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Introduction

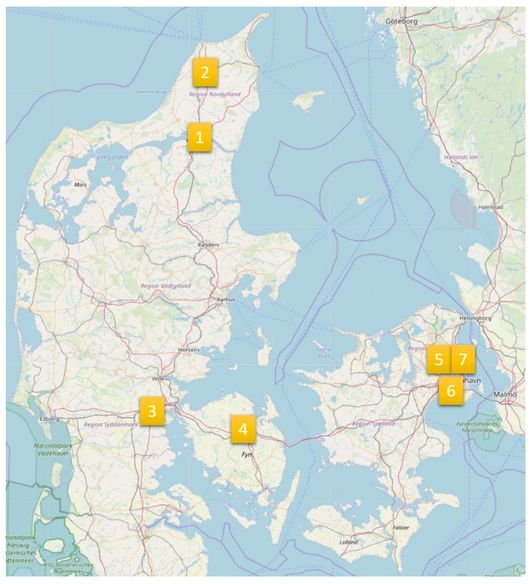
Accidents between straight-ahead running cyclists and right- or left-turning cars in signal-controlled intersections is one of the most common types of accidents between cyclists and cars. Over the years, Denmark has focused a great deal on these types of accidents without finding an effective measure. In an attempt to prevent these accidents, a report was published in 2014 (Rigspolitiet et al., 2014). The report proposes a number of initiatives that are expected to prevent these accidents, including bike boxes. Based on the report, the Danish Road Directorate has conducted a large-scale trial with bike boxes in 57 signalised intersections.

Aalborg University has evaluated the safety impact of the large-scale trial for the Danish Road Directorate.

A number of studies have evaluated bicycle boxes [Dill et al., 2002; Hunter, 2000; Bygrave et al., 2005; Atkins Services, 2005; Rodgers, 2005]. The studies have applied behavioural observations based on a few hours of video observations, which are subsequently manually analysed and/or questionnaires where users' perception of the bike box's contribution to their safety has been asked. None of the studies have been evaluated by accident before and after and none of the behavioural observations have been carried out following one of the acknowledge conflict study methods [Hydén 1987, Kraay 2013]

Methods

The Danish Road Directorate wanted a quick assessment of the safety impact of the bicycle boxes so that although the large scale trial included 57 intersections, it could not be expected that there in the 57 intersections would be a sufficient number of registered bicycle accidents that any possible change in accident rates could be determined with the necessary statistical significant. Therefore, it was decided to determine the safety before/after using conflicts as surrogate by accident. Due to the size of the budget and an estimate of the expected number of conflict, it was decided to record videos from one leg in 7 of the 57 intersections. The seven inter-sections were in large and medium-sized cities spread throughout Denmark and traffic varied from medium to high - see figure 1. We filmed for 16 hours on 19 weekdays before and after in each intersection. This would allow for a statistically safe result if the effect would be at least 30% and that there were observed 1.5 conflicts per weekday on average in the 7 legs in the before-period.
In the study we used the Swedish Conflict Technique and we used the following process for analysing the recorded videos: First, the recordings were analysed with the video analysis program RUBA (Madsen & Lahrmann, 2017). RUBA was used to find simultaneous arrivals, which in this project are defined to occur when the cyclist arrives at the conflicts point up to 5 seconds after or up to 5 seconds before the car – see Figure 2.



Figur 1 Geographical location of the seven intersections

Acknowledgement:
This study is based on an evaluation task that Aalborg University has conducted for the Danish Road Directorate

Figur 2 Screenshot from RUBA seclecting potential right turn conflicts

Only a small proportion of the simultaneous arrivals imply a high probability for a crach, but since each event is unique, and the progress of the event is important for if the situation is a conflict, all simultaneous arrivals are manually reviewed to decide if there is a potential conflict. Events are post-treated if:

- It is estimated to be a short distance from the first road user is leaving the two road users' common point of intersection until the next road user arrives at the same point.
- There seems to be a lack of interaction between road users, causing one or both road users to slow down at the last minute, or to perform evacuation maneuvers (accelerates, decelerates, changes direction) to avoid collision.
- The incident does not feel ok or feels dangerous. For example, if it is considered that there is something that makes it interesting to investigate the interaction more closely. This includes, for example, incidents where it is estimated that a collision can easily occur if something unexpected occurs.

Subsequent processing of potential conflicts has been done in the T-Analyst program (Trafvid, 2014). This program manually creates trajectories for the two parties in the potential conflict, and the program can then calculate how closely the parties were in collision, see Figure 3. In this project, the following limit values have been selected in T-Analyst TTCmin ≤ 2.0 sec, or T2, min ≤ 0.5 sec - cf. the Swedish Conflict Technique. Figure 4 shows a schematic representation of the procedure for data processing.

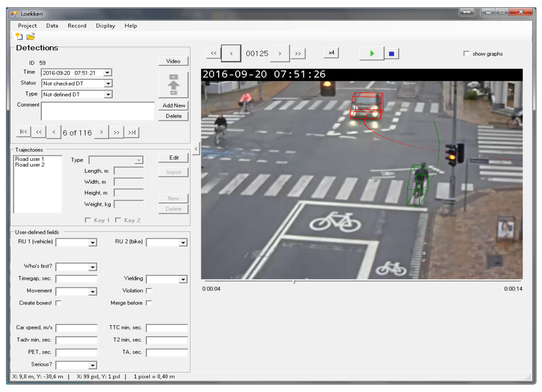


Figure 3 Screenshoot from T-analyst

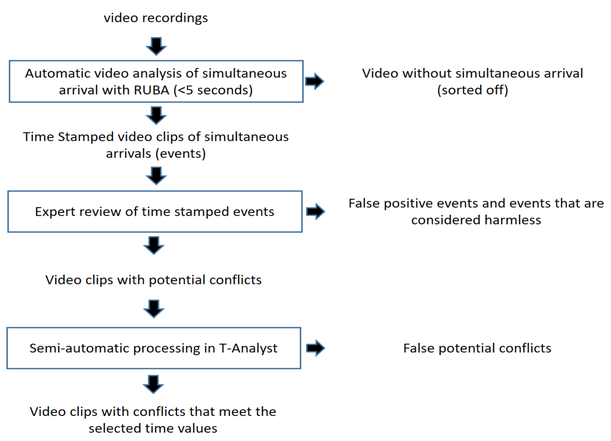


Figure 4 Schematic representation of the procedure for data processing

Results

Table 1 shows the length of the recordings and the number of conflicts divided between the two conflict types before and after and divided into the seven intersections.

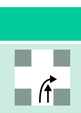
	Before			After		
						
	Recording (Hours)	Number of conflicts		Recording (Hours)	Number of conflicts	
Intersection No. 1	304	53	8	320	42	5
Intersection No. 2	292	7	4	320	9	2
Intersection No. 3	276	7	4	308	24	8
Intersection No. 4	295	43	8	320	35	18
Intersection No. 5	305	26	17	320	41	25
Intersection No. 6	90	68	14	160	61	30
Intersection No. 7	157	45	10	160	27	3
Sum	1719	249	65	1907	239	91

Table1 Number of hours of recordings and number of conflicts recorded by the 7 intersections

Place for IPAD

	Conflicttype							
								
	Conflict rates (conflicts/hour)		CRR (Relative risk)	p-value	Conflict rates (conflicts/hour)		CRR (Relative risk)	p-value
	Before	After			Before	After		
Intersection No. 1	0,174	0,131	0,75	0,17	0,026	0,016	0,59	0,36
Intersection No. 2	0,024	0,028	1,17	0,75	0,014	0,006	0,46	0,37
Intersection No. 3	0,025	0,078	3,07	0,01	0,015	0,026	1,79	0,34
Intersection No. 4	0,146	0,109	0,75	0,21	0,027	0,056	2,08	0,09
Intersection No. 5	0,085	0,128	1,50	0,10	0,056	0,078	1,40	0,28
Intersection No. 6	0,757	0,381	0,50	0,00	0,156	0,188	1,20	0,57
Intersection No. 7	0,287	0,169	0,59	0,03	0,064	0,019	0,29	0,06

Table 2 Conflict rates, conflict rate ratio and p-value for respectively. Right turn conflicts and left turn conflicts divided into the seven intersections. Values with red indicates where CRR is significantly different from 1

Table 2 shows conflict rates (number of conflicts per hour) before and after and the conflict rate ratio (CRR), which is the ratio between the conflict rate before and after. Table 2 shows that the conflict rate for right-turning conflicts in four intersections has a decline, but only the decline in intersection 6 and 7 is statistical significant. Three intersections have a rise, but only the rise in no. 3 is statistical significant. Looking at the conflict rate for the left-turn conflicts, they have fallen in intersection 1, 2 and 7, but have risen in intersection 3, 4, 5, and 6 but none of the changes is statistical significant.
The overall effect of the seven bicycle boxes is calculated by weighting the 7 conflict rate ratios (CRR) to one conflict rate ratio. The weighting of the effects of right turn conflicts is carried out with the so-called random effect log-odds-method, because the individual intersections varies a lot with respect to effect. For the left turn conflicts, we used the fixed-effect-log-odds-method as the 7 CRRs are more similar (Elvik et al., 2009) The weighted effect of right-turn conflicts in the seven bicycle boxes gives a CRR of 0.91, but since p value is 0.62, the decrease is not statistically significant. Also for left-turn conflicts, the weighted effect of the bike boxes is not statistically significant. Here we got a weighted CRR of 1.17 and thus an increase but with a p-value of 0.37.

Discussion

To determine the extent of the video recordings we when the project was planned based on past experience made the assumption that there would occur between one and three right-turning and left-turning-conflicts per day (16 hours) in each intersections. This condition has been met in the study, as we in average found 2.9 conflicts per day in the before period and 2.8 in the after period.
Unfortunately, the effects in the 7 intersections point in different directions, and when the effects are weighed with the log-odds method, the weighted effects have a high p value - respectively 0.62 and 0.37 - and it is not possible to conclude from these. Overall the study can't detect any safety effect of bike boxes in the 7 rebuild intersections.
A contributing reason for this is probably that the boxes were largely not used by cyclists. A systematical mapping of the use was not part of the evaluation, but consistent feedback from the observers of the potential conflicts was that they rarely saw cyclists in the boxes.

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