LEVEL OF SERVICE OF WINTER MAINTENANCE ON HIGH-VOLUME MOTORWAYS
– STRATEGIES, PROBLEMS AND LIMITS OF IMPLEMENTATION –

Dr.-Ing. Otmar Speth, P.E. (USA)

Bavaria State Road Administration; Germany
Head of Road Maintenance Section
Oberste Baubehörde im Bayerischen Staatsministerium des Innern
Franz-Josef-Strauß-Ring 4; D-80535 München, Germany
Tel.: +49-89-2192-3553/Fax: +49-89-2192-13521
E-mail: otmar.speth@stmi.bayern.de

1. Abstract

Based on highway-legislation roadmaintenance-authorities of Federal and State Roadadministrations in Germany agreed on an uniform level of service for road winter maintenance. The policy of level of service designates different quality-standards of service and driving conditions, depending on the category and function of a road and on certain weather- and winter-conditions. This policy furthermore takes into consideration the aim of minimizing harmful effects to the environment, compatibility with working time regulations of the maintenance personal and implementation of road winter maintenance at reasonable costs.

Motorways (so called "Autobahnen") in Germany today carry more than 40 % of the entire traffic volume of classified, rural highways and roads, although they represent only about 5 % of the total length of this roadnetwork. Maintaining traffic safety, optimum driving conditions and a high capacity of motorways all around the year, even during winter season is of great importance for the economy and in general for the driving public. As a consequence of an expected enormous increase of traffic in future time the quality of winter maintenance has to meet even rising standards.

Winter maintenance in Germany has already reached a high level. Nevertheless, not only because of budgetary reasons, great efforts are necessary to utilize all potential improvements to increase effectivity by appropriate measures.
The measures discussed in the paper are the result of experience and problem-analysis in winter maintenance practice especially in the State of Bavaria. Bavaria has the most areas in Germany with harsh climatic winterroad conditions.

Proposed strategies to pursue the striven aim include for example:
- Organizational measures, such as utilizing extended road weather information systems, the prewetted salt technology and optimizing the management of personal and equipment.
- Construction measures such as de-icing agent spraying systems and precautionary traffic regulations.
- Communicative measures by optimization of telecommunication among those responsible and involved in winter maintenance operations, especially the police forces, and by better, especially current information and warnings for the road users.
- Particular measures after occurrence of traffic congestion and collapses, when winter maintenance activities reach their limits, with the aim,
  - to get traffic moving again
  - to optimize drivers information service
  - to assist those drivers, trapped in long term traffic congestion's by relief services to reduce their impairment.

As a consequence of a still enormous increase of traffic on highvolume highways all possibilities and measures have to be utilized to keep up the presently designated level of service of winter maintenance also in future. This also includes to a far extent road users responsibility to modify their driving behavior according to winter road- and traffic- conditions.

2. Introduction – Traffic situation in Germany

During the past decades, particular the recent 10 years. Germany was faced with an enormous increase of traffic on the highways. Today passenger traffic (passenger-km) on the road amounts to more than 90 %, commercial traffic (tons of merchandise-km) to about 67 %, of the total traffic while the remainder traffic distributes its self to other travelling and transportation modes, i.e. on rail, water ways or air. Motorways in Germany (so called "Autobahnen"; all together 11.300 km, thereof in the State of Bavaria 2.300 km) carry more than 40 % of the total traffic on the entire classified rural, interurban road net (consisting of motorways, Federal-, State- and County roads), although they represent only about 5 % of the total length of this road net. The Average Daily Traffic (ADT) on motorways at present amounts to 50.000 vehicles/day, peak values to about 140.000 and maximum peak daily traffic to about 190.000 vehicles/day.

The enormous increase of traffic volumes in recent years will continue even more rapidly in future time as a consequence of political and economic developments, especially the European process of unification. The extension of the European Union to the east is expected to bring another 25 % of passenger traffic and 50 % of commercial traffic to the "transit-country" Germany within the next 10 to 15 years due to intensified economic cooperation's.

Maintaining traffic safety, optimum driving conditions and availability of sufficient capacity of motorways all around the year, even during winterseason is of crucial importance. As a consequence in future time the quality of winter maintenance has to meet increasing standards.

3. Winter maintenance policies – level of service

On one side road users demand and expect optimum driving- and safety-conditions even on winterroads. On the other side maintenance engineers today have to find a compromise between road safety, minimizing harmful effects to the environment by curtailing use of de-icing agents, compatibility with working time regulations of the personal, appointed to winter maintenance operations and implementation of winter maintenance at reasonable costs.

Under these conditions and based on highway-legislation roadmaintenance-authorities of Federal and State-Roadadministrations in Germany already years ago agreed on an uniform level of service for road winter maintenance. This policy designates different quality standards of service- and driving conditions according to

- the category of the road,
- and it's particular traffic function, characteristic and traffic volume,
- both, depending on certain weather-and winter-conditions.

In case of exceptional weather conditions however the service level desired can not be guaranteed any longer.
Substantial standard of this policy is the 24 hour ("around the clock") service of maintenance operations on motorways (Autobahnen) and other divided highways. On the remaining rural roads, winter maintenance is aimed to meet the requirements of daily commuter- and commercial traffic during the time between 6.00 a.m. (this means begin of winter maintenance operations at about 3.30 a.m. or 4.00 a.m. in the morning) and 8.00 p.m. respectively 10.00 p.m. according to regional traffic requirements.

For snow clearing-cycles of service vehicles the following time-periods are supposed to be obeyed:

- 4-/6-lane divided highways (Autobahnen) 2 hours
- highway interchanges 2 - 2 ½ hours, e.g. same cycle as for through-lanes or immediately afterwards
- federal and state roads 2 ½ - 3 hours

For pure salt spreading activities distinctly shorter time-periods are standard.

The policy of level of service complies with the statuary measures in highway laws in respect to road safety and liability and the technical and financial resources available. Road users cannot expect optimal driving conditions all the time; they are also required to take due account of possible changes or worsening of winter roadway conditions. This can go that far, that even on motorways chains for tires may be necessary at extreme road conditions.

4. Snow clearing and deicing strategies

Traffic carrying capabilities of highways are at an optimum on dry, respectively moist or wet surface conditions. Motorways (Autobahnen) in Germany are all over the year periodically overloaded by high traffic volumes. Slight interruptions of traffic flow are causing already congestion's of short or long duration. The situation is even more severe on slippery surfaces of snow- and ice-covered roads.

Therefore the strategy persued in Germany in connection with winter maintenance activities is to achieve again "black" i.e. snow-and ice-free pavements as soon as possible, with the aim, to keep traffic flowing as long as possible and to improve road safety: the so called "bare pavement policy".

Studded tires were abandoned in Germany already 1976 as a consequence of the enormous pavement damages. Intense investigations in the 1970ies revealed that the reduction of traffic safety through rain filled ruts in the pavement by the phenomenon of "aqua planing" – which means nearly the entire loss of skid resistance – caused more accidents all over the year, than were avoided by use of studded tires on winterroads.

5. Problems of traffic flow on high volume motorways in wintertime

The basis for implementing appropriate measures to increase effectiveness of winter maintenance on high volume motorways is a thorough observation and analysis of prevailing problems.

5.1 Problem patterns

Precipitation in form of heavy and sustainable snow fall or of freezing, respectively super cooled rain in connection with

- high traffic volumes in general, especially however large portions of heavy trucks; overloaded road sections as a consequence of commuter – (e.g. rush hour), recreational or other seasonal traffic peaks,
- topographically critical alignment with substantial uphill- or downhill-grades or with narrow curves,
- construction sites with narrow driving lanes and missing shoulders for emergency stops and,
- what the vehicles, especially heavy trucks are concerned, missing snow tires,
- incorrect driving behavior of motorists such as
  - unadjusted speed to winter road conditions; incorrect evaluation of traffic and road situations,
  - traffic congestion's occupying the entire pavement including hard shoulders serving as a storage area for vehicles standing in queues with no chance to open up small driving corridors for winter maintenance or other service vehicles to get through.

5.2 Consequences of the combination of these problem factors

- Slowing down of traffic, instable traffic flow, "stop and go"- traffic and finally collapse.
- Quick formation of snow packed layers by heavy traffic, gradually changing into icecovers, by rotating wheels because of lacking grip.
- Broken down vehicles, often standing across the lanes on uphill grades, especially heavy trucks not equipped with snow tires; this is one of the most serious problems.
- For safety reasons restraint or even refusal of truckdrivers at hillcrests to drive down again and continue their journey.
- Rear-end-collisions, if the safety margins are not kept to the front vehicle.

By combination of all these interference factors winter maintenance operations are hindered or even made impossible; maintenance vehicles themselves are finally trapped in congestion's; in this situation winter maintenance reaches it's limits!

Building up of congestion's of considerably length and duration even all night long will be unavoidable.

Special problems for the dissolution of congestion's not seldom arise as the result of motorists fallen asleep, frequently to be experienced in case of truck drivers, or even vehicles left by their drivers, who warm up in a close situated restaurant along the motorway.

Traffic congestion today regularly occur in winter- and in summertime frequently because of exceeding the capacity of the roadway. However to get traffic moving again on slippery snow and ice covered roads is by far more difficult and long lasting due to low friction conditions (slipping through of wheels, particularly when starting on uphill grades). Saltspreading activities in the narrow driving corridors between queues of standing vehicles is less effective; the distribution of salt by the moving traffic is missing.

In addition the impairment of the road users is by far more severe than for instance in summertime due to the climatic conditions, that are deep temperatures and temporal longer duration of the traffic collapses.

6. Winter maintenance measures

6.1 Organizational measures

Basically early initiated winter maintenance activities are a substantial contribution to keep traffic flowing and to increase road-safety. This includes following measures:

- Weather observations and road surveillance by nation-wide ice warning and Road Weather Information Systems (RWIS) meanwhile are standard for motorways. Further improvements are at present under way by installing weather surveillance stations and pavement sensors at all critical points all over the remaining road net. It is aimed at to set up an information-network with communities, neighboring states and possibly other countries.

  This enables meteorological services, in combination with general world wide atmospheric conditions, to provide even more accurate regional- and time-related weather forecasts.

  An optimal use of short-time and medium-time forecasts – in addition with available weather-satellite-pictures and weather-radar, to follow up movements of precipitation areas – allow road masters a better and more efficient planning of winter service operations.

- In principle prewetted salt technology nowadays is standard all over Germany and allows to fight already in advance against forecasted hazardous road conditions. Generally dry salt with 30 % $CaCl_2$-, $MgCl_2$- or NaCl-brine is used (the tendency goes to Sodium-Chloride, i.e. NaCl-brine!) The effectivity of prewetted salt exceeds the use of only dry salt and therefore allows a larger range of the salt spreading vehicles based on the same amount of salt. In addition with the prewetted salt technology – comparatively to using dry salt – savings up to 25 % to 30 % can be achieved.

- Preventive spreading of prewetted salt helps to avoid formation of ice or the bond of falling snow to the road surface under traffic at least to a certain extent. Today this technique and strategy is already standard practice in Germany.

- Experiences show that snow clearing and spreading services have, in respect to traffic safety a sensitive time related component. This requires:
  - shift working regulations and short term readiness of maintenance personal also outside regular working times, especially during night and on weekends based on foresighted personal planing and staff training,
  - control trips by winter maintenance vehicles during night for immediate salting activities on critical slipperiness-prone points along the roadnet, such as bridges or alignments through forests,
  - minimizing loading times by simultaneous refilling several vehicles with dry salt and brine at the same time by better loading techniques; larger loading capacity of maintenance vehicles to increase salting range,

- Early and intensified snow clearing already at low snow heights approximately starting from about 2 cm;
  more powerful vehicles for optimal snow clearing velocities, especially on uphill grades.

- Providing critical, mostly upgrade or downgrade road sections with additional salt deposits and basis for wintermaintenance vehicles, which are stationed there to guarantee quick presence and to achieve short term snow-clearing cycles.

- Supply of smaller vehicles for salting-operations in narrow corridors between queued vehicles after traffic has collapsed.

6.2 Construction measures and precautionary traffic regulations

- Installation of de-icing agent spraying systems, a stationary equipment to fight against black ice, rime ice and hoar frost for instance on accident prone concrete or steel bridges, typical "ice traps" or uphill or downhill grades. Roadway sensors and meteorological sensors detect the formation of ice or snow on the road surface and activate a spraying system for applying brine, in general using Ca Cl_2.

- Proper designation of bypass routes – so called U-routes with special traffic signing – between interchanges all the way along motorways. This allows motorists to be guided off the motorway, when there is a traffic collapse and bring them back in as soon as possible. However the pre-condition is to provide sufficient capacity for additional traffic and an intensified winter maintenance on these bypass roads.

- Building additional access possibilities to motorways for maintenance - and service-vehicles and the police, not for general traffic except in emergency situations to guide this traffic off the motorway.

- Preparation of traffic signing and proper equipment for closing up interchanges if necessary to avoid getting more traffic on already full lanes of the motorway.

6.3 Communicative measures

- Insuring a continuing telecommunication between roadmaster stations and maintenance vehicles by the road maintenance Very high frequency (VHF) transmitter/receiver system ("transreceiver-system") and mobile telephone for an effective and flexible guidance of winter maintenance activities.

- Close contact and exchange of information between roadmaster stations for motorways and for the other roadnetwork, even across State boarders for combined winter maintenance activities, if necessary**.**

- Thus initiating intensified snow clearing and salting on bypass routes or far extended circuitous routes to make traffic avoid congestion on motorways.

7. Information of public about driving in wintertime

7.1 General information

Already in advance of the winterperiod and also during winter motorists shall be repeatedly reminded of demands on proper traffic behavior, driving conditions and specific dangers on winter roads. In addition to that they shall be informed about what winter maintenance is capable to do and what not and where it's limits. This should be done by:

- news media, such as television, radio, the press, news papers and magazines and possibly internet,
- widely spread printed information material (leaflets) with special tips for driving in winter, supplied for instance in rest areas along motorway, at automobile-clubs, traffic safety-institutions, at communities and others authorities,
- official information signs along the motorways as a reminder for save driving (for example, to keep proper distance to cars ahead).

In detail advises for motorists shall include:

- proper "winter check up" of the vehicle, to guarantee functions also at cold temperatures,
- winter equipment, that are snow tires, and taking along chains,
- tips for driving and braking on a slippery road surface,
- recommendations, as to what to take along for long term trips for emergency-situations, such as tanks with reserve fuel, blankets, warm beverages, flashlight etc.,
- advises on the part of the police (e.g., keeping a corridor between queuing vehicles), of emergency services and rescue experts as well as physicians for behavior in longer lasting traffic congestion at cold temperatures.

7.2 Actual information and preliminary warnings

As a service to motorists current and regional differentiated forecasts concerning expected severe and extreme weather events (heavy snow fall, freezing rain etc.) shall be issued on traffic radio station in closer sequence, as done up to now. These preliminary warnings should be based also on RWIS information.

If critical situations in winter are ahead motorists also should be requested to abstain from planned trips or postpone them, as far as they are not absolutely necessary, or evade to other means of transportation.

8. Measures after occurrence of traffic congestion and collapses

8.1 Communication between roadmaster station and police

Highest priority should be given at first to all sorts of efforts to keep traffic moving and then to resolve congestion as quick as possible.
The necessary measures ask for a close cooperation and direct communication between winter maintenance personal and police-task-forces at the location of critical traffic events. The communication-lines between maintenance vehicles, responsible winter maintenance leader in the road master station on one side and police operations center, field office stations and police cars on the road need to be optimized by making use of all possible techniques, telephone, transreceiver-system and mobile telephone (handy).

By close coordination early in advance of begin of Winter, communication lines, certain principal patters for necessary operations as well as the reachability of the responsible staff by phone etc. needs to be agreed on and documented.

8.2 Measures with support by police forces

- Opening of narrow corridors through traffic congestion by police vehicles with blue flashing lights and acoustic signals (on two-lane two-way motorways according to traffic regulations in Germany between the lanes, on three-lane two-way-motorways between the middle and the left lane) when progress on hard shoulders, as far as they are available at all, does not succeed because of queuing vehicles even there.
- Piloting smaller maintenance vehicles for salting through the narrow corridors between the queuing vehicles.
- Stopping traffic in extreme situations, for instance at the head of congestion for snow clearing operations opposite to the driving direction, starting from the next interchange ahead,
- Guiding service-vehicles opposite to driving direction for recovering and towing away broken down vehicles.
- Closing access to motorways at interchanges, if necessary or directing traffic off the motor way or opening auxiliary exits.
- Wide range rerouting and directing heavy trucks to alternative motorways with less severe wintry surface conditions and
- As an innovation the equipment of maintenance vehicles with flashing lights and acoustic signals exceptionally on highway sections, where we know from experience about frequent extreme winter conditions. By this way it will be achieved, that winter maintenance personal is able to overtake functions of the police forces, who are available only to a limited extent because of different tasks, such as documenting traffic accidents. Thus, so far very good experience have been made.

8.3 Information on radio – traffic monitoring service

The existing system includes a direct traffic-information-transfer from police-vehicles on duty to State – and Federal Traffic-Information Centers, organizations of the police forces. From there information go to the broadcasting corporations and further on to particular radio stations.

Standard are today formalized official traffic-warnings within regular time intervals, usually one or one half hour, on a special so called "traffic radio station" even more frequently.

Information includes just any type of dangerous traffic situation, traffic congestion and collapses including their length caused whether by accidents or overloading of motorways and furthermore information about closed down single lanes, all lanes in one direction or total

close of motorways and all that supplemented with by pass recommendations and winter road conditions in general.

Traffic monitoring systems however urgently ask for an optimization as a service for motorists and as a support for efficient road maintenance operations and police activities, especially during wintertime.

Following improvements are on the way, still in preparation or planed:

- more frequent traffic information and warnings as it is the case today via different media, such as public and private radio-stations and Vehicle Message Systems (VMS).
- in wintertime focussing on driver information services by radio, providing complete, frequent, and as far as possible route-specific, precise, reliable, real time information on road weather conditions in order to even affect drivers behavior, if necessary.
- information to those motorists trapped in congestion about ongoing winter maintenance activities and duration of congestion as expected, and beyond that recommendations in regard to staying on, or leaving the motorway as well as information about winter road conditions on possible bypasses (U-Routes),
- extended and improved gathering of traffic and road condition surveillance data by automatic detection systems for traffic density- and traffic-flow-data as well as from RWIS and by private drivers, - there are thousands of them hired by automobile-clubs and radiostations on a voluntarily basis to forward messages,
- integration of other regional traffic information in Germany and from beyond the national boundaries.
- collection of all data by means of a comprehensive traffic-message-management in Traffic Information Centers; mutual exchange of messages among the 16 State- and the Federal Centers,
- installation of an European-wide digitized traffic warning system under the name "Radio Data System-Traffic Message Channel (RDS-TMC) with, in the background of normal broadcasting transmitted coded traffic and road weather messages. With radio receivers in the vehicle, which are equipped with a RDS-TMC decoders, these coded messages, - for example traffic congestion, winterroad-conditions, snowfall etc. - can be called up by motorists. Other broadcast transmissions will automatically be interrupted for this reason. A standardized data transfer procedure provides region- and route-specific information even in difficult languages.

  At present a pilot-project is on the way in the State of Bavaria, in Austria, in Switzerland and in Northern Italy. An European-wide compound of this system is planned for the future.

9. Particular measures during long lasting traffic collapses

Traffic collapses, even when lasting over night are not regarded as disastrous events. However auxiliary measures for trapped motorists by various emergency- and rescue-services may become necessary. In this connection, effective and foresighted planning and coordination on a regional basis are compulsory necessary.

9.1 Preventive planning-activities

Coordination and agreements ahead of wintertime between roadmaster-stations, police and county administrations, which are responsible for calling relief-organizations are an essential demand. This kind of preventive coordination is particularly given for centers along motorways, which are known from experience to be prone to forming frequent and severe traffic congestion and collapses in wintertime.

The following kind of coordinations need to be implemented:

- agreements about begin and time period for furnishing relief services,
- definition of kind and range of emergency assistance. Working up a check-list about necessary supply-functions and accessibility of competent and qualified organizations as well as their available assistance-potentials such as:

Supply functions	Organizations:
• warm beverages, food • blankets • fuel • medical service	• emergency organizations, Red Cross etc. • rescue organization, physicians • relief organizations • technical emergency services, towing services for broken down vehicles • fire-brigades with appropriate technical equipment

9.2 Implementation of relief measures

The decision, whether or not and at what moment the various services are to be requested, depends on the assessment of the presumable duration and scope of the traffic collapse and it has to be made locally by the police – forces in cooperation with responsible winter maintenance personal.

It should be considered, however, that an assistance to road users is much easier and more effective as long as they are standing in line in a congestion on the motorway, instead of being distributed all over the remaining roadnet after having left the motorway.

Very important in all these situations is it, to currently submit actual information to motorists on traffic radio about the traffic situation, winter maintenance activities and initiated relief and supply measurements.

10. Conclusion

With still an enormous increase of traffic on high volume highways we have to fear, that the traffic situation in wintertime – but also in summertime – will be getting worse. That means however that all possibilities and measures have to be utilized, to optimize quality of traffic flow and traffic safety and to minimize traffic congestion and collapses, just in order to keep up the presently designated level of service of winter maintenance.

Distinct improvements could only be achieved by rising available economic and financial resources. However the success of those efforts is limited. According to experiences, even with – theoretical – considerably exceeding expenditures the by far larger part of traffic interruptions, congestion and collapses can not be avoided.

It should be recognized, that maintaining traffic safety and traffic flow is a responsibility shared by winter maintenance authorities and road users. The latter should ensure their vehicles to be in good working order and suitable equipped, especially with winter tires. Further more, road users are under the obligation to modify their driving behavior according to winter road surface and traffic-conditions.