How to assess traffic safety? - Adapting methods to future challenges

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Everybody is an expert

• Everybody is a road user 60-70 minutes every day
• Lots of opportunities to develop ”suitable” theories about what is unsafe and who to blame
• Theories can be built on almost non-existing knowledge
• Great risk that theories are conform to “political interests”
• Speed is most often not one of the major contributions
• Proper – and systematic – safety assessment is rare
• Real experts are not always popular
Assessment – low priority

- Large investments in infrastructure (road, vehicles, etc)
- Limited interest in follow-up
- Safety promotion means a lot of collisions with other interests – and - no one is ever congratulating you for “no crashes”
- Compare the zebra crossing – the most common safety feature for pedestrians

- No wonder that ”15 Md81 falls down” every day on earth
The Swedish zebra crossing

- Introduced 100 years ago
- Few drivers yielded for pedestrians
- Research in the 1980-ies: highest risk at pedestrian crossings

- Conclusion: Drivers must yield for pedestrians \(\Rightarrow\) New law 2001
- Result: Many more drivers yielded
- Pedestrians are less attentive
- Risk for pedestrians *increased* even more
More or less the same everywhere!?

- A meta analysis made on all studies on the effects of zebra crossings (Elvik et al)

<table>
<thead>
<tr>
<th>Injury accidents</th>
<th>Pedestrian accidents on 2-lane roads</th>
<th>-8</th>
<th>(-43;+51)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury accidents</td>
<td>Ped. acc. on multi lane roads</td>
<td>+88</td>
<td>(-32;+424)</td>
</tr>
<tr>
<td>Injury accidents</td>
<td>Ped. acc. on all roads</td>
<td>+44</td>
<td>(-6;+121)</td>
</tr>
<tr>
<td>Injury accidents</td>
<td>Motor vehicle acc.</td>
<td>+9</td>
<td>(+25;+59)</td>
</tr>
</tbody>
</table>
And what about...

- All other engineering measures (intersection design, round-abouts, etc)
- All IT-solutions, like Electronic Stability Control..., ABS, Emergency braking etc

How is safety defined and how is it assessed?
## ESC - All light vehicles

<table>
<thead>
<tr>
<th>Injury/fatality</th>
<th>Type of crash</th>
<th>Best estimate</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury</td>
<td>All crashes</td>
<td>-3 %</td>
<td>(-5;0)</td>
</tr>
<tr>
<td>Fatality</td>
<td>All crashes</td>
<td>-26 %</td>
<td>(-39;-10)</td>
</tr>
<tr>
<td>Injury</td>
<td>&quot;ESC-crashes&quot;</td>
<td>-23 %</td>
<td>(-29;-16)</td>
</tr>
<tr>
<td>Fatality</td>
<td>&quot;ESC-crashes&quot;</td>
<td>-58 %</td>
<td>(-75;-28)</td>
</tr>
<tr>
<td>Injury</td>
<td>Coll with ped, bic or animal</td>
<td>-14 %</td>
<td>(-28; +3)</td>
</tr>
<tr>
<td>Fatality</td>
<td>Coll with ped, bic or animal</td>
<td>+9 %</td>
<td>(-7;+28)</td>
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</table>

## ABS

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<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>All crashes</td>
<td>All crashes</td>
<td>+1%</td>
<td>(-4;+6)</td>
</tr>
<tr>
<td>All injuries</td>
<td>All crashes</td>
<td>0%</td>
<td>(-6;+6)</td>
</tr>
<tr>
<td>Fatalities</td>
<td>All crashes</td>
<td>+4%</td>
<td>(-6;+14)</td>
</tr>
</tbody>
</table>
And what about powerful cars

What role do they play in the interaction with different kind of road-users, particularly pedestrians and bicyclists....

.... And what is the result from a safety point of view

Get behind the wheel, take the reins of up to 445 horsepower and go from 0-60 mph in just 4.3 seconds. With this much electrifying power and precise handling at your command, every drive will be truly invigorating. [http://www.bmwusa.com/vehicles/5series.html](http://www.bmwusa.com/vehicles/5series.html)
We are lacking the pre-crash history

The lady from Växjö
We need **surrogates** to accidents

- Crashes are **rare events** and are therefore associated with random variation (e.g. In Sweden there were “only” 28 pedestrian fatalities last year….)
- **Not** all crashes are **reported** and the level of reporting is unevenly distributed
- The **behavioural** or situational aspects of the events are not covered by police accident data
- **Crash analysis is a desk tool, not a field tool**
- We need **link** between accidents and behaviours
Why has this not been more obvious???

• “… a great many issues regarding proximal safety indicator measurement and application that have been misunderstood and even misinterpreted by safety analysts in the past. This has resulted in a general lack of support for methods such as the Traffic Conflict Technique, and has hindered the wider application and development of proximal indicators as potentially useful and resource effective measures of traffic safety in their own right…. ” (see e.g. Migletz et.al., 1985; Svensson 1992)
The link is called conflicts…

Serious Conflicts
Slight Conflicts
Potential Conflicts
Undisturbed passages

Accidents

Hydén, 1987
Main sources

- Review of current study methods for VRU safety. InDeV, Deliverable 2.1 – part 4
- Surrogate Measures of Safety. Tarko et al. ANB20(3) Subcommittee on Surrogate Measures of Safety ANB20 Committee on Safety Data Evaluation and Analysis. 2009.
The pioneers
Perkins and Harris 1967 at General Motors - 1

• The task was to study intersections and see whether GM cars performed differently in comparison to other makes of car with regard to safety. This first definition of a conflict was mainly based on brake light indications without any severity dimension.

• Studied traffic conflicts in order to evaluate the traffic conditions that It took 30-40 years for the car industry to again demonstrate an interest in active safety issues, in the form of Naturalistic Driving Studies.
A lot of interest in the 1970-and 80-ies

Severity was introduced
Two main approaches:
• Subjective severity scaling
• Closiness in time and/or space
Subjective severity rating

Subjective scale

- 5-degree scale (1: Precautionary braking… 5: Emergency braking). Spicer, 1971
- PLANFOR 1972 (starting point in Sweden)
- Malaterre and Muhlrad 1977
- Amundsen & Larsen 1977
- Merilinna 1977
- Zimmermann, Zimolong and Erke, 1977
- Güttinger 1977
- RISSER 1977

Severity scale based on braking rates.

Closiness in time/space

- Time Measured till the potential collision moment (TMTC) - Hayward (1971):
- Time to Collision (TTC) - Richard van der Horst, 1982, 1990
- Time to Accident (TA), i.e. TTC at the moment of start of evasive action. Hydén 1975
- Deceleration maps (Hakkert et al, 1977)
Combinations

• Kulmala (1984) developed a technique similar to the Swedish (Time to Accident smaller or equal to 1.5 sec). A conflict is serious if the evasive action is deemed uncontrolled
• Baguley (1984) further developed the Spicer’s model:
  A combination between Time before possible collision, the Type of evasive action, Severity of the evasive action and the Distance between conflicting vehicles when evasive action is terminated
• TTC, PET and DST
• TTC and Time to Zebra
Observation methods

- Manual observers; subjective rating, on-site
- Manual observers – in car
- Semi-automatic video recordings and analyses (van der Horst, Hupfer)
- Automatic analysis (Laureshyn et al, Sayed, Saunier et al)
In-car observations - 1

The pioneer: Ralf Risser: The Austrian “Wiener Fahrprobe”

- **Two observers**: One; „Coding observer“ records all driving actions on every single section of the route with the help of a standardised observation sheet.
- The "Free observer“ registers behaviour that cannot be foreseen systematically in his/her own words, like illegal or dangerous types of behaviour that are not "standard", including traffic conflicts, where an evasive action is necessary to avoid an accident.
- The Vienna study showed heterogenous results: **correlations** between the accident record of the subjects and their conflict numbers on the standardized test course **were rather low (< 0.2)** whereas the **overall correlations** between conflicts and accident numbers on the various sections of the test-course **were fairly high** (between 0.3 and 0.5)
- Conflict definition according to a semantic approach: defined as an event with narrow or very narrow avoidance of an accident, avoidance is characterised by braking, swerving or accelerating (very rare); very narrow = no time for any other reaction than just evasion. The benchmark is the trainer, high interrater-correlation is the goal, discriminatory power is supposed to improve by frequent joint observation and discussion of events.
Lots of techniques in the 1970-ies - ICTCT

- Different techniques with very different scope
- Great interest ➔ the organisation of a workshop in Oslo 1977
- Oslo definition of a conflict:
  "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"
- ICTCT was informally established in 1979, and formally in Vienna 1988
- Attempts to overcome the differences: Three calibration studies: Rouen, France 1979; Malmö, Sweden 1983 and Trautenfels, Austria 1985
Malmö 1983

9 teams being here with payment from their own organisations

View from Bergsgatan to the north-east
### Teams and definitions in the Malmö Study

#### Participants in Malmö

<table>
<thead>
<tr>
<th>Country</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>Ralf Risser</td>
</tr>
<tr>
<td>Israel</td>
<td>Shalom Hakkert</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>Joop H Kraay, Siem Oppe, Richard van der Horst, Paul Bakker</td>
</tr>
<tr>
<td>Sweden</td>
<td>Sverker Almqvist, Torbiorn Carlqvist, Lars Ekman, Christer Hydén, Klas Odelid, Håkan Persson, Ulf Pettersson, Åse Svensson, Stefan Zablocki</td>
</tr>
<tr>
<td>USA</td>
<td>William T Baker, Jim Migletz</td>
</tr>
<tr>
<td>Denmark</td>
<td>Ulla Engel, Lars Thomsen</td>
</tr>
<tr>
<td>Finland</td>
<td>Risto Kulmala, Erkki Ritari, Tuula Saarelma, Kirsi Salusjärvi</td>
</tr>
<tr>
<td>France</td>
<td>Brigitte Baigné, Dali Bouroga, Nicole Muhlrad</td>
</tr>
<tr>
<td>Germany</td>
<td>Jochen Gassner, Wieland Wessel, Bernhard Zimolong, Herbert Gstalter</td>
</tr>
<tr>
<td>Great Britain</td>
<td>Chris Baguley, Robin Helliar-Symons, Allan Wheeler</td>
</tr>
</tbody>
</table>

#### Definitions, severity scaling

<table>
<thead>
<tr>
<th>Country</th>
<th>Conflict definition</th>
<th>Severity scaling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden 1</td>
<td>fixed threshold</td>
<td>X</td>
</tr>
<tr>
<td>Finland</td>
<td>threshold function</td>
<td>speed</td>
</tr>
<tr>
<td>Sweden 2</td>
<td>fixed threshold</td>
<td>average speed and type of read user</td>
</tr>
<tr>
<td>Sweden 4</td>
<td>threshold</td>
<td>X</td>
</tr>
</tbody>
</table>

**Table 2.1:** Conflict definition and severity scaling used by each of the teams.

ICTCT, Lund October 21 2016
Conclusion: Very different in scope, BUT they follow one and only one common severity dimension. TTC was the main contributor.

The one-dimensional severity scale

Thank you Siem!!!
After some down period – new born interest

New approaches - 1

Lots of TTC variations

- Time-To-Zebra
- Time-To-Lane Crossing
- Reciprokal ttc, i.e. 1/TTC
- Time Exposed TTC (TET)
- “Examining the entire TTC curve”
- Calculations of TTC based on the closest distance between two vehicles, and the “closer rate”
New approaches - 2

- Deceleration to safety time (DST): Hupfer, 1997
- Safe stopping distance: Oh et al, 2006
- Potential Collision Speed (PCS): Mc Carley et al, 2007
- Delta-V: Johnson & Gabler, 2012
- Subjective assessment of risk (severity classification). Kocarkova 2012
New approaches - 3

• **Extreme Value Method**: Estimating the frequency of crashes based measured crash proximity (Songchitruksa and Tarko (2004). The EVM represents three considerable advantages over the traffic conflict technique:

• 1. The EVM abandons the assumption of a fixed coefficient converting the surrogate event frequency into the crash frequency,

• 2. The risk of crash given the surrogate event is estimated for any conditions based on the observed variability of crash proximity without using crash data,

• 3. The crash proximity measure precisely defines the surrogate event.

• The surrogate event selected in these studies….. was PET shorter than six seconds(!???)

ICTCT, Lund October 21 2016
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Various safety implementations

Safety criteria; examples from AAP and Google Scholar

Safety surrogate histogram, Aggregated Crash Index, rear-end collision risk index (RCRI), a multi-stage modelling framework, combination of conflicts and serious conflicts, continuous speed profiles, crash precursor events, risky behaviours/higher deceleration rate/higher non-stop right-turn rate/higher right-turn speed at stop line, post-encroachment time between cyclists and vehicles, weighted indicator aggregation for each interaction pattern

Impressive

Intellectual efforts – however the link to crashes is largely missing
Validity

• Is there any consensus??
• Hauer (Ezra) opposed the very idea of predicting accidents, ....... there was a greater need to prevent accidents rather than predict them
• Validity, according to Hauer and Gårder (1986): $\lambda=\pi c$
  - (Number of crashes expected to occur on an entity during a certain period of time ($\lambda$) = crash-to-surrogate ratio for that entity ($\pi$) x number of crash surrogates occurring on an entity in that time (c) or $\lambda=\pi c$)
• 'valid' if it produces unbiased estimates, the variance of which is deemed to be satisfactory
• The method producing the most unbiased estimate with the smallest amount of variance is that with the greatest degree of validity
• “An interesting finding with regard to these issues, is that proximal safety indicators can in some cases be a better predictor of the expected number of accidents than historical accident data (Migletz, Glauz and Bauer, 1985; Svensson, 1992).”
Validity – cont.

• … is not a matter of yes or no
• Validity is a concept that has to be “pursued” but cannot be completely “attained” (Brinberg & McGrath, 1985)
• Whether a certain level of validity is considered “sufficient” is therefore usually rather a matter of argumentation, debate and consent than a measurable aspect that should exceed a certain threshold.
Surrogate measure?

- “A surrogate measure should be based on an observable non-crash event that is physically related in a predictable and reliable way to crashes”
- “There exists a practical method for converting the non-crash events into a corresponding crash frequency and/or severity”. (Tarko et al. 2009)
Validation of the US technique(s) - 1

- Baker (1971) …strong correlations but difficult to interpret: “The data compiled in this study tend to support the hypothesis that conflicts and accidents are associated”
- Baker (1972) investigated the statistical relationship between accidents and conflicts based upon a field study. The collected data confirm the hypothesis that conflicts and accidents correlate, be it that the correlation was not very high. The used conflict technique appeared to be better applicable at intersections with low traffic volumes; according to Baker, this conflict technique can also be applied at other locations than only intersections.
Validation of the US technique(s) - 2

• Migletz et al 1985, used a modified version of the original technique where TA＞1.5 s: … there seems to be no observable advantage of using accident data compared to conflict data”

• Lord (1996) studied different conflict definitions..... conflicts with TA＜1.5 s had a significant correlation to the expected number of conflicts

• Paddock (1974) continued working with the General Motors technique…..can be a surrogate for accident studies, but also provides insight in the whole accident causation process.
Use of surrogate(s) and/or validation attempts - 1

- Spicer, 1971 (subjective scale): The rank order correlation between collisions and serious conflicts measured by time of day and place on the road appeared to differ significantly from zero. Spicer (1972) confirmed the earlier findings of the 1971 study; moreover, he found a stronger correlation between conflicts and accidents as the traffic volumes increased. Spicer (1973) repeated the 1971 study by adding another five intersections. Again, a significant relationship was found between conflicts and accidents, including a distinction by manoeuvre and by place on the road. Spicer concludes that his results justify the use of their conflict technique as a fast method to specify the safety of intersections.
• Erke & Zimolong, 1978 (subjective scale): …. similar traffic situations (manoeuvre, type of road user) have been distinguished with for some traffic situations highly significant correlations between observed conflicts and matching registered accidents.

• Malaterre and Muhlrad, 1976. …. found a significant relationship between conflicts and accidents and between conflict type and type of accidents.

• From the analysis of near-accidents, Hayward concluded that a time lower than one second would be a good criterion for near-accidents.
Clustering Surrogate Safety Indicators to Understand Collision Processes

- This work proposes a new similarity measure for time series that is applied to surrogate measures of safety and other indicators characterizing road user interactions.
- The method is applied to five indicators, including time to collision and probability of collision, for a large real-world dataset of traffic videos of collisions and conflicts.
- The results confirm the general assumption of surrogate methods for safety analysis that some interactions without a collision have very similar processes to collisions.
- It also highlights the danger of using a significant proportion of candidate interactions without a collision that seem to share little similarities with collisions.

(Clustering Surrogate Safety Indicators to Understand Collision Processes. Saunier & Mohamed. Department of Civil, Geological and Mining Engineering Polytechnique Montréal. August 1, 2013)


Accidents and conflicts: ...a sudden reaction presumed to be an avoidance manoeuvre
Large Scale Automated Analysis of Vehicle Interactions and Collisions. Saunier et al 2010

- The paper presents a refined probabilistic framework for the analysis of road user interactions…. the identification of potential collision points is used to estimate collision probabilities and their spatial distribution can be visualized.
- **Probabilistic time to collision** is also introduced, and interactions are categorized in four categories: head-on, rear-end, side and parallel.
- The framework is applied to a **large dataset of video recordings**
- …tackle the challenge of **automatically monitoring** all road users, including pedestrians, and extracting their trajectories. The data is collected using video sensors and computer vision techniques to process the video data
- the road users **could be tracked and their interactions studied**,
- The results demonstrate the **usefulness** of the approach in studying road user behavior and mechanisms that may lead to collisions.
Mining Microscopic Data of Vehicle Conflicts and Collisions to Investigate Collision Factors. Saunier et al, 2011

- The first phase of the project reported in this paper used microscopic data extracted from video sensors and data mining techniques to identify patterns in the traffic event database.
- This approach was demonstrated on a data set collected in Kentucky of 295 traffic events and contained 213 conflicts and 82 collisions.
- The decision tree confirmed the importance of evasive action in the interaction outcome. Three clusters were found from speed indicators extracted from road users’ trajectories: the cluster containing the fewest collisions had the lowest speeds of the three.
- …hints at the existence of conflicts that are dissimilar from most collisions and may therefore not be suitable for surrogate safety analysis.
Use of surrogate(s) and/or validation attempts - 6
Cross-comparison of three surrogate safety methods to diagnose cyclist safety problems at intersections in Norway

- Video data from three intersections in Norway
  1. **Three methods**: the Swedish traffic conflict technique (Swedish TCT), the Dutch conflict technique (DOCTOR) and the probabilistic surrogate measures of safety (PSMS) technique developed in Canada.
  2. The methods show similarities or are at least “compatible” with the accident records.
  3. PSMS reports many more safety-relevant interactions including less severe events. The location of the potential collision points is compatible with what the conflict techniques suggest, but the possibly significant share of false alarms due to inaccurate trajectories extracted from video complicates the comparison.
  4. Due to extensive use of microscopic data, PSMS technique relies heavily on **automated tracking of the road users** in video.
  5. However, **several limitations of the video** as a data source have been experienced
  6. The tested techniques still require enhancement, with respect to **... further validation**.

(Cross-comparison of three surrogate safety methods to diagnose cyclist safety problems at intersections in Norway. Laureshyn et al, *Accident Analysis & Prevention*, Available online 8 June 2016)
Use of surrogate(s) and/or validation attempts - 7

A comparison of collision-based and conflict-based safety evaluations: The case of right-turn smart channels

• Another objective of the paper was to compare the results of the collision-based evaluation with the results of a traffic conflict-based evaluation of the same treatment intersections. The comparison showed remarkable similarity between the overall and the location specific reductions in conflicts and collisions which provides support for using traffic conflicts in BA studies. The results also provide positive empirical evidence that can support the validity of traffic conflict techniques.

• 1/Sacchi, Sayed & deLeAA(59(2013)260-266
Use of surrogate(s) and/or validation attempts - 8
Investigating the gender differences on bicycle-vehicle conflicts at urban intersections using an ordered logit methodology

• Road user trajectories were automatically extracted, classified, and filtered using a computer vision software to yield 1514 interactions

• The discrete choice variable was generated by dividing post-encroachment time into normal interactions, conflicts, and dangerous conflicts. Stipancic et al. AAP Vol 97, Dec 2016
  • The discrete choice variable was generated by dividing post-encroachment time into normal interactions, conflicts, and dangerous conflicts. (>5s, 3-5se and <3s)

• Results indicated that an ordered model is appropriate for analyzing traffic conflicts and identifying key factors.

• These results will **contribute to and further the understanding** of gender differences in cycling within North America.

1/ Stipancic et al, AAP 97 (2016) 19-27
Largest safety studies: Analysis of Naturalistic Driving Study Data.

Project: Safer Glances, Driver Inattention, and Crash Risk

“A near crash involves any circumstance that requires a rapid, evasive maneuver by the subject vehicle, or any other vehicle, pedestrian, cyclist, or animal to avoid a crash. A rapid, evasive maneuver is defined as a steering, braking, accelerating or any combination of control inputs that approaches the limit of the vehicle capabilities. As a general guideline, subject-vehicle braking greater than 0.5 g or steering input that results in a lateral acceleration greater than 0.4 g to avoid a crash constitutes a rapid maneuver.”

No validation of surrogates: “As more crashes become available for analyses in the SHRP 2 data set, this near-crash surrogate issue can be investigated further and perhaps modeled”.

1 Victor et al. Transportation Research Board Washington D.C. 2015
Use of surrogate(s) and/or validation attempts - 10
Validation of Naturalistic Driving Studies – 2 (Aus)
The Australian 400-Car Naturalistic Driving Study:

……and, although large-scale studies may yield thousands of near-crash events, the **validity of near-crash events as surrogates for crash events remains unresolved**.

<table>
<thead>
<tr>
<th>Report</th>
<th>Criteria</th>
<th>&quot;Proof&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baker 1971</td>
<td>GM</td>
<td>…conflicts and accidents are associated</td>
</tr>
<tr>
<td>Baker 1972</td>
<td>GM</td>
<td>conflicts and accidents correlate</td>
</tr>
<tr>
<td>Migletz et al 1985</td>
<td>TA&lt;1.5s</td>
<td>no observable advantage of using accident data compared to conflict data</td>
</tr>
<tr>
<td>Lord 1966</td>
<td>TA&lt;1.5s</td>
<td>&quot;no observable advantage of using accident data compared to conflict data”</td>
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<td>Paddock 1974</td>
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<td>can be a surrogate for accident studies, but also provides insight in the whole accident causation process.</td>
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<td>Definition(s)</td>
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<tr>
<td>------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Hayward 1972</td>
<td>TMTC</td>
<td><strong>a time lower than one second</strong> would be a good criterion for near-accidents.</td>
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<tr>
<td>Saunier &amp; Mohamed 2013</td>
<td>Five indicators, including time to collision and probability of collision</td>
<td>that some interactions without a collision have <strong>very similar processes</strong> to collisions.</td>
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<tr>
<td>Saunier et al, 2010</td>
<td>Safety Indicators</td>
<td>The results demonstrate the <strong>usefulness of the approach</strong> in studying road user behavior and mechanisms that may lead to collisions.</td>
</tr>
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<td>Saunier et al, 2011</td>
<td>Mining Microscopic Data of Vehicle Conflicts and Collisions to Investigate Collision Factors</td>
<td>importance of evasive action in the interaction outcome…. the existence of conflicts that are dissimilar from most collisions and may therefore <strong>not be suitable for surrogate safety analysis</strong>.</td>
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<tr>
<td>Sacchi et al 2013</td>
<td>A comparison of collision-based and conflict-based safety evaluations:</td>
<td><strong>remarkable similarity</strong> between the overall and the location specific reductions in conflicts and collisions…. <strong>support the validity</strong> of traffic conflict techniques.</td>
</tr>
</tbody>
</table>
### Summary of validation studies - 2

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<th>Definition(s)</th>
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<td>Laureshyn et al 2016</td>
<td><strong>Three methods</strong>: Swedish TCT, DOCTOR and the probabilistic surrogate measures of safety (PSMS) technique developed in Canada.</td>
<td>The methods show similarities or are at least “compatible” with the accident records. PSMS reports many more safety-relevant interactions including less severe events. …..possibly significant share of false alarms due to inaccurate trajectories extracted from video complicates the comparison. Constitutes a rapid maneuver … a sudden reaction validity of near-crash events as surrogates for crash events remains unresolved</td>
</tr>
<tr>
<td>Victor et al, 2015 Buch &amp; Jensen Regan 2013</td>
<td>(No validation of surrogates) Conflicts (No validation of surrogates)</td>
<td></td>
</tr>
</tbody>
</table>
Two durable techniques

• The Dutch technique DOCTOR

• The Swedish Traffic Conflicts Technique
DOCTOR - Dutch Objective Conflict Technique for Operation and Research

- Encounter
- Critical situation
- Conflict
  - Conflict Severity (overall)
  - Probability of collision
  - Extent of consequences (injury severity)

Courtesy: Richard van der Horst
Extent of consequences (injury severity)

- Conflict type (who -> who)
- Speed
- Evasive action
  - No reaction
  - Controlled
  - Uncontrolled
- Type of action
  - Braking
  - Accelerating
  - Swerving

Courtesy: Richard van der Horst
a/ Probability of collision, defined by

![Diagram of TTC and PET scales]

b/ Overall Severity of conflict according to DOCTOR

<table>
<thead>
<tr>
<th>Extent of consequences</th>
<th>Probability of collision</th>
<th>TTCmin</th>
<th>PET</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No 2-1.5 1.5-1 1.0-0.5 0.5-0</td>
<td>&gt;1.0 1.0-0.5 0.5-0</td>
</tr>
<tr>
<td>0 very small</td>
<td>- - - 1 1 2</td>
<td>- - 1 2 3</td>
<td>- 1 2</td>
</tr>
<tr>
<td>1 small</td>
<td>- - 1 2 2/3 3</td>
<td>- 1 2 3</td>
<td>- 1 2</td>
</tr>
<tr>
<td>2 reasonably large</td>
<td>- 1 2 2/3 3 4</td>
<td>1 2 3</td>
<td>- 1 2</td>
</tr>
<tr>
<td>3 large</td>
<td>1 2 2/3 3 4 5</td>
<td>2 3 4/5</td>
<td>- 1 2</td>
</tr>
</tbody>
</table>

Extent of consequences based on type of road user (mass, vulnerability), who is approaching who, approach speed, controlled or uncontrolled evasive action (swerving, braking, accelerating, etc.)

Courtesy: Richard van der Horst
Validation efforts - 1

- Observation of 4 blackspots in 2-yr period
  - Pijnacker (T-junction) + Delft (3 signalized intersections)
- Rough data: 8 years of video material
- Selection: Collisions (# police-reported?) whole period
  Incidents when observed
  Conflicts (analyses ala ‘DOCTOR’ method) one day

- Methodology to determine driver behavior in the pre-crash phase
- Insight in the chain of elements of human behavior that either is resulting in, or avoiding an accident

Courtesy: Richard van der Hors
ICTCT, Lund October 21 2016 52
Validation efforts - 2

- VIDARTS (VIDeo-based Analysis of Road Traffic Scenes)
- collisions and conflicts

Transformation from video to street
Semi-automatic procedure
-\( V, \text{DIST}, \text{TTC}, \text{TTC}_{\text{min}}, \text{PET}, \text{etc.} \)
Validation efforts - 3

- Traffic conflicts and analysing deviant behaviour together with road scene analyses give good insight in potential traffic safety problems at intersections. Good resemblance with results analysis of collisions from video.
- Remarkably, frequently, another road user (in)directly involved in pre-crash process
- Observing and scoring conflicts according to DOCTOR method from video feasible and advantageous compared to original method with observers on the street
- Time-related measures such as TTC and PET are promising surrogate safety measures for predicting accident risks by microscopic traffic simulation models
Renewed interest in Traffic Conflict Technique DOCTOR

- Bicycle- bicycle conflicts: a systematic observation of behaviour from video
- Evaluation of attention-increasing measures at a black spot intersection (Hillegersberg)
- PROLOGUE, combination of in-vehicle and site-based observations
- Evaluation of small-scale infrastructural measures at rural black spots in Bangladesh
- EU-proposal InDeV: In-Depth understanding of accident causation for Vulnerable road users
To conclude

• We do not have to wait for accidents for improving road environment and traffic management
• Systematic observation of behaviour (including traffic conflicts) already gives you lots of clues for improving road safety at intersections
• Also good basis for the development of in-car systems
• Site-based observations complementary to naturalistic driving studies
• Strong need for automated video analysis of road user behaviour-> good progress, InDeV project!
• Link between TTCmin (NL) and TTA (Lund)?
  – TTCmin = -1.43+0.96*TTCgas
The Swedish Traffic Conflicts Technique

Two basic concepts

– Time to Accident (TA); time to the potential collision point from the moment one of the road users starts an evasive action

– Conflicting Speed (CS); speed from the moment one of the road users starts an evasive action
Definition of alternative severities and severity zones for testing-

1/ The risk in terms of accident to conflict ratio should increase continuously from the "lowest" zone.
2/ Accident severity, i.e. number of fatal and serious injuries in relation to the total number of injuries should increase with zone.
Conflicts (4-6 hours) and 6-7 years of accident data from 115 intersections

Car - Pedestrian

(Time to Accident (TA))

(Collision Speed (CS))

Conflicts

Accidents

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From: Hydén 1987
ALT.DEF 2 fulfilled the criteria best

For definition of a serious conflicts

0,5 seconds margin was added

Conflicting Speed (kph)

kph

TA-value(sect)

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Conflicts and accidents belong to the same process, just with different degree of seriousness (most often)

- Patterns are very alike
- Accidents have a TA-value that is approx 0.5 seconds smaller and a CS that is approx 10 km/h higher than serious conflicts
- Accidents represent a logical continuation of the serious conflicts on a severity scale
Conversion factors ($\pi$)
Conflicts to accidents

<table>
<thead>
<tr>
<th>Traffic class</th>
<th>Car - Car</th>
<th>Car-Unprotected road-user</th>
</tr>
</thead>
<tbody>
<tr>
<td>1+2</td>
<td>3.3 (2.2-6.0)</td>
<td>15.5 (12.7-19.1)</td>
</tr>
<tr>
<td>3+4</td>
<td>12.1 (9.4-16.3)</td>
<td>86.9 (70.4-106.9)</td>
</tr>
</tbody>
</table>

The values should be multiplied by $10^{-5}$. The 90% confidence intervals are within brackets.
Swedish TA versus TTCmin

TA=1.1sec

CS=43km/h

TA=1.1sec
Use of the Swedish Technique

- Lots of presentations, training courses and projects using the TCT – for almost 40 years - much thanks to Sverker (Almqvist)

Large-scale trial with 21 small roundabouts

- A two year project in Jaipur India. (Åse and myself)

- No routine-based use(rs)
"Collision course"

- Rural much more complicated than urban, much greater distances, many more potential outcomes
- Serious conflicts are different from non-serious conflicts, much shorter distances
- Advanced algorithms does not seem necessary regarding serious conflicts
- Rear end conflicts very different
- With automatisation; much more advanced algorithms possible – however – to what benefit?
Methodological issues - 2

Why only the **serious** conflicts?

- Chin and Quek (1997) suggest that discounting the information from ‘*slight*’ and ‘*moderate*’ conflicts is contrary to the main intention of proximal safety indicators, which is to provide a more comprehensive source of information than accident data.

- Swedish researcher Svensson (1998) has studied the frequency patterns of both serious and non-serious conflicts and concluded that there may be significant differences in the shape of the ‘*safety pyramid*’

- Actually; **every** single event has its ”safety history”, however only serious conflicts are ”good enough” crash surrogates
Evasive action

• Archer 2005: Not all the specified driver actions are necessarily evasive in nature….but rather as a precautionary action to reduce the risk potential.

• The argument that accidents are preceded by conflicts suggests that conflicts, in terms of evasive actions, must exist prior to an accident occurrence. This assumption has often been questioned - It has been pointed out that many accidents and near misses have arisen largely because drivers have failed to take any action in the first place.

• Comment:
  • If perceived collision course: The intention is always to take evasive action.
  • If failed: The Time to Accident (TA) = 0, equal to Class 5 in the Bristish (and others) severity scale
Methodological issues - 4

Reliability

- Little research
- OK, with training;
  - (eg. Shinar 1984: objective measure and two subjective measures. Correlations among the subjective measures and between the subjective measures and the objective measure…. The results yielded high intrarater and interrater reliabilities (\( .82 \leq r \leq .99 \)) and moderate concurrent validity relative to the objective measures (\( .43 \leq r \leq .66 \))
- DOCTOR and the Swedish Technique are tested "sufficiently enough"
- Automatisation raise new (big!) reliability questions
Probability of a collision and potential outcome of a collision

- Mostly focus on probability only
- Some few attempts to combine
- Swedish TCT is one; however it has a “poor model”
- DOCTOR is the main exponent for the combined measure, but validity?
- If validation based on probability is very challenging it is of course nothing compared with validating probability and outcome simultaneously
Validity – characteristics used

- Are associated
- Correlate
- No observable advantage (using accident data)
- Can be a surrogate
- Differ significantly from zero
- Stronger correlation (as traffic volumes increase)
- A significant relationship
- Highly significant correlations
- A time lower than one second (a good criterion for near-accidents)
- Very similar processes
- Usefulness of the approach
- Importance of evasive action
- ..not be suitable for surrogate safety analysis. (events dissimilar from most collisions
- Constitutes a rapid maneuver
- support the validity ..... remarkable similarity
Methodological issues - 7

Validity – valid "enough"?

• Characteristics do not seem to be “durable enough” because of few examples of continued efforts
Validity and/or Implementation

• Either validation and (almost) no implementation, or

• Implementation and (almost no) validation

• No large scale, long-term investments any more?

• Everybody has to write articles!
Implementation?

• Few examples! WHY?
• Naturalistic Driving Studies – valid results?

(However, further work is necessary to validate these scales. .......

........some activity types significantly increase risk (such as Texting and the aggregate category of Portable Electronics Visual-Manual). However, for Talking/Listening on Cell Phone, a strong significant decrease in risk was found.

• DOCTOR
• Swedish TCT
Automatisation - 1

- During a number of years, the English Transport and Road Research Laboratory (TRRL) focussed on the automated detection of vehicles with sensors in the road surface and a computer system to identify conflict situations (Older & Shippey, 1977). However, this development was stopped due to severe complications.
- Particularly Richard van der Horst but also Christoph Hupfer used semi-automatic techniques at early stages.
- Aalborg University (Tanja Kidholm Osmann Madsen) is developing a watch-dog function. I hope to assist a little… City of Bogota is ready to provide up to 12 hours (in a first stage) of video recordings from any of more than hundred cameras in any wished for direction
- Nicolas Saunier/Tarek Sayed (et al) and Aliaksei Laureshyn (et al) represent the driving force when it comes to utilising automatic techniques for ”conflict studies”
Automatisation - 2


• The interactions detected by the system as rear-end or head-on cover a lot of “normal” interactions, or at least not as severe as some computed indicators could imply. These limits are first and foremost the limits of the current video-based systems for road user detection and tracking in urban intersections. The second source of errors in this analysis was the challenging data quality and the lack of information.

• However, it is the authors’ belief that this system can be useful in the exploration of road safety data.
Automatisation - 3

• ..the semi-automated software T-**Analyst**. This software was developed at Lund University, Sweden, and is aimed at managing large amounts of detections in long video recordings. (T-Analyst, 2016. Software for Semi-automated Video Processing (accessed 18.02.16.). [www.tft.lth.se/software](http://www.tft.lth.se/software).

• The second important element of this approach is automation, as road user trajectories have to be extracted automatically, usually from video data, to make the application of the described framework practically feasible.

• ….but the **possibly significant share of false alarms** due to inaccurate trajectories extracted from video complicates the comparison….

• (Cross-comparison of three surrogate safety methods to diagnose cyclist safety problems at intersections in Norway Laureshyna, de Goede, Saunier, Fyhri. AAP xxx-2016)
Future?

• A great deal of safety improvements are regularly initiated by the car industry. What criteria are those improvements based on, and how is safety assessment carried out.
• Assessment based on scientifically validated techniques will become more and more important
• Cost – effective data collection is no.1 priority
• Validity issues i no. 2
• Broadened scope – cf Liveable cities – makes it important to have ”safety-related” surrogate, complemented with relevant behavioral measures
• We have to strengthen our position as the experts…
Future!

• And keep pushing the obvious fact; namely...

• Behavioural and conflicts are natural elements in safety assessment.
THANK YOU

GOOD LUCK