Draft Regulation on Driver Assist Systems to Avoid Blind Spot Accidents
Development of Test Procedure and First Verification Tests

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Structure

- Accidentology
- Definition of Relevant Parameters and Test Cases
- Definition of Assessment Criteria
- Verification Tests
- Test Results
- Conclusions
Accident analysis – statistics (police reported)

Right turning trucks and straight driving cyclists (extrapolation for Germany):

<table>
<thead>
<tr>
<th></th>
<th>Cyclists</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>injury accidents</td>
<td>640</td>
<td>55</td>
</tr>
<tr>
<td>seriously injured</td>
<td>118</td>
<td>16</td>
</tr>
<tr>
<td>fatalities</td>
<td>23</td>
<td>4</td>
</tr>
</tbody>
</table>

Main accident types
In depth accident analysis

- German In-Depth Accident Study
- Database of accident research of German insurers (UDV)

Records include sketches, photos, aerial images, reconstruction

Purpose: gain information about
- Road infrastructure
- Obstructions
- Velocities
- Trajectories
- Impact points
In depth accident analysis - results

- Daytime about 90 %
- 90 % dry weather
- Truck drivers sight O.K.; obstruction in only 9 %
- Only 22 % of the cases after previous halt of the truck
- In 90 % of the cases truck did not brake
- In 90 % of the cases bicycle moved
- Impact point at frontal part of the truck (up to 6 m towards the rear, see Figure)
- 90 % of fatalities with trucks above 7.5 t
- Traffic lights do not play any role
In depth accident analysis - results

Speeds:

- Bicycle and truck did not change their speeds during the accident in about two thirds of all cases.
- Truck speeds are below 30 km/h in more than 90% of all cases.
- Bicycle speeds are below 20 km/h in more than 80% of all cases.
Rough Classification of Scenarios

slowly  fast  slowly  faster

I  II  III  IV

distance (m)

Preconsiderations for Requirements

- Due to missing experience no emergency braking
- Warning (high intensity) only if accident is imminent in order to avoid annoyance (alert will be disabled)
- Since driver reaction time has to be taken into account warning will be too late in most of the cases and thus useless
  - Informational assistance (early but not annoying)
Difference between Warning and Information

- **Warning**
  - High intensity
  - If issued right, good effects in steering driver’s attention
  - High annoyance if issued too often → risk of deactivation

- **Information**
  - Low intensity
  - Low annoyance if issued too often → low risk of deactivation
  - Lesser effect in steering driver’s attention
Sketch of relevant parameters

Scenario characteristics (from accidentology)

- $v_{\text{Truck}}$: 10 to 20 km/h
- $v_{\text{Cycle}}$: 10 to 20 km/h
- Lateral separation: $A = 1.5$ to $4.5$ m
- Truck turning radius: $R = 5, 10, 25$ m
- Maximum lateral acceleration: $a_y < 3$ m/s$^2$
- Impact location: $L = 0$ to $6$ m

Assumed driver performance (conservative)

- Reaction time after driver information: 1.4 s
- Braking performance of driver: 6 m/s$^2$
Pass/Fail Criteria (1) – Impact on HGV Front

- Prevent HGV from crossing bicycle path
- Assistance System Information shall be early enough for driver to react
- Last Point of Information (LPI) reflects stopping distance
- Stopping distance results from assumed reaction time and brake deceleration (see slide 9)

\[ TTC_{LPI} = t_{\text{Reaction}} + t_{\text{Brake}} \]
\[ = 1.4 \text{s} + \frac{v_{\text{HGV}}}{2 \cdot 6 \frac{\text{m}}{\text{s}^2}} \]
Pass/Fail Criteria (2) – Impact to Side of HGV

- Still prevent HGV from crossing pedestrian path
- Crossing bicycle trajectory happens earlier
- Warning needs to be issued earlier – LPI shifts
- In most cases, HGV has not started to turn at that point

\[
TTC_{LPI} = t_{\text{Reaction}} + t_{\text{Brake}} + t_{\text{to impact point}} \\
= 1.4s + \frac{v_{HGV}}{2.6 \frac{m}{s^2}} + \frac{L}{v_{HGV}}
\]
Definition of Test Cases

- Necessary Sensor Field-of-View (SFOV)
  - Scenario characteristics define possible locations of bicycle relative to HGV
  - Assumed driver performance defines last point of information (LPI)
  - Heatmap (resolution 1mx1°) shows all possible bicycle locations from 4 s before LPI until impact
  - This does NOT mean the complete heatmap needs to be covered

- Define Test Cases
  - Derive test cases to fill SFOV space (=heatmap) most efficient
Test Cases and Assessment

- Information **MUST** be given at or before LPI
- Exact timing defined by manufacturer
- Tests will simulate at least 4s before LPI

<table>
<thead>
<tr>
<th>ID</th>
<th>$v_{\text{Truck}}$ [km/h]</th>
<th>$v_{\text{Cycle}}$ [km/h]</th>
<th>R [m]</th>
<th>Initial lateral separation [m]</th>
<th>Impact location with respect to front of truck [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
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<td>5</td>
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<td>20</td>
<td>20</td>
<td>25</td>
<td>1.5</td>
<td>6</td>
</tr>
</tbody>
</table>

Bicycle 4s before LPI
Test Equipment – Pretests

- **Vehicle**
  - Truck, manually driven, without trailer
  - Position estimation: GeneSys DGPS
  - Position transmitted to dummy propulsion system

- **Dummy**
  - Standard commercial static pedestrian dummy (4 active systems „EuroNCAP Pedestrian“)
  - Regular bicycle with custom carrier mechanism

- **Dummy Propulsion**
  - 4a „Surfboard“ commercial Dummy Propulsion with prototype software
  - Synchronisation of triggering time
  - Custom belt tensioning reel
Proposed Test Dummy - Regulation

- Crashable Cyclist Dummy is in the process of being finalized
- Specifications will be included in Draft Regulation as soon as available
Test Setup

- $L$ – Impact location from front of truck
- $A$ – Initial lateral separation of HGV and Bicycle
- $R$ – Turning Radius of HGV
3 Test Cases: Presentation of Results

- **Case 1**
  \(R=5\text{m}, L=6\text{m}, A=1.5\text{m}, v_{HGV}=10\text{km/h}, v_{Bicycle}=20\text{km/h}\)

- **Case 4**
  \(R=10\text{m}, L=0\text{m}, A=1.5\text{m}, v_{HGV}=10\text{km/h}, v_{Bicycle}=20\text{km/h}\)

- **Case 6**
  \(R=25\text{m}, L=6\text{m}, A=4.5\text{m}, v_{HGV}=20\text{km/h}, v_{Bicycle}=10\text{km/h}\)
Test Case 1 (Example)

4s TTC for bicycle start is too low - cycle still accelerating at LPI. Longer propulsion system needed for this.
Test Case 4 (Example)
Test Case 6 (Example)
Test Results and Conclusions

- Prototype information system implemented in HGV
- Test Scenarios carried out:
  - Case 1, 0/4 tests passed, bicycle movement starts late
  - Case 4, 4/4 tests passed
  - Case 6, 3/4 tests passed
  - Other test scenarios were not possible because of bug in dummy control software (to be fixed soon)
- Manual driving using cones is possible (driving robots not required)
- Manual speed control is possible
- Corridors for trajectory and speed will be defined
Conclusions

- Accidentology shows that accidents between truck and bicycle occur:
  - With right-turning trucks
  - Constant and slowly moving trucks and bicycles
  - Pedestrians are not relevant in these accidents
- A Test Procedure has been defined based on accidentology
  - Requirements for an information-only system
  - Test setup and pass criteria
  - Tools
- Verification Tests for 3 out of 7 test cases have been successfully performed