Video-recorded accidents, conflicts and road user behaviour: a step forward in traffic safety research

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Abstract

TNO Human Factors conducted long-term video observations to collect data on the pre-crash phase of real accidents (what exactly happened just before the collision?). The video recordings of collisions were used to evaluate and validate the safety value of in-depth accident analyses, road scene analyses, and behavioural observations (including traffic conflicts). Digital video recordings have been made at four urban intersections for a period between 19 and 22 months (24 hours/day). Collisions and conflicts have been analysed quantitatively using the VIDARTS (VIDeo Analysis of Road Traffic Scenes) approach and conflicts scored according to the criteria of the DOCTOR (Dutch Objective Conflict Technique for Operation and Research) technique.

In total sixteen collisions could be identified from video, ten car-car collisions, two single-vehicle accidents, two car-bicyclist/moped collisions, one single-bicyclist and one single-scootmobiel accident. For each collision, a detailed description is available of the process just before and during the collision phase. The conflicts that were scored (either randomly during the collision scanning process or systematically for one day) clearly illustrated typical safety problems and resulted in several observations about the typical lay-out and functioning of the intersection at hand. As an example, this is illustrated for one of the four intersections.

In general, traffic conflicts and deviant behaviour, together with road scene analyses give a good insight in potential safety problems at specific intersections from a road users’ perspective. The collected collisions helped a lot to get a better insight in accident causation processes and to value the results of conflict observations and road scene analyses. With respect to the collisions, remarkably, in most cases, another road user was (in)directly involved, either as a distracting or as a contributing element. Time-related measures such as Time-To-Collision (TTC) and Post-Encroachment Time (PET) are promising surrogate safety measures for analysing encounters between road users at intersections and certainly have potential to serve as predictors of accident risks, for example for the development and application of traffic safety modules in microscopic traffic simulation models.

Introduction

The project Integral Approach of the Analysis of Traffic Accidents IAAV (in Dutch: Integrale Aanpak Analyse Verkeersongevallen) was initiated by three TNO institutes (Automotive, Human Factors, and Prevention and Health), all being involved in traffic accident research from their own expertise perspective. The main objective of IAAV is the development of an integral multidisciplinary approach on the investigation of traffic accidents (Hoogvelt et al., 2007). As a part of this, the main contributions by TNO Human Factors included road scene
analyses (Van der Horst & Martens 2007) and video observations of both collisions and traffic conflicts (Van der Horst et al., 2007). Road-scene analyses have the purpose from a road-users’ point of view to identify road-scene elements that may incite road users to display (aware or unaware) high-risk behaviour, resulting in conflicts between road users, unsafe driving behaviour or even accidents. The current paper deals with the long-term video observations to collect data on the pre-crash phase of real accidents (what exactly happened just before the collision?) and traffic conflicts.

Accident statistics may have an important general monitoring function and form a basis for detecting specific traffic safety problems, but the information available from it is inadequate for analysing and diagnosing, defining remedial measures and evaluating effects. Systematic observations of driver behaviour, combined with knowledge of human information processing capabilities and limitations, offer wider perspectives in understanding the causes of safety problems and modelling driver behaviour in both normal and critical situations. The processes that result in near-accidents or traffic conflicts have much in common with the processes preceding actual collisions (Hydén, 1987), only the final outcome is different. The frequency of occurrence of traffic conflicts is relatively high, and they offer a rich information source on causal relationships since the preceding process can be systematically observed.

In the past, several Traffic Conflict Techniques (TCT) have been developed. In the Netherlands, the DOCTOR (Dutch Objective Conflict Technique for Operation and Research) method was developed by the Institute for Road Safety Research (SWOV) and TNO Human Factors. This TCT was primarily a result of an international calibration study which took place in Malmö under the auspices of the ICTCT (International Cooperation on Theories and Concepts in Traffic Safety) in order to compare existing techniques (Grayson, 1984). A comparison with video-taped conflicts and accidents (Van der Horst, 1984), indicated that severity scores, performed by individual observers, were mainly correlated to Time-To-Collision (TTC) and type of accident. The DOCTOR technique identifies a critical situation if the available space for manoeuvre is less than is needed for normal reaction (Van der Horst, & Kraay, 1986; Kraay, Van der Horst & Oppe, 1986).

Neither the analysis of accident statistics nor the study of road user behaviour include direct observation of accidents. When conducting road safety research, there is a real need to have reliable information on the pre-crash phase of an accident. Direct observation of actual collisions would help a lot to a better understanding of the causes of the underlying processes and safety problems (Noordzij & van der Horst, 1993). Moreover, the relationship between accidents and conflicts can be studied in detail if quantitative data on both the process resulting in accidents and the process resulting in conflicts are available. Van der Horst et al. (2007) give a detailed description of the long-term video recordings in the IAAV study. The focus of this paper is on the method of long-term video recordings and on an analysis of the traffic safety problems at one of the four IAAV locations based upon collisions, conflicts and deviant behaviour.

**Method**

**Selection of IAAV video locations**

The original IAAV project plan envisaged permanent video-observations at eight locations in Delft and surroundings for about one year (24 hours/day). The change from analogue to digital video (needed for the long-term recording period and the huge amount of video data to be stored) appeared to be much more complex than foreseen in the original plan. To reduce the amount of the (more expensive) equipment we limited the recordings to four locations for a two-year period. In this way, also the manual selection process of collisions by human observers (the developments in automatic image processing techniques appeared to be slower than anticipated in the beginning) was reasonably under control. The selection
of appropriate locations started with a check in the BLIK database of the Transport Research Centre of Rijkswaterstaat. A selection was made of intersections with a relatively high traffic accident record (minimally 4 police-reported accidents/year) in Delft and surroundings with high traffic volumes. 20% of all serious traffic accidents occur at such locations (Noordzij & van der Horst, 1993). Another important selection criterion for a suitable location is the potential for mounting a camera unobtrusively at a sufficiently high position. The following locations and observation periods have been realised:

- Location P1: Pijnacker (Vlielandseweg-Boezemweg), 1 November 2004 - 1 September 2006 (22 months),
- Location D1: Delft (Provinciale weg -Van Foreestweg), 1 November 2004 - 1 September 2006 (22 months),
- Location D2: Delft (Delflandplein), 1 March 2005 - 1 September 2006 (19 months),

**Location P1: Pijnacker, Vlielandseweg - Boezemweg**

![Figure 1: Left: Location P1 Pijnacker as seen from one of the two video cameras with the reference points for the transformation from the image plane to the plane of the street in blue and an example of a vehicle measuring point in red; Right: Layout of location P1 in Pijnacker with the directions indicated (1 = Boezemweg, 2 = Vlielandseweg direction Pijnacker, 3 = Vlielandseweg direction Zoetermeer.](image)

This is an unsignalised T-junction. The Vlielandseweg is a busy main road (speed limit 50 km/h) and the Boezemweg is the minor road that gives access to an industrial area. The Vlielandseweg has a one-sided two-way bicycle track, separated from the main road by interrupted concrete curbs, see Figure 1. Traffic from the Boezemweg has to yield to the traffic on the Vlielandseweg, indicated by a yield sign and yaw teeth marking on the road. Video recordings have been made by two surveillance cameras, unobtrusively mounted in two existing lampposts.

The other IAAV-locations are signalised intersections in Delft, Location D1: Provinciale weg – van Foreestweg/Ruys van Beerenbrouckstraat being a large-scale signalised intersection (see Figure 2, top left), Location D2: Delflandplein (Figure 2, top-right) is a large-scale and complicated signalised skewed intersection with approaches in a curve and three of the four approach directions being main-like roads including a separate tram/bus lane, and Location D3: Westvest – Zuidwal (Figure 2, bottom left), is a large-scale partly signalized T-junction. Bus traffic enters and leaves the intersection from and to a separate tram/bus lane by crossing the intersection in its own traffic light cycle phase. The bus lane at the intersection makes the lay-out of the intersection rather complicated. Van der Horst et al. (2007) give a more detailed description of these intersections.
Video recordings

The video recordings were made with one or two black/white CCD cameras and stored on 3 hard disks of a PC-based system that enabled continuous 24 h/day recordings for a period of at least two weeks. The video-images were stored as separate JPEG pictures in a time-directory structure (date, hour, minute). A time-lapse factor of four was used, resulting in 12.5 fields/s that were stored. In this manner, the Minute subdirectory contains 60 x 12.5 fields. Each field has a resolution of 768x288 pixels. In order to save some more disk space, special software was installed that enabled the exclusion of specific areas of no interest, and a motion detection filter that, in case there was no motion detected for several seconds, an image excluded from storing. After two weeks the 3 hard disks were exchanged by empty ones for a new recording period. The full hard disks were taken to the laboratory and scanned manually by human observers for collisions. After this, the hard disks were re-used.

Analysis

From the video recordings as stored on hard disks, collisions were selected manually by human observers. In a previous study it was already proven that the manual selection of collisions by observing video recordings eight times as fast as real time by human observers was a reliable and reasonably efficient procedure (van der Horst & Bakker, 1990). Unfortunately, the developments in automatic image processing techniques appeared to be
slower than anticipated in the beginning of the project. Apart from the real accidents, about
400 peculiar/deviant/striking events have been more or less randomly selected by the human
observers. The video scenes of the collisions and of these events were stored separately on
hard disk units of the analysis computer and saved for later analysis.

The more or less randomly selected events by the human observers have been inspected for
a second time. This process resulted in a limited number of conflicts and some observations
about the functioning of the intersection at hand. In case of a conflict, these situations have
been analysed quantitatively and scored according the criteria of the DOCTOR methodology
(Kraay, van der Horst & Oppe, 1986) (except that these scores were given from a judgment
of the video images and not directly by observers in the field). The severity of the conflict is
scored on a scale from 1 to 5, taking into account (1) the probability of a collision and (2)
the extent of the consequences if a collision had occurred. The probability of a collision is
determined by TTC and/or the Post Encroachment Time (PET) (Van der Horst, 1990). The
extent of the consequences if a collision course had occurred is mainly dependent on the
potential collision energy and the vulnerability of the road-users involved. Affecting factors
are the relative speed, available and necessary space for manoeuvre, the angle of approach,
the type and condition of road-users, etc. Moreover, an arbitrary day has been taken for
each location for which potential conflict situations have been selected.

The stored collisions and conflicts were analysed quantitatively. This analysis consisted of
measuring positions of tires on the road surface in the video co-ordinates, a transformation
to street co-ordinates, and for each time step (every 0.08 s) calculating derivative measures.
In this manner, trajectories of the road users involved became available. The measures
included speed, acceleration, and interaction measures relative to the other road user
involved such as mutual distance, Time-To-Collision (TTC) en Post-Encroachment Time (PET)
with the help of the VIDARTS (VIdeo Analysis of Road Traffic Scenes) technique (van der

Collisions, conflicts and deviant behaviour

In this section, the results of the quantitative analysis of collisions, conflicts and deviant
behaviour are presented in detail for one of the four IAAV video locations (location P1:
Pijnacker, Vlielandseweg - Boezemweg) as an example of the approach. In Van der Horst et
al. (2007) a detailed description of the collisions and conflicts at the other locations is given.

Collisions

At this location, a T-junction with a yield priority regulation, in total four collisions were
identified during the 22-months period of video observations, two car-car collisions, one car-
bicyclist collision and a single-bicyclist collision.

Car-car collisions

One car-car collision was a minor collision between a first car from the minor road and a
following car waiting behind the first car. The collision occurred at 12:15 h in the afternoon
with a sunny sky. The first car waited for a while (about 18 s) from the minor road, and
initiated a forward movement after five cars from the right had passed as well as three cars
on the main road had made a right turn from the left. The fourth car from the left went
right on at a speed of about 40 km/h and being suddenly confronted with the accelerating
car from the minor road, made a heavy evasive swerving manoeuvre into the lane for
opposing traffic. This interaction was scored as a very serious conflict (overall severity score
of 4) with a TTCmin of 0.5 s and high potential consequence score (see also the Conflicts
section). The minor road car driver braked hard and backed up. While doing this, he hit the
car waiting behind him. So, apparently, the driver from the minor road overlooked the fourth
car from the left, either because this car was at least partly occluded by the last car that
turned right or assuming this one would turn right as well (as did the three previous cars).
The second car-car collision occurred at 23:05 h at night, dry road. A car from the minor road approached the intersection, stopped for about 10 s to let a car from the right pass and started to accelerate while a car approaching from the left on the main road was about 60 m away. The speed of the main road car at that moment was a little over 20 m/s (72 km/h). At 1.6 s before impact the minor road car starts braking hard and stops halfway on the main road lane. 2 s before impact the main road car starts braking (he can not swerve because of an opposing car present) but is not able to stop in time and hits the minor road car in the front with a speed of about 20 km/h. There appears to be no personal damage, but the main road car is not able to start again and had to be pushed away from the main road by hand. Apparently, when deciding to proceed, the minor road driver was only focussing on the car from the right and did not pay attention to traffic from the left. While conducting the left turning manoeuvre he discovered the presence of the car from the left and stopped abruptly halfway in the path of the approaching car. The main road car braked with a moderate average deceleration level of 4.1 m/s².

**Car-bicycle collision**

This collision was the most severe one of the whole project with a bicyclist, crossing the main road just in front of a car, seriously injured. The accident at 8:25 h in the morning during dawn. It was dry weather, but the road surface was wet. A first van is turning left from the minor road after 3 cars from the right had passed. After the passing of a 4th car from the right, a second van from the minor road turns left. In the meanwhile a bicyclist is approaching the intersection from direction (2) on the separate bicycle track (see Figure 1) and wants to cross the main road to continue into the direction of the minor road. Also a car from direction (2) is approaching the intersection with a speed of at least 72 km/h. At time is 5.5 s before impact, the bicyclist is looking over his right shoulder to the right for the first time for about 1 s. His view on the main road car from (2) is occluded by the first van from the minor road that is now driving on the main road in direction (2). At 3.2 s before impact the bicyclist looks for the second time to the right for a short period of time (0.64 s). During this look he could have seen the main road car. The second van turning left from the minor road, is next to the bicyclist at 1.68 s before impact at the moment the bicyclist makes a right turn from the bicycle track to cross the main road diagonally directly behind this van. Apparently, the second look was rather short, more or less automatically made and of the type ‘looked but failed to see’ as he had decided to cross directly behind the van. The bicyclist is riding with a speed of about 5 m/s (18 km/h). At 1.1 s before impact the occlusion by the van is over, and, in principle, both road users involved could have seen each other again. At that moment the bicyclist again looks to the right and is initiating an avoiding manoeuvre by steering to the left but no escape from the collision is possible anymore. The speed of the car at that moment is still about 72 km/h. He starts braking but can not avoid the bicyclist anymore. The impact speed of the car hitting the bicyclist is about 18.4 m/s (66 km/h). The bicyclist is hitting the car in the front, is thrown into the air, and hits the top of the windscreen with his head about 0.32 s after impact. He makes a flip over and separates from the car at the right side at 1.1 s after impact, hits the road surface at 1.3 s and shifts over the road surface for about 1.9 s before laying still and out of consciousness. The bicycle was flying through the air, hit a fence at the corner of the intersection rather heavily with the rear wheel (that is indented because of this contact), bounced upwards while making a complete flip over and smashed down on the ground. The car has a braking distance after impact of about 29 m. The average deceleration level is 5.8 m/ s². At the moment of the collision, a little girl on a bicycle is waiting for turning left from the minor road. The bicycle is passing her in the air at a very short distance, and the bicyclist is getting to lie still just in front of her bike. She seems to be so shocked by the event that she turns and rides away.
**Single-bicycle accident**

This accident occurred at 19:49 h while it is dark (with public lighting on) and the road surface is wet. A bicyclist is coming form the minor road and wants to cross the main road to turn left and continue his path on the separate bicycle track at to opposite side of the intersection. He crosses the main road in front of a car coming from the left from direction (2), see Figure 1. That car is driving at a speed of 47 km/h. The car-bicycle encounter is a slight conflict (severity score 2) with a PET of 1.1 s and a high severity of the potential consequences. After the bicyclist has passed the pathway of the car he is unable to avoid one of the separation curbs between the main road and the bicycle path. He falls over his steer on the road surface, but does not seem to be hurt heavily as he stands up afterwards.

**Conflicts**

As indicated, apart from the collisions, the human observers also collected about 400 peculiar/deviant/striking events. The arbitrary day for which potential conflict situations have been selected was April 25th, 2006 for all four locations. Potential conflicts were selected during rush hour periods and a period in between, viz. 7:00 – 10:00 h, 11:00 – 14:00 h, and 15:00 – 18:00 h. For these periods, also traffic counts of relevant traffic flows were conducted from video (see Van der Horst et al., 2007).

The one day conflict observation at location P1 resulted in many potential or slight conflicts that were related to a left-turn manoeuvre from the minor road while interfering with traffic on the main road. On average, each hour 116 vehicles make the left-turn manoeuvre, with about 300 vehicles/hour on the main road in each direction. In the morning between 7:00 and 9:00, mainly bicyclists from the bicycle track cross the main road towards the minor road (113 in total), in the evening (16:00-18:00) the opposite movement is most common (120 bicyclists in total). Table 1 only gives the severe conflicts (score 3 or higher). Conflict 444 and 446 typically represent the conflicts of vehicles turning-left from the minor road while traffic from the left has to react in order to avoid a collision. Conflict 447 and 448 are special cases.

Table 1: Severe conflicts at location P1 for one day (9 hours) of conflict observation (BU=public bus, B=Bicycle, C=Car, TR=Truck, V=Van, P=Pedestrian, M=Moped, MB=Motorbike). C32 means Car from direction (3) towards direction (2) (for directions, see Figure 1).

<table>
<thead>
<tr>
<th>#</th>
<th>Road users</th>
<th>Time</th>
<th>TTC (s)</th>
<th>PET (s)</th>
<th>Potential consequence</th>
<th>Total severity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>444</td>
<td>V12-C23</td>
<td>7:01</td>
<td>1-0.5</td>
<td>Low</td>
<td>3</td>
<td>C23 (speed 40 km/h) braking hard and swerving to avoid V12 that did not give right of way</td>
<td></td>
</tr>
<tr>
<td>446</td>
<td>V12-C23</td>
<td>9:04</td>
<td>1-0.5</td>
<td>Low</td>
<td>3</td>
<td>C23 (speed 50 km/h) braking hard and stopping, V12 entered intersection without stopping</td>
<td></td>
</tr>
<tr>
<td>447</td>
<td>C31-MB32</td>
<td>11:29</td>
<td>0.8</td>
<td>High</td>
<td>4</td>
<td>MB (speed 73 km/h) overtakes C31 while it turns left</td>
<td></td>
</tr>
<tr>
<td>448</td>
<td>B12-C23</td>
<td>16:37</td>
<td>1-0.5</td>
<td>Moderate</td>
<td>3</td>
<td>C23 (speed 28 km/h) passes left-turning C2 unexpectedly at the right, B12 has to stop</td>
<td></td>
</tr>
</tbody>
</table>
Table 2 gives the conflicts that randomly were selected during the collision scanning process of the video recordings. These cases illustrate the typical safety problems at this intersection, viz. the difficult left-turns from the minor road, and the crossing of the main road by bicyclists from and towards the bicycle track. Seven of the 20 conflicts include a crossing bicyclist. Most of these are severe conflicts, partly bicyclists from the bicycle track that try to use the same gap in the main road flow as do left-turning vehicles from direction (1) to (2), and partly right-angle conflicts of crossing bicyclists from the minor road and traffic from the left. Car-car conflicts mainly are conflicts between left-turning vehicles from the minor road and main road traffic from the left.

Table 2: Conflicts at location P1, randomly selected during total observation period (BU=public bus, B=Bicycle, C=Car, TR=Truck, V=Van, P=Pedestrian, M=Moped, MB=Motorbike). C32 means Car from direction (3) towards direction (2) (for directions, see Figure 1). Mod. = moderate.

<table>
<thead>
<tr>
<th>#</th>
<th>Road users</th>
<th>Date</th>
<th>Time</th>
<th>TTC (s)</th>
<th>PET (s)</th>
<th>Potential consequence</th>
<th>Total severity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B12-C23</td>
<td>06-11-04</td>
<td>19:49</td>
<td>1.5-1</td>
<td>high</td>
<td></td>
<td>2</td>
<td>See bicycle accident</td>
</tr>
<tr>
<td>11</td>
<td>B12-C23</td>
<td>28-01-05</td>
<td>10:57</td>
<td>1-0.5</td>
<td>high</td>
<td></td>
<td>4</td>
<td>B does not seem to notice C that swerves to opposing traffic lane</td>
</tr>
<tr>
<td>58</td>
<td>B21-C12</td>
<td>07-03-05</td>
<td>16:16</td>
<td>0.5-0</td>
<td>Mod.</td>
<td></td>
<td>3</td>
<td>Utilizing same gap</td>
</tr>
<tr>
<td>64</td>
<td>B21-C12</td>
<td>26-02-05</td>
<td>12:10</td>
<td>0.5-0</td>
<td>Mod.</td>
<td></td>
<td>4</td>
<td>Utilizing same gap</td>
</tr>
<tr>
<td>71</td>
<td>TR13-V32</td>
<td>14-03-05</td>
<td>11:51</td>
<td>0.5-0</td>
<td>low</td>
<td></td>
<td>3</td>
<td>TR13 on opposing traffic lane to make right turn</td>
</tr>
<tr>
<td>100</td>
<td>C12-V23</td>
<td>08-04-05</td>
<td>15:40</td>
<td>1-0.5</td>
<td>Mod.</td>
<td></td>
<td>3</td>
<td>V23 swerving</td>
</tr>
<tr>
<td>107</td>
<td>B12-C23</td>
<td>20-04-05</td>
<td>16:17</td>
<td>2-1.5</td>
<td>low</td>
<td></td>
<td>1</td>
<td>Complex situation</td>
</tr>
<tr>
<td>112</td>
<td>C12-BU23</td>
<td>24-05-05</td>
<td>17:25</td>
<td>1-0.5</td>
<td>low</td>
<td></td>
<td>2</td>
<td>C12 half on main road</td>
</tr>
<tr>
<td>114</td>
<td>C1.-V23</td>
<td>20-05-05</td>
<td>13:43</td>
<td>1.5-0</td>
<td>low</td>
<td></td>
<td>2</td>
<td>Complex situation, C1. goes straight-on had to wait for bicyclists</td>
</tr>
<tr>
<td>120</td>
<td>C12-V23</td>
<td>06-07-05</td>
<td>17:47</td>
<td>1.5-1</td>
<td>1.5-1</td>
<td>Very low</td>
<td>1</td>
<td>Low speed</td>
</tr>
<tr>
<td>121</td>
<td>C33-C23</td>
<td>07-07-05</td>
<td>11:46</td>
<td>0.5-0</td>
<td>Mod.</td>
<td></td>
<td>4</td>
<td>C33 U-turn, C23 has to brake hard</td>
</tr>
<tr>
<td>128</td>
<td>C12-C23</td>
<td>01-07-05</td>
<td>17:17</td>
<td>1.5-1</td>
<td>Very low</td>
<td>1</td>
<td>Low speed</td>
<td></td>
</tr>
<tr>
<td>199</td>
<td>V32-V23</td>
<td>10-09-05</td>
<td>14:18</td>
<td>1.5-1</td>
<td>low</td>
<td></td>
<td>2</td>
<td>V32 overtakes queue, head-on conflict</td>
</tr>
<tr>
<td>226</td>
<td>C12-C23</td>
<td>05-10-05</td>
<td>16:43</td>
<td>1-0.5</td>
<td>low</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>239</td>
<td>B21-C23</td>
<td>03-11-05</td>
<td>17:35</td>
<td>0.5-0</td>
<td>Mod.</td>
<td></td>
<td>4</td>
<td>C23 brakes hard and swerves</td>
</tr>
<tr>
<td>316</td>
<td>C12-B31</td>
<td>06-01-06</td>
<td>09:08</td>
<td>0.5-0</td>
<td>Mod.</td>
<td></td>
<td>4</td>
<td>Utilizing same gap</td>
</tr>
<tr>
<td>318</td>
<td>C12-C23</td>
<td>06-01-06</td>
<td>14:05</td>
<td>1-0.5</td>
<td>high</td>
<td></td>
<td>4</td>
<td>C12 1m on main road, speed C23 high (70 km/h)</td>
</tr>
<tr>
<td>342</td>
<td>C12-C23</td>
<td>20-01-06</td>
<td>14:36</td>
<td>1.5-1</td>
<td>Mod.</td>
<td></td>
<td>2</td>
<td>C12 via opposing lane, speed C23 65 km/h</td>
</tr>
<tr>
<td>371</td>
<td>TR12-C23</td>
<td>23-02-06</td>
<td>18:47</td>
<td>1-0.5</td>
<td>Mod.</td>
<td></td>
<td>3</td>
<td>C23 tries to overtake right-turning car</td>
</tr>
<tr>
<td>377</td>
<td>V12-TR23</td>
<td>24-03-06</td>
<td>14:05</td>
<td>0.5-0</td>
<td>high</td>
<td></td>
<td>5</td>
<td>TR23 with alarm lights on, has to brake very hard to avoid V12</td>
</tr>
</tbody>
</table>
Deviant Behaviour

The inspection of the more or less randomly collected 400 peculiar/deviant/striking events, resulted in several observations about the functioning of the intersection at hand. Apart from special events such as the passing of fire-brigade vehicles, a bicycle race, a switching off of the traffic lights, a blocking of an intersection by manoeuvring trucks, or break-down of vehicles, the selection of events also resulted in various examples of deviant behaviour of road users that could be related to the typical lay-out and functioning of the intersection in relation to the strategic, manoeuvring, and control level of the driving task.

Apart from various conflicts as already reported above, there are many cases that clearly illustrate the difficult task of making a left-turn from the minor road at location P1. Frequently, vehicles have to wait rather long before they encounter a suitable gap in both traffic flows with sometimes relatively high speeds on the main road. Sometimes, left-turners from the minor road start this manoeuvre and have to interrupt it again because of another vehicle approaching from the right or left with as a result standing still again partly on the main road. Another problem of this intersection is the usage of an acceptable gap by both left-turning traffic from the minor road and bicyclists from the bicycle track that want to cross towards the minor road at the same time. Now and then, the intersection is used by road users to make a U-turn, but as the space is very limited, this often results in interfering with other traffic. Big trucks from and towards the minor road have difficulty in conducting their manoeuvre.

Discussion and conclusions

In total, sixteen collisions could be identified from video. Unfortunately, for the methodology development (but of course, luckily for the road users), this number is very low, much lower than anticipated in the original project plan. Apparently, accidents that are linked to a specific intersection in the BLIK database may refer to a larger area than the area covered by the camera, and therefore, some of them may have been missed by the video observations. From the sixteen accidents as collected by the long-term video recordings, ten were car-car collisions, two single-car accidents, two car-bicyclist/moped collisions, one single-bicycle, and one single-scootmobiel accident.

From the analysis of the video recordings, it is clear that there are basically two main problems at intersection P1, viz. the left-turn manoeuvre from the minor road (Boezemweg) and the bicycle traffic crossing the main road (Vlielandseweg) from and to the bicycle track. Especially, the left-turn manoeuvres from the minor to the main road appear to be problematic due to the limited sight on traffic on the main road, the frequent traffic on the main road and its relatively high speed (average speed of free driving cars is well over 50 km/h). It happens frequently, that minor-road car drivers stop with their car-front already partly on the main-road carriageway, and in this way directly interacting with traffic from the left. Sometimes the minor-road left turning cars try to use the same gaps as bicycles from the cycle track crossing the main road. The gap acceptance problems for minor-road traffic also occur for bicyclists to the minor road from the separate bicycle track. The relatively high speed of the main-road traffic is contributing to the task difficulty of crossing or merging traffic. The collisions as occurred at this intersection during a 22 months period of video observations properly reflect these findings. The results for the other three locations can be found in Van der Horst et al. (2007).

In general, it can be concluded that traffic conflicts and deviant behaviour, together with road scene analyses give a good insight in potential safety problems at intersections from a road users' perspective, well in line with the results from the analysis of the collisions. Remarkably, in most cases, another road user was (in)directly involved, either as a distracting or as a contributing element, for example by occluding the view of one of the road users involved.
This study once more made it clear that conflict observation and scoring the severity according to the criteria of the DOCTOR technique from video are feasible. In the past this approach was also successfully applied for analysing road user behaviour at railway level crossings (van der Horst & Bakker, 2004). It even has some advantages over observing conflicts directly at street level as you can have repeated looks on what actually happened. Time-related measures such as Time-To-Collision (TTC) and Post-Encroachment Time (PET) are promising surrogate safety measures for analysing road-user encounters at intersections and certainly have potential to serve as predictors of accident risks, for example for application of traffic safety modules in microscopic traffic simulation models.

In this study, the video recordings of collisions were intended to be used as a means to validate the separate approaches of in-depth accident analyses, road scene analyses and behavioural observations (including conflicts). However, the results obtained together with the further technological development to be expected for automatic video analysis techniques of real world traffic scenes, let us wonder whether this approach can be applied for collecting more naturalistic driving behaviour data and getting a better understanding of the processes of interactions among road users. Not only from inside the car as in the 100-car study in the United States (Neale et al., 2005), but also from the outside at intersections. Recently, the potential of this so-called site-based risk approach looking at all of the traffic passing through a given road segment is recognised as complementary to in-vehicle studies in the large scale SHRP-II programme in the US (Strategic Highway Research Program II).

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References


