GPS CONTROLLED SALT SPREADING AND SECTION BASED FORECASTS

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ABSTRACT

GPS controlled salt spreading enables salt distribution on the whole road surface with automatic adjustment of spreading dosage, width and symmetry while the driver can concentrate on following the route. This technology is developed because automatic data collection from salt spreaders has shown that even well skilled drives can't adjust spreading width and symmetry in a proper way and drive the truck at the same time.

The technology is also essential to implement salting with different dosages based on forecasts for the salt needed along a route. Today the same dosage is used on the entire route even that we know that the salt needed won't be the same.

KEYWORDS

AUTOMATIC DATA COLLECTION / GPS CONTROLLED SALT SPREADING / SECTION BASED FORECASTS

1. WINTER SERVICE IN DENMARK

Denmark is a flat country with typical coast climate situated in the Northern part of Europe, covering an area of 44,000 square km, and a population of 5.5 million people. The highest point is only 173 meters above sea level. Denmark has two main road authorities:

- The Road Directorate is responsible for 3,800 km state roads including 1,000 km motorways.
- 98 municipalities responsible for 68,000 km of paved roads

The main winter issues in Denmark are hoar frost and freezing wet roads due to temperatures floating from plus degrees in the daytime to minus degrees during the night. Per season, we have, in average, app. 100 salting actions and 5-10 days with snow, and in total just 30-50 cm of snowfall. The snowfall can vary from nearly nothing to several meters.

The Danish Road Directorate operates six 24h winter centrals which manage the winter service on state roads. They decide when, where and how to call for salting and snow removal. Private contractors are delivering trucks and drivers ready for operation 24h from October,1 to April 30.

At the winter central, the persons on duty operate two software tools. They use VejVejr, a Road Weather Information System (RWIS), to assist them in taking the right decision on when to go out and where. Once the decision has been made, they use Vinterman, a

Winter Maintenance Management System (WMMS), to handle the call-out and registration of all ongoing actions.

On all main roads, preventive salting is done to avoid slippery situations. Salt is spreaded on the entire road, and the driver adjust spreading width and symmetry of the road while he drives the truck.

2. MOTIVATION FOR DEVELOPING GPS CONTROLLED SALT SPREADING

Vinterman contains automatic data collection from the salt spreaders since 1998. It has a general interface to the spreaders, to ensure presentation of data from different manufactors within the same software. Figure 1 below is an example of data collection from one salting action. This detailed documentation shows all spreader settings made on the route in red during salting and in black during transportation.

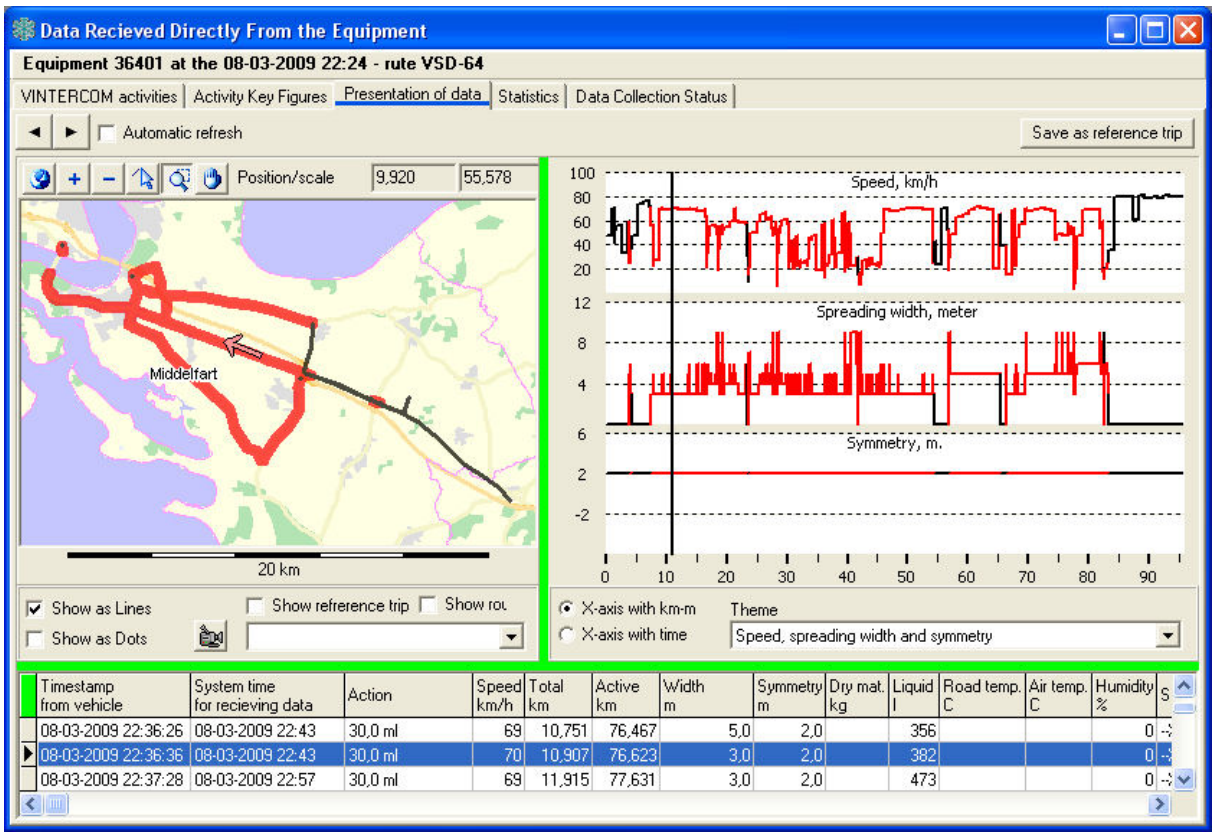

Figure 1 – Vinterman Presentation of Data from One Action

In figure 1, the speed, spreading width and symmetry is shown as a graph. It is obvious that the spreading width is adjusted regularly, while the button for adjusting the spreading symmetry is left untouched. This is a very typical situation which means that bus stops, turning lanes etc. only rarely is treated as they should. Analyses has shown that less than half of all necessary adjustments are made by even very experienced drivers.

The reason for the lack of spreader adjustments is simple. It is very difficult, or almost impossible, to do all adjustments correctly throughout a junction with turning lanes etc. at a speed of 50-70 km/h, and still be able to handle the traffic situation. In Denmark, it is forbidden by law to handle a mobile phone during driving. Letting the driver do five

adjustments of spreading width and symmetry during seven seconds while passing a junction is not forbidden, but in terms of traffic safety it is not recommendable.

The conclusion was that a system for automatic adjustments of the spreader would improve the quality of the salting, by spreading salt only where it is needed. At the same time it would have a positive effect on traffic safety, if the driver wouldn't have to adjust the spreader control box.

In 2003, the project "GPS Controlled Spreading" was initiated in Denmark in cooperation with salt spreader manufactures on the Danish marked. During the winter of 2004/05 the first products were available, and in the winter of 2009/10 we will have GPS Controlled Spreading on more than 100 routes in urban areas and open land, delivered by four different manufactors.

3. HOW DOES IT WORKS

The four products on the Danish marked are not at the same development state and usage, but the basic principles are the same. Below follows an introduction to the set-up of GPS Controlled spreading, using the most common product in Denmark.

The first step is to record the route with all the correct settings. This usually takes place with a salt spreader simulator installed in an ordinary car. The route is driven by an experienced driver who is familiar with the route. The driver does all the settings without driving. When recording, the speed is lower in e.g. junctions and even full stops can be made to ensure registration of all the correct settings with a high level of accuracy. The recording can also take place in a truck with a traditional spreader, but a patrol car with beacon light and a simulator is usually more practical. In general, it is worth spending time on making the recording as perfect as possible.

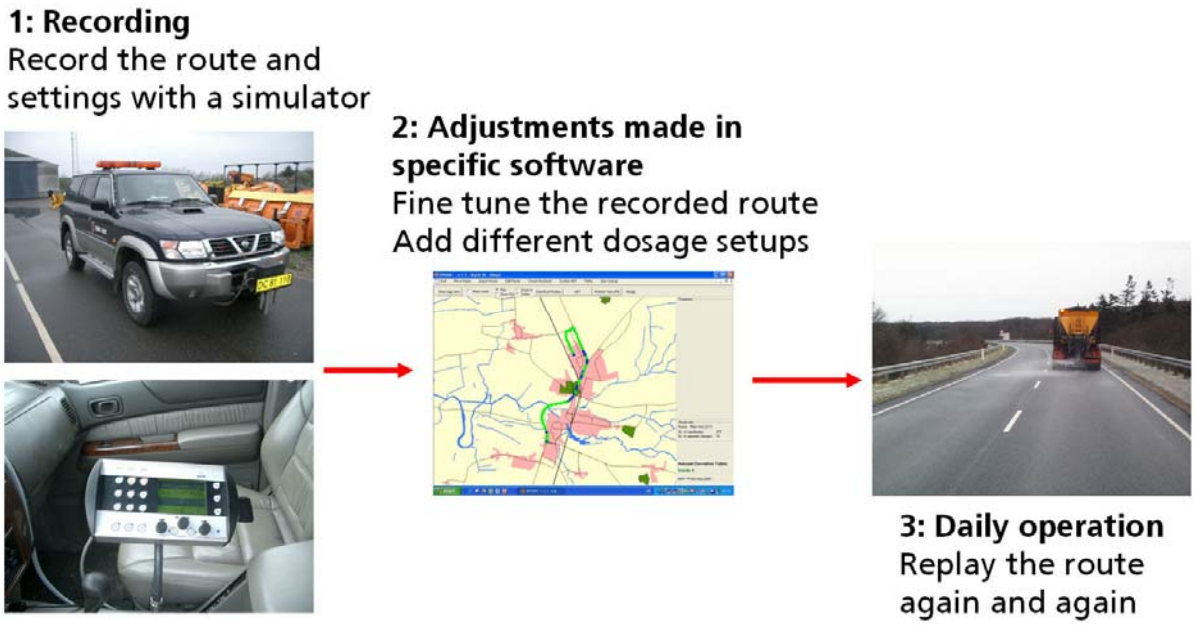

Figure 2 – Steps in Preparing a Route for GPS Controlled Spreading

After recording, the route data is transferred to a pc by using a memory card. On the pc, the route can be presented including all the settings. Within this software the route can afterwards be fine-tuned by adding extra settings, or move the position of a setting a little bit. In the first versions of GPS Controlled Spreading it was not possible to adjust the recorded trip. However this has been necessary in order to handle minor adjustments without recording the entire route all over again.

When the recorded route is adjusted in the pc software, it is transferred to a real salt spreader by a memory card. At this stage, it can be stored in different versions with e.g. different dosages. After this, the driver just has to select the correct entry when he starts salting, and the spreader will automatically change dosage, symmetry, spreading width etc., and the driver now only has to drive the route.

After installing software etc. it takes app. half a day to record, tune and install a route into a control box ready for use for GPS Controlled Spreading.

Based on experience, routes in open land trough small cities have app. 200 changes in settings, and routes in urban areas have up to 700 changes in settings. In both cases it is routes of 2-2½ hours driving.

4. OPERATION AND ACCURACCY

When the project started, the focus was on two important factors. The system had to be accurate, easy and intuitive to work with during the daily operations. In the initial specification of GPS Controlled Spreading, the accuracy was defined as a precision within five meters. Due to the mechanic elements in a salt spreader, a change in e.g. spreading width cannot take place instantly. Five meters in length is equal to 0.3 seconds of driving at 60 km/h. Neither the driver nor the mechanics can do more precise adjustments than this today.

In the daily operation it has been an important issue, that the driver can override the automatic replay with e.g. symmetry changes due to heavy side wind or by pressing “max dosage” at places with drifting. The same way, the system must act adequately if the driver leaves the route and return to it later. This could be in situations where he needs to stop for fuel or food, or might need to go to the depot for reloading.

The different products have met these challenges in different ways. Until now, we have seen the requested accuracy. In at least one product they have used special algorithms to improve the accuracy of the GPS signal in combination with speed-dependent settings, where the speed can take the mechanical delay into calculation. This combination has resultet in a very satisfied accuracy.

During the first route recordings, it was clear that it had not been possible for a driver to make all the adjustments at the control box before. In average, there had been between 2 and 6 changes in settings per minute, but most of the adjustments were usually concentrated in e.g. junctions. When salting at a speed of 50-60 km/h (~15 meter/second) there might be a need for 4-8 adjustments on the control box within a few seconds.

The drivers of the salt spreaders have been very positive about this new technology. It makes their job easier and gives them more time to focus on the traffic and just surveying that the spreader is “doing the job”. Even experienced drivers are saying that salting by using GPS Controlled Spreading gives a better result than they could ever do. .

5. SECTION BASED FORECASTS

In Denmark, there is a dense network of app. 350 road weather information stations placed along the roads. From each station we get a forecast for road temperature, dew point etc. to ensure a fine base for taking the decision regarding salting or not. These measurement stations are usually placed at cold spots while the road temperature between these stations usually is higher.

Today, most spreader manufacturers can deliver a tool to change the dosage according to the present road temperature by using a sensor placed on the truck. When doing preventive actions it will be much more beneficial to be able to salt according to the forecast for the road temperature during the entire route. Figure 3 below shows an example of a 75 km route where the temperature even in a flat area can vary up to 7 degrees. At the figure, the temperature forecast is shown with the corresponding salting dosages. Normally, the dosage will be the same during the entire route, as we only have forecasts on station level, which usually will be at the two coldest places.

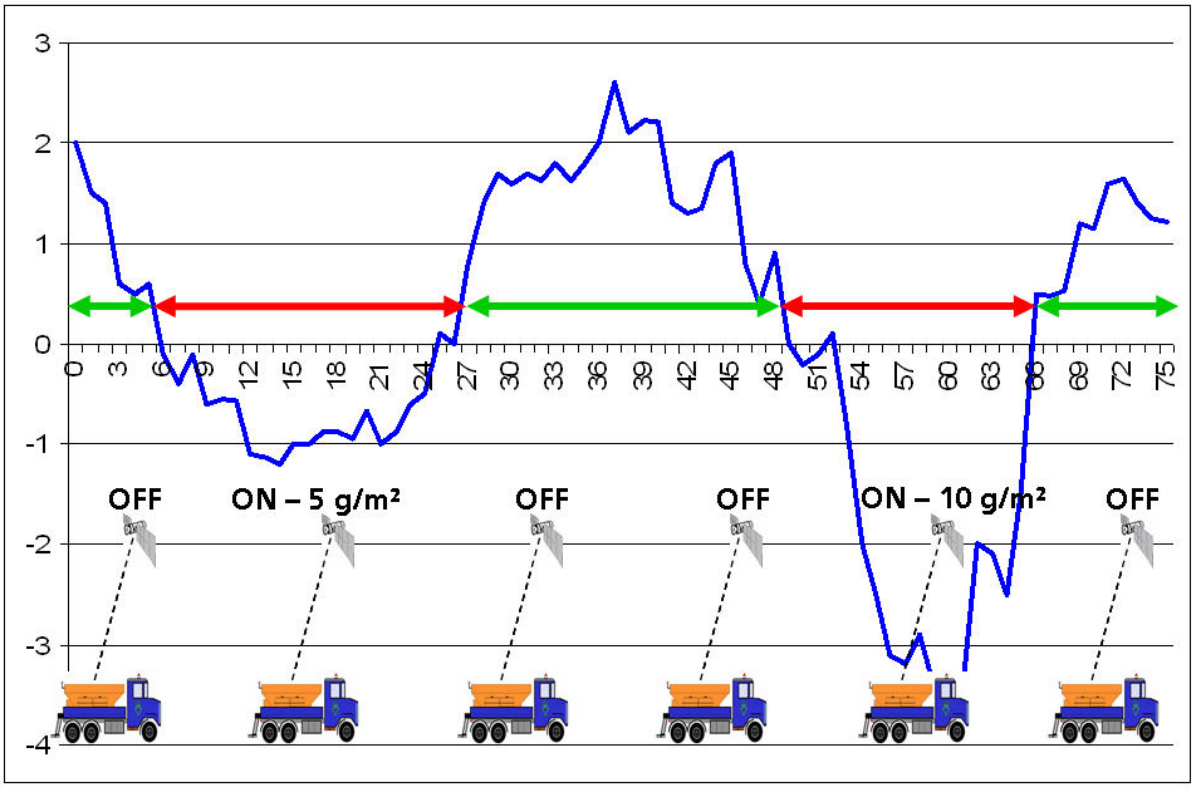

Figure 3 – Forecast for the Lowest Road Temperature along a Motorway Route

At the moment, the Danish Meteorological Institute has developed a model for section based forecasts, and has made them available in our RWIS. In order to be able to make a section based model, there is a demand for temperature measurements along the route under different weather conditions. This can be done by a separate vehicle, but today we equip new spreaders with temperature sensors which automatically send measurements with the data collection from each action. This gives app. 100 temperature profiles for each route per winter season. These measurements are used for tuning the model and to verify the quality of the forecasts.

6. FIELD TEST

Late in the winter of 2008/09 we implemented automatic transfer of the section based forecasts to our VMMS, so now we are ready to call out for salting based on forecasts. Unfortunately, the spreaders are not ready yet to receive a forecast automatically on the fly when initiating a call-out. Therefore, the very first tests have been postponed to the summertime as shown at figure 4.

Figure 4 – Field Test of Salting Based on Section Forecasts

The field test done with a salt spreader simulator installed in a van has proved that GPS Controlled Spreading is a good way to ensure different dosages along a route according to a forecast.

The result of the test did show a successful adjustment of the dosage according to the forecast on a specific winter day in March. When automatic transfers of the forecasts are present it is easier to implement section based forecasts on the specific routes. The driver just has to accept an automatic download of a route specification before starting and everything will work automatically.

The benefits are an obvious saving in salt due to a lower dosage on parts of a route. However, this will only be present in specific weather situations, and when we have a high quality of the section forecasts. It is expected that the salt savings over time will be up to

20% in rime situations. Along with freezing wet roads, rime is the most common winter problem in Denmark.

Due to the stage of this technology, it is expected that the road weather model for section based forecasts will need several upgrades over time, to archive an adequate quality. It is important with a high quality in forecasts, in order to archive the salt saving goal.

CONCLUSION

The implementation of automatic data collection has given a valuable documentation of all salting actions. On the other hand, this documentation has also shown that the quality of the adjustment of the control box during the salting action could be improved.

GPS controlled salt spreading has automated the adjustment of the spreader control box, which has given a much more precise and repeatable salt spreading. Bus stops, turning lanes etc. is never forgotten. At the same time GPS controlled salt spreading is the ideal tool to use to gain benefit from section based forecasts.

Implementation of section based forecasts is still under development, but the first field tests have taken place, and have proved that GPS controlled spreading is an ideal tool to benefit from section based forecasts. It is expected that this technology will lead to a lover salt use over time.