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Topic: Winter maintenance management system

Public Roads Administration, Iceland
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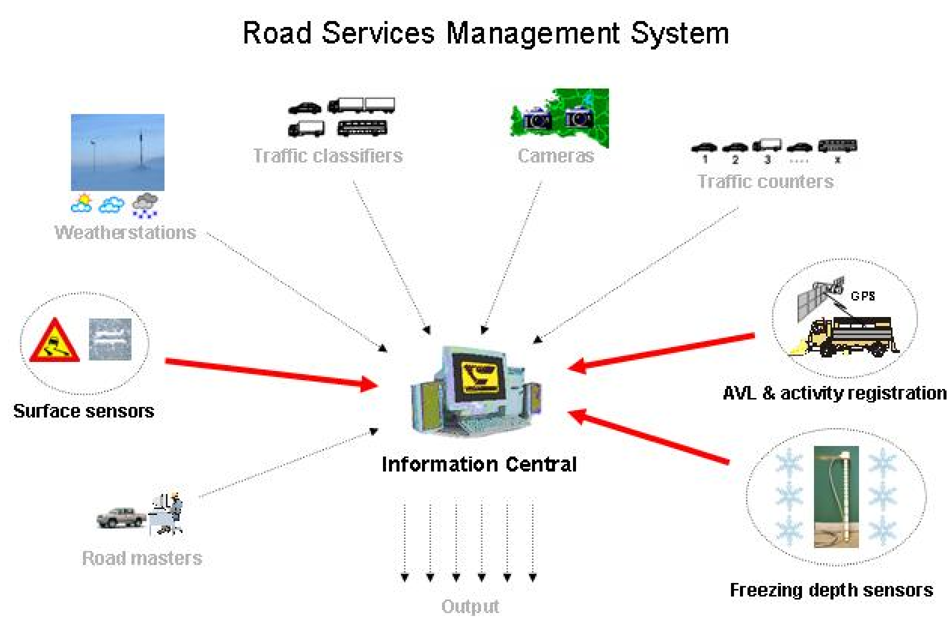
Icelandic winter maintenance management system

The winter maintenance management system in Iceland is a centralised computer system, where 18 road masters enter information about road passability and weather in the relevant regions. Information from winter stations, cameras, road slipperiness sensors, freezing depth sensors, traffic classifiers and counters, as well as information on the location and activities of the equipment used for winter services is also entered into the system. In this lecture, Nicolai Jonasson and Einar Palsson will discuss three important things being developed at the Public Roads Administration that are a part of the management system: freezing depth sensors in roads, road surface condition sensors and automatic vehicle location/activity recording of winter service vehicles.

Below is a schematic of the structure of the winter services management system in Iceland.



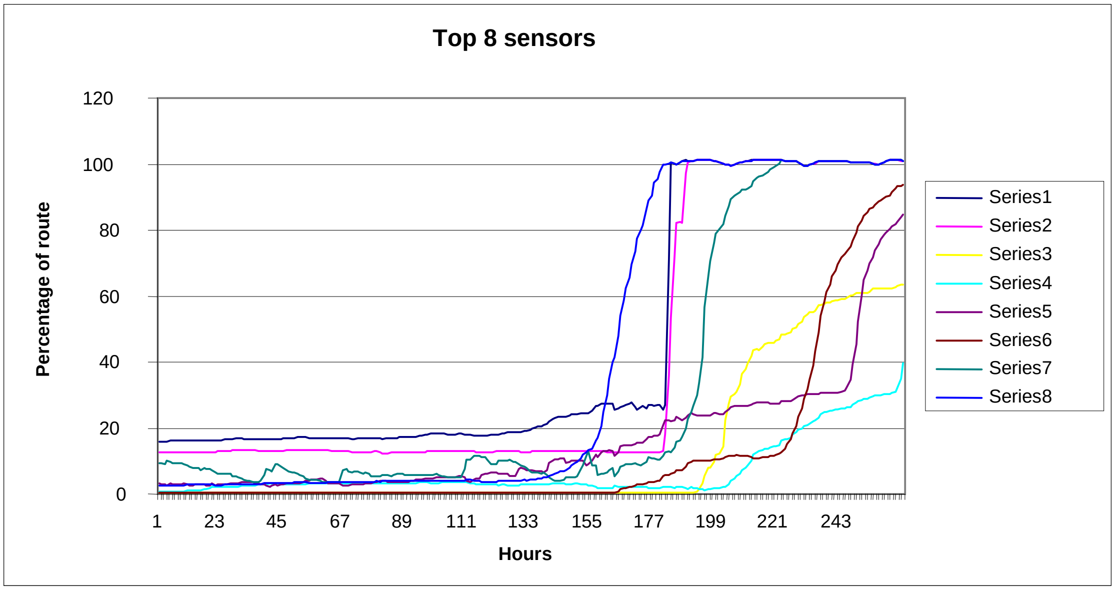
Measurement technology to control axle weight limits

Every spring it is necessary to control the axle weight of vehicles on a number of roads as a precaution against their being ruined when their subgrade support layers are thawing. It is very difficult to determine with sufficient advance notice when to impose the weight limits, and it therefore often happens that the carrying capacity has already deteriorated before the weight limits are set, which can lead to permanent deterioration of the road's carrying capacity and durability and/or cause damage to the pavement.

The goal of this project is to develop methodology and/or a mathematical model to determine when and what weight limits shall be set, based on automatic measurements of temperature and conductivity in a road cross-section along with information from Public Roads Administration weather stations and weather forecasts of the Icelandic Meteorological Office. Being able to see when it is timely to impose weight limits clearly reduces the chances of roads being damaged because weight limits were not timely set. It is also clearly advantageous for truckers to have timely knowledge of whether weight limits are to be set for a road in the next few days.

At the conclusion of this research and development work, it is the ultimate goal to be able to control weight limits automatically from a control centre in the Public Roads Administration Services Department. Temperature and conductivity sensors in roads all over Iceland will transmit information that a mathematical model will process and indicate when weight limitations shall be set.

Initial efforts at the beginning of the project focused on designing a freezing depth sensor that could be easily and quickly placed in a road. The prototype of the freezing depth sensor had 16 conductivity sensors at 50-mm intervals for the first 500 mm and at 100-mm intervals for the next 700 mm. The total length of the rod was therefore 1.2 m. Electronically controlled data gathering equipment was also developed that is connected to a "data logger" unit, and the data are then transmitted by telephone to the Public Roads Administration centralised computer system where the measurements are processed. It was decided to place the first freezing depth sensors in different winter microclimates - on the one hand, in the southwest part of Iceland (Dýrastadir) and, on the other, in North Iceland (Vatnsskard). For comparison with measurements from the experimental freezing depth sensors, humidity and temperature sensors were implanted in the road and calibrated. The measurement results after the first winter were somewhat contradictory, but the results nevertheless seemed so promising that a decision was made to improve the freezing depth sensor and add temperature measurement to each sensor. The emplacement procedures were also revised to make the measurements more secure. However, the winter of 2002-2003 was so mild that there was not much road freezing, and few measurements were therefore obtained as a basis for conclusions. The project was therefore extended for one year, and an improved version of the freezing depth sensor was built and placed in Skagafjördur in North Iceland.



Graph showing change of state from ice to water for the 8 top sensors

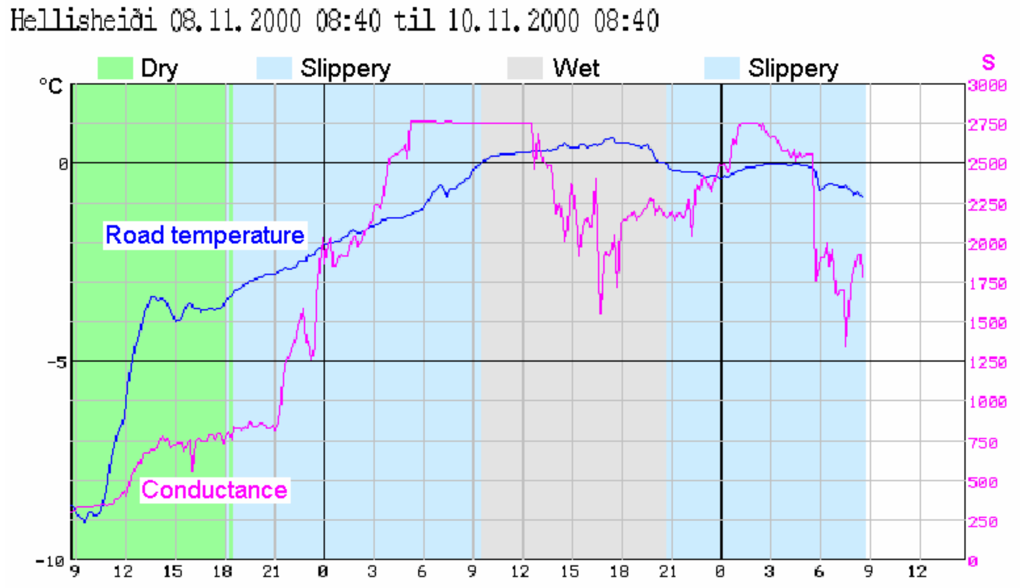
After the experience of previous years, the researchers believe that development of the freezing depth sensor and electronic reader make secure measurements likely. Also, revised methods for emplacement and securing of the equipment have led to more fail-safe measurements.

Measurement of road surface conditions

The goal of the project was to develop a sensor that could indicate whether a road surface was dry, wet or slippery. The sensor had to be capable of interfacing with Public Roads Administration weather stations or be an independent unit at the points in the road system where the relative risk of slipperiness is greatest. The climate on mountain roads in Iceland can change suddenly, and it is difficult to forecast the onset of slipperiness with certainty. Also, blowing snow can make a road slippery even though temperature and humidity readings from weather stations show that the road ought not to be slippery.

The Public Roads Administration's first experiments with equipment to measure slipperiness of road surfaces were made in 1997. In designing the solution, it was decided to implant conductivity and temperature sensors in the surface of the road, thereby precluding a possible difference between conductivity measurements of a material other than that in the surface of the road. The first device was placed on Hellisheidi Fell, which is a mountain road east of Reykjavik. However, it later came to light that this location was not a good choice because of its distance from the Public Roads Administration Centre. It took some time to calibrate the device and verify the reliability of the readings. The first findings held promise, and it was decided to continue research with this measurement method.
The data coming from the device are sent to a centralised computer system for processing. No final interpretation and presentation of the data have been developed, but the graph

below shows road temperature and conductivity and, in the background, whether the road surface is slippery, wet or dry.



Experiments in measuring road surface conditions were not done for some time, but now a revised version of the method is ready, and five measuring devices will be put in place near Reykjavik in November 2003. The main changes in the new version are a new, electronically controlled reader for the measuring devices in the road surface and a revised technique for placement of the devices in the surface of the road. Plans call for presenting the findings of the new test in the spring of 2004.

AVL & activity registration

Summary

Can automatic vehicle location and activity registration be utilised for settlement of winter services? Automatic vehicle location equipment, consisting of a telecommunications device (GSM) and sensors, was installed in snow removal equipment with a salt and brine spreader as well as front and under teeth to automatically collect information about location, activities, speed, distance and time. The control equipment was purchased from the manufacturers of the spreader since it was available (in this instance, this was the manufacturer of the salt and brine spreader - EPOKE). Emphasis was placed on developing data reception and processing and testing the reliability of the equipment. Upon receipt of data from a device, the grid position is slotted into the road system, i.e., information about activities is collected for certain roads and stretches of road for further processing. In this way, additional information can be collected about the scope of service programs, activities, driving, use of materials, lengths of road cleared, etc., for each road, region, etc., for any period.

The first findings indicate that, after processing, the information obtained with the above-specified equipment provides so good and reliable an overview of quantities, for

example, of materials, driving and time spent for each section of road that the findings may be used for final settlement of winter services and quality control. Correct arrangement and placement of sensors and good monitoring of the equipment's functioning are prerequisites for reliable and good findings.

Introduction

The Public Roads Administration's road services in winter as well as summer are considerable, and great sums of money are allocated to this category. Rapid technical developments in equipment and communications have made it feasible to utilise this technology to monitor and record road services, not least automatically. Thus, increased information can be obtained on the scope of service programs, quantity of materials and time to utilise for managing road services. In addition, increased recording simplifies monitoring of the quality of services and can promote improved utilisation of funding. The price and precision of positioning equipment has become acceptable for practical use, and manufacturers of vehicles have begun to utilise it. In Iceland, the Public Roads Administration has tested solutions for automatic vehicle location and activity recording with data transport through the TETRA system and, now, via the GSM mobile telephone system. The TETRA system is an interesting alternative; it is well suited to data transport since the data are received in almost real time. If there is always a need to know where equipment is located in the road system in real time, then TETRA is a good solution. However, its limited coverage still restricts its actual use except in SW-Iceland.

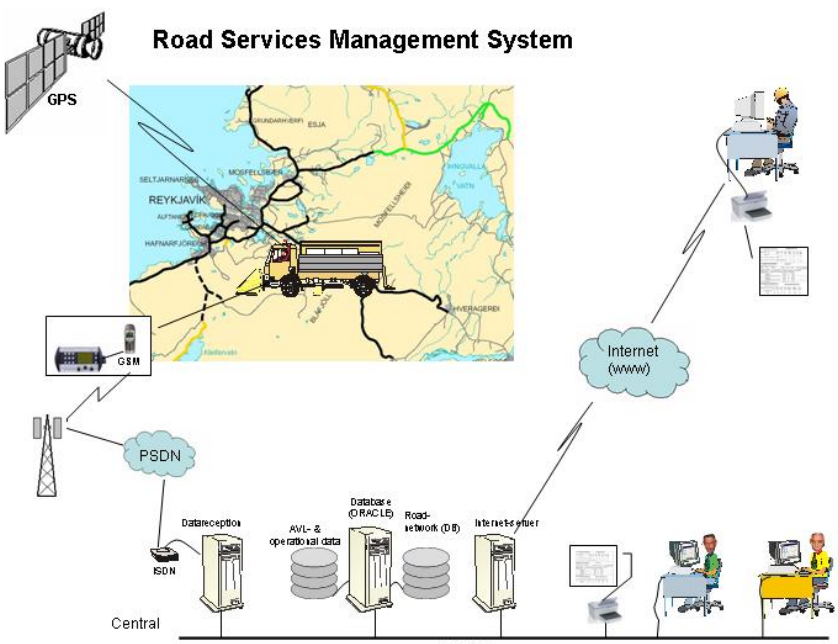


Figure 1: A schematic representation of automatic vehicle location and activity recording

The manufacturers of de-icing equipment, for example, EPOKE and STRATOS-NIDO, have developed solutions for automatic vehicle location and activity recording for their equipment with data transport over the GSM mobile telephone system. The manufacturers have designed control equipment for productivity and spreading in accordance with a vehicle's capabilities and speed. Data consequently indicate variable use of materials that would otherwise have had to be set at a fixed rate, such as the quantity of salt in grams/m^2, relative to the total quantity of material used. These standard solutions are optimised to produce a planned result for each piece of control equipment and are purchased with service contracts.

Vehicle location and activity data

A fundamental aspect of utilising vehicle location and activity data is to pinpoint the vehicle's location in the road system. As soon as data from vehicles is input, it is identified with a road in the Public Roads Administration's road database.

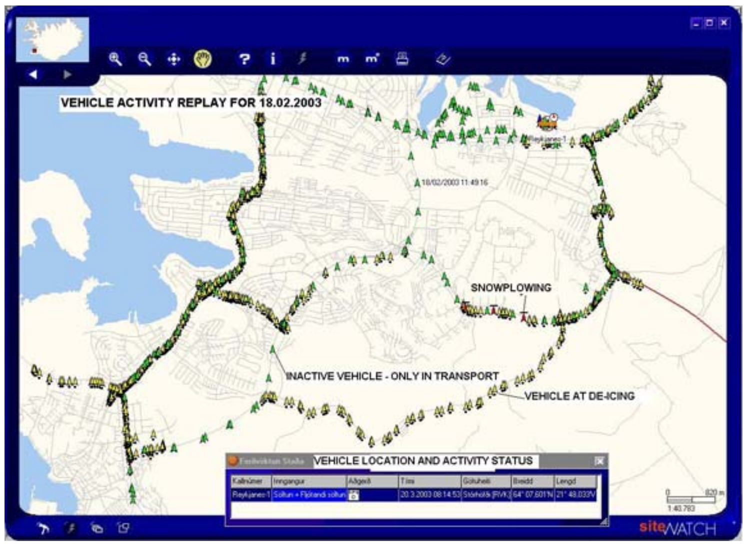


Figure 2: Automatic vehicle location and playback of activities of a vehicle on the SiteWatch server

Testing and examination of the data revealed a certain practical problem in slotting in the location of the vehicle on the road. Snow ploughing and de-icing are done on highways as well as the streets of towns and the capital city. Since the performance of activities on roads can have more than one cost-party (city and/or state), it must be possible to segregate activities by streets or "settlement routes".

The solution entails making a data cover defining the areas around sections of road to distinguish between the parties/payers responsible for activities.

Figure 3: Areas around sections of road (settlement routes)

In processing, it is interesting to get a summary of a vehicle's driving broken down by driving route (road, snow route or settlement route). On the other hand, it is of less interest to break down driving of a vehicle by intersections or approach and exit lanes. This is important if activity data are utilised for settlement, for example, regarding contractors. A contractor makes a bid for winter services for certain roads/streets. For settlement, it must be possible to distinguish between the contractor's driving and activities on roads/streets not on the settlement routes since the contractor's activities on such routes do not fall within the tender. On the other hand, a reasonable settlement route must include driving on ramps, access roads and exits, turnarounds, etc. An access route is therefore defined as the areas through stretches of road/streets that the operations manager deems to be within the normal limits of the driving route for the vehicles servicing it.

Processing - reports

Standardised reports on data have been designed to provide an overview based on snow routes: quantity figures for materials and time, service hours and activities as well as daily settlement. Finally, provision is made for transferring the results of automatic vehicle location and activity recording within the internal Public Roads Administration system for further processing and settlements with contractors.

Reports are published on an intranet, so that operations managers as well as contractors can, at the end of the day, get an overview of the day's activities by defined settlement routes.

A reliability evaluation of automatic vehicle location was done for stretches of road. For several days the odometer reading was recorded at the beginning and end of trips. Comparison of the recorded distances indicated that the odometer showed 852 km, while automatic vehicle location showed 825 km, a difference of 3.2%. The evaluation was of driving in an urban area, and automatic vehicle location was set at an interval of 500 m.

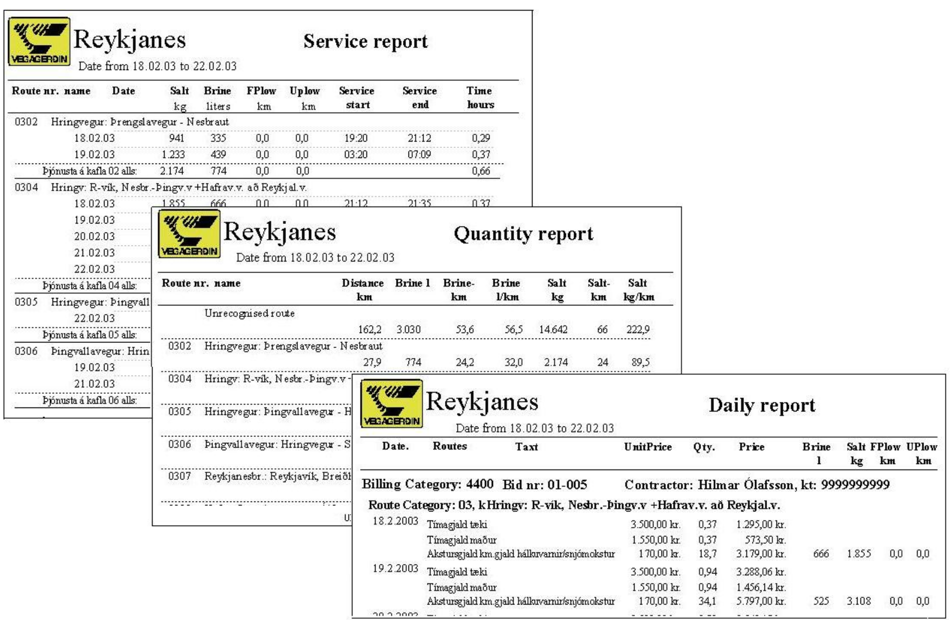


Figure 4: Quantity report, daily report and service report