

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 | Operational Mode | Operational Scenario | Environmental Details | Situational Analysis | | | Function | Deviation | Deviation Details | Hazardous Event (Breaching effect) | Event Details | Hazardous Event Description | Hazardous Event Classification | | | | | | Determination of ASL and Safety Goals | |
|-----------|-----------------------|----------------------|-----------------------------------|----------------------|--|------------------------|--|--|--|---|--|---------------------------------|--------------------------------|--|---|--|---|---|---------------------------------------|---|
| | | | | Situation Details | Other Details (optional) | Item Usage (function) | | | | | | | Exposure (of situation) | Rationale (for exposure) | Severity (of potential harm) | Exposure (for severity) | Controllability (of hazardous event) | Rationale (for controllability) | ASL Determination | Safety Goal |
| HA-001 | CM03 - Normal driving | OS04 - Highway | EN01 - Normal condition | SD02 - High speed | Driver rubbernecking a gripping steering wheel loosely | LD1 - Correctly used | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver with haptic feedback. | DV04 - Actor effect is too much | Oscillating steering torque applied exceeds the limit. | EY00 - Collision with other vehicle | Lateral collision with vehicle on either left or right side. | Driver loses control of vehicle | E2 - Low probability | Since its duty to abuse LKA feature, driver won't be doing it quite often. Probability of this event happening is low. | S3 - Life threatening or fatal injuries | High speed will have greater impact during the collision | C3 - Difficult to control or uncontrollable | If LWD applies torque in one direction, driver might react and apply torque in the opposite direction. This behavior can repeat and will cause car to swerve badly. | C | The oscillating steering torque from LDW should be limited. |
| HA-002 | CM03 - Normal driving | OS03 - Country Road | EN01 - Normal condition | SD02 - High speed | | LD2 - Incorrectly used | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane | DV03 - Function always activated | Driver takes hands off the steering wheel | EY00 - Collision with other vehicle | Lateral collision with vehicle on either left or right side. | Driver loses control of vehicle | E2 - Low probability | Since its duty to abuse LKA feature, driver won't be doing it quite often. Probability of this event happening is low. | S3 - Life threatening or fatal injuries | High speed will have greater impact during the collision | C3 - Difficult to control or uncontrollable | Since driver is depending on the LKA for the direction, direction can change if road condition change for example, curve ahead. | B | Time duration of LKA should be time limited to prevent the misuse of LKA as an autonomous driving. |
| HA-003 | CM03 - Normal driving | OS01 - Any road | EN06 - Rain (slippery road) | SD01 - Low speed | Night time + reflection of light on the road | LD2 - Incorrectly used | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver with haptic feedback. | DV02 - Function unexpectedly activated | Oscillating steering torque applied unnecessarily. | During rain, reflection of headlights from oncoming cars on the road can cause camera to detect lane lines incorrectly and activate LDW feature | Lateral collision with vehicle on either left or right side. | Driver loses control of vehicle | E2 - Low probability | Occurrence of this event is happening less frequent so probability is low. | S2 - Severe and life-threatening injuries | During rain, normally people don't drive fast, so impact could be less severe. | C3 - Difficult to control or uncontrollable | Traffic condition in the surroundings can change the outcome. Driver maybe able to control the car or maybe not. So picked the higher controllability. | C | LDW shouldn't be activated if its raining. Driver should remain in the control of the car. |
| HA-004 | CM03 - Normal driving | OS04 - Highway | EN05 - Cross-wind (lateral force) | SD02 - High speed | | LD1 - Correctly used | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane | DV02 - Function unexpectedly activated | Steering torque applied could be counter intuitive. | Combination of crosswind and steering torque could cause car to swerve badly. | Lateral collision with vehicle on either left or right side. | Driver loses control of vehicle | E2 - Low probability | Occurrence of this event is happening less frequent so probability is low. | S2 - Severe and life-threatening injuries | High speed will have greater impact during the collision | C3 - Difficult to control or uncontrollable | Traffic condition in the surroundings can change the outcome. Driver maybe able to control the car or maybe not. So picked the higher controllability. | B | If LKA is getting activated frequently during short time span, LKA should deactivate itself and let driver control the car. |

Hazard & Risk Analysis Definitions

Operational Mode

| ID | Mode | Remarks | Reference |
|------|------------------|--------------------------------|-------------------------|
| OM01 | Parked | Car is parked, ignition is off | OM01 - Parked |
| OM02 | Ignition on | Car is parked, ignition is on | OM02 - Ignition on |
| OM03 | Normal driving | Car is driving | OM03 - Normal driving |
| OM04 | Backward driving | Car is driving | OM04 - Backward driving |
| OM05 | Degraded driving | Limp home mode | OM05 - Degraded driving |
| OM06 | Towing (active) | Towing another car | OM06 - Towing (active) |
| OM07 | Towing (passive) | Being towed by another car | OM07 - Towing (passive) |
| OM08 | Service | Vehicle is in repair garage | OM08 - Service |
| OM09 | N/A | not applicable or not relevant | OM09 - N/A |
| | | | |

Operational Scenario

| ID | Scenario | Remarks | Reference |
|------|-----------------------------|--------------------------------|------------------------------------|
| OS01 | Any Road | road type | OS01 - Any Road |
| OS02 | City Road | road type | OS02 - City Road |
| OS03 | Country Road | road type | OS03 - Country Road |
| OS04 | Highway | road type | OS04 - Highway |
| OS05 | Mountain Pass | road type | OS05 - Mountain Pass |
| OS06 | Off Road | road type | OS06 - Off Road |
| OS07 | Road with gradient | road attribute | OS07 - Road with gradient |
| OS08 | Road with bump | road attribute | OS08 - Road with bump |
| OS09 | Road tunnel | road attribute | OS09 - Road tunnel |
| OS10 | Road with construction site | road attribute | OS10 - Road with construction site |
| OS11 | N/A | not applicable or not relevant | OS11 - N/A |
| | | | |

Situation Details

| ID | Scenario | Remarks | Reference |
|------|---------------------|--------------------------------|----------------------------|
| SD01 | Low speed | driving attribute | SD01 - Low speed |
| SD02 | High speed | driving attribute | SD02 - High speed |
| SD03 | Normal acceleration | driving attribute | SD03 - Normal acceleration |
| SD04 | High acceleration | driving attribute | SD04 - High acceleration |
| SD05 | Normal braking | driving attribute | SD05 - Normal braking |
| SD06 | High braking | driving attribute | SD06 - High braking |
| SD07 | N/A | not applicable or not relevant | SD07 - N/A |
| | | | |

Item Usage

| ID | Mode | Remarks | Reference |
|------|------------------|--------------------------------|-------------------------|
| IU01 | Correctly used | Intended usage | IU01 - Correctly used |
| IU02 | Incorrectly used | Unintended usage (foreseeable) | IU02 - Incorrectly used |
| IU03 | N/A | not applicable or not relevant | IU03 - N/A |
| | | | |

Environmental Details

| ID | Scenario | Remarks | Reference |
|------|----------------------------|--------------------------------|-----------------------------------|
| EN01 | Normal conditions | weather attribute | EN01 - Normal conditions |
| EN02 | Sun blares (degraded view) | weather attribute | EN02 - Sun blares (degraded view) |
| EN03 | Fog (degraded view) | weather attribute | EN03 - Fog (degraded view) |
| EN04 | Snowfall (degraded view) | weather attribute | EN04 - Snowfall (degraded view) |
| EN05 | Cross-wind (lateral force) | weather attribute | EN05 - Cross-wind (lateral force) |
| EN06 | Rain (slippery road) | road attribute | EN06 - Rain (slippery road) |
| EN07 | Snow (slippery road) | road attribute | EN07 - Snow (slippery road) |
| EN08 | Glacé (slippery road) | road attribute | EN08 - Glacé (slippery road) |
| EN09 | N/A | not applicable or not relevant | EN09 - N/A |
| | | | |

Deviation

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

Hazardous Events (possible effects)

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

Exposure

| ID | Description | Duration (of situation) | Frequency (of situation) | Reference |
|----|----------------------|---------------------------------------|--|---|
| E0 | Incredible | | | E0 - Incredible |
| E1 | Very low probability | Not specified | Occurs less often than once a year for the great majority of drivers | E1 - Very low probability |
| E2 | Low probability | <1 % of average operating time | Occurs a few times a year for the great majority of drivers | E2 - Low probability |
| E3 | Medium probability | 1 % to 10 % of average operating time | Occurs once a month or more often for an average driver | E3 - Medium probability |
| E4 | High probability | >10 % of average operating time | Occurs during almost every drive on average | E4 - High probability |

Severity

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

Controllability

| ID | Description | Remarks | Reference |
|----|--|---|---|
| C0 | Controllable in general | Controllable in general | C0 - Controllable in general |
| C1 | Simply controllable | 99 % or more of all drivers or other traffic participants are usually able to avoid harm | C1 - Simply controllable |
| C2 | Normally controllable | 90 % or more of all drivers or other traffic participants are usually able to avoid harm | C2 - Normally controllable |
| C3 | Difficult to control or uncontrollable | Less than 90 % of all drivers or other traffic participants are usually able, or barely able, to avoid harm | 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 |