

INNOVATIVE SOLUTIONS WITH 80 AND 100KM/H RURAL DISTRIBUTOR ROADS

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INTRODUCTION

Since the formal introduction of Sustainable Safety (SWOV 1992, Schermers and van Vliet, 1999 and 2002) in 1997, road authorities in the Netherlands have been challenged with the realisation of a road network based on three rural road classes and two urban road classes, each class with its own unique functional and operational characteristics. In urban areas there are distributor (50km/h) and access (30km/h) roads. In rural areas there are freeways (100 and 120km/h), distributors (80km/h) and access (60km/h) roads.

Design guidelines for rural roads in the Netherlands stipulate that regional motorways have separate carriageways whereas 2 lane rural distributors preferably have a single carriageway with a physical directional separation and therefore a general overtaking ban. It is also recommended that parallel roads be provided to accommodate agricultural and slow traffic (e.g. bicycles). However, in some cases this is not feasible or possible and therefore exceptions need to be accommodated. An example of such a situation is the proposed regional motorway, the N340 between Zwolle and Ommen in the Province of Overijssel in the Netherlands.

During 2000 the need arose to expand the current understanding and knowledge with regard to the layout of especially 100km/h regional motorways and 80km/h rural distributor roads. This paper provides an overview of the road safety situation with respect to these roads in the Netherlands. It discusses the experience with respect to various layout alternatives and gives a perspective on possible future solutions.

OVERVIEW OF SUSTAINABLE SAFETY

During the early 1990's the Dutch Government, in close consultation with the SWOV, decided that a more long term and permanent solution to the road safety problem in the Netherlands was needed. Although reactive approaches had been applied in the past and had been reasonably effective, it was realised that these efforts (also called the spearhead policy) which targeted alcohol in traffic, speeding, hazardous locations, children and elderly in traffic and safety devices would by themselves not be enough to meet the goals set out in transport policy (MPV II and SVV II). Consequently government issued a "twin-pronged" traffic and transport policy (MPV III, 1991) that aimed at intensifying the spearhead policy and introduced the pro-active and long-term sustainable safety vision.

Sustainable safety is a holistic (systems) approach where all aspects of the road transport system are geared to one another with the focus on minimising the negative effects resulting from the interaction between man, vehicle and road infrastructure (SWOV, 1992, Schermers and van Vliet, 1999 and 2001). In this approach the human being takes a central role since they are largely unpredictable and consistent behaviour is not sustainable over the long term. Also the relation between function, form, legislation and usage with the system is important where function relates to the intended use of road infrastructure, form to physical design and layout, legislation to rules and regulations regarding infrastructure and usage to the behaviour of road users on that infrastructure.

A sustainable safe traffic system comprises:

- A road environment adapted to the limitations of road users;
- Vehicles equipped with technology to simplify the driving task and provided with devices that protect occupants and other road users; and
- Road users who are well informed and adequately educated.

Sustainable safety provides for essentially only three classes of road in its hierarchy, namely:

- Roads with a through function (for the rapid movement of through traffic);
- Roads with a distributor function (for the distribution and collection of traffic to and from different districts and residential areas); and
- Roads with an access function (providing access to homes and shops whilst ensuring the safety of the street as a communal meeting place).

Each category of road has a design that is compatible to its function whilst at the same time ensuring the optimum levels of safety. All road categories should comply with the following road safety principles:

- Functionality (preventing unintended use of the infrastructure)
- Homogeneity (preventing major variations in the speed, direction and mass of vehicles at moderate to high driving speeds; and
- Predictability (preventing uncertainty among road users).

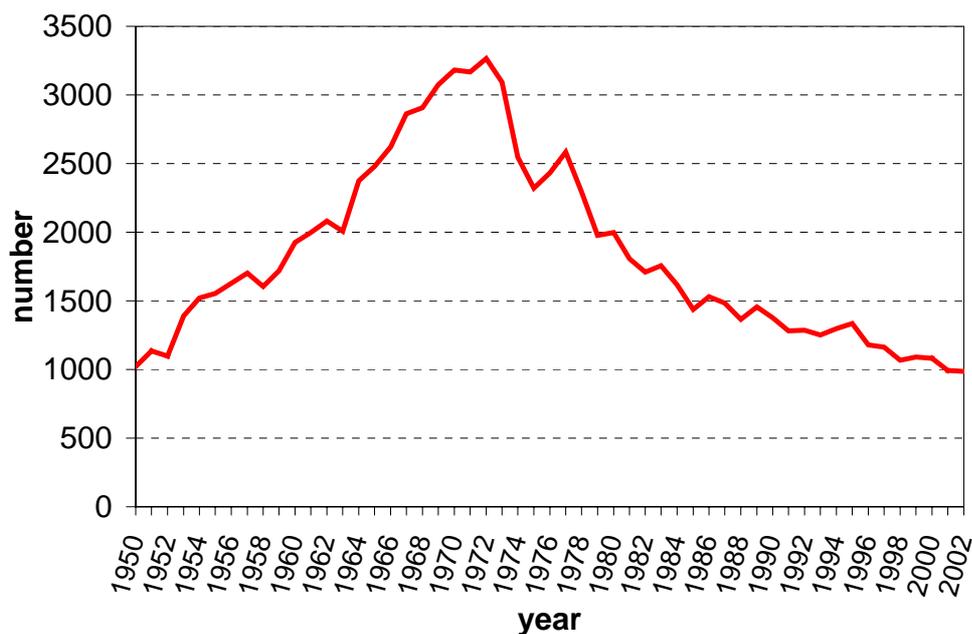
The underlying principle of sustainable safety is based on a systems approach that aims to ensure that road users are provided a road traffic system that stimulates correct behaviour and, where that is absolutely not possible, minimises the possible negative effects. It is a pro-active approach that intends preventing road traffic accidents and at worst, minimises the severity of these.

Sustainable Safety is not just a concept but has since its implementation in 1997 become an integral part of the design, operation and maintenance of the road traffic environment in the Netherlands.

ROAD SAFETY PERSPECTIVE

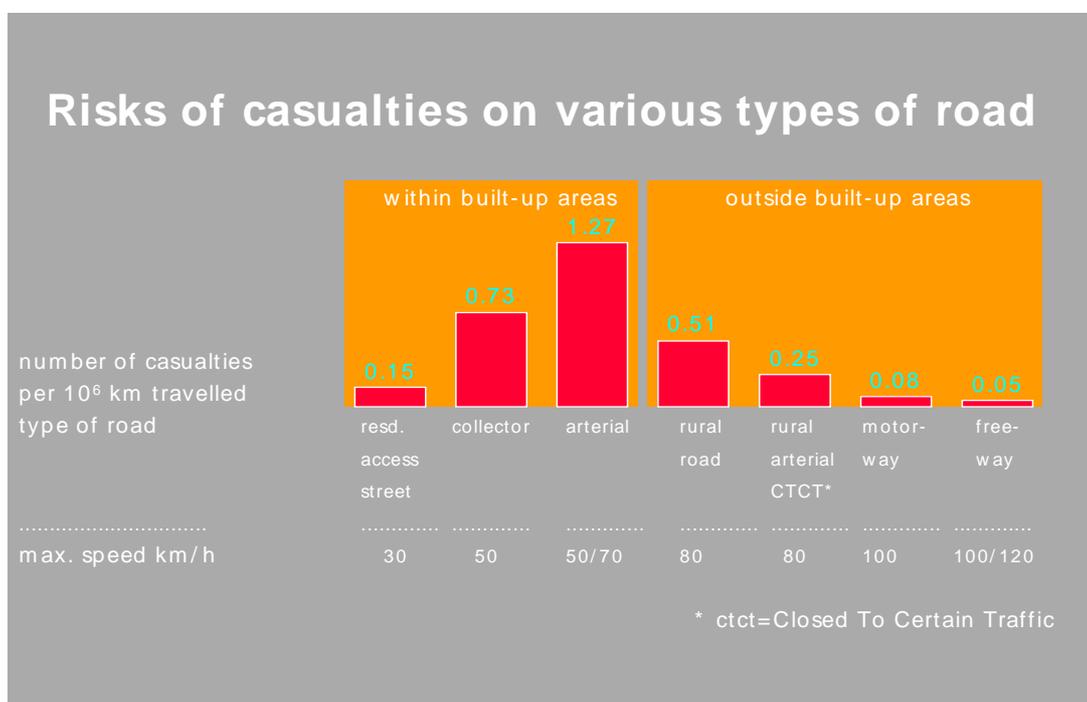
In 2003 the Netherlands had 1088 people killed and 18420 seriously injured casualties resulting from road traffic accidents. Although the trend since the mid 1970's has been downward (Figure 1) the country still places a high priority on continually improving road safety and has set its target at a maximum of 640 fatalities in 2020 (Ministry of Transport 2004).

Figure 1 : Number of traffic fatalities in the Netherlands



The underlying motivation for re-classifying the Dutch road network was based on the fact that roads with predominantly one function (access or flow) had significantly lower accident rates (Figure 2). Roads with both an access and a flow function (typically urban and rural distributor and collector roads) are comparatively unsafe and therefore a major challenge awaits Dutch road authorities to remedy this situation by applying the principles of sustainable safety to particularly these road types.

Figure 2 : Accident risks by road type and speed limit (SWOV, 1998)



ISSUES RELATING TO RURAL DISTRIBUTOR ROADS

Although it is the long-term goal to physically realise the road network classification intended by Sustainable Safety, it remains a fact that a large number of rural roads, especially distributor roads, do not comply with the requirements for such roads. The ambition of sustainable safety that distributor roads should comply to the following operational requirements:

- Single carriageway, 2-lane road with a maximum speed of 80 km/h
- No agricultural or slow traffic shall make use of these roads (i.e. parallel roads are to be provided);
- Property accesses shall be restricted to an absolute minimum (preferably none);
- Overtaking is generally not permitted (physical directional separation or at least barrier lines);
- Hard shoulders and/or turnouts shall be provided to accommodate broken down vehicles; and
- Intersections are preferably roundabout controlled or even grade separated (especially intersections where slow traffic such as bicycles are present).

These requirements are an ideal and in the short term the Netherlands will have to provide other solutions that contribute toward ultimately achieving this. However, in the short term the reality is that the Netherlands has a number of different types of these roads, often with very different layouts and features (Figure 3). These differences are not surprising since these roads were designed according to old road network hierarchy principles and guidelines. However, considering the aspirations of sustainable safety in providing an almost self-explaining road network, it is clear that a lot of effort is required, from a road user perspective, to provide a consistent and standard layout for these roads.

Figure 3 : Current layout of distributor roads in the Netherlands (pictures courtesy P v Vliet, AVV)

3a : 80km/h no overtaking



3b: 100km/h, no overtaking



3c: 80km/h, partial overtaking



3d: 80km/h partial overtaking

Figure 3 (cntd.): Current layout of distributor roads in the Netherlands

3e : 80km/h overtaking



3f: 80km/h partial overtaking



3g: 80km/h No overtaking



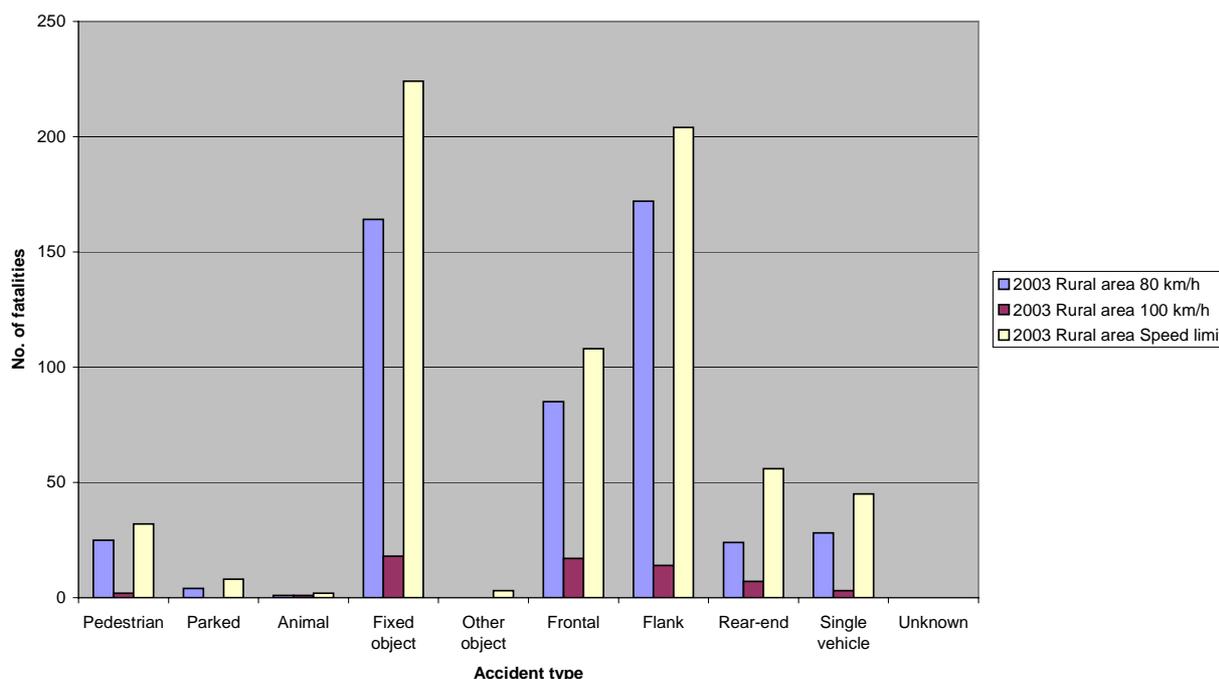
3h: 80km/h No overtaking



3i: 100km/h no overtaking

In 2003 there were 682 traffic fatalities (66% of the total) registered on Dutch roads outside the built area (Figure 4). Of these some 74% (49% of the total) occurred on 80km/h roads and 9% on 100km/h roads (6% of the total). Examining the predominant accident type it is apparent that 33% of all fatalities on rural roads occur as a result of accidents with fixed objects, 30% of all fatalities as a result of flank (right-angled/side-swipe) accidents and a further 16% of all fatalities as a result of head-on collisions.

Figure 4 : Registered fatalities on 80 and 100km/h roads



From a road safety perspective it is clear that improvements to these roads are desired.

During 2000 road authorities were confronted with the problem of addressing these issues. A central discussion was whether or not to introduce a general overtaking ban on these roads. If the answer was yes then the question arose as to which road layout and design should be applied to ensure the correct road user behaviour. It was also realised that an overtaking ban was not always feasible and therefore some exceptions would be expected. In these cases some form of overtaking would have to be provided for and the question was which form should be generally adopted as the standard.

RESEARCH

As a result of these discussions the Ministry requested the Transport Research Centre (AVV) to investigate these issues and to develop possible solutions to, on the one hand, remedy the road accident problem and on the other, to improve road user behaviour and expectancy on 80 and 100km/h rural distributor roads.

The AVV commissioned DHV to undertake the study in distinct phases:

- A literature review focussing on finding quantitative and qualitative results on the traffic flow and safety effects of various overtaking alternatives on single carriageway, two lane rural roads as opposed to banning overtaking (DHV, 2000). Furthermore, the consultant was asked to scope and identify a dynamic micro-simulation model that could be used to simulate a variety of overtaking conditions.

- Surveys at a number of locations in the Netherlands representing situations with and without overtaking (DHV, 2001). These locations had to comply with a number of criteria such as minimum length, traffic volume and composition, sight distances etc. At each location, traffic data (e.g. volumes, composition, speed distributions, overtaking manoeuvres, platoons, etc) were collected over a one-week period and analysed. To establish whether vehicles had overtaken required number plate surveys and these were also used to randomly select 3000 car drivers to whom attitudinal survey questionnaires were mailed. Finally a road safety analysis was conducted.
- Micro-simulation modelling (DHV, 2002). From the first phase the Dracula model (Liu, 1999), developed by Leeds University, was selected as the most suitable for simulating situations with and without overtaking and under a range of traffic, driver and visibility conditions.

The literature revealed that overtaking lanes could be an effective road safety measure (DHV, 2000). The experience in Germany, America, Canada and Australia revealed that road safety and also driver comfort are significantly better on 2-lane roads with overtaking lanes when compared to standard 2-lane roads (where overtaking is permitted). In Germany 3-lane roads, where the centre lane is used as an overtaking lane, are nearly twice as safe as traditional 2-lane roads.

In the Netherlands it was found that introducing an overtaking ban on traditional 2-lane roads reduced accidents by 21% and this caused the accident rate (casualties/million-vehicle-km) to drop by 38%. The experience in the Netherlands also revealed that an overtaking ban had a positive effect on speeds (average, distribution, standard deviation) whilst overtaking was largely eliminated.

As part of the DHV study, a road safety analysis of 235 kilometres of 100km/h and 200 kilometres of 80km/h roads was conducted. This revealed that approximately half of the injury accidents on 100km/h roads occurred between intersections whereas that proportion was 60% on 80km/h roads. The remainder occurred at intersections. Rear-end, head on, right angle, side-swipe and single vehicle (run-off road) accidents were predominant on these roads. Although head-on accidents contribute to roughly 7% of all accidents, they contribute to nearly half of all the fatalities and 25% of all serious injury accidents.

Traffic surveys were conducted at four locations in the Netherlands. At each location traffic measurements using video were conducted at three points along the route. Based on the video images, an analysis of average platoons (defined as situations where there are three or more vehicles following at headways smaller than 2s) was conducted. This revealed that the number and length of platoons did not materially differ between situations where overtaking was permitted and where it was banned. During off-peak periods approximately 45% of vehicles (average volumes around 300- 400 vph/direction) travel in platoons whereas this increases to around 70-75% in the peak periods (at volumes of between 600 and 750 vph/direction). Heavy Goods Vehicles (HGV) were at the head of the platoon in between 17 and 38% of the platoons observed.

The analysis of overtaking behaviour revealed that on the two roads where overtaking is not permitted between 3 and 7% of vehicles illegally overtake. In addition, an analysis of free-flow speeds revealed that an overtaking ban had virtually no influence on average free flow speeds. Furthermore, the average free-flow speeds did not materially differ from the average platoon speeds (free flow average speeds ranged between 78 and 91km/h whereas platoon speeds ranged between 80 and 87km/h).

Attitudinal surveys (questionnaires) were sent to some 3 000 road users. Nearly half of these were completed and returned. This was a far higher response than the estimated required sample of 750 and therefore 800 of these were analysed and providing a statistically

representative sample. 65% of the sample was aged between 30 and 55 years old, 85 % of respondents were car drivers and 75% used these roads at least on a weekly basis.

Respondents were given photos depicting overtaking and non-overtaking situation and were asked a number of questions relating to their preferences. Approximately 22% of all respondent preferred a situation where overtaking is permitted whereas the remaining 78% indicate a preference for some form of overtaking ban. The majority of these indicated a preference for a double barrier line as the means to facilitate the ban. The majority of respondents agreed with the statement that the situation with an overtaking ban was safe whereas they disagreed with the statement that the situation was safe with overtaking allowed.

The final part of this research entailed microscopic traffic simulation of various layouts with overtaking lanes. The Dracula simulation model (Liu, 1999) was selected as the most appropriate model, especially since it could simulate overtaking on overtaking lanes (i.e. in the same direction) and overtaking using the opposing traffic lane (i.e. using gap acceptance criteria). The model was calibrated and validated for the Dutch situation using data measured on a provincial road (N48). The modelled results in terms of platoons and overtaking manoeuvres compared favourably with that observed. The model tended to under-predict actual speeds and this can be explained by the fact that the model considers the speed limit as the actual maximum. In practice this is seldom the case and it is therefore advisable to set the speed limit in the model closer to the observed maximum speeds (85th percentile value).

Four road conditions (overtaking ban; passing lane; shared overtaking lane in the centre and extra lanes at intersections), two speed regimes, two traffic conditions with two mixes and 4 different sight distances (giving 64 situations) were modelled. With respect to platooning and speeds, the model indicated virtually no differences between the alternatives. Furthermore there appeared to be virtually no differences in terms of traffic flow, delays etc. when one compared the overtaking alternatives to the alternative with no overtaking.

The simulations did reveal that the cars tend to overtake more often than what they get overtaken. As expected the opposite was true for HGV. Furthermore, the number of overtaking manoeuvres increases with increases in the proportion of HGV. The proportion of overtaking manoeuvres, at a given percentage HGV and maximum speed, on the 2+1 road remains similar in peak and off-peak situations whereas this is not so in the other overtaking alternatives (lower proportion overtake in the peak).

From a traffic engineering point of view the 2+1 option appears to perform better than the other alternatives and therefore was selected as the preferred alternative for situations where overtaking is to be provided. Also from a road safety perspective this option was preferred to the standard 1x2 option (where the opposing lane can be used to overtake) and the alternative where a passing lane is provided.

The results of these studies culminated in recommendations being submitted to the Ministry (Schermers, 2002). These subsequently formed the basis for the Province of Overijssel to further investigate the possibility of the 2+1 layout as one of the alternatives for upgrading the N340 between the towns of Zwolle and Ommen.

PROVINCIAL ROAD N340 (ZWOLLE TO OMMEN)

The Province of Overijssel established its new road categorisation plan in 1999 and subsequently took it up in its Provincial Traffic and Transport Plan (PVVP). In this plan the N340 has been given the highest status, namely that of traffic corridor. By implication this means that ultimately a 16 kilometre regional motorway should be realised between the towns of Zwolle and Ommen. The Province commissioned a planning study in conjunction with an Environmental Impact Assessment and alignment evaluation. The primary goals stated for this road were:

- The road between Zwolle and Ommen should be upgraded to the status of traffic corridor in order to provide easy access to the north-east of the province whilst drawing through traffic away from the alternative route (N377).
- Reduce the number of accidents
- Minimising the negative impacts and as far as possible blending in with the environment.

The planning study revealed that the costs for a road based on the principles of Sustainable Safety and in accordance with current guidelines were prohibitive and the realisation phase of the project was terminated. It was recommended that the province investigate cost effective alternatives to this optimal solution. A central question in this endeavour was "How can we be frugal yet achieve an effective and sustainable level of service from the perspective of traffic flow? "

A modular approach was adopted to facilitate the selection of alternatives. In principle two layouts were adopted and for each a basket of optional measures was proposed. Depending on available funds, specific wishes etc. these measures could be applied to achieve an optimal low cost solution. The two basic layouts were considered, a reference layout based only a slightly adapted version of the existing road and a layout with an overtaking lane. As optional measures were a separation between driving directions, the layout and number of intersections, the layout of the rail crossing, the layout of merging/weaving zones and considerations for future traffic accommodation during road works.

Both layouts could be accommodated within the existing reserve. The modified reference layout provided for a 2-lane road with parallel side roads for slow traffic. The paved width varied (due to choices in the directional separation and presence of hard shoulders) between 7,9m and 13,2 m whereas the total cross-section (including parallel roads varied between 26 and 32,6 metres. The 2+1 layout provided for a three-lane road with parallel roads and had a paved width varying between 11,3 and 14,8m and a total cross-section of between 29,4 and 36 metres.

In both layouts two options for achieving the directional separation were assessed, namely regular barriers (concrete New Jersey) and cable barriers (wire rope). The study concluded (Grontmij, 2003) that both layouts are feasible and will have a positive effect on traffic flow and road safety, both in the short and long term. The road safety effect are largely attributable to reduction in the number of intersections, grade separation of intersections with vulnerable and cyclist traffic and the physical separation of the driving directions.

A comparison based on cost effectiveness (using construction costs, cost of time, cost of accidents, cost of maintenance etc.) revealed that although more expensive, the 2+1 alternative would be more cost effective than the modified reference layout. In addition the investment cost to realise the optimal design of the 2+1 road, with parallel roads and a number of full and partially grade separated junctions was estimated at €60 million, less than half of the cost of the original design. The Province sees the 2+1 alternative as a solution to

phasing the implementation of a dual carriageway motorway. The first carriageway will in the short to medium term function as a 2+1 road until such time that traffic demand reaches levels that warrant a second carriageway. Also the intersections are semi-permanent and are either at-grade, partially or fully grade separated. At grade intersections are roundabouts that in the long term will be replaced with grade-separated junctions. Also the partially separated junctions will be upgraded to full separation when the second carriageway is constructed. By phasing the implementation the province can spread its investment over a longer period and at the appropriate moment in time.

However, the study cautions that the Netherlands has no experience with wire rope barrier systems or with the 2+1 alternative and recommends that further study be initiated to support the further development of the project (detailed design and implementation, monitoring and evaluation).

THE SWEDISH EXPERIENCE

Based on the results of the various studies in the Netherlands, the Transport Research Centre (AVV) of the Ministry of Transport, Public Works and Water Management decided to form a study group with representatives from the Ministry, the Provinces and CROW (the organisation responsible for developing guidelines for road design). The purpose of the study group was firstly to broaden the understanding of 2+1 roads and secondly to determine the experiences with respect to using wire rope systems as guardrails.

Since Sweden is a country that has published a number of studies (Bergh et. al.; Hylander) relating to the road safety experiences with regard to 2+1 roads, the study group visited officials of the Swedish National Road Authority in September of 2004 (Schermers, 2004). Site visits and visits to wire-rope manufacturers were organised as part of the tour.

Prior to 1998 Sweden had an extensive asphalt road network comprising some 212 000 kilometres in length. Of this some 8 000 kilometres is motorway/freeway and 4 000 kilometres is traditional 13m 1x2 rural roads with speed limits of 90 or 110km/h. In addition they have 1x2 roads with a narrower cross-sections (11,5m).

From a road safety perspective, 2x2 roads without a central guardrail scored poorly as did 1x2 roads with wide lanes and shoulders. Also it was found that the 2+1 road without some form of directional separation did not perform all that favourably from a road safety perspective. Consequently the SNRA investigated the possibility of introducing the 2+1 road with some form of separation, preferably a cable-barrier. Original estimates by the experts indicated that this type of layout could reduce the number of fatalities on these roads by as much as 60%.

In 1998 the SNRA obtained approval to conduct 6 pilot projects with the 2+1 road with cable-barriers to separate the driving directions. These projects were so successful that the Swedish Minister of Transport sanctioned the construction of a further 15 projects over the next two years. Since then nearly 1 000 kilometres of this type of road (Figure 5) has been realised with the ambition to construct another 2 000 kilometres by the end of 2007.

The existing 2+1 road network comprises 450 kilometres of semi-motorway (with grade-separated intersections) and 520 kilometres of traditional 2+1 road (at grade intersections, 3 lanes, cable-barriers, turnouts for breakdowns). These roads carry traffic volumes of between 5 000 and 22 000 vehicles per day.

Evaluations (Bergh et al, 2002; Hylander, 2002) have shown that the introduction of 2+1 roads with cable barriers has reduced serious injury accidents by, on average, nearly 50%. From a cost-benefit point of view it is estimated that the economic costs are recovered in 5,3

years if travel timesavings are taken into account and 9,5 years without the saved costs of time.

Figure 4 : Example of a 2+1 road in Sweden (Picture courtesy P van Vliet, AVV)



Although the benefits of the 2+1 roads in Sweden far outweigh the disadvantages, the SNRA points out that the following matters need careful attention when designing these roads:

- Layout of intersections
- Speed limits
- Traffic management during roadworks and at incidents (such as accidents)
- Retroreflective materials on the upright poles of the cable-barrier system
- Transition zones
- Beginning of the cable barrier
- Turnouts

CONCLUSION

Based on the evaluations and the visit to Sweden, AVV has recommended that a pilot project in the Netherlands should be further explored. However, since the Netherlands has significantly more motorcyclists than does Sweden, it is anticipated that opposition to the cable-barrier will become a serious topic for discussion. This has already been evidenced in the Province of Overijssel where the Motorcycle Action Group (MAG) reacted vehemently to the proposals for the N340, labelling the cable-barrier as criminal and likening it to an egg-cutter. Consequently the matter of directional separation of traffic on such roads in Holland is presently being assessed and a decision in this regard is expected early in 2005.

The 2+1 option is certainly seen as an innovative solution to situations where overtaking needs to be provided or where short to medium term traffic volumes do not justify the construction of a motorway with separate carriageways although this may be justified in the longer term. In the latter situation the 2+1 option offers the opportunity to introduce the

eventual motorway using a phased approach. First one carriageway is constructed which in the short to medium term (10-15 years) operates as a 2+1 road (preferably with full grade separation) and then the second carriageway is constructed (with the added benefit that traffic need not be badly disrupted) and the road functions as a normal dual carriageway (motorway or freeway).

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