CEDR

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des Directeurs des Routes

Conference of European
Directors of Roads

Winter service research needs

May 2015

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This document expresses solely the current view of CEDR. Readers should not regard these views as a statement of the official position of CEDR's member countries

1 Executive summary

CEDR task group N3 (Winter maintenance standards) was tasked with providing CEDR with information about winter maintenance standards, procedures and operational methods and challenges as well as a list of possible research topics from the field of winter service that could be used in the coming 2015 CEDR research call.

The group divided its work into 3 working phases:

To begin with, information about winter service organisation was obtained through the exchange of information at task group (TG) meetings and the exchange of e-mails between members of the TG. In the second phase, a questionnaire about operational activities and problems in providing winter service was drawn up and distributed among members of the TG and other CEDR members. The questionnaire was logically organised according to 7 topics and contained a total of 37 questions. The group achieved a very good response rate of 55% from all CEDR members and was able to compile quite a lot of useful information for comparative analysis. The analysis was carried out on ten questions, determined as the most adequate for comparison. The analysis can be summed up as follows:

1 Most countries organise their winter service at state level.

2 Winter service is generally provided by a state-owned or private company.

3 Generally speaking, all analysed countries find it difficult to ensure the drivability of roads in winter time.

4 The main problems that countries face when providing winter service are: problems connected with salt spreading, heavy traffic, and operational problems relating to manpower and financial resources.

5 The standards and regulations for providing winter service generally meet the requirements of road users.

6 All analysed countries use some kind of system that connects road weather stations and sensors. They also have access to data from meteorological authorities, weather forecasts, etc.

7 Weather and traffic information is mainly obtained from national meteorological authorities, weather forecasts, floor sensors, and road weather stations

8 Most countries use the following measures for operational interventions: 1) intervention according to previously prepared road condition scenarios, 2) required levels of road drivability,

3) intervention on the basis of MDSS and Road Weather Information Systems (RWIS), 4) the time interval in 24h in which the road needs to be drivable.

9 The usage of advanced technologies in winter service varies greatly from country to country; only a small amount of the technological solutions available are actually in use.

10 The main topics suggested for research relate to the salting of roads, the monitoring and evaluation of the efficiency of winter service activities, new gritting materials, Maintenance Decision Support Systems (MDSS), and new weather forecasting technologies.

After reviewing the answers to the questionnaire and carrying out comparative analysis, the task group was able to identify the research topics that would probably be of common interest to all CEDR members. Topics were rated according to their importance for the analysed countries:

1 Guidelines for winter service

2 Calibration mechanisms for machinery

3 New gritting materials

4 Maintenance Decisions Support Systems (MDSS)

5 Salt and gritting material consumption

The task group then focused on coming up with solutions for its task and comparing possible ways forward. The task group concludes that with regard to winter service topics, CEDR members can choose between three solutions:

1 CEDR invests in the above-mentioned research topics, which are recognised as being of common interest to all members of the group and to the NRAs that answered the questionnaire.

2 CEDR does not invest in research topics from the field of 'winter service' as there is enough ongoing research already but should instead invest in obtaining information about research results and new technologies relating to the above-mentioned topics.

3 CEDR continues its investment in the topic of winter service through the work of its task groups, focusing its attention on 'How to improve maintenance with less money?'

After comparing the solutions (their social, economic, and environmental consequences), it seems that solution No. 2 is the most appropriate for CEDR members in the current circumstances. Consequently, CEDR task group N3 (Winter maintenance standards) recommends that CEDR does not include the topic of winter service in its research call, but first invests in obtaining information about completed (and on-going) research from the field of winter service, which should be abundant. Additional funds could be better invested in encouraging countries to implement new, already available technologies into their winter service practice.

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3 Definition of the issue (problem)

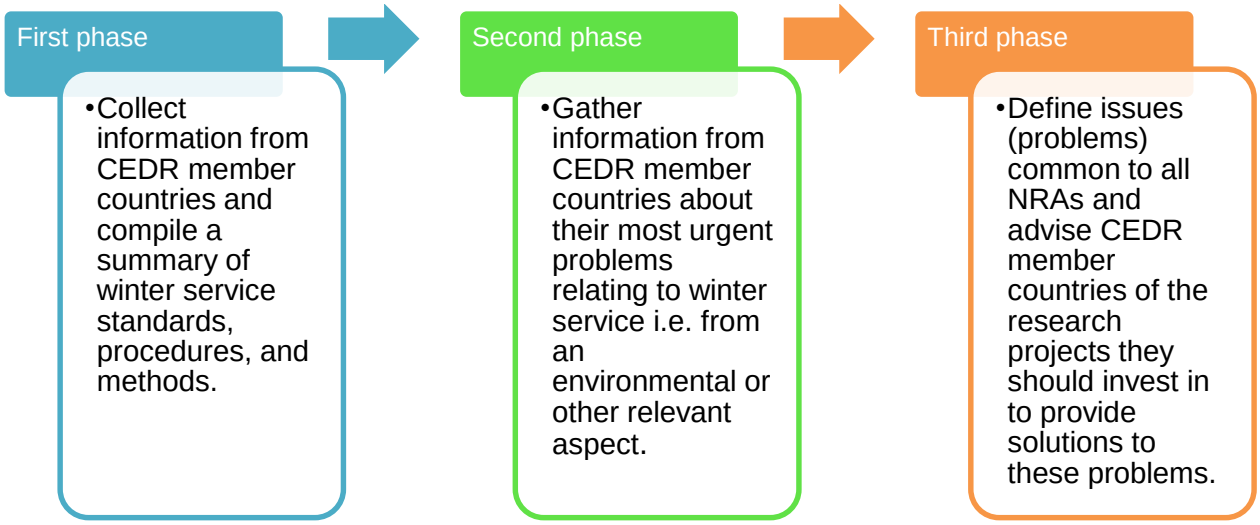
The efficient operation of road networks in winter, including snow removal and anti-skid measures, is an important role for European road administrations. Legal obligations and operational standards that define the works to be performed differ throughout Europe.

Purpose: the main goal of task group N3 was to help countries, CEDR members, to be able to compare their levels of service and identify common problems in providing winter service for the end-users. As written in the CEDR Strategic plan 2013–2017, the task of this group was to provide CEDR with a list of possible research topics from the field of winter service for eventual future CEDR research calls. Once common problems have been identified, interested NRAs can then invest together in research projects that will provide solutions to their most urgent issues.

Scope: the task group sought to compile available information about winter service standards and procedures from 25 CEDR member countries. This information includes data about the applied legal standards and procedures, systematic regulation of winter service, operational methods, and equipment and materials used. The group decided to focus on gathering and comparing information about operational difficulties and the most urgent issues relating to winter service.

The group reviewed research that has already been completed and work on the same topic. It began with the work and data about winter service from the WRA-PIARC 'Snow and Ice Databook 2010' , which was found to be more general and not as specific as defined in the mission of this group. The next step was to liaise with WRA-PIARC technical committee 2.4 Winter service, which is working on similar topics and organises a PIARC Winter Road Congress every four years, in order to exchange research ideas.

Methodology: most information and data was obtained from responses to the questionnaire that was drawn up by the working group. Some was obtained from face-to-face contact between the members of the group. The working activities were organised in three phases:



Two task group meetings were planned and an additional one with the members of the WRA-PIARC Technical committee 2.4 Winter service was held during the international winter road congress in Andorra in February 2014 in order to avoid a duplication of work.

4 Possible ways forward (solutions)

4.1 Obtaining the data

Task group N3 (TG N3) began its work with the mandate from CEDR to identify the most problematic winter service issues common to all CEDR members countries (or at least to the members of the group) on which further research needs to be carried out in order to improve winter service in the future. Members of the group took the vision of improving winter service to mean achieving a more environmentally sustainable, user-friendly, operationally efficient, and cost-effective winter service. The diagram below (Fig. 1) shows some of the issues that were seen as a starting point for the task group's work. Some of these issues later proved to be problematic in different states.

Fig. 1: Some of the issues that were seen as a starting point for the work of TG N3

In order to get a clearer picture of the actual features and difficulties of winter service in different countries right now, the group needed more in-depth information. It was decided that the necessary data about winter service in different member states would be gathered:

- from the WRA-PIARC Snow and Ice Databook 2010,
- through personal contact at TG meetings (i.e. from members of the task group), and
- through a questionnaire (sent to TG members and all other CEDR member countries).

A review of the Snow and Ice Databook 2010 showed that the information in this document is, although very rich, rather inconsistent. Very detailed data is available for some countries but not for others. Moreover, most of the information focuses less on winter service procedures and more on the climatic conditions in the countries and some basic operational concepts. The group concluded that although this document provides a very comprehensive overview of winter service in PIARC member countries, it could not be used for the purposes of this group.

Consequently, the focus was placed on gathering information directly from the representatives of the member countries (group members) and through a questionnaire. Group members exchanged certain information about the organisation and the most problematic issues relating to winter service in their countries at the task group's kick-off meeting. However more in-depth data was gathered later on through the questionnaire that will be presented in later chapters of this report.

The following sections provide brief descriptions of the organisation of winter service in the countries that are members of this working group.

4.1.1 Slovenia

Slovenia is quite a mountainous country with a largely continental climate, which means cold winters with relatively large quantities of snow and on rare occasions sleet and icy rain. Legally speaking, the period of winter service lasts from 15 November until 15 March, but winter service is provided outside this period if the need arises. During this period, winter service and maintenance activities must be organised around the country. Such activities are under the constant scrutiny of end-users. As Slovenia is also a transit country, inadequately equipped heavy-goods vehicles often have to be cleared off the road in the winter period.

Regular and winter management and maintenance of state roads in the Republic of Slovenia is a mandatory public service of special importance for which the Government of the Republic of Slovenia is responsible. The legal framework basically consists of three main legal acts:

- *The public law about roads (Zakon o cestah),* which is the basis for all subsequent legal acts in the field of road management, maintenance, and safety.
- *The rule on the types of maintenance works on public roads and on the level of regular maintenance of public roads (Pravilnik o vrstah vzdrževalnih del na javnih cestah in o nivoju rednega vzdrževanja javnih cest),* which includes, among other things, the prescribed standards.
- *The regulation on the implementation of public service of state roads maintenance (Uredba o načinu izvajanja gospodarske javne službe vzdrževanja državnih cest)*

Financial resources for the management, maintenance, and safety of state roads are provided by the State Budget of the Republic of Slovenia, which is audited annually by the Court of Audit of the Republic of Slovenia.

The responsibility for maintaining motorways and expressways in Slovenia lies with DARS d.d. (DARS, Motorway Company in the Republic of Slovenia) which is a 100% state-owned company. It has nine motorway bases across Slovenia. Winter maintenance accounts for approximately 10% of all motorway and expressway maintenance activities and 23% of total annual maintenance costs. The main standard for DARS in winter is: regardless of the severity of weather conditions, at least one driving lane on motorways must be drivable at all times and snow height must not exceed 10 cm. The responsibility for other state roads lies with the Ministry for Infrastructure, more directly with its subsidiary body, the Slovenian Roads Agency (SRA), which manages main and regional state roads. SRA deals with investment maintenance (i.e. when major maintenance or repair works requiring extensive funding are needed on an existing road) as well as with regular maintenance (e.g. grass-cutting, etc.) and carries out its maintenance duties through contracts with individual companies.

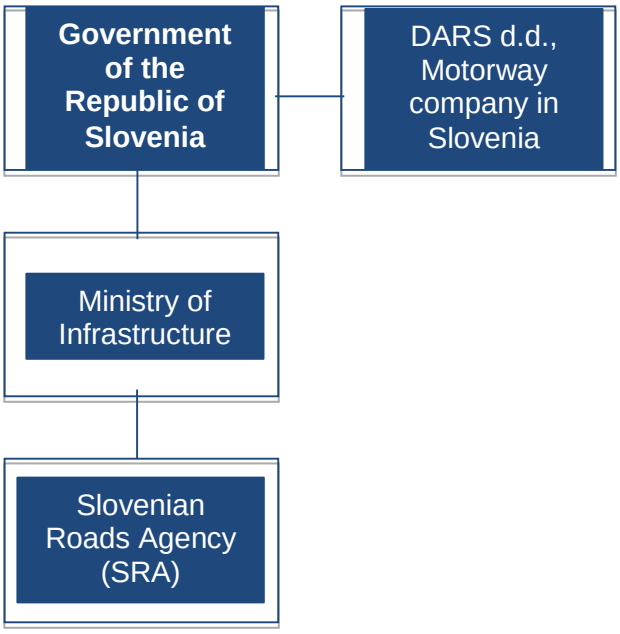


Fig. 2: The organisational structure of Slovenia's main road authorities

For the purpose of regular and winter maintenance on main and regional roads, Slovenia is divided into nine regions according to different geographical characteristics. There are 55 road-maintenance bases across Slovenia. These are used by the concessionaires, who are also responsible for providing enough gritting material for the winter.

Slovenia has approximately 39,000 km of categorised roads, of which 606 km of motorways and expressways, 144 km of slip roads (ramps), 21 km of junctions and 50 km of service roads are the responsibility of DARS d.d., 6,000 km of main and regional roads are the responsibility of the SRA, and 31,600 km of other roads are the responsibility of the municipalities.

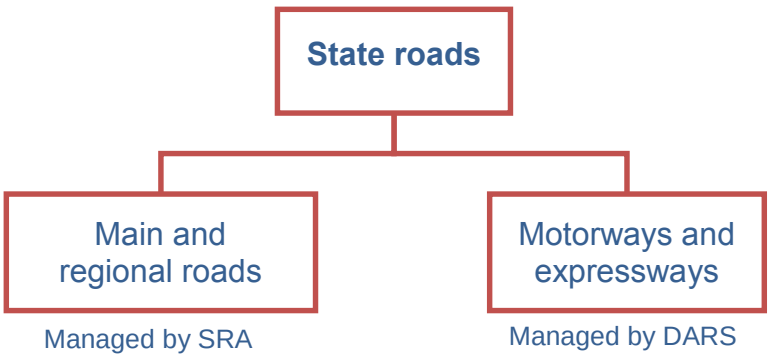


Fig. 3: Division of state roads in Slovenia

Fig. 4: The regional division of road maintenance on the Slovenian state road network (under the jurisdiction of the Slovenian Roads Agency)

The official *'Rule on the types of maintenance works on public roads and on the level of regular maintenance of public roads'* divides state roads in the winter period into six priority classes on the basis of:

- the category of the road or its connectivity role,
- the density and structure of traffic,
- geographical and climatic conditions, and
- special local circumstances.

1st class: includes motorways and expressways, where drivability must be ensured 24 hours a day. In snowy conditions, drivability must be ensured on all driving surfaces, important crossings, access

roads to larger car parks, and on stopping/emergency lanes. In heavy snowfall, at least one driving lane and access roads to larger car parks must be drivable.

2nd class: includes main roads, main urban roads, and more important regional roads. These roads must be drivable between 5 a.m. and 10 p.m. In the event of snowfall, 2 hours delay is allowed between 10 p.m. and 5 a.m.

3rd class: includes other regional roads, more important local roads, collecting urban and rural roads that need to be drivable between 5 a.m. and 8 p.m. In the event of snowfall, 2 hours delay in allowed between 8 p.m. and 5 a.m.

4th class: includes other local, urban, and rural roads that need to be drivable between 7 a.m. and 8 p.m. with shorter delays allowed during snowfall and with longer delays (up to 1 day) allowed in the event of heavy snowfall.

5th class: includes public paths, parking facilities, and cycle paths where drivability is ensured according to local needs. In the event of snowfall, delays of up to 1 day are allowed; in the event of heavy snowfall, delays of up to several days are allowed.

6th class: includes roads that are closed during the winter period.

Important factors that determine the implementation of winter service in Slovenia are mainly: temperature fluctuations around 0°C and the associated reoccurring frost-melting cycles, traffic loads, growing expectations of road users, and changing travel behaviour conditioned by the growing number of daily commutes in and out of city centres, mainly Ljubljana.

Available resources and assets for winter service	DARS	SRA + concessionaires	Total
Employees	621	1,130	1,748
HGV and special vehicles	175		175
Inspection vehicles	92	120	212
Snow ploughs (frontal and side)	239	410	649
Towing spreaders	0	251	251
Automatic spreaders	160	133	293
Snow cutter (plug-in and self-propelled)	26	31	57
Other machinery and vehicles	21	650	671
Salt depots and silos	34	5	39
Chloride tanks	18	110	128
Snow posts	23,300	240,000	263,300
Winter traffic signs	662		662
Snow palisades (m^2)	2,500	13,200	15,700

The main gritting materials used in Slovenia are salt (NaCl), calcium chloride (CaCl2), magnesium chloride (MgCl2), and sand. Salt is used down to temperatures of -8°C, wet salting with a mix of NaCl and MgCl2 solution down to -18°C, and a mix of NaCl and CaCl2 solution down to -22°C. A mix of salt and sand is used only in special circumstances in cases of icy rain and icy road driving surfaces. As a gritting material, sand alone is also used very rarely, mostly in cases of icy rain or

hardened snow on driving surfaces. Consumption of gritting materials in winter service fluctuates from year to year depending on the intensity of snowfall and other winter conditions.

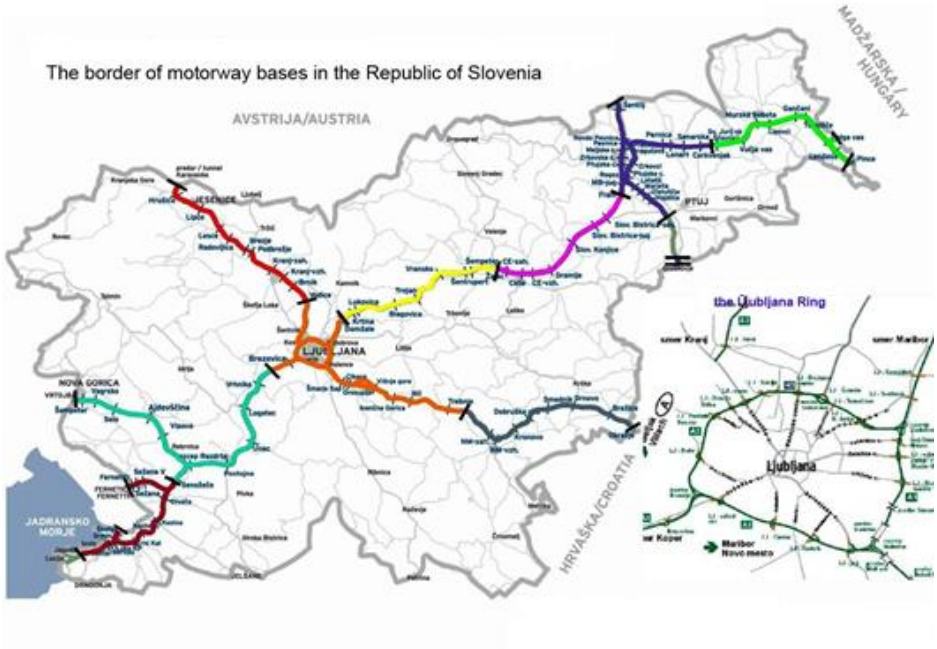


Fig. 5: Motorway bases of the DARS d.d. company
(which is responsible for maintaining Slovenian motorways)

There are 24 known problematic road sections on Slovenia's main and regional roads. These sections are problematic because of their configuration and location (steep slopes, shadowy location, bora wind, sudden icing, etc.). To better monitor the condition of critical road sections in the winter period, more video cameras and weather stations are being connected to the **R**oad **W**eather **I**nformation **S**ystem (RWIS). The system incorporates current and past data from road weather stations, detailed previews with charts, alarms (via web applications, SMS, and e-mail), previews of weather station equipment and its condition, system administration, data exchange, modelling of road weather forecasts (road surface temperature and condition), etc. Currently there are 68 road weather stations on Slovenian motorways and expressways and 20 road weather stations on main and regional roads.

DARS d.d. operates the traffic information centre where all data about weather and road conditions in Slovenia is gathered from road cameras, road-weather stations, control centres, the Office for snow and avalanches, the police, road maintenance and inspection crews, road users, radio stations, and other sources. Decisions about activating snow ploughs and gritting units are made on the basis of all available information. Although winter service is not yet carried out via an automatic MDSS system that would directly connect road weather stations with snowplough teams in the field, that is the intention for the future. Traffic information is also passed on to the public via the Internet, radio, television, and teletext, via smart phones and certain navigation devices, etc.

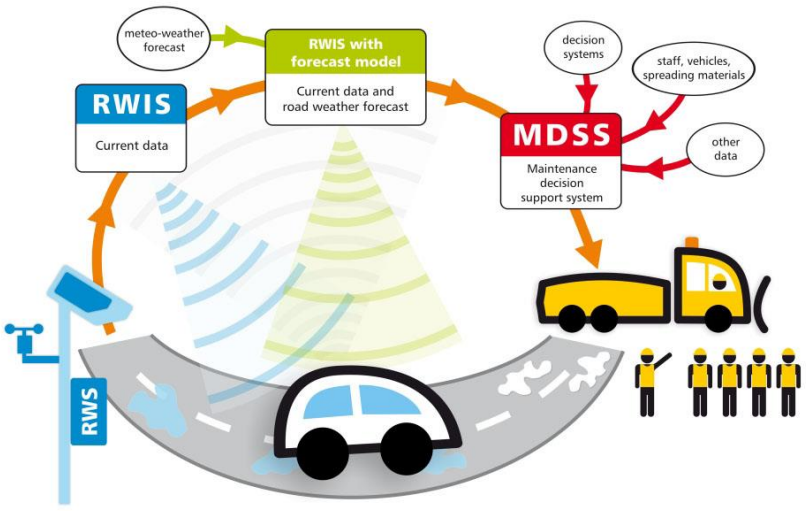


Fig. 6: Road weather information system and connection with MDSS

Goals for the future development of winter service in Slovenia

Slovenia is geographically very diverse, which means that the weather varies greatly from region to region. For this reason, an efficient network of interconnected road weather stations needs to be put in place across the country. In addition to weather forecasts, this network will provide reliable real-time images of conditions on motorways, expressways, junctions, main roads, and more important regional roads.

A more efficient system of monitoring traffic conditions also needs to be established, the focus being on monitoring the quantity of vehicles and type of traffic. This will enable reliable predictions of possible traffic jams and expected additional loads on traffic flows. Due to the large quantities of gritting materials used, a system for controlling and optimising gritting procedures on all winter service vehicles needs to be put in place in order to reduce the expenses relating to gritting materials.

Both DARS d.d. and the SRA will eventually have to face a so called 'black road challenge'. Ensuring almost clear roads even in heavy snowfall is, of course, very welcome, but this kind of winter service is too expensive. A decision between accommodating road users and saving substantial financial resources (€200,000–500,000 per winter season) will have to be made at the highest state level, regardless of the likelihood of complaints from road users. Naturally, gritting materials must not be reduced at the expense of a decrease in drivability and ice on roads and must still protect maintenance crews against criminal liability.

4.1.2 Denmark

Denmark is one of the most exposed countries as regards 'road slipperiness', because temperatures fluctuate around 0°C during winter. The average temperature for winter is normally 1.2–2.2°C. The temperature remains below 0°C all day on around 20 days per year. Snow depths during the winter

season vary between 10 cm and 40 cm; snowy weather occurs a maximum 20 times nationwide during winter. Until now, preventative salting has been used to avoid slippery roads, which means that salt is spread on roads before the road becomes slippery. This outcome can be ensured with the help of the Road Weather Information System, a technology used by the Danish Road Directorate and most municipalities to decide whether to start salting or not.

The road network incorporates trunk roads (main national roads) and municipal roads as defined by the Road Act. There are approximately 70,500 km of municipal roads, which are managed by the municipalities. They account for about 95% of the public road network. There are approximately 3,800 km of national roads, which are managed by the Danish Road Directorate. They account for the remaining 5% of the public road network. Nevertheless, public roads account for 45% of all vehicle kilometres travelled. In short, 45% of all traffic in Denmark travels on 5% (3,800 km) of national roads every day.

Fig. 7: The Danish road network

In accordance with the Law about Winter Service and the Clearing of Roads, the Danish road authorities are obliged to take action to clear snow and prevent slippery surfaces on public roads and paths. For footpaths, the responsibility can be placed on the owner of the adjacent property. The road authorities determine to what extent and in what order snow is cleared and steps are taken to combat slippery roads. Guidelines for worker performance are determined under the direction of the police. Winter service is usually provided throughout Denmark from 1 October to 30 April. Before the winter period begins, materials and equipment are checked and repaired, and staff members are trained in comprehensive programmes. The launching of winter service activities depends on the weather forecasts. Technological procedures are established and tests are normally planned and scheduled outside the winter seasons. The plan for carrying out winter service activities contains all

instructions for personnel and their duties. It also includes guidelines for the measurements that have to be taken in specific climatic situations.

Clear roads no matter what the weather

Danish road authorities plan winter services for their own roads. The Winter Service Unit is responsible for the entire national road network. All convenient jobs (haulage by truck) are done in accordance with the EU's Service Directive and are managed by private haulage contractors. It is not always easy to predict slippery roads as weather conditions can change very quickly. Therefore, the Winter Service Unit cooperates with a number of agencies and uses advanced systems to assist in monitoring. The Winter Service Unit cooperates in particular with the Danish Meteorological Institute (DMI) and uses its special weather forecasts for road monitoring and radar and satellite imagery. Moreover, because the Road Weather Information System “VejVejr” (Road Weather) provides comprehensive monitoring and forecasting facilities, winter monitoring provides the best possible basis for make decisions as to when to begin road salting.

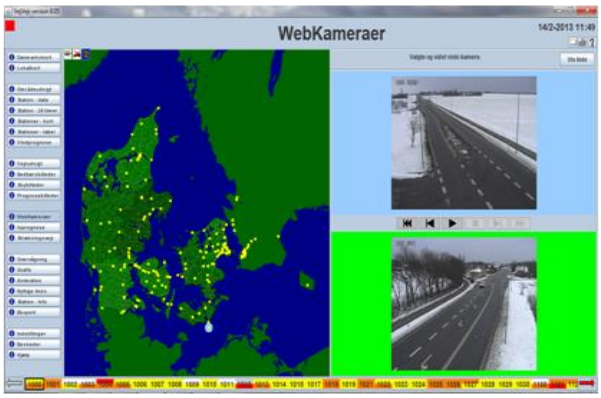


Fig. 8: Screenshot of the Danish Road weather system

Fig. 9: A solar-powered road weather station

Information about the road and weather situation from monitoring systems, webcams, police, information from citizens, and winter monitoring is also used to obtain a comprehensive picture of conditions. Winter monitoring includes driving on roads to examine and determine the need for additional maintenance activities. The Road Weather Information System highlights icy driving situations before they actually arise, enabling preventive salting before the road becomes icy. The stations are primarily located at the coldest places along the road network. The system has also affected the importance of control posts; patrols are now less significant. However, patrols are still used when necessary (in the event of snowfall, etc.). The Road Weather Information System is based on a network of approximately 400 road weather stations, half of which are on national roads and half on municipal roads.

Denmark has one operation centre which is supplied with information by the Danish Road Weather Information System and operates the winter management system VINTERMAN. The Danish Road Directorate owns approximately 210 spreaders and 600 snow ploughs for preventing slippery roads, mostly pre-wetted salt-spreaders together with a couple of combination spreaders and liquid spreaders. Denmark still uses brine. It typically takes 3 hours to complete a salt route (from call-out

to finished task), which covers an area of approximately 400,000 m². Each spreader, including stand-by spreader, covers only 45 km of roads. There is a salt depot for every 200 km of road. All new vehicles are supplied with stationary GPS equipment.

In a typical winter in Denmark, there are about 100 call-outs for salting due to the threat of icy conditions on approximately 4,000 km of national and regional roads. Salting as a result of snowfall, on the other hand, occurs only 20 times a year. Preventive actions are taken to salt the roads before they get slippery. The decision on whether a call-out is necessary is made at winter operation centres. Local contractors carry out the actual activity. Two computer systems have been developed to support these tasks at the winter centre: the Road Weather Information System (RWIS) and VINTERMAN. It is possible to inform motorists of icy roads and poor weather conditions at both local and national level with a high degree of accuracy.

Fig. 10: Salting in progress

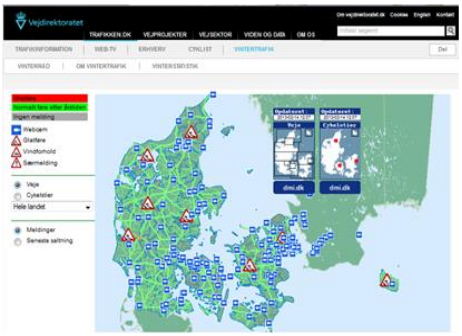


Fig. 11: Screenshot of www.vintertrafik.dk

This information is communicated by the Road Directorate's Traffic Information Centre, a central station in the Danish Road Directorate, which is open 24 hours a day and which maintains contact with road authorities, the Danish Meteorological Institute (DMI), the police, the emergency services, etc. Information is distributed by radio, telex, etc., and by direct telephone contact when motorists call or use the website www.vintertrafik.dk.

4.1.3 Spain

Spain is a southern European country located on the Iberian Peninsula. Its territory extends over 505,954 km², bound in the north by the Bay of Biscay and the Pyrenees (which covers the border between Spain and France), in the east by the Mediterranean and in the west by Portugal and the Atlantic. The country's population numbered 46.8 million in 2011, representing a density of 92 inhabitants per square kilometre. Spain is a parliamentary monarchy, composed of seventeen so-called autonomous communities or regions.

In administrative terms, the Spanish road network is organised under three different levels of authority: firstly, the state-run road network, which is dependent on the Central Administration's Ministry for Public Works (Ministerio de Fomento); secondly, the regional-run road networks (run by autonomous communities); and, finally, the road networks run by county and town councils.

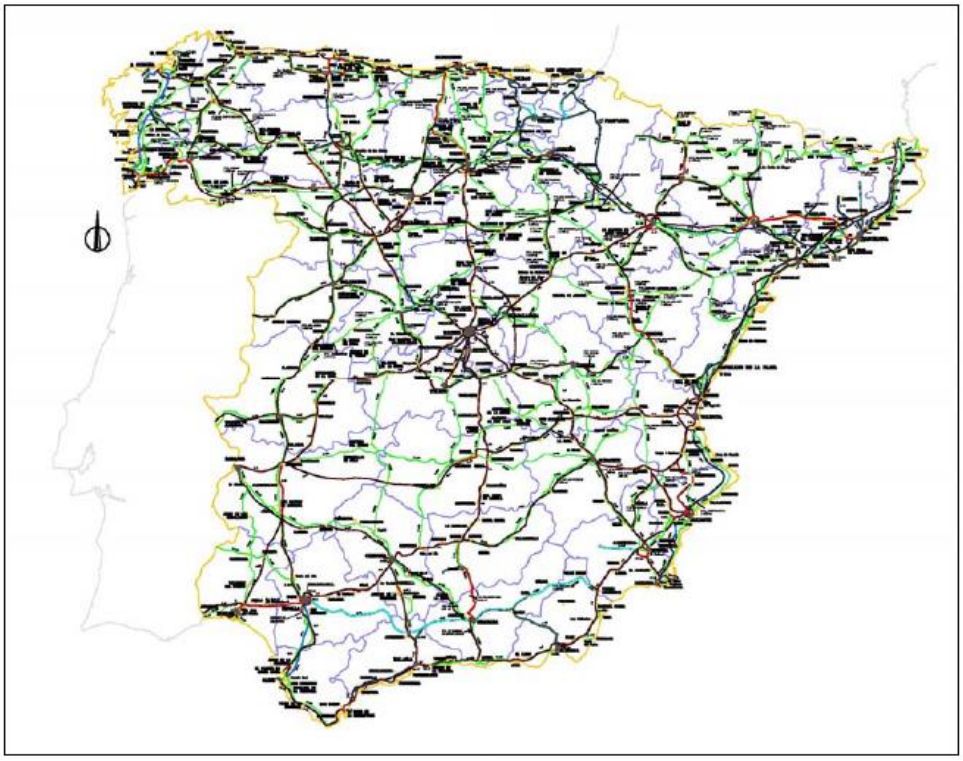


Fig. 12: Spain's road network (main roads)

Different road networks feature the following lengths of road, split into high capacity roads (motorways, dual carriageways, etc.) and normal- to low-capacity roads (single carriageways, smaller roads). As can be seen in the figure above, the state-run network accounts for only a small fraction of the total network, barely 15%. It does, however, carry a substantial portion of the actual traffic in Spain, especially when one looks at heavy goods vehicle (HGV) traffic:

Spain: road network (2011)		
State run network	High capacity roads	11.346 km
	Normal to low capacity roads	14.970 km
	TOTAL	**25.835 km (15.6%)**
Regionally and locally run network	High capacity roads	4.840 km
	Normal to low capacity roads	135.233 km
	TOTAL	**140.073 km (84.4%)**
Spanish Network	**TOTAL**	**165.907 km**

Spanish network: traffic (2011)		
Total traffic	State run network	121.686.000 vehicles/km (51.8%)
	Regional and locally run roads	113.121.000 vehicles/km (48.2%)
	TOTAL	**234.807.000 vehicles/km**
HGV traffic	State run network	16.184.240 vehicles/km (62.7%)
	Regional and locally run roads	9630340 vehicles/km (37.3%)
	TOTAL	**25.814.580 vehicles/km**
Spanish Network	**TOTAL**	**165907 km**

Fig. 13: Spain's road network and HGV data

Virtually all of the authorities responsible for roads outsource part of their maintenance tasks to private firms, which carry out the maintenance work on the majority of the infrastructural elements involved, generally including winter service tasks.

The state network is divided into roads directly managed by the state (Central Administration) and toll roads. Toll roads are managed entirely by private companies that have been given concession contracts, which means that the concessionaries are responsible for the performance of winter service works. The road network, on the other hand, is directly managed by the state. This network is currently divided into 154 maintenance sectors; private firms are responsible for the performance of winter service works. These contracts include not only winter service works but all operation and maintenance works, and are called 'integral maintenance contracts'. For each sector, the selected contractor has to perform all the necessary works, which requires having all the human and material resources available according to the terms of reference that govern the contract. The owner manages the contract and oversees the contractor's performance. The total duration of the contract is a maximum six years, including possible extensions.

On the state-run road network, the strategies for performing winter road maintenance works are outlined in documents entitled 'winter service operating plans', which are drafted for each sector. These plans include situations that might arise, and the staff and technical resources required to tackle each one. The aim is to reduce the number of disturbances to traffic to the minimum stipulated for each section of the sector roads, depending on the established service level. This service level, which is established on the basis of the service note of October 2006, is taken as the degree of transportability that a certain section of the road must have during the winter season, irrespective of the climate in the region. It is based exclusively on functional criteria.

For each of the three service levels established, the maximum number of disturbances that may occur as a result of snow and ice, and the maximum length of these disturbances, are defined.

The disturbances and alterations in traffic flow considered are: 'hold-ups in the movement of heavy vehicles (HGV), which is understood to be a measure that seeks to prevent these vehicles from straddling the road; 'use of chains on light vehicles', which is intended to increase the traction of vehicles in conditions of poor adherence to the road surface due to the presence of snow or ice; 'total stoppage of road traffic', when there are no vehicles straddling the road, but the enormous quantity of snow makes it impossible for vehicles to move; and lastly 'blocking of the road', which is a situation in which no traffic can move, due to the presence of vehicles on the road, usually heavy vehicles straddling the road, and queues of trapped light vehicles.

Service Level 1 is the most demanding with respect to winter service, and the one with the best effects in terms of drivability of the section of road where it is implemented. On the road sections where this service level is assigned, the objective is to ensure that the road is permanently in normal conditions, with blockages or hold-ups of any vehicles as a result of snow in all circumstances. To reach this service level, permanent monitoring must be maintained and winter service must constantly be provided. In snowy conditions, the movement of heavy vehicles is prohibited and light vehicles are required to use chains whenever necessary in an attempt to reduce the obstruction time as much as possible. Once the cause (snowstorm) has ended, a maximum period of two hours is permitted for the restoration of normal driving conditions.

On sections of road to which Service Level 2 is assigned, every effort is made to ensure normal road conditions at all times, and alterations in traffic due to snowfalls are permitted in the case of important episodes. At most, a blocked road is permitted, with traffic hold-ups affecting all vehicles. Logically, a longer period (four hours) is permitted for the restoration of normal traffic conditions once the storm has ended. For this level, preventive and corrective measures are taken when necessary throughout the winter season, and permanent monitoring services are only provided when there is warning of adverse weather conditions.

Service Level 3 is the least demanding of all. As a general rule, this level is assigned to sections of road that are of little importance to the system as a whole. In this case, the roads are maintained, but alterations in normal traffic conditions due to snowfall are permitted provided that the intensity of the storm makes it necessary to move staff to meet the requirements of roads assigned a higher service level. Consequently, the service is provided on a discontinuous basis, depending on the need to act in nearby areas at a higher level. For this level, no limits are established as regards the blocking of the road or the interruption of traffic flow, and no maximum times are set for restoring normal driving conditions.

NS	Phenomenon	Interrupt of heavy traffic		Chains Light Vehicles		Total Blockage		Blockage	
		Number	Time	Number	Time	Number	Time	Number	Time
NS-1	SNOW	Indeter.	t+2 h	Indeter.	t+2 h	0		0	
	ICE	0		0		0		0	
NS-2	SNOW	Indeter.	t+4 h	Indeter.	t+4 h	Once	t+4 h	once	t+4 h
	ICE	0		0		0		0	
NS-3	SNOW	Indeter.	-	Indeter.	-	Indeter.	-	Indeter.	-
	ICE	0		0		0		0	

(Indeter. = Indeterminate number of times) (t+xh= time the storm lasts plus x hours)

Fig. 14: Maximum number of disturbances caused to traffic due to snow and ice and maximum times in each case (desirable objectives)

For the purpose of clearing the sides of the road in general, a series of maximum times are established from the time the storm ends, ranging from 6 hours for Service Level 1 to one day for Service Level 2. No time limit is established for Service Level 3 with respect to clearing the sides of the road.

An important aspect of the 2006 service note is that no traffic disturbances or alterations that are caused by the presence of ice are permitted for any of the service levels considered. Logically, all these values are taken as desirable values and are therefore useful when it comes to dimensioning the resources and establishing the work systems of the operating plans.

Information on weather forecasting is supplied by the Meteorology State Agency (AEMET) through the issuing of bulletins and a daily adverse weather prediction when snowfalls that exceed determined thresholds are expected.

Since the year 2000, all machinery involved in winter service work on the state-run road network has been gradually fitted with GPS locating systems which, connected to the control centres by mobile telephone, are used as an aid to fleet management for snow-clearing machines. In addition to supplying the real-time positioning of every vehicle, the system installed comprises several on-board sensors that relay information on de-icer spreading and snow-clearing blade status in order to provide precise knowledge of the type of work each machine is performing. The data supplied by the GPS and the different sensors on board the vehicles are stored in a database, thus providing the possibility of creating a large range of reports on the tasks actually being carried out. This system has proved to be extremely useful as it enables the poor weather episodes experienced to be studied and conclusions to be drawn with a view to improving the service provided.

In relation to the infrastructure, the Fixed Automated Spray Technology (F.A.S.T.) system has been installed to prevent the formation of ice on some roads. The use of these systems has important advantages for those singular points (such as elevated structures) that are affected by extreme temperatures or humidity and require special attention. Its major drawback is the high cost of deployment and maintenance.

4.1.4 Lithuania

Lithuania lies in the northern part of a temperate climate zone. Its climate is described as moderately cold with snowy winters. The close proximity of both the Baltic Sea and the Atlantic Ocean has a very significant impact on the climate. Cyclones from the Baltic Sea and the Atlantic Ocean determine the changes of temperature and rainfall in this region. These cyclones also impact heavily on low-temperature fluctuations, which provide perfect conditions for black ice. There is snow cover in the northern and eastern regions of Lithuania by around 15 November at the earliest and on the coast about 10 days later at the latest. In snowy winters, snow can be as deep as 90 cm. Generally, in the north eastern regions, snow cover lasts between 95 and 105 days; in the rest of the country, between 75 and 90 days. The climatic conditions in Lithuania during cold periods are very conducive to dangerous meteorological phenomena, such as freezing rain.

Due to the country's special climate, Lithuanian roads are operated under winter conditions for up to five months of the year, which means that winter road maintenance accounts for the biggest part of routine maintenance in this region.

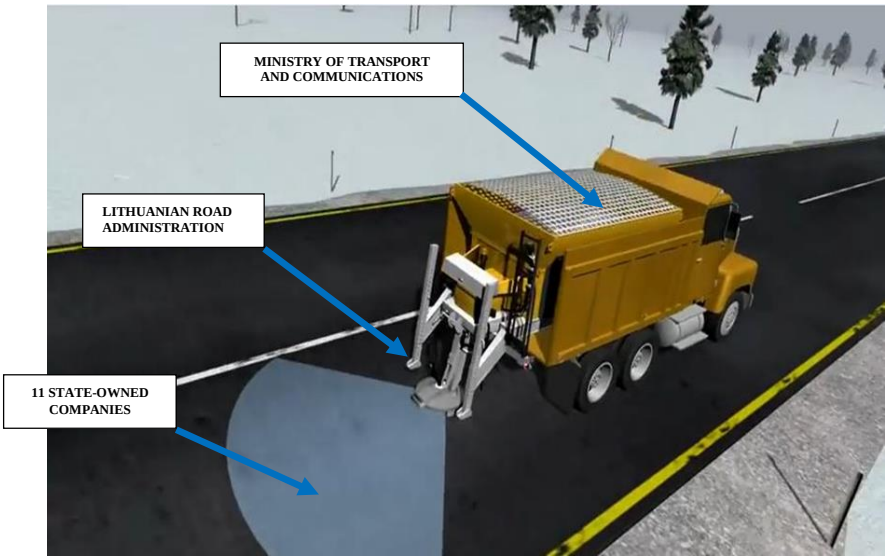


Fig. 15: Pictorial representation of areas of responsibility in Lithuania

The Lithuanian Road Administration (LRA) under the Ministry of Communications is a public institution established by the government of the Republic of Lithuania and is responsible for organising and coordinating the rehabilitation, maintenance, and development of state roads. It is not responsible for municipal roads. The LRA is the client for all road maintenance works. The contract territories are grouped according to Lithuania's counties: there are 10 contract territories, which are covered by 10 profit-seeking state-owned road maintenance companies, and one contract territory for motorways. The state-owned road maintenance companies have between three and six road service units, totalling 46 roads services units.

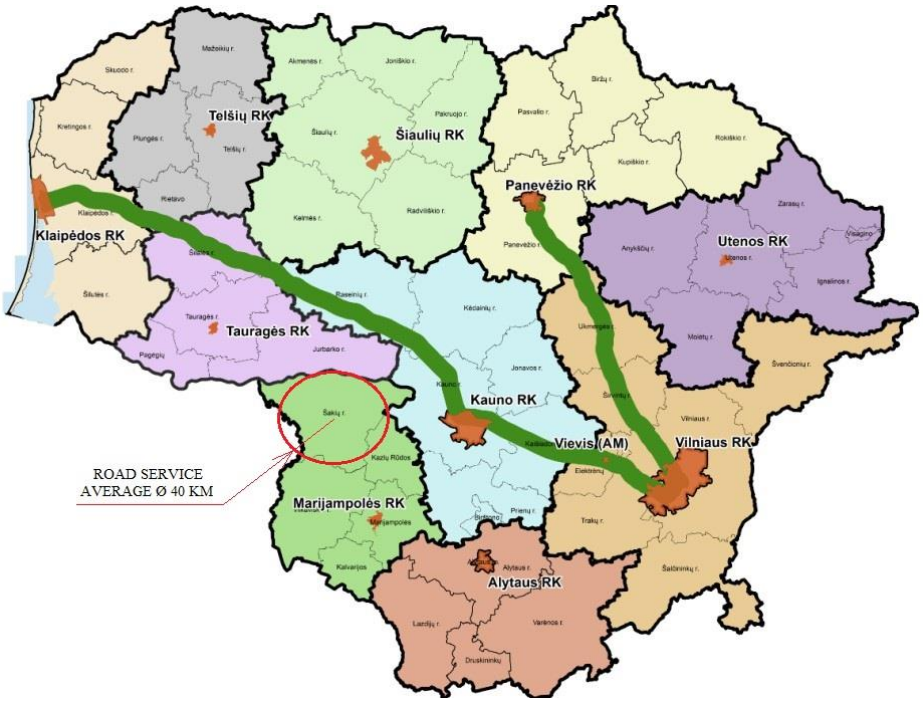


Fig. 16: Road maintenance contracting territories (green line shows the motorway contracts)

Each road category is maintained in accordance with one of the three maintenance levels: high (level 1), medium (level 2) and low (level 3). The level of maintenance applicable to a particular category of road is selected by the LRA depending on the level of financing. The level of maintenance is approved by the LRA when concluding road maintenance contracts with state maintenance companies. Before each winter season, they identify routes for road cleaning and spreading and make schedules, which are approved by the LRA.

The road network of national significance consists of 21,254 km of roads, of which 1,745 km are main roads, 4,936 km are national roads, and 14,573 km are regional roads. The LRA collects information about the weather on roads and road conditions in several ways: the transfer of information from regional administrations by telephone, the electronic transfer of information using the LRA information system, and the collection of information from the RWI system (107 road weather stations, 250 cameras). The LRA processes this information and posts it on the website of the LRA Traffic Information Centre (www.eismoinfo.lt). All road users and road maintenance service employees can use this information in real time.

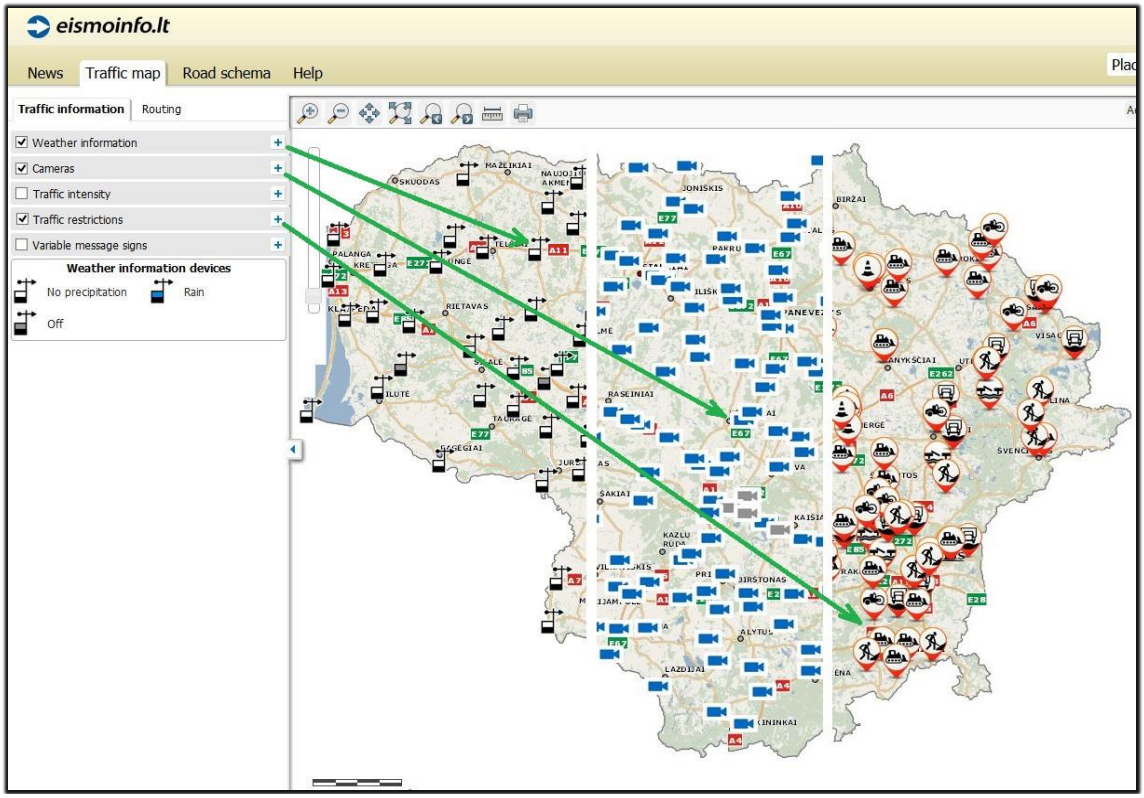


Fig. 17: Screen shot of the Lithuanian traffic information system.

4.1.5 Latvia

The total length of Latvia's roads and streets is 73,275 km. These roads are classified as state roads, municipal roads, forest roads, or private roads. Public transport uses 20,093 km of state roads and 38,480 km of municipal roads and streets. Municipalities are responsible for maintaining their own roads; the state is responsible for maintaining state roads. State roads are divided into 1,674 km of main roads, 5,388 km of regional roads, and 13,038 km of local roads.

The government has established winter service standards for state roads and municipal roads. Five road maintenance classes with different levels of maintenance have been defined. The maintenance level corresponds to traffic intensity and road classification. Maintenance quality requirements for each class are defined by quality indicators, such as unevenness, snow thickness, and performance time. Indicators change according to weather conditions and the time of day. Weather conditions are divided into three groups: stable weather conditions, changing weather conditions, and extreme weather conditions.

Municipalities mostly provide winter service by involving private contractors through open tenders. In accordance with the Road Law, the state grants rights to state-owned contractors to perform winter service works. The Ministry of Transport acts as a client, and SJSC 'Latvian State Roads' acts as a supervisor on behalf of the ministry.

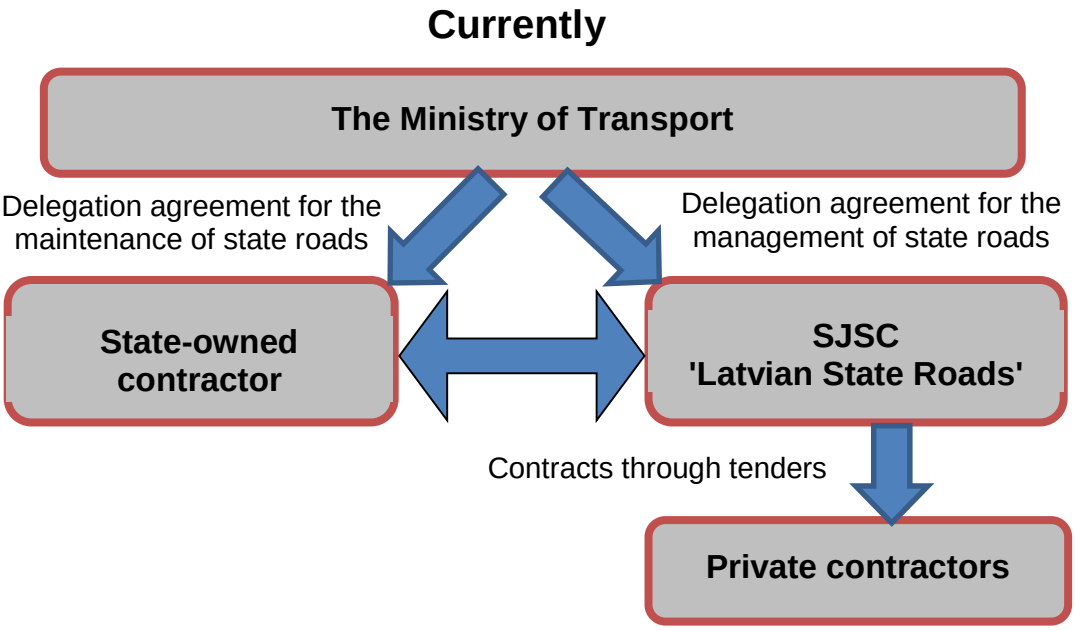


Fig. 18: Organisation of state road maintenance in Latvia

The winter service period in Latvia starts on 1 November and lasts until 31 March. This means that all public roads have to be maintained according to winter service standards during this period. 24-hour monitoring in 26 road districts has to be organised on state roads, and the public must be provided with information about the drivability of state roads. State-owned contractors provide winter service works using their own machinery and manpower in 26 local regional units.

Average daily traffic density vehicle per day	Winter service classes		
	Main roads	Regional roads	Local roads
more than 5,000	A	A	A1
1,000–5,000	A1	A1	A1
500–1,000	A1	B	B
100–500		C	C
less than 100			D

Roads free of snow and ice

Roads covered with snow and ice during cold winters

Roads covered with snow and ice

Fig. 19: Winter service requirements in Latvia

Before the winter season, the Ministry of Transport approves the list of state roads and their winter service classes.

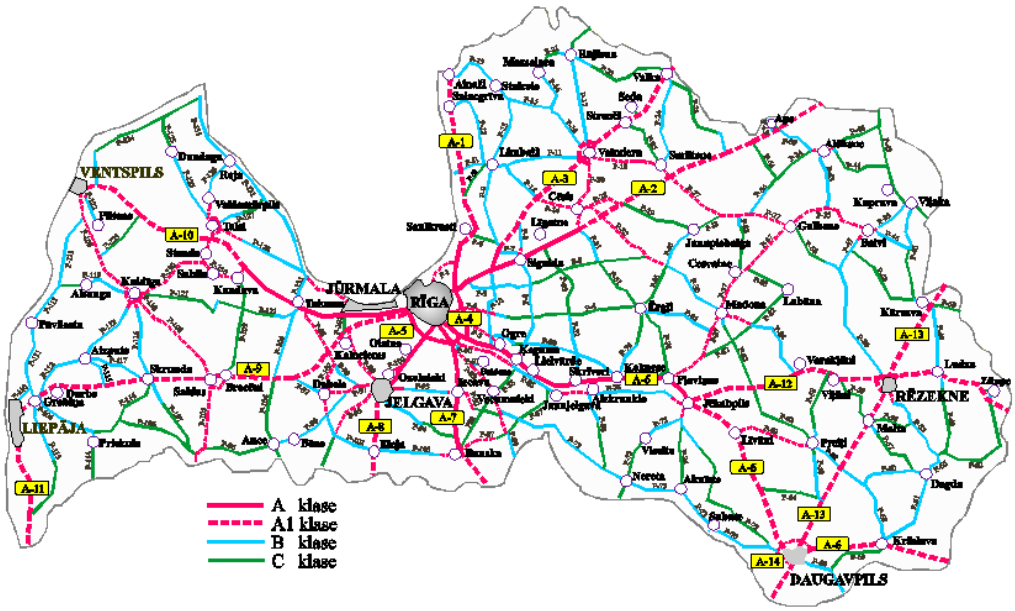


Fig. 20: Road maintenance classes on main and regional roads in Latvia

SJC 'Latvian State Roads' provides the contractor with data from road weather stations, images from road video cameras, and information from the meteorological office. Road weather stations and video cameras are situated together along main roads. Latvia has 53 weather stations and video cameras. At present, the road weather information system shows current and past weather and road conditions. Latvia intends to use the road weather information system (RWIS) for road weather forecasts in the future.

Latvian contractors use snow ploughs equipped with wet salt spreaders for the maintenance of roads belonging to classes A, A1, and B. Usually the spreading rate is 10–20 g of sodium chloride per square metre. All spreaders are connected to an online control system with automatic data registration via GPS. The spreader operator makes decisions about the spreading pattern and rate on the basis of road weather information, the actual road situation, and personal experience.

4.1.6 Italy

Winter climatic conditions in Italy vary greatly across the country, resulting in a wide variety of climates and microclimates. Consequently, particular attention must be paid to the possibility of snowfall even in those areas where it appears unlikely, i.e. in regions located in the south and near the sea. Snow itself also varies from region to region, being dry and light in the north and wet and heavy in the south.

Anas S.p.A. is a public entity. It was founded in 2002 following the transformation of the *Ente Nazionale per le Strade* (Italian National Roads and Highways Authority). It is a joint-stock company with the Ministry of Economy and Finance as its sole shareholder and is subject to the control and technical and operative supervision of the Ministry of Infrastructures and Transport. The ANAS road network consists of 25,000 kilometres of roads, including national roads, motorways, and non-tolled highways.

Fig. 21: The ANAS road network

The ANAS governance model includes 21 regional offices, including a special office for the management of the A3 highways connecting Salerno and the Reggio Calabria in southern Italy. This decentralised model allows ANAS to closely manage its own road network.

Fig. 22: The ANAS organisational model

Every year, ANAS receives a limited budget from the Italian government for the funding of winter maintenance. According to previously identified maintenance needs, ANAS road managers distribute this budget to ANAS regional offices, which are responsible for the planning and performance of maintenance operations along their own networks. Because of the limited resources available, most of the activities are outsourced to external contractors.

The Ministry of Infrastructures and Transport has established standards and service levels for snow and ice removal activities on national roads and motorways. These performance indicators fall into the following major categories:

- Travel safety
- Service regularity/frequency
- User information
- Level of service
- Travel comfort
- Service for disabled people

Winter road management in Italy includes the following activities:

- *Snow removal:* this includes the removal of the layers of snow, mud, and ice from the pavement, verges of the carriageways, bridges, viaducts, and tunnels (entrance-exit portals).
- *De-icing treatment:* this consists of the spreading of de-icing salts on roads and/or anti-icing mixtures (salts and aggregates) in order to prevent ice formation on pavements on bridges, viaducts, and near tunnels (entrance/exit portals).
- *Emergency assistance:* this consists of snow removal and anti-icing treatment by means of ad hoc teams operating in emergencies (call-outs).
- *Felling of dangerous trees and removal of the discarded material:* this consists of the removal of trees damaged by snow by cutting off branches and subsequently cutting them to pieces.

Fig. 23: Ploughing performance

Fig. 24: Snow blower in action

The regional offices constantly plan such activities according to the weather and altitude characteristics of the relevant regions. The availability of staff and means to tackle unexpected emergencies and/or unforeseeable situations is guaranteed. When planning, a number of factors are taken into consideration: not only bad weather conditions (snow falls and/or ice), but also the need to maintain a high standard of service, while reducing the risks on the managed road and motorway networks. All these activities are carried out by trained teams equipped with mechanical equipment, snow blowers, blades, and salt-spreaders. The foreseen activities are normally carried out continuously over a 6 month period (November–April) 24 hours a day, on both working days and holidays. All activities are carried out in such a way as to cause the least traffic congestion as possible. The above-mentioned activities are generally implemented according to the following scheme:

- Snow removal and anti-ice treatment: for a period of 4–6 months, depending on the frequency of snow falls and frost formation and in accordance with the topographic characteristics of the network.
- Emergency activation: call-outs (triggered by ANAS monitoring personnel, police, etc.) as a result of emergency situations, generally within 60 minutes of the call-out, 24 hours a day, on both working days and holidays.

Meteorological information and forecasts are provided by the Italian Air Force (Aeronautica Militare Italiana) which oversees the collection and processing of data and meteorological products (analyses, forecasts, advice, etc.) across the country. The surveys are carried out by satellites and

by a network of meteorological stations across the country. Information to users, broadcast by radio, are processed and disseminated by the information centre CIIS by means of the following national networks:

- RTL (102.5 MF) updated every 30 minutes between 6.30 a.m. and 9.00 p.m.
- RADIO RAI : updated every 30 minutes at the most
- ISORADIO: (103 MHz):every 30 minutes covering the motorway network

Fig. 25: Coverage of *Isoradio*

In order to properly manage winter operations across Italy, a third body has been set up: the Viabilità Italia commission. This commission comprises experts from both Italian transportation operators (such as ANAS, Ferrovie dello Stato, and AISCAT) and Italian transportation authorities (such as the government and military forces) with the specific role of coordinating activities relating to the availability of the road network, which include also winter operations.

An analysis of last years' weather conditions and climate changes forced the Italian road authority to strive for greater coordination and synergy, above all on regional borders and on critical points on the network, and to adopt specific documents called 'Winter Plans', which are discussed every year with the Viabilità Italia commission. Viabilità Italia also introduced a common glossary and homogeneous standards in order to provide transportation authorities with a common framework for their work.

4.2 The questionnaire

In order to obtain more detailed data about winter service in individual countries, the group decided to draw up a rather comprehensive questionnaire that was then distributed to members of the group and to all other CEDR member countries (see Appendix 1). The questionnaire included 37 questions relating to seven main topics:

- Topic 1: the meaning of the term 'winter service' (2 questions)
- Topic 2: winter equipment for road users (4 questions)
- Topic 3: the elimination of heavy goods vehicles (HGVs) from traffic (2 questions)
- Topic 4: using standards, criteria, and regulations to ensure the drivability of roads in winter (6 questions)
- Topic 5: comparing different standards, criteria, and regulations to ensure the drivability of roads (12 questions)
- Topic 6: the organisation of operational winter service activities (10 questions)
- Topic 7: indicating main areas and topics for research (1 question)

As is evident from the number of questions in the individual topics, the emphasis in the questionnaire was on trying to compare standards and operational activities. However, the experts at the task group meeting agreed that the comparison of operational difficulties was the most important issue when it comes to the improvement of winter service. Consequently, when analysing the answers to the questionnaire, the group focused almost entirely on that aspect of winter service (see Appendix 1).

4.3 Possible solutions

Through the analysis of responses to the questionnaire, debate within the group, and consultation and contact with the WRA-PIARC technical committee on winter service, task group N3 concluded that there are three possible solutions to the task it was set by CEDR:

1 CEDR invests in research topics that are recognised as being of common interest to all members of the group and to the NRAs that answered the questionnaire. These topics are (ranked according to their importance for stakeholders):
   1 Guidelines for winter service
   2 Calibration mechanisms for machinery
   3 New gritting materials
   4 Maintenance Decisions Support Systems (MDSS)
   5 Salt and gritting material consumption

2 CEDR does not invest in research topics from the field of 'winter service' as there is enough ongoing or completed research on the topics that were viewed as problematic to all stakeholders. On the other hand, CEDR should invest in obtaining information about research results and new technologies relating to the above-mentioned topics.

3 CEDR continues its investment into the topic of winter service through the work of its task groups, focusing its attention on ''How to improve maintenance with less money?'

4.3.1 Description of solution No.1

The first solution seems to be the most logical step forward. The group identified the topics that were recognised by different countries as the issues that need to be solved in order to improve winter service and service levels. The topics are briefly described below.

1 Guidelines for winter service
Research needs to be done to determine various scenarios concerning the road and maintenance measures that would be used as a utility guide in the decision-making process.

2 Calibration mechanisms for machinery
A methodology for the calibration of machinery for winter service needs to be developed. This could be used as a CEDR standard.

3 New gritting materials
New gritting materials that could be used instead of salt, which is environmentally damaging and otherwise questionable, need to be developed.

4 Maintenance Decisions Support Systems (MDSS)
A cost-benefit analysis would need to be done for such a system and to solve the problem of 'information overflow' into the system; research on the implementation of such systems in winter service needs to be carried out.

5 Salt and gritting material consumption
Research needs to be done into the optimisation of the consumption of gritting materials. A comparison of salt consumption data in countries, according to the 'severity of winter', would be very beneficial. That would enable NRAs to successfully 'defend' their winter service expenses towards their respective authorities (the government) and the public.

The above-mentioned research topics could be used for the CEDR research call in 2015 in the field of winter service. The positive aspect of solution No. 1 is that CEDR TGR could include the topic of winter service in the next CEDR research call as this issue has not yet been covered in previous ERANET and CEDR calls. This would send out a positive message that CEDR is investing in something never before researched in this organisation. The decision to take this solution forward would, however, require some additional effort from CEDR and probably from task group N3 in particular in order to prepare the Description of Research Needs (DoRN) document that would be used for the call. Before the call can be made, the topics need to be reconsidered again in the light of the call for tenders, and requirements need to be defined more clearly.

The possible negative aspect of this solution is very much connected with solution No. 2. There is a risk of duplicating research that has, according to the members of the PIARC technical committee on winter service, already been done or is currently ongoing on the five topics identified by the group as being of interest to all. It seems that these issues are currently a global challenge to countries that must deal with winter conditions on their roads.

4.3.2 Description of solution No. 2

The second solution stems from the cooperation and exchange of ideas with the members of the PIARC technical committee 2.4 on winter service. The members of this group are experts who deal with the same research topics as CEDR's TG N3. Initial contact with the PIARC experts was established by the chairman of the technical committee, Mr Didier Giloppe of France, followed by a meeting during the International winter road congress in Andorra in February 2014 .

During this meeting, the PIARC colleagues pointed out that CEDR's TG N3 might be trying to conduct research in areas that are already being covered by extensive research all around the world and that it would be a pity to 'reinvent the wheel'. The suggestion from the PIARC technical committee was to abandon further investment in research on winter service for the time being and to instead focus on thoroughly investigating on-going research and obtaining information from it.

The positive aspects of solution No. 2 are first and foremost the financial savings that would hypothetically come from not investing in research itself but in just gathering information from existing research results. Secondly, instead of winter service topics, CEDR would be able to issue a call for other road-related research topics that are considered more vital.

However, the problem with this solution might be that CEDR doesn't actually own the information and research results on winter service and that its members are 'at the mercy' of the researchers (would they be willing to share their results? How much of it could be used in practice (patent rights etc.)). Another negative aspect might be that CEDR does not once again invest more significant funds in research on winter service, which may be viewed by some members as a neglect of an otherwise very important operational issue that is even 'politically sensitive' in a number of states. Furthermore, CEDR, aspiring to be a more eminent player in European road-related circles, needs to adopt a clear position on such an important topic as winter service. An easy way to do this would be to ensure that it is backed up with its own research on the issue.

4.3.3 Description of solution No.3

The third solution is that CEDR continues its investment in the topic of winter service through the work of its own working groups, but instead focuses its attention on the aspect of 'How to improve maintenance with less money?'

That means that CEDR would not neglect the issue of winter service, but just shift the emphasis to the management side of winter service instead of to new technologies, which are already being extensively researched by other stakeholders. The task group concluded that ultimately, this is the real question that road authorities are facing across Europe. These issues could also be dealt with within the topics of asset management. However, this would require a specific focus and the taking into consideration of the specifics of the winter period. The positive side of this solution is again lower costs, as further research into greater effectiveness of winter service is being done by CEDR's own task groups (experts). However, the need to investigate the technological research and results around the world remains, as there can't be any significant improvement in the management of winter service without an improvement in operational technologies. CEDR has already conducted quite thorough research into asset management and with this experience, it could adequately investigate the better management of winter service.

5 Comparison of the possible ways forward

There are three possible ways forward for the specific problem that this report addresses. In the previous chapter, three solutions were proposed and some of their positive and negative aspects highlighted. In this chapter, we look at these solutions again, this time from the perspective of their social, economic, and environmental consequences for the sustainability of winter service in the future.

Solution No.1

CEDR invests in research topics that were recognised as of common interest to all members of the group and to the NRAs that answered the questionnaire. The topics are:

1 Guidelines for winter service
2 Calibration mechanisms for machinery
3 New gritting materials
4 Maintenance Decisions Support Systems (MDSS)
5 Salt and gritting material consumption

The social consequences of this solution seem to be positive. Investment in researching new, more economical and ecological solutions for providing winter service would undoubtedly trigger positive responses and feelings among experts and later on – if new technologies are implemented – among the general public. However, the question remains as to the timeframe in which these new technologies might actually become part of everyday practice in CEDR countries, meaning that the social consequences of this particular solution would not be visible at first, but only later on, when the general public experiences the benefits of improved winter service.

The economic consequences of solution No. 1 would initially be direct and will come in a very short timeframe. If the proposed topics are approved by the CEDR EB and GB, they could become part of the CEDR research call in 2015, which means that financial contributions for research projects would have to be provided in 2015. The total funding required remains a matter for the CEDR GB to decide and depends on the number of topics that would be included in the call. It is difficult to say anything specific about the indirect economic consequences of the implementation of new technologies resulting from this solution. It can be assumed that new technologies for winter service would reduce the costs of winter service. However, it is at present too soon to speak about actual figures.

The environmental consequences can be expected to be very positive and viewed as a more 'long-term investment'. By their nature, new technologies focus on improving winter service, thereby making the process (among other things) more eco-friendly. New spreading materials, the optimisation of salt (and other agents') consumption, greater efficiency with improved decision-support systems etc., are all concrete benefits that should reduce the environmental impact of winter service activities.

Solution No. 2

CEDR does not invest in research issues from the field of 'winter service' as there is enough ongoing or completed research on the topics that were recognised as problematic for all stakeholders. On

the other hand, CEDR should invest in obtaining information about research results and new technologies relating to the above-mentioned topics.

The social consequences of this solution are hard to evaluate as they can be considered from two perspectives. One is the way CEDR is perceived by the expert public (i.e. researchers, the EC, other road organisations, industry, and winter maintenance experts) if the decision is taken not to invest in new research. It is likely that this decision would not resonate very well with experts working in winter service. On the other hand, social consequences also depend very much on the decision of CEDR member countries to implement new technologies. If new technological solutions are implemented, then positive social aspects will be directly experienced by road users through improved winter service.

The economic consequences of this solution would also be direct. One positive side would be the savings in CEDR's budget as there would be no direct funding of research projects. Some economic funds would, however, be needed in order to obtain information about research that is done by other stakeholders. Financial resources by NRAs would also presumably be the same as with solution No.1. Either way, the NRAs would need to invest in the implementation of new technologies to improve their winter service, only now the funds would be intended for the implementation of new technologies and would not be related to research. New technologies are expected to reduce the cost of winter service.

The environmental consequences would basically be the same as with solution No.1. By their nature, new technologies focus on improving winter service, thereby making the process (among other things) more eco-friendly.

Solution No. 3

CEDR continues its investment in the topic of winter service through the work of its own task groups, but instead focusing its attention on the aspect of 'How to improve maintenance with less money?'

The social consequences of this solution may initially seem rather negative. The community of road experts might get the impression that CEDR is neglecting the issue of winter service as it is not investing anything in research in this field. Additional PR activity would probably be needed in order to explain to experts that CEDR is in fact working on winter service but is rationalising its resources in this field by not duplicating research that is already being done all over the world. CEDR would continue its own work on winter service issues within its own working groups, focusing more on the management and life-cycle cost issues of winter service.

The social consequences for the general public would presumably be minor, as individual countries (CEDR members) invest in new technologies for winter service independently of the decisions and research done in CEDR. There should, therefore, be no negative correlation between the 'non-investment in research' by CEDR and the 'quality of winter service' in individual CEDR member countries.

The economic consequences here would also be minimal. There would be no need to invest in special research, only in the expert work of the CEDR working group for winter service in the next cycle. As regards the economic consequences for CEDR members, the situation is the same as for the social consequences outlined above, namely the investment in the improvement of winter service in individual countries is almost completely independent of CEDR findings. All results of CEDR research are no more than suggestions for improvement and are by no means obligatory for its

members. Consequently, it is entirely up to individual countries whether they want to invest in winter service.

The environmental consequences of this solution are not immediately apparent. If CEDR chooses not to invest in further research topics relating to winter service and if individual countries decide not to invest in new technologies, then the environmental consequences will be practically non-existent. However, if individual countries decide to upgrade their winter service, then it can be said that, as in the case of the two previous solutions, new technologies, by their nature, focus on improving winter service, thereby making the process (among other things) more eco-friendly.

	Social consequences		**Economic consequences**		**Environmental consequences**	
	positive	negative	positive	negative	positive	negative
Solution No. 1	✓	-	-	✓	✓	-
Solution No. 2	✓	-	✓	-	✓	-
Solution No. 3	-	✓	✓	-	-	✓

Fig. 26: Comparison of the three proposed solutions

Looking at the table above, it seems that solution No. 2 is the most favourable of the three. All three consequences (social, economic, and environmental) are viewed as positive. Task group N3 therefore recommends that CEDR members do not include the topic of winter service in the next CEDR research call, but instead invest in gathering information about completed (and on-going) research in the field of winter service, which should be abundant. Additional funds could be better invested in encouraging countries to implement available new technologies into their winter service practice.

6 Conclusions, recommendations and consequences for the directors of roads

The CEDR task group N3 (winter maintenance standards) set out to reach its objective (defining common research topics) in three successive phases by analysing standards and operational problems and providing advice on research into common topics of interest. However, soon after starting work, it became obvious that the main interest of all participating states lay in operational problems and the optimisation of operational procedures for winter service. The group therefore focused its attention and debates accordingly.

The data about winter service gathered by group members and the information obtained from responses to the questionnaire provided a sound basis for expert debates and for finding possible solutions to the task with which the group had been entrusted. The group identified three solutions/ways forward:

1 CEDR invests in research topics that are recognised as being of common interest to all members of the group and to the NRAs that answered the questionnaire. These topics are (ranked according to their importance for stakeholders):
   1 Guidelines for winter service
   2 Calibration mechanisms for machinery
   3 New gritting materials
   4 Maintenance Decisions Support Systems (MDSS)
   5 Salt and gritting material consumption

2 CEDR does not invest in research topics from the field of 'winter service' as there is enough ongoing or completed research on the topics that were viewed as problematic to all stakeholders. On the other hand, CEDR should invest in obtaining information about research results and new technologies relating to the above-mentioned topics.

3 CEDR continues its investment into the topic of winter service through the work of its task groups, focusing its attention on "How to improve maintenance with less money?'

In a comparison of the proposed solutions, the task group reviewed the social, economic, and environmental aspects of each solution and concluded that **solution No. 2 seemed to be the most convenient step forward** for CEDR at the present time. This solution roughly proposes that there is no need for considerable financial investment in research projects to improve winter service because considerable research has already been conducted on most of these issues around the world. This does not, however, mean that CEDR does not support innovation and improvements in winter service operations. CEDR should invest in obtaining research results from the above-mentioned topics and strongly encourage its members to use the new technologies in winter service. All states have expressed the wish to improve and optimise their winter service. All they need are technological solutions, information about how to use it, and some encouragement and financial investment to implement these solutions. In the course of discussions within the group and with colleagues from PIARC's technical committee 2.4 on winter service, TG N3 found out what research has already been done; all that is now needed are the results and the knowledge of how to implement the new technologies.

APPENDIX I: Analysis of the questionnaire and results

The group received answers to the questionnaire from 15 different countries: members of TG N3 and also other member countries of CEDR. The questionnaire was send to all 27 member countries, meaning that there was a response rate of 55%. Responses were received from Austria, Denmark, Estonia, Finland, Germany, Iceland, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Slovenia, Spain, and Switzerland. The group decided to focus its analysis on the 10 most important questions in the questionnaire:

1 How is winter service organised in your country?

2 Who is providing winter service in your country?

3 How difficult is it to ensure the drivability of roads in the winter period in your country? (answers to question No. 4.0 in the questionnaire)

4 What are the main problems in providing winter service? (answers to question No. 4.1 in the questionnaire)

5 Do standards and regulations for ensuring drivability on roads meet the requirements of road users? (answers to question No. 4.3 in the questionnaire)

6 Do your winter service providers use any kind of weather information system? (answers to question No. 5.8 in the questionnaire)

7 From which sources do you mainly obtain weather and traffic information? (answers to question No. 6.0 in the questionnaire)

8 What are the main measures you use for operational intervention on roads? (answers to question No. 6.1 in the questionnaire)

9 Which advanced technologies do you use? (answers to question No. 6.5 in the questionnaire)

10 Indicate the main topics or areas for research. (answers to question No. 7.0 in the questionnaire)

Conclusions of the analysis

Looking at the spreadsheet with the combined answers to the 10 questions, chosen for the analysis, it can be concluded that:

1 Most countries organise their winter service at state level (for higher categories of roads) and leave the organisation of winter service for lower categories of roads (mainly urban roads, streets, and cycle lanes) to local authorities.

2 Winter service is generally provided by a state-owned or private company via a contract agreement; public-private-partnerships (PPP) are very rarely used.

3 Generally speaking, all analysed countries find it difficult to ensure the drivability of roads in winter time. Most answers ranged from 'minor difficulties' to 'very difficult'.

4 The main problems that countries face when providing winter service are: problems connected with salt spreading (not enough salt, the ineffectiveness of salt at low temperatures, the harmful effects of salt on environment, etc.), heavy traffic and inadequately equipped HGVs, operational problems relating to manpower and financial resources, and complicated regional climates.

5 The standards and regulations for providing winter service generally meet the requirements of road users, especially on higher categories of roads. On lower categories of roads, there are some signs of road user dissatisfaction.

6 All analysed countries use some kind of system that connects road weather stations and sensors. They also have access to data from meteorological authorities, weather forecasts, etc. A minority of countries also uses an MDSS system that combines all this data and provides direct advice on winter service activities (salt quantity, route patterns, etc.) on the basis of modelling and computations.

7 Weather and traffic information is mainly obtained from national meteorological authorities, weather forecasts, road weather stations with floor sensors, and weather stations. Other sources (i.e. police, video cameras, information from road users, etc.) are used more rarely.

8 Most countries use the following measures for operational interventions: 1) intervention according to previously prepared road condition scenarios, 2) required levels of road drivability, 3) intervention on the basis of MDSS and Road Weather Information Systems (RWIS), 4) the time interval in 24h in which the road needs to be drivable (*numbers indicate hours*). Other measures are used more rarely.

9 The usage of advanced technologies in winter service varies greatly from country to country; only a small amount of the technological solutions available are actually in use. Countries mostly use GPS directing and tracking of ploughing and sprinkling and they invest in improvements of ploughs and sprinkler devices.

10 The main topics suggested for research relate to the following general research fields: the salting of roads (consumption of salt, optimisation of usage, wet salting), the monitoring and evaluation of the efficiency of winter service activities (cost-benefit analysis, measuring the performance of the contractors), new gritting materials (slipperiness-reducing materials, de-icing agents, environmentally friendly materials), Maintenance Decision Support Systems (MDSS), and new weather forecast technologies.

Question / Country	Austria	Denmark	Estonia	Finland	Germany	Iceland	Ireland	Italy	Latvia	Lithuania	Norway	Poland	Slovenia	Spain	Switzerland
How is winter service organized in your country?															
At state level															
At regional level		/	/	/			/		/	/	/		/		
At local level															
Who is providing winter service in your country?															
State-owned or private company by contract															
Public-private partnership (PPP)	/	/	/	/		/		/	/	/	/	/	/		/
How difficult it is to ensure drivability of roads in winter period in your country?															
1 not difficult at all	/	/	/	/	/		/	/	/	/	/			/	/
2 minor difficulties	/						/			/	/			/	
3 difficult	/							/							
4 very difficult		/	/	/							/			/	/
5 extremely difficult	/	/	/	/	/	/	/			/	/		/		
Which are the main problems in providing winter service?	High intensity of operation (24/7), impact of salt on pavement, imminent accident situations	Inability to spread salt evenly across the road, detection of "black ice", challenges to get all players to implement the plan, traffic jams	Traffic density, keeping roads open during heavy snow and blizzard, lack of resources	Slipperiness and quantity of snow for local roads and urban roads and streets.	Heavy snow, black ice, heavy traffic	Late timing on snow clearing, traffic jams on rush hours	High traffic volumes, high speeds and high user expectations, complicated, free flow junctions, lack of financial resources, equipment and staff	HGVs across the roads impede winter service	High costs of winter maintenance, extreme weather, traffic density and road construction	Salt can't be used during very cold weather; hard to ensure winter maintenance due to road construction in some sections	Salt is harmful for nature and can't be used during very cold weather; long response time by contractors	Traffic congestion and lack of funding.	Improperly equipped HGV, no compliance with legally adopted regulations for winter equipment, relaying traffic load to other roads due to traffic jams	High altitude, complicated regional climate, intense traffic, complicated road delineation	Heavy snowfall, accidents, sometimes shortages of salt
Do standards and regulations for ensuring drivability on roads meet the requirements of road users?															
Yes													/		
No	/	/			/			/		/	/				/
Do your winter maintenance providers use any kind of weather information system?	MDSS and AUSTRO CONTROL with specially designed weather forecasts for winter service units.	It is called Vejvejr.dk., owed by the state, covered with more than 400 road weather stations along the road network and 5 major radars. The system provides anything from meteorological parameters in real time and forecasts.	Estonian RWIS consists of 62 road weather stations, 79 road cameras and 4 VMS signs. Weather forecasts provided by the Estonian Met Office.	Weather stations and weather camera system in addition satellite and radar images	SWIS by German Weather Service	IRCA gathers data into central database, there are approximately 100 road weather stations countrywide, forecast period up to six days is used.	Vaisala Road DSS (Road Decision Support System)	Local weather info. systems; other data from National dpt. of Civil Protect.	RWIS that consists of 53 ESS (Vaisala rosa station), that are equipped with IP weather cameras, we are introducing MDSS	103 Road Weather Stations, meteorological forecast from Lithuanian Hydrometeor-ological Service	250 Road Weather Stations, the forecast is bought from Norwegian meteorolo-gical Institute	Ice sensors, meteorological info., cameras, temperature sensors on and beneath the surface	Road weather information system (RWIS) which represents data in web application; special road weather forecasts produced by physical model METRo	Fixed and mobile weather station, other specific weather prediction systems for specific road sectors (MDSS)	Weather stations along the motorways, "SwissMeteo" provides weather forecast

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Question / Country	Austria	Denmark	Estonia	Finland	Germany	Iceland	Ireland	Italy	Latvia	Lithuania	Norway	Poland	Slovenia	Spain	Switzerland
From which sources you mainly obtain weather and traffic information?															
National meteorological office	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather forecast	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Road weather stations with floor sensors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Weather stations	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partially	Yes	Yes	Yes
Road weather VMS	Yes	Yes	Yes	Yes	Partially	Yes	No	Yes	No	Yes	Yes	Partially	/	/	/
Video cameras	Yes	Yes	Yes	Yes	Partially	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Information system for conditions monitoring in individual area	Yes	Yes	No	Yes	Partially	Yes	Yes	No	No	No	/	No	Yes	/	Yes
Calls of road users	Yes	Yes	Yes	Yes	Partially	Yes	No	Yes	Yes	Yes	Yes	Partially	Partially	/	Yes
Information from the police	Yes	Yes	Yes	Partially	Partially	Yes	No	Yes	Yes	Partially	Yes	Partially	Partially	Yes	Yes
Information of road service providers on the field	Yes	Yes	Yes	Yes	Partially	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
What are the main measures you use for operational intervention on roads?															
Required level of road drivability				/				/							
Snow height at which an intervention is necessary				/				/				/		/	/
Required friction characteristics of road surface	/	/		/	/		/	/	/			/		/	/
Intervention according to the already prepared scenarios of road conditions in regard to weather conditions				/											
Intervention on the basis of MDSS and Road Weather Information System (RWIS)				/				/						/	
Required time for drivability of road in throughout the whole day hour-to-hour (*numbers indicate hours*)				/	24 24 24 6-22 7-20	24 6-24 7-22 4-01 8-20	24h as practicable	/	6-22 6-20	24 24 4-22 6-19 06-19 and 09-18	24 24 24 24 h 6-22	/	24 24 5-22 5-20 7-20	/	2 - 2.5 h for Motorways
Timeframe, when winter service providers are not present on roads	/	22-5 22-5	/	/	30 min all categories	23-6 21-7 24-4 19-8	/	/	24-3 22-3 20-6	22-4 19-6 06-19 and 09-18	23-03h for cycle lanes	/	/	/	/
In approximately what time (after the weather forecast by the weather service) and before the actual winter conditions take place (snowfall, ice, sleet), do you preventively sprinkle salt on roads? (in hours)	/	3 3 3	/	/	/	0,5 0,5	As close to before the commencement of the conditions as possible	/	/	/	1 1 1 1		2 2 8 8 8	No specific times are preestablished	/
Which advanced technologies you use?															
GPS directing and tracking of ploughing and sprinkling	Yes	Yes	Yes	Yes	Partially	Partially	Yes	Yes	Partially	Partially	Yes	Yes	Yes	Yes	Partially
Improvements of ploughs and sprinkler devices	Yes	Yes	Yes	Yes	Yes	Partially	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Laser detection of icing	Yes	Yes	No	/	No	No	Yes	No	No	Partially	Partially	No	No	No	Partially
Using thermo-graphics in designing of thermic maps	Yes	Yes	No	/	Partially	No	Yes	No	No	/	Partially	No	No	Partially	Yes
Pools for melting of removed snow and ice	No	No	No	/	Partially	No	No	No	No	No	Partially	No	No	Yes	Partially
Using a meter for measuring the salinity of road surface	Yes	Yes	Yes	Partially	Yes	Partially	No	No	No	No	Partially	Yes	Yes	Partially	Partially
Using a meter for measuring deceleration, connected to GPS in vehicles for determining friction skidding levels	Yes	No	Yes	Yes	No	Partially	No	No	No	Partially	/	No	Yes	No	Partially
Using a meter for measuring coefficient of friction in or out of the vehicles (towed meter)	Yes	No	No	Yes	No	Partially	No	No	No	Partially	Yes	No	No	No	Partially
Automatic melting of pedestrian corridors, parking areas, stairs and other public spaces	/	No	No	Partially	No	No	No	No	No	No	Partially	No	No	No	Partially

Question / Country	Austria	Denmark	Estonia	Finland	Germany	Iceland	Ireland	Italy	Latvia	Lithuania	Norway	Poland	Slovenia	Spain	Switzerland
Automatic »anti-slipping sprinklers«, installed on exposed places, such as viaducts, bridges, etc.	/	No	No	Partially	Partially	No	No	Partially	No	No	/	No	No	Yes	Yes
Centralized information systems for monitoring activities and conditions on roads, measuring of quantity of sprinkling material in »real-time«	Yes	Yes	No	/	Partially	Partially	Yes	Partially	Partially	Yes	/	Yes	Yes	Yes	Yes
Indicate main topics or areas for research?	Salt sprinkling and spreading: new methods for evaluating efficiency.	Cost benefit analysis, traffic impact on melting ice, capabilities of road sensors, de-icing management system	/	Anti-skid treatment in cold weather, winter maintenance without salt, real time informa-tion of winter conditions	Automatic spreading, road weather information sensors, Spreading during snowfall	Optimization of salt use, weather information services, friction improvement on rural roads, automated sprinkling and spreading	Measurement of residual salt on roads, automatic prompting for winter service decision making, alternative de-icers at low temperatures	New weather forecast technologies	How to increase winter maintenance effectiveness without substantially increasing its expenses	Slippery reducing materials, increasing winter maintenance effectiveness without increasing expenses.	Automatic slipperiness measuring, a tool for measuring performance of the contractors.	Advanced technologies to reduce costs of winter service, environmental friendly materials.	Automatic measuring of slippery, wet salting with NaCl, thermic maps, improving weather forcasting in relation to microclimatic conditions, costs of preventive gritting.	Maintenance Decision Support Systems (MDSS)	De-icing agents and equipment

Categories of roads:

- motorways
- semi motorways
- main roads for motor vehicles
- main roads
- regional roads
- local roads
- urban roads and streets
- cycle lanes

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