"An Evolution of Traffic Safety Measures - Accidents, Conflicts, Behavioural Observations and Task Analysis"

Prof. Dr. Wolfgang Fastenmeier
The Safety Continuum (I)

Safety

No hazard • Accident

Danger
The Safety Continuum (II)

- Dangerousness of Events
  - Traffic Conflicts
  - Near-Accidents
  - Accidents

- Standard Behaviour
  - Errors in Driving Behaviour
  - Frequency of Events

(Klebelsberg, 1982)
Interaction Model of the Road Traffic System

(Gstalter & Fastenmeier, 2010)
Problems of Accident Research

- Rare events with low reliability and predictive value with the exception of the assessment of trends in big collectives and over long periods of time
- Not all accidents are reported
- Accident protocols are distorted by questions of guilt and by lack of accuracy of information by accident witnesses and by subjective concepts of accident causation (“human failure”)
- Accident black spots usually only occur in sites with heavy traffic volume; black spot orientation for countermeasures is distorted by regression to the mean phenomenon
- The course of events leading to an accident can only be reconstructed in a retroanalytic fashion – it’s always a look back on critical events
- Underestimated significance of the haphazardness of accidents
- Accident data is not available for new traffic sites
- Before-after studies in safety evaluation take their time („waiting“ for accidents)
Alternative: Traffic Conflicts

Definition by Oslo Conference, 1977:

“A traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged.”
Traffic Conflict Techniques (TCT)

- Traffic Conflict Techniques (TCT) use subjective and/or objective data to indicate risk. Subjective methods operationalise the risk by evasive actions of road users (breaking or swerving). Objective measures use time-space criteria, e.g. time to collision (< 1.5 sec defines a conflict). But also this type of technique often uses human observers on the road.

- High match between subjective and objective methods (calibration studies)

- Most techniques differentiate between slight or serious conflicts (near accidents).

- Most investigations found positive correlations between accidents and conflicts on traffic sites (although this is not the principal purpose of TCT).

- TCT’s are mostly used for safety diagnosis of traffic sites or in the evaluation of safety measures in before-after studies.
Error Approaches

causes

Causal approach
Theoretical
System design
Why do errors occur?

Error

vs.

Probabilistic approach
Descriptive, empirical, pragmatic
Human reliability
System reliability
What errors do occur?

consequences
## Comparison of TCT and Error Approaches

<table>
<thead>
<tr>
<th></th>
<th>Traffic Conflicts Techniques</th>
<th>Error Approaches</th>
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<tbody>
<tr>
<td><strong>Diagnosis of</strong></td>
<td>Traffic sites</td>
<td>Quality of interaction between driver, vehicle and traffic environment</td>
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<tr>
<td></td>
<td>(Safety diagnosis using Before-after studies)</td>
<td>Driver assessment</td>
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<td>Effects of new technical systems</td>
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<tr>
<td></td>
<td></td>
<td>(Safety, MMI, Usability)</td>
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<tr>
<td><strong>Methods</strong></td>
<td>“On-site”-Observation by human observer</td>
<td>„In-car”-Driver behaviour observation</td>
</tr>
<tr>
<td></td>
<td>Technical recording of empirically observable events</td>
<td>Technical recording e.g. of car data</td>
</tr>
<tr>
<td><strong>Data</strong></td>
<td>Conflicts, Traffic violations, Traffic volume, Encounters</td>
<td>Errors, exposure, encounters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vehicle Dynamics</td>
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<td></td>
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<td>Physiological indicators, visual parameters</td>
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<td></td>
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<td>Self-assessment (Ratings, semantic differential)</td>
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<td></td>
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<td>Videorecordings and Videoconfrontation (Feedback to the driver)</td>
</tr>
<tr>
<td><strong>Evaluation-criteria</strong></td>
<td>Safety and effectiveness of traffic flow and interactions between traffic participants</td>
<td>Estimation of driver reliability</td>
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<tr>
<td></td>
<td></td>
<td>Comfort</td>
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<td>Acceptance</td>
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</table>

(from Gstalter & Fastenmeier, 2021)
Prerequisites for applying reliability analysis

- A definition and taxonomy of driving tasks
- A definition of correct behaviour in each of these tasks
- A list of errors as deviations from the correct actions
- An adequate observation method to register these events
Classification of driving tasks

Basic driving tasks

Tasks in longitudinal direction

Tasks in intersections

Other driving tasks

Definition of subtasks and segmentation in time and space

Analysis of behavioural requirements in subtasks

- Perception
- Expectations
- Judgement

- Memory
- Decision, Planning
- Driver action, car-handling

Additional attributes of task structure

Driver Errors

Assessment concerning

- Complexity
- Risk

Potential benefits

(from Fastenmeier & Gstalter, 2007)
Model of Information Processing (modified from Rasmussen, 1986)

Driver

Sensory signals of traffic situation

Unconscious Processes

Conscious Processes

Perception
- 1.1 Scan
- 1.2 Discover
- 1.3 Search

Expectation
- 2.1 - 2.7

Risk-monitoring

4.1 Long-term Memory
- Mental Models,
- Rules
- Procedures

4.2 Car-handling
- Checking
- e.g. 6.7

4.3 Rehearsal

Sequential Processor

3 Judgement
- 5 Decision/Planning

Mismatches Ambiguities

4.1 Lane keeping

Short-term Memory

Time-space Structures

(e.g. 6.1)

(e.g. 6.7)

(from Fastenmeier & Gstalter, 2007)
Subject Nr. ____  Measuring point ___1___3____6___8__

Situation type:  C1-K1 left

List of errors / Segments

1. Speed too fast
2. Speed oscillating
3. Inadequate acceleration
4. Inadequate deceleration
5. Headway too short (pushing)
6. Closing a narrow gap (squeezing)
7. Lateral distance too short to right side
8. Lateral distance too short to left side
9. No signals
10. Signals too late
11. Improper lane keeping at lane change
12. Inaccurate lane use at queuing space
13. Inaccurate lane use while turning
14. Inadequate lane choice
15. Adjustment too late
16. Adjustment wrong lane
17. Adjustment unsteady
18. Deceleration too late
19. Driving at yellow light
20. Jumping a red light
21. Not starting at green light
22. Entering junction not yet cleared
23. Persistent following
24. Does not use queuing space
25. Unassertive clearing of junction
26. Too far into crossing traffic
27. Unflexible at lane closures/bottlenecks
28. Other signing errors
29. Too far into pedestrian/cycle crossing
30. Impedes pedestrians
31. Impedes cyclists
32. Perseverance on right of way
33. Low checking ahead
34. Low checking to left
35. Low checking to right
36. Low checking to rear
37. Low lateral checking
38. No checking (glance sequences)

(Gstalter & Fastenmeier, 2010)
Example of a combined effort: Analysis of an Accident Black Spot

- Check of data sources
- Accident Analysis
  - Traffic Conflicts / Behav. Observations
- Data Analysis
  - Supplementary Task Analysis of related Driving and Cycling Tasks with SAFe
- Merging of Data and Derivation of Recommendations and Measures
## Accident Analysis

<table>
<thead>
<tr>
<th>Sum of Accidents</th>
<th>Accidents with Cycles</th>
<th>Percentage of Cycle Accidents with Personal Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>67</td>
<td>19 (28.4%)</td>
<td>63.0%</td>
</tr>
<tr>
<td>65</td>
<td>21 (32.3%)</td>
<td>58.3%</td>
</tr>
</tbody>
</table>
## Traffic Conflict Observations of 2 Days

<table>
<thead>
<tr>
<th>Observation Site</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Traffic Conflicts</td>
<td>17</td>
<td>12</td>
<td>16</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Observations</td>
<td>Observation Site</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Incoming car too far in cycle path</td>
<td>30</td>
<td>25</td>
<td>30</td>
<td>28</td>
<td>13</td>
</tr>
<tr>
<td>Pulling out and standing on cycle path</td>
<td>4</td>
<td>4</td>
<td>17</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Crossing forbidden zone</td>
<td></td>
<td></td>
<td>9</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>No signals while turning</td>
<td>9</td>
<td>24</td>
<td>30</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>Jumping red light</td>
<td>3</td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Incoming car ignores right of way of other cars</td>
<td>18</td>
<td>17</td>
<td>21</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Incoming car ignores right of way of cyclists</td>
<td>4</td>
<td>6</td>
<td>12</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Car pulling out ignores right of way of cyclists</td>
<td>1</td>
<td>1</td>
<td>27</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>Car on lane of bus- or Taxi</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Forbidden turning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>Velocity too high</td>
<td>4</td>
<td>8</td>
<td>16</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>
## Behavioural Observations of Cyclists

<table>
<thead>
<tr>
<th>Observations</th>
<th>Observation Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclist ignores stop-line of traffic lights</td>
<td>1</td>
</tr>
<tr>
<td>Incoming cyclist ignores right of way</td>
<td>2</td>
</tr>
<tr>
<td>Velocity too high (&gt; 20km/h)</td>
<td>3</td>
</tr>
<tr>
<td>Irregular movements of the cyclist</td>
<td>4</td>
</tr>
<tr>
<td>Correct checking before pulling out</td>
<td>5</td>
</tr>
<tr>
<td>Overtaking of other cyclist in forbidden zone</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Observations</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclist ignores stop-line of traffic lights</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Incoming cyclist ignores right of way</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Velocity too high (&gt; 20km/h)</td>
<td>8</td>
<td>18</td>
<td>18</td>
<td>26</td>
<td>15</td>
</tr>
<tr>
<td>Irregular movements of the cyclist</td>
<td>31</td>
<td>20</td>
<td>23</td>
<td>35</td>
<td>31</td>
</tr>
<tr>
<td>Correct checking before pulling out</td>
<td></td>
<td></td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Overtaking of other cyclist in forbidden zone</td>
<td>3</td>
<td>11</td>
<td>6</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>
Comparison of Accidents and Traffic Conflicts: Supplementary Analysis of Critical Driving and Cycling Tasks
Main Problems

Car Drivers:

- Cyclists are missed →
- “Looked but failed to see”: Driver looks, but he did not see the cyclist
- Cyclists approach unexpected: what is not expected is not searched for, what is not searched for, is not detected
- Drivers need at least 2 fixations (each ca. 300ms) plus 2 saccades (each ca. 50 ms) to spot the cyclists; if necessary repeatedly as cyclists are “too fast”
- Problem of Size Consistency (outline car vs. cycle) (“Size-Arrival-Effect”)

Cyclists:

- With eye contact: cyclists believe that drivers have seen them, which results in a (potential) misunderstanding (see above)
- Decision under uncertainty: does the car stop yes/no?
- Lack of cautious and careful behaviour, over-confident behaviour
In short: Achievement of Measures

- Number of accidents remains unchanged
- But this means an improvement:
  - Exposure in general was jumping up / especially for cyclists an increase of 35%
  - Less accidents between car drivers and cyclists
  - Shift to rear-end collisions between cars
Conclusions and Prospect

- A multitude of methods for different purposes has become available
- Greater efficiency of data gathering and better reliability of surrogate measures
- A more precise description and a deeper understanding of accident generating processes has been achieved
- Testing of hypotheses (e.g. developed from theories of driver errors) outmatches post-hoc assessments
Kontakt

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