Vägverket

Variable speed limits:

Evaluation of the road traffic controlled section

Trials with Variable Speed Limits (VSL) for different applications were carried out by the Swedish Road Administration in 2003 - 2008. The goal has been to demonstrate if and how VSL can contribute to a better speed adaptation in a cost-efficient way. Traffic controlled VSL is one application area. The speed limit is temporary adjusted downwards on major roads when traffic becomes dense and queue is building up.

There are technical equipments at the trial sites to collect traffic data (foremost flow, speed and density) and to control the VSL system. Variable speed limit signs with illuminated white figures in a red ring (regulatory) on dark background, or without a ring (recommended) are used to display the speed limits. On multi-lane roads the VSL signs are mounted on gantries above each lane. There are also sites where the signs are located at the road side.

The VSL project comprises 20 objects in total. Six out of these belong to the application area traffic controlled VSL. These are E6 Tingstadstunneln and E6 Mölndal (Åbro-Kallebäck), 137 Ölandsbron (also road surface condition and wind control), E18 Norrtäljevägen (southbound direction), E45 Götaleden and E18 Västmanland which was modified to another type of application (road works). The two latter ones have not been evaluated. The trial at E6 Mölndal initially comprised recommended speed displays. After a year these were changed into regulatory signs.

In order to clarify the goals and expectations and to answer questions regarding efficiency, attitudes and profitability, an evaluation program was established including the following activities

- Traffic data measurements and analyses
- Attitude surveys
- Operational data logging and analyses
- Socio-economical calculations (including traffic safety, traffic performance and environmental assessments) for at least one typical object within the application area
- International scanning

Operational follow-up

The examined sites have functioned well technically, except for Ölandsbron. The functional accessibility meets the set demand to display the correct speed limit during at least 99,5 % of the total time. There have been many operational interruptions on the Ölandsbron installation due to communications problems. These problems were later identified and solved.

Some drivers have given feedback and foremost reacted to the speed levels. Many of them consider the displayed speed limits sometimes lower than justified.

According to the police, the system at E18 Norrtäljevägen did not work satisfactorily. The police consider the drivers to believe that the displayed speed limits are recom-mendations and thus they disregard the regulations

and drive according to the prevailing conditions. Some adjustments of the system will be undertaken later this year.

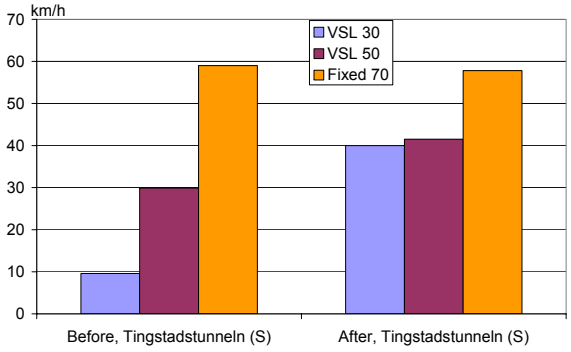
Traffic impacts

The traffic data measurements were carried out as pre- and post-studies during consecutive seasons with similar external conditions.

For the Gothenburg sites (E6 Mölndal and Tingstadstunneln) traffic flow increased by 3 - 5 % between the pre- and post-studies. The traffic conditions remained rather unchanged. However on E18 Norrtäljevägen the traffic flow has decreased by 10-20 % between the two measurements. This is probably a consequence of the introduction of congestion charges in the Stockholm area in the summer of 2007.

After the introduction of VSL, follow-up shows that the two lower speed limits have been activated during 9 % of the total time at Mölndal and Tingstadstunneln. For the Ölandsbron system the activity share for displaying 50 or 70 km/h was 7-11 % (summer time). The corresponding share for Norrtäljevägen was 11-12 %. Here the 50 km/h-message was displayed to more drivers than the maximum speed limit 100 km/h.

VSL has contributed to a considerable increase in the average speed at Tingstadstunneln during periods when the criteria for the two lower speed limits were met. This is illustrated in the figure below.



On the Mölndal section, speed is rapidly decreasing without VSL when traffic is becoming dense and there is a gradually rising risk for collapse in the northbound direction. At situations with queue formation and developed queue the actual speed is 30 km/h or lower on the northern part of the section. By using VSL the speed is dropping more slowly. A harmonized flow is obtained on a higher average speed level. Traffic throughput also increases marginally. In addition the speed difference between the lanes has been reduced in the direction towards the city. In the opposite direction the speed variation grows, however since the average speed gradually increases in the southbound direction, the traffic safety risk is limited.

During the first year of operation, recommended speed limits were displayed at the Mölndal trial section and after that the speed limits became regulatory. This design was selected to get some guidance as to whether recommended or regulatory speed limits are best suited for traffic controlled VSL. Recommended speed limits might primarily be useful as a warning to the driver when traffic starts to grow dense. On the other hand it might be inappropriate to mix different technical platforms on the same road link.

After the introduction of VSL the measured average speed for E18 Norrtäljevägen decreased, especially when the higher speed limits were displayed. The speed differences between lanes also decreased at these 90- and 100-levels. This is positive with regard to road safety.

On Ölandsbron the adaptation to the displayed speed limits is good. At the speed limit 90 km/h about 80 % of all drivers keep to a speed below that limit, regardless of direction on the bridge.

Driver attitudes

A majority of drivers show a positive attitude to traffic controlled VSL. This is more evident for Ölandsbron than the other sites, probably because this installation is also controlled by road surface condition and wind. However also at the other sites more than half of the drivers consider variable speed limits to be a good measure.

The drivers at the Mölndal section do not comprehend the difference between the variable road signs with a red ring (regulatory speeds) and without a ring (recom-mended speeds). Constantly lit signs (as at Norrtäljevägen) mean that only a few drivers believe that the signs may be out of order, as compared to the situation when signs are lit only when speed limits are lowered.

Fairly many drivers admit that their respect

for speed limits has improved following the launch of variable speed limits. Those drivers believing that the speed limit variations comply with the prevailing traffic situations pay most respect. Despite this most drivers violate the speed limits. The foremost reason is that they adapt to the traffic flow or they have not seen the speed limit message. Many drivers consider the speed limits to be lower than can be motivated by the traffic situation.

However, the driving behaviour has changed by the VSL introduction. Almost half of the drivers consider themselves as being more attentive to other vehicles.

Road Safety

Safety on traffic controlled VSL sections are influenced by the increased maximum permitted speed limit (at free flow) on one hand and the fact that VSL was introduced at dense traffic and queue formation on the other.
Results from floating car measurements indicate that sudden breaking manoeuvres at low speeds have become less common. International experiences suggest that traffic control through VSL or MCS with the basic speed 90-110 km/h has the potential to reduce injuries by about 10 %. A follow-up for Mölndal after two years of operation show that the accident ratio, that is the number of accidents per million vehicle kilometres, has been reduced by 20 % for VSL as well as MCS. The statistical basis however is too small to permit definite conclusions. Data regarding E18 Norrtälje-vägen indicate that there is no difference before and after the introduction of VSL.

Mobility and environment

The introduction of VSL in Mölndal and Tingstadstunneln has led to an increased average speed at moderate and dense traffic flow. It has also contributed to less frequently occurring congestion situations. Both impacts contribute to better mobility and reduced time consumption. The travel time on the whole section including Mölndal and Tingstadstunneln (12 km) was shortened by an average of 22 seconds, northbound direction, and 32 seconds, southbound direction. This means about 5 % improvement.

On the test section E18 Norrtäljevägen two bottlenecks have been identified during morning rush hours in the southbound direction. As regards the northern bottleneck the queues are built up ahead of the section where the VSL system was installed. This reduces the positive impact of VSL on traffic performance. However the situation at the southern bottleneck seems to have improved substantially.

The carbon dioxide emissions and the petrol consumption for the Mölndal and the Tingstadstunneln sections have increased slightly as a result of the raised speeds. This

is also the case for Ölandsbron while the environmental impacts on Norrtäljevägen seem to be marginal. The positive effects of a more homogeneous traffic flow were however not included in the calculations due to model limitations. The noise emissions dominate the environmental issue at Ölandsbron and for Norrtäljevägen particle discharge is the main problem.

Socio economics

Socio economic calculations were carried out for the Mölndal site. Time consumption on the section was reduced by an economical value of 36 mill kr/year or by 15 %.

As a basis for estimating the safety impacts, two years of statistics before implementation and two years after were used. These data show a 20 % decrease in the number of injury accidents. Since figures are shaky due to the short follow-up periods, the assumption was made that VSL contributes to half of that reduction (10 %). This corresponds to a value of 2 mill kr/year. According to the Samkalk program the environmental costs increase by 5 % meaning 2,6 mill kr/year.

The above calculated figures together with an estimated yearly cost of 37,2 mill kr, operations included, give a likely benefit-cost ratio of more than 10. The implemen-tation in the Tingstadstunneln is also believed to be a beneficial investment. However E18 Norrtäljevägen is probably not beneficial with the current VSL configuration.

Preliminary strategy

Variable speed limits seem to be an effective means for handling congestion and growing queues especially where the speeds tend to suddenly fall dramatically. This is especially valid on busy arterials with recurring capacity and traffic safety problems. Sections that are curvy, hilly and have road passages breaking the sight line could be suitable candidates for VSL.

A reasonable strategy would be to identify spots on major arterials where sudden speed drops often occur and where queues start to build up. On sections where queues during rush hours already have developed, the influence from VSL is rather small. In such cases it is more suitable with dynamic queue information since the drivers have to adapt their speed to the movement of the queue anyhow. When conditions are good (meaning low traffic flow) it should be possible to increase the maximum permitted speed limit. This speed limit should be displayed on fixed speed signs (switched off VSL). Lower speed limits are displayed on illuminated VSL at adverse conditions.

International experiences suggest that surveillance is an effective means of making the drivers adjust their speed to the displayed level. This leads to less speed variation and by that a more consistent traffic flow, effects that are expected to be durable. The information to the drivers about the functioning of the VSL systems need to be enhanced and widely distributed. It is also important to spread this information to the police, road authorities and other parties dealing with road traffic issues.

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