A FRAMEWORK FOR COST-BENEFIT ANALYSIS OF THE DUTCH ROAD SAFETY PLAN

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Foreword

This report presents a framework for cost-benefit analysis of the Dutch road safety plan. It was commissioned by the SWOV as part of its project on developing the next stage of the Dutch road safety plan. The main parts of the report were written during the author's stay as a visiting researcher at SWOV in December 1995.

The author wishes to thank Mr Fred Wegman of SWOV for inviting him to be visiting researcher. The assistance of Jan Mulder, Bob Roszbach and the staff of the SWOV library in retrieving the information presented in this report is gratefully acknowledged. Neither of these people can be blamed for the shortcomings of the report.

It is hoped that the report will be of use for road safety planning in The Netherlands.

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Executive summary:

A framework for cost-benefit analysis of the dutch road safety plan

This report contains a framework for cost-benefit analysis of the Dutch Road Safety Plan. The framework consists of the following main elements: (1) A short discussion of the implications for road safety policy of the Dutch concept of sustainable safety, (2) A discussion of formal techniques for priority setting, the kinds of information required to use these techniques and their limitations, (3) A survey of potentially effective road safety measures and the screening of these measures for inclusion in formal analysis of cost-effectiveness and cost-benefit ratio, (4) A critical examination of current Dutch road accident costs and a preliminary revision of these costs, (5) A summary of evidence concerning the safety effects of road safety measures subjected to analyses of their cost-effectiveness and cost-benefit ratios and (6) Preliminary estimates of the cost-effectiveness and cost-benefit at ratio at different levels of applications of different measures and their benefit-cost.

It is argued that the main implications of the concept of sustainable safety for road safety policy are: (1) that road safety policy should be based on ambitious, long term policy targets aiming at a radical reduction in the number of injuries, to take account of the fact that future generations are likely to put an even higher value on safety than the current generation, (2) that it is important to use safety measures as efficiently as possible, to minimize the amount of resources consumed by road safety and (3) that there ought to be more room for experimenting with new measures, subject to the condition that the results of those experiments are always evaluated and the results of the evaluations made public.

The role of formal techniques for priority setting in road safety policy is discussed. A basic problem in applying these techniques is that they are applied to ready made lists of alternative measures, but do not account for how these lists are obtained in the first place. The criteria of cost-effectiveness and cost-benefit ratio are defined and their strengths and shortcomings discussed. Cost-benefit ratio is the more inclusive of the formal criteria for priority setting, but does not include policy objectives referring to the fairness of distribution.

A set of safety measures proposed for The Netherlands is defined and the measures are screened for possible inclusion in a formal assessment of their costs and benefits by applying three criteria. The criteria refer to: (1)

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whether the measure has a documented safety effect or can reasonably be presumed to affect a known risk factor contributing to accidents, (2) whether the measure has already been applied to a large extent or can still reduce the number of accidents it affects and (3) whether an implementation performance function for the measure can be identified, to make it possible to introduce the measure according to the principle of declining marginal returns.

A critical examination of current Dutch road accident costs is performed. The costs are broken down on a per accident and per injury basis. The cost elements included are assessed on the basis of recent EU-recommendations for the estimation of road accident costs. It is concluded that current Dutch road accident costs do not include an economic valuation of lost quality of life. This cost element is likely to be the largest one. Highly preliminary comprehensive accident costs, including an economic valuation of lost quality of life, are prepared. These costs are more twice as high as the current cost rates. Guidelines for testing the validity of these cost estimates are proposed.

A summary of evidence concerning the safety effect of the 21 measures included in the formal analyses is presented. The amount and quality of evidence varies between measures, contributing to varying levels of uncertainty about the safety effects of the measures. For some measures, estimates of expected safety effects are available from meta-analyses of the results of evaluation studies. For others, estimates of expected safety effects are based on informal literature surveys. For new measures, that is measures for which there is no previous experience, only theoretical estimates of safety effects can be made. The main points of the procedures that can be used to derive theoretical estimates of safety effects are outlined.

Safety measures are ranked according to two criteria of effectiveness: (1) Cost-effectiveness, (2) Cost-benefit ratio. The rankings resulting from these criteria are compared.

1 INTRODUCTION

This report is a contribution to the Dutch Road Safety Plan and to the ongoing discussion in The Netherlands of the concept of sustainable safety. The main purpose of the report is to define a framework for cost-benefit analysis of road safety measures that are part of the Dutch Road Safety Plan and possible new road safety measures in The Netherlands. The report discusses the following main topics:

1 What are the salient aspects of the Dutch concept of sustainable safety and what are the implications of this concept for road safety targets and safety policy?

2 To what extent can formal techniques of priority setting be applied to road safety policy? What is, and what is not, included in a cost-benefit analysis?

3 How can potentially effective road safety measures be identified? What are the criteria for screening proposed safety measures with respect to potential effectiveness?

4 What is the recommended method for estimating road accident costs and what are the implications of adopting this method for the level of road accident costs in The Netherlands?

5 What are the expected safety effects of the measures that are part of the Dutch Road Safety Plan and other possible safety measures that can be introduced in The Netherlands? How reliable is available evidence of safety effects?

6 Which are the most cost-effective safety measures in The Netherlands? Which are the measures that have the highest cost-benefit ratios?

The report consists of eight chapters. Chapter 2 presents some reflections on the Dutch concept of sustainable safety and its implications for safety policy. In subsequent chapters the building blocks in the framework for cost-benefit analysis of the Dutch Road Safety Plan are put in place. Chapter 3 gives an overview of formal techniques for priority setting and discusses their role in policy making. It is pointed out that the formal techniques are applied to a ready made list of safety measures whose costs and effects are supposedly known; the policy maker is not told how to obtain this list in the first place. It is therefore important to make sure that the list of safety measures to which the formal techniques of cost-effectiveness and cost-benefit analysis are applied really contains the potentially most effective measures. Screening proposed safety measures for potential safety effectiveness is the subject of chapter 4. A three stage process of screening is conducted, resulting in a list of 25 safety measures for which a formal assessment of costs and benefits is made. Chapter 5 contains a critical examination of current Dutch road accident costs. It is concluded that current cost estimates are not appropriate for use in cost-benefit analysis and are likely to seriously understate the true benefits to society of improving road safety. Highly preliminary estimates of more comprehensive accident costs are proposed and guidelines are given for testing the validity of these estimates. Chapter 6 presents evidence of the safety effects of the 25

measures that are included in the cost-effectiveness and cost-benefit analysis. Available evidence is not of the same quality for all measures. For some measures, only hypothetical estimates of safety effects can be made. Chapter 7 first presents the cost rates that are used in cost-effectiveness and cost-benefit analysis. In subsequent sections preliminary cost-effectiveness analyses and cost-benefit analyses of the safety measures are presented. These analyses require further elaboration and discussion than what was possible within the time available for preparing this report. Chapter 8 is a summary of the report.

The report was written during my stay as visiting researcher at the SWOV Institute for Road Safety Research from December 4 to December 15 1995.

2 THE CONCEPT OF SUSTAINABLE SAFETY

The Dutch concept of sustainable road safety has been introduced as a basis for long term road safety policy making (Slop 1995). The essence of the concept, as explained by Slop, is to adapt the traffic system to man in every respect in order to avoid leaving to the next generation a transport system that it will regard as unacceptably unsafe.

In general, social changes can be regarded as sustainable if they do not diminish the opportunities of future generations to realize their conception of a good society (Brundtland et al 1987). A sustainable path of development is, in order words, one that can be continued without incurring future regrets and without necessitating drastic changes of policy sometime in the future. To be sustainable in this sense, public policy must adopt a long term perspective and rely on objectives and policy instruments that do not reduce the opportunities of future generations to choose the policy objectives and policy instruments they prefer.

It is obviously very demanding to implement a sustainable road safety policy. It involves not just choosing an ambitious target enjoying wide public support, but also implementing this target by means of policy instruments that are both effective and politically acceptable, while leaving future generations at least the same freedom of choice with respect to both targets and the means of realizing them as the present generation inherited. To explain more in detail why the task of creating a sustainable road safety policy is very difficult, a short look at the history of road safety policy may be instructive.

Let me start by asking if present road safety policy can be regarded as sustainable. In my opinion, the answer is «no», because the present level of road safety is not considered as acceptable. The present generation is, in other words, not satisfied with the level of road safety the preceding generation left it. If current road safety policy is continued, it seems likely that the next generation will pass the same judgement on this policy as the present generation passed on the policy pursued by the preceding generation: it did not give society an acceptable level of road safety.

It is perhaps too stringent to judge whether public policy in a certain area is sustainable or not in terms of the views prevailing at any time with respect to the solution of a social problem that policy is designed to solve. It seems likely that road accidents is a problem that will never be regarded as solved in an absolute sense. There will always be opportunities for further improvement; hence the test of sustainability ought to be whether a social problem is regarded as becoming less severe rather than worsening. But even by this criterion, current road safety policy is likely to fail the test of sustainability. We are not reducing the number of road accidents as fast and cheaply as our policy targets require us to do. If current policy is continued, the current safety targets set by

the Dutch government are unlikely to be realized (Dutch Ministry of Transport 1991). Moreover, safety targets themselves are likely to change over time. In most motorized countries, the number of accident fatalities reached an all time peak level around 1970-1973. In the subsequent years, the number of fatalities has been reduced to about half of the peak level in many countries. Such a decline in the number of fatalities was widely regarded as unattainable when the number of fatalities was at its peak level.

A related development has taken place with respect to the economic valuation of road accidents (Elvik 1995A). Official economic valuations of accident fatalities have been revised a number of times in the leading motorized countries. The revisions have generally consisted of raising the cost figures, particularly for fatalities. Recent revisions of official accident costs in several motorized countries (Great Britain, Sweden, Finland, New Zealand, Norway, the United States), involving a transition to willingness-to-pay based estimates of accident costs, lead to major upward revisions of previous cost figures. In many countries, official cost figures were more than doubled. This reflects a wish to assign higher priority to road safety in public policy making.

These changes are no doubt related to a steadily improving knowledge about effective safety measures. In the early nineteen sixties, the Norwegian Ministry of Justice argued that it was impossible to set quantified road safety targets, because effective measures to reduce the number of accidents were unknown. Such an argument cannot be used today. Effective safety measures are known. The major obstacles that prevent such measures from being applied to the maximum possible extent are that some of them are regarded as too expensive, while others are politically unacceptable (too unpopular).

Road safety is more demanded the richer a society is. This is not surprising; if safety is a normal good (in the economic sense of that term), the demand for it will increase as income increases. The fact that a wealthy society can afford to spend more on safety than a poorer society means that the willingness-to-pay for safety in a rich country like The Netherlands is likely to be quite high. Ambitious, long term quantified safety targets are likely to be widely supported. Such targets are a necessary, but not sufficient condition for implementing a sustainable development of road safety.

The real challenge in carrying out a policy aimed at a sustainable development of road safety is, in my opinion, not to choose an ambitious target, but to implement safety measures that will leave future generations the same freedom of choice with respect to targets and safety measures as the current generation enjoys. Safety measures tend to be introduced according to the line of least resistance. The cheapest, and perhaps most popular (or least unpopular), measures are introduced first. The most expensive, or most unpopular, measures are postponed. We are, in other words, leaving the harder choices to our successors. The more successful we are in implementing effective and politically acceptable safety measures, the more difficult becomes the task of future generations in finding effective and acceptable safety measures. In the short run it is of course difficult

to imagine that we would be able to deplete entirely the stock of effective and acceptable safety measures, leaving future generations with no choice for further improving safety other than drastically reducing mobility or resorting to other, at least currently unacceptable, means for improving safety. In the long run, however, the stock of currently known effective and acceptable safety measures is gradually being depleted.

On the other hand, new safety measures are being developed. Airbags are now becoming common in new cars. Information technology may offer new, as yet unknown, possibilities for improving road safety. A sustainable road safety policy, based on an ambitious long term quantified target, ought to include the experimental introduction of new safety measures as an essential ingredient. Public policy too seldom contains such an element of experimentation. It is usually rather conservative and based on well known measures. A more bold approach is likely to be called for in future road safety policy.

3 FORMAL TECHNIQUES FOR PRIORITY SETTING

The success or failure of road safety policy depends on a number of factors. The targets set for improving safety is an important factor. A recent OECD-report (OECD 1994), surveying the experience of OECD-member states in developing and implementing targeted road safety programmes, concludes that setting an ambitious long term quantified road safety target leads to more successful safety policies. A more detailed study of the experiences of Norwegian counties supports this conclusion: counties that set ambitious quantified road safety targets were more successful in bringing down accident rates than counties opting for less ambitious targets or purely qualitative targets (Elvik 1993A).

Ambitious targets can only be realized if effective safety measures are implemented. This in turn requires some method for assessing the effectiveness of safety measures in relation to their costs. The purpose of this chapter is to discuss formal techniques for assigning priority among road safety measures. Two related techniques will be discussed: cost-effectiveness and cost-benefit analysis. The limitations of these formal techniques, and the need for supplementing them with less formal means of policy analysis, will also be discussed.

3.1 The role of formal techniques for priority setting in a complete policy analysis

A complete policy analysis consists of a number of stages that can be distinguished logically. Deciding on the priorities to be set among alternative measures is just one stage in policy making. Figure 1 shows the stages of policy making that can be identified analytically (Elvik 1993B). The stages have been arranged in the order that appears to be logically the most natural one; no corresponding chronological order of the stages is implied. In fact, in actual policy making the various stages will not always be clearly identifiable at all. Figure 1 is, however, purely an analytical model and not meant as a literally correct description of policy making.

Logically speaking, the first stage of policy making is to determine constraints. By contraints is meant everything that is taken as given and beyond the influence of any acceptable policy instrument. In most cases, the decision with respect to constraints is taken implicitly. Policy makers concentrate on aspects they think can be influenced and disregard those that they think cannot be influenced. In most road safety programmes, traffic volume is taken as a constraint; no attempt is made to influence it. The Dutch Road Safety Plan is quite unique in having a target for the maximum amount of traffic growth for the period it covers. Another commonly accepted constraint is current budget levels. Current budgets constrain policy makers to proposing measures that can be financed without increasing total spending on safety. In general, it is fair to say that

formal models of policy making give no advice with respect to how policy makers can best determine the constraints that they ought to consider as binding.

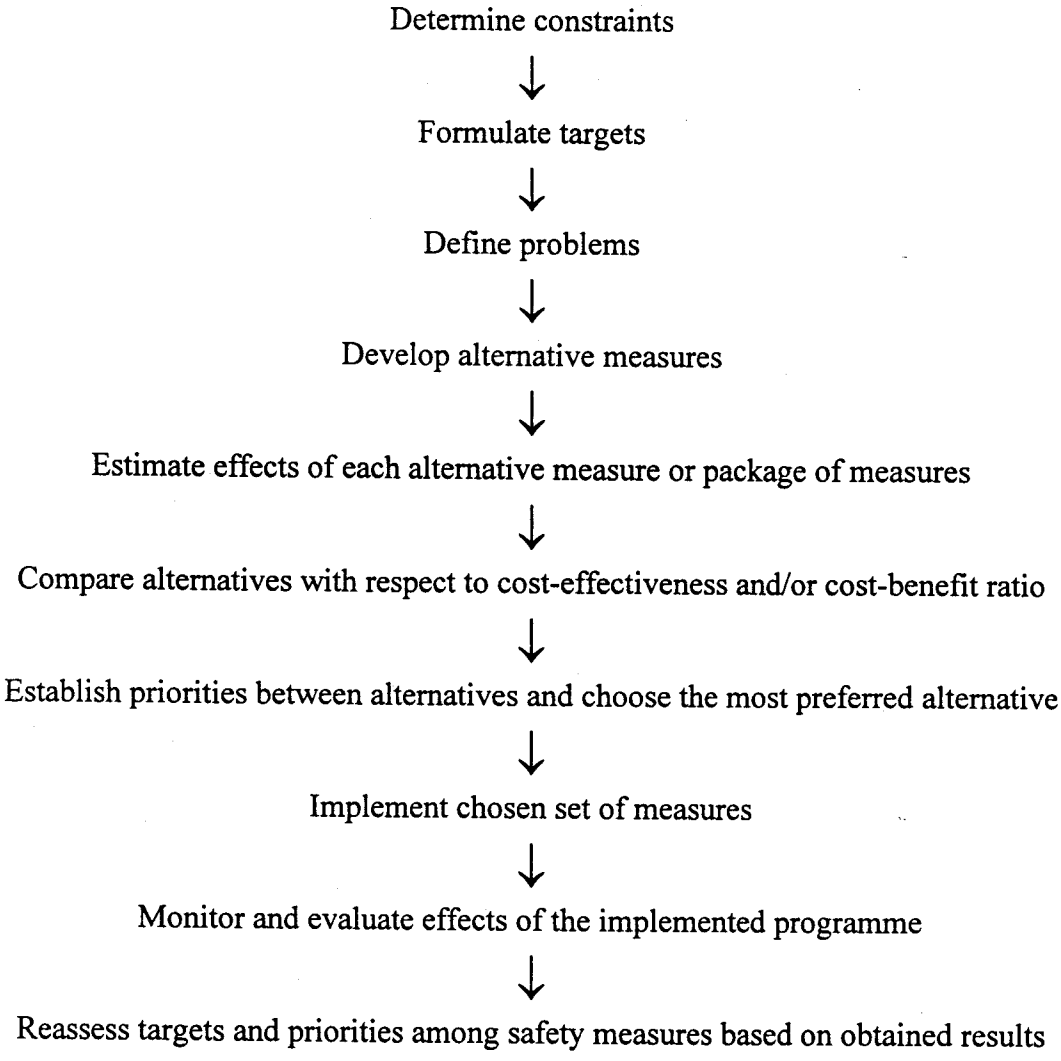

Figure 1: Logically distinct stages of policy making. Idealized model. Adapted from Elvik 1993B.

Determining constraints is a very important step in the policy making process. The subsequent steps of formulating targets, defining problems, developing alternative safety measures and estimating the effects of each measure determine the content of a targeted road safety programme. Yet, these important steps are hardly dealt with at all in formal models of policy making. Textbooks in cost-benefit analysis, for example, lay down principles for choosing between ready made alternative programmes with known effects (see, for example, Mishan 1988). The textbooks do not tell us how the alternatives are obtained.

There is little point in setting priorities strictly according to economic criteria of efficiency if the potentially most effective measures have been left out of the programme. It is therefore essential to supplement the formal techniques of priority setting by offering some guidance with respect to methods for identifying potentially effective safety measures, to make sure that all the really effective measures are included in the set of measures to which the formal techniques of priority setting are applied. Guidelines for screening proposed safety measures with respect to potential effectiveness are discussed in the next chapter of this report.

Before describing formal criteria for priority setting in more detail, I would like to stress the importance for successful policy making of the final stages of the model of policy making shown in figure 1. I refer to the stages of implementation, monitoring and evaluation, and reassessment of targets and safety priorities. Too many ambitious plans fail because they are incompletely implemented or not implemented at all. It is important to establish an information system to monitor in detail the implementation of safety programmes. Moreover, it is important to evaluate the effects of measures that are implemented. The effects predicted in safety programmes on the basis of evaluation studies are not always realized in practice (Björnskau 1991, Elvik 1995B). After a few years, a safety programme may have to be reassessed and targets may have to be adjusted.

3.2 Cost-effectiveness as a criterion for priority setting

The cost-effectiveness of a road safety measure can be defined as the number of accidents prevented per unit cost of implementing the measure:

$$\text{Cost-effectiveness} = \frac{\text{Number of prevented accidents of given severity in a given year}}{\text{Costs of implementing one unit of the measure in a given year}}$$

In order to estimate the cost-effectiveness of a road safety measure, the following information is needed:

1 An estimate of the effectiveness of the safety measure in terms of the number of accidents it can be expected to prevent per unit implemented of the measure

2 A definition of suitable «units» of implementation for the measure

3 An estimate of the costs of implementing one unit of the measure

4 A method for converting all costs of implementation to an annual basis

The effectiveness of a safety measure in terms of the number of accidents it prevents is generally a function of the number of accidents affected and the percentage effect of the measure on the accidents it affects:

Number of prevented accidents = Number of accidents affected x Percentage effect

The accidents that are affected by a safety measure will be referred to as target accidents. In order to estimate the number of accidents prevented per unit implemented of a safety measure, it is necessary (1) to identify target accidents (which may, in the case of general measures like speed limits, include all accidents), (2) estimate the number of target accidents expected to occur per year for a typical unit of implementation, (3) estimate the percentage effect of the safety measure on target accidents. This defines the numerator of the cost-effectiveness ratio of a safety measure.

To estimate the denominator, the first step is to define a suitable unit of implementation of the measure. In the case of infrastructure measures, the appropriate unit will often be one junction or one kilometre of road. In the case of area-wide or more general measures, a suitable unit may be a typical area or a certain category of roads. In the case of vehicle safety measures, one vehicle will often be a suitable unit of implementation, or, in the case of legislation introducing a certain safety measure on vehicles, the percentage of vehicles equipped with this safety feature or complying with the requirement. As far as education and training is concerned, the number of trained pupils according to a certain training scheme may be a useful unit of implementation. The unit cost will be the cost of training one pupil. It is difficult to define a meaningful unit of implementation for public information. It seems reasonable, however, to rely on the assumption that the effects of public information depend on the total volume of information. In that case, there is no need for counting units of implementation; effects are related directly to the total costs, rather than the unit costs. For police enforcement, the number of man-hours of enforcement activity per kilometre of road per year may be a suitable unit of implementation. The amount of automatic enforcement, for example by means of speed cameras, can be defined in terms of the number of hours of camera operation per site and the number of sites where speed cameras are used.

Once a suitable unit of implementation is defined, unit costs can be estimated. In order to make the cost-effectiveness ratios of different safety measures comparable, it is necessary to relate both the number of prevented accidents and the costs of implementing the measure to a certain time reference. This need arises because the relationship between costs and the duration of effects varies a lot between safety measures. Infrastructure investments, like converting junctions to roundabouts or installing road lighting, improves safety throughout their service life, which may be 25-40 years. Information campaigns or police enforcement, on the other hand, gives only short term safety effects. Measures introduced by means of highway signs or road markings may have a service life of some 5-15 years, depending on, for example traffic