COST ACTION 344: IMPROVEMENTS TO SNOW AND ICE CONTROL ON EUROPEAN ROADS AND BRIDGES

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1. Abstract

Effective snow and ice control is a vital service provided by European highway authorities in order to ensure, as far as possible, that road users can travel safely and with minimum disruption in cold and severe climatic conditions. The need for innovative snow and ice control techniques and processes has continued to grow as national and European road networks have developed substantially over recent decades. The demand for improvement, including the sophistication of the techniques and technology used, continues to be driven by the increasing need for safe and efficient national and international road freight and passenger transport and by the environmental and other policies affecting highways.

European Commission project, COST Action 344: Improvements to snow and ice control on European roads and bridges, started in April 1999, is a three-year project with participation from eighteen European countries.

The project aims are:

1) Review of existing international practices
2) Definition of snow and ice control requirements in different European climatic regions.
3) Specification of 'Best Practice' in different European climatic regions.
4) Development of guidelines for the integration of specified snow and ice control methods into network level road management and maintenance systems.
5) Recommendations for improvements to driver information and traffic management systems.
6) Recommendations for future research.

This COST Action will promote the exploitation of technological advances in the application and distribution of snow and ice control measures, with a view to providing significant environmental and safety benefits and lower operational costs. Millions of ECUs could be saved through lower operational costs and a reduction in adverse effects on the highway infrastructure and the environment. For the road users, more effective management of winter operations could lead to a reduction in traffic delays and accidents. For practitioners, implementation of 'Best Practice' should enhance standards and lead to Best Value being achieved. The implementation of Best Value could provide the means to measure the performance of the winter maintenance service within various road administrations.

Interim results of the COST Action are being disseminated to European and national policymakers, regional planners, engineers, road and vehicle operators, industry and academia. This approach ensures maximum dissemination of knowledge. The Internet, a CD-ROM, Email, handbooks and events such as workshops, conferences and seminars are being used to target a wider audience.

2. Introduction

Effective snow and ice control is vital to ensure, as far as possible that road users can travel safely and with minimum disruption in cold and severe weather conditions. However, it is important that the winter maintenance service is provided at an affordable price and that 'Best Value' is achieved with minimum environmental impact and traffic disruption, and with high standards of safety. Information on 'Best Practice' is therefore essential to ensure widespread implementation of appropriate standards of service.

The need for innovative snow and ice control techniques and processes has grown over recent decades in line with the development of national and European road networks. The demand for improvement,

including the sophistication of the techniques and technology used, continues to be driven by the increasing need for safe and efficient road freight and passenger transport, and by the environmental and other policies affecting highways.

The COST Action 344: Improvements to snow and ice control on European roads and bridges, started in April 1999 and is part funded by the European COST (Co-operation in the field of Scientific and Technical Research) programme (EU, 1999). The Action (www.cordis.lu/cost-transport/home.html) is a three-year project with participation from eighteen European countries. TRL is the Chair of the COST Action and represents the UK Highways Agency, which is responsible for the operation and maintenance of the Trunk Roads and motorways in England. VTI is the Vice Chair and represents the Swedish National Roads Administration, which is responsible for the operation and maintenance of the Swedish national road network. These organisations are members of the COST 344 Management Committee.

3. Objectives of the research

The main aim of the COST project is to improve the performance of snow and ice control methods and operations by defining the requirements for 'Best Practice' in different climate domains, across the EU and other COST member states. This will provide national highway authorities with information on the best materials, techniques and procedures to meet the changing demands of the European road infrastructure and, at the same time, harmonise safety and environmental standards. It will thus provide guidance to decision makers.

A significant contribution will be provided to meet the stated goals of the Transport European Road Network (TERN) as below:

- Sustainable mobility of persons and goods within the EU under the best possible social and safety conditions (Article 2.2a).
- Integration of environmental concerns into the design and development of the network (Article 5d).
- Promotion of network interconnection and inter-operability between the EU and the third world countries (Article 6).

Assessments of operational practices, employed at national level, are also expected to result in the development of objective criteria and benchmarks for various aspects of snow and ice control and their impact.

4. Work programme

The aims of the research project are:

a) To review existing international practices, involving the following elements:
   - terminology review and creation of a European glossary;
   - literature review covering the years 1990 to 2000 to establish the state-of-the-art practice and research in snow and ice control methodologies;
   - review of current research and development work, in both the public and private sectors;
   - review of current practices by evaluating selected case studies in targeted EU regions; and
   - creation of an inventory of snow and ice control methods, equipment and materials.

b) to define snow and ice control requirements in different European regions;
c) to determine 'Best Practice' in different European regions;
d) to develop guidelines for the integration of specified snow and ice control methods into network level road management and maintenance systems;
e) to make recommendations for improvements to driver information systems and traffic management systems; and

f) to make recommendations for future winter maintenance research, which has potential benefits for practitioners and road users.

Particular areas where further investigation has been proposed are:

- the most effective and least environmentally harmful de-icing/anti-icing materials, and the most effective treatments in the various climates encountered across COST member states;
- implications resulting from the introduction of innovative road surfacings to establish benchmarks for safe and effective winter maintenance;
- innovative Road Weather Information Systems (RWISs), which would benefit from a review of accuracy, reliability and the introduction of developing capabilities such as residual salt sensors; and
- road icing information and prognosis systems.

Investigations are also underway on the following:

- Operational procedures:
  - driver information systems using existing methods and innovative developments employing advanced telematics; and
  - the impact of methods designed to maximise traffic flows and reduce accident severity in winter conditions.

Information on many of these research elements has been drawn from the experience and knowledge of participating member states through detailed assessments and a review of current and ongoing research. The common interests and general objectives are shared by the member states and the planned work is drawing upon most of the relevant work currently in progress and planned within all COST countries together with the results of work undertaken previously.

5. Task Groups

Six Task Groups, TG1 to TG6 with nominated leaders, will run through the three-year life of the Action. The seventh group, TG7 will start in year 3 of the project. These Groups involve the most appropriate blend of technical expertise for the tasks from a broad geographical distribution across Europe to ensure an extensive input and high quality outputs. The Groups are:

TG1 – Information gathering, literature review and glossary
TG2 – Definition of requirements
TG3 – 'Best Practice'
TG4 – Future research
TG5 – Road management system
TG6 – Driver information systems
TG7 – Final report

Each Group has submitted at least one technical deliverable and, these will form a major part of the final report of the Action.

5.1 Task Group 1 - information gathering, literature and glossary

A glossary of winter maintenance terms in six languages – Dutch, English, French, German, Swedish and Spanish has been produced. It is expected that PIARC will adopt the COST glossary, in 2002 at the end of the Action, to complement its own glossary. A European review of literature from 1990 to 2000, which includes over 600 research papers and reports, has been divided into topics (weather and climate, equipment, effects, management, de-icing products, equipment for road users, risk management, strategy, design and construction of the road, costs of winter maintenance, road user information and overview).

The work has also identified about 150 current research projects throughout Europe on winter maintenance practice and management issues.

The review of literature and current projects has identified the gaps in our knowledge and thus where future research efforts should be directed.

5.2Task Group 2 – definition of requirements

The objectives of TG2 were to consider safety, environmental and information criteria, the management and operations of snow and ice control and, to identify improvements that would enable delivery of a more cost-effective and efficient service. To achieve this it is important to set down the components of a winter maintenance management system which, on balance, will produce a quality service. The work of TG2 complements the work carried out in TG3 - 'Best Practice'.

TG2 members have identified the following generic business areas as being of fundamental importance to road administrations:

a) **Service levels** – Relate to the winter maintenance operation itself and includes the effectiveness of the treatment in preventing ice and snow adversely affecting the highway. It does not however include safety and traffic movement considerations, which it is argued, are secondary effects and can be influenced by factors other than the quality of the winter maintenance operations.

b) **Environment –** Includes the effect of winter maintenance operations on the natural environment, including flora, fauna and marine life.

c) **Safety –** Includes the safety of the winter maintenance operatives and the road users. Care must be exercised to ensure that the reasons for safety performance are understood since factors other than the quality of winter maintenance may be relevant.

d) **Traffic movement –** Includes traffic flow during winter conditions, which may again be affected by factors other than effectiveness of the winter maintenance operation.

e) **Cost optimisation –** Includes analysis of all the factors that contribute to the delivery of a cost-effective winter maintenance service.

f) **Information to the administration –** Includes the provision and management of information about the performance of the operation so that proper accountability can be achieved.

g) **Information to the road users –** Includes the appropriate level of information to road users in various forms both before and during the journey made.

These generic issues are set out graphically in Figure 1. They have been disaggregated to a) identify more detailed issues requiring analysis and b) deliver the appropriate quality of winter maintenance service. Items (a), (b), (e), (f) and (g) above are those issues over which the administration has a significant level of control whereas items (c) and (d) are random occurrences influenced by other factors including driver behaviour.

The type of climate is also a prime factor - this depends on the altitude and geographical location, and is manifest through the frequency, duration and intensity of the winter weather conditions (COST 309, 1992). Conventional classifications can be made ranging from mild to very cold climates. A winter index is a given function of the number of days with icy conditions with the minimum and mean temperature. This determines the frequency and duration of ice on the roads. A Road Weather Information System (RWIS) determines the adverse winter conditions in order to make the necessary decisions with sufficient time in hand. Winter weather conditions include snowfalls, ice, freezing rain, fog, snowdrifts, avalanches etc. Their frequency, duration and intensity depend on the meteorology of each area. The onset of winter weather triggers the resources needed to re-establish the serviceability of the road.

Important characteristics of the road are the road type (high capacity or conventional), carriageway

width, layout, gradient, pavement type, frequency and length of bridges and tunnels etc.

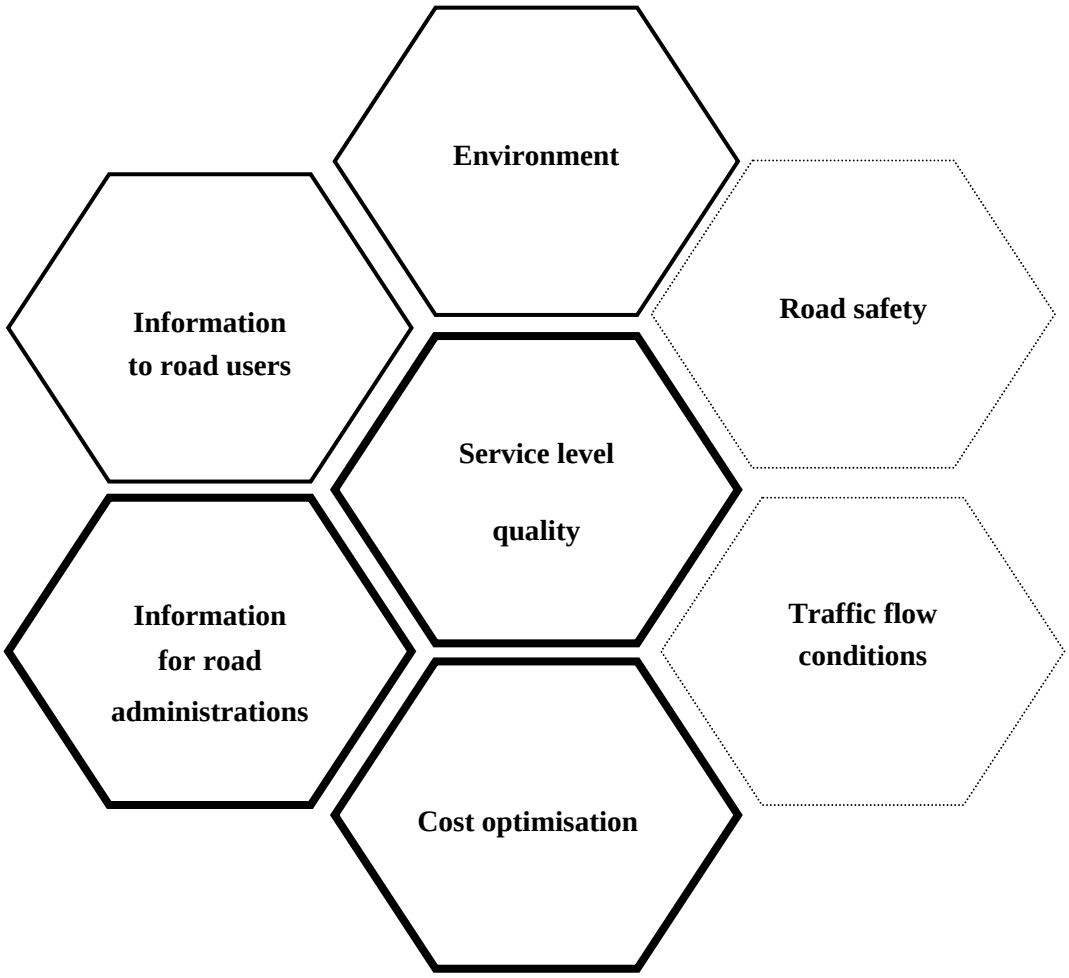

Figure 1. Schematic diagram of the links in the winter maintenance processes

Key:

Issues over which the administration has substantial control.
Issues over which the administration has significant control.
Issues over which the administration has limited control.

5.3 Task Group 3 – 'Best Practice'

The objectives of TG3 are to identify 'Best Practice' in the field of winter maintenance, including the impact of operations on the environment and benefits to service providers and road users. The identification of 'Best Practice' will encompass all the needs of the European Community specific to particular countries and/or climates involved in winter maintenance activities. A questionnaire, in the form of a detailed subject list, was prepared and distributed to EU member states to determine current winter maintenance practices. The responses have been compiled and compared for common climate domains (Scandinavian, Maritime, Central European, Continental, Mediterranean and Alpine). The

climate domains differ especially in temperature (daily and yearly), humidity, probability of snow, wind and expectations of the user. A wide range of practice, environmental issues and benefits have therefore been compared and evaluated.

When preparing a winter maintenance procedural statement, it is necessary to consider climate and weather information, methods, resources (eg manpower, equipment and materials) that will need to be employed. This will include information about chemical de-icers, gritting materials, mechanical snow and ice removal equipment, and special treatments applicable to certain types of road surfacing materials, bridges, cycletracks and pedestrian footways. It will also include developments in RWISs, specifically the measurement of residual chemical on the road surface. The efficiency of the chosen procedures can be measured using internal performance audit methods. An external audit could measure the number and severity of accidents, travel time delay, user satisfaction and environmental impact.

It is also important to have in mind the owner of the road, contract manager, operational staff and road users before decisions about winter maintenance procedures are taken. Fundamental issues, which influence winter maintenance, are climatic conditions, standards and legal obligations. Consideration of the points covered above will enable improvements in 'Best Practice' to be made throughout Europe.

5.4 Task Group 4 – future research

At present, various institutions are carrying out work into improvements in winter maintenance management, procedures, techniques, treatments, weather and climate, safety and other effects. Whilst valuable, these are largely uncoordinated initiatives and the COST Action has brought these together to identify 'Best Practice'.

The objective of TG4 was to identify the most important topics for future research activities in the domain of COST 344.

The work of the task group was carried out in three phases:

- identification of topics for future research;
- prioritisation of future research topics; and
- selection and task description of the most important topics for future research.

The topics for future research were collected via an e-mail survey sent to the COST 344 Management Committee and other international experts. About 90 respondents sent proposals for research topics. TG4 members analysed the list of about 200 different topics received and produced, by merging, a list of 93 research topics for prioritisation.

This topic list was used as a basis for an Internet survey, where experts from different countries and representing different organisations (authority, industry, research or academia) were asked to prioritise the research topics. In all, 57 experts completed the survey.

A number of topics were regarded as very important or important and TG members produced tentative research task descriptions for these topics. The six most important future research topics are:

1. Forecasting, measuring and modelling the road surface condition.
2. Winter maintenance and management policies and strategies (service performance, harmonised quality levels etc).
3. Costs and benefits of operational practice in rural and urban areas.
4. Effects of road weather conditions and winter maintenance on traffic flow and safety, capacity and road user behaviour.
5. More cost-effective, efficient and environmentally friendly de-icing products.
6. Weather-related traffic management and information systems optimal for traffic safety and efficiency.

5.5 Task Group 5 – road management system

A Winter Maintenance Management System (WMMS) is an important integral part of an integrated

Road Management System (RMS) and financial, quality, legal and social aspects need to be considered.

There are two levels of a WMMS that should be considered - the strategic level where the socio-economic consequences of a chosen winter maintenance strategy are calculated, and the day-to-day level used for the management of the winter maintenance activities.

On a strategic level, it is not the objective to define the level of service but to define which parameters have to be considered when defining the level of service. In practice, it is an optimisation process between costs and benefits, as far as is practicable, because of the limited funds available. The efficiency and effectiveness of the service provision and the chosen optimisation process, which must be continually reviewed, determines delivery. New research ideas need to be fed into this optimisation process to continually improve it and the subsequent service.

A WMMS on the day-to-day level may consist of several parts/systems such as:

- administrative information;
- route planning;
- Road Weather Information System (RWIS);
- call-out system;
- reporting and documentation of actions;
- information to road users; and
- follow-up of actions.

Some European countries have a WMMS that includes many of the above parts but many countries have one or more of the parts as separate systems, eg Road Weather Information System (RWIS). A RWIS includes outstations, which measure parameters close to the road, eg road surface temperature, and common meteorological information, eg wind speed, humidity etc.

TG5 members are considering the components and inputs and outputs required for a WMMS and its compatibility with other modules or systems in a RMS. Comments on the benefits of introducing a WMMS into a RMS will be included in the final report from the Action.

5.6 Task Group 6 –driver information systems

TG6 members are considering the effectiveness and benefits of driver information and traffic management systems for road users in adverse weather conditions. Information for drivers is essential if they are to travel safely on the road network in winter but the nature of the information given needs to be timely and accurate. Ways of disseminating the information could include telematics (in-driver vehicle systems), the Internet, radio, telephone, journals, teletext and variable message signs alongside the road.

It is recognised that road users comprise different driver groups, which have different needs for pre-trip and on-trip information. The driver groups have been identified as:

- Professional drivers (eg public transport, haulage, security services)
- Frequent drivers (eg commuters)
- Occasional drivers (eg school errands, tourists)
- Related businesses (eg travel agencies, private information services).

It is important to identify what sort of information each driver group requires. For example, Finland has carried out a study of the frequent and occasional drivers, and this is being examined in detail for the purposes of the Action. This work may be considered as a good example of ‘Best Practice’ and much can be learned from it.

A questionnaire has been compiled by TG 6 members and circulated to all the European members of the Action to seek answers to a series of questions regarding driver information and related information systems. The questions include:

- What actions are used now?

- What are the effects of these actions?
- What are the costs and benefits of driver information systems?
- What do road users need?
- What could be done better?
- What could be provided but is not?

The usefulness of information needs to be considered to avoid information 'overload' and the timing of this information is also important. Three stages of the information process are essential – at the onset of winter weather, during winter events, and in the case of a crisis. This will ensure that the drivers have timely information and can plan their journeys in advance or during their travel on the road network. When faced with exceptional circumstances such as heavy snowstorms and traffic difficulties, collaboration with the police and other bodies is essential.

Private radio systems utilise the information services of the roads administration in Iceland and Finland. For example, TRAVEL-GUIDE is a current project undertaken in Finland and is concerned with traffic management and information services. The approach is to specify a commonly agreed data exchange interface, via which private service providers have access to public organisation information and vice versa. The Viking Travel and Traffic Information Service (www.ten-t.com/viking) and its guidelines propose quality requirements for road weather and road surface condition information. Systems such as these described above are being investigated further in the COST Action.

5.7 Task Group 7 – final report

The final report will include summaries of the Task Group reports, benefits of the project to different user groups, a discussion, and conclusions together with overall recommendations.

6. Dissemination of information from the Action

A dissemination plan has been produced to promote the results of the Action to European and national policymakers, regional planners, engineers, road and vehicle operators, industry and academia. This approach will ensure maximum dissemination of knowledge. Results of the Action are to be disseminated to a wider audience by means of events such as workshops, conferences and seminars in the participating EU countries and member states and by e-mails and the Internet. At the end of the Action, the final report, a CD-ROM and a series of handbooks will be made available to interested winter maintenance personnel in the participating EU Countries and member states.

7. Summary

The COST Action will:

- Identify 'Best Practice' and emerging developments within and between EU and other COST member states.
- Investigate necessary improvements to RWISs to introduce any latest available features such as residual salt sensors.
- Ensure that treatments are carried out to reduce any harmful effects in the environment.
- Assess the impact of methods designed to maximise traffic flows and reduce accident severity in winter conditions.
- Generate recommendations for the integration of specified snow and ice control methods into network level road management and maintenance systems.
- Develop recommendations for further improvement in the dissemination of up to date and reliable information to practitioners and road users.
- Generate recommendations for improving the level and quality of user input information in snow and ice control decision making.
- Identify future research.

8. Benefits

The Action has promoted exploitation of technological advances in application and distribution of snow

and ice control measures leading to significant environmental benefits. With the application of the knowledge gained, millions of ECUs could be saved through lower operational costs and a reduction in adverse effects on highway infrastructure and the environment.

For the road users and communities, more effective management of winter operations will lead to a reduction in traffic delays and accidents.

9. Acknowledgements

The authors wish to thank the members of COST Action 344 Management Committee for their contributions to the project.

The work described in this paper forms part of the UK Highways Agency's research programme carried out by TRL and is published by permission of the Chief Executives of the UK Highways Agency and TRL.

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10. References

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