Bundesanstalt für Strassenwesen
V 5 - qs (TMS)

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Efficacy and economic efficiency

of

thawing agents spray systems

(final report)

(translated from the original German text)

Overview

1. Problem

Spray systems (TMS) using dew agents are used in stationary snow fighting. They are primarily meant to complete the action of the usual, mobile snow fighting using snow clearing and spreading vehicles as well as improve their efficacy. This TMS goal is achieved when locally limited snow fighting and pre-curative short notice measures on critical, for instance on potentially frosted places of the road system, are made unnecessary. A TMS is principally composed of two components : the spray system, which distributes the liquid dew agents (spraying nozzles, supply

network, pump and reservoir) and a control system triggering the spraying action (ice warning alarm system).

In the Federal Republic of Germany six TMS have been in use for quite some time. A seventh unit with a new concept was installed during the 90/91 winter on a bridge over the Dortmund-Ems channel on the A30. The systems differ mainly by their sizes, their position in the network, by the topographic and climatic environment and by the primary application.

The *Bundesminister für Verkehr (BMV)* took the opportunity of putting into service the up to now biggest large-scale installation on the A45 (Sauerland line) during the 1984/85 winter to charge the *Bundesanstalt für Strassenwesen (BWSt)* to analyse the efficacy of the system, especially with regards to its economic efficiency. The found allocation for additional systems and for operating procedure modifications on existing systems were largely made dependent upon the survey result. In an intermediate report, issued in 1988, the operational experience made with the four existing systems was described and summarised. The first criteria for the building of an additional system were defined in order to fight ice traps. This report included considerations about the economic efficiency of the biggest existing TMS.

With a length of approximately 6 km the TMS on the A45 (Sauerland line) is currently the longest system world-wide. This road section begins in Dortmund and continues until the Sauerland-heights. From 100 m above mean sea level it climbs to 532 m. In the route section between Hagen and Lüdenscheid overcomes a relief variation of approximately 200 m, a total of 127 m being in the area, where the 6 km long TMS system is installed (from 285 to 412 m above mean sea level). This relief is submitted to evident climatic variations. In the winter and up to a level of 250 m above mean sea level the road conditions can vary on short notice and pass from rain to snow and/or from positive to negative temperatures. These topographically caused climatic variations lead to numerous accidents due to icy roads. Trucks without the appropriate winter equipment are unable to overcome the slope on packed-down snow. They often slide and block the road partially or even completely.

In order to reduce the number of accidents and traffic jams, a TMS system was installed in 1984 and used for the first time during the 1984/85 winter. The objective was to keep the road free of ice caused by packed-down snow by spraying dew agents right at the beginning of a snowfall and until the snow clearing vehicles came into action.

2. Cost-benefit analysis

The problem described in paragraph 1 requiring the installation of such a system shows that operational savings are only possible under certain conditions. The reason is, and we want to point this out, that the TMS system is not designed to replace the winter service but rather to complete it. On the contrary, costs are generated for the delivery and the operation of the installation. Dew agent savings are not to be expected either. The number of winter services will not be reduced. Only long-time savings can be achieved by the fact, that precautionary winter services, readiness for action as well as additional control are no longer necessary. The reduction of the number of such measures creates a new potential advantage in these cases, where the road service centre is relatively far away from the exposed road segment.

The economic analysis doesn't take this aspect into consideration. Only the overall economic evaluation of the TMS measures is carried out in this survey.

In order to judge the economic efficiency, the method of the capital value has been used. In this method, all costs and benefits of the TMS are made comparable by compounding and discounting with reference to the time just before the investment took place (1984).

On the cost side it is fairly simple to work out the amounts relatively precisely. On the benefit side problems occur. In certain cases, it is only possible to get figures from the last six years of operation. It is therefore partly necessary to replace some annual values by mean values. For the period before 1984 annual values had to be mostly extrapolated.

2.1. Costs

The total costs for the system are composed of investment and operational costs. The operational costs consist of expenditures for dew agents, energy and personnel. Additional costs were generated by repair work, partly due to accidents. Special costs were incurred in an accident in 1986, where dew agents ran out onto the road track.

Summarising sheet of the cash values

Type of cost	*Cash value (DEM)*
Investment	1'437'000.—
Costs for dew agents	199'000.—
Energy costs	15'000.—
Personnel costs (salaries)	246'000.—
Repair costs	162'000.—
Special costs	88'000.--
Total cash value	**2'147'000.--**

2.2. Benefits

The benefits of a TMS system lie in the fact, that its effect brings savings in other areas. These areas are principally road safety, traffic conditions, environmental protection and protection of the users. The benefits generated by the environmental protection and protection of the users are not taken into consideration in monetary terms as it is for instance not possible to quantify the reduction of pollutant emission due to reduced fuel consumption and stress of the drivers.

The benefits regarding road safety were calculated by considering the annual number of accidents due to winter conditions (snow, icy patches) in two seven year periods before and after the system installation. The figures were then compounded and discounted with reference to 1984. The cash values positive difference of both periods corresponds to the benefit cash value of avoided accidents. It is assumed, that the benefit is caused only by the TMS system. Having only data about accidents

for the 5 years preceding the installation of the TMS systems and six years after it average values had to be taken for the missing years. For the calculation of the accident costs on the TMS road section, the BASt accident valuations were used.

The benefits obtained with better traffic conditions result firstly in savings due to the absence of traffic jams. The costs of traffic congestions are composed of changes of the vehicle operating costs and the costs of the time spent by the road users. These changes are worked out by using the calculation method shown in the RAS-W.

The vehicle operating costs are composed of the base operating costs, which are in a first approximation not proportional to the speed, and the costs due to fuel consumption, which is depending on the vehicle speed. The benefit cash value obtained by operating cost savings is then worked out by using a mean value bearing interest related to 1984. Only the 7 years preceding the installation of the TMS system were taken into account. As no jams were registered after it, at least this sum could be saved. Due to the increasing volume of vehicles, the real saving is by far higher.

To work out the total costs of traffic congestions it is necessary to consider the loss of time for the road users. To calculate this time the same average speed was used independently from the vehicle type. The hourly rates were taken from the RAS-W. With the discounted hourly rates related to 1984 and the proportional traffic structure, the costs for vehicles and users, the average hourly rates could be calculated. This average value allows one to calculate the cash value of the benefit using the saved costs for the period between 1977 and 1983.

The total benefit can therefore be worked out as follows :

Benefit due to saved costs concerning the road safety	DEM 1'786'000.--
Benefit due to saved costs concerning the traffic conditions	DEM 2'246'000.--
Total benefit generated by the system	DEM 4'032'000.--

2.3. Benefit-cost-factor

The following table compares the cash values of the costs and the benefits :

Costs	*Benefit*
DEM 2'147'000.--	**DEM 4'032'000.--**

Based upon a seven years survey following the installation of the TMS system, the total cash value of the benefit exceeds by DEM 1'885'000.- the cash value of the generated costs. The profitability factor of the system (benefit/costs) is therefore

$$\mathbf{F_W = 1.9}$$

for the considered survey period.

3. Assessment

The use of the TMS system on the A45 between Hagen and Lüdenscheid was supposed to reduce the number of accidents by 50 % as well as reducing traffic congestions. The objectives have been fully achieved.

A total of 99 accidents due to winter conditions occurred during the five years preceding the installation of the system, corresponding to a yearly average of 19.8 accidents. In the six years following the system installation 50 accidents or 8.33 accidents/year were registered. A reduction of the quantity of accidents by 57.9% results from the comparison between both averages. It is therefore clear, that the TMS system has a positive effect on accidents. Even if it is not provable, how much the reduction in accidents is due to the TMS system, it is presumed for the calculation, that the benefit can be imputed to the TMS system.

Traffic congestions due to trucks and freight vehicles, unable to manage the slope during the winter, could not be registered after the installation of the TMS system.

The main objectives of a winter service are :

- to guaranty the usability of the roads in order to maintain the traffic on the road network
- to guaranty sufficient road safety

even in winter conditions. These factors are the decisional basis for the use of the TMS system.

Icy roads can have a negative influence on the traffic conditions and safety especially where :

- local icy conditions occur, which cannot be detected by the road user and which make it more difficult to adapt his behaviour to the prevailing road conditions, or
- adverse topographic or climatic conditions lead to sudden and important snowfalls and to icy conditions, which can generate important traffic disturbances.

According to the results of the present survey, the use of the TMS system should not be limited to some, relatively short road sections. Roads with heavy traffic and a high percentage of heavy vehicle traffic should be equipped with the TMS system especially

- in sections with long and steep gradients
- to reduce traffic congestions due to icy conditions.

Even more than in the case of ice traps, it is absolutely necessary to meticulously plan such a system and not only to take physical aspects in consideration.

4. Outlook

Seven years after having used the trial installation on the A45 at Lüdenscheid and considering experiences on other installations used in the country, the future installation of additional thawing agents spray systems is recommended for safety reasons when individual cost-benefit estimates prove their profitability.

With the TMS system it is possible to ease the situation concerning accident in winter conditions. Suddenly occurring glazed frost can be efficiently fought. In cases of sudden and heavy snowfalls it is possible to maintain the snow in such a condition, the it can be evacuated by the regular winter service, thus preventing compacted snow roads.

Experiences made on existing installations have lead to improvements on the user and mainly on the supplier's side, which have already been widely taken into account on the newest installation on the A30 at Rheine (bridge over the Dortmund-Ems channel). Future and longer installations will take into account the benefits of currently installed TMS systems and detected faults and defects should no longer occur. The transposition of collected experiences can improve the profitability factor at future cost-benefit analysis.

5. In the abstract

With a length of 6 km, the thawing agents spray system (TMS) used on the A45 (Sauerland line) is the longest installed in Germany. The system is located at an altitude ranging between 285 and 412 m above mean sea level and in a climatically critical area, where in winter the road surface conditions may change very quickly due to very quick changes from rain to snow and/or from positive to negative temperatures. These conditions lead to numerous accidents due to ice on the road and generate tenacious congestions. In order to reduce the number of accidents it was decided to take a TMS system into service during the winter 1984/85.

After the installation of this system, the number of accidents on the equipped road section and due to winter road conditions was reduced by more than 50%. A dramatic reduction of 85% could be observed for accidents with light injuries. Accidents leading to light material damage could be reduced by 60%, whereas accidents with heavy material damage could only be reduced by 25%.

Assuming that the reduction of the number of accidents is a consequence of the TMS installation, the cost-benefit analysis shows that the system works cost efficiently. This analysis was carried out by considering economic aspects. As far as possible, it takes into account the previous fix and variable costs and compares them with the benefit of saved costs due to accidents and traffic congestions. Total costs of previously DEM 2'147'000.—can be compared to a total benefit of DEM 4'032'000.--, resulting in a profitability factor of 1.88.

The survey carried out by the *Bundesanstalt für Strassenwesen* has proven the profitability of the spray system using dew agents. It is advisable to take individual profitability estimations into account when planing further installations meant to ease situations caused by ice traps and to support the activity of the winter service on road sections specially subject to ice and heavy snowfalls.