Decision Support System for Winter Maintenance - Research and Practice

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ABSTRACT

Maintenance of roads and bridges in winter is a serious challenge for road services with roadway safety, economic efficiency and low environmental impacts bearing in mind. The most important problem is the timely making of effective decisions for treatment types and timing of treatment. In order to support winter maintenance personnel, an interactive, automated decision-support system MeteoTrassa for winter road maintenance has been developed.

The system uses a variety of data: road weather station network, weather radar, mesoscale model, road weather and surface condition forecast model, and thermal mapping. It collects and processes information from various sources and makes recommendations on road treatments based on a predetermined algorithm tailored to the particular road authority's resources. Four algorithms for different types of de-icing agents and operational practices have been implemented. The system generates specific guidance based on current weather and forecasts which includes information regarding treatment procedure, timing, rate and location. Also an user can interact with the system to correct the treatment plan. The system includes a prediction module to forecast temperature and state of the road and precipitation for tactical time period (0-4 or 6 hours). Road surface temperature and condition forecast is based on the atmospheric boundary layer model. Precipitation forecast is based on actual weather radar data and velocity and direction of radio echo movement.

System has been successfully used in operational practice by road services in several regions of Russia with different climate.

Keywords: winter maintenance, DSS, decision cases.

1   INTRODUCTION

Winter road maintenance is an important application field of meteorology in those areas which experience frequent snow, sleet, ice, and frost. RWIS and maintenance decision support systems (DSS) are designed to help winter maintenance to take proper action at right time and right place to keep up safety on the roads and save costs of winter maintenance [1]. In most regions of Russia, winter is the longest season. In order to support winter maintenance personnel, an interactive, automated decision support system MeteoTrassa for winter road maintenance has been developed [2]. The system provides road services with all the necessary tools to monitor the state of roads and analyse weather conditions within the service region. Also, the system includes a special-purpose treatment recommendation module that supports winter maintenance personnel in the decision-making.

2   THE DECISION SUPPORT SYSTEM AND ITS COMPONENTS

The decision support system is subdivided into several modules, as represented in Figure 1.
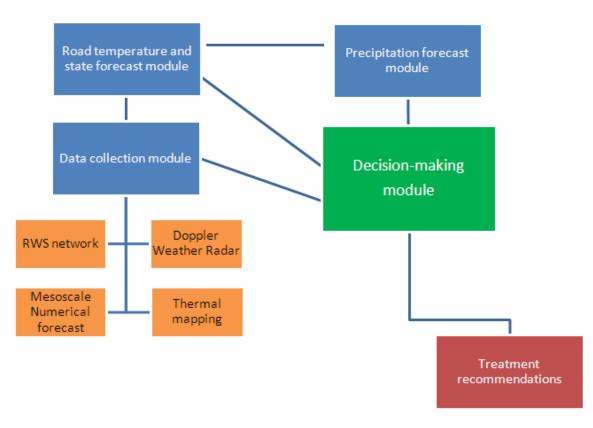
Figure 1. Decision-making system overview.

Description of the modules:

- *Data collection module*
  Performs the collection and preprocessing of data from different sources. As intitial data, the system uses road weather station network data, Doppler weather radar data, mesoscale numerical forecasts and thermal mapping.

- *Road temperature and state forecast module*
  Performs road weather and surface condition forecast based on the atmospheric boundary layer model.

- *Precipitation forecast module*
  Performs precipitation forecast based on actual radar data and velocity and direction of radio echo movement.

- *Decision-making module*
  Processes current road weather data, road weather and surface condition forecasts and precipitation forecasts. Calculates the treatment recommendations based on the selected algorithm and with prognostic information taken into account.

3 ALGORITHMS

The algorithm is the heart of decision-making system. At present, four different algorithms have been implemented. Algorithms are created on the basis of road meteorology with road maintenance operational practices taken into account. Usage of different de-icing agents results in different recommendations. All algorithms are based on the similar principle: from the whole set of meteorological conditions, those ones are selected under which it is necessary to treat the roads. Thus, the final set of decision cases is formed. Then treatment guidance is produced for such a set, in dependence of the available de-icing agent. An example of several decision cases is shown in Table 1. This algorithm is developed by IRAM in collaboration with the experts of Krasnoyarsk Road Administration. It includes 15 decision cases.

Weather conditions				Treatments		
Air temperature	Road temperature	Precipitation and humidity	Road state	Ploughing	Treatment type	Value
Ta > 0ºC Temperature decrease is expected	Ts < 0ºC	rain, sleet	glaze	no	NaCl 50%	30 g / m2
0ºC > Ta > -7ºC Temperature increase is expected	Ts < 0ºC Ts < Ta	rain, sleet	glaze	no	NaCl 50%	100 g / m2
0ºC > Ta > -7ºC Temperature decrease is expected	Ts < 0ºC Ts < Ta	rain	glaze	no	Sand and gravel	200 g / m2
Ta < 0ºC	Ts < 0ºC Ts < Td	relative humidity > 90 %	dry	no	NaCl 50%	120 g / m2
Ta < -7ºC Temperature decrease is expected	Ts < 0ºC Ts < Td	relative humidity > 90 %	dry	no	NaCl day: 15-20% night: 5-10%	50 g / m2 30 g / m2

Table 1. Decision cases example.

4　FORECASTING MODULE

Road weather stations provide complete information about current road state at the installation site, however this information is not sufficient to produce adequate treatment recommendations. In order to road services can react to weather changing in time, the information about future weather conditions is urgently needed. The system warns users as to where and when ice or frost is likely to form providing sufficient time to apply de-icing agents ahead of a danger. Forecasting module enables the user to obtain prognostic characteristics for tactical time period 0-4 (or 0-6) hours. Prediction of air temperature and road surface temperature is performed using the atmospheric boundary layer model. Forecast is performed for the individual points (at road weather stations installation sites). Thermal mapping data is used to get route forecast. Also, precipitations are the one of the key factors influencing road conditions. Precipitation forecast is performed on the basis of Doppler weather radar data. An example of Doppler weather - radar based precipitation forecast is represented in Fig.2.
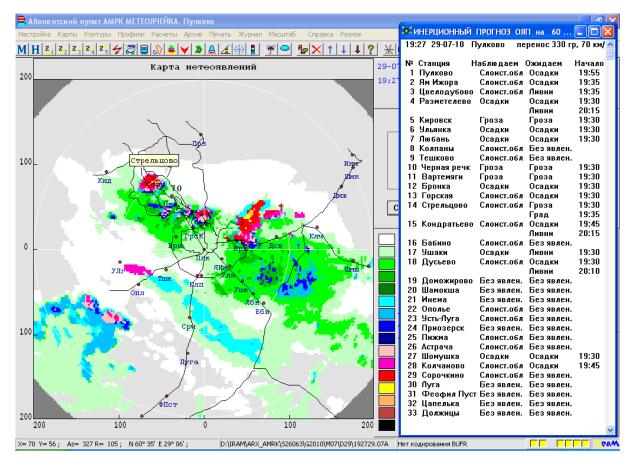

Figure 2. Weather - radar based precipitation forecast.

When the forecasts are available, winter road maintenance operatives can determine much more accurately which sections and which traffic lanes of the road need treating. This means they can selectively treat routes, or segments of routs, in order to operate more effectively, and reduce costs without comprising safety.

5　FUNCTIONS AND USER INTERFACE

The system enables the user to:

- monitor information from road weather stations;
- get recommendations for treatments;
- interact, if needed, and to create treatment plan;
- save treatment plan.

An example of MeteoTrassa main window with information from road weather stations network and forecasts is represented in Fig.3.
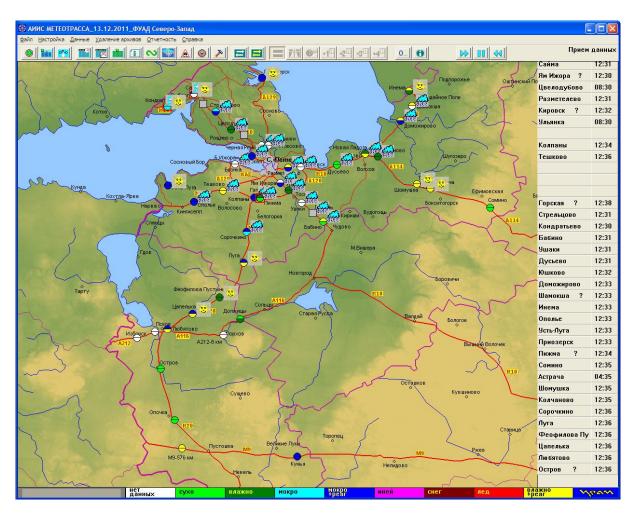
Figure 3. Main window of MeteoTrassa.

An easy-to-use Java-based Graphical User Interface provides access to all of the functions and settings of the decision-making module. An example of decision-making module user interface is represented in Fig.2. The module gives brief information about current road weather and treatment recommendations depending on forecast. Treatment recommendations include the following information:

- Recommended treatment procedure (chemicals, abrasives, combination chemicals plus abrasives, plough),
- Recommended chemical amounts, chemical concentration and dilution rates
- Timing of initial treatment and necessity of subsequent treatment
- Recommended pretreatment.

It is planned to provide the highway engineer with an online map where the salting routes are colour-coded depending on the treatment required.
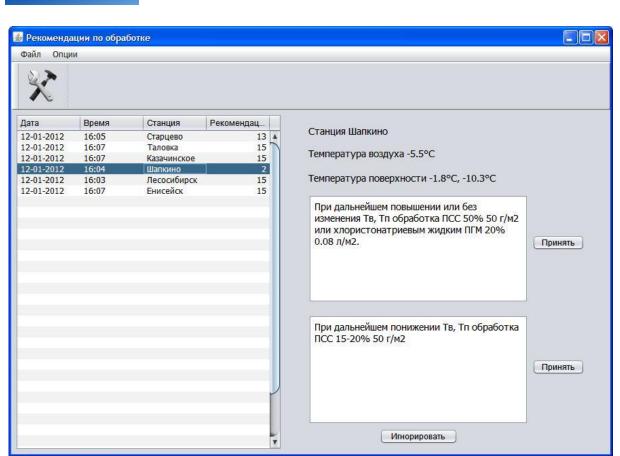
Figure 2. Decision-making module user interface.

6 CONCLUSION

Decision-support systems play an important role in road maintenance, taking care of many factors and providing road services with simple instrument for effective winter maintenance.

Adapted algorithms enable the user to operate the system in regions with different climate applying various de-icing agents. MeteoTrassa system has been successfully used in operational practice by road services in several regions of Russia.

7 REFERENCES

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