

Hazard Analysis and Risk Assessment													
S. No	Function	Hazard	Hazard Id	Driving and Operating Situation (Ref.)	Effect of failure	Description of the Hazardous Event	Severity 0-3	Justification - S "Please refer to the item"	Probability 0-4	Justification on - E	Controllability 0-3	Justification - C	Resulting ASIL
Activation	No activation when activation is intended	H1	Scenario 1	Lateral collision	The driver is distracted and the car is moving towards the road lane at a speed < 1 m/s, the driver (> 0.78s to collision, at least one meter on each side of the vehicle) is unaware of the fact that the system is not active, so his level of attention is lower. A crash against the guard rail or other vehicles can occur as a consequence. Ref. [2] for details on the numbers	3	V > 50 kph	4	Highway (happens every drive)	1	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. No counter action from the ALC. Ref. [1] for details on the numbers.	B	
			Scenario 2	Lateral collision		3	V > 50 kph	4	Highway (happens every drive)	1	Driving on a curve, the user has more than 0.76 second (> 0.3s) to regain control of the system. No counter action from the ALC. Ref. [1] for details on the numbers.	B	
			Scenario 3	Lateral collision		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every drive)	2	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. No counter action from the ALC. Ref. [1] for details on the numbers. Lower grip due to wet road reduces the controllability of the vehicle	B	
			Scenario 4	Lateral collision		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every drive)	2	Driving on a curve, the user has more than 0.76 seconds (> 0.3s) to regain control of the system. No counter action from the ALC. Ref. [1] for details on the numbers. The reduced grip due to rain reduces the controllability of the vehicle.	B	
			Scenario 7	Lateral collision		3	V > 50 kph	4	Highway + Traffic (Happens every drive)	2	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (> 0.3s) leading to lower controllability.	C	
	Unwanted activation	H2	Scenario 5	Collision with the Rear-End of the Overtaken car	The driver is overtaking and the system activates (not wanted by the driver). The system will then try to steer back to the center of the lane, steering in the direction of the overtaken car. This will lead to a possible crash against the overtaken car.	3	V > 50 kph	4	Overtaking in Highway (Happens Every drive)	2	Tight overtaking in highway, very reduced distance from the overtaken car, dry conditions. The time to impact is about 0.5 s (> 0.3s). Lower controllability	C	
			Scenario 6			3	V > 50 kph	3	Overtaking in Highway + Rain conditions (Happens Every month at least, not every drive)	3	Tight overtaking in highway, very reduced distance from the overtaken car. The time to impact is about 0.5 s (> 0.3s). Very low controllability due to wet conditions.	C	
			Scenario 12	Collision with pedestrian or bike	The driver is activating the system in urban areas, or outside the highway anyway. This leads to an hazardous situation. The system is not designed to react to these conditions.	3	V < 50 kph, which leads to 35.4% mortality for the pedestrian according to [4] for collisions with pedestrians. Anything above 10% is S3 according to [5]	4	Urban Area (Everyday scenario)	2	Time react is less even at low speed due to close proximity of objects and pedestrians	C	
			Delayed Activation (0.5 secs)	H3	Scenario 12,3,4,7	Same cases as No activation	Same cases as No activation	3	V > 50 kph	4	Highway (happens every drive)	2	Same considerations as for "No activation"

Figure 1: HARA for Activation Function

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Active steering		Excessive steering	H4	Scenario 1	Lateral collision (spinning)	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s (> 1 s to collision) and the car steers excessively back to the center of the lane. This can lead to spinning and eventual collision with the guardrail or other vehicles	3	V > 50 kph	4	Highway (happens every drive)	3	Straight line driving, the user has more than 1 second (>0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Ref. [1] for details on the numbers. Also, if the steering is very fast the car can start spinning, and in that scenario, the controllability is impossible.	D
				Scenario 2	Lateral collision (spinning)		3	V > 50 kph	4	Highway (happens every drive)	3	Driving on a curve, the user has more than 0.76 seconds (>0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Ref. [1] for details on the numbers.	D
				Scenario 3	Lateral collision (spinning)		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every drive)	3	Straight line driving, the user has more than 1 second (>0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Wet conditions make it even more difficult to control. Ref. [1] for details on the numbers.	C
				Scenario 4	Lateral collision (spinning)		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every drive)	3	Straight line driving, the user has more than 0.76 seconds (>0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Wet conditions make it even more difficult to control. Ref. [1] for details on the numbers.	C
				Scenario 11	Lateral collision		3	Lateral collision 30 < V < 50 kph	3	Low Speed Traffic Jam in Highway (Happens at least every month but not every drive)	3	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (>0.3s) leading to lower controllability. The user has also to act against the ALC system to regain control of the system. This leads to lower controllability.	C
				Scenario 7	Lateral collision		3	V > 50 kph	4	Highway + Traffic (Happens every drive)	3	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (>0.3s) leading to lower controllability. The user has also to act against the ALC system to regain control of the system. This leads to lower controllability.	D

Figure 2: HARA for Steering Function - Excessive Steering

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S. No	Function	Hazard	Hazard Id	Driving and Operating Situation (Ref.)	Effect of failure	Description of the Hazardous Event	Severity	Justification - S *Please refer to the item	Probability	Justificati on - E	Controll ability	Justification - C	Resulting ASIL
							0-3		0-4	0-3			
Active steering		Hazard	H5	Scenario 1	Lateral collision	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s (> 1s to collision) and the user is steering the car back to the center of the lane. The ALC steers in the opposite direction, trying to drive the car towards the guardrail. This can lead to lateral collision or spinning and eventual collision with the guardrail or other vehicles	3	V > 50 kph	4	Highway (happens every drive)	2	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Ref. [1] for details on the numbers.	C
				Scenario 2	Lateral collision		3	V > 50 kph	4	Highway (happens every drive)	2	Driving on a curve, the user has more than 0.76 seconds (> 0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Ref. [1] for details on the numbers.	C
				Scenario 3	Lateral collision (spinning)		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every)	3	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Wet conditions make it even more difficult to control, spinning can result and controllability in that case drops. Ref. [1] for details on the numbers.	C
				Scenario 4	Lateral collision (spinning)		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every)	3	Straight line driving, the user has more than 0.76 seconds (> 0.3s) to regain control of the system. The user must work against the ALC system, leading to lower controllability. Wet conditions make it even more difficult to control, spinning can result and controllability in that case drops. Ref. [1] for details on the numbers.	C
				Scenario 1f	Lateral collision		3	Lateral collision 30 < V < 50 kph	3	Low Speed Traffic Jam in Highway (Happens at least every month but not every drive)	3	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (> 0.3s) leading to lower controllability. The user has also to act against the ALC system to regain control of the system. This leads to lower controllability.	C
				Scenario 7	Lateral collision		3	V > 50 kph	4	Highway + Traffic (Happens every drive)	3	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (> 0.3s) leading to lower controllability. The user has also to act against the ALC system to regain control of the system. This leads to lower controllability.	D

Figure 3: HARA for Steering Function - Opposite Steering

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S. No	Function	Hazard	Hazard Id	Driving and Operating Situation (Ref.)	Effect of failure	Description of the Hazardous Event	Severity 0-3	Justification - S "Please refer to the item"	Probability 0-4	Justification - E	Controllability 0-3	Justification - C	Resulting ASIL
	Active steering	Insufficient steering	H6	Scenario 1	Lateral collision	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s and the user is not steering to the center of the lane. The system steers insufficiently, leading to a possible collision with the guard rail or other vehicles. The time to collision is anyway slower than the other cases because of partial control by ALC.	3	V > 50 kph	4	Highway (happens every drive)	1	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. No counter action from the ALC, the user simply needs to apply more torque. Ref. [1] for details on the numbers.	B
				Scenario 2	Lateral collision		3	V > 50 kph	4	Highway (happens every drive)	1	Driving on a curve, the user has more than 0.76 second (> 0.3s) to regain control of the system. No counter action from the ALC, the user simply needs to apply more torque. Ref. [1] for details on the numbers.	B
				Scenario 3	Lateral collision		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every)	2	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. No counter action from the ALC, the user simply needs to apply more torque. Wet conditions reduce the controllability. Ref. [1] for details on the numbers.	B
				Scenario 4	Lateral collision		3	V > 50 kph	3	Highway + Rain (Happens at least once every month, but not every)	2	Driving on a curve, the user has more than 0.76 second (> 0.3s) to regain control of the system. No counter action from the ALC, the user simply needs to apply more torque. Wet conditions reduce the controllability. Ref. [1] for details on the numbers.	B
				Scenario 1f	Lateral collision		3	Lateral collision 30 < V < 50 kph	3	Low Speed Traffic Jam in Highway (Happens at least every month but not every drive)	2	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (> 0.3s) leading to lower controllability. The user doesn't have to act against the steer torque from ALC, simply provide additional torque.	B
				Scenario 7	Lateral collision		3	V > 50 kph	4	Highway + Traffic (Happens every drive)	2	Driving in traffic, on a straight line. Lower controllability due to the reduced time to collision. Due to the closeness of the other vehicles. We consider 0.5 meters of lateral distance between vehicles as a worst case scenario. So the time to collision might be in the order of 0.5s (> 0.3s) leading to lower controllability. The user doesn't have to act against the steer torque from ALC, simply provide additional torque.	C

Figure 4: HARA for Steering Function - Insufficient Steering

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Deactivation	No deactivation when all conditions for deactivation are met	H9	Scenario 12	Collision with object or pedestrian	The driver is activating the system in urban areas, or outside the highway anyways. This leads to an hazardous situation. The system is not designed to react to these conditions.	S3	V < 50 kph	E4	Urban Area (Everyday scenario)	C2	Time react is less even at low speed due to close proximity of objects and pedestrians		B
			Scenario 5	Frontal Collision with the rear end of the overtaken car	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s and now the driver wants to overtake another car, but the system doesn't deactivate, leading to a sudden realization of the driver. The ALC system will try to steer towards the center of the lane. This can lead to lateral collision	S3	V > 50 kph	E4	Highway (happens every drive)	C2	Tight overtaking in highway, very reduced distance from the overtaken car, dry conditions. The time to impact is about 0.5 s (> 0.3s). Lower controllability		C
			Scenario 6	Frontal Collision with the rear end of the overtaken car	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s and now the driver wants to overtake another car, but the system doesn't deactivate, leading to a sudden realization of the driver. The ALC system will try to steer towards the center of the lane. This can lead to lateral collision	S3	V > 50 kph	E3	Highway + Rain (Happens at least once every month, but not every drive)	C3	Tight overtaking in highway, very reduced distance from the overtaken car. The time to impact is about 0.5 s (> 0.3s). Very low controllability due to wet conditions.		C
	Unwanted deactivation	H10	Scenario 2	Lateral Collision	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s and the ALC system is steering the car back to the center of the lane. The ALC suddenly deactivates, leading to a sudden realization of the driver. This can lead to lateral collision or spinning and eventual collision with the guardrail or other vehicles	S3	V > 50 kph	E4	Highway (happens every drive)	C2	Driving on a curve, the user has more than 0.76 second (> 0.3s) to regain control of the system. Lower controllability of the system due to unexpected deactivation. Ref. [1] for details on the numbers.		C
			Scenario 4	Lateral Collision	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s and the ALC system is steering the car back to the center of the lane. The ALC suddenly deactivates, leading to a sudden realization of the driver. This can lead to lateral collision or spinning and eventual collision with the guardrail or other vehicles	S3	V > 50 kph	E3	Highway + Rain (Happens at least once every month, but not every drive)	C3	Driving on a curve, the user has more than 0.76 second (> 0.3s) to regain control of the system. Lower controllability of the system due to unexpected deactivation. Even lower controllability due to hazardous event happening in wet conditions. Ref. [1] for details on the numbers.		C
			Scenarios 1,3,7	Lateral Collision	The driver is driving on the highway moving laterally towards the lane at a speed < 1m/s and the ALC system is steering the car back to the center of the lane. The ALC suddenly deactivates, leading to a sudden realization of the driver. This can lead to lateral collision or spinning and eventual collision with the guardrail or other vehicles	S3	V > 50 kph	E4	Highway (happens every drive)	C1	Straight line driving, the user has more than 1 second (> 0.3s) to regain control of the system. No counter action from the ALC. Ref. [1] for details on the numbers.		B
	Delayed deactivation (> 0.5s)	H11	5	Frontal Collision		S3	V > 50 kph	E4	Highway (happens every drive)	C2	Tight overtaking in highway, very reduced distance from the overtaken car, dry conditions. The time to impact is about 0.5 s (> 0.3s). Lower controllability		C
			6	Frontal Collision		S3	V > 50 kph	E3	Highway + Rain (Happens at least once every month, but not every drive)	C3	Tight overtaking in highway, very reduced distance from the overtaken car. The time to impact is about 0.5 s (> 0.3s). Very low controllability due to wet conditions.		C

Figure 5: HARA for Deactivation Function

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Warning	No Warning for Unintended Lane Crossing	Delayed Warning for Unintended Lane Crossing	H12	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		False Warning for Unintended Lane Crossing	H13	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		No Activation Signal	H14	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		Delayed Activation Signal	H15	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		False Activation Signal	H16	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		No Deactivation Signal	H17	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		Delayed Deactivation Signal	H18	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		False Deactivation Signal	H19	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
		False Lane Detection Signal	H20	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
			H21	All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM
				All	No DIRECT hazard related to the failure of Warnings		S0	V > 50 kph	E4	Occurs in every drive	C0	Every Driver is able to control the vehicle	QM

Figure 6: HARA for Warning Function