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FRAMEWORK FOR ASSESSING THE IMPACTS OF SPEED

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ABSTRACT

The MASTER framework for assessing the impact of speed described in this paper considers the effects of speed on accidents and accident costs, time and vehicle operating costs, as well as environmental effects. The framework can be applied to the assessment of direct (link level) and indirect (network level) impacts. The assessment of impacts takes place on three levels: a) monetary impacts, b) other quantitative impacts, and c) qualitative impacts. Distributional impacts are described by indicating population or road user groups that are affected differently by the various effects. Special attention has been paid to the ease of application, transparency of the calculations and clear presentation of the results. The framework allows the user to select the impact functions (e.g. how accidents or exhaust emissions depend on speed) and unit values of monetary effects. This enables the use of the latest research results and the consideration of national or local preferences. The use of the MASTER framework is illustrated with a case from Finland.

1 INTRODUCTION

This paper pertains to the question, *what are acceptable ranges of speed of road traffic* and presents a framework that can be used in answering that question. The points of departure for the development of the assessment framework were that it should be

- applicable from the level of individual links to whole road networks;
- interpretable in monetary terms as far as practically possible without forgetting impacts that are difficult to express monetarily;
- transparent in the sense that the bases of all the calculations are made explicit;
- easy to modify when new information of the impacts of speed or evaluation of effects becomes available and

- flexible enough to allow regional and cultural differences in the weighing of different effects of speed

The general background, development and structure of the assessment framework have been described in more detail in the two MASTER reports (*Kallberg & Toivanen 1997, 1998*).

2 SOCIO-ECONOMIC FEASIBILITY

The framework aims at providing means for decision-makers to establish the *socio-economic feasibility* of a given speed management policy. The two central facets involved are the *magnitude* and the *distribution* of the impacts. Information on these is necessary in determining:

- *Efficiency*—efficient use of society's scarce resources, i.e. minimisation of costs when outputs (objectives) are given or maximisation of output (achievement of objectives) with a given budget.
- *Equity*—factors as distribution of income, costs and benefits, equal growth possibilities among regions or citizen groups, and minimum level of service offered to all groups or regions.

The socio-economic viewpoint implies that all relevant impacts—positive and negative—are included regardless of to whom they accrue. Thus for example fiscal fuel taxes are netted out of the calculations, as they are a cost for consumers but a benefit for government.

The difference between *private costs* and *social costs* is important. The assessment of the socio-economic feasibility of a policy is based on the costs experienced by society. This is *not* equal to the sum of the costs incurred by individuals, because not all costs are perceived by individuals. In the context of the costs (and benefits) associated with the speed of travel, even if we assume that each driver chooses his/her speed rationally,

> "there is no reason why the factors that lead drivers to choose particular speeds should result in levels of speed that are preferable from the point of view of society as a whole, because some important gains and losses to society resulting from vehicles being driven at different speeds are not experienced individually by their drivers." (*Allsop 1990*)

Hence, it is important to distinguish between *privately optimal speed* and *socially optimal speed,* which correspond to the speed with the least private and social costs, respectively. It is acknowledged that using money as the common unit of the impacts is a controversial issue. Some of the principles at stake are briefly reviewed in section 4.

3 IMPACTS OF SPEED

Figure 1 summarises the direct and indirect impacts of the speed of traffic. In the following, the causal links (a) to (m) are briefly discussed. Those from (a) to (k) are relevant in all cases, whereas those from (l) to (m) are considered only at the level of transport networks.

3.1 Vehicle operating costs

Speed directly affects fuel consumption, but it may also indirectly affect mileage, see point (k) below. There is no major difference between private and social vehicle operating costs, although a motorist driving more slowly than others may inadvertently increase the fuel costs of other drivers.

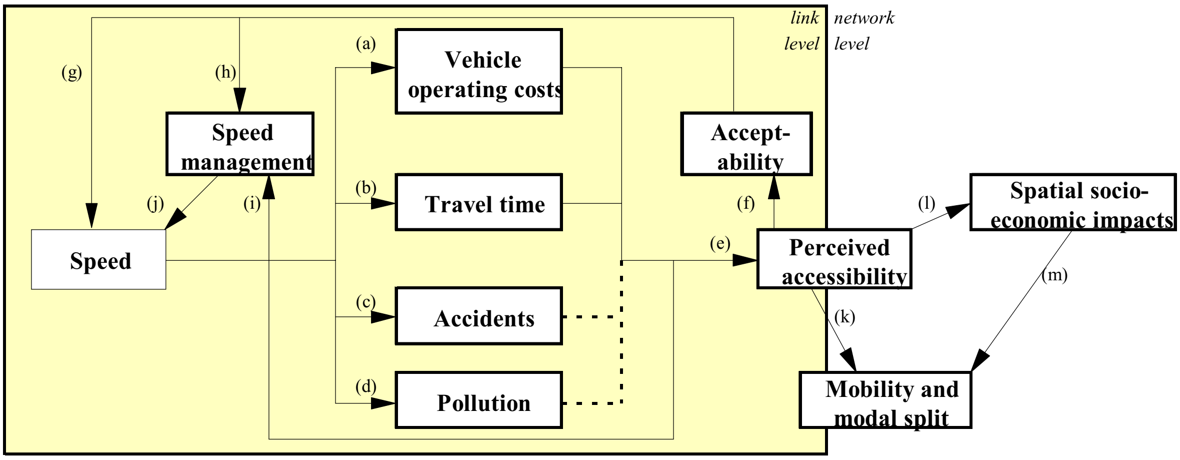

Figure 1. A summary of the direct and indirect impacts of the speed of traffic. See text.

3.2 Travel time

(b) As travel time equals distance/speed, mean speed has a direct effect on travel time. However, especially in urban conditions a considerable part of the travel time may be spent not moving at all or moving at very low speeds because of traffic lights and/or congestion. Not considering this has resulted in overestimating the time penalties of lower speeds (*Plowden and Hillman 1996*).

Private and social time losses do differ to the extent that drivers cause time losses to other people without considering them in making their speed decisions,

3.3 Accidents and accident costs

(c) The fact that increasing driving speed inevitably leads to decreased safety has been confirmed by numerous studies. Generally, an increase of 1 km/h in the mean speed of traffic is expected to increase the number of injury accidents by approximately 3%, and the effect on serious and fatal injury accidents is even greater, up to 5% or 6% (*Elvik et al. 1989, Andersson et al. 1991, Andersson & Nilsson 1997, Finch et al. 1994, ETSC 1995, Ranta & Kallberg 1996*). Thus speed affects both (i) the frequency and (ii) the severity of accidents.

3.4 Pollution

(d) Speed has a considerable effect on pollution, including noise. The relationship between speed and emission is typically a U-shaped or monotonously ascending (for the oxides of nitrogen) curve. With regard to noise, the relationship is also monotonous with a lower speed always resulting in a lower noise level. Another MASTER report (*Robertson et al. 1998*) deals with the relationships of speed with pollution, noise and vibration in more detail.

3.5 Impacts on perceived accessibility

(e) When an individual decides on whether or not to make a certain journey, (s)he takes into account the benefits from making the journey as well as the corresponding costs, at least in terms of time and money. Accessibility here means *the inverse of the total disbenefit caused by reaching the destination*. The farther the destination and/or the more it costs to reach there, the less accessible it is to the individual. The attribute 'perceived' is added because not all of the costs are taken into account, as is discussed in section above. The consideration of vehicle operating costs and travel time is only subject to practical estimation uncertainties. The other effects only play a minor role in assessing the costs of travel decisions.

3.6 Impacts on and of acceptability

(f) A driver's subjective perception of the impacts of speed on the (dis)benefits of making the trip determines the acceptability of each possible speed and leads to the choice of the speed with the highest acceptability, i.e. the privately optimal speed (g). Another MASTER report addresses the question of acceptability of speeds and speed limits (*Risser & Lehner 1998*).

Asking road users and residents directly about speed management policies could be the best way to assess acceptability. Ideally, the interviewees should be provided with comprehensive information on the impacts of any proposed speed change, such as that produced by applying the MASTER framework. However, care should be taken not to cause an information overload.

(h) In a democratic society, the attitudes of the public affect the speed management policies adopted. There is no inherent guarantee that decisions will lead to increased net benefits to society. The extent to which this happens is dependent on the decision-maker's interest and ability to search for the common good in the midst of conflicting information, among which there should be objective information on the impacts of speed (i).

(j) Finally, speed management in the form of speed limits, their enforcement and other means mentioned in section 2.3 is one of the factors that determine the speeds of traffic.

3.7 Mobility and modal split

(k) Changes of perceived accessibility obviously have impacts on travel decisions: destinations and frequencies of trips may change or the trips may be made using a different mode of transport. This holds in principle from the level of an individual link to the network level.

3.8 Network-level impacts

(l) If the policy in question permanently changes locations' accessibilities in relation to each other, spatial socio-economic effects may occur in the long run: people and companies move to other locations. For example, greater speed of travel allows a household to relocate farther from its workplaces to areas where the household may be able to obtain a larger dwelling for costs similar to those prior to the move.

(m) The decision to move farther from the workplaces has a direct effect on the amount of kilometres travelled. In addition, in the new location, some other mode of transport may be more attractive than one used previously.

3.9 Other impacts

Figure 1 does not aim to be exhaustive. Changes in the overall mobility and modal split may naturally have multiplier effects on the impacts (a) to (d) in Figure 1. Importantly, from the speed-management viewpoint, these changes may affect the socially optimal average speed (i.e. that average speed of traffic that causes the least social costs).

Changes may occur in the volume and type of transport infrastructure needed because of alterations in the spatial pattern of activities, mobility and modal split. This can have various impacts on all four categories of direct impact (a to d) as well as on locational values—i.e. biological or historical assets—that may be threatened by infrastructure construction.

4 DRAWING THE IMPACTS TOGETHER

4.1 Aggregating quantitative impacts

Given that all the costs and benefits of a policy can be described and, where feasible, quantified in their own terms, the remaining task before making a decision is to weigh them against each other. In order to assess the minimisation of inputs and maximisation of outputs, they will both have to be *aggregated* using a common unit. Monetising is the most frequently used means of comparing things that have no common measure.

Many of these impacts do not have a market price, because there is no market for them (they are called externalities, e.g. accidents or pollution). The values for externalities may be derived using a variety of methods. These include e.g. the actual costs needed to repair or prevent damage; the amounts of money people are willing to pay to avoid the externality, or the amount of money they would have to be paid to feel compensated. There are numerous other techniques for determining the monetary values of environmental goods that can selectively be applied to the assessment of also other externalities (see e.g. *Dixon et al. (1994)* for an overview).

Because of practical difficulties as well as issues of principle, the point of departure cannot be the monetisation of all the impacts to yield a single efficiency measure (net present value, benefit-cost ratio etc.). For example, assessing the value of human life entails ethical considerations that transcend economic analysis (*Dixon et al. 1994*). In addition, determining the existence value of e.g. biodiversity as such, independently of any needs and considerations of humankind, is not possible.

4.2 Distribution of impacts

Efficient use of society's scarce resources is usually not the sole factor that affects the welfare of citizens. There are often several objectives concerning equity and distributional factors that are considered by society to be equally important, sometimes even more important, than efficiency. Equity comprises such factors as distribution of income, costs and benefits, equal growth possibilities between regions or citizen groups, and minimum level of service or income.

It is obvious that different groups of road users may have different optimal speeds (e.g. heavy and light vehicles). This is not a problem as such for framework design, but the desirability of addressing this issue from the equity viewpoint implies the use of impact functions with sufficient resolution.

4.3 Previous assessment methods

Examples of previous studies of comprehensive effects of speed are *Plowden & Hillman (1996), Rietveld et al. (1996)* and *Andersson et al. (1991)*. Our work has benefited from these studies. However, they all tackled a predefined assessment task whereas our aim has been to construct a framework, i.e. *a set of guiding rules and principles*, to be applied as widely as possible in speed management assessment. In addition, little attention has been paid to the distribution of the impacts in the studies mentioned.

5 STRUCTURE OF THE MASTER ASSESSMENT FRAMEWORK

5.1 Framework structure

The MASTER framework consists of three distinct phases: 1) outlining, 2) measurement and 3) assessment. Each phase can be divided into a number of steps (Figure 2).

The phases and the steps within them are sketched in the following sections. The indexing from A to L below refer to Figure 2.

1. Outlining ⇒	**2. Measurement** ⇒	**3. Assessment**
A. Deciding the measure or policy to be tested	D. Choosing the impact functions or models and gathering data	H. Summarising the net impacts
B. Deciding on link or network level assessment	E. Deciding on which impacts to monetise at what monetary value	I. Analysing the distributional effects
C. Establishing which impacts are relevant to the case concerned	F. Making the calculations	J. Making sensitivity tests with the key assumptions
	G. Analysing the extent of non-quantifiable impacts	K. Analysing the acceptability of the policy
		L. Analysing the overall socio-economic feasibility of the policy

Figure 2. Structure of the MASTER framework.

5.2 Outlining

A) The first stage is the *definition of the measure or policy* to be assessed. The MASTER framework can be applied to a wide range of cases, for example reduced speed limit on a road section or network, increased speed enforcement, vehicle type specific speed limiters or installation of speed humps on an urban road.

B) The second step is to decide whether a *link level* assessment (see Figure 1, page 37) will catch all the pertinent effects of the policy, or if a *network analysis* is to be preferred. The former assumes that speed does not affect travel decisions (and consequently traffic volumes, modal split etc.) and is more straightforward. The latter takes into account the indirect effects of speed on travel decisions and can be laborious. It should be noted that even a measure that concerns just one link may have wider impacts if it e.g. diverts traffic to new routes.

C) Scoping is performed, i.e. the *impacts that are included* in the assessment are selected. The aim is to simplify both the assessment task and the subsequent decision-making by confining the study to relevant impacts only. For example, the impacts of speed on noise can be considered not relevant in an industrial area. In such cases the reasons for exclusion should be explained and, if feasible, an authorisation from the decision-makers should be obtained. Public participation is also encouraged whenever possible.

5.3 Measurement or estimation of impacts

The second phase is the measurement or estimation of the impacts selected in phase C above. This task entails the four steps listed in Figure 2.

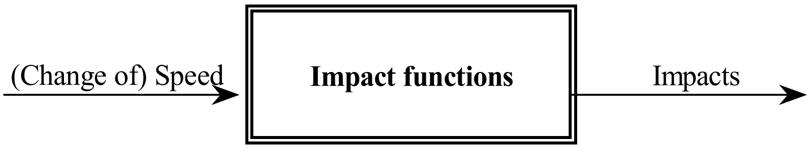

Figure 3. The role of impact functions.

D) Selection of *impact functions* and collection of input data: Impact functions describe how the various effects depend on speed (Figure 3). These functions can be in the form of equations, curves or tables. The determination of impact functions and data collection must be compatible with each other and with the policy to be tested.

At the link level, the minimum data set typically consists of the length of the road section, annual average daily traffic volume, mean speed of traffic before and after the speed change, expected annual number of injury accidents before the speed change and emission and noise characteristics of the vehicle fleet.

As the focus is moved onto the network level, there are additional information needs on what impacts influence, and how, travel decisions and mode choice as well as on how changes in perceived accessibility affect spatial patterns, and how they in turn impact on the transport system. Application of a network model preferably featuring land-use transport interaction may become necessary for the assessment of these impacts.

E) Determination of *which impacts are monetised*. The framework is open to varying degrees of monetisation of the impacts. Monetisation is not a purpose in itself, but it aims at more informed trade-offs between different impacts. In all cases, the monetary values used and their sources must be explicitly presented.

F) *Calculation of impacts*: Figure 4 illustrates the chain of impacts that are measured. At a minimum, the calculations consist of two stages, but there may be more depending on the depth and scope of the study.

As a first step, the impacts in the present situation must be measured or estimated in order to establish benchmark values against which changes in the impacts can be compared. In cases in which the speed change concerns only part of the vehicles, the determination of impacts in the initial situation should be made separately for a) the whole flow and b) the part of the flow that is affected.

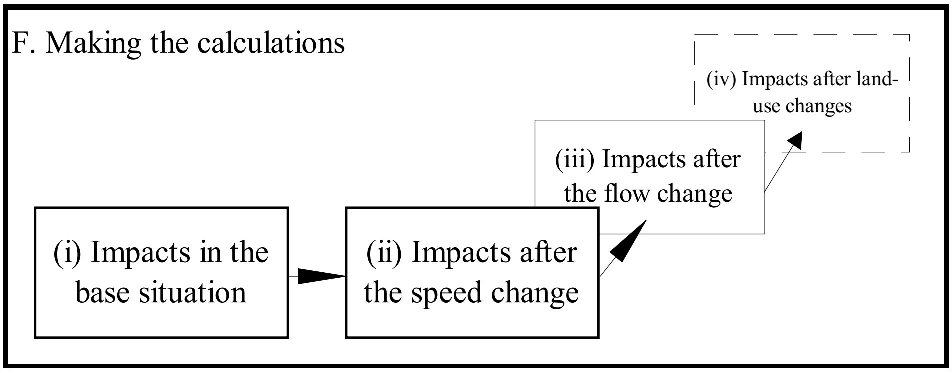

Figure 4. The process of impact mediation.

At the link level, the next step is to calculate the same impacts using the new speed(s). If the speed change concerns only part of the vehicles, then this analysis is usually limited to the respective part of the flow. A sensitivity test may be performed using some cautious elasticity figures to see whether the results change markedly if a change in volumes is also assumed.

However, if there is an accepted procedure for determining the effects on the traffic volumes, both the speed change and the change in volumes may be introduced into the calculations at the same time thus combining stages (ii) and (iii).

Whichever the case, the calculations including changes in the traffic volume must be made using the consumer surplus approach, not the difference between the sums of vehicle operating and travel time costs. Otherwise, considerable errors may occur.

If the assessment concerns just one link, the indirect impacts on the volumes—i.e. those caused by changes in land-use patterns following the original changes in volumes—are most likely insignificant. However, in the case of managing speeds on a network, these impacts grow in importance. A network-level assessment does not proceed in steps (ii) to (iv) but includes model runs in the base situation and in the final situation in which all the three levels of impact are included.

G) *Non-quantifiable impacts*: It must be emphasised that an impact is no less important just because it cannot be quantified. The term 'measurement' does not refer here to quantifiable impacts only: measurement could be defined as the process of following the causal chains originating in the phenomenon being studied as far as reasonable in order to provide information for making judgements concerning their significance. For example, the feelings of (un)safety of pedestrians and cyclists, the barrier effect caused by traffic for both people and animals, or the stress of drivers are all affected by the speed of traffic. Impact assessment is not just mechanical calculation; it requires experts in very different fields, including e.g. sociology, psychology and biology.

5.4 Assessment of impacts

In the third and final phase, the results are summarised and analysed in accordance with Table 1. The impacts of speed management policy are grouped into three categories, monetised, other quantitative, and qualitative. Within each category, both the total magnitudes of the impact and its distribution are considered.

Table 1. Classification of the impacts.

	Magnitude of impact	Distribution of impact
Monetised impacts	*E.g. time costs*	*Who gains, who loses?*
Other quantitative impacts	*E.g. noise impacts (if no unit monetary values for these impacts are available)*	*Who benefits, who suffers?*
Qualitative impacts	*E.g. feeling of (un)safety*	*Who benefits, who suffers?*

H) *Summarising the magnitudes of impacts*: The monetary values are calculated component by component (i.e. vehicle operating, travel time, accident and pollution costs) and then added to yield the total net benefits or costs of the policy being tested.

This step also includes summarising the other quantitative and qualitative impacts. The analyst performing the assessment should objectively present the most relevant consequences of the policy tested. All the information relevant to value-based judgements should be provided, but the judgements should be left to the decision-makers. In case of doubt on what is relevant, the analyst should choose to include rather too much than too little information.

I) *Distribution of impacts*: Groups experiencing the impacts of the policy differently are identified. The effects of the policy must be examined from the viewpoint of each of these groups. Finally, groups that benefit and those that suffer are highlighted. It should be noted that even if the total net change in the magnitude of the impacts is low there may be important distributional factors to take into account. The sensitivity to changes in input data of both the magnitude and the distribution of the impacts is analysed.

J) *Sensitivity tests*: The data available for the assessment is often imprecise or uncertain. Sensitivity tests are therefore essential. For example, in the assessment of planned policies it is often difficult to predict how the policy affects driving speeds, and calculations can be made using different assumptions (as in the example in section 6). Another candidate for sensitivity testing is time costs, because there is no consensus on the significance of small travel time changes. Therefore sensitivity testing could include exclusion of all travel time changes less than e.g. one minute per vehicle from the calculation of time costs.

K) *Acceptability* of the policy among the public is important information for the decision-makers. Its assessment should be based on proper surveys among relevant people, not just those opinions presented in the media. The respondents in the survey should be informed of the expected impacts of the policy (e.g. on accidents, travel times, vehicle operation costs, pollution and the distribution of effects between road user or citizen groups) prior to asking them about its acceptability.

K) *Establishing the socio-economic feasibility* of a policy. As already stated, the purpose of the assessment is not to indicate an indisputable outcome regarding the socio-economic feasibility of a policy, but to provide all the necessary information for those elected to make such judgements. Therefore, a concise and objective analysis of the impacts is the end product. If possible, the analyst should explicitly discuss the value judgements related to the different options, based solely on the results of the assessment. All the data, assumptions, functions or models and intermediary results must be easily accessible to the decision-makers at their request.

6 APPLYING THE MASTER FRAMEWORK

6.1 Testing process

During the MASTER project, the framework presented in the previous section was applied to three real test cases in three countries – Finland, Hungary and Portugal. In each country, the analyst chose the test case and worked independently based on a previous working paper describing the framework (*Kallberg & Toivanen 1997*) and a spreadsheet file designed to help in the calculations. This section reviews briefly the Finnish study. The other cases and all the completed spreadsheets showing the details of the calculations can be found in *Kallberg & Toivanen (1998)*. Although all three cases deal with speed limits, the framework is equally suitable to the assessment of other kinds of measures that change the speed of traffic.

In Finland, the test case was completed in close co-operation between the Finnish National Road Administration (Finnra) and LT-Consultants Ltd where Sami Toivanen, the co-author of the framework, then participated in the work.

6.2 Extending wintertime speed limit to semi-motorways[1] in Finland

Introduction

Presently, a major part the trunk road network in Finland (10,100 km out of 13,070 km) is subject to a lower speed limit during winter (four to six months during October–April). The wintertime reduction is from 120 to 100 km/h on motorways and from 100 to 80 km/h on other roads. A policy test was carried out on extending the wintertime limit to the slightly over 200 kms of semi-motorways. The present limit of 100 km/h was lowered to 80 km/h for a period of five months.

The average daily traffic volume on the semi-motorways is about 11,500 vehicles during summer and 8,700 during winter. 12% of the traffic are heavy vehicles, almost exclusively goods vehicles. It was assumed that no change in the traffic volume take place because of the new limit.

Presently, the average speed is 97 km/h in the summer and 94 km/h in the winter. It was assumed that a speed limit of 80 km/h would lower the winter-time average speed to 88 km/h. This assumption was subject to sensitivity tests: average speeds of 90 and 85 km/h were used as the minimum and maximum speed changes, respectively.

In Finland, the experiments with lower wintertime speed limits began in 1987. During the first two winters, about three-fourths of the drivers said they accepted the winter limits (*Peltola 1991*). An interesting feature was that the percentage of those saying that they were irritated at least to some extent was much lower (44%) than of those who thought the lower limits irritated other drivers (85%). New interviews were conducted in 1992 when the winter limits had been made regular (*Finnra 1992*). The share of supporters had declined to about two-thirds. In addition, the shares of those irritated had increased.

Input data and calculation methods

The Finnish Road Administration provided the information on traffic and personal injury accidents (PIAs) making use of the automatic traffic surveillance data and the road data bank. The Finnra procedures were in the main followed in the calculation of user costs, i.e. the shares of different trip types, monetary values per time unit for the

[1] Semi-motorways in Finland are rural two or three lane single-carriageway roads with grade-separated junctions and access limited to motor vehicles with structural speed exceeding 40 km/h (thus excluding mopeds and agricultural tractors, for example).

trip types and the speed-dependency of vehicle operating costs. One exception was made: half of the fixed costs are routinely considered dependent on the speed of the vehicle. No justification for this was found, and the fixed costs were considered to have a constant value per kilometre.

All taxes were excluded from vehicle operating costs used. Fiscal taxes represent only a transfer payment in socio-economic analysis.

The five-year-average of the number of PIAs, deaths and injuries per summer and winter were used together with the Finnra unit costs for deaths and average injuries to derive the cost of an average PIA in the before-situation. The number of accidents and their costs in the after situation were calculated on the basis of the Swedish model (*Andersson & Nilsson 1997*).

Emission factors used in the LIISA system developed by VTT (*Mäkelä et al. 1996*) were applied to establish the impact on the emissions of air pollutants. Interpolation was used as the factors are only presented for speeds 50, 60, 70, 80, 100 and 120 km/h, and thus the results should be interpreted with caution. The emissions were converted into monetary values using the latest Finnish research results (*Finnra 1997*).

Impacts on noise were calculated using as the indicator the number of people living within the noise zones of 55 to 65, 65 to 70 and above 70 dB ($L_{Aeq,07-22h}$). The zone widths were calculated with simplifying assumptions according to the co-Nordic road traffic noise calculation model. Average municipal population densities were used to determine the number of residents. This method has previously proved to be reasonably reliable (Finnra, 1991). Noise disturbance was converted into monetary values using the latest Finnish research results (*Finnra 1997*).

Finally, the distribution of the impacts among relevant groups in society was estimated.

Results

Table 2 summarises the results regarding monetary impacts. The policy brings benefits to society: the net change of social costs is about MECU –1.9 per winter, which represents 2% of the total costs. The single largest change occurs with accident costs, MECU –2.5 (-27%) per winter, with time losses increasing worth about MECU +1.6 (+6%) per winter.

Table 2. Monetary impacts (kECU per winter) of extending the wintertime speed limit to semi-motorways in Finland.

	Before	After	Change	
Vehicle operating costs	50 828	50 379	-449	-1 %
Time costs	26 831	28 455	1 624	6 %
Accident costs	9 298	6 812	-2 486	-27 %
Air pollution costs	2 795	2 707	-88	-3 %
Noise costs	4 519	4 003	-516	-11 %
Total	**94 271**	**92 355**	**-1 916**	**-2 %**

Sensitivity tests

The results of the actual policy test (mean speed decreases from 94 to 88 km/h) and the sensitivity tests are summarised in Figure 5. The assumption of minimal speed change (MIN, from 94 to 90 km/h) reduces the net change in the social costs to MECU –1.3 per winter. The change in accident costs by MECU –1.8 per winter remains decisive for the net effect, while time costs increase by MECU +1.1 per winter. The upper limit of the anticipated speed change (MAX, from 94 to 85 km/h) alters the net costs with MECU –2.5 per winter. Accident costs change by as much as MECU –3.6 or 38% per winter, while time costs grow by MECU +2.5. In all cases, vehicle-operating costs remain the clearly largest cost item representing over 50% of the total costs. They change relatively little as they include also the fixed costs that are independent of speed.

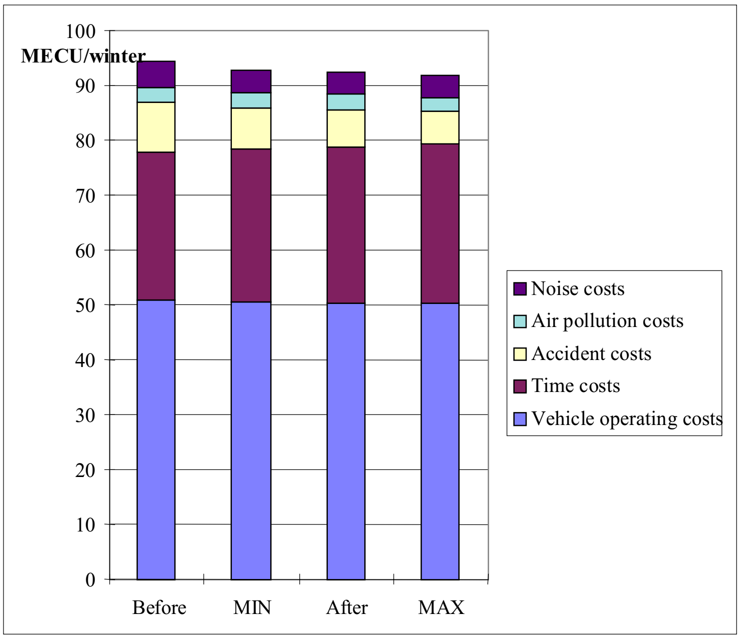

Figure 5. Summary of the impacts of introducing a wintertime speed limit on semi-motorways.

Distribution of the impacts

In all cases the group that is most affected by changes in vehicle operating costs (VOC) and travel time costs (TTC) is private motorists, which is natural as cars (and vans) form 88% of the traffic on semi-motorways. However, their share of the changes in these costs is slightly larger, about 92% (see Figure 6). The shares of coaches are 3.5% of the VOC savings and 5.8 % of the TTCs as compared to the 1.0% of the traffic, whereas the shares of goods traffic of these cost changes (4.7% and 2.5%, respectively) are clearly smaller than their share of the flow (11%). The coach traffic receives a smaller portion of the VOC savings and pays a larger portion of the TTC increase than lorries. Thus, when one looks at the sum of the changes in vehicle operating and time costs, coaches take a share of almost seven times their share of the traffic whereas the share of goods traffic is only about one seventh of its share of the traffic flow on semi-motorways. The explanation to this is that the share of time costs is much higher for coaches than lorries (57% vs. 28% in the initial situation).

The impact functions used do not predict vehicle-type specific accident rates. Thus, it can only be stated that all road users benefit from reduced accidents.

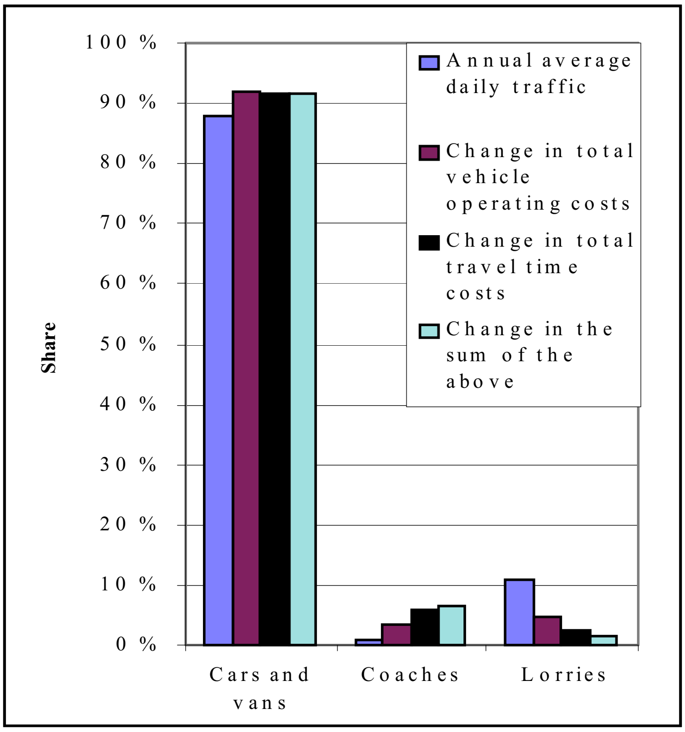

Figure 6. Shares of the vehicle types of the traffic as well as of changes in vehicle operating and time costs.

For pollution, it is hard to say which group benefits most. First, it must be noted that the absolute changes of pollutant concentrations are bound to be very small, even insignificant, which renders close to unimportant also the distribution of that change. In principle, however, it can be noted that those living at the roadside are exposed for longer periods than those inside the vehicles, but to lower concentrations than the latter are. The impacts of pollutants having more global effects can be deemed distributed evenly.

The greatest benefiters from the somewhat reduced noise levels are, in principle, the residents of the roadside, because their daily exposure time is much longer than that of any other group. Nevertheless, the noise levels inside the vehicles decrease as well. However, the reduction of the noise emissions and levels is so slight (0.6 dB) that it cannot be considered significant.

Discussion

It seems that even if lowering the winter-time speed limit by 20 km/h leads to a reduction in the mean speed of traffic of only 4 km/h, the policy will bring net benefits to society. The costs of implementing the policy are not considered, but it is not likely that they will come close to offsetting the effect.

One of the most interesting uncertainties in the calculation is related to accident costs. Although the cost of the average PIA was calculated from the numbers of deaths and injuries that have occurred in reality in order to take account of the fact that accidents are more severe on such high-speed roads as semi-motorways, the cost of the average non-fatal injury used was the national average (kFIM 155 = app. kECU 26). This is almost certainly too low a figure. While this procedure lead to costs of the average PIA that were 6 to 8 times the national average, the real cost is most probably even higher. Raising the cost of the average injury by kFIM 100 (app. kECU 17) increases the benefits to society with MFIM 1.2 (MECU 0.2).

Uncertainties are also present in monetising the impacts of pollution and noise. Especially the impacts of global warming are not easily predicted. As carbon dioxide, the most important greenhouse gas stands for a major part of the air pollution costs, changes in its unit value bring almost corresponding changes to these costs. For instance, if the unit price were tenfold, the total net benefits would be, in the MAX scenario, annually MECU 0.8 higher than in the before-policy situation. The present value is at such a low range that using one tenth of it would not markedly change the overall results.

This kind of data is one element influencing the *acceptability* of a speed management policy. However, it is the subjective perception of the impacts that is decisive for a driver to decide whether (s)he will exceed the speed limit or not. Given the trend in the support for the wintertime speed limits, it is not likely that the extension policy tested here would gain an overwhelming acceptance. Moreover, given that the net socio-economic benefits are, although clearly positive, quite low in relative terms, they could be offset by the anticipation of a negative public reaction by the decision-makers.

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