# Relevant test scenarios on proving grounds for the highway use-case - OICA views

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Submitted by the experts of OICA

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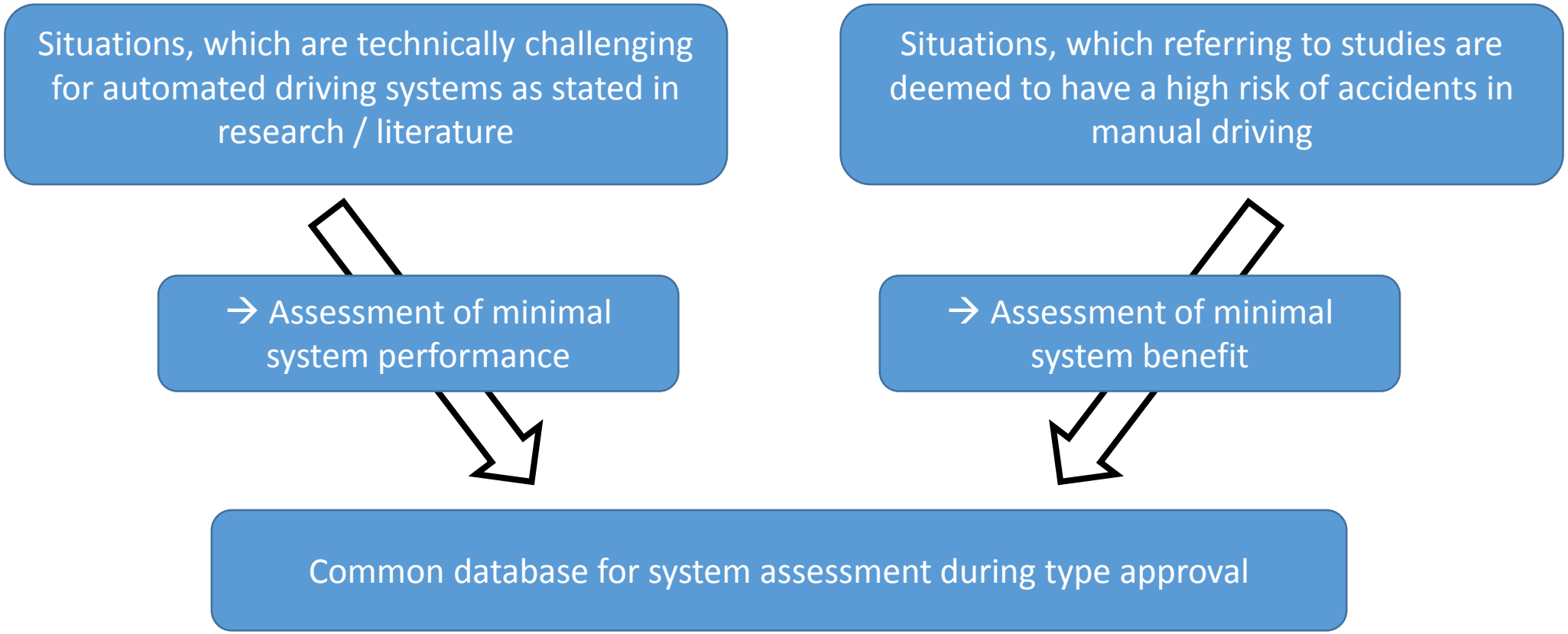
# Outline / Scope of thoughts with 3 steps

1. Define relevant or challenging test scenarios for automated driving functions in highway use cases which
   - have already been justified by 3rd party research – and therefore
   - can be agreed on between industry and contracting parties
   - form the basis for a still to be defined testing procedure during type approval
2. Define the corresponding criteria for the test scenarios, which are to be considered via simulation.
3. Define a subset of test scenarios, which are to be assessed by physical testing on a proving ground. Work out the respective test procedures and tools to perform these tests.

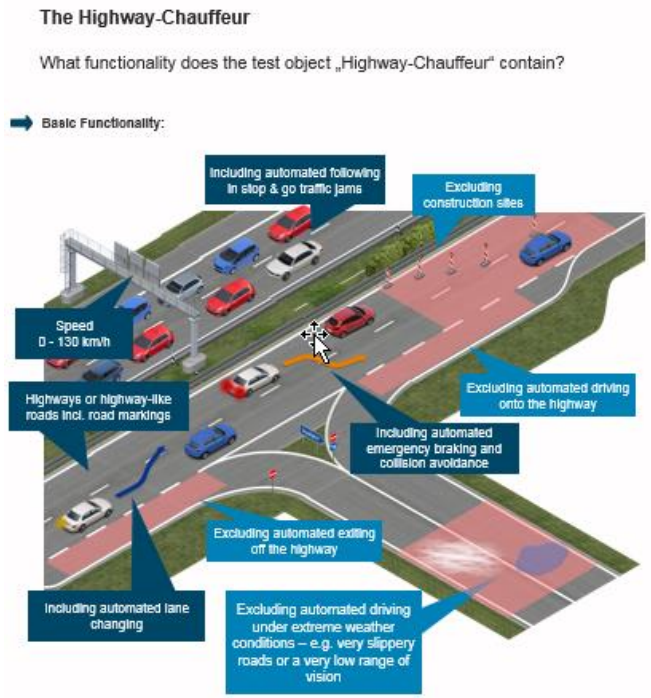
# Step 1) Approaches for the collection of scenarios



# Sources for technically challenging situations

Different research projects consider the evaluation of automated driving, e.g. PEGASUS (Germany):

- definition of an ODD for a highway chauffeur system
- definition of relevant scenarios that occur within and at the limits of the specified ODD.




Source: www.PEGASUSproject.de

# Challenging situations for technical systems

**Infrastructure**

- Speed limits
- Relevance of additional signs (weather, vehicle type, date & time)
- (Emergency) lane clearance
- Bad lane markings
- Asphalt cleavages
- Traffic lights on tunnels

**Normal traffic**

- Distance keeping (motorcycle)
- Speed adoption to curves, sight, weather
- No overtaking in right lane
- Relevance of front object (curves)
- Approaching slower vehicle
- Emergency corridor in congested traffic flow

**Traffic events**

- Approaching critical locations (narrow curves, construction sites, narrow lanes, wind, bumps
- Approaching traffic jam (camber)
- Reaction to cut-in
- Reaction to cut-out
- Broken- down vehicle on emergency lane

# Sources for hazardous driving situations

## Example: Germany – Databases, accidentology:

GIDAS (German In Depth Accident Study): Top ten accident types on German highways (similar data to be collected from other countries)

| Accident Types for Cars on Motorways (BAB) | | Injury Severity | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | fatal | | severe | | slightly | | no injuries / unknown | | Total n | Total % |
| UTYP | Description | n | % | n | % | n | % | n | % | | |
| 141 | straight longitudinal | 12 | 1,0% | 92 | 7,3% | 136 | 10,8% | 4 | 0,3% | 244 | 19,3% |
| 631 | lane change to the left | 5 | 0,4% | 28 | 2,2% | 85 | 6,7% | 1 | 0,1% | 119 | 9,4% |
| 612 | traffic jam rear-end collision 2 lanes | 0 | 0,0% | 16 | 1,3% | 78 | 6,2% | 1 | 0,1% | 95 | 7,5% |
| 613 | traffic jam rear-end collision 3 lanes | 1 | 0,1% | 20 | 1,6% | 52 | 4,1% | 0 | 0,0% | 73 | 5,8% |
| 601 | rear-end collision with moving vehicle 1 lane | 3 | 0,2% | 17 | 1,3% | 43 | 3,4% | 0 | 0,0% | 63 | 5,0% |
| 102 | collision in curve | 1 | 0,1% | 18 | 1,4% | 37 | 2,9% | 0 | 0,0% | 56 | 4,4% |
| 611 | traffic jam rear-end collision 1 lane | 0 | 0,0% | 8 | 0,6% | 38 | 3,0% | 1 | 0,1% | 47 | 3,7% |
| 602 | rear-end collision with moving vehicle 2 lanes | 1 | 0,1% | 15 | 1,2% | 31 | 2,5% | 0 | 0,0% | 47 | 3,7% |
| 771 | sudden tire damage | 1 | 0,1% | 15 | 1,2% | 31 | 2,5% | 0 | 0,0% | 47 | 3,7% |
| 761 | driver falling asleep | 4 | 0,3% | 17 | 1,3% | 20 | 1,6% | 0 | 0,0% | 41 | 3,2% |

# Step 2: Selection of scenarios

- Collection of scenarios:

  for both paths for consideration of scenarios from different data sources

  - Technically demanding scenarios
  - Scenarios with high relevance in accident data bases
- Selection of test cases:
  - group the different scenarios to families
  - describe representatives of the families, which lead to „test cases“
  - test cases can be evaluated in simulation
- Expectation on outcome of the test cases / families for evaluation.
  - Definition of pass / fail criteria in the respective test cases

# Step 3: Development of physical test procedures

- A subset of the test cases is available for execution on test tracks („physical test cases“):
  - Feasibility: Availability of technical boundary condition (targets, propulsion systems,…) and avoiding dangers for testing personel
  - Complexity and handling of test scenarios
- Procedures and tools for these physical test cases are to be developed.
- Statistical and technical parameters for the respective test cases are to be agreed upon.

# Summary

- 3 step approach to the assessment of automated vehicle functions is proposed
  - Collect scenarios („What is to be considered?“)
    - via technical considerations („challenging scenarios“)
    - via national accident data bases
  - Define assessment criteria („What is expected?“)
  - Work out test procedures („How to show, that the requirements are met?“)
- Following the proposed route requires much coorporation, in order to enable automated driving systems, which have the potential to increase overall traffic safety.
- OICA suggests to consider as a first step the most relevant scenarios (lane change / merging, end of traffic congestion …)
- Alignment with the results of ACSF CAT B2 necessary

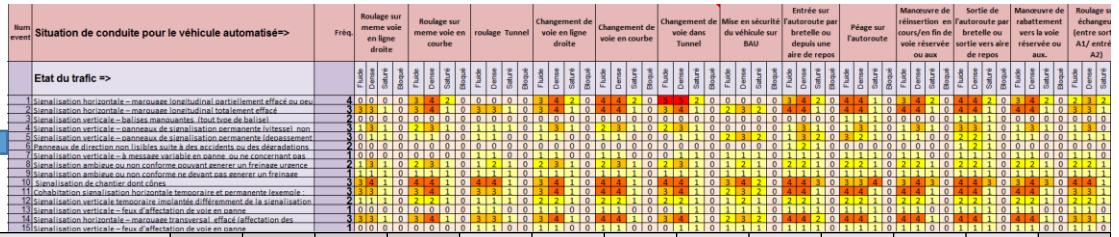
# Backup

# Sources for hazardous driving situations

## IFSTTAR (France):

- Data derived from French accidentology databases and interviews
- Classification of manual highway driving (17 scenarios with 4 possible traffic conditions → 68 possible driving scenes)
- Deduction of possible elementary events with critical impact to traffic safety
- Assessment of criticality of each combination, based on ISO26262 measures (and “expert rating”)

→ Focusing necessary (highest criticality – highest exposure – highest accident rate?)



| F = Fluent traffic / D = Dense traffic | Lane keeping Straight line | Lane keeping Curve | Lane keeping Tunnel (no GPS) | start of non overtaking zone | Lane changing Straight line | Lane changing Curve | Lane changing Tunnel | Lane changing to dedicated lane | Highway exit | MRM to Emergency Lane | exit from dedicated lane (low vh) | Highway entrance | Toll barrier |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane change by followed vehicle without flashing indicators | **F** | **F** | **F** | | FD | FD | FD | FD | FD | **FD** | FD | FD | FD |
| Cut off by other road user | FD | FD | FD | **FD** | FD | FD | FD | FD | FD | **FD** | FD | FD | FD |
| Vehicle overtaking (by) the right side | | | | | **FD** | **FD** | **FD** | **FD** | **FD** | **FD** | | | **FD** |
| Motorbike between lanes | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD |
| Static vehicle in front (traffic jam) | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD |
| Pedestrian detection | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD |
| Policeman/Roadman directing traffic | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD | FD |
| ground markings partially deleted | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | FD |
| ground markings totally deleted | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | FD |
| temporary ground markings (additionnal) | **FD** | **FD** | **FD** | FD | **FD** | FD | **FD** | FD | FD | **FD** | FD | FD | FD |
| working area (cones, etc…) | **FD** | FD | FD | **FD** | **FD** | FD | FD | **FD** | FD | **FD** | **FD** | FD | **FD** |
| Dammaged pavement ( "tar fittings" ?) | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | |
| No emergency lane | | | | | | | | | | FD | | | |
| fog (???) | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** | **F** |
| Flooded lane | FD | FD | FD | FD | FD | FD | FD | FD | FD | **FD** | FD | FD | FD |
| Glazing (exit of tunnel) | **FD** | **FD** | **FD** | FD | **FD** | FD | FD | FD | FD | **FD** | FD | FD | FD |
| Heavy rain | FD | FD | | FD | FD | FD | | FD | FD | **FD** | FD | FD | FD |
| | | | | | | | | | | | | | |
| Expected TOR while the driver is in a "bad" position | **FD** | **FD** | **FD** | FD | | | | FD | FD | | FD | FD | FD |
| Unexpected TOR with distracted driver | **FD** | **FD** | **FD** | FD | FD | FD | FD | FD | FD | | FD | FD | FD |
| Unexpected TOR with a wrong interpretation of the driving scene by the driver | FD | FD | FD | FD | FD | FD | FD | FD | FD | | FD | FD | FD |
| Unexpected TOR while the driver is in a "bad" position | **FD** | **FD** | **FD** | FD | FD | FD | FD | FD | FD | | FD | FD | FD |
| OR by driver | | | | | | | | | | | | | |
| Unauthorized request of delegation by driver (out of ODD) | | | | | | | | | | | | | |

# Sources for hazardous driving situations

## US – Databases, accidentology:

FARS, NMVCCS, NASS (GES, CDS, CSI, CIREN) and Naturalistic (100 car and SHRP-2)

**Table 13.** Pre-Crash Scenarios of All Light-Vehicle Crashes

| No. | Scenario | 1-Frequency | Frequency | Rel. Freq. |
|---|---|---|---|---|
| 1 | Lead Vehicle Stopped | 974,855 | 975,000 | 16.41% |
| 2 | Control Loss Without Prior Vehicle Action | 528,930 | 529,000 | 8.90% |
| 3 | Vehicle(s) Turning at Non-Signalized Junctions | 434,892 | 435,000 | 7.32% |
| 4 | Lead Vehicle Decelerating | 428,067 | 428,000 | 7.20% |
| 5 | Road Edge Departure Without Prior Vehicle Maneuver | 333,706 | 334,000 | 5.62% |
| 6 | Vehicle(s) Changing Lanes – Same Direction | 338,309 | 338,000 | 5.69% |
| 7 | Animal Crash Without Prior Vehicle Maneuver | 305,102 | 305,000 | 5.13% |
| 8 | Straight Crossing Paths at Non-Signalized Junctions | 263,840 | 264,000 | 4.44% |
| 9 | Running Red Light | 253,618 | 254,000 | 4.27% |
| 10 | Vehicle(s) Turning – Same Direction | 221,791 | 222,000 | 3.73% |
| 11 | LTAP/OD at Signalized Junctions | 220,206 | 220,000 | 3.71% |
| 12 | Lead Vehicle Moving at Lower Constant Speed | 209,610 | 210,000 | 3.53% |
| 13 | LTAP/OD at Non-Signalized Junctions | 189,816 | 190,000 | 3.19% |
| 14 | Backing Up Into Another Vehicle | 130,701 | 131,000 | 2.20% |
| 15 | Vehicle(s) Not Making a Maneuver – Opposite Direction | 123,699 | 124,000 | 2.08% |
| 16 | Control Loss With Prior Vehicle Action | 102,617 | 103,000 | 1.73% |
| 17 | Vehicle(s) Drifting – Same Direction | 97,973 | 98,000 | 1.65% |
| 18 | Following Vehicle Making a Maneuver | 85,373 | 85,000 | 1.44% |
| 19 | Road Edge Departure With Prior Vehicle Maneuver | 67,528 | 68,000 | 1.14% |
| 20 | Road Edge Departure While Backing Up | 65,809 | 66,000 | 1.11% |

Highway relevance

**Table 1.** List of 44 Crash Scenarios

| No. | Title | Scenario Definition |
|---|---|---|
| 1 | Struck Human | A pedestrian crossing a multi-lane roadway was struck by vehicle. The driver was looking for other vehicles and traffic controls, but did not see the pedestrian. This crash occurs more frequently in urban areas. The weather is typically clear and the road is usually dry. |
| 3 | Struck Animal | A male driving home after dark on a rural two-lane country road in November struck a deer crossing the road. The driver could not avoid hitting the deer. |
| 9 | Drowsy | The driver fell asleep and drifted off the right side of the road and struck a telephone pole. Witnesses say that there was no attempt to brake or steer away from the pole. The crash occurred in a rural area at night. |
| 10 | Aggressive, Departure | The male driver was driving too fast, as well as cutting in and out of traffic, maneuvering the vehicle to the limits of control. The driver lost control of the vehicle and went into a skid. The driver left the roadway and struck the guardrail and then a tree. |
| 11 | Slick Road Departure | The driver lost control while driving on an icy, wet road. The driver tried to bring the vehicle back under control by braking and steering. The vehicle spun out and came to rest in the ditch. |
| 12 | Rough Road Departure | Due to the patched and eroded condition of the road surface, the driver lost control of the vehicle and left the roadway. |
| 13 | Avoidance, Departure | The driver was alert and driving along a surface street. Suddenly something appeared in the driver's path (e.g., child, bicyclist, or animal). The driver slammed on the brakes and swerved to avoid the immediate threat. The vehicle drove over a curb and into an object. |
| 18 | Impaired, Departure | The young (under 25) male driver, who was legally impaired, was driving too fast. He lost control of the vehicle, which left the roadway and overturned. The crash occurred in a rural area between midnight and 2 a.m. on a weekend. |
| 19 | Back Into Object | Vehicle A was backing out of a driveway and struck Vehicle B that was parked along the side of the road. Driver A did not see the other vehicle. |
| 22 | Ran Red "T-Bone" | Driver ran the red light. The driver saw the light turn yellow but decided to continue through the intersection. The majority of these crashes occur during daylight hours in urban areas. |
| 28 | Slick Road, Ran Stop | As vehicle approached an intersection, the driver noticed the stop sign, applied the brakes hard, but slid on the wet pavement into crossing traffic. (This group does not include the condition where there is no sign.) |
| 30 | Inattentive, Ran Stop | An inattentive driver in a vehicle, heading north, did not see a stop sign (two-way only) and struck an eastbound vehicle on the passenger's side. |
| 33 | View Obstruction | A vehicle, at a two-way stop sign, could not see adequately down the road due to the hill. This vehicle pulled out and was struck on the driver's side by a lateral-crossing vehicle. This crash is most likely to occur in daylight in rural areas. |
| 35 | Looked but Didn't See | Vehicle A was turning right at a two-way stop sign. The driver did not see Vehicle B approaching from lateral direction as Vehicle A turned into the lane. Upon turning, Vehicle A was struck by Vehicle B. |
| 37 | Sirens | A police car, with lights and siren on, slowed to cross through an intersection with a red light. Another vehicle was on the crossing road and did not see the approaching police car. |
| 38 | Left Turn Clip | Vehicle A, in an attempt to turn left, cut the corner too sharply and clipped Vehicle B waiting at the intersection. Vehicle A began the turn too early and misjudged the distance between cars. |