Vägverket

Variable speed limits:

Evaluation of the road weather controlled section

Trials with Variable Speed Limits (VSL) for different applications are carried out by the Swedish Road Administration (SRA). The goal is to demonstrate if and how VSL can contribute to a better speed adaptation in a cost-efficient way. Road weather controlled sections are one application area. For this type of application the maximum allowable speed limit is adjusted downwards to different levels when adverse weather and road surface conditions occur. Preliminary results from the first trial period are presented in this report.

Road weather stations (RWIS) at the trial sites collect weather data from the air as well as above and under the road surface. These data are processed by a weather model at the SRA Head Quarters from where alerts signals are sent to the regional Traffic information centre (TIC). Operators activate the Variable speed limit signs (VSL signs) with shining white figures in a red ring on dark background resulting in a change of the displayed speed limit. Every step is logged and the information is transmitted to a central data-base.

The trial sites included in the report are a 17 km section of E22 in the province ofBlekinge (Åryd-Ronneby), 55 km of E6 in Halland (Skottorp–Heberg) and the Uddevalla Bridge. The first mentioned two establishments are controlled based on the road surface condition and the Uddevalla Bridge is controlled based on crosswind.

The sections differ from each other. The site in Halland is a fairly traffic intense highway (18000 vehicles/day) while Blekinge is a three lane highway with centre crash barrier (2+1) and average daily traffic of approximately 8500 vehicles/day.

The evaluation programme involves the following main activities:

- Follow-up analyses of operational data
- Measurements and analyses of traffic data (traffic counts, speed- and performance studies)
- Driver attitude surveys (questionnaires in Blekinge and Halland)
- Cost-benefit analyses (including impact assessments regarding traffic safety, travel time and environment)
- Scanning (international experiences, etc)

Operational follow-up

The technical equipment functioned satisfactorily except for the communication system in Blekinge. Due to the problems in Blekinge the accessibility measure, meaning the share of time when all VSL signs could be correctly controlled at adverse weather conditions, was only registered to 62%. In Halland however the technical accessibility measure was 99.2 %. Due to wind sensor problems at the Uddevalla site, incorrect values were registered. This sensor is now disconnected.

The sign control procedure did not work fully satisfactorily. There are quality drawbacks in the operator support systems (such as the weather model, RWIS-data etc).

Since data from RWIS are delivered in 15 minutes cycles, alerts from the weather model arrive late and there could be big jumps in suggested levels. Contacts with the road maintenance contractor are needed for confirmation of indicated severe road surface conditions (levels 80 and 60 km/h) and for information about completed ploughing and salting mission. This might take long, especially at night, before the contractor has moved to the site. During that time the speed limit might be insufficiently decreased by the operator although the conditions call for lower limits. This might give the drivers a false message. Improvements are needed.

Traffic impacts

Traffic data were collected in pre and post studies carried out during two consecutive winter seasons. A second follow-up was accomplished in Blekinge a year later to observe the long term effects. The speed adaptation was clearly improved by the VSL system at both sites (Halland and Blekinge). This is especially true for passenger cars. The most evident impacts occur at low speed limits. The average speed is then 15-20 km/h below the level that the drivers choose during corresponding adverse conditions with traditional fixed signs. See figure below.

The average speed in Halland increased only by 2 km/h during good conditions despite the fact that the highest speed limit was changed from 110 to 120 km/h. One might speculate why it did not increase more. One reason could be that it is unclear to the drivers where the VSL system starts and ends. Another explanation could be that they consider the speed limit around 110 km/h to be comfortable.

The increase of the maximum permitted speed limit in Blekinge from 90 to 110 km/h made the average speed to increase by 4-5 km/h. This is also valid for Uddevalla although there was no raise of the speed limit there. Thus the observance of the highest speed limit increased. In Blekinge the observance of the speed limits also improved when wet road surface or snow (displayed 100 and 90 km/h respectively).

However the observance of the lowest speed limits at severe road surface conditions decreased as expected.

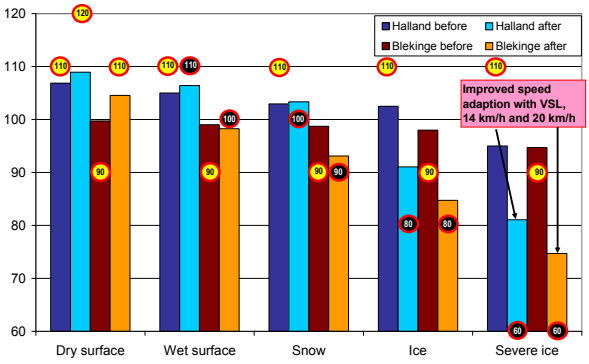

Figure: Average speeds at Hökaslätt in Halland and Bräkne-Hoby in Blekinge (both directions) at different road surface conditions with and without VSL

It can be concluded that the VSL system gives a minor contribution to better speed adaptation at fairly difficult conditions. At hard and very rough conditions (snow, ice, and severe ice) the VSL system gives significant extra stimuli to the drivers to adjust their speed properly.

Long time measurements were conducted in Blekinge one year after the first measurement period with the system operational.

The results show a continuing decrease of the average speed to an even lower level than during the first follow-up period. This is especially evident when 60 km/h is displayed.

Attitudes

The drivers´ respect of the speed limits strengthened with the introduction of VSL. In total, more than 90 % of the respondents in Halland and about 70 % in Blekinge consider the system to be good. The most frequent comment to why the system is good is that it contributes to a more harmonised traffic flow. About 80 % of the drivers believe that they have become more attentive regarding the road surface when passing an activated VSL sign. A majority of the respondents in both surveys also believes that displayed speed limits are in line with the current weather and road surface conditions while about one third disagree to this. Almost half of the drivers in Blekinge thus consider the signs sometimes being out of order or that the wrong speed message is displayed. Regardless of the reason behind this opinion, it is important to display speed limits that are apprehended as correctly as possible with regard to current road surface conditions. Otherwise it will be difficult to maintain public credibility.

The drivers believe that observance and speed adaptation can be increased by more speed enforcement. However to an even higher degree they think that information about the reasons for decreasing the speed limits leads to better attention and
observance.

Traffic safety

Traffic safety, represented as difference in accident figures, was calculated using the traditional power model based on measured speeds and traffic load during different road surface conditions. The Halland study revealed no difference with regard to the total number of accidents. However the number of fatalities and severely injured increased by 4% (at 80 % functional accessibility). Statistics shows 11 people killed or severely injured before the introduction of VSL. After the introduction the number of fatalities and severely injured decreased from 22 to 15 individuals during the first two years. This tendency is promising.

For the Blekinge case figures from the accident database STRADA state that the number of accidents with injuries increased from 4 to 13 during the first three years and that the number of fatalities and severely injured increased from 1 to 2 individuals after the introduction of a raised maximum permitted speed limit and VSL. However the follow-up periods are far too short. Thus it is important to continue the accident analyses over longer periods of time.

Performance

The idea behind weather controlled variable speed limits is to be able to accept higher speeds at good conditions (dry surface) as a trade off for differentiated speed regulations during periods with adverse weather and road surface conditions. In Halland the time consumption decreased by 1.3 % while using VSL in combination with a raised maximum speed limit. The corresponding figure for Blekinge is 1.4 %. Thus the impact on time consumption is minor.

Environment

The environmental impact from VSL is marginal. Raising the maximum speed limit in Halland from 110 to 120 km/h resulted in 0.6 % increase of carbon dioxide emissions. This is however partly compensated by a decrease in emissions during periods of lower speeds at adverse weather conditions. The resulting impact for Halland is 0.4 % increase. A conclusion is that VSL solely influence the environment positively although to a negligible degree.

In Blekinge the increase of carbon dioxide emissions is 2 % caused by the raise of the maximum speed limit from 90 to 110 km/h just before the introduction of the VSL system.

Socio economic impacts

The socio economical calculations for Halland reveal a benefit cost ratio of +1.6. Thus the investment is beneficial provided that correct speed limits are displayed during 80 % of the time when adverse weather conditions occur. This accessibility level however is not sufficient to make the investment in Blekinge beneficial (benefit cost ratio +0.8). A sensitivity analysis shows that the accessibility level for correct speed limit display that adverse weather conditions need to be prevailing for 92 % of time in order to obtain the same benefit ratio as in Finland (+1.9).

Analyses of different isolated measures for Blekinge indicate that raising the maximum speed limit from 90 to 110 km/h alone results in significant negative safety consequences. However the introduction of VSL, when the maximum speed limit is 110 km/h, is a very profitable measure (benefit cost ratio +7.6). The analysis also indicates that a decrease of the maximum permitted speed limit to 100 km/h in combination with a reduction of the number of alert or speed display levels of the VSL system to three levels, which has been suggested, will become a very valuable measure.

Suggested action

To obtain profitability, better accessibility is necessary especially in Blekinge, which means that the part of time when correct speed is displayed during adverse conditions must reach a higher level than measured during the trials. Improved profitability
might also be received by reducing and adjusting the displayed speed levels. This implies that steps must be taken to improve the technical performance and the operational handling of the system.

In a short time perspective the following actions might be relevant:

- Improve the communications system in Blekinge. More robust technique need to be installed
- Improve the data delivery from RWIS. Data must be requested more frequently than today (15 minutes) in order to react upon sudden weather changes like heavy summer rainfalls
- Improve the support systems of the TIC. The VSL routines need to be integrated in the normal work instructions
- The lowest displayed speed limits should be activated directly upon alarm after a short check of the RWIS data, meteorological prognosis and possibly cameras. If needed, an adjustment of the displayed speed limit may be made based on contact with the maintenance crew
- New road surface sensors need to be sufficiently tested and validated using friction measurement equipment during actual conditions

On a long time span:

- Introduce a common principle for variable speed limits on weather controlled road sections. Three levels are suggested (good, severe and very severe driving conditions) in 20 km/h steps and the lowest at 50 km/h.
- Adjust the criteria to this three level principle also for sections with wind force control.
- Introduce fully automatic control (monitored from Traffic Information Centre)

In order to achieve even better speed adaptation to the prevailing road surface conditions the following measures should be considered:

- Conduct frequent speed checks. Develop automatic enforcement systems to handle variable speed limits. Average speed enforcement systems (section control) might be suitable for weather controlled VSL.
- Introduce dynamic information about the reason for a lower speed limit. This is important at situations when surface conditions are difficult for the driver to detect (black ice etc) but it is also essential for systems controlled by more than one type of condition (weather, traffic etc)

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