REALISING THE BENEFITS OF FINNISH SNOW-HOW BY TURNING IT INTO PRODUCTS AND SERVICES

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ABSTRACT

More frequent extreme weather conditions will lead to a greater demand for road weather services for more efficient winter maintenance operations and the reduction of weather-related accidents. In the European Union, extreme weather conditions were estimated to result in costs of approximately €15 billion every year. Finland has had to adapt to changing weather conditions in managing its transport system, and this has led to the accumulation of winter-related expertise both in technology and best practices that could be translated into better and more products and services. In Finland, this could mean annual benefits of up to €30 million. Enablers for these new services could be different types of mobile measurements and the availability of open weather-related data. Urban environments, on the other hand, provide unique challenges for acquiring and utilising road weather information.

1. INTRODUCTION

By current estimates the frequency of extreme weather phenomena will increase significantly in the future. This will lead to an increasing demand for more weather and road weather services to improve the efficiency of winter maintenance and to reduce weather-related accidents. Finnish experience on dealing with harsh Nordic winter conditions can be invaluable in this changing climate.

2. IMPACT OF WEATHER

The costs of extreme weather phenomena have been investigated in the EC-funded EWENT project that ended in 2012 [1]. Within the European Union, the annual costs due to these phenomena were estimated to be around 15 billion euros. Of these, 10 billion euros come from road traffic accidents and 2 billion euros from accidents of pedestrians and bicyclists. The biggest benefits would therefore come from reducing the number and severity of accidents.

Regarding road transport, the EWENT project also obtained some real winter maintenance costs in the Helsinki region due to extraordinary snowfall in during the winters of 2009–2010 and 2010–2011 [1]. For the city of Vantaa, the costs of snow blowing and removal increased significantly due to the extraordinary winter conditions. The result was a 1000% increase in removal costs compared to normal winters (from 100,000€ to over 1,000,000€), and more than a doubling of the snow blowing costs (from 500,000€ to over 1,200,000€).

Similar developments were observed in Helsinki as well (Table 1) [1]. Winter maintenance costs over the same two winters that had an abundance of snowfall exceeded the budgeted levels by more than 50%. The budgeted levels represent typical winters, whereas the exceptional snowfall shows the impact of such events on service contracts.

This shows that cost variations to the budgeted can in extreme situations vary between 50% and 100% even in regular day-to-day maintenance operations.

Table 1 - Winter maintenance costs (euros) in the city of Helsinki, 2009–2011 (modified from [1]).

Winter maintenance	**2009**	**2010**	**2011**
Budgeted	21,430,000	21,900,000	20,800,000
Actual	21,065,000	30,500,000	35,300,000*
* forecast covering the early part of the year (winter maintenance)			

In Finland, unit values for road maintenance on national roads exist as well (based on Finnish Road Administration statistics from 2008, according to [1]):

- Winter maintenance: 991€/km/year
- Highway maintenance: 3 350–6 063€/km/year
- Main road maintenance: 1 595–4 000€/km/year
- Regional roads: 530–935€/km/year
- Feeder roads: 430–739€/km/year
- Light traffic pathways: 412–1 304€/km/year
- Supporting infrastructure maintenance: 382€/km/year.

3. BENEFITS OF SNOW-HOW

Weather and road weather services have been shown to provide significant benefits to society. The weather and road weather services for public roads that were in use in Finland in 2007 were estimated to bring total benefits of €16–€32 million [2]. The clear majority of these benefits result from the reduced number and severity of personal injury accidents and thus reductions in medical costs, lost time and loss of well-being. More advanced information services were evaluated to potentially even double these benefits.

In 2007 in Finland, the benefits related to winter road maintenance came primarily from three sources: reduction of unnecessary and belated operations and needed materials (sand, de-icing substances) [2]. In total, the benefits translated into €2.7 million in cost savings consisting of savings of €400,000 in reduced need for materials, €450,000 in less unnecessary operations, and €1.8 million in fewer operations that were undertaken late.

The same 2007 study also identified pedestrians and bicyclists as a potential target group for weather and road weather information and services that could yield significant safety benefits. In this user group, the benefits come from preventing slipping accidents. It was estimated that current weather and road weather services targeting end-users reduce slipping accidents requiring medical attention annually by 1,000–1,500. This reduction would result in cost savings of €49–€73 million every year, as the average cost of such a slipping accident was estimated to be approximately €50,000. In addition, weather and road weather services provided to road maintenance operators were estimated to prevent about 2,500 slipping accidents requiring medical attention, resulting in additional annual savings of €120 million. Based on the study, the total benefits of Finnish weather and road weather services for pedestrians and bicyclists in 2007 thus ranged from €170 million to €190 million.

4. MORE EFFECTIVE UTILISATION OF WEATHER INFORMATION

One especially potential opportunity for increasing the effectiveness of road weather services is the proliferation of smartphones around the world. Smartphones offer the possibility of providing more relevant information to users while they are on the move. The relevancy of the information is enhanced by the positioning capabilities present in all smartphones making it possible to know the location of the user.

4.1. Mobile measurements

Mobile measurement devices can be integrated into vehicles (e.g. remote sensors using infrared) or they can be separate mobile devices such as smartphones. Integrated mobile solutions can utilise information from the vehicle's electronic stability control (ESC) system or calculate friction based on the differences in rotation speeds of the vehicle's axles [3]. The system utilising axle rotation speeds, developed by VTT Technical Research Centre of Finland, is suitable for all cars regardless of their make and model. The system has so far been used in heavy lorries, but it is also directly compatible with other heavy goods vehicles. In its current state, the slipperiness data from the system can be used by passenger cars, and in the future they could also be producing slipperiness observations.

Mobile device measurement solutions utilise the built-in sensors (e.g. accelerometer) in the device to estimate the friction on the road based on developed models when doing braking manoeuvers. Mobile optical measurement devices work similarly to stationary optical ones.

Malmivuo has tested different mobile measurement devices [4]. All of the tested friction measurement devices were found to be sensitive to variations in the braking distance during measurements. This means that some experience is required from people using these kinds of friction measurement devices to measure the road condition as the braking distance needs to be kept relatively similar in each measurement. Optical mobile sensors were also examined, and they were found to have some difficulties in identifying the most slippery conditions. The test also developed a method for testing the reliability of friction meters so that they can be approved for use in monitoring winter maintenance operations.

Haavasoja et al. [5] compared a continuous optical skid resistance meter against a friction meter that requires braking. The results showed that the two instruments agreed within about 0.10 units when measuring the friction coefficient. The authors state that this accuracy would allow for various winter maintenance applications (e.g. quality control and maintenance operation optimization).

As mobile device measurement solutions that are based on measuring the deceleration during braking currently require some expertise in maintaining the braking distance constant, these kinds of solutions are mostly suitable for professionals who are actively monitoring the condition of the road. These include winter maintenance operators and people responsible for monitoring these maintenance operations.

Integrated solutions that do not require active participation from the driver seem more promising as sources of road condition information on a scale that would significantly improve its coverage. A key issue in gaining wider adoption of integrated solutions is identifying suitable vehicle fleets that could be used as sensors on the road network. Potential fleets include buses, taxis, security company vehicles, vehicles owned by cities and municipalities and trucks.

4.2. Availability of data

One important development that touches on road weather data as well is the opening of public data sources for use free of charge. In Finland, the Finnish Meteorological Institute has opened [6] a lot of their weather data, including some forecasts, for commercial or non-commercial use free of charge according to the requirements of the European Commission's INSPIRE [7] directive.

The availability of road weather data is not as clear everywhere. In Canada [8], RWIS data is owned by the provinces and their service providers, and there is not much sharing as the data is provided by different service providers. This means that there is no open road weather data in Canada – road weather information is not even widely available to the general public. Reported reasons for this are the attempt to preserve a competitive advantage, and a fear of liability related to lack of maintenance operations when conditions would have warranted them.

On the data front, regulation by the European Commission [9], motivated by the fact that bad weather and slippery roads are among the most common causes of accidents, requiring motorists to receive timely information without any additional cost will increase the pressure to provide safety-related weather and road weather information free of charge. This, in turn, will likely lead to better and more varied availability of road weather data thus offering up new possibilities for combining the data as part of new, more intelligent services. Among the most frequent causes of accidents are bad weather and slippery roads (15% of fatal accidents in France and around 20% in Finland).

4.3. Urban snow-how

Cities and their urban environments pose some special challenges both for road weather services and for winter maintenance in general [10]. Urban areas typically consist of several very local micro-climates that behave very differently compared to each other and the prevailing general climate in the surrounding area. This means that road conditions must be measured quite locally meaning a large number of measurement stations if stationary devices are used.

Cities also have a lot of traffic, and the goal of maintenance operations is to keep the transport infrastructure in a usable condition. This means quick snow removal after snowfall and preventive actions in conditions where slipperiness is expected. Most important routes are prioritised to optimise the effect of maintenance operations on the efficiency of the transport network.

Identification and prediction of slipperiness is one the most important tasks in urban environments as it is on the highway network as well. However, the same tools that work on highways do not necessarily work in cities. Optical sensors do not detect the effect of gravel on icy road surfaces, and friction measurements based on measuring deceleration using mobile solutions face some difficulties as well [11].

Similar difficulties also affect maintenance equipment: most maintenance vehicles are designed for highways, not for use in cramped urban environments. Some maintenance vehicles are too bulky for city streets. An optimal solution would be a maintenance vehicle that could be used for both snow removal and transporting the snow away [10].

Special locations pose additional challenges. Bridges can turn slippery in an instant, and bus stops can become hazardous when snow gets packed on the road surface making it extremely difficult for buses to stop and start back up again. Unmaintained bus stops can result in delays in public transport and even in accidents.

In urban environments, traffic lights can be located in places where the street is not level and one or either directions are uphill. In slippery or snow-packed conditions this can pose some challenges especially for heavy traffic that can get stuck and block traffic and cause traffic incidents that result in extended congestion or accidents.

Pedestrians and bicyclists are another special challenge in cities. Keeping walkways from becoming slippery requires foresight on the conditions, but is quite profitable from the society's point of view [2]. Heating solutions are effective but expensive – their cost/benefit ratio can be improved by scheduling the heating for times when snowfall or slipperiness is likely.

An answer to these challenges is neither simple nor trivial. Road weather stations on the highway network give a good overview of general weather and road conditions, but additional information about conditions in the city are needed. This calls for a sensor network on the city streets to provide localised information for identifying and predicting slipperiness and snowfall. As stationary optical sensors have not been found very useful in urban conditions, the solution could be provided by mobile measurements. Integrated solutions that do not require active participation from the driver appear to have the biggest potential.

5. TURNING SNOW-HOW INTO PRODUCTS

Due to its geographical location and the presence of four seasons, Finland has had to adapt to changing weather conditions in designing, managing and maintaining its transport system. This necessity has led to the accumulation of winter-related expertise both in technology and best practices. Translating this expertise and experience into improved products and services would benefit both the companies involved in producing these services and the society as a whole.

The Finnish Road Weather Excellence (FIRWE) project aims at doing exactly that. It started in 2012 and its goal is to develop a prototype combining different products and services into a unified service concept. Figure 1 shows the data sources, components and related stakeholders of this concept. The concept will enable different actors in the weather service value network to develop and offer new value-added service modules without the need for a complex background system and separate marketing channels. For end-users, this unified service provides road weather related services through a single window and as such enables the utilisation of road weather information in a timely manner in maintenance operations and in planning how to get from one place to another. The first phase of the FIRWE project will run through 2014.

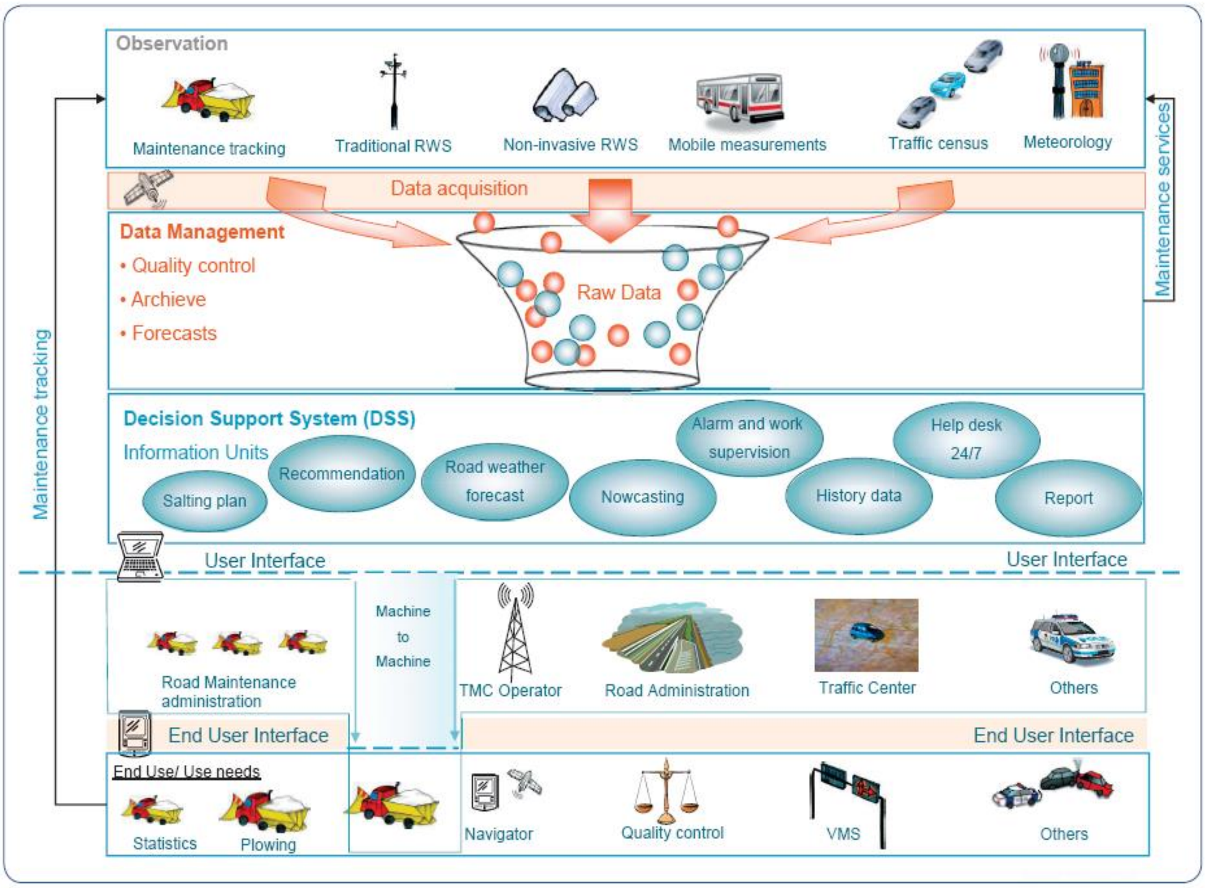

Figure 1 - Data sources, components and stakeholders of an expanded Road Weather Information System (Source: FIRWE project brochure).

6. CONCLUSIONS AND DISCUSSION

Open data will be, and has already been, an important enabler of new and innovative services, and this is likely to be the case in the field of weather and road weather services as well. However, open data is not a reality everywhere, as the example of Canada demonstrates. The lack of open data is not the only data problem facing Canada, as there also seems to be a problem in the availability of basic road weather information to the general public. Russia, on the other hand, is only building up its RWIS systems and is more focused on just having some information available. As Japan is only planning to open their national open data portal [12], Europe seems to be at the forefront of open data with the United States close behind.

One interesting topic in better enabling the development of products and services is the interoperability of road weather data between different countries. Finland, Russia and the Baltic countries have shared and combined road weather information that is presented at the balticroads.net web site for a number of years. The European DATEX II standard for ITS on European roads offers one interoperable way of exchanging transport related data, but there are still limitations to how road weather data can be presented in DATEX II form. Active participation by RWIS actors in the different countries to the standardization work is thus called for.

In conclusion, mobile measurements and open data translate into more content and building blocks for new and improved services. This can pave the way for increasing the accuracy of road weather information and forecasts. Combining these more robust building blocks with existing services can improve the level of service experienced by the end user.

This is especially true with services targeted to pedestrians and bicyclists. However, you also need feasible business models and benefit and revenue sharing logic for the new services in the changing business environment for the entire RWIS value network. From this point-of-view the tendency towards more open data can also be seen as a challenge, not just an opportunity.

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