

## Surface Condition Management

### A global concept for winter maintenance operations

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## 1 Introduction

Road maintenance operations in winter aim at providing the road users with clean and safe pavement conditions. Although the objective is clear, the variety in available methods and equipments sometimes prevent the professionals from making the best use of all resources : the lack of communication or real time data sharing between the various key players prevent them from adapting their activities to a fast evolving situation.

The Boschung group of companies has analysed this problem and come up with a global concept : the **Surface Condition Management**.

## 2 Characterization

The first step of this analysis was to characterize the various activities and equipments being part of winter maintenance operations. With this respect, a two-dimensional chart has been defined : the various types of activities are represented in the vertical dimension, while the types of equipment are grouped horizontally.

		Equipment	
		Mobile	Fixed
Activities	Surface Condition Assessment		
	Surface Treatment		
	Surface Data Management		

Fig. 1

### 2.1 Activities

The various activities have been grouped based on their objective and the type of information they provide. Basically, the activities linked to typical winter operations can be grouped in three levels :

#### 2.1.1 Level 1 : Surface Condition Assessment activities

The purpose of these activities is to provide accurate and reliable information about pavement/runway and weather conditions. Getting a good understanding of the real time situation on the complete road network or airport, together with history and forecast data,

allows the maintenance crew to carefully monitor the situation. Early warnings and alarms are used to draw personnel's attention when the conditions get too close to critical levels and require decision-making. This advanced information will allow the maintenance crew to defuse potentially dangerous conditions by planning preventive treatments.

Another important role of the Surface Condition Assessment activities is to provide a feedback of on-going operations : the measured pavement/runway conditions will automatically reflect the effectiveness of treatments applied.

The very crucial role played by the Surface Condition Assessment activities must not be underestimated. Nearly all the saving and optimization potential in winter maintenance operations lies in the reliability and accuracy of the information obtained at this level.

### *2.1.2 Level 2 : Surface Treatment activities*

Usually triggered by the aforementioned assessment activities, the treatment activities group all snow removal and de/anti-icing operations. The purpose of these activities is to maintain the pavement/runway in safe and practicable conditions, thus keeping the traffic in motion.

In order to be efficient, the Surface Treatment activities have to meet the following 3-dimensional requirements :

- Space : occur at the right place
- Time : occur before the driving conditions get critical
- Intensity : be proportional to the conditions they intend to cure

Development of critical conditions on a road network or on an airport rarely takes care of driving directions, distance from the maintenance center or flight priorities. Early warnings can provide enough reaction time to reach the critical spots, although the drive of a fully equipped and loaded vehicle to treat only a distant location may not turn out to be cost-effective. Therefore, a smart combination of fixed, locally installed anti-icing equipment and mobile "wide range" vehicles is the best way to meet the "Space" and "Time" requirements with a minimum amount of resources. Once again, the availability and sharing of timely and accurate information is of paramount importance. Besides, a detailed knowledge of the current local conditions allows to optimize the "Intensity" requirement.

### *2.1.3 Level 3 : Surface Data Management activities*

The two previous levels clearly show the importance of information gathering and sharing in the Surface Condition Management concept. The purpose of the Surface Data Management activities is therefore to ensure proper use, storage and display of the data.

With this respect – and due to the evolution of the hardware and software technologies - customers' expectations have increased, which could not be easily fulfilled by available software solutions. These new requirements on data management software can be described as follows :

- Easy access to data : classical client-server type software application are perceived as being limitative, as they need dedicated access computers. Customers want to have the ability to check the situation from their office or home computer.
  - ⇒ Software application should be based on web technologies, allowing access to the data via a standard browser.
- Easy distribution of data : data is no more confined to the road maintenance centers : higher levels in the organization want to have an overview of the situation. Besides, a

lot of data measured in the Surface Condition Management concept can be very valuable for Traffic Management systems (fog warning for example). Many customers propose also their own web site with on-line traffic and road condition information.

⇒ Software application should provide a standard interface for data exchange with other applications. Security of the data must however be guaranteed.

- Intuitive displays : although detailed information is still necessary for analysis and statistical purposes, the decision making process has to be quick, and personnel without much technical knowledge must have the ability to clearly identify a critical situation.

⇒ Data display should be map-based, with visual indication of critical situations.

## 2.2 Equipment

The activities described in the three aforementioned layers make use of specific equipment. Although each equipment can be used individually, the analysis above has demonstrated that the ability to acquire and share data is the only way to increase the overall system efficiency. As shown in the first part of this chapter (see fig. 1), the equipment used in winter road maintenance can be grouped in two categories : **mobile** (automotive) and **fixed** equipment. Both categories have a similar architecture (see fig. 2 below), based on the activity layers described in the previous section.

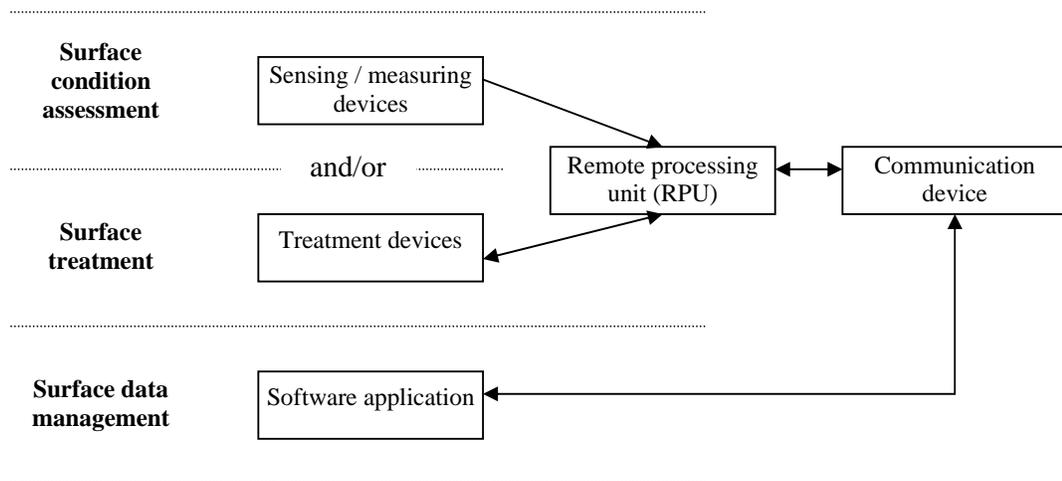


Fig. 2

Fig. 2 clearly shows the information flows : local automation of treatment activities can be achieved by coupling the sensing device to the treatment device through the RPU. Remote actuation of local treatment activities can also be performed from the software application.

### 2.2.1 Category 1 : mobile equipment

This category groups all sensing and treatment devices installed on vehicles, as well as the RPU and communication hardware to ensure proper acquisition, temporary storage and transmission of data.

Mobile equipments have the advantage of covering large road networks, and can be sent to specific locations. The drawbacks are however that they are depending on traffic fluidity (cannot go through if the traffic is already stopped), and need time to reach the assigned locations. As a consequence, the decision making process has to be realised far in advance if a timely action is desired.

Fig 3 below shows examples of mobile equipment.

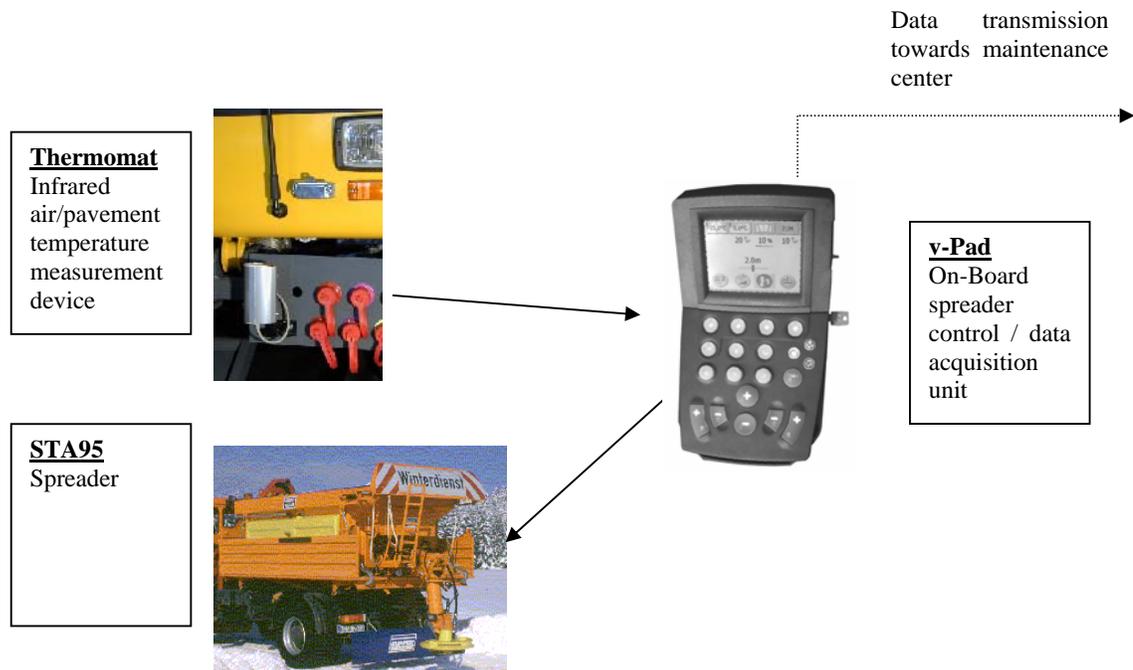


Fig 3

**Note :** the pavement temperature readings are directly used by the spreader control unit to automatically adjust salt quantity.

### 2.2.2 Category 2 : fixed equipment

This category groups all sensing and treatment devices installed permanently at fixed locations, as well as the RPU and communication hardware to ensure proper acquisition, temporary storage and transmission of data.

Fixed equipments are complementary to mobile equipments : they are independent of traffic congestion, and can be activated immediately upon critical conditions. The drawback is that they are confined to a specific location.

A smart combination of both mobile and fixed equipment is the best way to achieve optimal winter maintenance.

Fig. 4 below shows examples of fixed equipment.

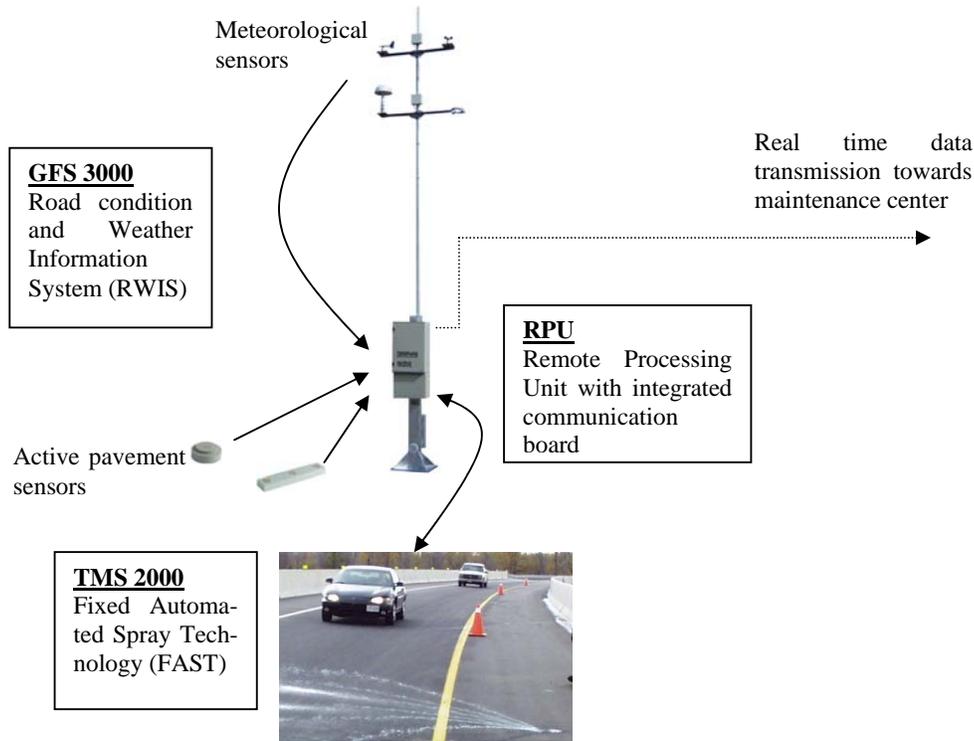


Fig 4

**Note :** Pavement and weather conditions measurements are directly used in the RPU to automatically activate thawing agent spray system.

### 3 BORRMA-WEB, the backbone of Surface Condition Management

Until now, the “equipment” (software) used for Surface Data Management activities always reflected a distinction between mobile and fixed equipment, each group having its own software suites for data display, storage and analysis.

However, the characterization described in the previous sections has demonstrated significant similarities at process level between mobile and fixed equipment. Furthermore, our analysis has shown the necessity to share data from both sources in order to optimise the overall performances of winter maintenance.

Taking all the above into consideration, the Boschung Mecatronic company has developed a unified software application meeting the various requirements of the Surface Condition Management concept : the **Borrma-Web**.

#### 3.1 Easy access to data

The Borrma-Web application software is based on a 3-tiers type application server. This unique platform makes use of the latest web technologies and runs on a Java virtual machine. It is therefore independent from the operating system of the hosting server. An integrated load

balancing function allows to use several machines in parallel, thus offering an unequalled flexibility to cope with any system dimension.

Access to data is performed via a standard browser. Upon customer's wish, the application server (or a second machine) can be installed outside the intranet, and thus allow access to the data from the Internet.

Fig. 5 below shows a typical IT network.

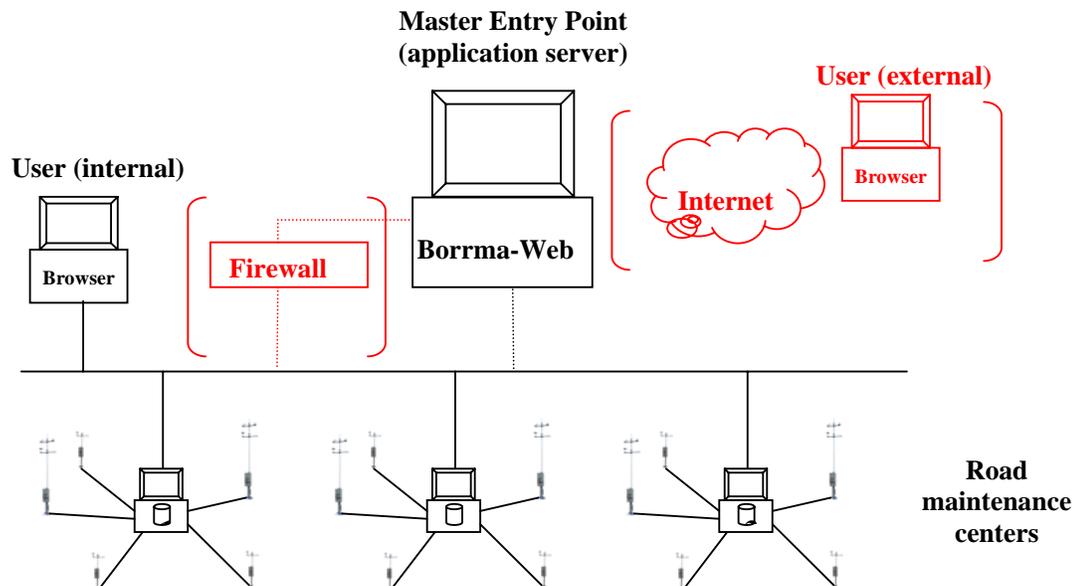


Fig 5

### 3.2 Easy distribution of data

The Internet Server platform described above provides special web services for data exchange. Standard XML requests via SOAP protocol will allow any authorized user (software application) to instantly get the desired data. As for human users, software applications will be granted a username and password, and get a specific profile detailing what sets of data can be viewed, or what actions can be performed (acknowledgement of alarms for example).

### 3.3 Intuitive display

Alpha-numerical and graphical displays allow for detailed analysis of special weather events. Reports and statistics can be generated for performance analysis or other administrative purposes (invoicing, benchmarking, etc.).

However, the main tool is the so called **dynamic map**. This display is based on a geographical map of the area. Standard zooming and scrolling functions are provided. All components of the Surface Condition Management concept which are delivering information (weather stations, spray systems and vehicles) are displayed at their geographical location,

together with a configurable flag for real time data. This display summarizes the global situation, with current weather stations readings, spray systems and/or vehicle status. In order to enhance the ergonomy of the display, the road network is **colored** based on user-configurable parameters. For example, alarms generated from the RWIS will color adjacent road segments, which will be turned back to “green” once they have been treated (fixed spray system, or mobile salt spreader). A user configurable trail can be assigned to all mobile equipments, showing the past activities : its color code will reflect the tools used by the vehicle. The objective of this new display is to provide a quick and geographical notification of the critical zones, together with the position and status of available resources.

Fig. 6 below shows a typical dynamic map display.

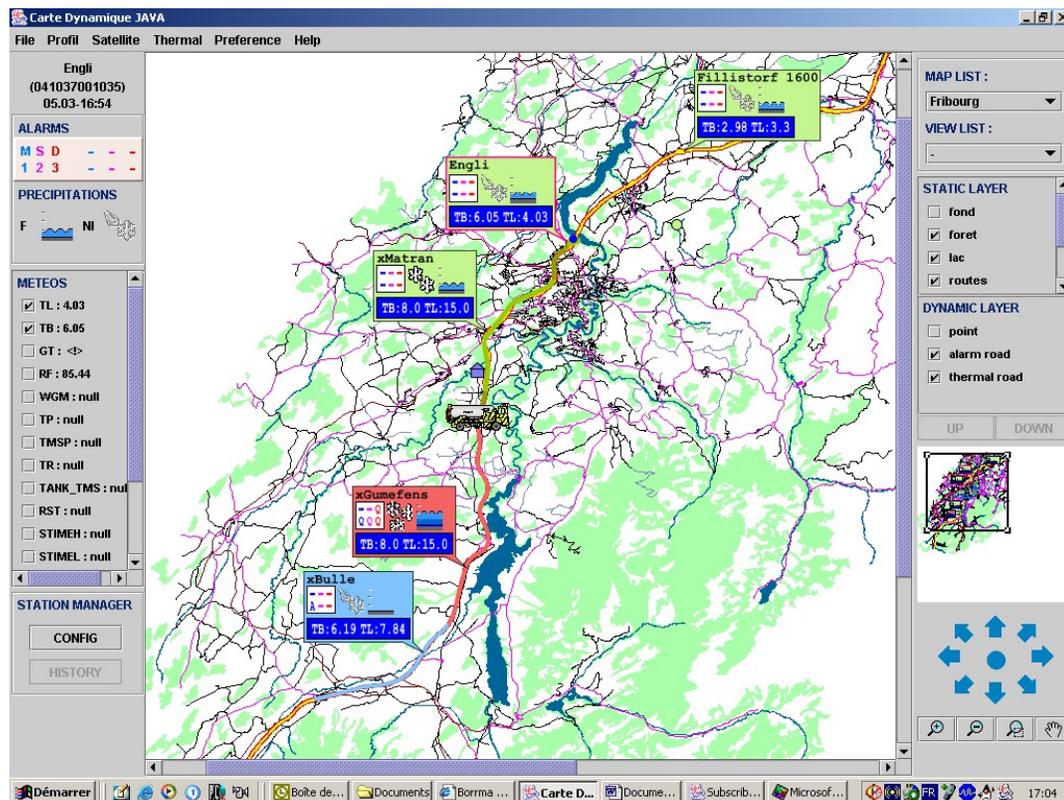


Fig 6

A time cursor allows the user to go back in the past : all values, colors and vehicle positions will change to the value they had at the time specified by the cursor. This allows for a quick analysis of the evolving situation. The same cursor allows also to go in the future : powerful forecasting algorithms provide detailed RWIS-level forecast, which will be displayed using the same color coding.

## 4 Summary



Fig 7

Boschung’s Surface Condition Management concept makes use of state of the art equipment, and goes one step further by integrating them in an overall comprehensive software application. The overall efficiency gained in the data collection and sharing activities can be summarized as follows :

Characteristics	Value added	Domain improved
Accuracy of integrated measurements and forecasting	Timely decision making	<b>Security</b> (always be there when necessary)
Increased range of information	Proportional response to situation	<b>Ecology</b> (only spread what is necessary)
On-line information about available resources	Dynamic management of resources	<b>Economics</b> (only do what is necessary)

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