GREEN LIGHT FOR ISA?
THE EFFECT OF INTELLIGENT SPEED ADAPTATION ON THE TRAFFIC FLOW

Geertje Hegeman

ABSTRACT

Intelligent Speed Adaptation (ISA) is a system that limits vehicles at the speed limit. Research in Sweden, England and the Netherlands has shown that it has a positive impact on safety. The current study compares traffic flows under ISA with those in the present of regular traffic lights. The model results show that ISA is able to replace traffic lights at crossroads with a clear major flow. This important positive effect will improve the support for ISA, which was originally designed for safety reasons.

INTRODUCTION

Many countries in Europe have defined targets for reduction in number of traffic fatalities and –injuries. The most zealous target is the 'Zero vision' of Sweden (Webpage). The Netherlands aim to reduce the number of fatalities with about 30% and serious injuries with 25% by 2010 compared with 1998 (NVVP, 2000). Within the same time period, England aims to reduce the number of people killed or seriously injured by 40% and for children the aim is 50% (webpage). With the currently used safety tools, these targets seem very ambitious and almost unreachable. Fortunately, some new in-vehicle safety tools are being developed. For example ISA, Intelligent Speed Adaptation might be an indicated tool to achieve safety targets in future. Besides the technical development of this tool, it is important to work on the acceptation from the start. Because ISA attacks the freedom of car drivers (they are not able to speed anymore) it is important to work on positive thoughts about the system. Therefore this research is done on the influence of ISA on traffic flow, especially at junctions with traffic lights. It is thought those if some cars have ISA, platoons will be formed at the main road, so that cars from the minor roads can easily cross or merge the main road. Because this 'gap making' is the task of some traffic lights, these might be unnecessary if ISA is introduced. Thus, this paper describes a theoretical research on the effect of ISA on the traffic flow and if these effects could make some traffic lights superfluous.

This paper start with a short literature review research carried out on ISA. Secondly, the theoretical determination of the effect of ISA on the traffic flow is described. Finally, it is discussed how these theoretical findings could be used in real world.
INTELLIGENT SPEED ADAPTATION (ISA)

There are three major ISA types. First, the open ISA system, which is an advisory system. Each time when the vehicle exceeds the speed limit a signal auditory or visual, is given. The driver is free to choose whether or not the react to this sign. Second, the semi-open system, which gives a resistance at the gas pedal as soon as the speed limit is exceeded. Drivers are still able to succeed the speed limit but it cost more effort. Thirdly, the compulsory system, which overrules the driver as soon as the speed limit is exceeded. The vehicle cannot drive faster than the speed limit. To date, many European countries have done field trials and questionnaires for all three systems.

Sweden was the first country with a field trial with an open ISA system (Vägverket, 2001). Many trials have taken place since, in which many vehicles were involved. These trials were mainly aimed at acceptability and Sweden doesn’t know yet what to do with all the data they’ve collected.

In England, a simulator study, a simulation study and a field trial took place (Carsten and Jamson, 2000). In the simulator study it was found that drivers with ISA accept smaller headways, but this effect wasn’t confirmed in the field trial and the simulation study. The latter showed that ISA didn’t have a significant effect on travel time.

In the Netherlands, a field trial with the closed ISA system was done on acceptability and technical possibilities (AVV, 2001). 20 vehicles drove around for one year, which changed driver every two months. One of the results of this trial was the positive effect on the opinion on ISA after driving around with it.

Denmark did a trial with the so-called INFATI system (Intelligent Fartilpasning), an open ISA system (Lahrmann and Boroch, 2001). 24 private owned Toyotas were equipped with INFATI. The researches specially looked at the influence of ISA on different road types, different speed limits, different environments and different times. The main conclusion was that the INFATI system did have an effect.

In Finland, four different systems were compared (Päätalo et. al., 2001). The first was only a route guidance system, the second the route guidance system with an open ISA system, the third was the route guidance system with closed ISA system and the fourth the route guidance system with a driving style recording system. There was no difference between trip times between the systems. The test drivers had to fill in questionnaire after they had driven the systems in a random order. Some drivers reported that they found the closed ISA system ‘dangerous’ and ‘irritating. Almost all drivers preferred the route guidance systems with the driving style recording system.

THEORETICAL INFLUENCE OF ISA ON TRAFFIC FLOW

For this study a microscopic simulation model was used to measure the effect of ISA on traffic flows. All parameters ISA might have influence on, are varied within a range and for all combinations of parameters simulations were run.

Structure

To judge the influence of ISA on the traffic flow, the performance of ISA was compared with the performance of a traffic light. One of the tasks of a traffic light is to give traffic from minor roads sufficient possibilities either to cross or to merge onto the main road. Secondary,
these possibilities need to be right in time. The starting point for the scene is a junction of an obvious main and minor road. The question to answer is whether or not ISA is able to platoon the vehicles on the main road in such a way that vehicles from the minor roads get enough possibilities to either cross or merge onto the main road.

The dynamic traffic model *Integration* was used as the research tool. Parameters that might have influence on the traffic flows were varied within this model. At first, the percentage of vehicles with ISA is an important parameter. Indeed, this parameter actually determined the size of a platoon. In addition to ISA percentage, flows on the main road and minor roads, length of the road (distance from ‘start’ till junction), speed limit and initiation vehicles (the distribution of following distance between the cars when they get on the network) were the analysed parameters. Table 3.1 shows all parameters with the variation values. For every combination of parameters, one hour simulation was run.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Scale</th>
<th>Start-end value</th>
<th>Interval</th>
<th># Classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage ISA</td>
<td>#</td>
<td>4-20 en 0% en 100%</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Traffic flow</td>
<td>Persons Car Unit per Hour</td>
<td>500-1750</td>
<td>250</td>
<td>6</td>
</tr>
<tr>
<td>Road length</td>
<td>Metres</td>
<td>200-1000</td>
<td>200</td>
<td>5</td>
</tr>
<tr>
<td>Speed limit</td>
<td>Km/h</td>
<td>30 km/h</td>
<td>40 km/h</td>
<td>50 km/h</td>
</tr>
<tr>
<td>Initiation</td>
<td>Seconds</td>
<td>Uniform</td>
<td>Negative exponential</td>
<td>Traffic light</td>
</tr>
</tbody>
</table>

To measure the influence of ISA on the traffic flow, the performance of ISA was compared with the performance of a traffic light. Whether or not to place a traffic light, is usually determined by means of the criterion of Slop (CROW, 1996). This criterion calculates $\alpha$, which shows if a measure is not wished ($\alpha < 1,0$), wished but not necessary ($1,00 \leq \alpha \leq 1,33$) or necessary ($\alpha > 1,33$). For the boundary values of $\alpha$ ($\alpha = 1,00$ and $\alpha = 1,33$) the matched flows of the main road and the minor road were calculated. Next, of all the simulated variants, the number of possibilities to cross the main road or to merge into the main road is calculated. A possibility to cross the main road is defined as a gap in the main stream of at least five seconds. Every next vehicle only needs two extra seconds. So a gap of nine seconds is counted as three possibilities to cross the main road. Then, the number of possibilities to cross the main road is compared with the traffic flow of the minor road for the boundary values of $\alpha$. Now, if the number of possibilities to cross the main road (ISA) is larger than the calculated traffic flow on the minor road (traffic light), the performance of ISA is good enough to give the minor road sufficient possibilities to cross the main road or to merge into the main road.

**ISA graph**

The results of this theoretical research of the effect of ISA on the traffic flow, is called ‘the ISA graph’. For each combination of the varied parameters, a graph can be made. Figure 3.1 shows the ISA graph for the following combination of parameter values:

- One in twelve vehicles has got ISA (about 8%);

---

1 In this case a measure is a traffic light. For example a roundabout could also be a measure, but is in this case not gained.
• The length of the road from the ’start’ to the junction is 200 metres;
• The speed limit is 50 km/h;
• The initiation of the vehicles is a-select (negative exponential).

*Figure 3.1 The ISA-graph*

Within the graph, the white area shows the area in which a traffic light is not desirable. The light grey area is the area in which a traffic light is desirable but not necessary, and the dark grey area is the area in which a traffic light is necessary. The marked area (checked) is the area in which ISA produces ‘enough’ possibilities to cross the main road. According to the figure, this is the case for most of the area in which a traffic light is desirable but not necessary and for a large part of the area in which a traffic light is necessary. The addition that the criterion of Slop becomes unreliable if the flows are bigger than 1250 PCU/h has to be added to the explanation of the graph.

In Table 3.2 are the results of the influence of the parameters on the performance of ISA summarised. Especially traffic flow and road length have big influence of the created possibilities to cross the road. It was expected that a bigger flow on the main road would lead to less possibilities to cross the main road, but this expectation was not as large as four times fewer possibilities to cross the main road as the traffic flow grows. Also, it is quite obvious that a longer road distance from the start till the junction will lead to more possibilities to cross the road, because vehicles get more time to ‘platoon’ behind an ISA vehicle. But as the results show, even a short distance such as 200 meters seems to be enough to reach this goal.

*Table 3.2: Results of the comparison of every combination of parameter values which could have an influence on the performance of ISA.*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Influence on number of possibilities to cross the road (shortened by pcr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISA percentage (van 0 tot 100%)</td>
<td>Small, between 5 and 20% almost the same pcr</td>
</tr>
<tr>
<td>Traffic flow (500, 750, 1250, 1500, 1750) PCU/h</td>
<td>Deceleration pcr around four times as big as ac-</td>
</tr>
</tbody>
</table>
USEFULNESS RESULTS

Sensitivity

Within this research, two sensitivity studies have been done. The first one was about the variables of the simulation model for which the value is determined by the seed. Examples of these variables are desired maximum speed and distribution of vehicle headways at the start of the simulation. For a few trials, a number of simulations were run with different seeds. The influence of the seed appeared to be small, but larger if the percentage of ISA is higher. This could be explained by means of the platoon theory. According to this theory, ISA vehicles tend to be the head of a platoon. The vehicle at the head of a platoons are able to drive with their ‘desired speed’, i.e. the speed which is determined by the seed. All the leading vehicles are in the following mode and the vehicle in front of him/her determines their speed. The influence of the seed on the number of possibilities to cross the main road is larger, when more vehicles have ISA.

The second sensitivity study was on following behaviour, determined by the parameters free speed, speed at capacity, capacity of the road, critical density, and variability factor. The last determines the variability in minimum headway of the vehicles. Before the simulations were done, the value of these parameters was carefully chosen. The influence of these parameters was large. Especially the capacity: the grater the capacity, the more possibilities to cross the main road. The used value of the capacity was 1800 PCU/h. According to on-road measurements, 1800 PCU/h is on the low side. Values of 2000 PCU/h are sound. Therefore, the measured number of possibilities to cross the main road could only be an underestimation rather than an overestimation of the real number. This means that the effect of ISA on the number of possibilities to cross the main road can only be larger or similar to the number that was found in this research.

In practice

According to the theoretical results, ISA could take over the task of a traffic light according to the number of possibilities to cross the main road or the merge into the main road, in case of an obvious main road and if traffic light are desired but nor necessary. A second task of a traffic light is to give these possibilities at the right time. To know what the effect of ISA on this second task is, simulations were run for a real existing situation. An existing road site with an obvious main road, four junctions with traffic lights and one ‘give-way’ junction was simulated. According to the criterion of Slop, at two of the four traffic light junctions a traffic light is necessary and at the other two traffic lights are desirable but not necessary. Three variants of the scene were simulated. One is the real life situation, with four traffic lights. For the second one, the traffic lights were removed and the dedicated turning lanes, offset lanes, were used to separate the driving directions. The latter means that both driving directions have a single lane and one left-turning vehicle is able to stand in between the two lanes. The third variant is exactly the same as the second, but now one in twelve (+/- 8%) have ISA.

| Road length (200, 400, 600, 800, 1000 m) | Longer road length, more pcr. Biggest acceleration between 200 and 400 meters |
| Speed limit (30, 40, 50 km/h) | For all trials, differences less than 10% |
| Initiation (uniform, a-select, traffic light) | With a few exceptions, difference is less than 10% |
The three variants are judged on objective safety, subjective safety, traffic flow, environment, energy and costs. The results show that the performance of ISA variant in comparison with the performance of traffic light variant, is better on objective safety, traffic flow, milieu, energy. The judgement for the other two criteria, subjective safety and costs, depends strongly on suppositions and is hard to summarise. One could draw the conclusion that the existing situation could be improved on all criteria.

The overall conclusions were as follows. On junction with an obvious main road, no offset lanes for minor roads, but separate lanes for the two driving directions, ISA is a better solution for the traffic flow than traffic lights. Nevertheless, the variant with no traffic light and no ISA, also showed good results. Because of the latter, one could conclude that the changes in infrastructure (no offset lanes, separated lanes) are responsible for a big part of the positive effects of removing the traffic lights. The separation of traffic lanes, with a possibility for one left-turning vehicle to stand in between the two lanes, has a positive influence on traffic flow and safety. When the traffic flow reaches capacity, ISA could add an extra positive effect.

CONCLUSIONS

Research on ISA so far has been mainly based on safety, acceptability and technical development. The key question in these researches was not whether there would be an influence, but how great it would be. This research questioned if ISA has an influence on the traffic flow. The answer is yes and appears to be positive, the same as the effect on safety, according to almost every research study so far. When decision are made on implementing ISA as a safety tool, the positive effect on the traffic flow could be seen as a surplus. Besides, the positive effect on the traffic flow could also be used to strengthen the acceptability. According to the field trial at Tilburg (The Netherlands) field experience with ISA could also strengthen the acceptability (AVV, 2001)

ISA is one of the tools which could add a significant contribution to the aim of many European countries to lower the number of traffic causalities and injuries before 2010. With ISA the traffic flows more safely, without reducing the capacity.

LITERATURE.

Lahrmann, H., Boroch, T. (2001) INFATI User test – changes of behaviour, Aalborg University, Denmark

