

CENTRALISED WINTER SERVICE FOR MOTORWAY CENTRES

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1. Abstract

The federal motorways of the Federal Republic of Germany play an important role for both individual travellers as well as for the transportation of goods. Nevertheless, they are barely able to absorb the amount of traffic along certain stretches and during certain periods of the day, despite favourable weather conditions. Roadworks, accidents and particularly adverse conditions during winter also have a negative impact on the flow of traffic. The result is traffic jams of differing duration, some shorter and some longer.

The setting up of a centralised winter road maintenance service aims to prevent and to reduce disturbances and the risks associated with adverse road conditions during winter. In any event, the establishment of an efficient winter road maintenance service faces complications due to frequent and rapid variations in weather conditions and the additional requirements inherent upon putting into place an economically and ecologically viable service.

In order to satisfy the ever increasing requirements and in an effort to optimise the winter road maintenance service, the department of motorway construction of North Rhine Westphalien (Landesbetrieb Strassenbau des Bundeslandes Nordrhein-Westfalen) has created a winter road maintenance centre. Since winter 1997/1998 the coordination of the winter road maintenance service for the 14 motorway centres, which monitor the 1000 km network of roads, has taken place from this winter road maintenance centre. Thus the latter was able to replace the six call centres which existed heretofore.

It is at this winter road maintenance centre that all the essential data is pooled together and evaluated. Data and short term forecasts from the 100 measuring stations which detect black ice (GMA), as well as regional weather forecasts from the computerised system which monitors the weather and the state of the roads (SWIS) are all made available to the winter road maintenance centre. These sources of data are complemented by information from the police service. Where necessary, it is possible to obtain information from the national weather service, which is also available to provide advice and support. The necessary data and analysis in order to alert the winter road maintenance service personnel is communicated to the individuals responsible at the motorway centres for ordering said personnel into action. The winter road maintenance centre is constantly informed as to the state of play of these interventions and can, where necessary, for example in the case of extremely difficult weather conditions, request back-up support from emergency vehicles from neighbouring motorway centres.

The establishment of a winter road maintenance centre has resulted in an optimal winter road maintenance service, which is able to react in time. It is in this way that the formation of black ice is either stopped altogether or the duration of its presence is reduced. The use of salting (NaCl) has been reduced thanks to its application only at required points.

The use of a competent winter road maintenance service, which is coordinated by a winter road maintenance centre, has both economic and ecological benefits for the public purse. Moreover the economic savings have resulted in the closure of six call centres and a reduction in personnel costs thanks to automated monitoring systems in the fourteen motorway centres.

2. Introduction

Since the early eighties an increasing number of stations for detecting and measuring black ice (GMA) have been installed in order to monitor the state of the roads on the German national motorway system. The introduction of the SWIS (an information system for monitoring the state of the roads and the prevailing weather conditions), has led to an increasingly dense network of measuring stations. The data from these measuring stations has since been used in order to predict the weather conditions on the roads by the weather service. Monitoring the data from these measuring stations was the responsibility of the personnel in the motorway centre telephone call centres. Where there was a risk or occurrence of black ice, or in the event of a similar warning from the police service the winter road maintenance service personnel were alerted by the telephone call centre of the competent motorway centre.

The quality of the road monitoring varied heavily, depending on the abilities and experience of the personnel manning the telephone call centres. The interpretation of data and the alerts in connection with meteorological developments were carried out in a most unsatisfactory manner due to the fact that the required know-how was not available in sufficient quantities. Nor was additional training able to achieve substantial improvements to the situation.

Due to these experiences and because of the intended disbanding of the telephone call centres, the necessity of re-organising the road monitoring system and the coordination of the winter road maintenance service became apparent.

3. Objective

The economic importance of the roads as a means of transportation and particularly the key role played by the national motorways require a winter road maintenance service that can live up to the requirements imposed upon it.

The importance of the roads in Germany can be gauged from their use by both private and commercial users. Roads handle:

- Approximately 88 % of private travel as well as public transport by individuals (measured in persons-km); and
- Approximately 70 % of the commercial transportation of goods (tonnes-km) [1].

Almost 30% of all road travel takes place on the motorways.

Results of research undertaken by the Technische Hochschule Darmstadt [2] convincingly demonstrate the economic importance of the motorways and thus the benefits of an effective winter road maintenance service

If one considers the trend in road traffic on the German motorways over the last years, and if one takes the forecasts for future developments seriously then continued efforts to optimise the winter road maintenance service and its coordination are to be undertaken. Every day, the national motorways, which fall under the jurisdiction of the departments of motorway construction of the different "Landesbetrieb Straßenbau Nordrhein-Westfalen", must deal with approximately 67'500 vehicles. In the industrial centre of the Ruhr region (so-called "Ruhrgebiet") peak traffic flows of up to 110'000 vehicles are a daily occurrence.

The objective was thus to achieve a high-quality and economically viable optimised winter road maintenance service by means of a functional road and weather monitoring system, which would serve a qualified winter road maintenance centre. A thorough analysis of the problems faced has shown that these requirements can only be met by monitoring road and weather conditions over a large area as well as providing some kind of 24-hour intervention and coordination facility for the winter road maintenance service. The logical consequence was the setting up of a winter road maintenance centre.

The following benefits are expected to result from the setting up of a winter road maintenance centre:

- The data made available by the monitoring systems shall be correctly evaluated by competent technical personnel and thus the existing systems will be used more effectively;
- The state of the roads and the prevailing meteorological developments can be monitored over a larger area by pooling the essential data;
- The winter road maintenance service can intervene more rapidly and can be better coordinated;
- The quality of the winter road maintenance service will improve, which will in turn benefit road users and the economy;
- The organisation of the winter road maintenance service shall become cheaper.

4. Prerequisites and Tasks

In order to achieve the objectives which had been set, the essential information and data required in order to monitor the roads and enable the competent individuals to take the necessary decisions had to be pooled together and evaluated. The winter road maintenance centre had to be granted constant access to all the essential and current data on the state of the roads in the area to be monitored and had to be in a position to evaluate this data. Information as to prevailing and expected weather conditions was also a must as was the necessary know-how in order to assess the effects such conditions are bound to have on the state of the roads.

Furthermore, the winter road maintenance centre must be up-to-date as to the status of the different winter road maintenance services of the motorway centres.

Primary tasks of the winter road maintenance centre:

- Monitoring of the prevailing road and expected weather conditions;
- Monitoring of meteorological developments;
- Ordering into action of the winter road maintenance service;
- Coordination of the winter road maintenance service.

Secondary tasks:

- Keeping a record of the winter road maintenance centre's activities and those of the motorway centres;
- Checking of the technical soundness of the monitoring systems (measurement stations, data transfer networks etc.);
- Checking the operation of existing thawing agent spray systems.

5. Technical equipment at the winter road maintenance centre and motorway centres

The winter road maintenance centre and the various motorway centres are linked with the SWIS-Network and have access to all measuring station data and SWIS-forecasts.

The **winter road maintenance centre** is equipped with additional technical installations in order to deal with more complex tasks. Four personal computers (PCs) have been linked to the SWIS-Network in order to display the data received from the black ice warning stations. These PCs can thus be used in a flexible manner. Essentially, three PCs are used to simultaneously display the measuring stations with differing parameters. The fourth PC is used to visualise the SWIS forecasts, as well as the pictures from the precipitation radar stations and in order to keep records. A further PC is linked to the Internet and is used to gather additional weather information from the World Wide Web.

Linking the **motorway centres (AM)** with the SWIS-Network is necessary in order to ensure that:

- Coordination between the winter road maintenance centre and the competent motorway centres as to the operation of the winter road maintenance service takes place on the basis of the same information;
- The individual leading the winter road maintenance service is able to evaluate the state of the roads in his or her area of responsibility; and
- In the event of network problems, the task of monitoring the state of the roads may be handed over from the winter road maintenance centre to the motorway centres (back up level).

Finally the winter road maintenance centre is equipped with a fax machine and a modern telephone system.

6. Personnel

During the months where winter weather conditions prevail, the winter road maintenance centre is manned 24 hours a day. In order to do this, three shifts are necessary. For the five to six months of winter weather conditions, a staff of five to six people is sufficient, taking into consideration any leave that may arise in connection with accident or illness.

Work shift times:

- 06.00 am to 2.00 pm;
- 2.00 pm to 10.00 pm; and
- 10.00 pm to 06.00 am

Individuals with practical experience in carrying out winter road maintenance service will be hired. By means of additional training in evaluating data collected by the black ice detectors and thanks to receiving instruction in the basics of meteorology, the staff will be in a better position to carry out their tasks.

7. Managing the winter road maintenance centre

Managing the winter road maintenance service is essentially a job that involves monitoring the state of the roads, alerting the winter road maintenance service and, occasionally, coordinating the winter road maintenance services when they must act outside of the designated geographical areas of their motorway centres. The motorway centres are themselves responsible for determining, on a daily basis and depending on the expected weather conditions (SWIS forecasts), their needs when it comes to personnel in order to be ready to intervene. Those staff members that are on alert must at all times be reachable and must, where required, heed the call to intervene as part of the winter road maintenance service. The winter road maintenance centre advises the various motorway centres in determining how they may best meet the need to stay on alert.

7.1 Monitoring the state of the roads

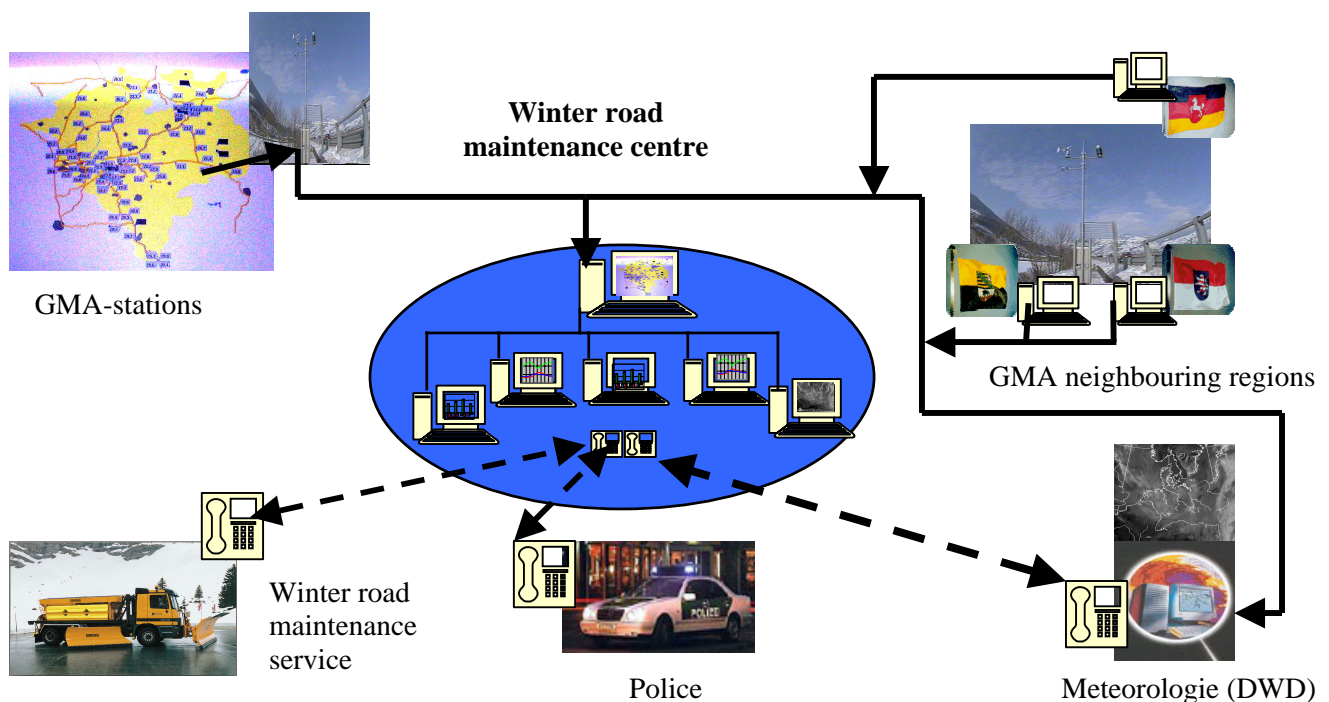
Data collected by the black ice detection stations is the most important source of information. As many as 100 such measuring stations exist within the national motorway network. The amount of up-to-date information such data contains must meet the requirements of the job. A black ice measuring station system with identical sensors is to be used. In order to determine the risks posed by black ice or frost, road sensors with active measuring systems (cyclical “cooling” and “heating” of the sensor’s surface) shall be used. Certain measuring stations will also be equipped with road sensors, which determine the freezing point of existing road moisture. Further important sources of information are the police service and the own weather service organisation.

7.2 Monitoring meteorological developments

In order to make correct decisions when alerting and coordinating the winter road maintenance service, it is essential to be informed as to the prevailing weather conditions and expected meteorological developments.

The following sources of information are thus available:

- The SWIS (information system covering the state of the roads and weather conditions);
 - detailed forecasts for climate areas, displayed by altitude (0 – 200 m, 200 – 400 m etc.)
 - Indications of the impact of the weather on road conditions with up-to-date information as to expected meteorological developments within the next 2 to 6 hours (e.g. the arrival of a snow storm);
- Pictures from the precipitation radar stations;
- Data from the black ice detection stations in neighbouring regions;
- Up-to-date data exchange with the German national weather service (DWD).



Picture 1: Information provider for the monitoring of road conditions and for ordering an intervention

7.3 Alerting the winter road maintenance service

Alerting the winter road maintenance service takes place on the basis of the information described above under 7.1 and 7.2. During the regular daytime working hours of the motorway centres (AM), this decision is communicated to the responsible team leader. Outside of these hours the decision will be communicated to the designated alert-ready team leader. These individuals then initiate the necessary measures for the area covered by their motorway centre on the basis of the information provided by the winter road maintenance centre.

The decision to initiate salting will essentially be taken on the basis of forecasts and alarms provided by the black ice measuring stations, as well as weather forecasts in addition to information provided by the police service. The aim of salting is to stop black ice from being created as well as to reduce to a minimum the life span of existing points of black ice. Because time requirements for salting amount to approximately two hours and because the necessary personnel also need approximately 30 minutes to get to the location in question, an exact analysis of the prevailing and expected road conditions is needed so that preventive salting does not take place unless completely necessary.

Where snow falls have been announced, information collected by the precipitation radar stations of the weather service and by the black ice measuring stations of neighbouring regions will also be evaluated. The precipitation zones visible on the radar screen are checked and verified against the precipitation registered by the black ice measuring stations. By observing the direction and speed of these zones, the correct and necessary decisions can be reached as to alerting and positioning the winter road maintenance service teams and their vehicles. The stated objective is to carry out salting prior to or at the start of a snowfall so that the snow does not stick to the road surface and so that any slush that is formed is swept away by the existing traffic. In the event of severe snowfall it should be possible to maintain driving conditions on the roads.

7.4 Coordinating the winter road maintenance service

Coordination, by the winter road maintenance centre, of an intervention by the winter road maintenance service team should be restricted to those cases where the team is required to act outside of its designated geographical area.

For example the winter road maintenance centre may order an already operational salting vehicle to continue salting in a neighbouring territory in order to remove the danger of emerging points of black ice. This might allow one to avoid calling in extra personnel and vehicles or machinery. This leads to cost savings and more efficient time-use.

In the event of extreme weather conditions involving large snowfalls coordination of winter road maintenance service teams becomes necessary. Where problems of capacity arise at one motorway centre, these must be alleviated by means of the available resources at other motorway centres. Because of its information advantage, the winter road maintenance centre can initiate the necessary measures much faster and in a manner which is more precise than the motorway centres in question. Extreme situations can thus be dealt with much more effectively and their otherwise inevitable consequences, such as traffic jams, can be avoided.

The local running of an intervention of the winter road maintenance service remains with the competent motorway centre.

8. Experiences

The running of the winter road maintenance centre over the last four winters has proven that it has led to increased efficiency in the organisation of the winter road maintenance service and an improved level of quality of the latter's operations. Thus the expectations of the winter road maintenance centre have been fulfilled.

The participation of the winter road maintenance centre in alerting the winter road maintenance service teams on the basis of the available information systems has, in time, increased to 90%. The remaining percentage of interventions was due to the independent decisions of the motorway centre staff working on 'round-the-clock winter service operation (shift operation) on the basis of their own independent monitoring. On average, in the last three years of operation, approximately 1'100 interventions have been ordered per winter.

Because the motorway network subject to monitoring is spread out over vastly differing topographical regions – flat country with an altitude of 50 metres above sea level to mountainous terrain with an altitude of approximately 550 metres above sea level – the requirements incumbent on the various winter road maintenance services also differs greatly. These differing requirements, regions that involve increased incidence of black ice and frost, as well as regions with a greater share of snow fall, often require a different approach when it comes to monitoring road and weather conditions and ordering service teams into action. These requirements are met by having the necessary personnel on hand.

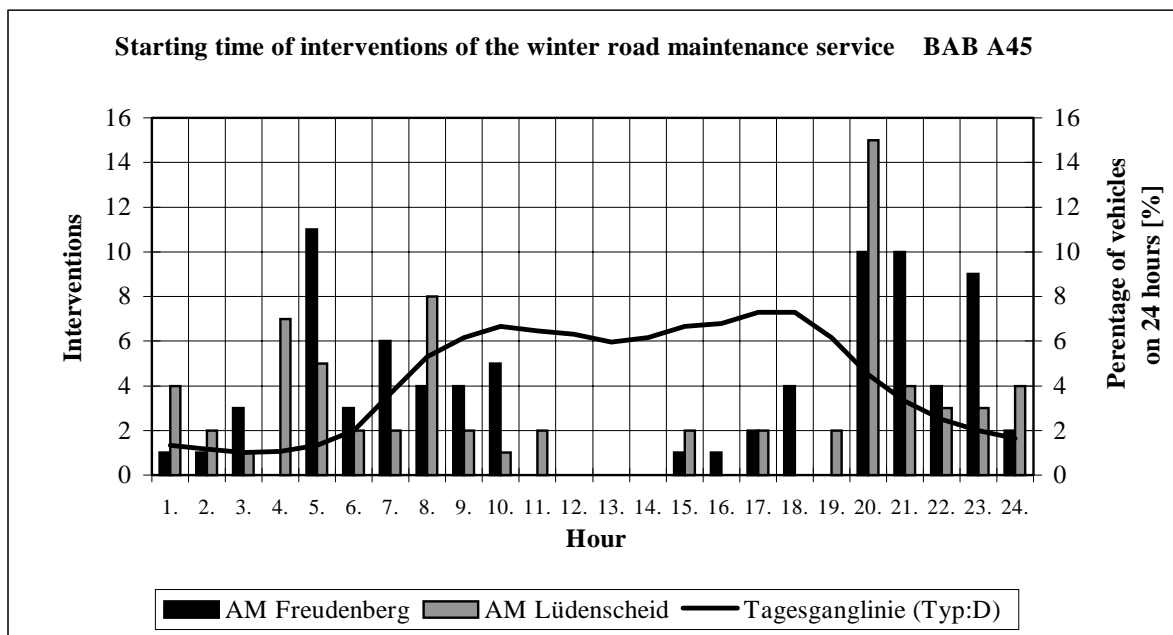
The value of the winter road maintenance centre has been proven by the efficacy of the winter road maintenance service. On the stretches of motorway covered there have been no cases of severe disturbances despite the fact that, at times, extremely critical weather conditions have prevailed, involving long snowfalls. Due to the fact that developments to road and weather conditions could be predicted with much more accuracy thanks to the abilities and know-how of staff, it was possible to raise the percentage of preventive operations by the winter road maintenance service.

Cooperation with meteorologists from the *Deutsche Wetterdienst* was further developed by the existing central weather service. An on-going dialogue between the responsible meteorologists and the personnel of the winter road maintenance centre provides a comprehensive view of current weather patterns and their possible consequences for the state of the roads. The information available to the motorway centres has improved greatly.

It has been shown that in the case of moving snow falls, the correctly timed use of the winter road maintenance service can minimise disturbances and risks for road users, but also facilitates the carrying out of the winter road maintenance service's tasks. This is particularly valuable in times of peak traffic flows.

Picture 2 shows the starting time of operations of the winter road maintenance service depicted at different hours of the day for two neighbouring motorway centres, whose stretches of motorway lie in a region with high snow falls.

In addition, the curve of daily traffic flows has been shown for the stretch of motorway (during a 24 hour period) and for the working days of Tuesday to Thursday. This stretch of motorway (a section of the A 45 between Freudenberg and Lüdenscheid), has an average daily traffic volume of between 62'000 and 68'000 vehicles, of which 18.2% are trucks and other heavy vehicles during the day (6 am to 10 pm). This percentage rises to an average of 44.1% at night [3].



Picture 2: Starting time of interventions of the winter road maintenance service

If one considers the starting time of interventions, ignoring the usual circulation times (salting: 2 hours; clearing: up to three hours) and ignoring also the curve of daily traffic flows, one can see that all operations of the winter road maintenance service, which began between 5 am and 8 pm, were carried out under the most critical conditions due to the prevailing high traffic volumes.

This was particularly the case under snowfall conditions. Interventions that were carried out during day time were often winter road maintenance service interventions caused by snowfall. As a rule, heavy snowfalls resulted in serious road traffic problems. Only when interventions could be made on time was it possible to limit these problems. Weather conditions such as these can be better predicted by the weather service centre and thus facilitate the winter road maintenance service becoming operational on time.

Winter road maintenance service interventions that took place over more than one district resulted in experience and greater certainty being gained and have come to be accepted by the management of the various motorway centres.

The following benefits have been achieved by the winter road maintenance centre:

- **More economically rational monitoring of road conditions due to the existence of only one centre;**
- **Good coordination of stand-by alertness between the different motorway centres in anticipation of the expected weather conditions;**
- **Competent and specifically targeted use of winter road maintenance operations, particularly of a preventive nature;**
- **Increased level of information due to more intense data exchanges between the weather service and the motorway centres;**
- **Reduced differences in the state of the roads from one district to another;**
- **Winter road maintenance service interventions which took place over more than one district could be very well coordinated and can be carried out whenever necessary;**
- **Centralised access to information on winter road maintenance service operations and road traffic problems (accidents, winter traffic jams);**

Monitoring the state of the roads with differing black-ice detection systems does not make sense. Collecting data on the state of the roads with differing road-surface sensors leads to differing forecasts and alarms. The various signal processing systems which lead to an alarm being set off can not all be managed in one centre because uniform interpretation is not possible.

The winter road maintenance centre is in a position to monitor the described road network by means of the 100 measuring stations and to call into operation the winter road maintenance service. Particularly heavy burdens are imposed where winter road maintenance service is required in the entire geographically designated area. For example, at one time, due to the inevitably intensive exchange of information between the motorway centres and the weather service, as many as 200 telephone calls were necessary during one shift (eight hours). This represents the outer limits of what can be handled. The extension to a larger network including further motorway centres would be possible by increasing the level of personnel. In doing so, it would make sense to increase staff in a flexible manner in accordance with the level of work as dictated by expected weather conditions.

The staff of the winter road maintenance centre see themselves as providing a service to the motorway centres and have, by means of the quality of their work, achieved a high level of acceptance. This has been an indispensable factor in the effective carrying out of the winter road maintenance service.

Further optimisation can be expected in the future by the use of video monitors at critical winter road maintenance service points and by means of improving the forecast models of the weather service as well as improving the black ice sensor equipment.

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