1 A New Approach to Traffic Planning and Street Design in Sweden

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ABSTRACT

According to Vision Zero, speed is regarded as a very important and integral factor. From traffic safety point of view it is said that:

1. On roads where there is a risk for head-on collision a car is not allowed to drive faster than 70 km/h.
2. In streets where there is a risk for a side impact collision a car is not allowed to drive faster than 50 km/h.
3. In streets where a car can hit a pedestrian or a bicyclist a car is not allowed to drive faster than 30 km/h.

More or less as a logical consequence of these basic premises, a hierarchical division of streets and roads, based on speed, has been introduced in Sweden as follows:

1. 70 km/h-road or Through traffic route
2. 50/30 km/h-street or Main street or Urban arterial road
3. 30 km/h-street or Residential street
4. Walking speed streets or Woonerfs
5. Lanes for pedestrians and bicycles (pavements, footpaths, squares, bicycle paths, etc.)

The idea has also been introduced to change the standard 50 km/h streets in built-up areas to 50/30 km/h-streets, 30 km/h-streets and walking speed streets wherever pedestrians, bicyclists and car traffic intermingle.

Keywords
road traffic safety, Vision Zero, clearly distinctive design, distinctly different types of streets
1.1 MOTIVES FOR THE NEW APPROACH

In the mid-fifties we decided in Sweden not to allow cars to drive faster than 50 km/h in our cities. We also decided that the exceptions to that speed limit were to be very few. We adopted this decision because we wished to control the increasing volume of car traffic, but also because it was considered "comfortable" to drive the car at that speed, considering vehicle construction. Earlier there had been no speed limit at all for car traffic in cities.

The streets, or more specifically "the public places" in a town, are subject to many different demands and desires from its inhabitants. Needless to say, the possibility for driving a car in a city should exist, at least on most streets. However, it must also be possible to go by foot, by bicycle and by public transport. Public places in a town have a great inherent potential for both planned and unplanned encounters, which should be made possible, and even facilitated, by the design of the streets in a city. These places should be accessible to everyone, including children, the elderly and disabled persons, and certainly not only to those holding a driving licence.

Guidelines for traffic planning were issued in Sweden in 1968 and in 1982. On both occasions, it was a clearly hierarchical division of the streets, but a 50 km/h speed limit was retained on practically all urban streets, contrary to what occurred in Holland and Denmark, for instance.

In order to satisfy as many as possible of the different demands and wishes that inhabitants have on public places in a town, we are now trying a new approach to traffic planning and street design.

1.1.1 Urban Street Classification

Until now, a street in a town has often been classified according to how it is used by cars. We talk about thoroughfares, through traffic roads, local streets, collector roads and access roads. The list does not stop here. However, from these designations the impossibility of having one type of street for every word or phrase is quite obvious. Too many levels in a hierarchical structure becomes unwieldy and infeasible.

Also, it is a fact that a local street, for instance, does not only have local traffic. Very often there is traffic on a local street that is travelling more or less through; often there is also some collector traffic.

A system of street classification that could be very clear is based on the speed permitted. One advantage of this is the possibility of including an accurate description concerning function, street design and behaviour worth aiming at for each type of street.

1.1.2 A Street must have a Clearly Distinctive Design

One of the most important aims in connection with street design is to give people using the street the ability to understand - preferable intuitively
- what kind of street they are on,
- what (traffic) behaviour is expected from them,
- what (traffic) behaviour they can expect from others.

For that reason the different types of streets must have their own clearly distinctive design. It must be obvious from this design what has been prioritised; e.g., vehicle accessibility on Traffic Routes / 70 km/h roads, and consideration to children, the elderly and disabled persons on woonerfs. This must be clearly understandable to adults, children, the elderly or disabled persons alike. And it must be understood intuitively.

1.1.3 Vision Zero and its Implication for the Design Philosophy of the New Approach

In Sweden, according to the present-day road traffic safety goals, the number of fatalities and injuries shall be continually decreased. Drawn to its logical conclusion, this ultimately means that no one will be killed or injured in road traffic.

The so-called Vision Zero states that:

*In the long run, no one will be killed or seriously injured within the road transport system. In order to fulfil this vision, the responsibility for road traffic safety must be shared according to the following principles:*

- The designers of the system are always ultimately responsible for the design, operations and use of the road transport system and are thereby responsible for the level of safety within the entire system.
- Road-users are responsible for following the rules for using the road transport system set by the system designers.
- If road-users fail to obey these rules due to a lack of knowledge, acceptance or ability, or if injuries do occur, the system designers are required to take the necessary further steps to counteract people being killed and/or seriously injured.

With this Vision Zero approach, the concern for human life and health is an absolutely mandatory element in the design and functioning of the road transport system. This means that a road traffic safety mode of thinking must be clearly integrated into all the processes that affect safety within the road transport system. The level of violence that the human body can tolerate without being killed or seriously injured shall be the basic parameter in the design of the road transport system.

According to Vision Zero, speed is regarded as a very important and integral factor. From traffic safety point of view it is said that:

1. On roads/streets where there is a risk for head-on collision a car is not allowed to drive faster than 70 km/h.
2. On roads/streets where there is a risk for a side impact collision a car is not allowed to drive faster than 50 km/h.
3. On roads/streets where a car can hit a pedestrian or a bicyclist a car is not allowed to drive faster than 30 km/h.
More or less as a logical consequence of these basic premises, a hierarchical division of streets and roads, based on speed, has been introduced in Sweden as follows:

1  km/h-road or Traffic route for long distance driving in a town, and where walking and cycling is prohibited
2  km/h-street or Main street or Urban arterial road for driving between city blocks; however, when driving through zebra crossings, cars are not permitted to drive faster than 30 km/h.
3  km/h-street or Residential street for driving within a residential district and for driving to or from a 50/30 km/h-street.
4  Walking speed street or Woonerf for driving to a destination along the street or a street nearby.
5  Lanes for pedestrians and bicycles (pavements, footpaths, squares, bicycle paths, etc.) where motor vehicles are strictly forbidden, a domain exclusively for pedestrians and cyclists.

4 and 5 serve some traffic function, but are primarily intended to satisfy as many as possible of the different demands and wishes that the inhabitants of a town place on public places.

1.2 ACCOUNT OF THE NEW APPROACH
Hierarchical Division of Streets and Roads

1.2.1 Through traffic route or Urban arterial road or...
Mostly 70 km/h, sometime 50 km/h, seldom 90 km/h

1.2.1.1 Function
The through traffic route is intended for longer car journeys through built-up areas passing by one or more residential areas. The through traffic route has through traffic and distribution traffic, but no access traffic. There is no parking permitted along a through traffic route. A through traffic route has no residential function.

The through traffic routes consist of those streets and roads where priority is given to the efficient transport of people and goods by car at steady, moderate speeds within a street and road network capable of handling the prevalent traffic volume. The good accessibility offered to motorists within through traffic routes is perceived as so advantageous that motorists choose this network for everything except the shortest local trips.

1.2.1.2 Street Design
The alignment of a through traffic route is often of high standard and as far away from nearby buildings as possible. The through traffic route is often, but not always, situated in suburban areas or on the periphery of built-up areas.

Distances between intersections are long enough for the intended speed level.

There is often road space available to enhance the safety of errant vehicles. Rigid, stationary objects in the roadside area have been either positioned, designed or
shielded so as to protect motorists from serious injury in the event of head-on collision or side impact collision when unintentionally driving off the carriageway. The carriageway has often two traffic lanes for car traffic in each direction, sometimes even more.

A through traffic route is segregated from pedestrian and bicycle traffic, and any road connection to adjacent neighbourhoods is intended for car traffic only.

As there are no pedestrians or cyclists on a through traffic route, there are no pedestrian pavements and no bicycle lanes.

Vulnerable road-users have been provided with grade-separated interchanges for crossing traffic routes. For movement parallel to the through traffic route network, there are pedestrian and bicycle paths that have been totally segregated from car traffic; e.g. by vegetation, a safety fence or sufficient distance between the carriageway and the pedestrian and bicycle path.

Due to the longer distances between intersections, the accessibility gains on the 70-km/h stretches are more obvious. Despite the higher speed level, the environmental impact on the surroundings is moderate due to the distance to houses and buildings.

1.2.1.3 Behaviour
The speed limit is mostly 70 km/h on through traffic routes. The speed at intersections may not exceed 50 km/h if there is any risk of side impact collision. This is ensured through traffic calming measures, e.g., a roundabout, or - ultimately – through road informatics technology.

If there are short distances between the intersections, the speed limit is restricted to 50 km/h, even on unbroken stretches. The speed limit is ensured through a traffic calming design, even on unbroken stretches. Motorists accept the low speed here because higher speeds would only have a marginal time-saving effect due to the relatively short distances between intersections. The speed limit is also felt to be well motivated due to the relative proximity of housing developments.

The speed 90 km/h is sometimes possible even in built-up areas if the alignment and the intersections are of very high standard, and if the distances between intersections are long.

In the year 2010 we think that through traffic routes will constitute 10-20% of the street network in built-up areas in Sweden.

1.2.2 Street, Main Street or Urban Street or …

1.2.2.1 Function
The 50/30 km/h-street is used by cars and by bicycles going from one neighbourhood to another nearby. The traffic in a 50/30-km/h-street is mostly local; there is collector traffic and access traffic and sometimes even through traffic.

Parking can be permitted along a 50/30-street, especially in central areas.

A 50/30 km/h-street could have a business or a residential function. Also a 50/30 km/h-street is often the showcase window of the neighbourhood, with shops and
other business activities, creating the need for loading and unloading areas and kerbside parking.

Very often a 50/30 km/h-street is not a boundary between two neighbourhoods, and therefore pedestrians, bicyclists, children, the elderly and disabled persons often need to cross it.

1.2.2.2 Street Design

The carriageway normally only has two lanes for ordinary car traffic. The 50/30 km/h-street also has wide bicycle paths and wide pedestrian pavements, affording cyclists and pedestrians good accessibility, safety and security. Furthermore, these wide walkways and paths provide the potential for creating an attractive, pleasant street space that is also environmentally suitable for children, the elderly and disabled persons.

Where there is heavy bus traffic, the 50/30-street is designed with bus lanes.

An intersection between two 50/30 km/h-streets always has pedestrian and bicycle crossings. These crossings are designed so that a car cannot drive through them at speeds exceeding 30 km/h, keeping in mind children, the elderly and disabled persons. Some intersections, where there is a special need, are designed as a pedestrian pavement on which cars are not permitted to drive faster than walking speed; i.e., between 5 and 10 km/h.

On unbroken stretches where there is no crossing pedestrian or bicycle traffic, cars are permitted to drive a maximum of 50 km/h.

Where the situation demands and city plans permit, the 50/30-km/h street has a central reserve equipped with a safety fence to ensure that pedestrians and cyclists cross the street only at places designated for this purpose.

There are special areas for loading and unloading on 50/30 km/h-streets but as little kerbside parking as possible.

The 50/30 km/h-street is designed so that pedestrians and cyclists are given as much space as possible, while the area for car traffic is limited in accordance with the purpose of the street traffic. As far as possible, destination points in the surroundings are concentrated and located so that pedestrian and bicycle traffic needing to cross a 50/30 km/h-street can be steered naturally to the pedestrian and bicycle crossings.

1.2.2.3 Behaviour

Pedestrians and bicyclists cross a 50/30 km/h-street at designated pedestrian and bicycle crossings.

In the year 2010 we think that 50/30 km/h-streets will constitute 20-25% of the street network in built-up areas in Sweden.
1.2.3 km/h Street Residential Street, Wohnstrasse, or Rue Residentielle, or...

1.2.3.1 Function
The 30 km/h-street is a street in a residential area, where priority is given to the local inhabitants, thus designating its function. The 30 km/h-street shall be an attractive, pleasant street space and an environment suitable for children, the elderly and disabled persons.

As far as vehicles are concerned, a 30 km/h-street is used only by local bicycle and car traffic that originates in or has a destination within the neighbourhood. 30 km/h-streets nearly always have access traffic, sometimes collector traffic, but never through traffic.

1.2.3.2 Street Design
A 30 km/h-street has pedestrian pavements and a carriageway. The carriageway is as narrow as possible, i.e., between four and six meters. Thus, there is space for the pedestrian pavement to be as wide as possible, providing great potential for creating an attractive, pleasant street area suitable for children, the elderly and disabled persons alike.

Especially in the inner city areas, 30 km/h-streets provide part of the need for short-time parking. Parking spaces are designed and located with care, paying consideration to their being an aesthetically attractive element within the street environment.

A 30 km/h-street has no marked pedestrian or bicycle crossings, no bicycle paths and no traffic signals. Sometimes there are bicycle roads in 30 km/h-areas.

Traffic calming measures guarantee safe, secure interaction between pedestrians, cyclists and motorists. One good traffic calming measure is an elevated crossing, signalling that in 30 km/h-areas priority is given to pedestrians. This solution will help elderly people to move about, especially those in wheelchairs. It also makes pushing prams easier. Roundabouts represent another good traffic calming solution.

1.2.3.3 Behaviour
The normal way to move within a 30 km/h-area is usually on foot or by bicycle; walking canes and wheelchairs are also prevalent as is the use of a “rollator“ (a walking aid that is very common in Sweden). Young parents often push prams.

Within a 30 km/h-area it is natural to cross a street as a pedestrian or a cyclist arbitrarily, either anywhere along the street or at street crossings.

In the year 2010 we think 30 km/h-streets will constitute 25-30% of the street network in built-up areas in Sweden.
1.2.4 Walking Speed Street (woonerf or pedestrian street or ...)

1.2.4.1 Function
The walking speed street is a communal outdoor space shared by everyone living by the street. It is a street especially for children, the elderly and disabled persons. A walking speed street is an attractive, pleasant street space for meetings, play and recreation. It is used by cars and by bicycles only when they come from a destination or go to a destination along it or a street close nearby.

1.2.4.2 Street Design
The walking speed street is designed as communal outdoor space shared by everyone living by the street. The entire walking speed street is intended for everybody; it is not divided into separate lanes for different types of „traffic“. It is designed entirely at the same level; i.e., there are no kerbs.

1.2.4.3 Behaviour
The street is designed and regulated so that the maximum speed for cars does not exceed walking speeds; i.e. 5 to 10 km/h, with an average speed of around 7 km/h depending on who is walking.

This type of street has often been created on the initiative of the property owners and the local residents, with both groups supporting the construction and maintenance operations.

Pedestrians and bicyclists always have the right of way.

In the year 2010 we think that walking speed streets will constitute 20-25% of the street network in built-up areas in Sweden.

1.2.5 Car-free Area (lanes for pedestrians and cyclists)
These include all the town footpaths and bikeways, walkways, parks, greenways, recreation areas, market squares and playgrounds as well as all the neighbourhood areas where cars have been prohibited.

1.2.5.1 Function
The car-free area in a town has a great inherent potential for both planned and unplanned encounters, which should be made possible and even facilitated, by the urban street design. In this type of area it is possible for pedestrians, bicyclists, children, the elderly and disabled persons to move around safely and securely in built-up areas.

A main objective of a car-free area is to be able to interconnect as many of its parts as possible and make it possible for people to walk or cycle within the area without having to confront the risks, conflicts and disturbances associated with motor traffic.

1.2.5.2 Street Design
The walking areas and pedestrian and bicycle paths have moderately steep inclines, surfaces are smooth and even, and the street furniture is well designed. There are
attractive outdoor spaces for meetings, play and recreation. There is good street lighting as well as other design details that make everyone, including children, the elderly and disabled persons, feel safe and secure.

Motor vehicles can be granted exemptions to enter the car-free area, but only on the terms set by pedestrians and cyclists. The car is not allowed to drive faster than a person can walk, and that ranges between 5 and 10 km/h, depending on who is walking.

1.2.5.3 Behaviour

Many car-free areas serve no traffic function at all. Some are particularly designed to enable the mobility of children, the elderly and disabled persons.

Pedestrian pavements and bicycle lanes also serve a traffic function, and must be situated and designed accordingly. Bicyclists must be able to move at speeds up to 30 km/h on bicycle tracks and on certain greenways; however, in other places such as woonerfs, bicyclists are required to ride at walking speed.

1.3 THE NEW APPROACH IN REALITY

1.3.1 Demonstration Project / The Jönköping Case Study

A traffic system designed more or less according to the philosophy presented above entails an investment of slightly more than SEK 200 million in the Jönköping street network. This means approximately SEK 4,000 per inhabitant in the area in question. With an average depreciation period of 30 years and a 5% cost of capital, the annual cost of investment amounts to approximately SEK 13 million, or SEK 260 per inhabitant and year. The increased operational costs have been assessed at SEK 5.4 million per year, or a little more than SEK 100 per inhabitant and year.

In Sweden, about 7.2 million people live in urban areas. If the situation in Jönköping is considered to be representative, an application of the philosophy in whole Sweden means an investment need of slightly more than SEK 28,000 million. The increased operations and maintenance costs for this investment amounts to about SEK 750 million per year.

The purpose of this study has been to describe the measures required in the physical environment and to endeavour to provide a rough outline of the impact of the new traffic system. Space has not permitted a sensitivity analysis of the figures presented. On the other hand, an attempt has been made to describe the methodology used in each analysis to make it possible to evaluate the results.

In our assessment, the measures proposed in Jönköping will reduce the number of actual injuries in urban traffic by slightly more than 20%; i.e., from about 235 to about 186 per year. The reduction is greatest for serious injuries, which means an approximate 30% reduction in accident costs. This represents about SEK 40 million per year lower costs to society. Accidents reported by the police are expected to be reduced by 43%, from an average of 81 to 46 cases of injury per year.

That the reduction is not greater depends on the large number of accidents occurring between vulnerable road users only. This category of accident accounts
for about 50% of all injuries incurred within the municipal network, and is an area upon which the measures contemplated will not have an impact. In order to be able to effect a reduction here, other measures are required, some of which would be undertaken within the physical environment, such as better cycle paths and better separation between cyclists and pedestrians.

The major safety gains are obtained on the local residential streets - speed limit 30 km/h and woonerfs - which account for two-thirds of the injury reduction and one-third of the investment costs. If, moreover, the speed limit is reduced to 30 km/h on 10% of the main streets normally used by vulnerable road users in addition to an implementation of a 30 km/h limit - or alternatively physical separation measures - at certain selected spots where vulnerable road users normally cross main streets, almost 90% of the reduction “possible” will be covered. In such a case, approximately 60% of the total investment costs will have been consumed.

One could pose the question as to the impact that modest re-construction measures and a posted 30 km/h speed limit would have on local residential streets. In the city of Graz, such a system has been implemented for a few years. Traffic supervision in Graz is, nonetheless, considerably more intensive than in Sweden. It has been possible to reduce the cases of injury reported by the police in Graz by about 25%. The reduction in our case is expected to be 43%.

A reduction in the average speed of motorised vehicles entails longer travel times. These are expected to increase on major through streets by almost 1,800 hours on weekdays, which corresponds to slightly more than two minutes per inhabitant and day. It might be considered questionable to assess this in another way, but if the Swedish National Road Administration project analysis principles were to be applied, this time consumption represents an additional cost for motorists of SEK 43 million per year. In this case, it has not been possible to estimate the gains in travel time won by pedestrians and cyclists through the implementation of more physical separation measures nor their shorter waiting times at junctions. Neither has it been possible to estimate the shorter waiting times experienced by motorists exiting local residential streets.

Public transport is hit hardest by the speed reduction measures normally used to implement speeds of 30 km/h (like speed bumps designed according to the Watts model). If users of public transport services are to be able to maintain travel times, the frequency of service must be increased. According to our calculations, this entails doubling the vehicle fleet necessary, which corresponds to an additional cost of about SEK 40 million per year. Measures catering to buses, i.e., those which are not more speed-restrictive to buses than to cars, are more or less necessary on streets with scheduled bus traffic. Such measures limit the increase in cost to about SEK 3 million per year while maintaining the average travel time.

Emergency rescue vehicles will be affected in the same way. Preliminary calculations made by the Fire Department show that the ensuing extra time entailed would lead to an increase in human injury and in property damage amounting to about SEK 3 million per year within the area under study; i.e., about SEK 60 per inhabitant. The impact on ambulance and police vehicles has not been investigated.
Goods distributors within urban areas will in all probability react negatively to the measures due to reduced accessibility and increased travel times. Vehicle costs will probably also increase. No calculations have been made within this project.

A more in-depth analysis of the environmental impact has not been conducted. The Swedish Road and Transport Research Institute has, on the other hand, calculated the implications of a general reduction in the speed limit to 30 km/h. The results corroborate what has been found in German experience: certain types of vehicle emissions will increase while most will decrease. In general, the noise level can also be expected to decrease somewhat.

Re-construction of the traffic environment according to the proposed concept has an impact upon several other factors in society in addition to those mentioned in the foregoing. There can be a long-range social effect that more people will want to live centrally in cities, in part, perhaps due to the reduced barrier effect of traffic. Elevations of the carriageway at street intersections to walkway level, in combination with lower traffic speeds, will substantially ease access for children, the elderly and physically disabled persons. The measures proposed will also create a more aesthetically pleasing traffic environment in our cities. Certain sources maintain that these measures will moreover lead to positive effects within many different areas of society.

When compiling the results from the impact analysis, there is an obvious risk of misinterpretation, especially regarding those evaluations expressed monetarily. There are several assumptions and circumstances that are not illuminated. For instance, it is not entirely certain that effects expressed in the same terms can be directly compared, even if the term of measurement is money. Despite these reservations, an attempt at an overall compilation of results is presented in the following table.
Table 14  Impact of the application of “Vision Zero” on the physical environment in urban areas (test site Jönköping)

<table>
<thead>
<tr>
<th>Impact on</th>
<th>Effect</th>
<th>Cost / inhabitant</th>
<th>Cost / year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments</td>
<td>+ 4,000 SEK</td>
<td>+ 13 million SEK</td>
<td></td>
</tr>
<tr>
<td>Operations / Maintenance</td>
<td>+ 100 SEK / year</td>
<td>+ 5.4 million SEK</td>
<td></td>
</tr>
<tr>
<td>Injuries</td>
<td>- 800 SEK / year</td>
<td>- 40 million SEK</td>
<td></td>
</tr>
<tr>
<td>Travel time in cars</td>
<td>+ 1,800 hours / day</td>
<td>3.30 SEK / day</td>
<td>+ 43 million SEK</td>
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<tr>
<td>Travel time for vulnerable road users</td>
<td>Reduction</td>
<td>- ?</td>
<td>- ?</td>
</tr>
<tr>
<td>Public transport</td>
<td>at least 3 new buses</td>
<td>+ 60 SEK / year</td>
<td>+ 3 million SEK</td>
</tr>
<tr>
<td>Fire department</td>
<td>greater delay</td>
<td>+ 60 SEK / year</td>
<td>+ 3 million SEK</td>
</tr>
<tr>
<td>Ambulance</td>
<td>greater delay</td>
<td>+ ?</td>
<td>+ ?</td>
</tr>
<tr>
<td>Police</td>
<td>greater delay</td>
<td>+ ?</td>
<td>+ ?</td>
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<tr>
<td>Goods distribution</td>
<td>more delivery vehicles</td>
<td>+ ?</td>
<td>+ ?</td>
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<tr>
<td>Vehicle emissions</td>
<td>somewhat reduced</td>
<td>- ?</td>
<td>- ?</td>
</tr>
<tr>
<td>Noise</td>
<td>somewhat reduced</td>
<td>- ?</td>
<td>- ?</td>
</tr>
<tr>
<td>Social structure</td>
<td>more people living in the city centre</td>
<td>- ?</td>
<td>- ?</td>
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<tr>
<td>Barriers</td>
<td>fewer and less forbidding</td>
<td>- ?</td>
<td>- ?</td>
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<tr>
<td>Disabled persons</td>
<td>enhanced possibilities</td>
<td>- ?</td>
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<td>Aesthetics</td>
<td>Positive</td>
<td>- ?</td>
<td>- ?</td>
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<tr>
<td>Social</td>
<td>enhanced possibilities</td>
<td>- ?</td>
<td>- ?</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
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</table>

The table shows that there are many questions that must be clarified before a complete impact analysis can be made. There is thus much leeway for several new studies and research projects.

Another important question focuses on how best to reduce accidents involving vulnerable road users only. These represent half of the injuries in Jönköping. Needless to say, several different measures must be taken, but what are the measures that can be suitably undertaken in the physical environment?

1.3.2  Planned Demonstration Projects

The Municipalities in Sweden are now working on elaborating a street classification according to the philosophy contained in this paper.

Based on the results of this classification, plans are currently underway to demonstrate and evaluate Vision Zero and the five types of streets described. In 1999, at least seven different demonstration projects that adhere as far as possible to the philosophy have been scheduled.