# ROAD WEATHER INFORMATION SYSTEMS (RWIS) – EXPERIENCES FROM SLOVENIA

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**Abstract:** *Weather information is an important input data for traffic management systems and traffic infrastructure management systems. CGS plus d.o.o. is the leading company for Road Weather Information Systems in Slovenia. They developed RWIS for DRSI (Slovenian Road Agency) and DARS (Motorway Company in the Republic of Slovenia). The purpose of implementing RWIS is reduction in the costs of winter road maintenance (with an expected saving of at least 20% on spreading materials), optimisation of road winter maintenance services, increasing safety for drivers, reducing traffic congestions and reducing environmental pollution. Road weather forecast is the critical point and the heart of the decision support system, which provides recommendations on road maintenance routes and actions.*

**Keywords**: *Road Weather Information System (RWIS), Road Weather Station (RWS), METRo model, Winter Maintenance Decision Support System (MDSS), ITS, Slovenia.*

## 1. INTRODUCTION

The weather severely affects a broad spectrum of our activities, including traffic, which is one of the most important sectors of the European economy. Climate change has altered weather patterns and led to more intense weather events. The increased occurrence of extreme weather events has a significant impact on traffic safety and causes damage to the traffic infrastructure.

During the winter period, many countries experience severe winter conditions. Especially snow and ice make the transportability difficult and present several challenges for the winter maintenance service. Optimization of maintenance locations, timing, types and rates has an important impact on the road efficiency and safety.
Weather information (the current weather situation and weather forecast) is an important input data for traffic management systems and traffic infrastructure management systems:

- Providing safer roads [1-2]. The influence of weather on the road safety is not directly derivable from statistics; however, there is no doubt that weather conditions determine road conditions and influence the driver's behaviour. The estimated economic cost of weather-related crashes alone amounts to nearly $42 billion annually [3].

- Reducing winter road maintenance costs (i.e. salt consumption, work hours). Efficient ice control and snow removal is based on anti-icing strategy which involves the application of chemicals to the road before the forecasted event. Studies have shown that it should take place not more than 1–2 hours before snowfall. Smaller amount of salt (5–10 g/m²) is usually applied compared to the de-icing technique. There are many reports or quotations of substantial savings on winter road maintenance costs, i.e. [4-5].

- Reducing the environmental damage from over-salting [6].

## 2. ROAD WEATHER INFORMATION SYSTEMS (RWIS)

Road Weather Information System (RWIS) technology provides vital information on pavement and weather conditions needed for roadway maintenance operations. RWIS technology is typically used for monitoring snow and ice, but it can also be used for high winds, flooding, or visibility. It consists of Road Weather Stations (RWS) and web-based application. RWIS enables maintenance and operations personnel to monitor changing weather conditions in real time and make informed and timely decisions.
The most important sensor of a road weather station (RWS) is the so-called road sensor that monitors the temperature of road surface, the thickness of water film, the salt concentration and indicates the freezing point temperature. Road sensors are embedded in road surface or mounted on a pole, performing non-contact measurement. Road weather stations are equipped also with meteorological sensors for measuring the temperature, relative air humidity and precipitation, with sensors for solar radiation, wind speed and direction, and with digital cameras. The measurements are stored in the station's logger.

From the RWS logger, the measurements are transferred by different telecommunications technologies to the central database of the road weather information system (RWIS), which is a web-based application

offering various displays of current measurements at RWS locations, displays of the archived data and the metadata on stations and sensors. The application can also trigger alarms. CGS RWIS is 'opened' system and supports RWSs of different producers and is custom-designed.

### 2.1. Road weather forecasting

For the purpose to support the anti-icing operations, weather forecasts of high spatial and temporal resolution are essential. Precise forecasting of the time and duration of precipitation, precipitation type and amount, pavement surface condition as well as road surface temperature (RST) are critical. Cost benefit researches [7] show that the significance of weather forecasts decreases with the scale of time from nowcasts to short-term, medium-term, and long-term forecasts and that the improvement of weather information accuracy is critical to achieving more savings in winter maintenance.

More detailed weather information, such as road surface temperature (RST) and road condition, is needed to support anti-icing and other winter maintenance operations. The most common approach to forecasting road conditions is the energy-balance model, based on a one-dimensional diffusion equation:

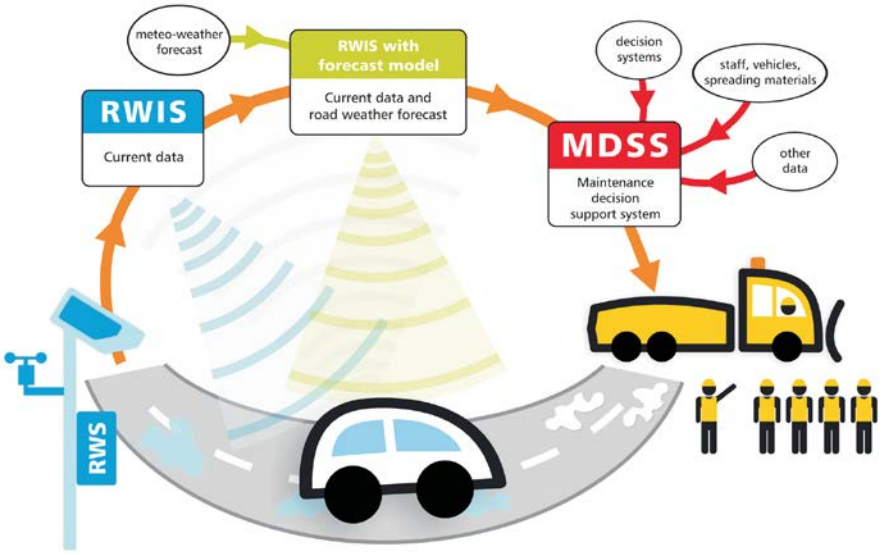
$$\frac{\partial \mathrm{q}}{\partial \mathrm{t}} = -\mathrm{K}\frac{\partial^2 \mathrm{q}}{\partial \mathrm{x}^2},$$

where $q$ is heat flux in the road, $t$ time, $x$ depth and $K$ heat capacity of the road.

Together with the input of atmospheric forecasts and observations from a Road Weather Station (RWS), physical models produce local road forecast (roadcast): the RST, which is the most important parameter for determining the road surface condition (i.e. dry, wet, ice, snow).

Road weather forecast is the critical point and the heart of the decision support system, which provides recommendations on road maintenance routes and actions. Therefore some important improvements of physical models were developed at CGS company by upgrading the calculation with anthropogenic flux input and sun-shadow algorithm as well as with statistical approaches [8].

Forecasting road and driving conditions a few hours in advance leads to reliable expectations of glaze ice and thus effective preventive spreading, which is important from environmental as well as economic points of view. The short-term weather forecast (nowcasting) is therefore key to increasing the efficiency of the RWIS and the winter service.




**Picture 1.** *Weather information for road winter maintenance*
*Source: CGS plus d.o.o.*

### 2.2. Winter Maintenance Decision Support System (MDSS)

A Maintenance Decision Support System (MDSS) is a tool that utilizes weather forecasts and observations to assist managers in making appropriate decisions to best utilize resources when planning for and treating snow and ice. One of the most important functionality is generation of treatment recommendations for road sections.

## 3. RWIS AND MDSS IN SLOVENIA

Road Weather Stations have been utilized to assist Traffic Management Services in Slovenia for many years. The need for this assistance is particularly pronounced in winter time since Slovenia is located in a meteorologically diverse territory between the western Alps, northern Adriatic and Pannonian Plain. With a growing number of RWS, their integration into a comprehensive road weather information system (RWIS) became inevitable. Management and maintenance of the road network in Slovenia is divided between the Slovenian Roads Agency (DRSI), primarily responsible for main and regional roads, and the Motorway Company in the Republic of Slovenia (DARS), responsible for motorways. Each of the two has its own network of RWSs, installed on representative road sections or constructions.

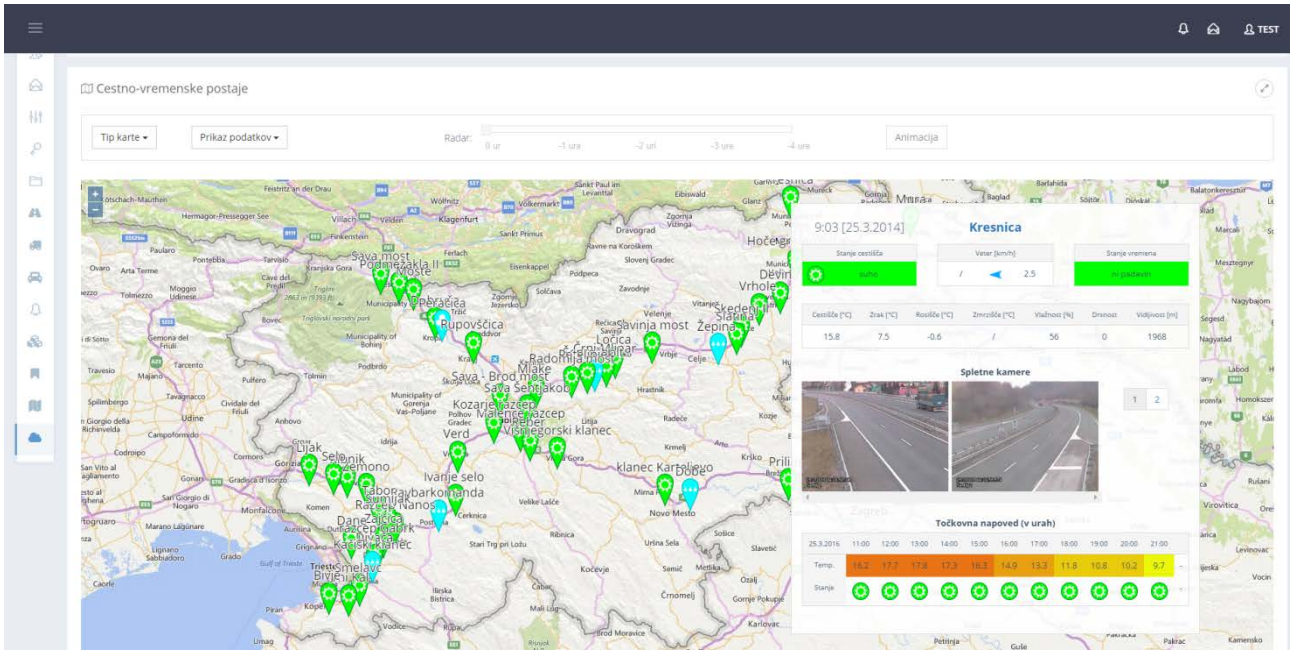
Owing to a gradual and long-term network construction process, the RWIS systems of both road management companies differs substantially in their age, installed sensors, manufacturers and other characteristics. The Slovenian Roads Agency was the first organization to begin the integration, followed shortly by the Motorway Company in the Republic of Slovenia. For this particular reason, we have now two partly different systems that are likely to be integrated in a comprehensive RWIS in the future. Both RWISs were developed by our company CGS plus d.o.o. Nevertheless, due to many similar characteristics, the functionality of the two systems can now be described as a uniform and comprehensive system. There are nearly 90 road weather stations (RWSs) altogether on Slovenian roads, situated mostly on motorways and regional roads.

Beside the RWSs data, short-term weather forecasts of high temporal and spatial resolution from INCA/ALADIN meteorological systems of National weather service ARSO are used. The INCA (Integrated Nowcasting through Comprehensive Analysis) system has been developed primarily for providing improved numerical forecast products in the nowcasting with very short time range (up to 12 hours) and high spatial resolution of 1 km. The INCA analysis and nowcasting data include temperature, humidity, wind, and the amounts and types of precipitation [9, 10]. A widely used physical model for forecasting the RST and road condition METRo was incorporated into RWIS.

Experiences of using METRo model showed that the RMS error for the RST predictions were generally satisfactory but could be too high at some sites, especially for the predictions around noon. Generally, to solve this problem, physical model was improved with further parameterisations of the relevant physical phenomena (anthropogenic influence, traffic influence, shadowing from the near objects, road physical characteristics) and combined with statistical techniques (i.e. regression, neural network) to improve the quality of input or output variables.

In winter 2015/2016 the DARS RWIS was upgraded with additional functionalities and become a Maintenance Decision Support System (MDSS) which supports managers in making appropriate decisions. Developed MDSS is able to calculate METRo forecasts on the whole Slovenian motorways with 30 m spatial resolution and 1 hour time resolution (up to 24 hours in advance) and supports high-resolution weather forecasting system (INCA and ALADIN). Such road forecasts can support winter maintenance decision with automatically treatments selection (MDSS provides time, type, amount and place of each treatment). System is developed as a modern cloud-ready web application in the MVC (model-view-controller) framework Laravel 5.

Furthermore, thermal mapping on the whole Slovenian motorways were performed in 2016 with equipment, developed only for this purposes. Results were used to provide better route-based forecasts and for road weather stations and its sensors optimisation.




**Picture 2.** *Weather information on Slovenian motorways*
*Source: DARS d.d.*

## 3. CONCLUSION

Slovenia is equipped with one of the most efficient road weather information systems and decision support systems in Europe. Slovenian knowledge and local experiences were integrated in the system which was recognised as advanced and innovative also by professional public abroad.

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