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Assessing the safety of routes in a regional network

Atze Dijkstra *

SWOV Institute for Road Safety Research, Leidschendam, The Netherlands

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ABSTRACT

In the Netherlands, the concept 'Sustainable Safety' is the leading vision in road safety policy and research. The main goal of a sustainably safe road transport system is to reduce the annual number of road crash casualties to a fraction of the current levels. An important requirement that follows from this vision is that the quickest route and the safest route should coincide. This paper focuses on the design of a method which enables the planner to establish the safety effects of existing route choice, and also those of changes in route choice. The traffic safety assessment is carried out by quantifying the safety level of a route on the basis of those characteristics of the route that are assumed to be related to safety. This paper examines the quantitative relationship between the assessment of the route's safety level and the conflicts (at junctions) involving vehicles travelling along that route. These conflicts are detected in a micro-simulation model. Different routes in a regional network which were travelled by the modeled vehicles were used for the analysis.

This method of quantifying the safety level of routes will make it possible to evaluate road network structures from a safety perspective. It is expected that by optimising the design of the network and by influencing route choice a (more) sustainably safe traffic system can be achieved.

1. Introduction

In the Netherlands, the concept 'Sustainable Safety' (Koornstra et al., 1992; Wegman and Aarts, 2006) is the leading vision in road safety policy and research. The main goal of a sustainably safe road transport system is that only a fraction of the current annual number of road crash casualties will remain. It is of great importance for a sustainably safe traffic system that, for each of the different road categories, road users know which behaviour is required of them and what they may expect from other road users. Their expectations should be supported by optimising the recognisability of the road categories.

The main principles concerning the road infrastructure in a sustainably safe traffic system are functionality, homogeneity, recognisability/predictability, and forgivingness.

The functionality of the traffic system is important to ensure that the roads are used in accordance with the intended use. This principle has resulted in a road network with only three categories: Through Roads, Distributor Roads, and Access Roads. Each road or street may have only one function; a Distributor Road, for example, may not have any direct dwelling access.

The homogeneity principle is intended to avoid large differences in speed, direction, and mass by separating traffic types and, if that is not possible or desirable, by making motorised traffic drive slowly. According to the recognisability principle, the design of the road and its environment should enhance the predictability of any traffic situation that may occur. If crashes are unavoidable, the severity of the consequences should be minimised by specific facilities on or near the road; this is the forgivingness principle.

* Address: P.O. Box 1090, 2260 BB Leidschendam, The Netherlands. Tel.: +31 70 3173388; fax: +31 70 3201261.
E-mail address: atze.dijkstra@swov.nl

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Sets of requirements have been specified for each principle. For the present paper the following requirements are relevant: journeys should follow safe roads as much as possible, journeys should be as short as possible, and the quickest and safest route should coincide (CROW, 1997).

Many studies have focused on the Sustainable Safety requirements; Wegman and Aarts (2006) give an extensive overview of these studies. However, very little attention has been paid to the consequences of the functional requirements, particularly the route choice issues (Hummel, 2001). Therefore, Dijkstra (2011) focused on the road safety effects of route choice and route management measures. This paper presents a method to find these safety effects.

Throughout the paper 'DV' will be used as an abbreviation of Sustainable Safety.

2. Route choice and road safety

An important functional requirement in a sustainably safe road network is that the chosen road type is in accordance with the desired functional division of traffic over the road network. Sustainable Safety also requires residential areas to be 'as large as possible'. This requirement influences the mesh width of the Distributor Roads (van Minnen, 1999; Krabbenbos et al., 2002). The connections between residential areas depend on the numbers of inhabitants as well as on the types and presence of facilities. The potential transportation demand determines the necessity and capacity of the connections. The resulting roads and intersections are normative for the composition of a sustainably safe road network (Dijkstra, 2011).

The consequence of requiring the safest and quickest route to coincide is that cars will be led through residential areas as these areas comprise very safe streets. This can be prevented by an additional requirement stating that a route should only follow Access Roads at its beginning and end, and that the rest, the vast majority of the route, should be along Through-Roads. In order to achieve such a route choice, the journey time of a route going through residential areas must be longer than that of a route that follows Through-Roads. In addition, the route choice can be influenced by in-vehicle guidance or indications alongside the road, and possibly also by the layout of the road and its environment.

Sustainable Safety wants to incorporate road safety in transportation planning. In the planning phase it should be determined whether the network will function according to the specified network requirements, especially those regarding safety. It is difficult to review the consequences of a traffic plan[1] because of the large amount of data that plays a role in such plans. That is why planners often use traffic models and simulation models. The classic traffic models assign the total traffic volume to the road sections of the different networks. In micro-simulation models, however, it is possible to allow separate vehicles to follow a route through a network. The route choice of each simulated vehicle depends on a number of previously established preconditions and on various variables that are a function of in-vehicle equipment, facilities along the road, the driver's motive, time of day, and interaction with the rest of the traffic. In this way it is possible to determine in advance how the route choice will change when in-vehicle information is provided or when road facilities are planned. AVV (2002) gives a general overview of the features and possibilities for the use of simulation models.

Modelling route choice will provide answers to the planning issues of Sustainable Safety; the safety effects of Sustainable Safety, however, are a separate issue to be dealt with.

2.1. Objectives and structure of the paper

This paper focuses on the evaluation of a method which enables the planner to determine the safety effects of existing route choice, and also, changes in route choice. For an evaluation of the differences regarding the safety level of each route, safety indicators are required. Fig. 1 shows how the safety indicators are related to the road network and the routes in the network. Safety indicators are widely used for various purposes, a short review of different types of safety indicators is given in Section 3. An important indicator is a so-called conflict (see definition in Section 3). These conflicts can be detected in a micro-simulation model (Section 4). These conflicts appear to be related to crashes (Section 5). Additionally, an indicator was introduced that expresses the characteristics of a route, and, moreover, the relationship of these characteristics with safety (Section 6). Section 7 describes the kind of relationships between this indicator and the conflicts calculated by the simulation model. Section 8 shows how these relationships are validated. Section 9 will give conclusions and recommendations.

3. Modelling road safety – road safety in a traffic model

Many traffic policy measures are aimed at changing traffic behaviour, which in its turn, will affect road safety. Traffic behaviour on the level of road sections and junctions can generally be described by the number of vehicles, the travelling speeds, the headways, etc.

Road safety, however, can be described in various ways. The distribution of crashes over a road network largely depends on the distribution of traffic over that network; the more traffic there is, the more crashes there will be. Crash density and crash rate are common indicators to express the mutual relation (Janssen, 1994, 2005). Crash Prediction Models are another

[1] A traffic plan generally deals with all phases of the traffic and transportation planning process, from travel pattern analyses to the design of the transportation network (elements).