THE EFFECTS OF A VARYING SPEED LIMIT AT A HIGHWAY JUNCTION

An example of the use of the TCT in Finland

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The Finnish traffic conflicts technique

In our definition, a conflict is a traffic situation, where in the begin-
nning of the evasive action the time-to-collision (TTC) is 1.5 seconds or
less. A conflict is a severe one, if the evasive action is uncontrolled.
In addition, we define potential conflict situations which are quite close
to conflicts but have a higher TTC than 1.5 seconds. According to the
ICTCT calibration studies, our potential conflicts resemble the minor
conflicts of other conflict techniques.

In our conflict studies we always count also traffic volumes and all forms
of "unwanted behaviour" in addition to conflicts and potential conflict
situations. Traffic volumes in different flows and for different road user
categories are essential for calculating the risks for hazardous situ-
ations and for control purposes in before and after studies. Thus we can
compare different locations and different study periods. The various forms
of "unwanted" traffic behaviour (traffic violations, exceptional driving/
walking routes etc.) are very useful for diagnostic purposes.

We nearly always use video at our conflict studies despite the higher
costs. The video tapes are used for:
- checking the conflict and potential conflict scorings,
- traffic counts,
- calculation of speeds, waiting times etc.,
- tapes of collected conflicts (observer training, problem illustration
  for planners and decision makers).

The main applications of our TCT can be divided into two categories: 1) 
safety diagnosis of a location and 2) before and after study on the
effects of some safety measure. Some examples of our recent conflict
studies in both categories are listed below.

1) Safety diagnosis
- various accident black spots
- different types of pedestrian
crossings
- identification of possible minor
safety measures for heavily
trafficked highway junctions
- junctions of service stations
- identification of critical daily periods for the timing of a varying speed limit

2) Effect studies

- renewal of the road traffic law
- channelisation of highway junctions
- separation of bicyclists and pedestrians on their common path
- reconstruction of the main street of small towns
- different timing strategies for signal control at junctions with high pedestrian flows
- varying speed limit

The study on a varying speed limit is included in both categories, which is why it has been chosen as an example to be studied more closely.

Varying speed-limit - the before study

The Roads and Waterways Administration (RWA) in Finland has completed some studies of a varying speed limit. These studies have dealt with the opinions of the road users, their observance of the speed limit, and the speed limit's effect on speeds. The varying speed limit of these studies was located on road sections passing a school.

The results of these studies were quite satisfactory. The RWA decided to try the varying speed limit also at a highway junction. The junction selected for this experiment is on a heavily trafficked highway connecting the centre of Helsinki to some neighbouring towns. At the studied X-junction the minor road leads to a small town. The junction is shown in Figure 1.

![Figure 1. The studied junction.](image-url)
The minor road has stop signs at the junction. The speed limit on the main road is 80 kmph. The main road is channelized at the junction, and has an additional lane southwards from the junction for about 100 metres. Both safety and capacity problems were known to exist at the junction, and especially for the drivers turning left from the minor road. As the highway is to be reconstructed within five years, the RWA hoped that the varying speed limit would be a sufficient but not too costly measure for improving the capacity and safety of the junction.

The purpose of the before study was, in addition to gathering data for the effect study, to identify the time periods when the speed limit should be 60 kmph instead of the usual 80 kmph.

On the basis of the RWA's information and our visits to the junction we decided on making the studies on workingdays at 7 - 9, 11 - 13 and 15.15 - 17.15. The following data were gathered at the field studies on two days:
- hazardous situations (conflicts and potential conflicts)
- vehicle speeds on the main road
- traffic volumes in different flows
- minor road service times
- "unwanted" traffic behaviour

The results of the before study are summarised in Figure 2. The measurement periods were divided in periods of fifteen minutes in order to identify the problem periods at the junction. The safety and capacity (left turns from the minor road) problems seemed to be concentrated on periods from 7.00 to 8.00, and from 15.45 to 16.45. Left turns were an essential part of the safety problem at the junction, as a left turning vehicle was involved in 60% of all hazardous situations observed.

The traffic volumes in the congested direction were also at their highest during the aforementioned periods. Because of this the mean speeds in the congested direction were quite low, approximately 64 kmph, during these periods.

Based on the results of the before study we recommended that the varying speed limit should be 60 kmph on workingdays from 7.00 to 8.00, and from 15.45 to 16.45, and otherwise 80 kmph. The RWA agreed upon our recommendations and implemented the varying speed limit signs at the junction in the summer of 1985.
Figure 2. Summary of the results of the before study.
The after study - the effects of the varying speed limit

The after studies were carried out in the beginning of October, 1985, exactly one year after the before studies. The measurement periods and days were the same.

Figure 3 shows the mean speeds and traffic volumes on the main road in both directions at the before and after studies.

Figure 3. Traffic volumes and mean speeds on the main road.
Traffic volumes on the main roads were approximately 13% higher at the after studies than during the before studies.

The mean speeds in the congested direction were always below 60 kmph during the 60 kmph speed limit periods. The speeds were 6 - 15 kmph lower than during the corresponding periods in the before studies. The speeds against the congested direction had not decreased as clearly. A part of the decrease (approximately 3 kmph) was due to the increase of traffic volumes. Interestingly, the high volumes caused a delay in the effect of the speed limit change during the afternoon periods. The nearly continuous platoon on the main road adapted its speed according to the just changed speed limit 10 - 15 minutes after the actual change.

During the periods when the speed limit remained 80 kmph even at the after studies the mean speeds in the southbound flow on the main road had increased. The increase was about 3 - 5 kmph during the periods 7.00 - 8.00 and 11.15 - 12.15 despite the slightly higher traffic volumes. The changes of the mean speeds in the northbound flow seem to follow the changes in traffic volumes.

The capacity of the junction in regard to the left turning flow from the minor road is, of course, highly dependent on the traffic volumes on the main road. Because of this, we plotted the minor road service times against the main road traffic volumes. This is shown in Figure 4. The main road volume was calculated as the sum of the northbound flow and half of the southbound flow. The southbound flow was halved on the basis of the additional lane in that direction. Each observation represents the data of a period of 30 minutes.

Figure 4. Minor road service times and main road volumes.
The four observations of the 60 kmph periods do not seem to differ from the 80 kmph observations when the clearly visible relation between the service times and main road volumes is taken into account.

We studied the number and risk of hazardous situations separately for the 60 kmph and 80 kmph (after study) periods. Table 1 shows the number of vehicles involved in hazardous situations, traffic volumes, and their ratio in different traffic flows for the periods with the 60 kmph speed limit during the after study.

The risk of hazardous situations was usually lower in the after studies. The risk decreases were significant in the northbound flow on the main road, and almost significant for the whole junction. During the after studies the risk was higher in the southbound flow on the main road than in the before studies, although not significantly.

The number of conflicts had decreased from 6 to 1 despite the higher traffic volumes.

Especially the number and risk of situations between a left turning vehicle from the minor road and a straight driving vehicle from the southern approach of the main road had decreased. Their number had decreased from 16 to 7.

Table 2 shows the corresponding figures for the periods with the same speed limit of 80 kmph during both before and after studies.

The number and risk of hazardous situations had increased during these periods. The risk increased significantly for the left turning vehicles from the minor road. The risk increase was almost significant for the southbound flow on the main road, and for the whole junction.

The risk increase was clearest for situations between a left turning vehicle from the minor road and a straight driving vehicle from the northern approach of the main road.

The number of hazardous situations had increased most during the periods from 8.00 - 9.00, during which the speeds in the southbound flow had also increased most.

Most of the safety problems at the junction are caused by the left turning traffic from the minor road, whatever the speed limit. Especially left turning lorries and buses caused problems. They accounted for 10 - 20% of the vehicles but for almost 50% of the hazardous situations. These heavy vehicles accelerate very slowly from standstill but according to our observations their drivers seemed also to take higher risks in regard to the main road traffic probably relying on their vehicles' greater mass.
Table 1. The number of vehicles involved in hazardous situations, total number of vehicles and their ratio at 7 - 8 am and 3.45 - 4.45 pm for different vehicle flows at the before and after studies.

<table>
<thead>
<tr>
<th>Vehicle flow</th>
<th>Hazardous situations (C)</th>
<th>Traffic volume (E)</th>
<th>Risk 100 C/E</th>
<th>Signif. of risk difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>MAIN ROAD, from south</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>26</td>
<td>15</td>
<td>3340</td>
<td>3578</td>
</tr>
<tr>
<td>- straight</td>
<td>26</td>
<td>15</td>
<td>2514</td>
<td>2756</td>
</tr>
<tr>
<td>- to the left</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>MINOR ROAD, from east</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>31</td>
<td>24</td>
<td>880</td>
<td>1040</td>
</tr>
<tr>
<td>- straight</td>
<td>4</td>
<td>4</td>
<td>208</td>
<td>310</td>
</tr>
<tr>
<td>- to the left</td>
<td>26</td>
<td>17</td>
<td>602</td>
<td>546</td>
</tr>
<tr>
<td>MAIN ROAD, from north</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>14</td>
<td>20</td>
<td>3040</td>
<td>3316</td>
</tr>
<tr>
<td>- straight</td>
<td>12</td>
<td>18</td>
<td>2740</td>
<td>3002</td>
</tr>
<tr>
<td>- to the left</td>
<td>2</td>
<td>2</td>
<td>288</td>
<td>282</td>
</tr>
<tr>
<td>MINOR ROAD, from west</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>5</td>
<td>3</td>
<td>92</td>
<td>132</td>
</tr>
<tr>
<td>- straight</td>
<td>5</td>
<td>2</td>
<td>62</td>
<td>104</td>
</tr>
<tr>
<td>- to the left</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>TOTAL</td>
<td>76</td>
<td>62</td>
<td>7352</td>
<td>8066</td>
</tr>
</tbody>
</table>

1) * significance of risk difference 95 %, (*) 90 %
Table 2. The number of vehicles involved in hazardous situations, total number of vehicles and their ratio at other measurement hours than 7 - 8 am and 3.45 - 4.45 pm for different vehicle flows at the before and after studies.

<table>
<thead>
<tr>
<th>Vehicle flow</th>
<th>Hazardous situations (C)</th>
<th>Traffic volume (E)</th>
<th>Risk 100 C/E</th>
<th>Signif. of risk difference 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>After</td>
<td>Before</td>
<td>After</td>
</tr>
<tr>
<td>MAIN ROAD, from south</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>10</td>
<td>21</td>
<td>1180</td>
<td>1224</td>
</tr>
<tr>
<td>- straight</td>
<td>2</td>
<td>4</td>
<td>356</td>
<td>394</td>
</tr>
<tr>
<td>- to the left</td>
<td>7</td>
<td>17</td>
<td>718</td>
<td>724</td>
</tr>
<tr>
<td>MINOR ROAD, from east</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>5</td>
<td>11</td>
<td>3192</td>
<td>3690</td>
</tr>
<tr>
<td>- straight</td>
<td>2</td>
<td>9</td>
<td>2038</td>
<td>3310</td>
</tr>
<tr>
<td>- to the left</td>
<td>3</td>
<td>2</td>
<td>314</td>
<td>320</td>
</tr>
<tr>
<td>MAIN ROAD, from north</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>1</td>
<td>3</td>
<td>140</td>
<td>180</td>
</tr>
<tr>
<td>- straight</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>- to the left</td>
<td>1</td>
<td>2</td>
<td>120</td>
<td>20</td>
</tr>
<tr>
<td>MINOR ROAD, from west</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- to the right</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>- straight</td>
<td>1</td>
<td>2</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>- to the left</td>
<td>0</td>
<td>1</td>
<td>12</td>
<td>40</td>
</tr>
<tr>
<td>TOTAL</td>
<td>28</td>
<td>52</td>
<td>8888</td>
<td>9950</td>
</tr>
</tbody>
</table>

1) * signifigance of risk difference 95 %, (*) 90 %
The additional lane provoked some forms of unusual behaviour during both before and after studies. Firstly, some of the vehicles in the southbound flow used the lane for overtakings, which caused also some hazardous situations at the end of the lane. Secondly, many of the left turning vehicles used the additional lane for accelerating after having crossed the both ordinary straight driving lanes on the main road. This type of behaviour is against traffic rules but in our opinion improves the safety and capacity of the junction.

The conclusions of the study are listed below:

1) The changes in the speed limit sign were seemingly observed quite well, although in the congested traffic the speed changes can be due to only some of the drivers observing the changed speed limit.
2) The lower speeds caused by the 60 kmph speed limit improved the safety of the junction.
3) The increase of the driving speeds on the main road during the 80 kmph periods caused an increase in the number and risk of hazardous situations.
4) The speed limit changes had no apparent effect on the capacity of the junction in regard to the left turning traffic from the minor road.
5) The additional lane for the southbound traffic after the junction seemed to improve the safety and capacity of the junction.
6) The left turning vehicles, and especially lorries and buses, caused most of the safety problems observed.

The results obtained in this study are not necessarily applicable to other junctions as such because of the unusual layout (additional lane). Furthermore, the after studies were carried out only six weeks after the instalment of the varying speed limit signs. Drivers probably adapt their behaviour according to the varying speed limit as they get used to it. That is why we have proposed to the RWA that the after studies should be carried out also in October, 1986.