

STANDARDIZATION OF WINTER MAINTENANCE OPERATIONS ON ROAD NETWORK IN THE CZECH REPUBLIC: SUCCESSFUL WAY TO KEEP THE RELATION BETWEEN BUDGET AND QUALITY

T. POSPISEK & D. KONECNY
CROSS Zlin, Czech Republic
POSPISEK@CROSS.CZ & KONECNY@CROSS.CZ

ABSTRACT

Czech Republic is on the threshold of new contracts with suppliers of winter maintenance. The six-year period, when the maintenance of state roads was performed on the basis of old contracts and technical conditions, is coming to an end. It is obvious that over the last six years winter maintenance went incredibly forward. National road authority felt that for the new period it is necessary to update the contractual terms and conditions that should take into account the experience and contemporary know-how. Special working group has been created to prepare new conditions following several fundamental goals. Safety on the roads is the primary goal. At the same time, however, there is a pressure to perform winter maintenance on a limited budget, while maintaining or even improving the quality of maintenance.

The paper describes the key parameters of contractual terms to ensure the fulfilment of these objectives. In the first place it is a change of the current model of financing winter maintenance by introducing a dual-band model, which includes the lump sum of winter maintenance. Optimization was also carried out in other areas like vehicles, information systems and dispatching. Please see inside.

1. INTRODUCTION

Czech Republic is on the threshold of new contracts with suppliers of winter road maintenance. The six-year period, when the maintenance of state roads was performed on the basis of old contracts and technical conditions, is coming to an end. It is obvious that over the last six years winter maintenance went incredibly forward. National road authority felt that for the new period it is necessary to update the contractual terms and conditions that will take into account the experience and contemporary know-how. Special working group has been created under the Ministry of Transport to prepare new conditions following several fundamental goals. Safety on the roads is still the primary goal. At the same time, however, there is a pressure to perform winter maintenance on a limited budget, while maintaining or even improving the quality of maintenance. Another strong requirement which was identified based on experience from previous seasons is a standardization of winter maintenance across the Czech Republic.

The paper below describes the key parameters of contractual terms to ensure the fulfilment of these objectives. In the first place it is a change of the current model of financing winter maintenance by introducing a dual-band model, which includes the lump sum of winter maintenance. Optimization was also carried out in a special division of the road network into new maintenance areas, in defining the optimal number of spreaders and special mechanisms and in definition of mandatory sensor equipment. Technical conditions also describe the role of the dispatcher as a key person in the management of maintenance operations. New conditions also introduce a new central information system for keeping records of the maintenance performed during winter season.

1.1. Winter road maintenance in the Czech Republic

Winter road maintenance in the Czech Republic is ensured by the owner or the administrator of the roads. Roads of Ist and higher class are owned by the state, which is represented by the **Ministry of Transport**. The Ministry administers the roads mostly through its state-funded organization, the **Road and Motorway Directorate of the Czech Republic** (RMD).

The RMD performs winter maintenance by its own departments on highways and some motorways (which are formally Ist class roads). Winter maintenance is ensured by the Centres of administration and maintenance of highways and the Centres of administration and maintenance of motorways.

Maintenance of Ist class roads is performed by **contractors**. This means that under a contract with the Ministry of Transport, eventually with the RMD the maintenance is performed by contractual private companies – so far mainly region-funded organizations. Contractor performs all activities required by the contract at his own expense and then, at the end of the calendar month, he bills the authority for performed maintenance according to the official list of activities.

Roads of IInd and IIIrd class are owned by **regions** (administrative divisions of the Czech Republic). Regions perform the administration and maintenance of roads mainly by their own region-funded organizations, the Administration and Maintenance of Roads. In some regions the original region-funded organization has been transformed into a private company owned by the region – a joint-stock company, eventually a limited liability company.

Table 1 – Road length in the Czech Republic in kilometres by January 1, 2013 [1]

<i>Highways</i>	<i>Motorways</i>	<i>Ist class roads</i>	<i>IInd class roads</i>	<i>IIIrd class roads</i>	<i>Total</i>
751.2	442.1	5 807.9	14 542.9	34 172.3	55 716.5

Table 1 shows the extent of road network in the Czech Republic. There are **1193 km** of roads of highway type which are administered by the state directly. Further there are nearly **6 000 km** of Ist class roads which are maintained by contractors – the part of this particular road network is of our concern in this paper. Highways, motorways and Ist class roads form the backbone communications network of the Czech Republic.

For the record it should be stated that apart from the winter maintenance the maintenance contracts (old ones as well as new ones) include partially also the **routine maintenance** including, but not limited to, inspection routes, manual cleaning of roads, installation / removal of portable traffic signs, patching potholes, and straightening of posts of traffic signs or delineators.

2. INITIAL CONDITIONS

Present division of the road network reflects the **administrative boundaries** of 13 Czech regions, with a few specialities.

The problem is that the division is administrative. Experience confirms that such a division negatively affects the maintenance operations in specific cases. There are cases described when the practicability of the road in winter conditions dramatically changes when passing the region boundary due to different approach to maintenance,

inappropriate setting of maintenance circuits, inappropriate location of maintenance centre in connection with critical spots on the maintenance circuits.

Also problem can arise in relation with the specific character of the road section at the boundaries. Typically it is a problem when the critical road stretch in a region is divided between two maintenance areas. Such critical stretches should be treated as most uniformly / consistently as possible. Another problem of administrative boundaries is clear from the driver of maintenance vehicle point of view. It is that it is not possible to make a U-turn easily in the middle of the road without a safe turning point.

The road authority hopes that the new division of maintenance areas will help **to minimize the negative effects to optimize the operations**. Also the emphasis will be placed on approval of winter maintenance plan in relation to proper setting of maintenance circuits.

The working group has defined new maintenance areas considering possibilities for setting the maintenance circuits, considering road stretches with special treatment plan (without salt), optimal extent of the area and other issues stated above.

New areas are classified into categories according to usual **onset and overrun** of winter conditions (length of winter season in fact). In this period, the mechanisms are required to be in operational condition, which is taken into account when making a claim to lump sum of winter maintenance.

The standard winter season goes from **November 1 to March 31**. But some areas experience onset of adverse weather conditions earlier than others and also some areas undergo longer overrun of winter conditions than others. Therefore, the onset and overrun is defined for several areas before and after the standard winter season. The onset shifts the start of the season for category 1 up to September 1. The overrun shifts the end of season on April 30.

During the onset and overrun period of the season a defined part of required maintenance vehicles (spreaders with snowploughs) must be in operational condition, ready for the necessary treatment of roads. The areas with onset and overrun can invoice a specific part of the lump sum of winter maintenance to cover this special requirement.

The existing contracts were signed for 6 years ending with the winter season of 2012/2013. It is obvious that the length of the contract significantly affects the possibilities for applicants regarding the bid price in relation to high investment demands of the winter maintenance, uncertainty of severity of upcoming winter seasons and other related issues.

*In regards to change in contractual terms it was decided that the **new contracts** will be for 4 years only. Also the final decision was made that the tender for 2013/2014 to 2016/2017, which is a **pilot project** in fact due to new conditions, will be announced **only for a few selected maintenance areas** so it will be evolution rather than revolution.*

3. NEW FINANCIAL MODEL

For the current contracts which were prepared 6 years ago, there were **unit prices** which covered together all the **variable** and all the **fixed costs** of the contractor. It means no lump sum was present in these contractual terms. For example the price was set for one kilometre of ploughing. This unit price covered the operation costs (driver, fuel) as well as managing costs like spare parts, depreciation etc.

Under such a financial model, basically **two extreme scenarios** can happen. When an extremely severe winter comes, the state budget will run out of money. On the other hand when an extremely mild winter comes, the contractors will have no money to cover the fixed costs, to pay people, vehicles, buildings etc. Based on this experience, it was decided to change the financial model.

So the new financial model introduces a **dual-band model**. Besides traditional maintenance activities (see table 2) the novelty is the **lump sum of winter maintenance**. This lump sum is claimable for at least 150 days per season (regarding the category of the maintenance area) and should cover all the fixed costs of the contractor. It means depreciation of vehicles, spare parts, buildings, services, staff of the maintenance centre and all other operating costs.

Table 2 – Key winter maintenance activities in the official list

<i>Name of the maintenance activity</i>	<i>Unit</i>
Spreading chemicals (excluding material)	km
Spreading chemicals (excluding material) with ploughing	km
Spreading grit (excluding material)	km
Spreading grit (excluding material) with ploughing	km
Inspection routes by personal car	km
Inspection routes by spreader	km
Snow removal by front plough	km
Snow removal by tractor rear plough	hour
Lump sum of winter maintenance	day
Spreading material – salt NaCl	t
Spreading material – grit	t
Brine of NaCl	l
Brine of MgCl ₂	l
Brine of CaCl ₂	l

On the other side the **unit prices** of maintenance activities were reduced accordingly to cover only the variable costs. It means direct wages, direct material and fuel. As an example we can indicate that the unit price of a kilometre of ploughing was reduced by more than 50 %.

Nevertheless, the **sustainable budget** of the whole winter maintenance is maintained. The only change is that the budget is divided between the activities in a different way. Under such a financial model above stated two extreme scenarios are not applicable. When a sequence of severe winters comes, the state budget can hold on because the excess in maintenance performance will not be so financially crucial (because the fixed costs are separated from unit prices). And when a sequence of mild winters comes, the contractors can survive because of the lump sum.

The unit prices are one part of the financial model. The second part is made of **amount of units**, expected for each maintenance area per year, which differentiate the areas in respect to usual winter severity. It is obvious that the areas are quite different speaking about winter conditions, their intensity and frequency in the area.

While the unit prices of activities are unified for all selected areas, the amount of units per year can be totally different and defines the total budget allocated for different areas.

Inside the working group a group of specialists has deeply analyzed historical amounts of activities in all maintenance areas, long-term regional winter severity and other crucial parameters in order to determine **expected amounts of activities** per area and year; a year that can be labelled as 'an average' or 'a standard' in a period of last 50 years – regionally for each maintenance area.

It is more than clear that each winter season is different (generally as well as regionally) and it is not possible to easily extrapolate the amounts of units from last few years. For this reason the working group has used the so called winter maintenance index to evaluate the long-term winter maintenance severity in all parts of the road network.

The **winter maintenance index** (WMI) has been developed together by the Czech Hydrometeorological Institute (CHMI) and the company CROSS Zlin and it features the historical evaluation of weather and specific local conditions for each square with a side length 500 metres covering the road network.

One part of the analysis is the description of long-term weather trends and regional differentiation of winter severity, while the second part is based on short-term (6 years) records of performed winter maintenance. The analysis of historical performance of winter maintenance in the Czech Republic showed that there are quite large differences in approach to winter maintenance in different parts of the country. Let's call it a '**local standard of winter maintenance**'. Sometimes you notice that you drive a black road in one region, while neighbouring roads are partly white with snow.

Certainly this is not the proper state. So the working group had to find 'a standard', 'an average' and based on this standard, which depends on current best available practices and technologies, the expected amounts of activities were defined for selected maintenance areas.

3.1. Central purchase of road salt

Another feature which should lead to standardization of winter maintenance operations is a **central purchase of road salt** by the road authority.

The central purchase will ensure the unification of required **quality of salt**, which is essential for the successful treatment of roads. In the past, the poor quality of salt forced several suppliers to increase the instant amount of salt while spreading or to frequently repeat the treatment, which implies greater financial costs while the maintenance effect is still the same.

The **amount of road salt** needed to cover the demands of all maintenance areas was defined within the analysis described above in the paper. It means by the historical analysis of long-term winter severity using winter maintenance index and short-term records of salt consumption.

4. STANDARDIZATION OF WINTER MAINTENANCE

The legislative framework for winter road maintenance is stipulated in **Act No. 13/1997 Coll.**, on roads, and the Ministry of Transport **Decree No. 104/1997 Coll.**, implementing above stated Act on roads.

In the tender conditions, the Ministry of Transport stated the basic philosophy and other rules for contractual relationship with contractors. The authority requires that the basic philosophy of maintenance (routine as well as winter) at the contractor's side is **reasonable optimization of performance**, respectively costs covering the scope of the contract.

In the winter maintenance, this requirement must be confronted with the requirements of the Decree for the **mitigation of defects in the practicability of roads**, respectively with the intention to maintain the safety of roads.

The contractor makes all activities required by the contract at his **own expense** and then, at the end of the calendar month, **invoices** the authority for all performed activities according to the official list of activities and other terms of billing.

The contractor prepares the **operational plan of winter road maintenance** before each winter season. This plan is a fundamental document describing how the winter maintenance will look like in a specific area. It contains all the information about the dispatching centre, vehicles, key persons, the system of maintenance (ordinary and extraordinary), available technologies, setting of maintenance circuits, etc.

The operational plan is then approved by the authority which means that it is complying with the requirements and philosophy of maintenance. After the approval the plan is mandatory for the contractor and he should act according to it throughout the whole season.

Under the new contracts the road authority will require that the plan is strictly prepared on the basis of the **official template**, which will result in standardization of all plans, and that all its parts comply with the contract requirements.

The contractor must operate a **dispatching centre** of corresponding specification for winter maintenance management. The dispatching centre must be occupied by appropriately qualified **dispatcher** (see chapter 6), whose primary task is the continuous management of winter maintenance. The dispatching centre must be designed for uninterrupted operation during the winter season.

The contractor must also operate the **maintenance centre**, which will be properly equipped according to contractual requirements. Requirements include particularly appropriate mechanization, human resources and storage space for spreading materials.

The **location** of maintenance centres as well as the location of dispatching centre, the location of storehouses of spreading materials and configurations of maintenance circuits for each vehicle is the responsibility of the contractor. These points are afterwards included in the operational plan. The authority requires that these issues are solved as optimal as possible in response to local conditions to meet the maintenance philosophy. For this reason the **buffer zones** were defined around each maintenance area where is it desirable to locate the properties.

The contractor also has a duty to properly report the amount of activities performed and to properly keep the records in so-called **logbook of winter maintenance**. On the basis of a duly records an invoice is generated, approved and prepared for payment by the authority.

4.1. Technologies of winter road maintenance

The contractor is obliged to follow the legislative and contractual framework in performing the winter maintenance and to use the **best available techniques** to mitigate defects in the practicability of roads. Available technologies of winter road maintenance are specified in the Decree in its Annex 7.

The contractor is obliged to continuously **strive to optimize** each winter maintenance intervention, especially in terms of the proper balance of number of runs and selected spreading weight (g/m^2).

The contractor must be familiar with the principle of **selective maintenance** when the maintenance circuit is not strictly treated in its entire length, but only those road segments are treated which need it currently or in the near future in connection with the development of the weather situation.

The Decree defines the common **spreading materials**, namely sodium chloride (NaCl) as a primary dry salt as well as brine, calcium chloride (CaCl_2) and magnesium chloride (MgCl_2) as alternative brines, and also inert materials like sand, grit and crushed slag.

The Decree also deals with the technology of **pre-wetted salt**, when a dry salt is sprayed with brine solution which ensures earlier activation of salt on roads. This technique is prevailing on Ist class roads in the Czech Republic. In specific cases however, dry salt only or brine only can be applied on roads.

The contractual terms deal also with anti-icing and de-icing approaches. It is apparent that in specific cases the **preventive (proactive) salting** may lead to cost savings compared to conventional technique of eliminating or reducing defects in practicability after their formation (retroactive maintenance).

5. MAINTENANCE VEHICLES

Another area which was revised by the working group is concerning the maintenance vehicles, especially the **spreaders**. Firstly, the working group has determined the number of vehicles necessary to cover the selected maintenance areas in an optimal way.

The number of vehicles is based on a thorough analysis of the pertinent road network. Also the working group took into consideration the geographic possibilities for setting of the maintenance circuits, the width of roads (dual carriageway with 2 lanes in each direction normally requires two spreaders working in tandem), the risky road stretches and also the roads with extraordinary mode of maintenance (roads in protected areas or areas with sources of drinking water).

Based on the winter severity analysis, described above in the paper, it was also stated if the maintenance area needs any **special mechanism**, for example snow blower to fight with occasional large amounts of snow.

Secondly the working group concluded on a specification and an equipment of maintenance vehicles. It was stated that the age of vehicles is not limited if it can comply with all the technical requirements according to contractual terms.

The technological equipment of vehicles (spreaders) includes mainly technical facilities for performing the winter maintenance (hoppers, spreading extension, plough). The vehicle has to have an **on-board electronic unit** to control the operation of ploughing and spreading from the cab. The Decree stipulates that before each winter season the vehicle should positively pass the test for compliance of set and real amount of salt (g/m^2) spread from the vehicle while driving.

The spreaders that perform the winter maintenance on Ist class roads under the given contract should also be equipped with a **position tracking system**. The system gives the information about the position and time of maintenance as well as parameters of performed maintenance. So in each position record there is also information on ploughing yes/no, spreading material (dry salt, salt + brine, brine), amount of salt, and possibly other parameters such as width of spreading or side regulation.

Newly the spreaders can be equipped with **other devices** that can provide other important data, for example the temperature of road, road condition and ambient temperature. Such sensors are currently being tested in the Czech Republic and generally it is expected that their time will come in next few years since there are efforts to utilize such data in road weather information system as well as in maintenance decision support system.

The data from all the technical parts of the system is integrated by the central electronic unit, packed and sent online via wireless network into the data centre for subsequent processing and utilization – for example within the fleet management system or for the purposes of reports of performed maintenance within the central information system (see chapter 7).

5.1. Personal vehicles for inspection routes

The personal vehicle to be used as a vehicle for inspection routes newly must also have a device for **contactless detection** of road surface condition and measurement of surface friction (slipperiness) and temperatures in real time. Together with information from a position tracking system the data should be transmitted to the data centre.

So far the problem of inspection routes was quite clear. The observations are inherently subjective and there are no factual recordings of the observations. Since there are devices on the market these days, the road authority supports the exploitation of the sensors for winter road maintenance purposes.

The data can be used both for informing the dispatcher (and public consequently) and also as an input into road weather information system (RWIS) and maintenance decision support system (MDSS).

6. DISPATCHING CENTRE

The contractor is obliged to operate the dispatching centre of required specification. As stated in the chapter 4, the dispatching centre should be operated during the whole winter season without interruption and it should be occupied by a qualified dispatcher.

The costs for the dispatching centre are covered by the lump sum of winter maintenance.

So far there was no standardization regarding the operation schedule of the dispatching centre and changing of the dispatchers, but the recommendation now is that the shift is for **12 hours** and the changing is realized at **8 a.m.** and **8 p.m.**

The dispatching centre should be in relevant distance from the roads in question. The optimal **location for dispatching centre** seems to be this near the geographic centre of the area, in the immediate vicinity of some of the roads in question and in the end it is also recommended to take into consideration the location of existing road weather stations as a tool for remote monitoring of the situation on the roads.

The novelty in the new contractual terms is an initial **certification of dispatchers** and their regular retraining. All the dispatchers of the contractor, who perform dispatching service under the contract, must have a valid certificate certifying successful completion of dispatcher training.

The road authority considers the dispatcher as a key element for the success of the winter road maintenance – both regarding the safety on roads as well as optimization regarding limited budget.

With the intention to unify, respectively to set up and maintain the qualification (and the quality) of dispatchers the road authority will organize regular training, always before the winter season. The training is designed to be one-day and will concern a cross-section of three fundamental issues: 1) the legal framework, 2) basics of meteorology (including road weather information system and the interpretation of its data) and 3) the performance of winter maintenance (best available technologies, maintenance management, and computer skills with a focus on central information system).

7. CENTRAL INFORMATION SYSTEM

Another novelty which should be introduced by the new contractual terms is a **central information system** covering the entire record keeping of winter road maintenance during the whole winter season in one environment.

The system is designed for **keeping records** of the course of winter maintenance, daily reporting of **performed maintenance** (e.g. salt consumption), and also for regular **transmission of information** on weather and road surface conditions. For all these activities the serving dispatcher is responsible.

The dispatcher is obligated to fill in a **central logbook** continuously according to the guidelines gained within the training of dispatchers, especially the current weather and road surface conditions, the activity of maintenance vehicles in the field, incidents (e.g. accidents, congestions, and road closures), etc.

The system in its complexity will serve the dispatchers as well as the contractor and the road authority. The detailed reports of performed winter maintenance are sources for argumentation as well as for evidence of activity and invoicing. The system will allow easy access to data for all authorized persons, including automatic scheduled or requested checks and validations of data.

The central information system should also keep the records of **road salt**. It means for each storehouse the system should log every replenishment of salt and also to count down daily salt consumption so there is still updated information on amount of salt in the storehouse.

The system will also be connected to a **central database** of data from maintenance vehicles (see chapter 5). For this purpose the **unified communication protocol** has been defined in order to standardize the data exchange and allow the data integration into a central database.

7.1. Checking the adequacy of the winter maintenance performance

The central information system will also feature a subsystem for winter maintenance performance **adequacy check**. This is one of the control mechanisms aiming at achieving and maintaining a **uniform standard** of winter maintenance throughout the Czech Republic (see also a 'local standard of winter maintenance' in chapter 3).

This is an expert system for evaluating the adequacy of reported performance (number of kilometres of spreading, number of kilometres of snow removal, consumption of salt and other spreading materials) based on evaluation of meteorological and local conditions.

Based on algorithms of **winter maintenance index** (WMI) mentioned in chapter 3, the system allows determining adequate performance for each area of maintenance, but in nature it is calculated for each square 500x500 meters covering the roads.

Local conditions are evaluated based on detailed GIS data from Road and Motorway Directorate of the Czech Republic, including especially digital elevation model and a precise road layer. **Weather conditions** are evaluated using the data from all available weather stations in an area – it means road weather stations and CHMI climatological and meteorological stations. Key parameters such as precipitation, humidity and temperatures are evaluated to result in winter index for each maintenance area which stands for **winter maintenance severity**.

The system is used to **identify deviations** from the 'standard' level of maintenance, from a standard reaction to specific weather conditions. The standard is determined analytically through a statistical interpretation of relation between winter severity and maintenance performance from large number of contractors. See a schematic drawing in the figure 1.

When a deviation is identified, the impulse for a **local inspection** is generated so the maintenance personnel can find what went wrong, what caused the deviation and how they should proceed next time. So the system provides a sort of feedback resulting in standardization of winter maintenance operations among different contractors and maintenance areas.

For the road authority the system is a tool for elaborate **comparison of different contractors** working in different climate conditions, on different extent of road network.

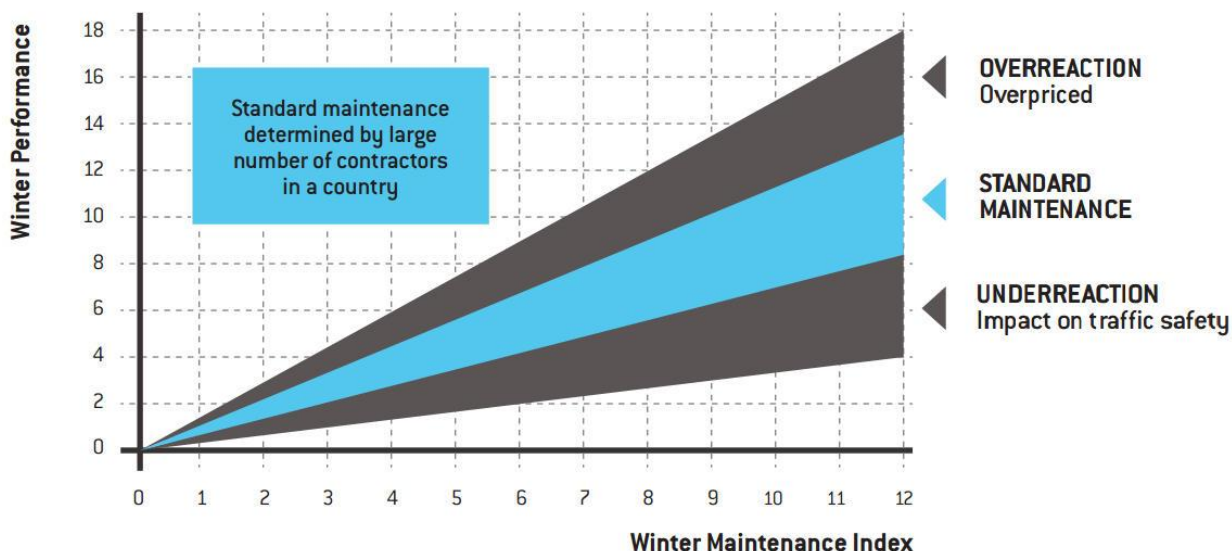


Figure 1 – Standard maintenance dependency

8. CONCLUSION

A working group of the Ministry of Transport hopes that the pilot project introducing the new approach to winter road maintenance will be successful in the selected maintenance areas and that the new contractual terms finally can be spread to the whole country.

The experience from several previous winter seasons is that there is always something to improve in order to keep the roads safe and at the same time to keep the costs in a reasonable level.

The standardization of approaches to winter maintenance is a never-ending challenge, but we all know that this is the way we have to take for keeping the relation between the quality and the budget. We also believe that through the assessment of the adequacy and usage of RWIS and MDSS systems it is possible to optimize the winter maintenance and reduce its overall financial costs while maintaining quality.

The result of performed treatment is the road condition and slipperiness (friction). Both of these variables can be objectively measured by fixed or mobile sensors these days, enabling us to frequently survey the roads to be able to evaluate the real objective of winter road maintenance.

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