light detection.</li> </ul>	<ol style="list-style-type: none"> <li>1. Initiate a planned transition early enough.</li> <li>2. Use the behavior of other vehicles for orientation.</li> </ol>
	End of the motorway	<ul style="list-style-type: none"> <li>- Toll stations</li> <li>- Roundabouts, traffic lights, crossings</li> <li>...</li> </ul>	<ul style="list-style-type: none"> <li>- Map data</li> <li>- Traffic sign recognition</li> <li>- lane / object detection</li> </ul>	<ol style="list-style-type: none"> <li>1. Initiate a planned transition early enough.</li> <li>2. Behavior of other road users to identify road course.</li> <li>3. Emergency Maneuver to react to an imminent collision.</li> </ol>
<b>Environmental</b>	Sun glaring	<ul style="list-style-type: none"> <li>- Sensor performance might be limited</li> </ul>	<ul style="list-style-type: none"> <li>- Sensor status</li> </ul>	<ul style="list-style-type: none"> <li>- Reduce Speed</li> <li>- Use redundant sensors that are not affected by sun glaring and/or map data for lane keeping and object detection.</li> </ul>
	Nighttime, dusk and dawn, low illumination	<ul style="list-style-type: none"> <li>- Sensor performance might be limited</li> </ul>	<ul style="list-style-type: none"> <li>- Light sensor</li> <li>- Sensor status</li> <li>- time of day</li> </ul>	<ul style="list-style-type: none"> <li>- Use redundant sensors that are not affected by low illumination.</li> </ul>
	Rain	<ul style="list-style-type: none"> <li>- Sensor performance limited</li> <li>- Road adhesion affected</li> </ul>	<ul style="list-style-type: none"> <li>- Rain sensor/wipers</li> <li>- Car2Car/Backend data</li> </ul>	<ul style="list-style-type: none"> <li>- Reduce speed,</li> <li>- Use redundant sensors that are not</li> </ul>

		- Aqua Planing in heavy rain	- Weather information - Means to detect road wetness	affected by rain and/or map data for lane keeping and object detection.
	Fog or bad air quality, resulting in poor visibility	- Viewing distance limited	- Sensor detection - Sensor monitoring - Weather Data	- Reduce speed - Use redundant sensors that are not affected by poor visibility and/or map data for lane keeping and object detection.
	Snow/ice	- Low road adhesion	- Outside temperature - Weather information - Car2Car/Backend data - ESP intervention - Optical snow detection	1. Avoid operation below a certain outside temperature. 2. Upon detection: a. adapt speed, b. apply safety strategy for missing lane markings if necessary
<b>Dynamic</b>	Dynamic lane closures	- Lane change necessary	- Traffic sign recognition - Behavior of other road users - Map data	1. Ensure collision avoidance with any relevant obstacles in the ego lane. 2. Adapt to behavior of other road users. 3. Initiate a planned transition on road sections with dynamic traffic signs.
	Hard shoulder temporarily available for regular traffic	- Could require a lane change to obey traffic rules	- Traffic sign recognition - Behavior of other road users - Map data	No imminent danger, therefore no need for special safety strategy in order to ensure lane keeping during transition.

While transitioning the control back to the driver could be one strategy, continuing operation at a reduced maximum speed could also be a strategy to cope with some of the above described conditions.