SWOV Fact sheet

Functionality and homogeneity

Summary
Functionality and homogeneity are two of the five Sustainable Safety principles. The functionality principle aims for roads to have but one exclusive function and distinguishes between traffic function (flow) and access function (residence). The homogeneity principle aims at differences in mass, speed and direction of vehicles using the same traffic space being as small as possible. Functionality and homogeneity are at the basis of the categorization of roads into through roads, distributor roads and access roads. All road authorities in the Netherlands have now categorized the Dutch road network 'on paper' and have begun to actively reorganize the roads according to the functional and operational requirements. The progress made, however, is not entirely clear. On the other hand, it is clear that it is not always possible to meet the requirements for all roads without very far-reaching adaptations. Furthermore, there are roads that are not easily given a sustainably safe layout due to mainly lack of space and by a mixture of traffic functions: the so-called 'grey roads'. The Dutch Information and Technology Platform for Infrastructure, Traffic, Transport and Public Space CROW has formed two working groups to find solutions for these types of problems. A possible solution may be an adapted categorization method that explicitly takes account of conflict types and the safe speeds related to them. This categorization method therefore does not only look at the functionality of roads, but, more so than was the case previously, takes the homogeneity principle into account.

Background and content
The Sustainable Safety vision takes 'man as a measure of all things' as a starting point and its purpose is to prevent (serious) crashes and, when this is not possible, to limit the consequences of crashes (reduction of injury severity). Sustainable Safety was initially based on the principles functionality, homogeneity and recognizability (Koornstra et al., 1992). In 2005, the principles (social) forgivingness and state awareness were added (Wegman & Aarts, 2005; see also the SWOV Fact sheets: *Background of the five Sustainable Safety principles*; *Sustainable Safety: principles, misconceptions, and relations with other visions*; *Recognizable road design*; *Social forgivingness* and *State awareness, risk awareness and calibration*).

The present fact sheet will go into the principles functionality and homogeneity. First, these concepts and their origin will be discussed. Next, we will briefly go into the functional and operational requirements, some difficulties with their application in practice (‘grey roads’) and possible solutions.

What does Sustainable Safety mean by functionality and homogeneity?
The *functionality* principle aims at a clear division of roads into categories on the basis of their traffic function. Sustainable Safety distinguishes three road categories: 1) through roads to enable traffic to travel between origin and destination as fast and as safely as possible (traffic has the highest priority); 2) access roads that provide (direct) access to the buildings at the locations of origin and destination where residing is most important (traffic is a guest here) and 3) distributor roads that connect through roads and access roads (flow at road sections and exchange at intersections).
The *homogeneity* principle aims at the smallest possible differences in mass, speed and/or direction between road users, so that sustaining serious injury in crashes is (almost) impossible. Homogeneity results in a smooth traffic flow on road sections and reduced speeds at intersections. In practice this involves: adaptation of the road environment to minimize the speed differences between road users and, where this cannot be done, taking measures to separate different types of road user, either physically or timewise.

What is the background of the functionality principle?
The concept functionality was first introduced in Buchanan's report *Traffic in Towns* (1963). Based on the two functionalities of roads, flow and providing access, Buchanan proposed a road network hierarchy consisting of four road types: primary, regional and local distributor roads and access roads. The Buchanan report was the basis for the Dutch woonerf and has also been the inspiration for further investigation of the relation between flow (traffic function is dominant) and access (residence function)

(Goudappel & Perlot, 1965). The results of the Goudappel & Perlot study indicate a rather complex hierarchy consisting of eight different road types, from motorway to woonerf. Based on the work by Buchanan and Goudappel & Perlot, Janssen (1974) formulated four functional requirements for the categorization of roads:

1. consistency of characteristics within a road category;
2. continuity of characteristics within a road category;
3. little variety in characteristics within a road category;
4. recognizable road categories for road users.

Functionality is also an important principle in the Sustainable Safety vision. The main distinction that is made in Sustainable Safety is that between a residential function and a traffic function. The residential function includes a living space (e.g. premises, pavements) where the priority is residing (e.g. inhabitants, personnel). The flow function requires traffic space, a public area with traffic as a priority. As roads always have some kind of traffic function, two extremes are distinguished: facilitating the traffic flow at high speeds on the one hand, and providing access to premises on the other. The first extreme is called a *flow function*, in which motorized traffic travels fast, efficiently and safely. This high speed traffic drives on the carriageway in the same direction, at (approximately) the same speed, and has (approximately) the same mass. Exchange takes place by converging and diverging and the road layout does not allow longitudinal or lateral conflicts. The other extreme provides an *access function* which allows all types of vehicles to use the carriageway in both directions at low speeds, vehicles can travel in longitudinal and transverse direction (intersections/crossings) and there is interaction with slow traffic (pedestrians and cyclists). The road layout is such that road users can expect discontinuities (e.g. traffic humps) and that there is not really a continuous traffic flow.

The large difference makes it necessary that each traffic function has its own road category. This results in a strong distinction between roads with an obvious flow function and roads with an obvious access function. These extremes are connected by distributor roads which have an important flow function in addition to this connecting function. The access function is concentrated on the lowest order roads and is used as little as possible for distributor roads. This tripartite makes the Sustainable Safety road categorization much simpler than that by Goudappel & Perlot (1965; *Figure 1*).

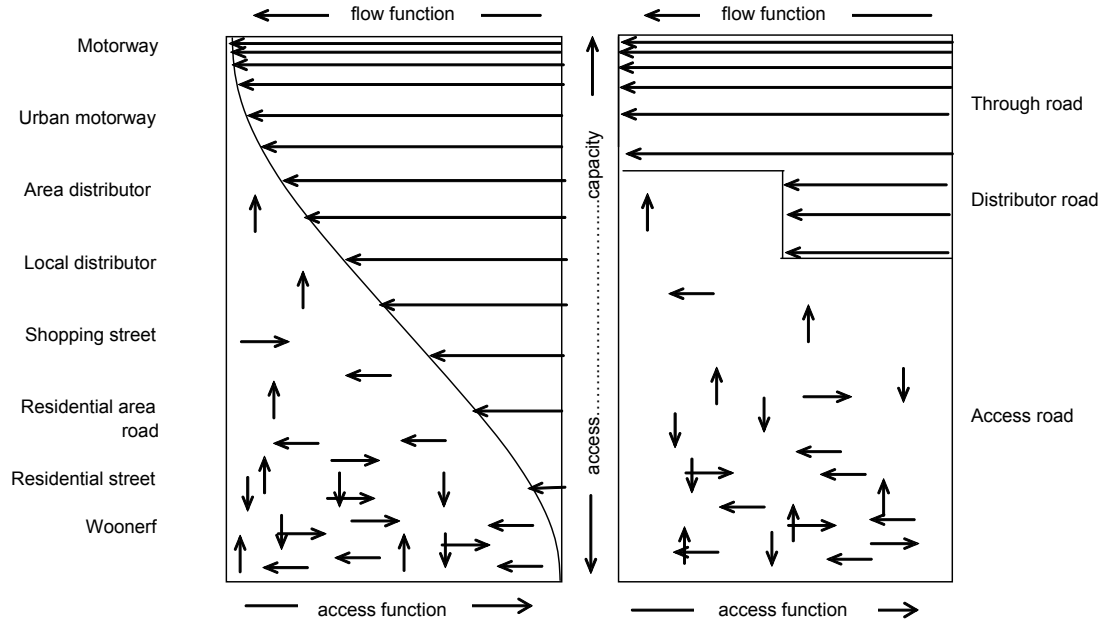

Figure 1. *Categorization of roads and streets by access and flow function: on the left according to Goudappel & Perlot (1965) and according to Sustainable Safety on the right.*

What is the background of the homogeneity principle?

The pursuit of homogeneous traffic flows is prompted by the fact that the human is physically vulnerable. Injury in crashes is due to this vulnerability, in other words to the biomechanical properties of the human, and of the combination of released kinetic energy and the vehicle's physical properties. These latter two factors are determined by differences in speed, mass and direction of the road users,

in brief the degree of homogeneity. The more homogeneous the traffic, the lower the risk of (severe) injury.

According to the homogeneity principle, it is necessary to apply measures to minimize the speed in situations with large differences in driving speed and direction. If there are also large differences in mass measures must be taken to separate the different road users, e.g. separate fast motorized traffic from bicycles and light mopeds. At those locations where road users with large mass differences still use the same traffic environment, speeds must be as low as possible. These are all possible ways to reduce the number of conflicts with serious or fatal consequences. Given the possible conflicts in different situations, Wegman & Aarts (2005), following the Swedish 'Vision Zero', have proposed safe speeds for different road situations (*Table 1*).

Road situation by road user	Safe speed (km/h)
Roads with conflicts between cars and slow traffic	30
Intersections with lateral conflicts between cars	50
Roads with possible frontal conflicts between cars	70
Roads without frontal or lateral conflicts	≥ 100

Table 1. *Safe speeds dependent on road situation and conflict types*.

How have functionality and homogeneity been worked out in guidelines?
In the late 1990s, the three original Sustainable Safety principles, functionality, homogeneity and also recognizability, were translated into twelve so-called 'functional requirements' (Janssen, 1997). These requirements were later incorporated in the manual published by the Dutch Information and Technology Platform for Infrastructure, Traffic, Transport and Public space CROW (CROW, 1997). The twelve requirements for a sustainably safe categorization and layout of the road network are:

1. residential areas must be adjoining and as large as possible;
2. a minimal part of the journey is travelled on relatively unsafe roads;
3. journeys must be as short as possible;
4. shortest and safest route must be the same;
5. searching behaviour must be avoided;
6. road categories must be recognizable;
7. the number of traffic solutions must be limited and uniform;
8. conflicts with oncoming traffic must be prevented;
9. conflicts with intersecting and crossing traffic must be prevented;
10. different road user types must be separated;
11. speed must be reduced at potential conflict locations; and
12. obstacles alongside the carriageway must be avoided.

Requirements 1 - 4 relate to the road network, 5 - 7 are requirements in relation with routes. Requirements 6 - 12 apply to road sections, 5 - 12 also apply to intersections, and 6 and 7 also apply to transitions between road categories. The twelve functional requirements have been used in the step-by-step plan categorization (CROW, 1997). They determine the ultimate 'ideal' concerning the *functions* of roads in a road network. This ideal has been laid down in a categorization plan. In addition to the functional road safety requirements, this plan also takes account of matters like accessibility, liveability and environment.

For the actual *layout* a number of operational requirements for roads and intersections have been formulated (CROW, 1997); the functional categorization of roads, the functional requirements, and the possible conflicts have been taken into account. This makes these operational requirements a translation of the categorization plan and they are responsible for the difference between the three road types: flow, distributor and access roads.

How are functionality and homogeneity put into practice?
The Sustainable Safety principles functionality and homogeneity have for the first time been explicitly used in the Start-up Programme Sustainable Safety. The Start-up Programme mainly addressed road categorization, the layout of 30 and 60 km/h areas, priority on through roads, mopeds in the carriageway, and priority for cyclists coming from the right. To assess existing layout in relation to the

desired Sustainable Safety layout, SWOV earlier developed the so-called Sustainable Safety Indicator as a tool for road authorities (Houwing, 2003).

Nearly all road authorities in the Netherlands have now made a categorization plan (Weijermars & Van Schagen, 2009) and this means that practically all roads in the Dutch road network have been categorized 'on paper' as access road, distributor road, or through road. This categorization mainly describes the ideal situation. This ideal is still being put into practice. In addition to zones 30 and 60, road authorities have been actively redesigning other roads to meet the functional and operational requirements as much as possible. It still is insufficiently clear how many roads have a layout in accordance with these requirements. Road authorities, however, have concluded that not all roads can meet the requirements without far-reaching adaptations. Although roads are put into one (mono)functional category, they often have more than one function, both flow and access. Furthermore, there are (mostly spatial) circumstances that stand in the way of fully meeting the functional and operational requirements. This is also referred to as the 'grey roads issue'.

How can functionality and homogeneity be implemented further?
The above-mentioned barriers for the application of functionality and homogeneity illustrate that some matters require further investigation. (Temporarily) addressing the 'grey roads issue' requires an adapted method for network structure and categorization, possibly with additional measures. In 2010, the Dutch Information and Technology Platform for Infrastructure, Traffic, Transport and Public Space CROW started two new working groups to find such solutions.

As early as in 2003, Dijkstra suggested the so-called cluster-based method as a starting point for adapted network structure and road categorization (Dijkstra, 2003). On a limited scale, this method has been used in for example a SafetyNet study (Arsénio et al., 2008). This led to a number of adaptations of the method: it was linked to the principles functionality and homogeneity (Dijkstra et al., 2007) and the new German guideline for network structure and layout of connections (RIN; Dijkstra, 2010). The result is a proposal to take the conflict types that can occur in a situation and the related safe speeds as a starting point (*Table 1*). Because conflict types are also considered, this categorization method not only takes account of the functionality of roads, but also of the homogeneity principle. *Table 2* contains several conflict types and safe speeds for urban distributor roads, in connection with a number of preconditions, or minimal layout requirements.

Traffic movement on distributor road	Conflicts with (on road section, crossing or intersection)	Safe speed (km/h)	Precondition
Motorized longitudinal	Cyclist same direction	30	Mixed/separated by road marking
Motorized longitudinal	Cyclist lateral		
Motorized longitudinal	Pedestrian lateral		
Cyclist longitudinal	Motorized lateral		
Motorized longitudinal	Motorized oncoming		Using the same lane/carriageway (not enough room for centre line marking)
Motorized longitudinal	Motorized lateral	50	
Motorized longitudinal	Cyclist/pedestrian same direction		Physically separated
Motorized longitudinal	Motorized oncoming		Separated by road marking
Motorized longitudinal	Motorized oncoming	70	Physically separated
Motorized longitudinal	Motorized same direction		

Table 2. *Safe speeds for motorized vehicles by conflict type on urban distributor roads (source: Dijkstra et al., 2007).*

Conclusion
Functionality and homogeneity are two of the five Sustainable Safety principles. The functionality principle aims for roads with one function only and distinguishes between roads with a traffic function

(flow) and roads with an access function (residential). The homogeneity principle aims for the smallest possible differences in mass and speed between vehicles that use the same traffic space.

Functionality and homogeneity are at the basis of road categorization according to Sustainable Safety. This categorization distinguishes between through roads, distributor roads and access roads. In the late 1990s, road authorities started making categorization plans in the Start-up Programme Sustainable Safety. At present, the Dutch road network has been categorized 'on paper'. However, it is not yet precisely known how many roads have a layout in accordance with their category's functional and operational requirements. On the other hand, it is clear that the Sustainable Safety requirements cannot be met for all roads without (often too) far-reaching adaptations. Furthermore, there are roads that cannot easily be given a sustainably safe layout, mainly due to lack of space and a combination of functions: the so-called 'grey roads'. Dutch Information and Technology Platform for Infrastructure, Traffic, Transport and Public Space CROW started two working groups to find solutions to these types of problems and to investigate whether the present categorization method needs to be supplemented or adapted. One possibility is a new method, proposed by Dijkstra (2010), which explicitly takes account of conflict types and the safe speeds that go with them. Therefore, this categorization method does not only take the functionality principle into account, but even more so than before, with the homogeneity principle.

Publications and sources

Arsénio, E., Cardoso, J., Lima Azevedo, C., Chaziris, A., Papadimitriou, E., Yannis, G., Gitelman, V., Duivenvoorden, K., Schermers, G. & Weijermars, W. (2008). *Safety performance indicators for roads : pilots in the Netherlands, Greece, Israel and Portugal*. Deliverable D3.10c of the EU FP6 project SafetyNet. European Commission, Brussels.

Buchanan, C. (1963). *Traffic in towns; A study of the long term problems of traffic in urban areas*. Her Majesty's Stationery Office, Londen.

CROW (1997). *Handboek categorisering wegen op Duurzaam Veilige basis – Deel 1 (voorlopige) Functionele en operationele eisen*. Publicatie 116, CROW, Ede

Dijkstra, A. (2003). *Kwaliteitsaspecten van duurzaam-veilige weginfrastructuur; Voorstel voor een stelsel van DV-eisen waarin alle DV-principes zijn opgenomen*. R-2003-10. SWOV, Leidschendam

Dijkstra, A., Eenink, R. & Wegman, F. (2007). *Met een veilige snelheid over wegen; SWOV-visie op 'de grijze weg'*. In: Verkeerskunde, vol. 58, nr. 7, p. 48-52.

Dijkstra, A. (2010). *Welke aanknopingspunten bieden netwerkopbouw en wegcategorisering om de verkeersveiligheid te vergroten? Eisen aan een duurzaam veilig wegennet*. R-2010-3. SWOV, Leidschendam.

Goudappel, H.M. & Perlot, J.A. (1965). *Verkeer en stad; Problematiek en ordening van het verkeer in middelgrote en kleine gemeenten*. Stedebouwkundige studies 4, VUGA Boekerij, Delft.

Houwing, S. (2003). *Praktijktest van de DV-meter; Gebruiksvriendelijkheid van een computerprogramma voor de analyse van DV-karakteristieken van een wegennet*. D-2003-7. SWOV, Leidschendam.

Janssen, S.T.M.C. (1974). *Verkeersveiligheid als criterium voor wegontwerp*. In: Wegontwerp en wegverlichting tegen de achtergrond van de verkeersveiligheid; Pre-adviezen congresdag 1974, 6 december 1974, Utrecht.

Janssen, S.T.M.C. (1997). *Functionele eisen voor de categorisering van wegen; eerste stap naar een handleiding voor duurzaam-veilige wegcategorieën*. R-97-34. SWOV, Leidschendam.

Koornstra, M.J., Mathijssen, M.P.M., Mulder, J.A.G., Roszbach, R. & Wegman, F.C.M. (1992). *Naar een duurzaam veilig wegverkeer; Nationale verkeersveiligheidsverkenning voor de jaren 1990/2010*. SWOV, Leidschendam.

Wegman, F. & Aarts, L. (2006). *Advancing Sustainable Safety; National Road Safety Outlook for 2005-2020*. SWOV, Leidschendam.

Wejermars, W.A.M. & Schagen, I.N.L.G. van (2009). *Tien jaar Duurzaam Veilig; Verkeersveiligheidsbalans 1998-2007*