Speed management through vehicle measures, Intelligent Transport Systems and Intelligent Speed Assistance

Dr. Sven Vlassenroot (Ghent University)
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• What is ITS?
  • Different types of ITS
• What are ADAS?
• What is ISA?
  • Different systems of ISA
  • How does ISA work?
• ISA – History
• Some Trials in depth
• Benefits and main results
• The future of ISA
What is ITS?

- **Intelligent Transportation System (ITS)** refers to:
  - efforts to add **information and communications technology** to transport infrastructure and vehicles
  - in an effort to manage factors that typically are at odds with each other, such as vehicles, loads, and routes
  - to **improve safety and reduce vehicle wear, transportation times, and fuel consumption.**
What are ADAS?

- We will focus on **Advanced Driving Assisting Systems (ADAS)**

  - ADAS are systems to help the driver in its driver process. When designed with a safe Human-Machine Interface it should increase car safety and more generally road safety.

Types of ADAS:

- In-vehicle navigation system with typically GPS and TMC for providing up-to-date traffic information.
- Adaptive cruise control (ACC)
- Lane/road departure detection/warning system
- Lane departure warning
- Lane change assistance
- Collision warning system
- **Intelligent speed adaptation or intelligent speed advice (ISA)**
- Pedestrian protection system
- Automatic parking
- Traffic sign recognition
- Blind spot detection
- Driver drowsiness detection
- Car2car communication
- Hill descent control
- Night vision
- Adaptive light control
What is ISA?

Intelligent Speed Adaptation are intelligent in-vehicle transport systems, that can

• warn the driver about speeding,
• discourage the driver from speeding or
• prevent the driver from exceeding the speed limit
## Different systems

<table>
<thead>
<tr>
<th>Level of support</th>
<th>Type of the feedback</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informing</td>
<td>Mostly visual</td>
<td>The speed limit is displayed and the driver is reminded of changes in the speed limit.</td>
</tr>
<tr>
<td>Warning (open)</td>
<td>Visual/auditory</td>
<td>The system warns the driver if he is exceeding the posted speed limit at a given location. The driver himself decides whether to use or ignore this information and to adjust his speed.</td>
</tr>
<tr>
<td>Intervening (half-open)</td>
<td>Haptic throttle (moderate/low force feedback)</td>
<td>The driver gets a force feedback through the gas pedal if he tries to exceed the speed limit. If applying sufficient force, it is possible to driver faster than the limit.</td>
</tr>
<tr>
<td>Automatic control i.e speed limiter (closed)</td>
<td>Haptic throttle (strong force feedback) and Dead throttle</td>
<td>The maximum speed of the vehicle is automatically limited to the speed limit in force. Driver's request for speeds beyond the speed limit is simply ignored.</td>
</tr>
</tbody>
</table>

Source: Morsink et al. 2006, SWOV
How does ISA work?

Source: e-safety/e-prevent
SMART GAS PEDAL™

Terminal

Position
Map memory
Log function
Communication

Elektronics for Mechanical unit

ODO meter/pulse
How does ISA work?

Source: LAVIA, France
ISA – History

• The pioneers: Saad and Malaterre, 1982

Source: Oliver Carsten, University of Leeds
ISA – History

1990s

- Trials in Sweden, culminating in the large-scale trial of 1999-2001
- EVSC project in Britain, 1997-2000
- Tilburg in the Netherlands: 20 cars used by 120 drivers (1999-2000)

Source: Oliver Carsten, University of Leeds
ISA – History

2000 and later

- Denmark (2000-1 and 2005-8)
- Finland (2001-)
- ISA-UK (2001-6)
- Two projects in Belgium (2001-2)
- LAVIA in France (2002-6)
- Austria (2003-4)
- Norway (2005-)
+ Australia (TAC SafeCar)
- Japan (Soft Car)

Source: Oliver Carsten, University of Leeds
Examples of trials

Sweden

- In the cities of Umea, Borlange, Lund and Linkoping approximately 5000 thousands vehicles had been equipped with:
  - two types of warning ISA (Umea, Borlange)
  - an intervening ISA (Lund).
- In Linköping, both informative and accelerator pedal systems were tested.

<table>
<thead>
<tr>
<th>Test site (type of ISA and road types)</th>
<th>ISA effect on speed limit violations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of vehicle kilometres travelled above speed limit, Pre-period</td>
</tr>
<tr>
<td>Lund – intervening ISA</td>
<td></td>
</tr>
<tr>
<td>30 km/h</td>
<td>33.7</td>
</tr>
<tr>
<td>50 km/h</td>
<td>28.2</td>
</tr>
<tr>
<td>70 km/h</td>
<td>35.9</td>
</tr>
<tr>
<td>Borlange – warning ISA</td>
<td></td>
</tr>
<tr>
<td>30 km/h</td>
<td>33.8</td>
</tr>
<tr>
<td>50 km/h</td>
<td>31.1</td>
</tr>
<tr>
<td>70 km/h</td>
<td>21.4</td>
</tr>
<tr>
<td>90 km/h</td>
<td>25.1</td>
</tr>
<tr>
<td>110 km/h</td>
<td>12.4</td>
</tr>
</tbody>
</table>

Source: SRA, 2002
Examples of trials

France

- A trial near Paris was held with the cooperation of car-manufactures
- three modes of ISA - advisory mode, voluntary active mode and mandatory active mode – were used
- Results of the pre-evaluation:

<table>
<thead>
<tr>
<th></th>
<th>Urban roads</th>
<th>Country roads</th>
<th>Motorway</th>
<th>Journey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed driven ≤ regulatory speed limit</td>
<td>74%</td>
<td>86%</td>
<td>93%</td>
<td>81%</td>
</tr>
<tr>
<td>Speed driven &gt; regulatory speed limit</td>
<td>26%</td>
<td>14%</td>
<td>7%</td>
<td>19%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 3. Distance driven at a speed lower than, equal to or higher than the speed limit, according to the type of road and the length of the journey (in %).

Source: Saad et al., 2007
Examples of trials

UK

2 urban trials in Leeds (1 private motorists, 1 fleet) and 2 rural trials in Leicestershire (1 private motorists, 1 fleet)

Phase 1
Without

Phase 2
With

Phase 3
Without

Mean of vehicle speed

Phase 1 Phase 2 Phase 3

Without Without

With

Source: Oliver Carsten

* denotes the mean difference is significant at the 0.05 level
** denotes the mean difference is significant at the 0.01 level
Examples of trials
Belgium
- Trial in Ghent with Active Accelerator Pedal.
- Some drivers were used as role-models in ISA-driving

<table>
<thead>
<tr>
<th>Speed limit (km/h)</th>
<th>AAP inactive (%)</th>
<th>AAP active (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>45.90</td>
<td>42.80</td>
</tr>
<tr>
<td>50</td>
<td>14.70</td>
<td>13.10</td>
</tr>
<tr>
<td>70</td>
<td>17.60</td>
<td>12.60</td>
</tr>
<tr>
<td>90</td>
<td>13.50</td>
<td>3.80</td>
</tr>
<tr>
<td>Total</td>
<td>16.30</td>
<td>13.10</td>
</tr>
</tbody>
</table>

Table 2.17. Percentage of driven distance while speeding, in the test area

Source: Vlassenroot et al., 2007
Examples of trials
Denmark
• Trial with young drivers and “pay as you speed system”
Source: Lahrman et al.
Examples of trials
The Netherlands

• A trial with a closed system
• 120 test drivers drove an equipped vehicle, each for 8 weeks.

<table>
<thead>
<tr>
<th>Speed limit (km/h)</th>
<th>Average speed when driving without ISA (km/h)</th>
<th>Average speed when driving with ISA (km/h)</th>
<th>Difference (km/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>28.9</td>
<td>25.1</td>
<td>-3.8</td>
</tr>
<tr>
<td>50</td>
<td>40.0</td>
<td>38.2</td>
<td>-1.8</td>
</tr>
<tr>
<td>80</td>
<td>57.3</td>
<td>57.0</td>
<td>-0.3</td>
</tr>
</tbody>
</table>
Effects of ISA

- General findings regarding ISA speed effects based on some trials and simulator studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Methodology</th>
<th>Country</th>
<th>Effect on mean speed</th>
<th>Effect on standard deviation of speed</th>
<th>Speed violations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comte (2000)</td>
<td>Driving simulator</td>
<td>UK</td>
<td>↓</td>
<td>↓</td>
<td>?</td>
</tr>
<tr>
<td>Peltola &amp; Kumala (2000)</td>
<td>Driving simulator</td>
<td>FIN</td>
<td>↑</td>
<td>↓</td>
<td>?</td>
</tr>
<tr>
<td>Van Nes et al. (2006)</td>
<td>Driving simulator</td>
<td>NL</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Brookhuis &amp; De Waard (1999)</td>
<td>Instrumented vehicle</td>
<td>NL</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Paatalo et al. (2001)</td>
<td>Instrumented vehicle</td>
<td>FIN</td>
<td>↓</td>
<td>?</td>
<td>↓</td>
</tr>
<tr>
<td>VVN (2006)</td>
<td>Instrumented vehicle</td>
<td>NL</td>
<td>?</td>
<td>?</td>
<td>↓</td>
</tr>
<tr>
<td>AVV (2001)</td>
<td>Field trial</td>
<td>NL</td>
<td>↓</td>
<td>↓</td>
<td>?</td>
</tr>
<tr>
<td>Lahrmann et al. (2001)</td>
<td>Field trial</td>
<td>DK</td>
<td>↓</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Biding &amp; Lind (2002)</td>
<td>Field trial</td>
<td>S</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Vlassenroot et al. (2007)</td>
<td>Field trial</td>
<td>B</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
</tbody>
</table>

Source: Morsink et al.
## Effects of ISA

- **ISA effects on safety**

<table>
<thead>
<tr>
<th>System type</th>
<th>Speed limit type</th>
<th>Best estimate of injury crash reduction</th>
<th>Best estimate of fatal and serious crash reduction</th>
<th>Best estimate of fatal crash reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Informing</td>
<td>Static</td>
<td>10%</td>
<td>14%</td>
<td>18%</td>
</tr>
<tr>
<td></td>
<td>Variable</td>
<td>10%</td>
<td>14%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Dynamic</td>
<td>13%</td>
<td>18%</td>
<td>24%</td>
</tr>
<tr>
<td>Voluntary automatic control</td>
<td>Static</td>
<td>10%</td>
<td>15%</td>
<td>19%</td>
</tr>
<tr>
<td></td>
<td>Variable</td>
<td>11%</td>
<td>16%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Dynamic</td>
<td>18%</td>
<td>26%</td>
<td>32%</td>
</tr>
<tr>
<td>Mandatory automatic control</td>
<td>Static</td>
<td>20%</td>
<td>29%</td>
<td>37%</td>
</tr>
<tr>
<td></td>
<td>Variable</td>
<td>22%</td>
<td>31%</td>
<td>39%</td>
</tr>
<tr>
<td></td>
<td>Dynamic</td>
<td>36%</td>
<td>48%</td>
<td>59%</td>
</tr>
</tbody>
</table>

*Best estimates of crash savings by ISA type and crash severity (source: Carsten & Tate, 2005)*
Effects of ISA

• ISA effects on the environment
  • have positive effect on reduction of emissions

• ISA effects on traffic efficiency
  • homogeneous traffic flow on traffic throughput predominantly show positive results

• ISA side effects
## Estimated effects of ISA on safety, environment, efficiency

<table>
<thead>
<tr>
<th></th>
<th>Type of system</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Informing (static)</td>
</tr>
<tr>
<td></td>
<td>Warning Intervening (static)</td>
</tr>
<tr>
<td></td>
<td>Controlling Limiting (dynamic)</td>
</tr>
<tr>
<td>Fatal crashes</td>
<td>≈ -20 %</td>
</tr>
<tr>
<td>CO₂</td>
<td>-2 to -11 %</td>
</tr>
<tr>
<td>NOₓ</td>
<td>-2 to -7 %</td>
</tr>
<tr>
<td>HC</td>
<td>-2 to -8 %</td>
</tr>
<tr>
<td>Travel time</td>
<td>- to 0 (high traffic density)</td>
</tr>
<tr>
<td></td>
<td>0 to + (low traffic density)</td>
</tr>
</tbody>
</table>
Users’ acceptance

• **Acceptance versus effectiveness paradox**
  
  *the more effective the system is, the less accepted it will be*

• **The driver**
  
  • Drivers, whose speed behaviour would benefit most from ISA, are accepting ISA the least.
  
  • Driver characteristics could especially be significant for the acceptance and furthermore for the real use of voluntary types of ISA

• **The road environment**
  
  • Credible speed limits
Implementation of ISA
Implementation strategies

- **Mainly market-driven – private cars**
  - Informative/warning ISA
  - Combination of functions (e.g. ISA+navigation+ACC)
  - Purchase motivation: less fines, more comfort, safety and environmental awareness, enriched traffic information

- **Mainly market-driven – professional fleet**
  - Economical advantage
  - Fitting in a company’s ‘safety culture’

- **Mainly government-driven**
  - Automatic controlling/limiting ISA
  - Create acceptance
  - Focus on high-risk groups (?)
Implementation of ISA

### Crashes Saved 2010 to 2070

<table>
<thead>
<tr>
<th></th>
<th>Slight Crashes</th>
<th>Serious Crashes</th>
<th>Fatal Crashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Driven</td>
<td>4%</td>
<td>8%</td>
<td>13%</td>
</tr>
<tr>
<td>Authority Driven</td>
<td>15%</td>
<td>25%</td>
<td>30%</td>
</tr>
</tbody>
</table>

- Benefit to cost ratios (accidents + fuel + \(\text{CO}_2\)):
  - Market Driven scenario 3.4
  - Authority Driven scenario 7.4

Source: Oliver Carsten, University of Leeds
Initiatives

- There are implementation initiatives in
  - London (Company-cars)
  - Stockholm
  - Gothenburg
- ISA or speed alert products can be found on navigation systems (Tomtom)
- ISA in the form of a camera-based system:
  - Opel
  - Saab
  - Mercedes-Benz
- Initiatives in creation of speed limit databases
Speed limit databases

- **Speed Alert project**
  Research on framework to harmonize the in-vehicle speed alert concept definition and to investigate the first priority issues to be addressed at the European level.

- **ActMAP**
  online incremental updates of digital map databases in the vehicle was investigated and created.

- **Others:** MAPS & ADAS, Feedmap,.....

- **National Road Databases:** Finland, Sweden, Flanders, France,...
Speed limit databases framework
conclusions

• ISA has a long history (already 20 years)
• ISA is beneficial in road safety and livability
• Small steps in implementation are made (city initiatives, speed limit databases)
• EU directive about speed limit databases

• Still the question: Why take it so slow to implement?
• Questions?

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More info on http://www.isaweb.eu