**INSTRUCTIONS:**
**Fill out the hazard analysis and risk assessment below.**
**HA-001 should be for the lane departure warning function as discus**
**HA-002 should be for the lane keeping assistance function as discu**
**Then come up with your own situations and hazards for the lane as**
**When finished, export your spreadsheet as a pdf file so that a revie**

| Hazard ID | Situational Analysis | | |
|---|---|---|---|
| | Operational Mode | Operational Scenario | Environmental Details |
| HA-001 | OM03 - Normal driving | OS04 - Highway | EN06 - Rain (slippery road) |
| HA-002 | OM03 - Normal driving | OS03 - Country Road | EN01 - Normal conditions |
| HA-003 | OM03 - Normal driving | OS02 - City Road | EN01 - Normal conditions |
| HA-004 | OM03 - Normal driving | OS01 - Any road | EN06 - Rain (slippery road) |

**ssed in the lecture.**
**ssed in the lecture.**
**sistance system. Fill in the HA-003 and HA-004 rows.**
**wer can easily see your work.**

| Situation Details | Other Details (optional) | Item Usage (function) |
|---|---|---|
| SD02 - High speed | | IU01 - Correctly used |
| SD02 - High speed | | IU02 - Incorrectly used |
| SD01 - Low speed | | IU01 - Correctly used |
| SD01 - Low speed | | IL02 - Incorrectly used |

| | Hazard Identification |
|---|---|
| **Situation Description** | **Function** |
| Normal driving on a highway during rain (slippery road) with high speed and correctly used system. | Lane Departure Warning (LDW) function shall apply an oscillating torque with very high torque (above limit) |
| Normal driving on a county road during normal conditions with high speed and an incorrectly used system. | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane |
| Normal driving on a city road during normal conditions with low speed and correctly used system. | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane |
| Normal driving on any Road during rain (slippery road) with low speed and incorrectly used system. | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver with haptic feedback |

| Deviation(action result) | Deviation Details | Hazardous Event (resulting effect) |
|---|---|---|
| DV04 - Actor effect is too much | The LDW function applies an oscillating torque with very high torque(above limit). | EV00 - Collision with other vehicle |
| DV03 - Function always activated | The LKA does not have a time limit for applying torque and might therefor be treated as a fully autonomous vehicle. | EV00 - Collision with other vehicle |
| DV02 - Function unexpectedly activated | System fails detecting the ego lane and applies steering torque incorrectly. | EV00 - Collision with other vehicle |
| DV02 - Function unexpectedly activated | Oscillating steering torque applied even when not required | EV00 - Collision with other vehicle |

| Event Details | Hazardous Event Description |
| --- | --- |
| High haptic feedback can affect driver's ability to steer as intended. The driver could lose control of the vehicle and collide with another vehicle or with road infrastructure. | The LDW function applies too high an oscillating torque to the steering wheel (above limit) |
| Usages outside of the intended capabilities of the LKA could lead to vehicle collision as situations it can not handle might occur. | The LKA does not have time limitation. |
| When applying incorrectly the steering torque could lead to go off road or hit another vehicle. | The LKA is incorrectly active. |
| Lateral collision with vehicle on either left or right side. | Driver loses control of vehicle |

| Hazardous Event Classification | | | |
|---|---|---|---|
| **Exposure (of situation)** | **Rationale (for exposure)(reason)** | **Severity (of potential harm)** | **Rationale (for severity)** |
| E3 - Medium probability | Driving on wet roads occur quite frequently but not daily | S3 - Life-threatening or fatal injuries | High speeds |
| E2 - Low probability | Misuse of this function is deemed to be uncommon | S3 - Life-threatening or fatal injuries | High speeds |
| E4 - High probability | Very likely to be driving on a city road | S1 - Light and moderate injuries | Driving at low speed in a city can produce just light or moderate harm. |
| E2 - Low probability | Misuse of this function is deemed to be uncommon | S2 - Severe and life-threatening injuries | During rain, people generally don't drive so fast, so less severe impact |

| | | Determination o |
|---|---|---|
| **Controllability (of hazardous event)** | **Rationale (for controllability)** | **ASIL Determination** |
| C3 - Difficult to control or uncontrollable | This hazard is difficult to control and results in loss of steering | C |
| C3 - Difficult to control or uncontrollable | This situation becomes difficult as driver doesn't have hand on steering | B |
| C1 - Simply controlable | Easy for the driver to oppose to the steering torque that the system produce | QM |
| C3 - Difficult to control or uncontrollable | Similar to HA-001 but as the vehicle can run on any road, and traffic condition may vary, and driver may or may not be able to control the vehicle | C |

**f ASIL and Safety Goals**

| Safety Goal |
| --- |
| The oscillation torque by the LDW function should be limited |
| The LKA shall be time limited and additional steering torque shall end after a given time interval so that the |
| If there is any problem with the subsystem responsible for lane tracking, LKA should be deactivated |
| LDW shouldn't be activated when raining and driver should control the steering and oscillating steering torque from the LDW shall be limited. |

EXAMPLE DISCUSSED IN THE PROJECT INSTRUCTIONS

| Hazard ID | |
|---|---|
| | **Operational Mode** |
| HA-001 | Normal Driving |

MORE EXAMPLES - Headlamp System

| Hazard ID | |
|---|---|
| | **Operational Mode** |
| HA-001 | OM03 - Normal Driving |
| HA-002 | OM03 - Normal Driving |
| HA-003 | OM03 - Normal Driving |
| HA-004 | OM03 - Normal Driving |
| HA-005 | OM03 - Normal Driving |

- Headlamp System

**Si**

| Operational Scenario | Environmental Details |
|---|---|
| City Road | Normal Conditions |

**S**

| Operational Scenario | Environmental Details |
|---|---|
| OS01 - City Road | EN01 - Normal conditions |
| OS01 - City Road | EN04 - Snowfall (degraded view) |
| OS03 - Highway | EN04 - Snowfall (degraded view) |
| OS02 - Country Road | EN01 - Normal conditions |
| OS02 - Country Road | EN04 - Snowfall (degraded view) |

**tuational Analysis**

| Situation Details (optional) | Other Details (optional) | Item Usage (function) |
|---|---|---|
| Low Speed | Night time + Obstacle on the road | Correctly Used |

**ituation Analysis**

| Situation Details (optional) | Other Details (optional) | Item Usage (function) |
|---|---|---|
| SD03 - Low speed | Night time + Obstacle on the road | IU01 - Correctly used |
| SD03 - Low speed | the road and no other | IU01 - Correctly used |
| SD03 - High speed | the road or upcoming | IU01 - Correctly used |
| SD02 - High speed | Night time + Oncoming vehicle | IU01 - Correctly used |
| SD04 - High speed | the road and no other | IU01 - Correctly used |

| Situation Description | Function | Deviation |
|---|---|---|
| Conditions at Low Speed at Night with an | Low beam illuminates the roadway in the dark | Function not activated |

| Situation Description | Function | Deviation |
|---|---|---|
| conditions with Low speed (Night time + | Low beam illuminates the roadway in the dark | DV01 - Function not activated |
| (degraded view) with Low speed (Night time + Obstacle on the road and no other illumination | Low beam illuminates the roadway in the dark | DV01 - Function not activated |
| (degraded view) with High speed (Night time + | Low beam illuminates the roadway in the dark | DV01 - Function not activated |
| Normal conditions with High speed (Night time | Low beam illuminates the roadway in the dark | DV01 - Function not activated |
| Snowfall (degraded view) with High speed (Night time + Obstacle on the road and no | Low beam illuminates the roadway in the dark | DV01 - Function not activated |

| Hazard Identification | |
|---|---|
| **Deviation Details** | **Hazardous Event (resulting effect)** |
| Both headlights stop working | Front collision with obstacle |

| Hazard Identification | |
|---|---|
| **Deviation Details** | **Hazardous Event (resulting effect)** |
| Both headlights stop working | EV04 - Front collision with obstacle |
| Both headlights stop working | EV04 - Front collision with obstacle |
| Both headlights stop working | EV04 - Front collision with obstacle |
| Both headlights stop working | EV08 - Collision with other vehicle |
| Both headlights stop working | EV04 - Front collision with obstacle |

| Event Details | Hazardous Event Description | Exposure (of situation) |
|---|---|---|
| the obstacle with injury | Total loss of low beam | E4 - High probability |

| Event Details | Hazardous Event Description | Exposure (of situation) |
|---|---|---|
| the obstacle with injury | Total loss of low beam | E4 - High probability |
| the obstacle with injury | Total loss of low beam | E1 - Very low probability |
| infrastructure with | Total loss of low beam | E2 - Low probability |
| the oncoming vechile | Total loss of low beam | E4 - High probability |
| infrastructure with | Total loss of low beam | E2 - Low probability |

| Hazardous | |
|---|---|
| **Rationale (for exposure)** | **Severity (of potential harm)** |
| night driving in the city is a regular activity | S1 - Light and moderate injuries |

| Hazardous | |
|---|---|
| **Rationale (for exposure)** | **Severity (of potential harm)** |
| night driving in the city is a regular activity | S1 - Light and moderate injuries |
| completely unilluminated roads | S1 - Light and moderate injuries |
| driving, however, heavy snow | S3 - Life-threatening or fatal injuries |
| country driving is part of regular driving | S3 - Life-threatening or fatal injuries |
| driving, however, heavy snow | S3 - Life-threatening or fatal injuries |

| Event Classification | |
|---|---|
| **Rationale (for severity)** | **Controllability (of hazardous event)** |
| In city traffiic, speed of vehicle is expected to be low | C0 - Controllable in general |

| Event Classification | |
|---|---|
| **Rationale (for severity)** | **Controllability (of hazardous event)** |
| In city traffiic, speed of vehicle is expected to be low | C0 - Controllable in general |
| In city traffiic, speed of vehicle is expected to be low | C1 - Simply controllable |
| On highway speed of vehicle is expected to be high | C2 - Normally controllable |
| On country roads speed of vehicle is expected to be high | C1 - Simply controllable |
| On country roads speed of vehicle is expected to be high | C3 - Difficult to control or uncontrollable |

| | Determination of ASIL and Safety Goals | |
|---|---|---|
| **Rationale (for controllability)** | **ASIL Determination** | **Safety Goal** |
| control the situation by applying brakes and there is additional illmunitation on | QM | Total Loss of Beam Shall Be Prevented |

| | Determination of ASIL and Safety Goals | |
|---|---|---|
| **Rationale (for controllability)** | **ASIL Determination** | **Safety Goal** |
| control the situation by applying brakes and there is additional illmunitation on | QM | Total loss of low beam shall be prevented |
| drivers usually drive at lower end of city speeds and hence are expected to be | QM | Total loss of low beam shall be prevented |
| illumination on road and hence >90% drivers are able to brake and control the | A | Total loss of low beam shall be prevented |
| road, it will be difficult for the average | B | Total loss of low beam shall be prevented |
| road, it will be difficult for the average | B | Total loss of low beam shall be prevented |

# Hazard & Risk Analysis Defi

**Operational Mode**

| ID | Mode |
|---|---|
| OM01 | Parked |
| OM02 | Ignition on |
| OM03 | Normal driving |
| OM04 | Backward driving |
| OM05 | Degraded driving |
| OM06 | Towing (active) |
| OM07 | Towing (passive) |
| OM08 | Service |
| OM09 | N/A |
| | |

**Operational Scenario**

| ID | Scenario |
|---|---|
| OS01 | Any Road |
| OS02 | City Road |
| OS03 | Country Road |
| OS04 | Highway |
| OS05 | Mountain Pass |
| OS06 | Off Road |
| OS07 | Road with gradient |
| OS08 | Road with bump |
| OS09 | Road tunnel |
| OS10 | Road with construction site |
| OS11 | N/A |
| | |

**Situation Details**

| ID | Scenario |
|---|---|
| SD01 | Low speed |
| SD02 | High speed |
| SD03 | Normal acceleration |
| SD04 | High acceleration |
| SD05 | Normal braking |
| SD06 | High braking |
| SD07 | N/A |
| | |

**Item Usage**

| ID | Mode |
|---|---|
| IU01 | Correctly used |
| IU02 | Incorrectly used |
| IU03 | N/A |
| | |

**Environmental Details**

| ID | Scenario |
|---|---|
| EN01 | Normal conditions |
| EN02 | Sun blares (degraded view) |
| EN03 | Fog (degraded view) |
| EN04 | Snowfall (degraded view) |
| EN05 | Cross-wind (lateral force) |
| EN06 | Rain (slippery road) |

| | |
|---|---|
| EN07 | Snow (slippery road) |
| EN08 | Glace (slippery road) |
| EN09 | N/A |
| | |

# nitions

| Remarks |
| --- |
| Car is parked, ignition is off |
| Car is parked, ignition is on |
| Car is driving |
| Car is driving |
| Limp home mode |
| Towing another car |
| Beeing towed by another car |
| Vehicle is in repair garage |
| not applicable or not relevant |
| |

| Remarks |
| --- |
| road type |
| road type |
| road type |
| road type |
| road type |
| road type |
| road attribute(property) |
| road attribute |
| road attribute |
| road attribute |
| not applicable or not relevant |
| |

(condition about speed control)

| Remarks |
| --- |
| driving attribute |
| driving attribute |
| driving attribute |
| driving attribute |
| driving attribute |
| driving attribute |
| not applicable or not relevant |
| |

(item whether or not work)

| Remarks |
| --- |
| Intended usage |
| Unintended usage (foreseeable) |
| not applicable or not relevant |
| |

(weather and road condition )

| Remarks |
| --- |
| weather attribute |
| weather attribute |
| weather attribute |
| weather attribute |
| weather attribute |
| road attribute |

| |
|---|
| road attribute |
| road attribute |
| not applicable or not relevant |
| |

| Reference |
| --- |
| OM01 - Parked |
| OM02 - Ignition on |
| OM03 - Normal driving |
| OM04 - Backward driving |
| OM05 - Degraded driving |
| OM06 - Towing (active) |
| OM07 - Towing (passive) |
| OM08 - Service |
| OM09 - N/A |
| |

| Reference |
| --- |
| OS01 - Any Road |
| OS02 - City Road |
| OS03 - Country Road |
| OS04 - Highway |
| OS05 - Mountain Pass |
| OS06 - Off Road |
| OS07 - Road with gradient |
| OS08 - Road with bump |
| OS09 - Road tunnel |
| OS10 - Road with construction site |
| OS11 - N/A |
| |

| Reference |
| --- |
| SD01 - Low speed |
| SD02 - High speed |
| SD03 - Normal acceleration |
| SD04 - High acceleration |
| SD05 - Normal braking |
| SD06 - High braking |
| SD07 - N/A |
| |

| Reference |
| --- |
| IU01 - Correctly used |
| IU02 - Incorrectly used |
| IU03 - N/A |
| |

| Reference |
| --- |
| EN01 - Normal conditions |
| EN02 - Sun blares (degraded view) |
| EN03 - Fog (degraded view) |
| EN04 - Snowfall (degraded view) |
| EN05 - Cross-wind (lateral force) |
| EN06 - Rain (slippery road) |

| |
|---|
| EN07 - Snow (slippery road) |
| EN08 - Glace (slippery road) |
| EN09 - N/A |
| |

**Deviation**

| ID | Deviation (Guideword)(error case details) | Remarks(final error result descri |
|---|---|---|
| DV01 | Function not activated | Activation error |
| DV02 | Function unexpectedly activated | Activation error |
| DV03 | Function always activated | Activation error |
| DV04 | Actor effect is too much | Quantitative error |
| DV05 | Actor effect is too less | Quantitative error |
| DV06 | Actor action too early | Timing error |
| DV07 | Actor action too late | Timing error |
| DV08 | Actor action before | Sequence error |
| DV09 | Actor action after | Sequence error |
| DV10 | Actor effect is reverse | Logical error |
| DV11 | Actor effect is wrong | Logical error |
| DV12 | Sensor sensitivity is too high | Quantitative error |
| DV13 | Sensor sensitivity is too low | Quantitative error |
| DV14 | Sensor detection too early | Timing error |
| DV15 | Sensor detection too late | Timing error |
| DV16 | Sensor detection before | Sequence error |
| DV17 | Sensor detection after | Sequence error |
| DV18 | Sensor detection is reverse | Logical error |
| DV19 | Sensor detection is wrong | Logical error |
| DV20 | N/A | not applicable or not relevant |
| | | |

**Hazardous Events (possibe effects)** (danger condition description)

| ID | Hazardous Event | Remarks |
|---|---|---|
| EV-07 | None | |
| EV-06 | Front collision with oncoming traffic | |
| EV-05 | Front collision with ahead traffic | |
| EV-04 | Front collision with obstacle | |
| EV-03 | Rear collision with trailing traffic | |
| EV-02 | Side collision with other traffic | |
| EV-01 | Side collision with obstacle | |
| EV00 | Collision with other vehicle | |
| EV01 | Collision with train | |
| EV02 | Collision with pedestrian | |
| EV03 | Car spins out of control | |
| EV04 | Car comes off the road | |
| EV05 | Car catches file | |
| EV06 | N/A | |
| | | |

| Reference |
| --- |
| DV01 - Function not activated |
| DV02 - Function unexpectedly activated |
| DV03 - Function always activated |
| DV04 - Actor effect is too much |
| DV05 - Actor effect is too less |
| DV06 - Actor action too early |
| DV07 - Actor action too late |
| DV08 - Actor action before |
| DV09 - Actor action after |
| DV10 - Actor effect is reverse |
| DV11 - Actor effect is wrong |
| DV12 - Sensor sensitivity is too high |
| DV13 - Sensor sensitivity is too low |
| DV14 - Sensor detection too early |
| DV15 - Sensor detection too late |
| DV16 - Sensor detection before |
| DV17 - Sensor detection after |
| DV18 - Sensor detection is reverse |
| DV19 - Sensor detection is wrong |
| DV20 - N/A |
| |

| Reference |
| --- |
| EV-07 - None |
| EV-06 - Front collision with oncoming traffic |
| EV-05 - Front collision with ahead traffic |
| EV-04 - Front collision with obstacle |
| EV-03 - Rear collision with trailing traffic |
| EV-02 - Side collision with other traffic |
| EV-01 - Side collision with obstacle |
| EV00 - Collision with other vehicle |
| EV01 - Collision with train |
| EV02 - Collision with pedestrian |
| EV03 - Car spins out of control |
| EV04 - Car comes off the road |
| EV05 - Car catches file |
| EV06 - N/A |
| |

**Exposure** (probability about whether we can be

| ID | Description |
|---|---|
| E0 | Incredible |
| E1 | Very low probability |
| E2 | Low probability |
| E3 | Medium probability |
| E4 | High probability |
| | |

**Severity** (error result)

| ID | Description |
|---|---|
| S0 | No injuries |
| S1 | Light and moderate injuries |
| S2 | Severe and life-threatening injuries |
| S3 | Life-threatening or fatal injuries |
| | |

**Controllability**

| ID | Description |
|---|---|
| C0 | Controllable in general |
| C1 | Simply controllable |
| C2 | Normally controllable |
| C3 | Difficult to control or uncontrollable |
| | |

elieve in system)

| Duration (of situation) |
| --- |
| |
| Not specified |
| <1 % of average operating time |
| 1 % to 10 % of average operating time |
| >10 % of average operating time |
| |

| Remarks |
| --- |
| No injuries |
| Light and moderate injuries |
| Severe and life-threatening injuries (survival probable) |
| Life-threatening injuries (survival uncertain), fatal injuries |
| |

| Remarks |
| --- |
| Controllable in general |
| 99 % or more of all drivers or other traffic participants are usua |
| 90 % or more of all drivers or other traffic participants are usua |
| Less than 90 % of all drivers or other traffic participants are usu |
| |

| Frequency (of situation) | Reference |
|---|---|
| | E0 - Incredible |
| Occurs less often than once a year for the great majority of dri | E1 - Very low probability |
| Occurs a few times a year for the great majority of drivers | E2 - Low probability |
| Occurs once a month or more often for an average driver | E3 - Medium probability |
| Occurs during almost every drive on average | E4 - High probability |
| | |

| Probability of Injuries | Reference |
|---|---|
| AIS 0 and less than 10 % probability of AIS 1-6 | S0 - No injuries |
| More than 10 % probability of AIS 1-6 (and not S2 or S3) | S1 - Light and moderate injuries |
| More than 10 % probability of AIS 3-6 (and not S3) | S2 - Severe and life-threatening injuries |
| More than 10 % probability of AIS 5-6 | S3 - Life-threatening or fatal injuries |
| | |

| | Reference |
|---|---|
| | C0 - Controllable in general |
| lly able to avoid harm | C1 - Simply controllable |
| lly able to avoid harm | C2 - Normally controllable |
| ıally able, or barely able, to avoid harm | C3 - Difficult to control or uncontrollable |
| | |

| Controllability | Exposure | Severity | | |
|---|---|---|---|---|
| | | S0 | S1 | S2 |
| C1 | E1 | QM | QM | QM |
| | E2 | QM | QM | QM |
| | E3 | QM | QM | QM |
| | E4 | QM | QM | **A** |
| C2 | E1 | QM | QM | QM |
| | E2 | QM | QM | QM |
| | E3 | QM | QM | **A** |
| | E4 | QM | **A** | **B** |
| C3 | E1 | QM | QM | QM |
| | E2 | QM | QM | **A** |
| | E3 | QM | **A** | **B** |
| | E4 | QM | **B** | **C** |

QM: quality management

ASIL: ABCD

| |
|---|
| S3 |
| QM |
| QM |
| **A** |
| **B** |
| QM |
| **A** |
| **B** |
| **C** |
| A |
| **B** |
| **C** |
| **D** |