WEATHER CONTROLLED ROAD AND INVESTMENT CALCULATIONS

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1 The Experimental Motorway

The weather-controlled experimental road section runs on the southern coast of Finland between the towns of Kotka and Hamina. The average traffic volume is currently 14 000 vehicles per day and it is forecasted to increase by 5 to 6 per cent every year. On the 14 kilometres motorway section there are 36 variable speed limit signs and five information boards, which are controlled according to weather and road surface conditions. The aim of the experiment is to make traffic more manageable and to improve traffic safety. (Pilli-Sihvola, 1995)

The speed limits vary between three, and in mid-winter two, different speeds. The road section normally has a speed limit 120 km/h in summer and 100 km/h in mid-winter. Lower speed limits are used when road conditions are poor. The information boards give pictorial and textual information on weather and road conditions and possibly other information too.

The road section is in an area were the weather changes frequently. In winter time, the temperature varies slightly above and below zero degrees Celsius and the southern winds bring humidity from the sea. It can rain or snow at any time during the winter season.

2 Evaluation Method of Socio-Economic Profitability

The road weather information system affects drivers behaviour. Changes in certain socio-economic costs can be estimated on the bases of the effects weather-controlled road has on speeds and number of accidents. The road weather information system has impacts that increase some of the socio-economic costs and decrease others. When the socio-economic impacts are compared with the investment and maintenance costs, the profitability and productivity of the system can be calculated. (Lähesmaa, 1995)

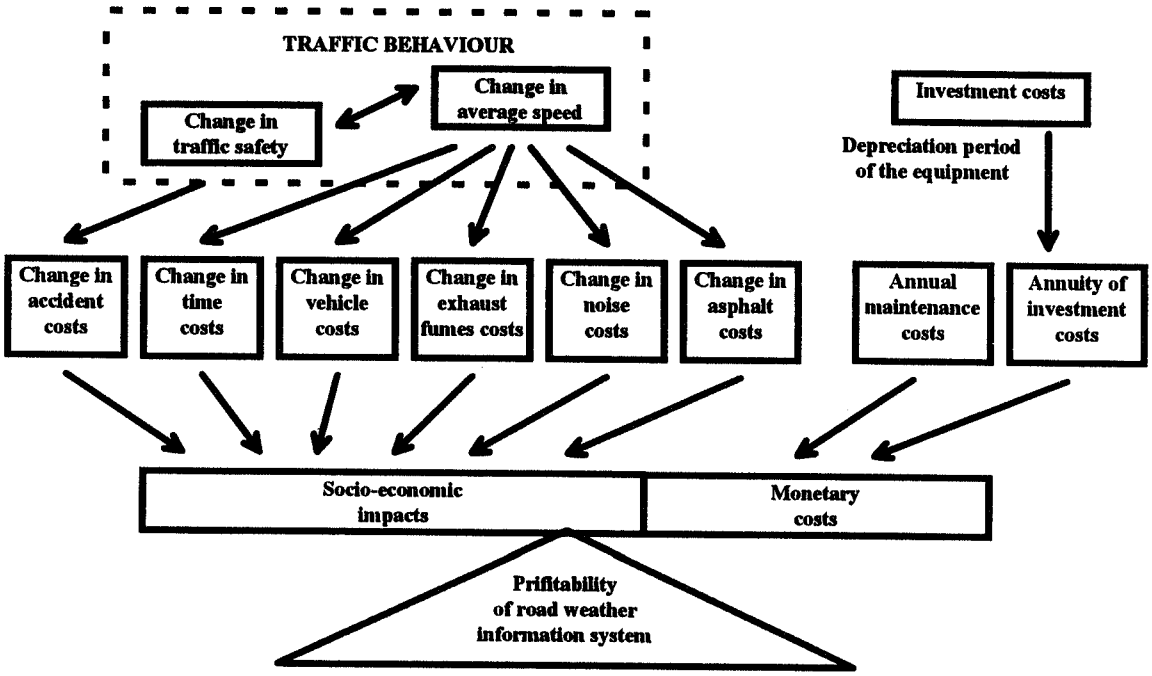

Figure 1. Profitability of the road weather information system.

2.1 Economic Parameters

Two economic parameters were used to evaluate how profitable and productive the road weather information system is for the society. These economic parameters were the annual benefit-cost factor and the remunerative rate of interest. In Finland similar types of parameters are usually used in traffic investment calculations.

The investment costs are treated in different ways depending on whether benefit-cost factor or remunerative rate of interest is calculated. In case of benefit-cost analysis, the investment costs from different types of equipment are divided into annual shares using the capital recovery factor. While remunerative rate of interest is calculated by dividing the one year's profit (the difference between annual incomes and costs) by the total amount of investment costs. The maintenance and socio-economic costs and benefits are always calculated for one year.

Benefit-cost factor

$$\frac{S - C_{sos}}{AN + C_{mai}}$$

AN = annuity of investment
C_{mai} = annual maintenance costs
C_{sos} = annual socio-economic costs due to weather control
S = annual socio-economic savings due to weather control

Remunarative rate of interest

$$\frac{S - C_{sos} - C_{mai}}{I}$$

I = investment cost

2.2 Socio-Economic Impacts

What impacts are taken into consideration in traffic investment calculations, is based on agreements. Factors that can relatively easily be estimated in terms of money were selected in the socio-economic evaluation. It was also considered important that the results from this evaluation method of the road weather information system would be comparable with results from other traffic investment calculations. The socio-economic factors used in this investigation are costs due to:

- accident
- time
- vehicle
- exhaust fumes
- noise
- asphalt surfacing

In this evaluation method changes in these factors, caused by the road weather information system, are calculated based on the accident rates and average speeds. Two values have to be determined both for the accident rates and for the average speeds on the road section. First values are given for the situation where no road weather information system is supposed to influence the traffic and the second values are caused by the reduced speed limits and warnings on the information boards. The costs are estimated before and after road weather information system and the differences are the socio-economic impacts of the system.

While the weather and road conditions vary, different speed limits and messages are used. Since the effects of the road weather information system also vary under different conditions, the effects have to be observed in parts. The traffic is first divided into summer and winter time, that are further divided, using the classification of the control actions, into three categories, where speed limits of 120, 100 and 80 km/h are used. The two values of accident rates and average speeds have to be specified in each of these categories.

The equations used to calculate the socio-economic impacts are presented in publication "Weather Controlled Road and Investment Calculations". (Pilli-Sihvola, 1995) The calculation principles and the prices for the road traffic costs are generally used by Finnish National Road Administration. (FinnRA, 1994) In this investigation the equations were deduced to such a form that the result of the equation is the change in cost. A negative result shows that the cost has decreased and a positive result shows that the cost has increased.

3 Profitability of the Experimental Motorway

3.1 Investment and Maintenance Costs

The investment costs of the Kotka-Hamina weather controlled road were about 8.2 million Finnish marks. The biggest expenses were the cabling needed for data transmission and distribution of electricity and the variable message and speed limit signs. These expenses cover slightly over 70 per cent of the total investment costs of the road weather information system.

The equipment of the road weather information system are believed to have different economic life times. Therefore the depreciation periods and values of equipment after the life time have to be estimated separately for each equipment. The longest depreciation period used in this investigation was 20 years and it was used for example for the cables. Much shorter economic life times were estimated for variable signs and computers. On average the depreciation period of the different road weather control equipment was about 14 years. When the investment costs of the system were divided into annual shares, the annuity of investment amounted to about 1 million Finnish marks.

The operation, surveillance and service of the weather-controlled road amount to about 360, 000 Finnish marks in annual costs. Some of these costs are problematic, since it is unclear which of the expenses are caused directly by this system. In addition to this it is difficult to estimate the service costs, since there is no previous experience. Because of the uncertainty it is supposed that the maintenance costs can be 5 percent smaller or 20 percent bigger than the original estimation. It is believed that the maintenance costs not can be significantly smaller, but if there happens to be any problems with the system the maintenance costs will increase rapidly.

The biggest maintenance costs are supposed to be caused by surveillance and telecommunication. These account for about 50 percent of the total maintenance costs. The telecommunication costs are relatively easy to estimate and the estimation is believed to be quite accurate, but at the moment it is not known how much surveillance the system will need and therefore the surveillance costs had to be estimated roughly.

3.2 Impacts on Driver Behaviour and Socio-Economic Costs

The impacts road weather control has on average speeds and accident rates had to be estimated based on the information available from other sources because the real effects of the experiment are as yet unknown. Therefore no absolute values could be used and three different (pessimistic, probable and optimistic) estimations were given to the average speeds and accident rates in each road condition category.

When the estimations done for different road condition categories were combined it was noticed that the yearly average speed was believed to decrease 0.4 to 1.4 per cent due to the use of

weather controlled message and speed limit signs. Even the variable signs were supposed to have reasonable effects on the average speeds while the road conditions are poor, the change of total average speed was quite low, since the weather and road conditions are usually fine. It was estimated, based on previous investigations, that in less than 20 per cent of the time conditions are certain that variable signs have to be used to decrease speeds.

The average yearly accident rate was believed to decrease 8 to 25 per cent. This seems quite remarkable change as average speeds decreased only slightly. The high impact on safety can be understood as the speeds are lowered during the bad road conditions, when accident risks are many times higher that in normal conditions.

Based on the impacts the road weather information system is believed to have on drivers' behaviour the changes of socio-economic costs were calculated. The costs decreased annually in all 0.85 to 2.1 million Finnish marks, probably about 1.5 million marks. The socio-economic impacts of different factors and their range are shown in figure 2. The savings are shown with negative numbers and the costs with positive numbers.

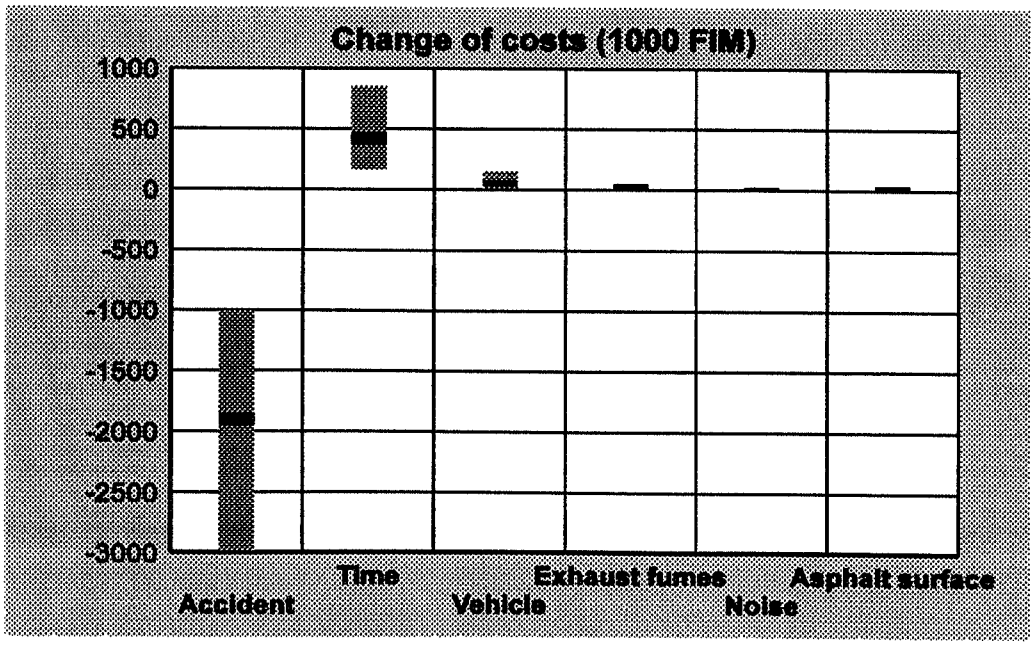

Figure 2. The changes of annual socio-economic costs (1000 FIM).

The saving of accident costs is believed to be distinctly the most significant factor. The increase of time costs decreases the accident benefit about 20 per cent. The changes of vehicle, exhaust fumes, noise and asphalt surfacing costs are small. In addition to this these factors have more or less compensating impacts.

3.3. Profitability

When the socio-economic impacts of the Kotka-Hamina weather-controlled road were compared with the investment and maintenance costs, the profitability of the system produces for the society could be estimated. Based on the assumptions in this investigation the most probable benefit-cost factor of the experimental road is 1.1 and the remunerative rate of interest is 14 per cent. This would mean that the benefit of the road weather information system are greater than the capital spent on it and that the system has been a socio-economically reasonable investment.

Because of the uncertainty and many assumptions in the evaluation process these values of the economic parameters not can to be considered as final values. Therefore it was essential to estimate how the parameter variations affect profitability.

Three different values were given for the annual maintenance costs and changes of average speed and accident rate. Based on the uncertainty of speeds and accident rates were ranges calculated also for the socio-economic impacts. When these assumptions were combined, the range of the system's profitability in all could be estimated. When all the pessimistic estimations were united the benefit-cost factor was about 0.6 and based on the optimistic assumptions the factor was believed to be 1.6. The remunerative rate of interest ranges correspondingly from 5 to 22 per cent. When the things causing uncertainty to the calculation are combined, the range of profitability in all is significant.

4 Conclusions

At the moment it seems that the Kotka-Hamina weather-controlled road has high potential to be a socio-economically profitable investment. However the uncertainty of the evaluation is still so remarkable that no final conclusions can be made. The Technical Research Center of Finland is performing research on the actual effects the experimental road has on drivers' behaviour. When the results from this research are available, the socio-economic calculations will became more precise.

In this investigation road weather information systems were evaluated only economically. Based on the preliminary estimations it seems that weather-controlled roads can be socio-economically profitable investments. If also the other factors are in favour of building such systems for other important highways in Finland, the socio-economic evaluation method is especially useful for comparing where road weather information systems can be used and what kind of systems should be used.

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