INNOVATIVE SOLUTIONS
FOR MANAGING WINTER SERVICE

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ABSTRACT

The Ministère des Transports du Québec (MTQ) is constantly seeking innovative ways to improve service delivery in a context of sustainable development and mobility.

Over the last few years, the Ministère has implemented intelligent transportation systems (ITS) designed to collect real-time operational data on a part of its vehicle fleet, using the latest technologies in instrumentation, communication and geomatics.

This has provided it with data constituting a new database of operational information that it can exploit and consult in both real and non-real time to optimize management of the resources devoted to winter maintenance activities.

Current development efforts are focused on optimal processing of the volumes of data recorded, the purpose being to provide tools for improving every phase of the operational process, from monitoring weather and operations to preparing strategies for winter maintenance activities, while also ensuring the uniformity of results.

These innovative projects will lead to new modes of management based on organizational criteria like effective and efficient management of resources (proactive rather than reactive), while maintaining a safe and fluid road network. The ultimate objective is to obtain the greatest possible benefit from this data throughout the winter service management process.

KEYWORDS

WINTER MAINTENANCE / DATA EXPLOITATION / INFORMATION SYSTEMS

1. INTRODUCTION

The advent of new technologies for the collection, transmission and processing of data has brought real benefits to the transportation field. Intelligent transportation systems (ITS) include applications in areas such as traffic management, accident prevention, emergency management, optimization of road maintenance operations and other more specific areas of intervention.

Winter road service is one of the areas that could most benefit from various kinds of ITS initiatives. To improve the management of that service, the realities of winter service must be mastered in all their complexity.

For this reason, over the last few years the Ministère des Transports du Québec (MTQ) has launched a series of ITS projects for the collection of real-time operational data on the road network, in order to optimize the management of winter maintenance. This dynamic approach is based on a variety of actions, all driven by a desire to improve the quality of services to users, to be a proactive organization, and to respond promptly to situations requiring decisions.

The first part of the present communication will review the various initiatives, often in the form of pilot projects, whose purpose has been to find solutions using pioneering technologies and management strategies.

The second part will present different ways of exploiting the data, in particular the application domains where ITS can give added value to the running of a road network.

Lastly, a series of reflections will clarify the reasons why such initiatives in intelligent transportation are now necessary, and the benefits to be obtained from them.

2. ITS INITIATIVES OF THE MINISTÈRE DES TRANSPORTS DU QUÉBEC

2.1. Road weather stations and monitoring the vehicle fleet

As in many road organizations, road weather stations have been installed progressively to create a network of observation points (in the case of part of the strategic road network, every 30 kilometres). These stations collect many kinds of information, both in terms of road-related meteorological observation and in terms of the roadway itself (air temperature and humidity, atmospheric pressure, wind and precipitation levels, road temperature at the surface and at different depths).

Two kinds of road weather stations have been installed: a model that provides all of the information listed above, and a less costly model that can be deployed in greater numbers and which only collects information on air temperature, humidity, and temperature at the surface of the roadway and beneath the ground.

All of these road weather stations are linked to a communications network so their data can be received in real time.

The resulting measurements are recorded in a database that is integrated into weather forecasts, improving their precision and providing the basis for now-casting. The data is also used to illustrate reports on every significant weather event, and soon will provide the input for development of an index to be used in evaluating the difficulty of winter maintenance. Such an indicator will provide material for a comparative analysis of efforts devoted to road maintenance along different routes, at different operations centres and in different regions.

Since 2000, the MTQ has also taken the initiative of instrumenting patrol vehicles, outfitting them with an assembly kit to collect data on:

- air temperature;
- humidity (dew-point temperature);
- roadway surface temperature.

A newer version also measures altitude, enabling the user to consider elevation-related differences in road weather parameters, such as variations in air temperature or types of precipitation from one location to another.

The data is recorded in a rugged portable unit that manages all of the measurements collected and is directly linked to a vehicular router for the remote reading of data in real time. This equipment, now in regular use by operational staff, provides information that facilitates the prediction of road ice phenomena (both black ice and white ice). Going forward the data will also be fed into sector-specific databases designed to improve understanding of the behaviour of roadway surface temperature over a given route. Tools for predicting surface cooling of the roadway are currently in development.

These new data collection technologies are thus contributing to a better understanding of the real-time behaviour of road weather parameters, enabling more precise assessment of road weather situations. When processed, this data also constitutes a knowledge base about targeted events in particular sectors.

A combination of measurements is also taken aboard several hundred vehicles currently operating under the MTQ. This data permits remote monitoring of the activities of snow-removal and de-icing vehicles, both those of the MTQ and those of private enterprises under contract to the Ministère.

All of this information is collected in real time and made available through an application on the MTQ's intranet. GPS receivers indicate the locations of the vehicles, whose progress can be followed on a thematic map. At each control centre, this map provides an overview with all of the road weather information for the entire region.

2.2. Information processing systems

Hosted on the intranet of the MTQ are applications for visualizing data and making queries.

Operational information obtained through vehicular data communication (VDC) is presented on a map interface. Various elements of the map can be customized on the fly to meet the needs of the moment. This allows staff to track the movements and activities of vehicles in real time, or to recreate events later in order to analyze their various stages after the fact.

Multiple layers of information can be parameterized and superimposed. The road network, administrative boundaries and maintenance routes can be activated or deactivated as the user prefers. When a vehicle icon is clicked, a balloon with detailed information appears. Figure 1 shows a view of the user interface.

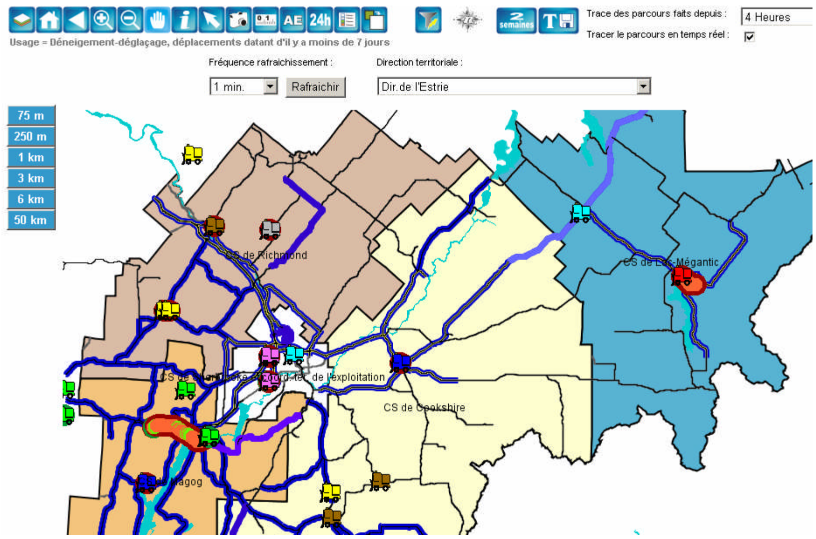


Figure 1 – User Interface (VDC)

Pre-programmed reports are issued periodically, and pivot tables enable the user to make queries.

The plan is to enhance this information processing system with more and more extensive capabilities in terms of linking different kinds of information in real time: operational data, road weather measurements, geographical context, etc.

2.3. A new type of data collection for surface and adherence conditions

Recently the MTQ has been exploring wireless technologies, more particularly instruments based on the principle of remote sensing. Though the information they gather is very complete (air temperature and humidity, surface temperature of the roadway, surface condition and estimated adherence of the roadway), the units are not especially cumbersome. They do not require heavy equipment and can be moved occasionally from one place to another when desired.

One application allows real-time access to data along with an image of the roadway captured by a high-quality camera. Alarms can be configured to warn the user when thresholds are reached, e.g. by e-mail.

One version of this type of instrument has been attached to a vehicle to provide the same information along a chosen route. This technique yields precious information during surveillance patrols, helping to identify and characterize sections of road that are more susceptible to a deterioration of traffic conditions.

3. APPLICATIONS FOR ITS INFORMATION

An integrated monitoring centre (IMC) is a road weather nerve centre where all of the information converges for an entire region. The first IMC was created in 2002 as a response to needs regarding weather monitoring, road weather surveillance and the coordination of emergency situations. Two workstations are present (Figure 2), each with multiple screens on which to optimize the management of information.

There is a large panoramic screen on which staff can place the most relevant windows, such as those for weather radar, the interface of the MTQ's road weather stations, the vehicular data communication interface, or surveillance cameras on the road network.

Figure 2 – Integrated Monitoring Centre

This is where the variable message signs scattered around the regional territory are activated, informing road users in standardized language designed for effective communication.

The IMC plays a strategic and crucial role throughout the process of managing road weather events, whether big or small. Its contribution includes:
- monitoring road weather;
- deploying resources;
- preparing strategies;
- monitoring and adjusting operations;
- managing communications;
- assessing the achievement of objectives.

The IMC is at the centre of all actions on or concerning the road network (Figure 3). Drawing on tools that give it a view of the whole, it can manage road weather events with the benefit of perspective, supplying information that is much appreciated by operational staff dealing with realities on the ground. By monitoring road weather, the IMC can verify the accuracy of forecasts and assess the expected impact on roadways in the network. Observations collected on the road and combined at the IMC provide a better perception of conditions in the very short term.

To assemble resources and prepare interventions *before* road weather conditions deteriorate, operational staff need highly reliable information up to two hours before an expected situation.

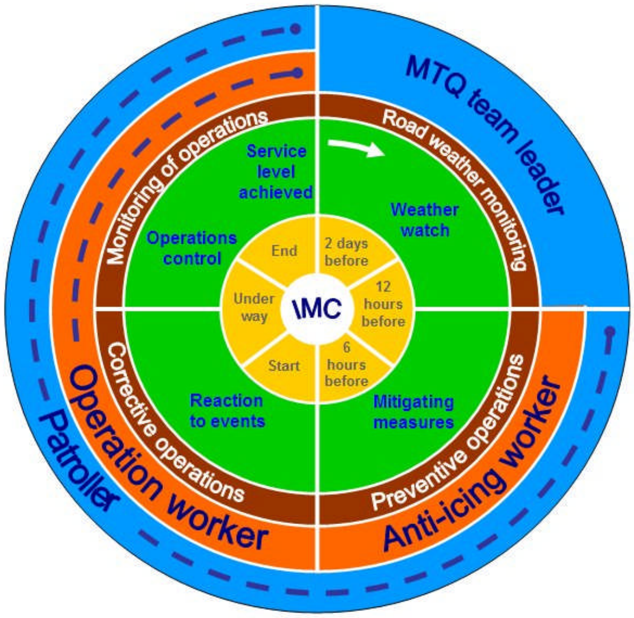


Figure 3 – Activity Process in Winter Maintenance

Functioning on a more global level, the management of winter maintenance activities works through three main channels to offer quality services:

- collecting information to evaluate and anticipate winter maintenance activities;
- using information to develop strategies and to implement and adjust activities;
- correcting the decision-making process for further improvement of services.

3.1. Improving aids to decision-making

Since this structure was put in place, decision-making has become easier for operational staff. More or less intensive monitoring is done depending on the timing of a road weather event, as well as during and after it, so that the situation is continually re-evaluated along with the risks associated with road weather phenomena.

This new approach toward monitoring road weather events has enabled the introduction of preventive measures and the use of anti-icing techniques. Spread over the roadway prior to an event, liquid anti-icing compounds work to preserve the safety level of traffic lanes until resources arrive to perform the traditional corrective operations.

This decision-making process has contributed greatly to increasing the use of preventive measures, which require particularly rigorous and regular road weather monitoring.

In addition, a pre-alert/alert process is triggered and conditioned by weather warnings or information from the MTQ's observational network. When alert levels are reached, IMC workers broadcast the information by messaging the people concerned in order to shift into the phase of mobilizing resources.

Here an important factor to consider is the varying intensity of an event across the road network. Certain sectors will be affected first or to a greater degree. The IMC helps operational staff identify these zones by alerts that can be activated at particular places in the territory, and by using predictive tools that account for spatial variations in road weather phenomena.

The operational staff regularly checks in with the IMC, doing so more frequently when road weather events are expected in order to track their progress. Information from fixed road weather stations, operational activities in other sectors and in-vehicle measurements (from mobile road weather stations) supply the operational staff with a variety of tools to aid decision-making.

All of this data is highly appreciated, especially at times when, during a road weather event, the winter maintenance supervisor has to decide how to deploy resources, let workers take a break, manage shift changes and so on.

For example, the supervisor must allow for at least 2 hours in which to requisition and send out workers, since the latter need time to inspect the maintenance vehicles, load the proper spreading materials, and set out with the equipment on their maintenance routes.

3.2. Monitoring the deployment of resources

Monitoring the deployment of resources is essential for optimizing maintenance operations and taking a proactive rather than a reactive approach.

The real-time cartographic interface reveals critical information like delays in the passing of maintenance vehicles. The IMC is particularly effective when it detects, for example, that nothing has been done on a given snow-removal route. IMC staff contact the operations manager to learn the reason for the situation and offer assistance. Such interventions result in a more uniform level of service to users throughout the road network.

Monitoring the turnaround time of maintenance vehicles, which varies by route, ensures that no sector is forgotten for snow-removal or de-icing. In a major, long-lasting weather event the operational staff depends on this support, for only by having a view of the global situation can it stay in control of the situation. Parts of maintenance routes are easily overlooked for snow-removal or de-icing, causing delays in the return to acceptable service levels. Using the cartographic interface to monitor operations helps detect this type of anomaly and be proactive.

3.3. The contribution of ITS to winter maintenance operations

Collecting data on meteorological, road weather and operational conditions helps improve the quality of snow-removal and de-icing activities. Such data can also reveal road weather parameters that tell the maintenance supervisor that winter maintenance is about to become more complicated, or on the contrary, that less work will be needed to return to acceptable service levels.

Road weather monitoring conducted both before and during an event makes it possible to track changes in parameters like wind, which can accelerate pavement drying but can also cause blowing-snow situations. When conditions improve, knowing this fact can result in spreading less salt or in adopting a strategy more likely to achieve acceptable service levels.

Using the VDC interface, it is also possible to obtain the exact quantities of materials spread during a storm. The operations manager can use this information to make a better assessment of whether or not additional spreading should be done. A tool has been developed to facilitate this task, giving not only the quantities to spread but the best proportion of ice melters and abrasives. Based on an artificial intelligence program that uses a neural network, the software learned the task by assimilating a multitude of real cases. Given inputs for a variety of road weather parameters, it recommends the proportion of types of materials and the amount to spread in tonnes per kilometre, along with a ‘confidence’ index for its suggestion.

Operational reports for three different time scales provide useful data for improving the management of winter maintenance. Real-time reports produce information about the state of things during the course of a road weather event, thereby aiding decision-making. The post-storm report reviews what happened after the fact, providing information that can be communicated to staff while it is still fresh in memory. Lastly, the post-season report looks back over the entire winter season, highlighting the main events and indicating how severe the winter was in terms of the frequency and type of interventions and the efforts expended to return to safe road conditions. These reports will become a knowledge base for the ongoing improvement of winter maintenance practices, while also ensuring the continued expertise of operational staff.

4. PROSPECTS FOR THE DEVELOPMENT AND IMPLEMENTATION OF ITS SOLUTIONS FOR WINTER ROAD SERVICE

4.1. Budgetary and environmental considerations

As winter maintenance activities become more and more costly, controlling expenditures is increasingly essential. Service level requirements have risen in recent years, as have the operating costs of machinery and the costs of spreading materials. Workforce renewal is no longer as simple as in the past, due to social and economic constraints that are perhaps more numerous than in other sectors of road transportation.

Contract prices have thus risen steadily over the last few years, while the number of replies to calls for tender has gone down. In short, winter maintenance is becoming increasingly expensive.

In this context, investments in ITS may seem enormous, since new technologies are involved and development budgets must be allocated. But institutions that focus on how investments pay off are showing that this kind of financial commitment is profitable.

Beyond purely economic concerns, spreading materials end up in the environment, with varying impact depending on the immediate surroundings. A number of studies have demonstrated that chlorides in melting agents propagate in multiple ways after spreading: by wind, by infiltration into the ground or groundwater, or by runoff. Moreover, sections of road that are located in sectors classified as particularly fragile, due to the proximity of a lake, watercourse or endangered ecosystem, are subject to restrictions for winter maintenance.

It is now compulsory in Canada to prepare a road salt management plan for better control of contaminant release at snow dumps and locations were spreading materials are stored. In keeping with sustainable development, such plans recommend using new technologies to facilitate the improvement of winter maintenance operations by using spreading practices at the right time, in the right amount, in the right proportion (abrasives/melters), and at the right location.

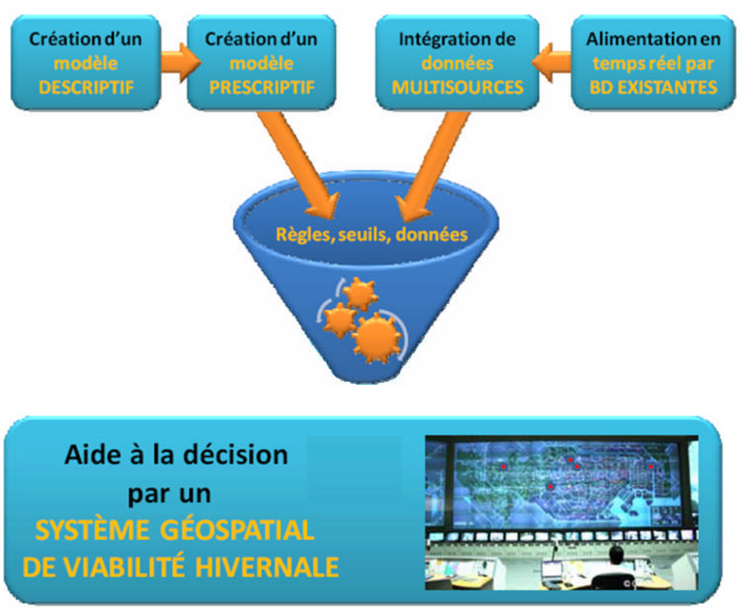
4.2. Toward new modes of management

The MTQ, the municipalities and the agencies in charge of managing the road network must now consider new approaches and utilize different management modes to compensate for rising costs and continue to provide good driving conditions on our roads. In addition to yielding decision-support systems, the collection and management of data generated through ITS also provides a series of indicators that help to improve winter maintenance management in the medium and long term. Thus, for ITS to be optimally profitable, a more technical analysis of road weather phenomena is needed, and this information must be effectively managed and integrated into every facet of the process of winter maintenance.

A reflection along these lines was therefore launched recently at the MTQ, bringing together managers for innovative thinking about all of the processes involved in ensuring winter road service, as well as on the contractual relationship between the MTQ and the private companies it uses for maintenance across its territory. Besides providing information to both operational staff and road users, ITS can reshape the decision-making and management architecture of the organizations in charge of the road network.

It is essential for the current management modes to find ways of capitalizing on all of the data collected by the MTQ in its winter maintenance activities. As part of its orientations for the near future, the MTQ plans to improve the complementarity of all of its data collection systems, to make its winter service information more coherent. This initiative is driven by recent concerns to avoid the creation of huge databases that will never be utilized. The goal is to take advantage of the latest approaches in geomatics in order to move away from a descriptive mode, in which the entire body of data provides information on MTQ activities, toward a prescriptive model which includes MTQ-specific components and optimizes decision-making on maintenance operations.

Capitalizing on telemetry data



5. CONCLUSION

For years, the MTQ has been taking numerous steps to learn more about the characteristics of road weather phenomena throughout its territory. Information processing via decision-support and analytical systems allows staff to be proactive and gain better control over deteriorating road conditions. The deployment of monitoring centres (IMCs) centralizes information and provides a continuous overview of unfolding events and winter maintenance activities.

Though it is hard to put numbers to the benefits, these multiple initiatives have improved the management of winter operations. The MTQ is committed to modernizing, and is consolidating its proactive management approach. Based on a better understanding of how to run the road network, this approach seeks above all to enable decisions to be made in real time, anticipating the development and deterioration of weather events. This makes it easier to adjust operational strategies as things unfold, deploying resources at the right time and increasing the proportion of preventive interventions, to ensure optimal quality of service right from the start of a road weather event.

In addition, these technologies have brought a better understanding of how the road network behaves in different types of weather events, resulting in enhanced operational practices and modes of management. Also in this context, ITS can play an important role in facilitating knowledge transfer when experienced employees retire, offering attractive prospects for the future thanks to the optimization of post-event and season reports and the development of indicators.

Added to better management of MTQ activities is the potential to better inform road users about the quality of service available, promoting safe driving while optimizing maintenance costs and respecting the environment. Indeed, the implementation of ITS for winter maintenance brings us ever closer to the very promising concept of intelligent roadways. Based on sophisticated communications between vehicles and infrastructures, such a system would provide users with levels of service, safety and traffic flow that would be highly superior to what we have today.

These new management modes offer substantial benefits, primarily by improving transportation flow and safety for road users. The project also generates added value in terms of the economic gains resulting from better transportation flow. Finally, its environmental added value is also significant: by reducing engine idling time, it cuts greenhouse gas (GHG) production.