# Hazard Analysis and Risk Assessment (Example)

Front Lights Manager

## Participants

| Name, department | Qualification | Experience |
|---|---|---|
| | | |
| | | |
| | | |

## Analyses of situation

### Definition of possible functional failures

| Failure # | Description |
|---|---|
| F1 | Low beam (right) turns off |
| F2 | Low beam (left) turns off |
| F3 | DRL (left) turns off |
| F4 | DRL (right) turns off |
| F5 | Fog light (left) turns off |
| F6 | Fog light (right) turns off |
| F7 | High beam (right) turns off |
| F8 | High beam (left) turns off |

We will call F1+F2 the failure “total loss of low beam functionality” due to F1 and F2 contemporary faults. This is due to F1 and F2 reasonably can share a single point of failure, so are not independent.

### Driving scenarios

*Describe the possible driving situations and define the status of the vehicle you want to consider*

#### Description of the possible driving situations

- DS1 Driving with daylight
- DS2 Driving at sunset or dawn
- DS3 Driving during the night inside a city or illuminated roads
- DS4 Driving in foggy conditions
- DS5 Driving during the night in highway or rural roads without illumination

#### Definition of the vehicle status

- VS1 Driving at high speed
- VS2 Driving at low speed

### Considerations

*Describe driving situations for each status of the vehicle*

| Scenario # | Driving situation | Vehicle status |
|---|---|---|
| S1 | Driving with daylight (DS1) | Driving at high speed (VS1) |

| | | |
|---|---|---|
| S2 | Driving with daylight (DS1) | Driving at low speed (VS2) |
| S3 | Driving at sunset or dawn (DS2) | Driving at high speed (VS1) |
| S4 | Driving at sunset or dawn (DS2) | Driving at low speed (VS2) |
| S5 | Driving during the night inside a city or illuminated roads (DS3) | Driving at high speed (VS1) |
| S6 | Driving during the night inside a city or illuminated roads (DS3) | Driving at low speed (VS2) |
| S7 | Driving inside fog (DS4) | Driving at high speed (VS1) |
| S8 | Driving inside fog (DS4) | Driving at low speed (VS2) |
| S9 | Driving during the night in highway or rural roads without illumination (DS5) | Driving at high speed (VS1) |
| S10 | Driving during the night in highway or rural roads without illumination (DS5) | Driving at low speed (VS2) |

ONLY FOR EXAMPLE PURPOSES

# Analysis

## Estimation matrix

| | | Scenarios | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ~~S1~~ | ~~S2~~ | ~~S3~~ | ~~S4~~ | ~~S5~~ | ~~S6~~ | ~~S7~~ | ~~S8~~ | S9 | S10 | **Top event (worst case)** | **ASIL** |
| **Failures** | F1 | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | S:3 E:3 C:1 | S:3 E:3 C:1 | S:3 E:3 C:1 | QM |
| | F2 | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | S:3 E:3 C:1 | S:3 E:3 C:1 | S:3 E:3 C:1 | QM |
| | F1+F2 | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | S: E:3 C2: | S: E:3 C2: | S:3 E:3 C:2 | B |
| | ~~F3~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F4~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F5~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F6~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F7~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F8~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F9~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |
| | ~~F10~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E:3 C:~~ | ~~S: E:3 C:~~ | ~~S: E:4 C:~~ | ~~S: E:4 C:~~ | ~~S: E: C:~~ | ~~?~~ |

## Scenarios – Comment of entries

***Start with the description of what happens and then assign the parameters.***

### **(S9)** Driving during the night in highway or rural roads without illumination (DS5) at high speed (VS1) – **(F1)** High beam (right) turns off

| | | |
|---|---|---|
| *Effect* | The driver loses illumination power on the right side of the road | |
| *Statement S* | Life-threatening injuries (survival uncertain), fatal injuries due to<br>• Side impact with a narrow stationary object with medium speed<br>• Rear/front collision with another passenger car with medium speed<br>Front collision with passenger compartment deformation | *S3* |
| *Statement E* | 1 to 10 % of average operating time[1] | *E3* |
| *Statement C* | More than 99% of the average drivers or other participants are able to avoid harms | *C1* |

### **(S10)** Driving during the night in highway or rural roads without illumination (DS5) at low speed (VS2) – **(F1)** High beam (right) turns off

| | | |
|---|---|---|
| *Effect* | The driver loses illumination power on the right side of the road | |
| *Statement S* | Severe and life-threatening injuries (survival probable) due to<br>• Side impact with a narrow stationary object with low speed<br>• Rear/front collision with another passenger car with low speed | *S2* |

[1] In this case the criteria to be adopted is the "duration" over the total operating time. See this table extract from German: "Fahrsituationskatalog" VDA_702_062015.pdf

| Catalogs of driving situations | | | | | | |
|---|---|---|---|---|---|---|
| ID | Main structure | Sub group | Assessed situation | E - Duration | E - Frequency | Additional info |
| FU010 | Environment influences driving | Visibility conditions | Driving in poor visibility conditions (fog / glare ...) with visibility less than 50m | E2 | E2 | - |
| FU020 | Environment influences driving | Visibility conditions | Driving in the dark without low light (no street lights, no moon, no light by other traffic participants).<br>Roadside is difficult to see | E3 | … | Duration:<br>Very conservative for densely populated areas (EU) |
| FU030 | Environment influences driving | Visibility conditions | Driving in the dark with residual light (e.g., street lighting, light from other traffic participants, twilight).<br>Roadside is seeable | E4 | E4 | Normal driving situation for the rush hour in the dark season |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| | | |
|---|---|---|
| | • Front collision without passenger compartment deformation | |
| *Statement E* | 1 to 10 % of average operating time | *E3* |
| *Statement C* | More than 99% of the average drivers or other participants are able to avoid harms | *C1* |

**(S9)** Driving during the night in highway or rural roads without illumination (DS5) at high speed (VS1) – **(F2)** High beam (left) turns off

| | | |
|---|---|---|
| *Effect* | The driver loses illumination power on the left side of the road | |
| *Statement S* | Life-threatening injuries (survival uncertain), fatal injuries due to<br>• Side impact with a narrow stationary object with medium speed<br>• Rear/front collision with another passenger car with medium speed<br>Front collision with passenger compartment deformation | *S3* |
| *Statement E* | 1 to 10 % of average operating time | *E3* |
| *Statement C* | More than 99% of the average drivers or other participants are able to avoid harms | *C1* |

**(S10)** Driving during the night in highway or rural roads without illumination (DS5) at low speed (VS2) – **(F2)** High beam (left) turns off

| | | |
|---|---|---|
| *Effect* | The driver loses illumination power on the left side of the road | |
| *Statement S* | Severe and life-threatening injuries (survival probable) due to<br>• Side impact with a narrow stationary object with low speed<br>• Rear/front collision with another passenger car with low speed<br>• Front collision without passenger compartment deformation | *S2* |
| *Statement E* | 1 to 10 % of average operating time | *E3* |
| *Statement C* | More than 99% of the average drivers or other participants are able to avoid harms | *C1* |

**(S9)** Driving during the night in highway or rural roads without illumination (DS5) at high speed (VS1) – **(F1+F2)** Total loss of low beam functionality

| | | |
|---|---|---|
| *Effect* | The driver loses illumination of the road during driving | |
| *Statement S* | Life-threatening injuries (survival uncertain), fatal injuries due to<br>• Side impact with a narrow stationary object with medium speed<br>• Rear/front collision with another passenger car with medium speed<br>• Front collision with passenger compartment deformation | *S3* |

| | | |
|---|---|---|
| *Statement E* | 1 to 10 % of average operating time | *E3* |
| *Statement C* | Between 90% and 99% of the average driver or other traffic participants are able to avoid harms | *C2* |

**(S10)** Driving during the night in highway or rural roads without illumination (DS5) at low speed (VS2) – **(F1+F2)** Total loss of low beam functionality

| | | |
|---|---|---|
| *Effect* | The driver loses illumination of the road during driving | |
| *Statement S* | Severe and life-threatening injuries (survival probable) due to<br>• Side impact with a narrow stationary object with low speed<br>• Rear/front collision with another passenger car with low speed<br>Front collision without passenger compartment deformation | *S2* |
| *Statement E* | 1 to 10 % of average operating time | *E3* |
| *Statement C* | Between 90% and 99% of the average driver or other traffic participants are able to avoid harms | *C2* |

*All the exposure in the analyzed scenarios has been determined in terms of frequency for the considered situation (driving*

## Hazards

| | |
|---|---|
| H1 | Total loss of low beam functionality |
| H2 | |

### H1

This hazard potentially could cause the driver to lose control of the vehicle, leave the road and collide with environmental parts.

**Exceptions and Boundary Conditions to H1:**

- The loss of low beam is only to be seen as risk in case of bad viewing conditions (night, fog, etc.).
- The loss of both low beam lights on a curvy, unlighted rural road is evaluated as a most critical situation.
- The loss of only one low beam is not considered to be directly leading to a hazardous situations however, it is a latent fault and will be included in the concept advisement.

The ASIL B rating is based on the severity rate exposure rate and the controllability identified during hazard analysis and risk assessment.

## Safety goals

| | |
|---|---|
| SG1 | H1 → Prevent total loss of low beam |
| SG2 | |

### Results

| **Failure/malfunction** | **Safety goal** | **ASIL-level** | **Safe state** | **Fault tolerance time** |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| F1 + F2 | SG1 | B | Low beam activated | 500 ms$^2$ |

## Relevant failure modes for H1

MF1: Failure of the detection of the detection of the turn-on/turn-off conditions of lamps.
MF2: Failure of the evaluation and implementation of the light request function which is used to turn lights on.
MF3: Failure of the activated lamps.

[2] Loss of low beam during night drive with activated lights shall be considered.