Intelligent Speed Adaptation (ISA): A Successful Test in the Netherlands

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Abstract

In the Netherlands, an Intelligent Speed Adaptation (ISA) system has been successfully tested in practice for one year. In this test the ISA system controls the speed limit of a car. The on-board computer is connected with dGPS (differential Global Positioning System) and the different speed limits are programmed for roads and areas. If the local speed limit is exceeded, the fuel inlet is automatically restricted. In this respect, the Dutch test differs substantially from trials undertaken elsewhere (for example in Sweden). The primary goal of this field study is to examine whether ISA would be a realistic option as an instrument for controlling speed limits in the future. The Dutch ISA test fits within a broader European policy and research context.

From October 1999 till October 2000 a trial was conducted by the Transport Research Centre (AVV) of the Dutch Ministry of Transport in the city of Tilburg. Twenty passenger cars and one city bus were equipped with the ISA system. Three speed limits were used: 30, 50 and 80 km/h.

The evaluation program focuses on system technology, driving behavior, user ergonomics, and user acceptance and public support. Therefore data was collected through questionnaires, automatic data loggers and note books. Speed patterns were investigated also, by means of automatic data loggers. Final results were published in February 2001 and presented in this paper.

Résumé

Aux Pays-Bas, un système ISA (d'adaptation intelligente de la vitesse) fait l'objet depuis un an d'un essai pratique qui s'avère une réussite. Dans cet essai, c'est le système ISA qui commande la limite de vitesse d'une voiture. L'ordinateur de bord est connecté à un dGPS (differential Global Positioning System) et les différentes limites de vitesse sont programmées en fonction des routes et des zones. En cas de dépassement de la limite de vitesse locale, l'arrivée du carburant est automatiquement limitée. Les essais hollandais dans ce domaine diffèrent notablement des essais effectués ailleurs (par exemple en Suède). L'objectif essentiel de la présente étude sur le terrain est de déterminer si l'ISA est une solution réaliste comme instrument de contrôle des limites de vitesse pour l'avenir. L'essai ISA des Pays-Bas s'intègre dans le contexte plus large de la politique et de la recherche européennes.

Entre octobre 1999 et octobre 2000, un essai a été effectué dans la ville de Tilburg par le Centre de recherche (AVV) du ministère hollandais des transports. Vingt voitures particulières et un autobus ont été équipés du système ISA. Trois limites de vitesse ont été utilisées : 30, 50 et 80 km/h.

Le programme d'évaluation s'intéresse essentiellement à la technologie du système, au comportement de conduite, à l'ergonomie pour l'utilisateur ainsi qu'à l'acceptation par l'usager et au soutien du public. Des données ont donc été recueillies par l'intermédiaire de questionnaires, d'enregistreurs automatiques de données et de carnets de notes. Les configurations de vitesses ont également été étudiées au moyen d'enregistreurs automatiques de données. Les résultats définitifs ont été publiés en février 2001 et sont présentés dans cet article.
Road Safety in the Netherlands

The policy goal, set in 1986, is to reduce the number of traffic fatalities by 50% in 2010 and to reduce the number of injured people by 40% (as compared to 1986). To achieve these goals a renewed road safety approach is required. In the early 90s the Sustainable Safety Program was launched. This program focuses mainly on road classification and design, legislation, education and enforcement. However, creating smart roads and creating ‘smart’ drivers is not enough. Creating smart vehicles might be a way to go.

A study into the costs and benefits of lowering speeds of cars in the Netherlands has shown that enforcing the current speed limits would lead to a reduction in the number of hospital admissions by 15% and in the number of fatalities by 21%. Besides obvious safety advantages there are also environmental savings to be expected as well. Fuel consumption and carbon dioxide emissions would decrease by 11% and the emission of nitrogen oxides by 11%. These positive effects would lead to a decrease in the cost to society worth a total of US$ 250 million per year in the Netherlands. For these reasons, intelligent speed adaptation (ISA) must be considered as a new, intelligent way to solve speed violations.

About ISA

ISA is a collective name for systems in which the speed of a vehicle is permanently monitored within a certain area. When the vehicle exceeds the speed limit, the speed is automatically adjusted. We can distinguish three ISA variants:

The closed variant

This variant can be seen as the mandatory variant, because it works with an enforced speed adjustment: the system intervenes directly with the fuel supply. As a result it is impossible to exceed the speed limit.

The half-open variant

This system is also referred to as the intelligent gas pedal. If the speed limit is exceeded, the driver needs to use more force to push the accelerator. This involves so much effort that adjustment of the speed is the more likely reaction. However, it remains possible for the driver to overrule and thus to control the system. As such, the adjustment of the speed has a voluntary character.

The open variant

The open ISA system does not intervene with the gas supply or the accelerator. When the driver exceeds the speed limit in an area in which a speed limit applies, he or she is informed or warned by a visual or auditory signal, or a combination of both. This variant is in a sense also voluntary (it is a warning system, not a control system).

ISA initiative in the Netherlands

In 1997 the Dutch Minister of Transport ordered a pilot study to look into the feasibility of forced speed reduction by technical means. Although this was an important political signal, it was recognized from the beginning that the individual driver might not have such a positive attitude towards this new speed control measure. If technology demands too much of people’s ability to change - and technology always changes faster than
people can - people will resist the change. Technically, of course, we can restrict people’s driving speed. However, we need to know if people want us to do that.

Together with the city of Tilburg and the province of Noord-Brabant, the Dutch Ministry of Transport initiated a trial to gain experience with ISA in order to examine whether ISA would be a realistic option as an instrument for speed control. Feasibility is assessed in technical and operational respect as well as social respect.

By choosing the closed ISA variant, the Dutch test distinguishes itself from other ISA options chosen in Sweden and the United Kingdom. Whereas Sweden predominantly goes for open options by informing and warning drivers when exceeding the speed limit, a more restrictive but still open ISA option is chosen in the United Kingdom by allowing the driver to exceed the speed limit despite the counter pressure on the gas pedal. Two main reasons did choose the Dutch administration for the full mandatory ISA option. First reason is to avoid overlap with tests elsewhere in Europe, and second reason is to enable a thorough study of public acceptance of just the ISA option that includes the maximum advantage in terms of reduced speed and corresponding increase in traffic safety in terms of fatalities and traffic injuries.

Technology used

The ISA system used in Tilburg is of the closed variant. The on-board computer of the ISA system contains a virtual map of the test area with information about the speed limits desired. A differential Global Positioning System (dGPS) determines accurately to two meters in which speed zone of the map the car is situated. When an ISA vehicle drives into a preprogrammed area, the speed limiting mechanism is activated at a predetermined speed. If the vehicle speed is exceeded, the fuel inlet is automatically restricted. The system does not control the brakes. The ISA test in Tilburg does not need beacons along the road or a whole network of cables. The system was equipped with an emergency button that could be activated by pushing it.

The ISA test applied in the city of Tilburg includes four maximum speed levels: 18, 30, 50 and 80 km/h. The 80 km/h speed level is applied on two regional roads. The other urban roads are limited to 50 km/h (collectors) and 30 km/u (residential roads). The 18 km/h speed level was included in the test to allow for low speed level in the immediate environment of a school for young children and nearby the central shopping center of the residential area. However, the 18 km/h speed limit was removed halfway the test.

The setup of the ISA test

The Dutch ISA test was executed in the city of Tilburg between October 1999 and September 2000. 20 passenger cars and one city bus were equipped with the ISA technology. The on-board computer was connected with dGPS (differential Global Positioning System) and the different speed limits were programmed in a map. The test cars are being used by 120 test drivers from the residential area Campenhoeof and by 20 bus drivers. Each test
driver had the test car available for a period of 8 weeks. The first two weeks are non-active ISA weeks: the driver got used to the car and the ISA system. After this period the ISA system was activated and the complete test area was regulated by the speed limits set. The only way to escape from the system was by using the emergency button.

During the test period, communication to all participants played an essential role, not only for the public in general, but for the test drivers and for the residents of the Campenhof district in particular. Besides letters to the inhabitants, personal correspondence, leaflets and brochures, a special ISA information center was opened in the district during more than a year.

**Evaluation program**

To examine whether ISA is a feasible option for speed control in the future, four main objectives for the test evaluation were set: technology, driving behavior, user ergonomics and user acceptance and public support.

**In-car ISA technology**

One of the objectives of the test was to prove the ISA technology used in the vehicles. The installation and the function of the hardware and the software was evaluated.

**Driving behavior**

The main questions to evaluate are:
- Will ISA lead to a more homogeneous speed pattern?
- Will ISA lead to the desired speed control?
- Will the ISA drivers drive more relaxed?
- Does ISA have a positive effect on traffic safety and safe driving?

The driving behavior was examined by network speed data and driver experiences. Each test driver used the ISA test car for eight weeks. During the first two weeks, the ISA system was switched off. One reason for this was to allow the test drivers getting used to the new car. The other reason was to be able to compare ISA driving behavior with non-ISA driving behavior. Driving behavior was determined by dataloggers. Every two seconds, the board computer logged the time, position, direction and actual speed of the ISA car and the actual occurring speed limit. In order to structure the speed pattern analysis, the road network of the test area was divided into road sections. Fifteen road sections in the test area were selected for detailed analysis. For each section the average, deviation and maximum speed was determined and compared for situations with and without the ISA system functioning.

To evaluate the test drivers opinion about the effects on their own driving behavior, the test drivers had to fill in questionnaires, before, during and two months after their eight weeks test period. Driver logbooks were used to collect information on test drivers experience. Finally, information was collected during two sessions with test drivers, one time in November 1999, the other in June 2000. Because this is a relatively small scale trial, it is not possible to show significant effects of ISA on traffic safety, emission and energy consumption.

**User ergonomics**

User ergonomics were examined by user’s experiences in order to improve the ergonomic use of the ISA system. In particular the ISA information...
User acceptance and public support

The user acceptance and the public support was of a great interest to the ISA test in the Netherlands. In respect, four groups were involved:

- the test drivers (users)
- the inhabitants of the residential area of Campenhoef (radius 2 km)
- the citizens of the city of Tilburg (radius 5 km)
- the population of the province Noord-Brabant (radius 20 km)

Each group consisted of 120 people. By questioning all groups before, during and after the actual trial period, a broad perspective of the attitude towards and the acceptance of ISA could be derived.

ISA test results

In-car ISA technology

- The programming of the map needs more accuracy than collecting road data from a map; a test drive is required.
- The speed limiter functions satisfactorily, although the equipment was replaced because of wire breakage due to vibrations.
- The GPS signal was disturbed by overhanging trees.
- There were technical problems related to the transition between the 18 and the 50 km/h speed level.

Driving behavior

From the dataloggers the following results turned out (see appendix):

- no speed limit within the ISA test area was violated;
- the average speeds decreed;
- a more homogeneous speed pattern is achieved;
- the effect of ISA increases when there are no traffic calming measures.

The surveys showed the following results:

- one quarter of the test drivers reported lower speeds within the speed limit;
- one quarter of the test drivers said they made less violation on other traffic rules;
- one quarter of the test drivers said they kept more distance from other road users;
- half of the test drivers reported hardly any speed compensation outside the ISA test area;
- at roads where the driving speeds generally exceed the speed limit some test drivers reported some irritation from other road users (tailgating); the test drivers felt embarrassed about this situation;
- almost one third of the test drivers report a reduction in the attention for the driving task, while an equal number report an increase in attention.
**User ergonomics**
- The emergency button is necessary; during the test period the button was used only twice.
- A (acoustic) signal for system failures and speed limit change is requested by majority.
- The visibility of the display at night should be enhanced.
- The ISA system might cause distraction.
- A smoother change of speed limit is desired.

**User acceptance and public support**
User acceptance and public support are very important issues to the Dutch test. In the next tables the results of the user acceptance is presented.

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### Table 1  User experience of ISA versus non ISA

<table>
<thead>
<tr>
<th></th>
<th>test drivers passenger cars</th>
<th>test drivers city bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>more enjoyable</td>
<td>22</td>
<td>60</td>
</tr>
<tr>
<td>no difference</td>
<td>23</td>
<td>25</td>
</tr>
<tr>
<td>less enjoyable</td>
<td>52</td>
<td>10</td>
</tr>
<tr>
<td>no opinion</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Table 2  User appreciation of ISA

<table>
<thead>
<tr>
<th></th>
<th>test drivers passenger cars</th>
<th>test drivers city bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>positive</td>
<td>64</td>
<td>90</td>
</tr>
<tr>
<td>neutral</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>negative</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>no opinion</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>total</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

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The user support is determined by surveying the attitude towards ISA before and during the test. The results are presented in table 3.

### Table 3  User attitude towards ISA before and during the test (0-M resp. 1-M)

<table>
<thead>
<tr>
<th></th>
<th>all test drivers</th>
<th>test drivers passenger cars</th>
<th>test drivers city bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>very positive</td>
<td>20 16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>positive</td>
<td>64 49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neutral</td>
<td>14 19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>negative</td>
<td>2 14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>very negative</td>
<td>0 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although the majority of the 120 test drivers experience the ISA system as less enjoyable (52%), the greater majority of the test drivers report a positive judgment on ISA use (64%). The majority of the 20 bus test drivers experience the ISA system as more enjoyable (60%), and most of the bus test drivers report a positive judgment on ISA use (90%).

Although the attitude decreases slightly from (very) positive to neutral during driving, a majority of the test drivers continue to support ISA (55%), while 19% of the response is neutral. A minority of the test drivers (16%) reject ISA in the end.

The public support (the non-drivers) is determined by surveying the attitude towards ISA before and during the test. Several area levels are distinguished. The results are presented in table 4.

### Table 4  Public attitude towards ISA before and during the test (0-M resp. 1-M) in several area levels

<table>
<thead>
<tr>
<th></th>
<th>Campenhoef residential area (r=2 km)</th>
<th>city of Tilburg (r=5 km)</th>
<th>province of Noord-Brabant (r=20 km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-M 1-M</td>
<td>0-M 1-M</td>
<td>0-M 1-M</td>
</tr>
<tr>
<td>very positive</td>
<td>20 13</td>
<td>9 11</td>
<td>9 5</td>
</tr>
<tr>
<td>positive</td>
<td>60 52</td>
<td>43 35</td>
<td>46 36</td>
</tr>
<tr>
<td>neutral</td>
<td>15 29</td>
<td>17 27</td>
<td>17 30</td>
</tr>
<tr>
<td>negative</td>
<td>5 5</td>
<td>27 21</td>
<td>21 21</td>
</tr>
<tr>
<td>very negative</td>
<td>0 1</td>
<td>4 7</td>
<td>7 8</td>
</tr>
<tr>
<td>total</td>
<td>100% 100%</td>
<td>100% 100%</td>
<td>100% 100%</td>
</tr>
</tbody>
</table>

The majority of the public generally has a neutral to positive attitude towards ISA before and
during the test. The closer the public gets in touch with ISA, the more support it will get. Although the (very) positive attitude decreased slightly during the test, a substantial amount of people remain neutral 27-30% to (very) positive 41-65%.

**Overall conclusions**

- The ISA system as tested in the Netherlands is technologically feasible; minor improvements are needed.
- As expected, the ISA test in Tilburg has proved a positive effect on driving behavior and speed patterns, although interaction between ISA drivers and non-ISA drivers can lead to undesirable maneuvers by the non-ISA drivers (passing, tail gating), therefore ISA will imply a positive effect on traffic safety at a large scale implementation.
- Infrastructure design and ISA must be harmonized.
- ISA Tilburg taught us a lot about user ergonomics; lots of suggestions are recommended by the test drivers.
- The ISA Tilburg test shows that great public support can be gained; adequate communication however is essential.

**ISA in European context**

A number of European countries cooperate intensively both on a policy as on a practical level. The most active countries with regard to ISA research are Sweden and the United Kingdom. In a sense the ISA Tilburg trial is relatively small scale compared to the ones in Sweden. However, the additional value of the Dutch research lies in the fact that the Dutch cars were equipped with the closed variant as opposed to the half-open and open ISA variants in Sweden. This closed variant is unique. Also, the technology used to equip the Dutch cars differs from the Swedish experiment. Instead of beacons, dGPS is used. Finally, social-cultural differences of the general public and the test drivers are looked into.

The United Kingdom has carried out theoretical and simulation studies and is also preparing a practical trial. Other European countries that are interested in ISA are France, Belgium, Finland and Norway. The aim of cooperation is to coordinate research and to provide a coherent policy and to determine the action to be taken by the European Union.

The ISA trial at Tilburg-NL is expected to contribute to a better understanding of the opportunities of this kind of speed control. The implementation of ISA can take many forms. It can be a voluntary, open (through signals), half-open (counter pressure accelerator) or closed mandated system. Used at all roads or at restricted areas. Applicable for all kind of drivers or a selected group.

Whatever product-market combination fits best in a specific situation, acceptance has to be achieved as a prerequisite to implementation. This ISA trial gives some insight into how this can be gained.

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APPENDIX Column 1

30 km/h street without traffic calming measures

Speed pattern without ISA

APPENDIX Column 2

30 km/h street with traffic calming measures

Speed pattern without ISA

Meetvak 605, onbegrensd rijden

Meetvak 1022, onbegrensd rijden

Speed pattern with ISA

Meetvak 605, begrensd rijden

Meetvak 1022, begrensd rijden

Speed pattern with ISA
APPENDIX Column 3

50 km/h distributor road

APPENDIX Column 4

from 50 km/h to 80 km/h distributor road

Meetvak 956, onbegrensd rijden

Meetvak 107, onbegrensd rijden

Speed pattern without ISA

Meetvak 956, begrensd rijden

Meetvak 107, begrensd rijden

Speed pattern with ISA

Speed pattern with ISA (0-180m) and without ISA (>180)
APPENDIX Column 5

80 km/h rural distributor road (speed control by camera)

APPENDIX Column 6

City bus (public transport)