Attachment A

Summary of the Swedish Guidelines for Climbing Lanes

June 2000
In this memo you will find some notes about when climbing-lanes should be considered according to the Swedish guidelines (VU 94).

**General**

Climbing-lanes have a good effect on traffic safety on two-lane roads. The accident reduction can be observed in the up-hill section but also on a section after the climbing lane.

![Diagram 1: Reduction of accidents on a two lane road.](image)

Climbing-lanes enable overtaking in the up-hill section and improve the level of service on a longer section after the slope, since an increase of the queue is avoided and existing queues are dissolved.

The effect on level of service, is mainly depending on the length of the slope, the gradient, the traffic flow, the percentage of heavy vehicles and the risk of queue in the beginning of the slope, for example, the alignment of the road and the traffic conditions on a longer section before the slope.

**Where and when**

Climbing-lanes should be considered, if the length between the point, where the speed of heavy vehicles is below 65 km/h, and the point where the speed again is above 60 km/h, exceeds 400 m.

That usually happens when the average gradient is 3% or more. If the average gradient is 2% the slope has to be longer than 1500 m.

If the speed is low before the slope, because of local speed limit, climbing-lane should be considered if the slope is longer than 1000 m and the average gradient is 1% or the slope is longer than 500 m and the average gradient is 2%.
Any general rule when a climbing-lane should be constructed in a slope that fulfill the criteria above is not possible to state. If a climbing-lane should be constructed or not has to be decided by considering comfort, level of service and traffic safety as well as construction and maintenance costs.

On two-lane roads with shoulders wider than 2 m, a climbing-lane normally can be created by changing the road markings.

A traffic-economic calculation can be made to determine the benefit of a climbing-lane by following the steps presented below. The benefits can be estimated from this diagram.

**Diagram 2: Estimation of traffic-economical benefit**

As can be seen in the diagram a climbing-lane is normally beneficial when the traffic volume is around 7500 vehicles per day and the gradient is 4%. If the traffic volume is around 2000 vehicles per day and the gradient is 5%, a climbing-lane should be considered.

**Location**

Climbing-lane should be located with full lane width on the section between the point where the speed of heavy vehicles has been reduced to less than 65 km/h and the point where the speed again has reach at least 60 km/h.

If the speed before the slope is lower than 65 km/h, the climbing-lane should have full lane width already in the beginning of the slope.
Example:

Determine location and length of a climbing-lane in the profile below. Reference speed is 90 km/h.

Heavy vehicles get a speed lower than 65 km/h at $L = 290$ m and a speed higher than 60 km/h at $L = 1420$ m. The stretch is 130 m long, i.e., longer than 400 m. Climbing-lane should be located between $L = 290$ m and $L = 1420$ m.
Traffic-economic calculation

Below the steps to calculate the effect on travel-time and traffic safety is presented.

<table>
<thead>
<tr>
<th>Step 1</th>
<th>The reduction of travel-time is calculated when the shoulders width is less than 2 m by following step 2 – 5.</th>
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</table>

When the shoulder width is more than 2 m the effect on travel-time is considered to be zero.

<table>
<thead>
<tr>
<th>Step 2</th>
<th>Determine the average flow (AADT) and the percentage of heavy vehicles.</th>
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<tr>
<th>Step 3</th>
<th>Calculate the average sight distance along the road in the uphill direction.</th>
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</table>

The sight distance should be calculated along a long section before and after the slope. The stretch should be at least 3 km before and 3 km after the slope.

\[
S = \frac{\alpha_1 l_1 + \alpha_2 l_2 + \ldots + \alpha_n l_n}{l_1 + l_2 + \ldots + l_n}
\]

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Calculate the average gradient and the length of the climbing-lane with full lane width.</th>
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</table>

The average gradient is normally calculated between the point where the gradient is 1% and the crest of the slope.

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<tr>
<th>Step 5</th>
<th>Calculate the reduction of travel time for private cars.</th>
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</table>

Inputs for the calculation are reference speed, average sight distance, percentage of heavy vehicles and the average gradient of the slope, see diagram.
Diagram 3: Calculation of reduction of travel time (passenger car hours per m climbing lane and year)
Step 6  Determine the benefit of traffic safety (accidents per km climbing-lane and year).

Inputs are average gradient, width of shoulders and AADT.

Diagram 4: Calculation of accident reduction

Step 7  Calculate the construction cost and the yearly maintenance cost for the climbing-lane.

Step 8  Calculate the Internal Rate of Return or the Net Present Value.