

INSTRUCTIONS:
Fill out the hazard analysis and risk assessment below.
HA-001 should be for the lane departure warning function as discussed in the lecture.
HA-002 should be for the lane keeping assistance function as discussed in the lecture.
Then come up with your own situations and hazards for the lane assistance system. Fill in the HA-003 and HA-004 rows.
When finished, export your spreadsheet as a pdf file so that a reviewer can easily see your work.

| Hazard ID | Situational Analysis | | | | | | | |
|-----------|-----------------------|----------------------|-----------------------------|-------------------|--|-------------------------|--|---|
| | Operational Mode | Operational Scenario | Environmental Details | Situation Details | Other Details (optional) | Item Usage (function) | Situation Description | Function |
| HA-001 | OM03 - Normal driving | OS04 - Highway | EN06 - Rain (slippery road) | SD02 - High speed | | IU01 - Correctly used | 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 steering torque to provide the driver with haptic feedback |
| HA-002 | OM03 - Normal driving | OS03 - Country Road | EN01 - Normal conditions | SD02 - High speed | | IU02 - Incorrectly used | Normal driving on country roads during normal conditions with high speed. | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane |
| HA-003 | OM03 - Normal driving | OS04 - Highway | EN01 - Normal conditions | SD02 - High speed | The vehicle enters a road construction zone where the white lane markings are overruled by yellow lane markings which might be laterally offset. | IU01 - Correctly used | Normal driving on a highway during nomral conditions with high speed. | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane |
| HA-004 | OM03 - Normal driving | OS03 - Country Road | EN03 - Fog (degraded view) | SD01 - Low speed | | IU01 - Correctly used | Normal driving on a country road during fog with low speed. | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver with haptic feedback |

| Hazard Identification | | | | | | | |
|--------------------------------------|---|---|---|--|-------------------------|---|---|
| Deviation | Deviation Details | Hazardous Event (resulting effect) | Event Details | Hazardous Event Description | Exposure (of situation) | Rationale (for exposure) | Severity (of potential harm) |
| DV04 - Actor effect is too much | The LDW function applies an oscillating torque with very high torque (above limit). | EV00 - Collision with other vehicle | 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). | E3 - Medium probability | Occurs once a month or more often for an average driver | S3 - Life-threatening or fatal injuries |
| DV03 - Function always activated | The LKA is always on. | EV00 - Collision with other vehicle | The driver misuses the function as if the car was a self-driving car and does not pay attention anymore and / or takes his hands from the wheel. | The driver does not use the function properly. | E2 - Low probability | Occurs a few times a year for the great majority of drivers | S3 - Life-threatening or fatal injuries |
| DV19 - Sensor detection is wrong | The camera sensor does not detect the color of the lane markings. | EV-02 - Side collision with other traffic | The driver does not overrule the steering torque applied to the wheel to prevent a side collision with another car in the adjacent lane. | The camera does not detect the correct lane markings. | E3 - Medium probability | Occurs once a month or more often for an average driver | S3 - Life-threatening or fatal injuries |
| DV13 - Sensor sensitivity is too low | The camera sensor does not detect the lane markings correctly in situations with low contrast like dense fog. | EV04 - Car comes off the road | A false haptic feedback in situations with degraded view might affect the drivers ability to steer the vehicle properly. | The camera does not detect the lane markings. | E2 - Low probability | Occurs a few times a year for the great majority of drivers | S3 - Life-threatening or fatal injuries |

| Hazardous Event Classification | | | Determination of ASIL and Safety Goals | |
|--|---|---|--|---|
| Rationale (for severity) | Controllability (of hazardous event) | Rationale (for controllability) | ASIL Determi nation | Safety Goal |
| Collision with another vehicle at high speed could cause fatal injuries. | C3 - Difficult to control or uncontrollable | Excessive vibration of the wheel will overwhelm the most driver and will prevent them steer the vehicle properly. | C | The oscillating steering torque from the lane departure warning function shall be limited. |
| If the car comes off the road fatal injuries could occur. | C3 - Difficult to control or uncontrollable | If the driver is distracted and / or does not has his hands on the wheel he looses control of the vehicle. | B | The lane keeping assistance function shall be time limited and the additional steering torque shall end after a given time interval so that the driver cannot misuse the system autonomous driving. |
| Collision with another vehicle at high speed could cause fatal injuries. | C3 - Difficult to control or uncontrollable | In road construction zone the white „standard“ lane markings are no longer valid if there are yellow lane markings on the road. | C | The lane keeping assistance shall be able to detect yellow lane markings and prefer them over white lane markings. |
| If the car comes off the road fatal injuries could occur. | C3 - Difficult to control or uncontrollable | In situations with degraded view when the driver is stressed anyway the vibration of the steering wheel could overwhelm the driver and prevent them steer the vehicle properly. | B | The lane departure warning shall not apply any torque to the wheel in case the lane markings are not clearly visible. |

EXAMPLE DISCUSSED IN THE PROJECT INSTRUCTIONS - Headla

| 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 |

mp System

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

| | | § |
|----------------------|---------------------------------|---|
| 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) | |

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

| Situational 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 | road and no other illumination | IU01 - Correctly used |
| SD03 - High speed | Night time + Obstacle on the road or upcoming curve | IU01 - Correctly used |
| SD02 - High speed | Night time + Oncoming vehicle | IU01 - Correctly used |
| SD04 - High speed | road and no other illumination | IU01 - Correctly used |

| Situation Description | Function |
|---|--|
| Normal Driving on a City Road in Normal Conditions at Low Speed at Night with an Obstacle on the Road | Low beam illuminates the roadway in the dark |

| Situation Description | Function |
|--|--|
| conditions with Low speed (Night time + Obstacle on (degraded view) with Low speed (night time + Obstacle on the road and no other illumination on (degraded view) with High speed (Night time + conditions with High speed (Night time + Oncoming (degraded view) with High speed (night time + Obstacle on the road and no other illumination on | Low beam illuminates the roadway in the dark Low beam illuminates the roadway in the dark Low beam illuminates the roadway in the dark Low beam illuminates the roadway in the dark Low beam illuminates the roadway in the dark |

| Hazard Id | |
|------------------------|------------------------------|
| Deviation | Deviation Details |
| Function not activated | Both headlights stop working |

| Hazard Id | |
|-------------------------------|------------------------------|
| Deviation | Deviation Details |
| DV01 - Function not activated | Both headlights stop working |
| DV01 - Function not activated | Both headlights stop working |
| DV01 - Function not activated | Both headlights stop working |
| DV01 - Function not activated | Both headlights stop working |
| DV01 - Function not activated | Both headlights stop working |

| entification | |
|---------------------------------------|-------------------------|
| Hazardous Event (resulting effect) | Event Details |
| Front collision with obstacle | obstacle with injury to |

| entification | |
|---------------------------------------|-------------------------------|
| Hazardous Event (resulting effect) | Event Details |
| EV04 - Front collision with obstacle | obstacle with injury to |
| EV04 - Front collision with obstacle | obstacle with injury to |
| EV04 - Front collision with obstacle | infrastructure with injury to |
| EV08 - Collision with other vehicle | oncoming vechile or road |
| EV04 - Front collision with obstacle | infrastructure with injury to |

| Hazardous Event Description | Exposure (of situation) |
|--------------------------------|----------------------------|
| Total loss of low beam | E4 - High probability |

| Hazardous Event Description | Exposure (of situation) |
|--------------------------------|----------------------------|
| Total loss of low beam | E4 - High probability |
| Total loss of low beam | E1 - Very low probability |
| Total loss of low beam | E2 - Low probability |
| Total loss of low beam | E4 - High probability |
| 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 |
| unilluminated roads while it is | S1 - Light and moderate injuries |
| however, heavy snow occurs a few | S3 - Life-threatening or fatal injuries |
| country driving is part of regular driving | S3 - Life-threatening or fatal injuries |
| driving, however, heavy snow occurs | S3 - Life-threatening or fatal injuries |

| s Event Classification |
|--|
| Rationale (for severity) |
| In city traffiic, speed of vehicle is expected to be low |

| s Event Classification |
|--|
| Rationale (for severity) |
| In city traffiic, speed of vehicle is expected to be low |
| In city traffiic, speed of vehicle is expected to be low |
| On highway speed of vehicle is expected to be high |
| On country roads speed of vehicle is expected to be high |
| On country roads speed of vehicle is expected to be high |

| Controllability | |
|------------------------------|--|
| (of hazardous event) | Rationale (for controllability) |
| C0 - Controllable in general | control the situation by applying brakes and |

| Controllability | |
|---|---|
| (of hazardous event) | Rationale (for controllability) |
| C0 - Controllable in general | control the situation by applying brakes and |
| C1 - Simply controllable | usually drive at lower end of city speeds and hence are expected to be able to control |
| C2 - Normally controllable | and hence >90% drivers are able to brake and |
| C1 - Simply controllable | information to be expected on country road, it |
| C3 - Difficult to control or uncontrollable | will be difficult for the average driver to control |

| Determination of ASIL and Safety Goals | |
|--|--|
| ASIL Determination | Safety Goal |
| QM | Total Loss of Beam Shall Be Prevented |

| Determination of ASIL and Safety Goals | |
|--|--|
| ASIL Determination | Safety Goal |
| QM | Total loss of low beam shall be prevented |
| QM | Total loss of low beam shall be prevented |
| A | Total loss of low beam shall be prevented |
| B | Total loss of low beam shall be prevented |
| B | Total loss of low beam shall be prevented |

Hazard & Risk Analysis Definition

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 | Glaze (slippery road) |
| EN09 | N/A |
| | |

| 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 |
| Being 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 |
| road attribute |
| road attribute |
| road attribute |
| not applicable or not relevant |
| |

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

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

| 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) |
|------|---------------------------------|
| 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 |
| | |

Hazardous Events (possible effects)

| ID | Hazardous Event |
|-------|---------------------------------------|
| 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 fire |
| EV06 | N/A |
| | |

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

| Remarks | 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 fire |
| | EV06 - N/A |
| | |

Exposure

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

Severity

| 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 |
| | |

| 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 usually able to |
| 90 % or more of all drivers or other traffic participants are usually able to |
| Less than 90 % of all drivers or other traffic participants are usually able |
| |

| Frequency (of situation) |
|--|
| |
| Occurs less often than once a year for the great majority of drivers |
| Occurs a few times a year for the great majority of drivers |
| Occurs once a month or more often for an average driver |
| Occurs during almost every drive on average |
| |

| Probability of Injuries |
|--|
| AIS 0 and less than 10 % probability of AIS 1-6 |
| More than 10 % probability of AIS 1-6 (and not S2 or S3) |
| More than 10 % probability of AIS 3-6 (and not S3) |
| More than 10 % probability of AIS 5-6 |
| |

| |
|----------------------------------|
| |
| |
| o avoid harm |
| o avoid harm |
| e, or barely able, to avoid harm |
| |

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

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

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

| Controllability | Exposure | Severity | | | |
|-----------------|----------|----------|----|----|----|
| | | S0 | S1 | S2 | S3 |
| C1 | E1 | QM | QM | QM | QM |
| | E2 | QM | QM | QM | QM |
| | E3 | QM | QM | QM | A |
| | E4 | QM | QM | A | B |
| C2 | E1 | QM | QM | QM | QM |
| | E2 | QM | QM | QM | A |
| | E3 | QM | QM | A | B |
| | E4 | QM | A | B | C |
| C3 | E1 | QM | QM | QM | A |
| | E2 | QM | QM | A | B |
| | E3 | QM | A | B | C |
| | E4 | QM | B | C | D |