WINTER SERVICE STRATEGIES FOR INCREASED EUROPEAN ROAD SAFETY – THE RESULTS OF COST ACTION 353

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ABSTRACT

The European COST Action 353 “Winter service strategies for increased European road safety” ran from April 2004 until April 2008. About 50 participants from 22 European countries have been intensively working to achieve the main objective of the Action – to develop a framework for the management of winter traffic for maximized road safety.

There is not a common European policy for winter road maintenance, but in future the level of service for European Road Networks should be consistent. It is extremely important for all parties involved in winter maintenance to be aware of new and innovative technologies emerging in many fields of technology that might be transferred or adapted for winter maintenance activities, capable of supporting best practices. Innovative techniques, new technological solutions for different problems, development of new products and new management systems are emerging daily and offer inexhaustible sources for possible improvements in winter maintenance.

The most interesting new and emerging technologies are identified within the scope of COST 353. In particular the rapid developments in IT, vehicle design and near space activity need to be watched carefully for practical techniques. Another main objective of COST 353 are case studies of Winter Maintenance Management Systems (WMMS) and their components in different countries and the use of these prototypes.

KEYWORDS

WINTER SERVICE / WINTER MANAGEMENT / MANAGEMENT SYSTEM / EMERGING TECHNOLOGIES / COST 353 / ROAD SAFETY

1. INTRODUCTION

COST- the acronym for European **CO**operation in the field of **S**cientific and **T**echnical Research - is the oldest and widest European intergovernmental network for cooperation in research. Within the COST Framework the COST Action 353 was initiated by United Kingdom as follow-up of COST 344 „Improvements to Snow and Ice Control on European Roads and Bridges“ and started in April 2004. It ran for a four year period until April 2008. The participating countries are shown in Figure 1.

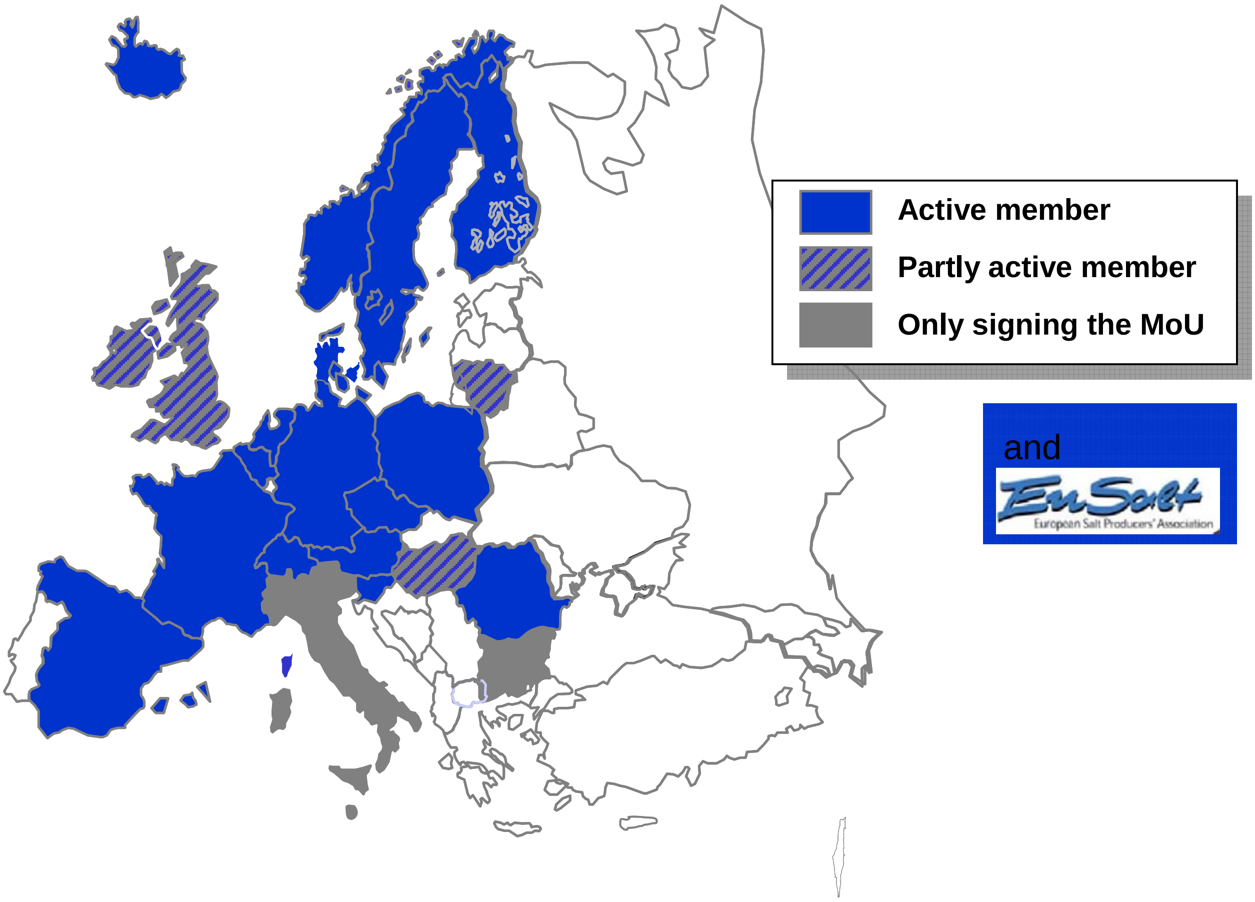

Figure 1 - Participating countries of COST Action 353

The main objective of the COST Action is to develop a framework for the management of winter traffic for maximised road safety. The framework for the COST Action includes both winter maintenance and traffic management tools, including Intelligent Transport Systems and Services (ITS), for application and implementation by road authorities on strategic, urban and rural networks. The expected outcome is a high level of service performance, low accident risks and minimal traffic delays to freight, road users and pedestrians on the whole European transport system. The secondary objective is to integrate new methods of winter maintenance management through the use of the latest technologies for data management, communication and vehicle positioning.

All activities of COST 353 were coordinated by a Management Committee (MC) (see Figure 2) and the main results of these activities are documented in a Final Report [1]. Main event for the dissemination was the European Conference "New Developments for Winter Service in Europe" in May 2008 in Bad Schandau (Dresden), Germany, where besides the results of COST Action 353 an overview of actual development and research in Europe was given [2].

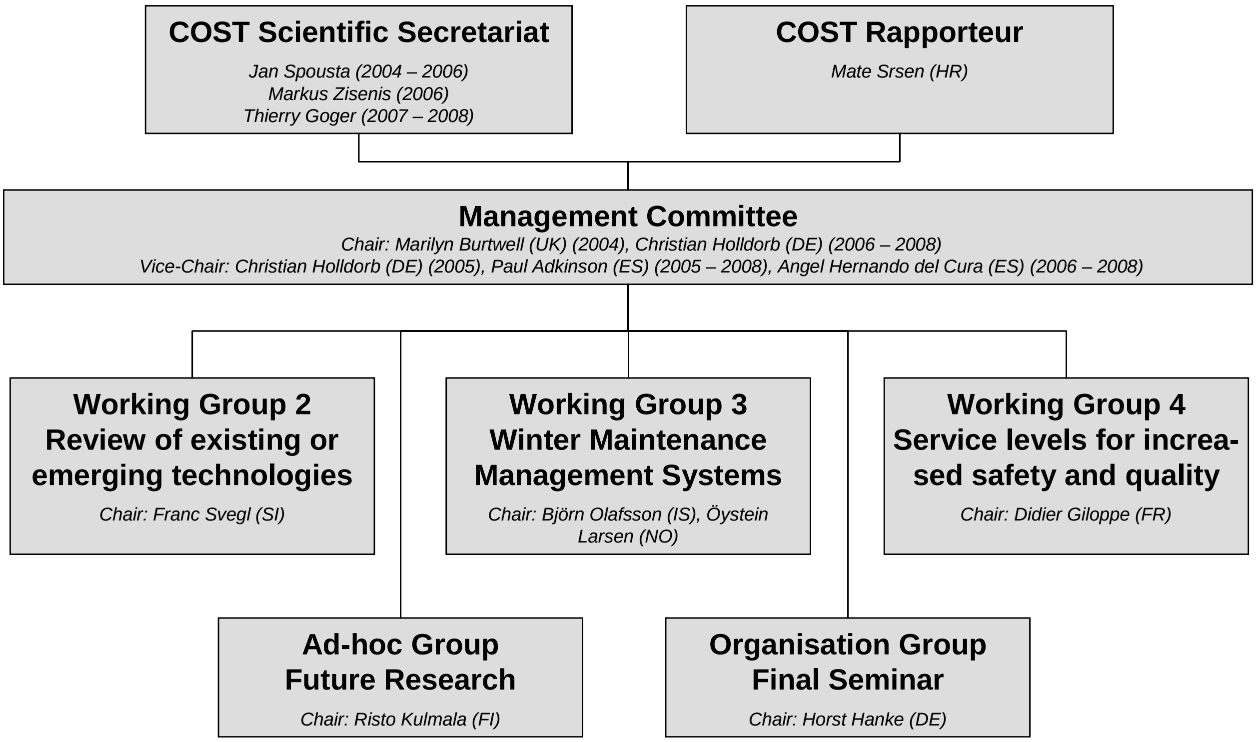

Figure 2 - Organization chart of COST Action 353

2. WINTER SERVICE ON THE EUROPEAN ROAD NETWORK

2.1. The European road network

Road classes are not particularly uniform across Europe. But in summary, one can say that Motorways, National Highways and Regional Roads (and sometimes the County Roads) form a type of higher quality network, which is in general administered by uniform organisations. The other roads are administered in a somewhat patchy way by local authorities.

The densities of the road and motorway networks are very variable in Europe and are related to the population and the capacities of financing which have existed in each country. It varies also in a significant way in the same country (for example the Scandinavian countries where the road networks in the south of the countries are much denser).

The main European road network is shown in Figure 3. The motorways in the 25 member states of the European Union have a total length about 60,000 km. The whole road network has a length of 4.7 Mio kilometres.

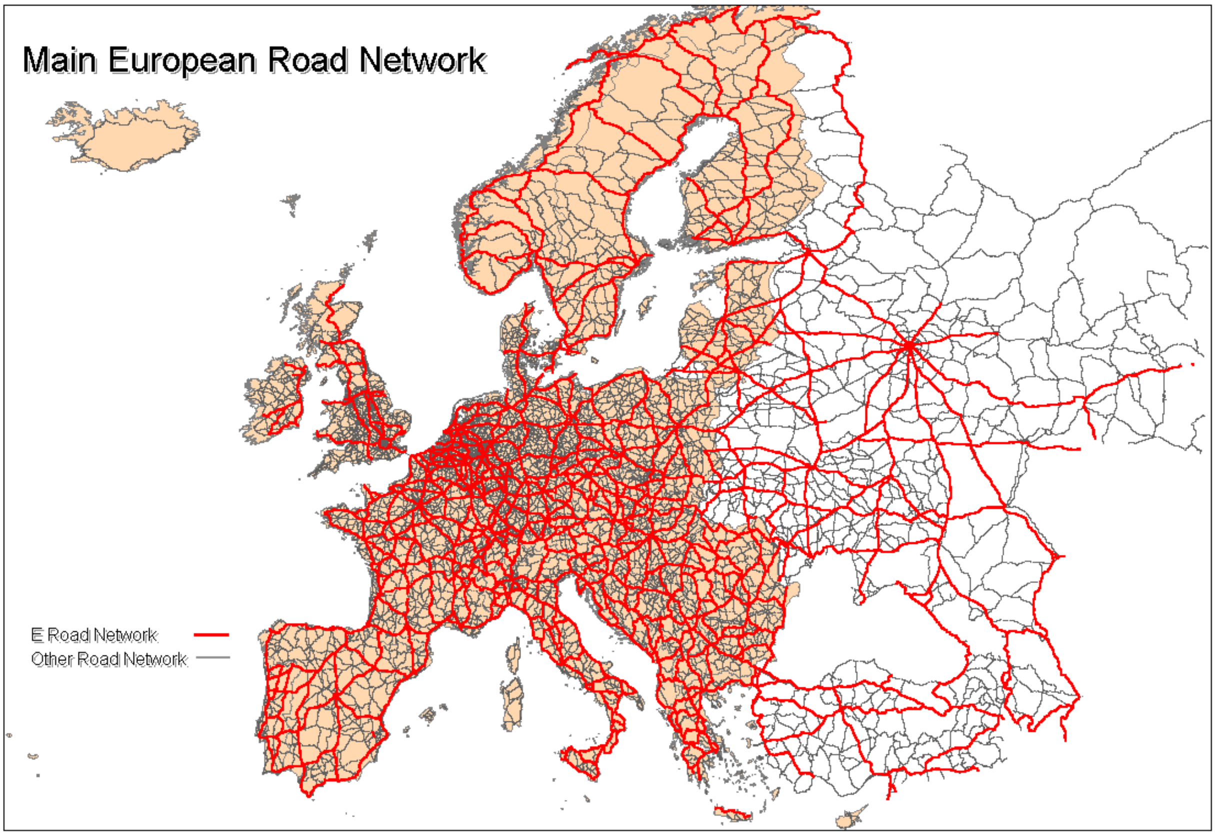

Figure 3 - Main European road networks; E-roads in red,
other roads of less importance in grey [1]

2.2. Climatic conditions in Europe

In the same way as the road network isn't uniform across Europe the climatic conditions are different. In Figure 4 six climatic zones are differentiated in ascending order based on winter rigour. The different classes are based on the average of the number of days of freezing over December January February and March during forty years (a certain amount of smoothing could be considered.)

- **W1 zone:** The winters are mild here and problems of winter maintenance arise during fluctuations of temperature around zero degrees which can cause freezing of road condensation. Snowfall is rare.

- **W2 zone:** The winters remain mild but temperatures around zero degrees are more frequent. In terms of winter maintenance the most encountered problems relate to the freezing of condensation or pre-existing moisture, with relatively rare snow-covered precipitations. The W2 zones relate to areas with strong density of population in the central part of the EU.

- **W3 zone:** The temperatures are lower and persist for longer, with more frequent and longer more significant snow fall, which remains for longer. The areas concerned are also densely populated parts of the EU.

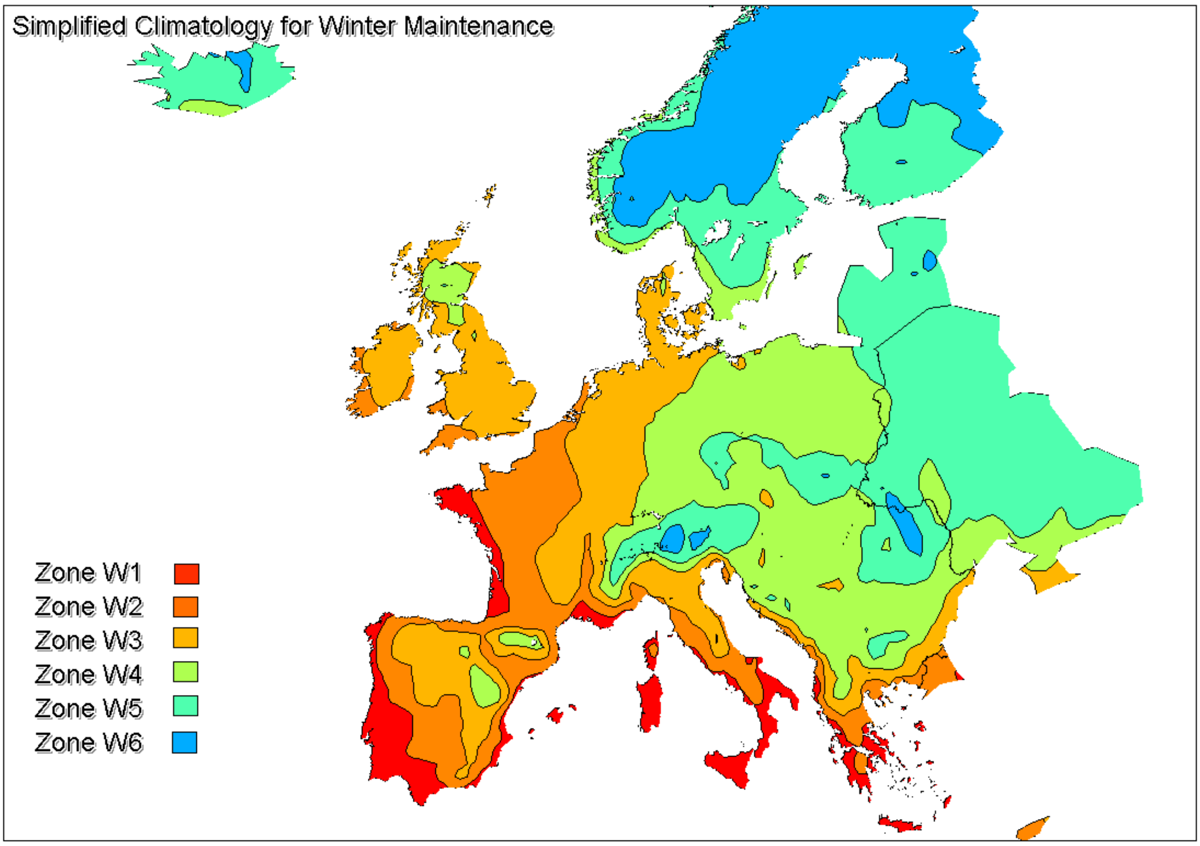

Figure 4 – Simplified climatology for winter maintenance. Based on the average number of frost days in winter months (December through March) [1]

- **W4 zone:** The W4 zone is strongly under the continental influence. The winters are harder here with low temperatures, sometimes for long periods and significant snowfall which lies on the ground. The problems of winter maintenance are significant both for snow clearance and the fight against ice. This zone also corresponds with populated areas.

- **W5 zone:** This zone relates to the continental part of Europe, the more northerly zones as well as part of the Alpine massif. The winters can be very hard, in particular in the mountain massifs and the central part of Europe. Snowfalls are abundant and the temperatures very low. Winter maintenance is driven by the need to maintain economic activity.

- **W6 zone:** This climatic zone covers the mountainous zones. The winters are very hard with falls of significant snow and temperatures very low, sometimes for long periods. Winter maintenance is essential to maintain economic activity and a "modern" way of life.

2.3. Recommendations for optimizing winter service and road safety in Europe

Because of the allocation of maintenance to EU and EEC Member States, there is no European policy for winter road maintenance. Member States and local authorities may operate their own maintenance equipment, hire contract services, and establish their own Level of Service goals. Level of Service may be based on pavement condition goals, traffic levels, or customer satisfaction. Winter road maintenance efforts vary based on climatic conditions, agency resources, and roadway characteristics. Higher classes of highways generally receive more attention. Motorways are typically cleared more completely and quickly. Critical areas like mountain passes may have snow-chain requirements for vehicle tyres, and some countries have winter tyre requirements.

Regional differences between average and extreme snowfall, temperature and air humidity create differences in how road maintenance agencies respond to winter weather, from continual and routine treatment to occasional and emergency response for infrequent events. In some Member States, maintenance agencies cooperate with traffic management centres and the police to close lanes during snow and ice control operations, impose lower speed limits during inclement weather, or restrict travel to vehicles with winter tyres or chains.

In future winter maintenance for European Road Networks should observe the following policies and operating principles:

- Winter maintenance aims at ensuring highest road safety and predictable driving conditions. A socio-economic model (a WMMS on a “strategic level”) supports decision on best winter maintenance.

- The Level of Service on heavily used European Road Networks (Trans-European Transport Road Network, Pan-European Transport Road Network, International E-Road Network) is consistent. The National Road Administrations offer safe conditions to the road users on all roads and to the winter conditions as well as the traffic volume adapted maximum mobility.

- The States Governments agree on a common Level of Service on heavily used European Road Networks and ensure that contractors keep the roads in the agreed conditions.

- The National Road Administrations provides the road users with information about the driving in winter conditions.

- Innovative road weather and traffic information systems are used to inform road users and contractors of the situations on the roads.

- Environmental effects are being reduced (e.g. by anti-icing with brine and pre-wetted salt).

The basis for a common European winter services level should be the same road qualities on the strategic network. This presupposes construction and maintenance standards. For example roadways should not have too deep ruts and a minimum friction level of the pavement should exist. The roads must possess a drainage, so that rain and meltwater can flow off completely and rapidly.

3. NEW AND EMERGING TECHNOLOGIES

New and emerging technologies will have decisive impacts on future developments in winter service and road safety. New materials, sensors and other electronics based on nanotechnology, satellite supported GIS and other measuring equipment, fast data transfer and decision making evaluation software tools, and models for local weather forecasting are just a few of the multitude of new developments, which will change the road infrastructure, bring new strategies, optimise winter service and improve road safety. However, human factors are equally important in improving road safety.

When looking for improvements in Winter Maintenance, researchers and practitioners should be prepared to look outside their own field. In particular the rapid developments in IT, vehicle design and near space activity need to be watched carefully for practical techniques, which can be adapted for use.

Both new and emerging technologies can present great potential to enhance winter road services and safety in the areas listed in Table 1.

Table 1 - Identification of improvement areas and expected outcome

Area of improvements	Examples of expected outcomes
Road infrastructure	Intelligent road; new sensor systems; information systems; ...
RWIS	New developments in forecasting and data analysis
Ice and snow removal	New techniques, techniques adapted to cities
Spreading technology	Equipment – vehicles, tools…. – alternatives to existing equipment – increase the speed, uniformity of spread – quality control system
Surface condition assessment	New techniques, residual de-icer
Data management / Exchange	Car and vehicle information systems for collecting data (Floating Car Data)
Maintenance Centres	Training of staff, safety systems, infrastructure
Equipment	Maintenance vehicles, engines, tools, auxiliary, sensors, truck warning system, rear visibility improvement, vehicle guidance system
Materials	De-icers,… - find alternatives, enhancement of existing materials, find the synergy between the road and de-icer, life cycle analysis
Management systems	Implementation of new tools
Road user information	Improve communication by telematics, geomatics ,…
Safety measures	Road user behaviour; common EU education program for winter conditions driving – winter driving test

The most interesting topics of the large corpus of work identified in COST 353 were classified according to improvement areas. Many of the techniques might contribute improvements in more than one area, and also might have some negative impacts. Table 2 gives an overview of this classification, with a broad assessment of the likely usefulness of the topic. A more detailed description of these technologies is given in [1].

Table 2 - Overview of technologies - COST 353

Technology	**Area of improvement**											
	Road infrastructure	RWIS	Ice and Snow removal	Spreading technology	Surface condition assessment	Data Manage-ment / Exchange	Maintenance centres	Equipment	Materials	Management systems	Road user information	Safety measures
Technologies in limited use												
Use of mobile sprayers in work areas	**XX**		**X**				**X**	**X**				
Sensor developments	**X**	**XX**	**X**		**X**	**X**	**X**	**X**		**X**	**X**	
RWIS Standardisation Activities		**XX**			**X**	**X**		**X**		**X**	**X**	
Use of Java map RWIS)		**XX**				**X**				**X**		
Warm wetted sand / Salt			**XX**	**X**				**X**	**X**			
Friction measurements					**XX**	**X**				**X**	**X**	
Infrared controlled spreading		**X**		**XX**	**X**	**X**	**X**			**X**	**X**	
Infrared assessment of road conditions		**X**			**XX**	**X**				**X**	**X**	
Non-contact surface temperature determination		**X**		**X**	**XX**		**X**				**X**	
Non-contact surface status determination		**X**	**X**	**X**	**X**						**X**	
Residual deicer determination		**X**	**X**	**X**	**X**		**X**			**XX**	**X**	
Salt management systems						**X**	**XX**		**X**	**X**		
Treated salt	**X**		**X**				**X**	**X**	**XX**			
GPS - Tracking						**X**	**X**	**X**		**XX**		
Jetbroom with a sweeper blower unit			**X**	**X**				**XX**				**X**
Use of algorithm in decisions							**X**			**XX**		
Use of web sites for road information		**X**				**X**					**XX**	**X**
On board user information		**X**				**X**					**XX**	
Avalanche protection			**X**									**XX**
Technologies available for implementation												
Emergency services – Saving time in ice and snow removal			**X**				**X**	**X**				**X**
Technologies needing adaptation												
Continuous fertilizer weighing – Precision agriculture					**X**				**X**			
DFIS – Floating car data system					**XX**	**X**	**X**			**X**	**X**	
Non-contact surface status determination		**X**	**X**	**X**	**XX**			**X**				**X**
Driver training							**XX**					**X**
Sensors involved in cereals yield measurements				**X**				**XX**				
Intelligent tyre					**X**	**X**	**X**			**X**	**XX**	
Technologies needing further research												
Temperature behaviour on bridges	**XX**	**X**			**X**						**X**	**X**
Spreading (recent researches)				**XX**				**X**				
Electromagnetic sensoring system of soil conductivity					**XX**							
Surface salinity determination		**X**			**XX**						**X**	
Phase change materials	**X**		**X**						**XX**			**X**
Nanotechnology	**X**		**X**									

Legend: XX = very positive development, **X** = positive development

- **Technologies in limited use in winter maintenance:** The technologies highlighted in this section are existing technologies which have been already trialed and adopted for Winter Maintenance. The extent of adoption varies. Some countries may use a process widely which has not even been trialed in others. In general, however, the technology has been used for less than 10 years.

- **Technologies available for implementation**: This section deals with technologies which have been adopted in other sectors, but which require little or no adaptation before use for highways winter maintenance.

- **Technologies needing adaptation:** Some technologies are either at an early stage of development or need considerable adaptation before they would be applicable to highways winter maintenance. Being aware of their potential in this field may enable the industry to influence the development of the technologies to serve winter maintenance

- **Technologies needing further research:** These technologies could have a great potential for winter service in the future, but further research is necessary to develop the technologies.

4. WINTER MAINTENANCE MANAGEMENT SYSTEMS (WMMS)

The IT systems available for the organisation and execution of a winter maintenance service can be classified in different ways. Furthermore, it becomes patent that WMMS are not separate stand-alone systems but contain components of the entire information and management system used in road administration. A classification is shown in Figure 5. The components on the left supply the basic information needed before the winter maintenance operation begins. The components in the centre of the chart are relevant during the operation. The components on the right use the data and information acquired during the operation. Apart from the components shown, other systems, such as salt storage management, are a part of a WMMS.

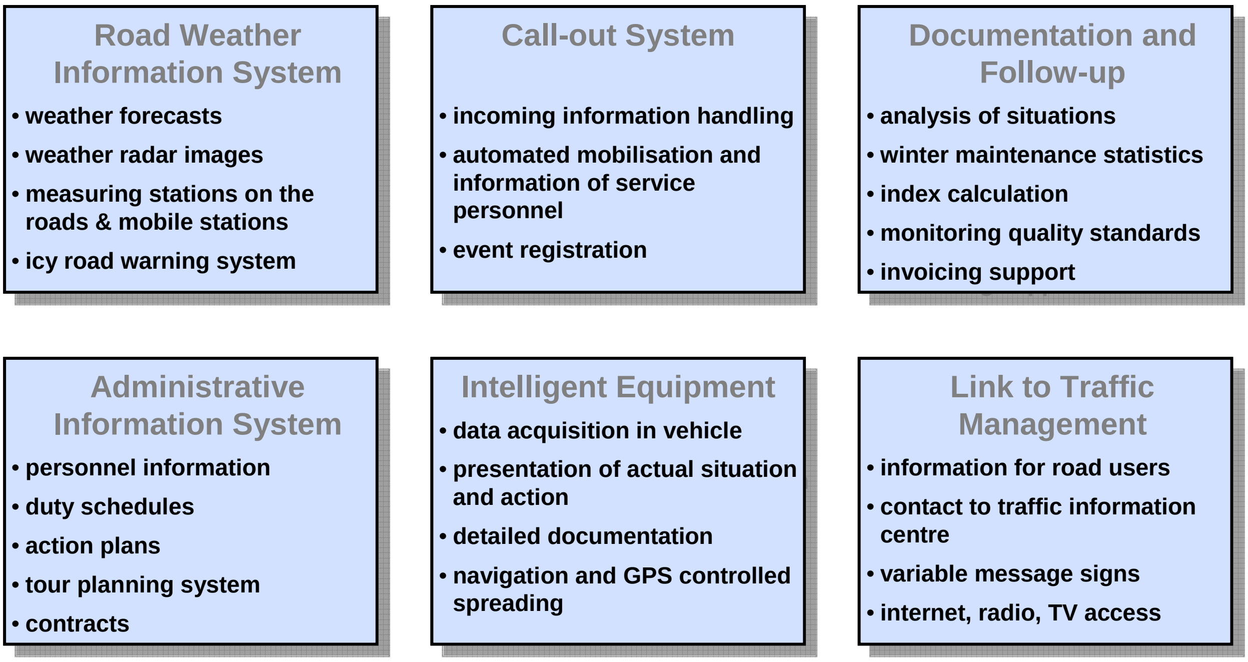

Figure 5 - Components of a Winter Maintenance Management System [3]

One of the main tasks of COST 353 has been to evaluate existing Winter Maintenance Management Systems in Europe. During the first part of the project an evaluation system including an evaluation table was made to make the evaluation as uniform as possible.

The evaluation considered both economical and functional aspects. With regard to the economical aspect, the evaluation of the implementation costs is made on one hand and the operational costs on the other. Functional aspects include the efficiency, use or benefits of the system The evaluation was made for today's systems and for expected future systems.

During COST 353 a description and evaluation of WMMS in participating European countries were made by winter experts in each country. Systems of the following countries were involved: Austria, Belgium, Czech Republic, Denmark, Finland, Germany, Iceland, Norway, Romania, Spain and Sweden.

The experiences with the different WMMS in use in Europe clearly indicate that these systems are efficient for optimising winter services. By optimising the management of a winter service, certain benefits could increase. Winter maintenance actions will be carried out faster and preventive actions to prevent slippery roads will become easier. As such, the risk of accidents and traffic jams will be reduced. Traffic safety during wintry conditions could increase significantly through the use of WMMS.

For road administrations and other operators the cost of a winter service can minimized by the reduction of operating and stand-by duties and by optimising the winter service strategy, especially through anti-icing actions that need a lower amount of spreading agents than de-icing strategies. This optimising of salt consumption is a benefit for the environment too. Particularly in areas with low population density and hard wintry conditions, WMMS enables the population to be informed about road conditions and winter maintenance actions so they can consider this when making decisions regarding the use of the roads.

Based on the results of the evaluation and new developments for WMMS the recommendations for an efficient WWMS are [4]:

- **Road Weather Information System (RWIS):** The quality of RWIS outputs could be raised to the level of giving suggestions for the timing and type of maintenance needed. The decision would lie with humans weighing the quality of RWIS information before implementing actions. This implies tying the outputs more directly, even automatically, to the next steps in the winter road maintenance process: the call-out system, traffic management, documentation and follow-up. The deeper integration of road weather information into the other parts of the WMMS will help to use the human resources involved more efficiently. Human attention time can be focused on difficult decisions by shifting routine activities from simple decisions to automation.

- **Administrative system:** The administrative part of the WMMS combines all information and procedures needed by operators and decision makers, and must support and assist operators and supervisors to manage all activities for their operations. Whether this will be a totally computer-based or paper system is still not the most important factor. What is paramount is the efficiency of the method adopted, both from technical and economic points of view.

- **Call-out system:** An efficient WMMS should contain automated call-out facilities combined with automated feedback from the drivers based on e.g. online data collection or SMS/Warp/Web communication. In this situation, the operator can focus more on handling the problems while all standard communications are made and registered automatically. This will increase the number of activities that can be managed by one person. Apart from automated call-out and feedback, it is always important that the WMMS gives the operator a clear overview of the situation during an action. The systems should help the operator to do the right things by containing predefined plans, strategies, etc. and must always ensure a clear overview. The main consequence of having an efficient call-out system as part of the WMMS is the ability of each operator to control a higher number of activities, obtaining a more standardised and well documented result at the same time.

- **Intelligent equipment:** The use of intelligent equipment in winter maintenance trucks is essential for winter service management. It has to be in use not only for data acquisition but also to assist the truck driver. Intelligent equipment has to be integrated into the whole WMMS. Online data transmission is important for flexible management of the winter service. Information about weather and surface conditions in the whole network could be collected by the winter operation vehicles and transferred online to the maintenance centre. However, even without online data transfer, collected data can be used for different analyses. Besides data and information gathering, intelligent equipment in the truck should be used for assistance of the driver through flexible route navigation and automatic adjustments of the spreader. Route navigation is essential for optimal performance just as GPS-controlled spreading is essential for quality improvement.

- **Documentation and follow-up:** The demand for documentation will probably increase in future due to different reasons. More outsourcing of Winter Maintenance will need more documentation of the work carried out and the winter standards achieved. Stricter environmental requirements will demand more documentation on the use of resources and chemicals. In case of claims from insurance companies after accidents and delays, it will become necessary to have documentation of the work carried out and achieved standards. In future, the technology for automatic data collection and registration will improve. Electronic systems will be developed, and the systems and equipment will become cheaper. This will make it possible to use more and better electronic systems for follow-up and documentation of winter maintenance. Electronic registration systems should replace manual form systems.

- **Traffic management and information:** Traffic management and information form an integral part of road network operation, which is foreseen to be the main task of road authorities and operators in the future. This change reflects the needs and requirements of the users of the road transport system wishing to be well informed and supported during their daily journeys and transportations. At the same time, technology development is very rapid. By the year 2020, cooperation between the industry, road operators and other stakeholders will make new information and communication technologies available, which will enable two-way communications between vehicles and drivers and between vehicles and (road side) infrastructures.

The evaluation of the different systems, and especially the evaluation of the weighting of the components, makes it clear that the requirements of a WMMS are individual and depend on specific requirements. These do not depend exclusively on traffic, road and climatic conditions, but also the type of winter service organisation and strategy. In particular, the extent and the method of the integration of private contractors in winter maintenance actions define the requirements of a WMMS. Because of the individual structure of each WMMS, the build-up and implementation of WMMS components are projects which need clear project management structures. Good planning and design of WMMS structures are very important for the efficient use of the WMMS as well as for cost minimizing.

Because of the rapid developments in information and communication technologies, the implementation of WMMS should be done step by step. On the other hand, with the implementation of WMMS new strategies and organisational structures will very often be implemented, so both have to be carried out in accordance with the other. After implementation, the training of the staff and a permanent quality control is necessary to ensure the efficient use of the system. Training of the staff means not only training with new software products or equipment, it means above all teaching the new methods and the efficient use of the WMMS components.

To implement WMMS step by step a modular structure is necessary. For a modular structure clear data structures and interfaces between the different modules are important. This requires standardisation as has commenced on a European level in CEN Project 337. Through modular structures, no black box system will be implemented. These systems will be open in order to allow the inclusion of components from different suppliers.

The winter maintenance manager can get a lot of information about weather and road conditions, traffic situations and on the actual winter maintenance actions. By using modern information and communication systems it will be increasingly easier to distribute this information to all relevant users. But it must be remembered that a clear presentation of the relevant information is very important for the adequate use of the data. For this, user interfaces will be more in focus in the future.

Many issues need to be solved in the near future to facilitate the emerging changes. Business models and cases need to be solved as well as the legal issues concerning security, privacy, liability, and free competition. Key topics for development also include agreements on harmonised quality levels for information, harmonised quality levels for infrastructure, interoperable road side units, interoperable on-board units, communications and spectrum requirements. Finally, the effects of the new systems and services need to be comprehensively assessed to show all their impacts on the users, the transport system and the society as a whole.

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