**Country report Sweden**

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**Abstract:**

The objective of this paper is to give an overview of the Swedish road system, highway policies and guidelines. Other objectives are to give an overview of research projects and some issues of special interest.  

The Swedish state owns major rural roads and major urban through roads. These roads are managed by the Swedish Road Administration (SRA) formally independent of the state government. The Swedish government has decided to merge all state transport authorities to take place in 2010.  

Investment projects on national state highways, some 8000 km, are to be decided within the next months for the period for 2010 – 2021. The SRA proposal is 9 Billion EUR including safety and environmental improvements. 1.7 Billion is designated to improved bearing capacity on many of roads being a part of the entire state road network, especially in the north of Sweden. Investments on regional state roads during the same period are 3 Billion. The total result is estimated to be some 30 less fatalities (level 2010) and 25 Million less vehicle hours per year.

398 persons were killed in road traffic 2008, 300 of them on state roads (mainly in rural areas). Head-on collisions and run-off accidents are dominating with some 20 and 35 %. Wide two lane roads are very cost-effective to convert to 2+1 with median barrier. Some 2 000 km are converted as yet. The results are very successful – some 80 % reductions of fatalities and 50 % reduction of severe injuries. Medians with and without barriers and centre line rumble strips have lately been implemented on a big scale on normal two-lane roads.

Some important objectives in Swedish transport policies are:

- to reach down to reduce the number of killed in road related accidents in 2020 compared with 2007 with the long term Zero-vision that nobody not breaking the system laws, i.e. sober, using seat belt and a modern car, no extensive over-speeding, should be killed or severely injured
- 60 % of state mileage with AADT over 2000 should be “safe” by 2015
- Energy consumption should be reduced by 80 % by 2030

An overview of the Swedish guideline for design of roads and streets was approved in June 2004. It was carried out in co-operation between SRA and The Swedish Association of Local Authorities (owner of the streets in the communities). A number of up-dates have been introduced; some of these are sight distances with median barriers, reversible lanes and geometric improvements at reconstruction projects. The feasibility guidelines for investment and rehabilitation projects were up-dated in 2008 supported by a data program called EVA.

The RDD-budget for road design is some 2.5 Million EUR with projects focusing on low-cost safety measures, design and build contracts, standardized design, vulnerable and disabled road users.

Speed management is crucial in the SNRA efforts to achieve traffic safety for 2020. The main tool for speed control is to augment the efficiency and the number of speed camera locations, now some 800 only in rural areas and only part-time equipped. The speed limit system has been reviewed with new speed limits 80, 100 and 120 kph during 2008-2009 changing speed limits on over 17 000 km saving some 14 lives per year losing 4 Million vehicle hours.
1. SWEDISH ROAD SYSTEM

There are 98 000 km state highways, 40 000 km community roads, 75 000 km private roads with subsidies and some 200 000 km private roads without subsidies, mostly forest roads. The Swedish state owns the state highways consisting of rural roads and major urban through roads. Traffic volumes vary from around AADT 150 000 on central E4 in Stockholm to some 20 000 km gravel roads with AADTs mostly below 100.

These roads are managed by the Swedish Road Administration (SRA) formally independent of the state government. The Swedish government has decided to merge all state transport administrations to take place in 2010. The new Swedish Transport Administration (name to be decided) will partly be governed and audited by the new Swedish Transport Agency.

1.1 Financial system and plans

Investment and maintenance in state highways are financed by the general Swedish fiscal system. Only two road toll projects exist as yet. These are the Öresund Bridge between Malmö and Copenhagen and the E 6 Svinesund Bridge between Sweden and Norway.

Further PPPs have been proposed and analyzed over a longer period. The present government has decided on co-financing of a number of larger projects; by far the biggest the 3 Billion EUR Stockholm Western By-pass, a 30 km mainly tunnelled 90 kph six lane motorway with a projected total cost of almost 3 Billion E (price level 2009) to be opened in 2020 estimated to have an AADT of 140 000 in 2035, see Figure 1 (http://www.vv.se/Vagarna/Vagprojekt/Stockholms-lan/Forbifart-Stockholm/). Co-financing should normally be interpreted as a mix of traditional state budget money with support from local authorities and toll money.

![Figure 1: Stockholm western by-pass project; location and cross-section](http://www.vv.se/Vagarna/Vagprojekt/Stockholms-lan/Forbifart-Stockholm/)

Investment projects on national, state highways, some 8000 km, see Figure 2, are proposed by SRA after a major regional political dialogue based on feasibility studies including effect descriptions towards the national and regional political transport objectives and cost-benefit analysis calculations.

Speed flow relationships between 9 m normal two-lane with 80 kph, 2+1-median barrier with 100 kph and motorway with 120 kph are shown in Figure 3 giving travel time and capacity advantages for the motorway design. Average accident costs per Million axlepairkm excluding intersections for these road types are estimated to be 3 900 E, 2 300 E and 2 100 E respectively, i.e. with a minor difference between 2+1 and motorway.

The final decision is taken by the state government in a long-term (normally 10-12 years) investment plan to be revised on average every five years. Investment projects on other state roads are analyzed in the same manner controlled by each regional council within a specified budget limit decided by the state government. Maintenance on state roads is mainly a SRA issue.
The government is to decide on a new national plan, for the first time jointly for all modes of transport, for 2010 to 2021. The proposal (17) assumes:

- Some 14 Billion EUR for road maintenance including bearing capacity, reconstructions and thaw measures and subsidies for private roads
- 8 Billion EUR for improvements on national road named projects with an extra 0.4 allocated for environmental projects and 0.9 for efficiency projects and some 3 Billion EUR on regional roads
- Named projects on national roads will decrease fatalities with 11 annually (level 2010), increase CO2-exhaustions with 55 000 tons and decrease travel times with 18 Million vehicle hours
- Environmental projects will reduce noise levels for 40 000 people, introduce 2000 fauna passages, take care of some 1000 cultural points, protect water supplies along 500-600 km with very high priority and 1000 – 1500 km with high priority according to inventories and treat 100 state urban through roads
- Efficiency projects on national roads will decrease fatalities with 8 annually and CO2-exhaustions with 10 000 tons. Calculations have not been done on travel time.
- Named projects on regional roads will decrease fatalities with 6 annually, increase CO2-exhaustions with 16 000 tons and decrease travel times with 6.5 Million vehicle hours.
- Regional safety measures will decrease fatalities by some 3 per year.

This result could be compared with the speed limit overview result obtained in 3 years giving some 15 saved lives (30 for the plan), 70 000 tons CO₂ and a loss of some 4 Million vehicle hours (25 Million).

SRA is then allocated a yearly budget, normally lower than anticipated in the long-term plan. The balance post in this equation is normally pavement maintenance. The maintenance distribution is annually some 0.3 Billion EUR on pavements, 0.1 on bridges, 0.1 on road equipment, 0.2 on winter, 0.04 on gravel roads, 0.03 on road informatics and 0.05 on ferry services.

1.2 Traffic performance in major conurbations

Traffic performance situation on major arterials in greater Stockholm, Gothenburg and Malmö, the three major Swedish cities, are continuously scanned using on-line traffic speed and flow measurements given by various detector devices. The Gothenburg system is in full production with Stockholm and Malmö still suffering from a number of missing links to be in operation in 2010.
Actual speeds and travel times are available on Internet (www.trafiken.nu) and on a number of VMS-signs. Monthly reports on average morning peak hour travel speeds are reported to the SRA Director General and on a quarterly basis to the government.

Average peak travel speeds (7 to 9 pm week days) in the Gothenburg area, see Figure 4, are in the range of 50 kph compared with an average posted speed limit of 80 kph. There are no very obvious travel time trends in Gothenburg. The general Swedish traffic growth during 2009 has been 1 % increase for cars and 5 % decrease for trucks.

1.3 Congestion fees

Decades of political debate introduced congestion taxes in the Stockholm central, see Figure 5, area excluding state roads, mainly the E4, in 2006 due to the outcome of the national election in 2002 forcing co-operation between the social democrats and the greens. The system has 18 gates and is fully automatic with a charge between 1 and 2 EUR, depending on time of day, to cross the cordon in any direction. The fee is due to the traffic. During peak-hours the fee is 2 EUR and in low traffic 1-1.5 EUR. The maximum fee is 6 EUR per day. The initial traffic decrease across the cordon was 22% (2006 compared to 2005 traffic levels). Since then, a growing number of alternative-fuel cars (which are exempted from the charge) have caused traffic to increase somewhat: traffic in 2009 was around 18% below 2005 levels (before the charges (ref 2). Today all political parties and most of the public seem to accept and appreciate the system with extensions due at least to Gothenburg.
The surplus, estimated to be approximately 50 Million E on a yearly basis, should by law used for road improvements within the Stockholm area.

1.4 State road network

Fatalities are dominated by single run-off and head on accidents with some 35 and 20 % of all fatalities, see Figure 6. The overall fatality rate is 0.008 with minor differences between road types and speed limits with two very positive exception, motorways and 2+1 median barrier roads, and one negative, high speed wide two-lane roads. This is an obvious outcome of the basic principles in the speed limit system, in operation since 1971.

![Average 2004-2009 Fatality distribution by accident type](image)

Figure 6 Swedish road traffic fatalities 2004-2009 by accident type

Over 20 % of the total mileage is traveled on some 1500 km 90 and 110 km/h motorways, only 2 % of the network length. The average AADTs are 32 000 (90 km/h) and 17 000 (110 km/h) on these motorways with superior safety records, only 20 killed per year and a fatality rate of 0.002. Single run-off accidents dominate with over 50 % for killed as well as for killed and severely injured together.

The 2+1-median barrier road has been a big success, see further on in this paper.

2. SWEDISH HIGHWAY POLICIES

SNRA policies (17) are controlled by a set of main objective for the transport area formulated by the state government in general wordings. The overall objective is to secure cost-effective and sustainable transport for citizens, trade and industry with a number of specific goals for accessibility for citizens, transport quality for trade and industry, traffic safety, environment and architectural design, regional development and a gender neutral transport system.

Some objectives, however, are quantified such as:

- to decrease the number of killed by 50 % and severely injured by 25 % from 2007 to 2020 with the long term Zero-vision that nobody not breaking the system laws, i.e. sober, using seat belt and a modern car, no extensive over-speeding, should be killed or severely injured
- road traffic CO2-emissions 2010 should be on the same level as 1990 estimated to be “missed” by 12 % (2 Million tons) with annual requirements on 90 000 tons
- CO-, NO2-, SO2-levels and "particle"-PPMs in urban areas should be under EU-limits
- Outdoor noise levels for dwelling-houses should be below 65 dBA 2007, for state roads 2005, still to be achieved
- Mileages of high-flow roads with high IRI's and rut depths should not increase
- Bus stops with more than 20 boarding passengers per day should meet standards for disabled passengers 2010
- The share of children with safe school ways should increase
- National roads with capacity problems should be improved
- 75% of state mileage with AADT over 4000 should be "safe" with physical median separation by 2020.

There are also more or less out-spoken specific goals in the present long-term plan on the system level for national roads:

- to finalize the motorway system from the Baltic Sea harbour Trelleborg in south east Sweden along the south and west coast via Malmö and Gothenburg all the way to Oslo in Norway.
- to finalize the motorway from Malmö-Helsingborg in southern Sweden up to Stockholm and further up another 200 km along the coast to Gävle.

Major efforts are under way to increase build and design contracts and contracts with mutual co-operation. The objective is at least 50% Build-Design-contracts 2010.

3. FEASIBILITY AND DESIGN GUIDELINES

The feasibility guidelines with measure-effect models for alternative designs have been up-dated with new socio-economic costs and some new knowledge on measure-effects (11) to be applied in the new investment plan. Typical accident costs and speed-flow relationships for common cross-sections are given above in section 1.1. Another example is FSI-rates (fatalities and severe injuries per year) for alternative intersection designs due to total incoming AADT see Figure 7.

![Figure 7 FSI-rate due to total incoming AADT, ratio secondary road AADT/primary road AADT and intersection type (A without left turn lane, C with left turn lane and F grade separated) at 90 kph](image)

The old design guidelines for highways and streets were combined, up-dated and published in 2004 Highway and Street Design (6) described at the last conference. A number of additions have been published later:

- 2005, Narrow medians with guardrail – in left curves the sight distance depends on the median barrier.
- 2006, Three new road types with median rumble strips and median barriers on narrow roads, see below.
- 2007, Barriers and slopes – new guidelines for guardrails before bridges.
- 2007, New guidelines for maintenance openings and rescue openings in median barrier.
- 2007, Right turn lane – smoother design.
- 2007, Guidelines for new speed limits 60, 80, 100 and 120 kph.
- 2008, Geometric design guideline for reconstruction projects.
- 2008, Guidelines for reversible lanes.
- 2008 New guideline for bus stops for disabled passengers.

A data-base with examples is available at www.trafikbanken.se. It contains good examples of road design from urban as well as rural areas. SRA and communities are allowed to enter examples in this data-base. It should be good examples from a safety, accessibility and aesthetic point of view. In addition to pictures the example will contain a description of the problem which was to be solved, the measure and follow-up studies.
A big project has just started with the following objectives:

- To clarify what is requirements and what is just good advice in the Swedish design guidelines. That means we will have two guidelines, one with requirements and one with just advice and recommendations how to design.
- We will also update the guidelines with new knowledge such as use of rumble strips.

4. RESEARCH POLICIES AND PROJECTS

SRA is financing research and development projects for some 40 Million EUR per year. Another research-funding state-agency VINNOVA also provides capital for R&D-projects. VINNOVA is a Swedish Agency for Innovation Systems, integrating research and development in technology, transport and working life. At the moment there are very few projects financed by VINNOVA in the area of road design.

The RDD requirements are described in the SRA Focus 2008 – 2017 (16) and the RDD plan 2009-2011 (12). These are important guiding tools for RDD bodies preparing applications to the SRA.

The RDD focuses on 11 development areas with a 2010 turnover of some 33 Billion SEK.

Individual researchers, research institutions and universities, consultant firms and so on are allowed to apply for funding to projects according to the RDD plan. Swedish research institutes, consultants and contractors within road design are working together within the Road Planning and Design network to strengthen Swedish research in an emerging European context.

Some projects of interests in this area are:

- METCAP to up-date the present, very old Swedish capacity manual TV 131 (5) and software Capcal (20)
- Follow-up studies of 2+1 roads with median barrier with final report 2008 (1)
- Development of safer road types on normal two-lane (6), see below
- Full scale experiments and simulations of run-off accidents at different types of roadside design published (3 and 4) claiming 1:4- and 1:6-designs to be less successful than anticipated, see below
- Full scale experiments with variable speed limits with very positive results (10), see below
- Road safety effects of different alignments
- Driver’s behavior as a function of road design, especially road width and lane width
- Traffic behavior – driver perception. Joint Nordic project reported elsewhere on this conference
- Traffic behavior – breaking distances. Joint Nordic project reported elsewhere on this conference
- Roundabout design for cyclists and disabled
- Design and build contracts – functional requirements for design
- Safety effects for pedestrians and bicyclists
- Low-cost safety measures in rural intersections with proposals rumble strips and simple variable speeds
- Standardized design to decrease costs

5. SOME INTERESTING DESIGN ISSUES

The design debate has to a great extent focused on how to contribute to the safety objectives in a cost-effective way. Other important or interesting issues are capacity improvements on high-flow arterials in Stockholm and Gothenburg, design criteria for bus stop standards for disabled passengers and speed-control measures on rural roads.

5.1 Motorway cross-sections

The first Swedish motorway Malmö–Lund, some 20 km, was opened in 1953 with a pre-war German design without outer hard shoulders, a narrow median, entries and exits without tapers and a concrete surface. The bulk of the present, normally 110 km/h rural motorway system, see Figure 8, have a 26.5 m cross-section with 2.75 m outer hard shoulders, 3.75 m traffic lanes, 1.0 m inner hard shoulder and median barriers (even on old wide medians), wide clear zones or safety fences and high profile, architectural bridge designs. The average construction cost is today some 7 to 8 000 E/m in rural environment.

The fatality rate for 110 km/h motorways has decreased from 0.0045 for 1993 - 97 to 0.0021 due to heavy implementation of median and side fences on older motorways. The fatality rate for single run-offs has decreased from 0.0017 to 0.0010 and the meeting and overtaking rate from 0.0011 to 0.0004.
A political intervention based on environmental impact concern triggered a number of alternative 4-lane projects in the mid 90’s with an 18.5 m cross-section with only 0.5 m hard shoulders, 3.5 m traffic lanes, 2.5 m median with barrier and simplified interchanges see Figure 8. These projects, some 100 km by now, have not met our expectations on safety performance. The FSI-rate (fatal and severe injuries per Million vehicle axle pair km) is almost 0.003, almost 50 % higher than modern motorways (1). The alternative 4-lane road is passed out from our new guidelines and replaced by a compromise for new designs with a 21.5 m cross-section with 2 m outer shoulder 3.5 m traffic lanes, 0.5 m inner shoulders and 2.5 m median. The barrier design is normally N2.

<table>
<thead>
<tr>
<th>Traditional 26.5 m:</th>
<th>Alternative 18.5 m:</th>
<th>Present design 21.5 m:</th>
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<tbody>
<tr>
<td>- 2.75 m outer shoulders</td>
<td>- 0.5 m outer shoulders</td>
<td>- 2.0 m outer shoulders</td>
</tr>
<tr>
<td>- 3.75 m traffic lanes</td>
<td>- 3.5 m traffic lanes</td>
<td>- 3.5 m traffic lanes</td>
</tr>
<tr>
<td>- 1.0 m inner shoulder</td>
<td>- 0.5 m inner shoulder</td>
<td>- 0.5 m inner shoulder</td>
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<tr>
<td>- 4.0 m median with barrier</td>
<td>- 2.5 m median with barrier</td>
<td>- 2.5 m median with barrier</td>
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Figure 8 Swedish motorway and alternative four-lane cross-sections from 70:’ies and further on

5.2 Low cost safety measures

The 2+1-cable barrier project, presented elsewhere at this symposium in more detail, with the first project opened in 1998 was early judged as a major success by politicians and public opinion. The cross-section is normally squeezed in within the existing 13 m paved width with everything to narrow according to traditional design, see Figure 9.

Over 2 000 km are opened as yet covering over 10 % of the state traffic load, mainly converted 13 m paved width roads. Some 30 % are 110 km/h semi-motorways, i.e. grade-separated, full access control, some 30 % 90 km/h semi-motorways and some 30 % normal 90 km/h roads, i.e. with at-grade intersections, accesses and vulnerable road users and slow-moving vehicles permitted. Speed limits are changed to 100 kph in 2008 – 2009 in the speed limit overview.

The result (1) is striking with an overall fatality rate almost equal to motorways giving a reduction with some 80 % and over 50 % including severe injuries. Some 50 lives are saved on a yearly basis for the existing projects with an overall investment cost of 0.2 Million EUR/km. SRA and VTI claim safety gains even for motor cyclists. Main disadvantages are major barrier crash repairs, 0.4 per Million axle pair km with work zone safety problems and also increased rutting problems, some 30-40 %, together inducing major economic costs but still very efficient.
5.3 Other high-speed design measures

Major efforts are now concentrated on improved safety design on normal two-lane roads (6.6 to 11.5 m paved width) with speed limit 90 km/h, some 10 000 km with some 90 fatalities per year, 40 % of those in head on and overtaking and 25 % in single run-offs and AADTs normally in the range 1000 to 5000. Based on a major feasibility study full scale applications are now under way with three main alternatives; rumble centre lines, rumble median with overtaking lanes and median barriers with overtaking lanes (9).

Some 4 000 km centre line rumble strips have been implemented since 2005, see more in detail in another Swedish paper at the symposium. The total effect on fatalities and severe injuries – estimated to be some 10-15 % based on Finnish and US results – has not been achieved as yet.

The single run-off FSI-rate – to be impacted – has decreased from 0.017 to 0.013, some 20 %, but the total FSI-rate is unchanged. It’s too early to draw any final conclusions with a total traffic load after implementation of some 3 Billion axle pair km.

Car and truck drivers are normally positive and motor cyclists tend to accept the strips. The noise disturbance distance to avoid levels above 45 dBA has been extended to 150 m to living houses giving an average of some 60 – 70 % rumble strips on a project.

The main component for the median alternatives is the addition of overtaking sections at slightly longer intervals than in the 2+1-concept with none-overtaking zones in between with information signs on next overtaking opportunity and a narrow median in between; rumbled or with a barrier, see Figure 10. Combined with side safety fences in sharper outer bends, fatalities and severe injuries are judged to decrease with some 30-40 % with rumble medians and 60-70 % with a barrier, highest for fatalities. The investments should partly, overlays, signs and road markings, be covered by maintenance money to facilitate a big scale implementation over a reasonably short period.

![Figure 10 Overtaking lane principles with rumble or barrier median](image)

Only one rumbled median project is opened as yet, the National road 33 outside Eksjö, see Figure 11. The first median project was opened in December 2009, National Road 26 outside Växjö, see Figure 11. 1+1-sections are squeezed into the existing 9 m width with 0.75 m outer shoulders, 3.25 m traffic lanes and a 1.0 m median with a N2-barrier.

![Figure 11 First rumbled median and median barrier projects, National 33 and 26.](image)
5.4 An accessible Sweden 2010

Sweden should be accessible in 2010. SRA is reviewing all bus stops on main roads and all service areas.

The objective is that bus stops with more than 20 daily boarding passengers should be designed for disabled users. The hard core requirements are suitable platform height (0.17 m), platform ramps (max gradient 2.5 – 8 %) and connection to adjacent walkway system, maximum 100 to 150 m, see Figure 12. Essential functions on service areas should also be accessible.

![Figure 12 Examples of accessible bus stops and service areas](image)

5.5 Roadside area design

Over 30 % of all Swedish fatalities are single run offs with a positive trend over the last six years hopefully due to extensive investments in improved roadside designs, see Figure 13.

![Figure 13 Single run off fatalities on Swedish roads 2004 to 2009](image)

Swedish efforts in roadside area design are described in more detail elsewhere at this symposium but could be summarized:

- clear zones, 10 m at 110 kph, with smooth slope designs or safety fences have been implemented on a wide scale since the early 90’ies inspired mainly by American research
- Follow-up studies on motorways confirmed expected reductions of severe injuries of some 20 %. There were also clear indications that the smooth roadside area concept is based on crucial overestimations of human nerves and capacity. The run-off driver is very often, if not sleeping, not very rational worsening consequences with panic wheel maneuvers.
- The overall conclusion was and still is that side fences in most cases have better safety performances, normally also cheaper to install.
- In-depth accident investigations, full-scale crash tests and simulation studies challenge earlier recommendations on 1:6 fill and cut designs claiming tougher designs to be as effective

A slope-located side barrier has been developed, possible to implement on existing 1:3 inner slopes providing better space for vulnerable road users, breakdown vehicles and maintenance, see Figure 14. The design is
approved for the standard European N2-requirements. It also handles an additional 5 degree crash with very good performance.

![Figure 14 Slope barrier design principles](image)

**5.6 Reversible lanes**

Reversible traffic lanes are used to manage traffic at major overlay works on urban motorways since a number of years. The first reversible lane project in normal traffic operation in Sweden was opened in 2006 on regional road 222 south-east of Stockholm, see Figure 15. Traffic flows vary between 18 000 veh/day in winter time and 28 000 veh/day; in summer time with huge week-end peaks. The project is two km with many local accesses with the Baltic south of the road. The design is very simple only with traffic poles on each side of the reversible lane and gates at the start and end of the section. Speed limit is 30 kph. Follow-up results are very positive (8).

![Figure 15 Reversible lane regional road 222](image)

**5.7 Traffic calming**

Several follow-up studies show good road safety results of traffic calming in urban areas. In Sweden the number of fatalities in urban areas has decreased in some years from some 150 per year to less than 100. Two measures claim the major part of the credit for this, traffic calming and redirecting car traffic from streets with vulnerable users to separated streets. However many groups of users are complaining of these traffic calming measures, especially bumps, for instance bus drivers, emergency vehicle drivers, wounded in ambulances, those living in the area and so on.

In many places we are looking for other suitable measures for traffic calming than bumps. Bumps are often not constructed according to the guidelines or deteriorated after some years due to heavy traffic loads. Road owners have been asked to check existing bumps and if needed rehabilitate them. An agreement is reached between road and public transport authorities, bus operators and bus drivers’ union on hump designs acceptable for traffic safety and bus drivers due to the EU directive on vibrations. The main restriction (14) is an in-ramp slope
between 6 and 8 degrees and rut depth deviations less than 0.02 m to avoid Sed,300-values below 0.5 MPa, see Figure 16.

![Figure 16 Hump design for safety and bus drivers’ health](image)

Roundabouts are often used as a traffic calming measure in urban areas with good results. Attempts with camera speed check-up have given positive experiences and will be established in many places where bumps are an unsuitable solution.

5.8 New traffic law for bicycle crossings?

The 1st of May 2000 a new law was introduced with absolute give way for drivers to pedestrians but not to cyclists on marked and signed crossings for pedestrians. The objective was primarily to give the pedestrians increased accessibility. The safety situation has roughly not been change due to the new rule. The assumption is that the give way rule only works at speed limit 30 kph or possibly 50 kph. All pedestrian crossings on streets with speed limit 70 kph have been eliminated and some on streets with 50 kph.

A similar law is now proposed for bicycle crossings. The idea of the new law proposal is to introduce a strict give-way rule for cars to bicycles at crossings marked with the bicycle road marking. This rule should also be combined with a give way sign if no hump exists.

6. SPEED MANAGEMENT MEASURES

Speed management is crucial in the SRA efforts to improve the traffic safety situation and to achieve the new long term traffic safety objective to decrease fatalities by 50 % from 2007 to 2020 in a cost-effective manner.

6.1 Speed limit review

Sweden was the first country to introduce compulsory speed limits in 1971. The base or default speed limit in rural areas became 70 kph. Higher speed limits, 90 or 110 kph, could legally be decided by the SRA Headquarter based on “accessibility, traffic safety and environment” according to the Traffic Act. Detailed criteria used at that time were road width and sight distance giving 90 kph on reasonable two-lane roads from 7 m paved width and 110 kph on wide two-lane roads (13 m), semi-motorways and motorways. Narrow roads in northern Sweden were allowed to have 110 kph due to long travelled distances. Lower speed limits on shorter sections could be settled by the regional councils.

The base or default speed limit in urban areas became 50 kph. The individual commune was given the power to decide on the limits of the urban area. They could also decide on changes to any other speed limit; 30, 70, 90, 110 within the urban area, even on state through roads. All regional and communal decisions could be appealed to SRA and SRA 90 and 110-decisions to the state government.

Many attempts failed over the years to review existing speed limits based on a more modern traffic safety strategy. A minor adjustment took place in 1997 decreasing many wide two-lane roads from 110 kph to 90 kph in southern Sweden.
SRA eventually succeeded to create support from all major stakeholders for a new speed management strategy combined with a speed limit overview in 2005 (7) to be based on four pillars:

- The road transport system should successively be adapted to the national transport goals and the Vision Zero
- Speed limit decisions should be coordinated with investment planning and decisions
- Speed limits should in the long run be adjusted to weather, road and traffic conditions (variable speed limits)
- The dialogue with drivers must be strengthened to improve drivers’ understanding of and respect for the speed limit system

A new bill was passed in 2007 via Parliament discussions based on the new speed management strategy adding 80, 100 and for motorways 120 kph (7) as new tools for SRA and also 40 and 60 for the other decision makers. The new Transport agency was given the role to deal with appeals instead of SRA.

SRA has later on during 2008 and 2009 reviewed all speed limit decisions on rural state roads. Most urban roads are due in 2010. New decision has been based on speed limit decision regulations containing (15):

- long-term objectives for accessibility, traffic safety in terms of median separation, roadside area, intersection design and separation of VRUs, environment and driver acceptance
- transport goal fulfillness, CBA and effect measurements based on the assumption to have an approximately 4 kph effect of a 10 kph speed limit change in both directions
- hearings with impacted regional and local authorities and the police
- a long term objective to have a 30-40-60-80-100-120-system with 10-steps claimed to be to difficult/complicated for drivers

Major changes have been implemented in the existing network:

- some 300 km motorways with very good design have been increased from 110 kph to 120 kph
- over 2 000 km 2+1-barrier roads are now posted 100 kph, before 90 kph with at-grade intersections and 110 kph with grade separation
- some 1 100 km northern two-lane roads decreased from 110 kph to 90 kph
- some 13 000 km two-lane roads decreased from 90 to 80 kph
- some 1 000 km two-lane roads increased from 70 to 80 kph

The total effects achieved based on the 4 kph-assumption are almost 14 saved lives, 34 000 less ton CO$_2$, less noise and 12 Million EUR less socioeconomic costs on a yearly basis. The con is some 3.4 Million more travelled vehicle hours. This could be compared with the outcome of the proposed investment plan

Preliminary follow-up studies indicate to be published:

- the 4 kph-assumption to be reasonable when speed limits are increased on motorways from 110 kph to 120 kph and on 2+1-median barrier roads from 90 kph to 100 kph
- the decrease in average speed to be some 2 kph when speed limits are decreased from 110 to 100 kph on normal two-lane roads and from 110 to 110 kph on 2+1-median barrier roads, in both cases with average pre-speeds clearly below the speed limit.
- the effect on average speed on speed camera roads to be some +5 kph at a 10 kph speed limit change from 90 to 80 and from 70 to 80 kph on normal two lane roads

### 6.2 Enforcement and speed cameras

Improved public understanding of the speed limit system combined with increased enforcement is fundamental. An overview of the overall speed behavior from 2003 is illustrated in Figure 17. A clear image materializes. The average car speed is more or less equal to the posted speed limit with some 60 % speeding with an average of 10 km/h avoiding speed ticket if caught.

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<thead>
<tr>
<th>Speed limit</th>
<th>Average car speed</th>
<th>% Mileage over speed limit</th>
<th>Average speeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>52</td>
<td>69</td>
<td>9</td>
</tr>
<tr>
<td>70</td>
<td>68</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td>90</td>
<td>91</td>
<td>56</td>
<td>11</td>
</tr>
<tr>
<td>110</td>
<td>111</td>
<td>59</td>
<td>12</td>
</tr>
</tbody>
</table>

Figure 17 Speed behaviour 2003
Later on a number of measures have been introduced to improve drivers’ speed limit obedience. The most important are:

- the speed control equipment margin is lowered from 10 kph to 6 kph
- the tickets, unchanged for decades, have been increased from 600 to 1200 SEK for speeding 10 kph
- Massive public campaigns have been carried out

Results are promising, see Figure 18, with an almost 10 % decrease in traffic load over the speed limit since 2005, a 2 % decrease in average speed on state roads and a 25 % decrease in traffic load more than 5 kph over the speed limit.

![Figure 18 SRA speed index (18)](image)

**Figure 18**  SRA speed index (18)

Speed limit acceptance and obedience are key factors in speed management judged to have a potential to save some 100-150 lives yearly and 700 000 Million tons CO₂. Test projects with speed cameras started in 1989. The system has gradually grown to more than 1000 cameras covering 1850 km split on 190 sections. Cameras are mainly located on normal two-lane rural sections judged to be black spot or high speed sections jointly by SRA and the police. There are also 26 mobile units used by the police.

All cameras are controlled by a central unit with an annual capacity of 230 000 tickets. Sweden still has driver responsibility giving a system a manual comparison of the video image detection of driver’s face with the driving license register photo. Camera installation costs, some 60 000 E/camera are covered by SRA. The operation of the system is optimized within the limit of 230 000 tickets.

Follow-up studies claim (19):

- average speeds after implementation to be a few kphs below the speed limit with bigger impact on higher percentiles
- speed effects are almost in the same magnitude in the uncontrolled direction
- the safety effect depends on the pre-speed giving an average fatality reduction of some 20-30 per cent and 20 per cent for the number of fatalities and severe injuries (FSI)
- speed reductions also contribute to reductions of road user costs and environmental impact
- the impact of one camera is some 6-8 km in one direction
- some 50 % cases are cleared out

6.3 Variable speed limits

SRA has also undertaken a large full-scale test with variable speed limits using VMS-signs (10). Some 20 sites were opened during 2004-07 covering various applications such as:

- intersections, bus stops and pedestrian crossings with lowered speed limits at activity close to the major road, see Figure 19
- major bridges with lowered speed limits at windy or icy conditions
- road sections with lowered speed limits at high traffic, queues or slippery road conditions
Results are promising, especially for intersections based on 4 sites with primary road AADTs around 10 000 and secondary road AADTs from 500 to 2 500, giving, see Figure 20.

- a more than 10 kph average speed reduction and a 6 kph reduction for the 85-percentile with active sign at high secondary road traffic volumes
- an approximately 30 % activation ratio at high secondary road volumes
- less impressive results at low secondary road volumes

<table>
<thead>
<tr>
<th>Site</th>
<th>Primary AADT</th>
<th>Secondary AADT</th>
<th>Vsign</th>
<th>Vmean</th>
<th>V_85</th>
<th>Change kph</th>
<th>Unactv Vsign</th>
<th>Time%</th>
<th>Vmean</th>
<th>V_85</th>
<th>Change kph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kyrkheddinge</td>
<td>11000</td>
<td>300</td>
<td>90</td>
<td>90.5</td>
<td>100</td>
<td>-8</td>
<td>-4</td>
<td>90</td>
<td>-2.5</td>
<td>-2</td>
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<tr>
<td>Vanneberga</td>
<td>10200</td>
<td>2500</td>
<td>70</td>
<td>70.8</td>
<td>80</td>
<td>-11.5</td>
<td>-6</td>
<td>90</td>
<td>-0.1</td>
<td>6</td>
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<tr>
<td>Fogdarp</td>
<td>11500</td>
<td>2100</td>
<td>90</td>
<td>88</td>
<td>101</td>
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<td>-6</td>
<td>90</td>
<td>.7</td>
<td>-5</td>
<td></td>
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<tr>
<td>Lemmeströ</td>
<td>12000</td>
<td>420</td>
<td>70</td>
<td>72</td>
<td>86.5</td>
<td>-4.8</td>
<td>-6</td>
<td>90</td>
<td>3.9</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Figure 20 Results for isolated intersections with variable speed limit

A DG-decision is taken to implement another 20 cost-effective intersection applications within the next 3 years.

Major work has also been done on ISA-applications in a number of test areas in Sweden.

REFERENCES

5. SRA (1977) TV 131 Capacity, queue length and delay (in Swedish) SRA TV131
20. Trivector and SRA Capcal manual 3.2 2005 Trivector