SWOV Fact sheet

Network Management and Sustainable Safety

Summary
There is a trend at the regional level to no longer concentrate traffic on motorways only, but to divert some of it to the secondary road network. This trend is known as Network Management. Because the secondary road network is less safe than the main road network, this strategy will inevitably result in more road crashes and casualties if no additional measures are taken.

SWOV has several methods available to examine at the network level which measures are necessary to prevent this decline in road safety: the road network test, the Sustainably Safe Indicator, the Road Safety Audit, and crash rate data. SWOV recommends having the results of a regional network management project tested for road safety aspects by an independent road safety auditor.

Background
It is common knowledge that crash rates on motorways are low. Although about 40% of all motor vehicle kilometres in the Netherlands are travelled on them, only about 10% of fatal crashes occur on motorways. The reason for the annual increase in motor vehicle kilometres not resulting in a proportionate increase in fatal crashes lies largely in the fact that most of this increase goes to the relatively safe motorways. Therefore, the regional trend to relieve the motorways of part of this increase by diverting traffic to the relatively unsafe secondary roads is worrying from a road safety point of view. This trend is known as Network Management.

In view of the low crash rates on motorways it remains to be seen if it's wise to introduce Network Management. After all, it diverts traffic from the safe motorways to the less safe secondary road network. If no changes are made to these less safe secondary roads there will be more casualties. In order to make this trend comply with Sustainable Safety, the road network should meet a number of preconditions and requirements.
This fact sheet briefly describes this trend, discusses the relevant requirements and preconditions, and finally describes methods of testing network management variants against road safety criteria.

What is Network Management?
For a long time now, the extension of the motorway network has lagged behind its increased use. In order to make the best possible use of the existing capacity, the national road authority has attempted to guide the streams of traffic in such a way that all available capacity is optimally used. Under the name of 'Traffic Management Architecture' ideas and instruments have been developed for traffic management at the national and regional level.

A Dutch report entitled *Movement by Cooperation* (2003) has, among others, concluded that the 'traffic flow problem' on the main road network is a national problem that occurs regionally in the shape of a commuter traffic problem during rush hours. The report also concludes that a different way of thinking is required. Instead of thinking in terms of extending the infrastructure, one should think in terms of a regional network approach. The entire supply and demand needs to be taken into account. Such an approach makes it necessary for various road authorities to work together.

Meanwhile, the Dutch government has taken the initiative for a regional network approach in approximately 25 regions. This approach is called Network Management. Each of the regions already has a capacity problem on at least one motorway, or will have such problems as a result of lengthy road works like the construction of rush hour lanes. The size of a region is determined by the problems detected and the possible room for solutions. Examples of such regions are the areas between the cities of Eindhoven and Tilburg, between the towns of Gouda, Alphen aan den Rijn and Schiphol airport, between the cities of Groningen and Assen, and the Rotterdam region.

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The Advisory Council for Transport, Public Works and Water Management (RvWW, 2007) gives a positive judgement on the experiences with Network Management.
A Network Management Manual (AVV, 2002) was drawn up to assist the activities of a region. The manual distinguishes nine steps:
1. starting the project;
2. establishing joint policy starting points;
3. drawing up a control strategy;
4. defining a frame of reference;
5. describing the actual situation;
6. determining and analysing bottlenecks;
7. developing services;
8. deciding on measures;
9. completing the project.

The term 'services' refers to the various levels at which measures can be taken and involves influencing traffic flow, redistributing traffic, influencing traffic demand, and influencing road capacity.

For the time being Network Management focuses on the aspects of the traffic flow. The Ministry of Transport has provided additional information about the practical applications of Network Management (AVV, 2004a). A specially developed calculation instrument (AVV, 2004b) makes it possible to predict the traffic effects in a quantified way. Because more car traffic will use the secondary roads, there will be unwelcome road safety and liveability effects. For the road safety aspects the Ministry of Transport will add a module to this calculation instrument (Goudappel Coffeng & AVV, 2005). In 2007, the Ministry of Transport has published a brochure (AVV & Goudappel Coffeng, 2007) about the possibilities of giving explicit attention to road safety when using the above manual.

Which approach does Sustainable Safety choose?
For the road classification according to the Sustainable Safety philosophy, CROW (1997) drew up twelve safety requirements. Some of these apply to the network level:
- residential areas of largest possible size;
- a minimum part of the journey along unsafe roads;
- journeys as short as possible;
- the shortest and safest routes are one and the same;
- avoid drivers having to search their way.

A leading principle in Sustainable Safety is categorization of roads: a road functions properly if its function, layout, and use are geared to one another. In a sustainably safe traffic system the flow and access functions are strictly separated. Each function has its own road type: through-roads and access roads. The roads that connect these two road types are called distributor roads. In addition to the flow function, a distributor road must facilitate the exchange of traffic between the other two road types. The separation of the flow and exchange functions of this road type should be achieved by the layout: the flow function should only be possible on road segments and the exchange function only at intersections. Each road type has a distinguishing speed limit. Through-roads are only found outside built-up areas.

For a sustainably safe road network it is also important that the chosen road types agree with the required functional distribution of traffic over the road network. In this context the distance between two roads of the same type (the mesh) of distributor roads and through-roads is important (Van Minnen, 1999). Little has been determined with regard to the intended meshes of these road types. Besides the mesh as such, the nature of the required connections between different types of residential nuclei is indicative for the construction of a sustainably safe road network (Dijkstra, 2003).

An important network requirement is that the shortest and the safest route should be one and the same. This requirement should not result in traffic going through residential areas, with their generally safe roads. This leads to the additional requirement that the major part of a route should consist of through-roads and, if there are not any or not enough, of distributor roads. Only the beginning and end of a journey are made along access roads. To achieve such a route choice, the resistance (= extra journey time) of a route through residential areas should be more than that of a route along through-roads and/or distributor roads. To allow the sustainably safe road network to function properly it is

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essential that through-road traffic can indeed flow. Otherwise the extra journey time of a route through residential areas is offset by the journey time (with tailbacks) of a route along through-roads. Another additional network requirement is that, in a sustainably safe road network, through-roads must never directly connect to access roads.

How do you test Network Management variations for Sustainably Safe criteria?
SWOV (Dijkstra, 2004 and 2005) has developed several methods to determine the extent to which Network Management variations at the *network level* meet the Sustainably Safe requirements:
- the network test;
- the Sustainable Safety Indicator;
- the road safety audit;
- crash rate data.

Methods have also been developed for testing at the road segment or intersection level, but this fact sheet does not discuss these applications.

Network test
The network test makes it possible to determine for a random area whether the existing connections and their categories agree with the road type categorization in Sustainable Safety. The population distribution in the area and the required accessibility are taken into account.

In every randomly drawn unbroken area, (residential) nuclei differ in many ways. The German guidelines for road categorization (FGSV, 2008) use the functions of each nucleus in a particular area (local government, jurisdiction, culture, and services) to divide them into four classes. There are different types of connections between the different types of nuclei that fit the traffic resulting from their functions (production/attraction of people and goods).

In Network Management, but also in other network analyses, the number of inhabitants per nucleus is important, because this to a large extent determines the number of journeys to and from a nucleus. To allow for sufficient distinction between nuclei and their mutual connections, we distinguish five types of nucleus. The choice of five centre types has to do with the number of road types in Sustainable Safety: each road type has two subtypes, with different speed limits. This means that there are six types and subtypes available to connect nuclei. This would lead to six nucleus types, but the road type access road has a subtype II with a speed limit of 60 km/h which is certainly not meant for a connection function. This leaves five relevant road types and consequently also five nucleus types (See the diagonal cells in *Table 1*). A type 1 nucleus has the largest population and a type 5 nucleus has the smallest.

Type of nucleus	Type of nucleus				
	1	**2**	**3**	**4**	**5**
1	ThRI	ThRI	ThRII	via nucleus type 2/3	via nucleus type 2/3/4
2		ThRII	ThRII	DRI	via nucleus type 3/4
3			DRI	DRI	DRII
4				DRII	DRII
5					ARI

Table 1. *Connection between different nucleus types: choice for road category and road type. ThR = Through-Road; DR = Distributor Road; AR = Access Road. Each road category is subdivided into two road types.*

The subdivision of the nuclei depends on the way the population is distributed over the area. An area with one main nucleus and many small ones has other upper and lower limits of the population classes than an area with relatively many medium sized nuclei.

The five nucleus types in this system result in 15 different types of connections (see the 15 cells in *Table 1*). Each connection type has its own position within the traffic network: a characteristic traffic volume moves between the different nucleus types. The capacity, i.e. the number of motor vehicles

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per typical rush hour criterion, of the connections must be adjusted to this. The Sustainable Safety road types must match the required capacity. Of course the chosen capacity must be in accordance with the traffic function of the connection. The access road function is not intended for connections between nuclei of any size. In the network test the access function has only been assigned to connections between two nuclei of type 5.
In the chosen system (see *Table 1*) no direct connections are required between nuclei of types 1 and 4, types 1 and 5, and types 2 and 5: the traffic between these nuclei pass through larger nuclei. However, such connections may in practice already be present or, for reasons that are not relevant here, may still be necessary.

Sustainable Safety requires residential areas to be 'as large as possible'. In principle, residential areas are situated between major roads; between through roads or distributor roads. According to the nucleus approach, rural residential areas can have connections between two or more nuclei of type 5. Road safety research has indicated no maximum size for rural residential areas. In urban areas the size of a residential area could be a maximum of 125 hectares (Van Minnen, 1999). With this maximum size both the traffic volume along streets that access the area (with regard to ease of crossing over and liveability) as well as the distances to be travelled within the area (exposure) are still acceptable.

The mesh and the distance between intersections both depend on the nucleus density of an area. The various road types also have a characteristic average intersection distance, although there can be large deviations from these averages. This intersection distance is less important for the test criterion than the current or intended intersection class which shows the road types that intersect. *Table 2* shows which intersection classes are permitted in a sustainably safe traffic environment or are regarded as undesirable.

Road type Crosses with	ThR100/120	DR80	DR50/70	AR60	AR30
ThR100/120	interchange	split-level	*undesirable*	*undesirable*	*undesirable*
DR80		roundabout	roundabout	roundabout	*undesirable*
DR50/70			roundabout	priority junction	priority junction
AR60			roundabout	raised junction	raised junction
AR30					raised junction

Table 2*. Intersection classes: typology and desirability of application. Source: SWOV proposal for CROW (1997) and for Info point Sustainable Safety (1999 and 2000).*

An important consideration in not using the intersection distance as a test criterion is the low correlation in practice between road type and intersection density. Regional and national data (Janssen, 2005) show that both urban and rural distributor roads have just as many intersections per kilometre as access roads, or sometimes more. This situation will hardly change in the coming years. It would be logical to reduce the intersection density on distributor roads, because this road type processes much more traffic. Reducing the number of intersections per kilometre would result into fewer disturbances. Apparently the regions regard such a structural adaptation as not feasible.

Detour length and route choice are of course interrelated: a route mainly along major roads will probably entail a larger detour than a short cut along country roads. The detour is measured in the deviation from the distance in a straight line. The test criterion is a route that is 60% longer than the straight line distance (Vaughan, 1987); motorists usually do not choose a route with a larger detour.

The test criterion for the route choice is the extent to which a journey is made by sequential choices of the next higher or lower road types (see the route diagram in *Figure 1*).

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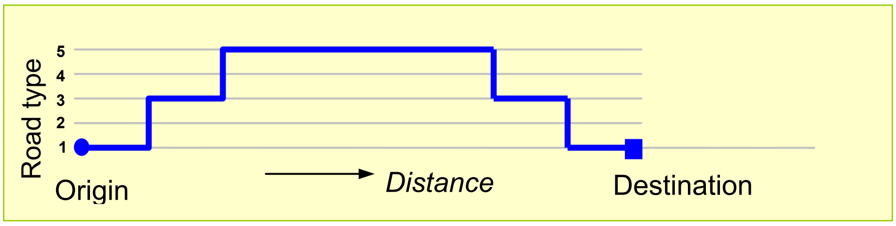

Figure 1. *Route diagram of a sustainably safe route.*

Sustainable Safety Indicator
The Sustainable Safety Indicator has been developed to test on all previously mentioned Sustainable Safety requirements when designing connections. Whether or not a design meets these requirements is determined by the presence and layout of specific design elements. The Sustainable Safety Indicator links design elements to the various requirements. The more elements of a design meet the requirements, the higher the Sustainable Safety level.

The testing for the Sustainably Safe requirements can take place in various design phases:
1. after planning the layout of the road network;
2. after a preliminary design;
3. after detailed design;
4. some time after the opening;
5. preceding maintenance and reconstruction.

The Sustainable Safety Indicator can also be used for existing roads and streets (from now on called phase 0).

Two types of design variables are distinguished: one type relates to the traffic and journey behaviour, and the other type refers to the traffic infrastructure. Not much is known about the actual traffic and journey behaviour in the initial planning phases, and models can only give an indication. In phases 4 and 5 and in existing situations the actual traffic and journey behaviour can be observed. There is sufficient knowledge about the traffic infrastructure in all phases. The chosen design variables for each Sustainable Safety requirement have been specified by Van der Kooi & Dijkstra (2000). Indicators have been drawn up that show which variables and characteristics are important for testing on these Sustainable Safety requirements. For example, for the 'Avoid drivers having to search their way' requirement, three indicators have been determined: the presence and location of signposting, indication of the through-route at direction-choice locations, and the presence of street lighting at direction-choice locations.

The Sustainable Safety Indicator needs much data about variables, indicators, and features. This data can be made available with existing measuring and observation methods. Depending on the phase concerned, the following approach is used for collecting data:
- desk study (results of model studies and route studies: phase 1; design drawings: phases 2 and 3);
- measurements (dimensions of all relevant elements, place on the road: phases 4 and 5);
- inspections (condition of the road environment: phases 4, 5, and 0);
- observations (traffic and journey behaviour: phases 4, 5, and 0).

For the input of this data, menus have been made which show during the input whether the data is correct and mutually consistent. The input is done for each road segment and intersection in one area or along one route (*Figure 2* shows an example of an input screen). After the input has been done, the Sustainable Safety Indicator immediately shows if the characteristics fit the chosen road type, by the colour of the input characteristics.

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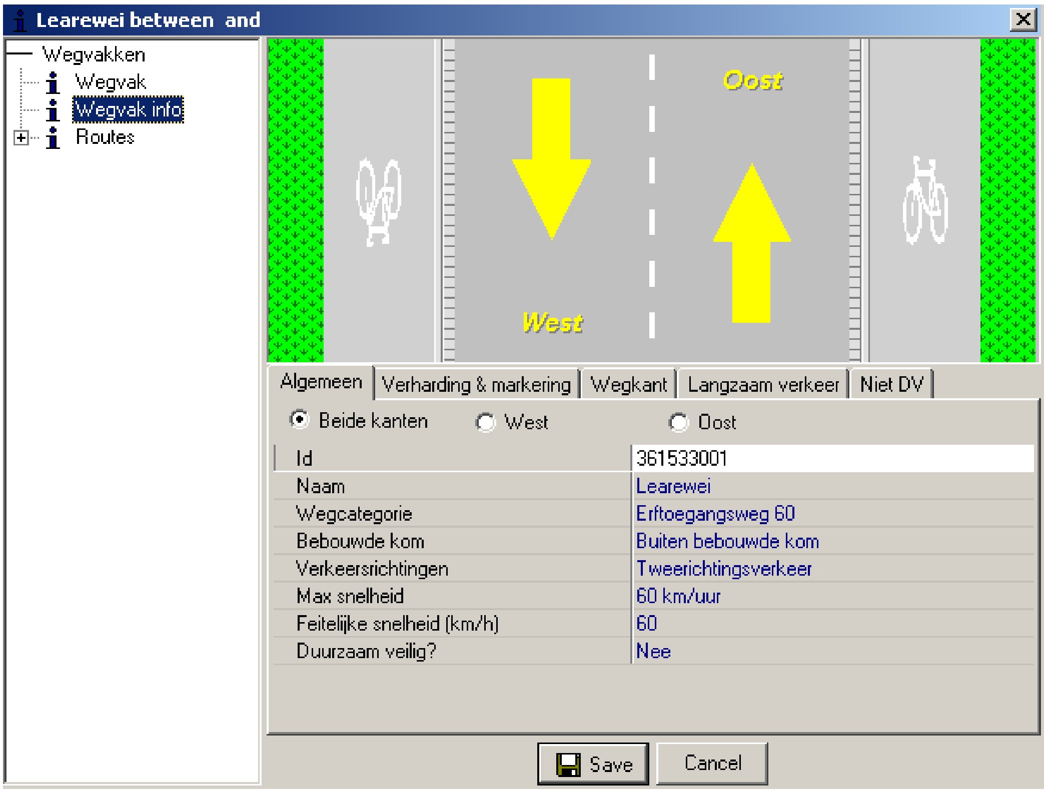

Figure 2. *Input-/Output screen for a road section (source: Houwing, 2003).*

Road Safety Audit)
A Road Safety Audit is an instrument to test if road safety is optimally embedded in traffic plans and designs (see the SWOV Fact sheet entitled *The Road Safety Audit and Road Safety Inspection* (2007). A plan or design is examined by independent road safety experts and, where necessary, they advise about possibilities of further improving road safety. A very important characteristic of the audit is that all types of road users (cyclists, pedestrians, the young, the elderly) are explicitly taken into account, as are all kinds of external circumstances (daylight, darkness, rain, snow). Using available information (e.g. provisional design, a categorization plan, a drawing a plan; all supplemented by relevant background information when useful) a specially trained auditor conducts the audit and writes down his findings and any recommendations briefly and succinctly.

Crash or casualty rate data
There is also a general calculation method to determine whether the total number of crashes or casualties in a road network will be altered by traffic measures. Average rates are calculated for each road type (core data). Changes in the distribution of the road length among the different road types and/or the traffic among the different road types result in different numbers of crashes and casualties. Immers et al. (2001); Dijkstra & Hummel (2004); and Janssen (2005) discuss applications of this method - see also SWOV Factsheet *Measuring (un)safety of roads*.
Furthermore it is possible to calculate crash rates by means of quantitative calculation models, given the physical characteristics of the road and the amount of passing traffic. These accident prediction models are still being developed (Reurings et al., 2006).

Conclusion
At the regional level there is a trend to no longer concentrate traffic on motorways, but to divert some of it to secondary roads. Because the secondary road network is not as safe as the main road network, this strategy will inevitably lead to more crashes and casualties if no additional measures are taken. SWOV has a number of methods available to examine at the network level which measures are necessary to prevent this road safety decline.

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Recommendations
The Network Management method is used by the Dutch Ministry of Transport to redistribute traffic differently across the road network. SWOV recommends supplementing the method with the possibilities as described in this fact sheet which can show the road safety consequences. We recommend getting an independent road safety auditor to test the road safety aspects of a Network Management project.

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(SWOV reports in Dutch have an English summary)

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