32\textsuperscript{nd} Winter Road Congress in Finland
Lahti 7–8th February 2018

CONFERENCE PAPERS
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DIGITALIZATION

Wednesday 7\textsuperscript{th} February 9.30–12.00 am

\textit{Chaired by Tuovi Päiviö and Jorma Vaskelainen}

\textbf{Tuovi Päiviö, M.Sc., Director, ELY Centre}

Tuovi Päiviö is a Director of Transport and infrastructure at Centre for Economic Development, Transport and the Environment (ELY Centre) in Uusimaa. She has 20 years of experience in road sector. She is especially interested in road maintenance and has previously worked as maintenance specialist and head of maintenance and head of maintenance development in Finnish Road Administration, Finnish Transport Agency and ELY Centre. She has been active in both Nordic and global co-operation in road maintenance previously in The Nordic Road Association and nowadays in World Road Associate PIARC.

\textbf{Jorma Vaskelainen, M.Sc., City engineer, City of Lahti}

Jorma Vaskelainen has been working as a city engineer for 15 years. His organization builds and takes care of all public areas in the city of Lahti. He has also long experience of international cooperation. He has been the chairman of IFME (International federation of Municipal Engineering) and a chairman of Finnish Association of Municipal Engineering.
Aurora Borealis – The Arctic Intelligent Test Ecosystem

Reija Viinanen & Ilkka Kotilainen, Finnish Transport Agency
Gun Sissel Dobakk, Norwegian Public Roads Administration

The Aurora Borealis Intelligent Corridor forms the test ecosystem for snowtonomous driving and transport and it has been designed for verifying and validating new Cooperative, Connected and Automated Mobility (CCAM) solutions and innovations in real Arctic winter conditions.

The intelligent corridor E8 starts from Tromsø, Norway continuing to Kolari, Finland. It has been made in cooperation with Finnish Transport Agency (FTA) and Norwegian Public Road Administration (NPRA). Both countries will test ITS solutions and intelligent, digital infrastructure for authorities’ purposes also. The automotive industry needs supporting digital infrastructure for CCAM testing as well as road managers are willing to get insights about demands and needs of the future’s infrastructure.

The cornerstone of the Aurora Borealis project is founded upon the realization that automated driving will not become widespread without weather-proof technological solutions. If these solutions do not work in all conditions, including on all kind of roads, their market is limited and usability is only on sunny days and good, easy roads.

One of the goal is to develop scalable cross-border solutions and harmonize e.g. road maintenance between the countries by using state-of-the-art ITS technological solutions. Another important target is to create new information system enhancing traffic information services for real customers, i.e. trucking companies and tourists as well as other road users. Accurate mapping of road performance and road structure together with numerous road/vehicle sensors describing road/weather conditions enable a real-time and proactive guidance of road maintenance and repair operations during winter periods.

Aurora Borealis project is focusing on automated driving, digital transport infrastructure and intelligent infrastructure asset management. Although autonomous driving provides great opportunities for the more safe and efficient transport system, there will be also potential infrastructure related risks that road authorities need to be prepared, like rut formation and roads’ structural conditions especially between seasonal changes. In intelligent transportation, the road beneath the vehicle also matters. The latest technology should be used for better diagnostics of traffic infrastructure and roads.

In Finland, the Aurora intelligent road contains 10 km public road section for technological test of intelligent and digital infrastructure as well as ensures testing for CCAM in extreme weather conditions. One of the ongoing activities on the test section is the Arctic Challenge project implemented in 2017–2019, funded partly by the EU CEF initiative and launched by FTA and Finnish Transport Safety Agency, Trafi. Arctic Challenge studies landmarks such as posts and poles with reflectors and ultra-wideband connectivity, accurate positioning with correction data, hybrid communication performance and remote control driving using 4G/LTE connectivity.

In Norway, the Borealis intelligent road contains 48 km public road test section for intelligent and digital infrastructure. Infrastructure will be utilized and it is available for testing in different projects and innovation challenges. Funding of the projects vary, some have been funded by the EU CEF initiative and some by the Norwegian Public Roads Administration. NPRA’s innovation challenges search for solutions regarding the condition of the road and traffic conditions and ad-hock events that happen on the road.

By using Aurora Borealis intelligent corridor, road authorities contribute traffic safety and promote traffic fluency and overall accessibility to both rural and urban destinations. Both FTA and NPRA want to get joint understanding about short and long-term actions for road managers and infrastructure owners, which measurements will be needed regarding to connected and automated driving.
Reija Viinanen, M.Sc., Director of Aurora collaboration Finnish Transport Agency

Ms. Reija Viinanen (M.Sc. in Agriculture and Forestry, University of Joensuu) has worked in regional development projects for more than 15 years in the Finnish Lapland and has strong cross-sectoral experience from the public private partnership and promoting local initiatives. Viinanen has led Aurora Intelligent Transport Test Ecosystem project since it started in 2015. From the year 2017 she has been working for Finnish Transport Agency (FTA) in the Mobility management and ITS unit and is in charge of the Aurora collaboration.

Ilkka Kotilainen, MSc.Ec. Project Manager at the Finnish Transport Agency

Mr. Ilkka Kotilainen (M.Sc. Ec.) is a Project Manager at the Finnish Transport Agency where he is working at the Mobility Management and ITS services unit. His responsibilities in the FTA are automated and connected driving projects. Previous experience in projects of Knowledge Management, Business Intelligence and Analytics as well as Human-computer interaction research in simulated and real-world driving environments.

Gunn Sissel Dobakk, MBA, Project Manager of ITS Borealis project in Norwegian Public Roads Administration

Ms. Gunn Sissel Dobakk (Bachelor in Information Technology and MBA in Management and economics and entrepreneurship, Nord University of Bodø) has worked for the Norwegian Public Roads Administration, NPRA, for more than 6 years. Within the area of Intelligent Transport Systems, ITS, where she has been involved in national systems for toll charging and ITS solutions, and now as Project Manager for the Borealis project. Before NPRA she has worked several years for the oil and gas related industry, facilitating IT systems, project planning and innovation projects.
Digitalization Improves Winter Maintenance

Riitta Annala, Project Manager, Solita Oy
Co-author: Ismo Kohonen, Maintenance Procurement Specialist, Finnish Transport Agency

In 2014, a team at Solita started developing a large information system for The Finnish Transport Agency. One of its most important features was the possibility to monitor winter maintenance events in real-time. In addition to including the real-time monitoring, the system should also be map-based and provide comprehensive reporting capabilities for the customer, and integrate with several internal and external systems. Furthermore, it should offer contractors an application interface through which they can deliver winter maintenance data from their own information systems. In short, the system would audit the contract compliance of the roads and waterways maintenance providers. The system was named HARJA, an acronym that constitutes the Finnish word harja, brush in English.

The first production deployment of HARJA on October 1st, 2016 included functionality for monitoring the road maintenance contracts, the main content of which is winter maintenance. During the two years the system was in development, the number of integrating systems grew substantially. HARJA attracted interest both inside the Transport agency and in the municipal offices around the country. Everyone wanted to join in. Currently HARJA is heavily integrated to various systems that collect operating data from the contractors. The data produced and complemented in HARJA is further transmitted to many end points, for example to be employed in financial administration and asset management systems.

At present HARJA includes maintenance and upkeep contract monitoring for the roads, waterways, channels and open bridges. Road repair contracts will become the last ones to join HARJA in the spring of 2018. In addition to contract monitoring, there are two other considerable features implemented in HARJA, namely the road user feedback management controlled by the Road Traffic Center and the safety irregularity reporting capabilities.

Finnish Transport Agency owns HARJA and it is mainly used for overseeing the maintenance contracts. The accompanying map functionality is used to track ploughing, salting, sanding and other winter and summer maintenance work in real-time. Product reports can be extracted on contract, ELY or country level. The reports provide summaries of the contractors’ performances within the contract.

HARJA has plenty of winter maintenance information that everyone wants. It creates various possibilities for sharing real-time maintenance information with customers. Road users might, for instance, like to see when the snow plough is coming their way or whether the road is salted and the surfaces evened out. Before any information can be shared, an agreement on the practices must be reached between the parties involved, which can be complicated.

The HARJA user base consists of The Finnish Transport Agency, ELY-centres, consultants and contractors. HARJA provides users an overall picture to monitor the maintenance work in progress. The Traffic Agency and ELY officials are allowed to observe all the data in the system whereas the contractors can view their own contracts. However, the contractors can inspect the real-time map presentation of the events of all contracts in their ELY area. This improves efficiency, transparency and co-operation between the operators.

In the future it will be possible to project the weather conditions and forecasts on the road network map in HARJA. The motivation for this is to see where the snowfall hits and whether the required measures are in progress on time, an hour after the snowfall begins.
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The main goal is to gather reported information from all contractors and supervisors in Finland in HARJA in order to ensure high quality in winter maintenance measures. As a result, the Finnish Transport Agency as a purchaser and all the road users get the service exactly as described in the maintenance contracts.

HARJA interface descriptions, source code as well as updated information on the development are available on: http://finnishtransportagency.github.io/harja/.

Riitta Annala, Project manager, Solita Oy

Riitta Annala work for a Finnish IT company called Solita and have managed a project called HARJA since November 2014. HARJA is a reporting system for road and waterway care and maintenance contracts. It’s implemented for the Finnish Transport Agency. HARJA is already in production and it’s used by The Finnish Transport Agency, ELY Centers and the Contractors.
Digitalization reshapes the Road Maintenance Management

Oiva Huuskonen, Development Manager, Lic.Sc (tech.), (Destia Oy)
Markku Tervo, Unit Manager, Centre for Economic Development, Transport and the Environment
Lauri Kettunen, Professor, University of Jyväskylä, COB Jalonne Ltd.

Ii digital contract work 2016-2021

Ii five-year contract work takes place at the coast of the Bay of Bothnia. It includes testing and development of new technology and operating models to comprehensively digitalize road maintenance management. The customer is the ELY-center (Center for Economic Development, Transport and the Environment) of Lapland, and the contractor is Destia OYJ. Development is supervised by a group of representatives of the Finnish Transport Agency, the ELY-center, and the contractor. This enables evaluation of operating models and development of technology to cater to the information needs of the client, contractor, and the road users.

Digital operating model

In brief, digitalization of maintenance management stands for use of new technology and reform of operating models throughout the operating chain. Real-time information arises from the work process and to a great extent from various highway user groups. The development work covers automatic data acquisition of the road network, data systems, analysis techniques, and operating model of the work supervision. The production of information digital, mobile, and real-time.

Commonly available technology enables fast and easy acquisition and distribution of a broad body of information. This inevitably changes the service expectations of road users, e.g. via the social media. In order to meet these changing expectations, maintenance operators must renovate the information acquisition procedures. Technology helps make the maintenance real-time and transparent to supervision. It also enables savings to both the client and the contractor via a more efficient targeting of operations and allocation of resources.

Road inspections and crowd-sourcing of information

In the present operating model, the work supervisors inspect the entire road network under contract once a week during the winter. Moreover, the ELY-center areal managers and quality control consults partially cover the road network by car to make additional inspections. Most of the observations are visual and manual documentation is tedious on the road. The friction measurements and quality deviation reports get documented with the greatest accuracy. The present inspection model produces little material that can be accurately referred to later or can answer road users’ real-time question about maintenance. Crowd-sourcing requires an operating model where substantial amount of road data is gathered by the road users. This significantly improves the coverage and timeliness of the view of the road condition.

In Ii contract work, Posti (Finnish postal service) sources data from its local delivery vehicles by means of Jalonne RoadData mobile solution. Other prospective data sources during the are regular service transporters and taxicabs. In future, the safety and autonomous driving solutions by car manufacturers may serve as important data sources. Some latest models already share information among cars of the same make about slippery roads, status of wipers and safety devices. In order to get this data available, EU-level norms must be made to require public delivery of time-critical safety data.

Signals

Crowd-sourcing produces data at a fast rate. It is therefore critical to automatically recognize the parts of the road network that require closer inspection. We call such automatically produced indications of inspection demand signals. Signals can be produced from image and sensor data, data of weather and road conditions, and data gathered by various vehicle-mounted measurement devices, such as a continuous friction meter.

Automatic analysis is a crucial element in the use of image and sensor data. Sensor-based signals are united with a map application to recognize areas that require closer inspection. Such features like surface roughness, potholes and bumps can be automatically estimated to faster and more accurately schedule maintenance operations.
Use of image and sensor data

Jalonne RoadData system acquires the road network data with smartphones. Still photography and sensor capabilities of the smartphones are central in this stage. Photographs enable good retention of detail and conditions at later inspections.

Jalonne RoadData system consists of a smartphone application, database server, data analysis, and a browser-based user interface. A vehicle-mounted smartphone gathers the data from the GNSS, inertial and other sensors, and sends it to the information system. This data is synchronized with the photos. The application can also record and store video on demand, synchronize it with the sensor data, and transmit it to the information system when the circumstances permit. The adoption of 5G technology will increase the volume of video material. It will also provide real-time machine vision opportunities.

Digital supervision

An important development point is the planning and execution communication of the client and the contractor. The new operating model is to supplement the present mobile operation reporting, especially on planning information, and execution of deadline-regulated and common maintenance tasks. It is a challenge to organize use of data from various sources such that the recording is done only once. The entire chain of procedures from the client to the maintenance worker must be taken in the account in the development.

New technology

The societal expectations of digital reform of old operating models are based on recent breakthroughs in IT-technology. Smartphones with camera, GNSS, inertial sensors, significant storage and processing power have become commonplace. The smartphone is a globally mass-produced product, whose performance to price ratio is very appealing. Data can be acquired with smartphones virtually everywhere, and their ubiquity promotes crowd-sourcing. Most of Finland and its major roads are covered by the mobile network. This makes virtually real-time transmission on the road viable. Data link subscriptions are practical and cheap. Whereas the smartphone is a key to crowd-sourcing data acquisition, cloud servers enable storage of great amounts of data and its broad distribution. Highway maintenance needs for cloud computing and storage can be satisfied with reasonable expense, but data hoarding soon becomes expensive. Processing of crowd-sourced data should also be well targeted for economy. Retrieval and presentation of photographic data, signals, and processed results are realizable with a browser-based application. This sidesteps the burden of installing and updating specific client-side software.

In conclusion, it is possible to gather and manage the information for highway maintenance purposes with reasonable cost. Digitalization both lowers the cost and raises the quality of service. Especially the exact data acquired makes it faster to react to problems.

Realization of digital road maintenance

The development of digital tools in the Ii contract work has been done in collaboration of the client, the contractor and an IT-developer. The objective is to match the concrete needs of highway maintenance to latest possibilities provided by IT. The key question of maintenance digitalization is the conversion of the acquired information to fluently human-readable form. The road maintainer has to recognize and anticipate the repair targets on the road network. The smartphones just provide a bulk of photos, GNSS-produced coordinates, and sensor readings. Without automated data processing, it is impossible for a human to look and read through all this material to identify the repair targets. Human comprehension works by connecting observations into relations and functions. For example, snow storm in a weather forecast makes a person automatically infer difficult driving conditions and the need for a snow plow.

When the relations and functions are technically expressible, practical needs become translatable to algorithms for a computer. For example, the freezing of road surface is related to humidity and the temperatures of the road and air. When these three quantities are expressed with numbers, one can construct a function that answers whether the road freezes or not, and whether salt is needed to thaw the road. A general rule for maintenance digitalization is to seek for functions that explicitly answer to relevant practical questions. This approach works surprisingly well. Fig 1 presents processing results from a windshield-mounted smartphone: driving direction, speed, trajectory, kinetic energy, and the roughness of the road.
Some functions related to road maintenance can only be expressed by enumeration of cases. For example, no surefire recipe is known to answer whether a photo contains traffic lights. However, this would be a necessary intermediate stage in evaluation of the condition of all traffic lights along a route. When presented the photo, a human can quickly tell whether there is a traffic light or not. This amounts to classification of the photos to two annotated lists, one of photos with traffic lights, and the other without. The AI (Artificial Intelligence) and machine vision have recently attracted a lot of publicity. They are tools to approximate functions (partially) expressed in terms of such lists. Given a sufficiently large number of annotated training photos, the AI can approximate whether a random photo belongs to one of the trained classes. The reliability of the approximation increases with the coverage of the training set. So, where possible, one should formulate road maintenance needs in terms of well-defined functions that can be evaluated exactly. Where this cannot be attained, AI can provide useful approximations.

Conclusion

Contract work tests new technology and its capability to automate and facilitate highway maintenance. Real-time road condition information arises from everyday maintenance work processes, and to a great extent, other road users. The crowd-sourced data is automatically processed to extract the information needed in highway maintenance. This increases the accuracy and reliability of observations, making it possible to better allocate maintenance operations by actual need.

Fig. 1 Driving direction, speed, trajectory, kinetic energy, and road roughness estimated by Jalonne RoadData system with smartphone-acquired data.

Fig. 2 Traffic signs recognized by machine vision. Machine vision may not recognize all objectives, and sometimes produces false positives. The reliability of the machine vision improves with a more extensive training set. The set should contain both traffic signs and objects that should not be regarded as traffic signs.
Oiva Huuskonen, Lic.Sc (tech.), Development Manager for Road Maintenance, Destia

Oiva Huuskonen works as a Development Manager for Road Maintenance in Destia. He has a long work experience in the development of technology in the care services.

Markku Tervo, Unit manager, ELY Centre

Markku Tervo, Unit Manager in Road Maintenance, is working for the Centre for Economic Development, Transport and the Environment at Northern Purchasing area.

Lauri Kettunen, Professor, University of Jyväskylä

Lauri Kettunen is a professor of information technology at University of Jyväskylä and the chairman of board of Jalonne Oy. He has a long experience in exploiting modern science to find new solutions for topical pragmatic needs.
Collecting Weather Information by Mobile Road Condition Monitors

Taisto Haavasoja, CEO, Ph.D., Teconer Ltd.

Knowing prevailing weather information is vital for driving in winter conditions and also for winter maintenance to optimize salting and plowing actions. Traditionally automatic weather data collection has relied on fixed road weather stations. Despite the advantage of producing continuous temporal data fixed weather stations fall short in providing an accurate overview of road conditions in between the weather stations. It has turned out that especially during bad road conditions the information provided by fixed stations is intermittently misleading. E.g., comparing Traffic Situation on Finnish Transport Agency’s web service to recently measured mobile road conditions reveals often disparity.

The purpose of this pilot program is to investigate feasibility of using public transportation buses and commercial trucks as a platform to collect mobile spatially continuous road condition data. Mobile measurements in harsh conditions are challenging as such. It turned out that installing the sensor in front of a bus behind the front grill is a favorable location to increase the service interval.

Another challenge is to arrange frequent enough repetition of measurements over a given road section to maintain the data up to date. To meet the challenges, five long distance buses, one city bus and two trucks were equipped with optical road condition and surface temperature sensors. The city bus runs in Helsinki, the other buses between Helsinki-Turku-Rauma and Helsinki-Kuopio-Kajaani. The trucks transport mineral ore from Kevitsa mine to Kemi harbor. An average daily mileage with the long distance buses is about 500 km, with the city bus about 300 km and with the ore trucks 650 km taking into account weekly days off and occasional vehicle down times due to periodic service. Thus one long distance bus can cover on average 50 km daily with about 2 hour measurement interval, which is a fair compromise to obtain adequately fresh weather data.

To cover the main highways of about 5000 km in a country like Finland would require nearly 100 installed buses. The estimated total annual cost of depreciation, service and communication is around 3000 € per one bus and thus the annual cost of a country wide system would be 300 k€. Annual service cost of fixed stations in Finland is nearly 1.5 M€ and corresponds to 115 €/km. Adding depreciation costs of fixed stations more than doubles this figure. In comparison, mobile data with 2 hour interval is available at 60 €/km. In conclusion, a mobile road weather system is an appealing option.

Taisto Haavasoja, Ph.D. (Phys), Teconer

Taisto Haavasoja, Ph.D. (Phys), has a scientific background in ultra-low temperature superfluid physics. After a post graduate period in the Bell Telephone Laboratories (ATT) he started at Vaisala in 1984 as a sensor researcher and later as a product development manager in the area of road weather stations. His group developed many generations road condition sensors and weather stations. Since 2008 Taisto Haavasoja has been managing director of Teconer Ltd, which produces mobile road condition monitors and industrial moisture sensors.
Real Time Videos and Computer Vision - Savings in Road Maintenance without Quality Loss

Markus Melander CEO, M.Sc., Vaisala Ltd.
Co-author Ilari Pihlajisto, Senior developer, Vaisala Ltd.

Computer vision and deep learning are reveling interesting possibilities to enhance manual inspections, field data collection from road networks and information generation from different sources. Remoted monitored contracting is a concept that takes feasible parts of new technology to serve road maintenance contracting. Vaisala as long term market leader, for road weather information and decision support systems, is taking initiative to develop and examine together with chosen partners new kind of model to create remote monitored roads. Concept combines road weather stations, video stream and sensor data from vehicles to provide necessary information for decision making and monitoring networks.

Markus Melander, M.Sc., Head of Business Development, Vaisala Ltd.

Markus Melander is former CEO of Vionice Ltd which was bought by Vaisala late 2017. He is also FTA Senior project manager. As former head of development project Digiroad 2 and FTA’s Digitalization program Markus has been years in front row of development of Finnish road sector. Since 2016 Markus has been CEO of computer vision startup Vionice.
Towards Industrial IoT in Winter Road Maintenance

Johan Odelius Senior Lecturer, Ph.D., Luleå University of Technology, Sweden
Virve Karsisto Researcher, M.Sc., Ph.D student, Finnish Meteorological Institute

The Internet of Things (IoT), or the so called Industrial IoT, will change the way winter road maintenance is done today. Quick analysis of high-speed data transferred between connected devices and sensors may enable high level of automation and a better road maintenance planning.

A three years joint-project between Finland, Sweden and Norway is currently on-going to demonstrate such technologies, while involving new sensors, forecasts and maintenance planning in real road environment. The project is titled WiRMa (Industrial Internet Applications in Winter Road Maintenance) and it is funded by Interreg Nord EU financing programme.

Improvements of road maintenance are crucial on regions where extreme winter weather conditions are present. Implications of deterioration or faults in road accessibility can strongly affect the living conditions and the commercial activities in cold regions. As the road conditions change continuously with the weather and other parameters, as for instance location, an IoT approach that looks into the different aspects of the real situation need to be proposed.

In this presentation three different by somehow interconnected aspects on IoT in winter road maintenance will be presented and discussed: 1) Improving road weather forecasts based on information from new vehicle sensor packages, 2) Planning the maintenance in quickly changing weather conditions and 3) Research on sensor technology to characterize type of road icing to improve winter road condition monitoring.

Johan Odelius, Ph.D, Senior Lecturer, Division of Operation, Maintenance and Acoustics, Department of Civil, Environmental and Natural Resources Engineering, Lulea University of Technology

Johan Odelius received his Ph.D. from Luleå University of Technology in Sweden in 2010 and is currently a senior lecturer at the research area of Operation and Maintenance at the same university. He is working as researcher, supervisor and teacher in the area of condition based maintenance (CBM). Main research focus is on real-time condition monitoring and prognostic modelling of railway and road.

Virve Karsisto, M.Sc, Researcher, Finnish Meteorological Institute

Virve Karsisto received her MSc from the University of Helsinki in meteorology in 2014. Currently, she is a fourth year PhD student in the University of Helsinki’s doctoral programme in atmospheric sciences. Her PhD studies, carried out at the Finnish Meteorological Institute (FMI), focus on forecasting winter road conditions through numerical modelling, with the aim of improving the quality of road condition forecasts through the use of observations from cars.
MAINTENANCE

Wednesday 13.00–15.00 pm

Chaired by Timo Paavilainen, YIT Ltd. and Pekka Rajala, ELY Centre

Timo Paavilainen, Manager, YIT Ltd.

Pekka Rajala, Unit Manager in Road Maintenance, is working for the Centre for Economic Development, Transport and the Environment at Southern Purchasing area. Pekka Rajala works also as the Chairman of the nationwide road maintenance network of Finnish Transport Agency.
Winter Maintenance and the Annual Costs of Pavements
Timo Saarenketo CEO, D.Sc. (Tech.), Adj.Prof., Roadscanners Group

The effect of winter maintenance operations on the lifetime costs of pavements has not been largely studied in Finland or in other countries. The formation of ruts in pavements has been mainly explained by studded car tyres or by permanent deformations caused by heavy trucks during the spring thaw weakening. Now a new research project, PEHKO 2015-2025, that focuses on the diagnosis of the root causes of pavement rutting, has revealed new information on how improved winter maintenance can have a major impact on pavement lifetime costs.

The PEHKO research has shown that several winter maintenance practices and techniques should be improved. A key reason for permanent deformation problems in road shoulders is that water from melting snow walls can infiltrate into basecourses under pavements due to cryosuction. This water as it freezes forms ice lenses which create frost heave. Later, when these lenses finally thaw the unbound base course material can have water contents of higher than 100% saturation level. This leads in turn to rapid deformations under truck loading. This water problem can be avoided by removing any snow walls before they start to melt. The first monitoring results from the PEHKO project of the early removal of snow walls have already shown savings of 10-20% in annual pavement lifetime costs. In addition to these savings traffic safety has also been improved as melting water does not form water ponds on the road shoulder. Such ponds, as they freeze, can cause major friction problems. Road markings will be similarly more visible, a factor that will be needed for the new autonomous vehicles.

Another major source of increases in annual pavement costs has been found to be poorly performing and/or frozen access road culverts. These need to be opened up before water levels start to increase in the adjacent ditches during the spring.

Finally, the latest finding from PEHKO on reasons for high pavement rutting has been the excess use of deicing salt on road sections with thin pavements. In these sections water will flow due to osmotic forces through the porous thin pavement. This leads to saturated basecourses that deform during the spring thaw under heavy trucks. The first results indicate that 1.5-2.5 times higher annual rutting values can occur in sections where the use of deicing salt has been extensively used.

Timo Saarenketo, Ph.D., Adj. prof., CEO, Roadscanners Group

Dr. Timo Saarenketo is the CEO of Roadscanners Oy. He also works as an Adjunct Professor at the Tampere University of Technology. He has specialized in Ground Penetrating Radar (GPR) and other Non-Destructive Testing based road and bridge and other traffic infrastructure analysis, pavement and road design, rehabilitation design, road material surveys. A special interest is also low traffic volume road asset management in cold climate areas. Over the last few years he has also been working on an analysis of the impact of new heavy trucks on the condition of the pavement structure.
Modern Methods of Accurate Snow Removal – Effects on Driving Experience

Rauno Kuusela  Quality Manager, Destia Oy
Co-author Janne Mäkipää, Arctic Machine Ltd.

Idea
Cleaner is Better
Road Salt is maintenance worker’s solution to the problem that wise worker doesn’t even have.

Background
Main reason for traffic problems during winter time relate to water combined with the temperature of road surface. If the temperature is below zero but dry no problem. Simultaneous water in any form (show, packed snow, slush, hoar frost, rime, ice) and coldness cause various problematic conditions.

You can manipulate the surface temperature but only with big money and for small areas only. So, let’s look more at the water in numerous forms. According to the theme of this paper we try to implement wise solutions only, sorry to say you need the others also sometimes.

Root cause number one is snow. If there isn’t snow, there can’t be slush or packed snow either. Further on – no snow no melting water that re-freezes to ice. With dry asphalt surface, there is no slipperiness and (just about) no need for salting and/or sanding. Main solution for safer traffic is not salting or increased salting it’s snow removal as clean as possible. After ploughing the may be some need for chemical treatments is the weather gets colder and traffic gets lower and/or temp surface is below temp dew point. But dosage is some 50-75% lower compared to “ploughing by salting-method.

Table. How much salt / m² is need for totally preventing freezing

<table>
<thead>
<tr>
<th>Case</th>
<th>Water g/m² and thickness [mm]</th>
<th>Forecast temp - 2°C</th>
<th>Forecast temp - 4°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>50 g / 0,05 mm</td>
<td>2 g</td>
<td>3 g</td>
</tr>
<tr>
<td>B</td>
<td>100g / 0,1 mm</td>
<td>4 g</td>
<td>6 g</td>
</tr>
<tr>
<td>C</td>
<td>500g / 0,5 mm</td>
<td>20 g</td>
<td>40 g</td>
</tr>
</tbody>
</table>

Amount of rest water greatly depends on evenness of road surface, in the end of winter the can be up to 25 mm deep longitudinal ruts. Rut depths like 15 mm are common. For 15 mm max depth can mean 10 mm average so for road with 4 wheel 50 cm wide ruts there is $4*500*15*1000 /10^6$ kg water = 5 kg extra water for every road meter.

But the is more to come. Drivers and cars don’t like the splash of salty and dirty water, more windshield washing fluid needed, lower visibility, stress and frustration. Drivers may even lower the driving speed (not that often really).

Wet surface means more noise (+3 dB). Water + by studded tires milled asphalt make perfect milling/polishing paste for deepening ruts. Some observations point that with wet surface at -3°C there is 2-3 times more wear that with dry asphalt and 20°C.

There are many reasons to make the road dry again or as dry as possible. But heavy trafficked main roads with deep ruts are tough. Traditional plow with solid blade is not good enough. You need methods like scooping, wiping, picking maybe blowing or grilling

Better solutions and test results
Test site and pictures of the testing methods will be shown.
For evaluation, the were old and new solutions like:
1. stiff plough-blade, number 1 and 2
2. stiff plow-blade with double blade
3. flex-element blade plough + double blade
4. flex-element blade plough + double blade with hydraulics-spring-controlled rubber blade pressure

Best result gave 4) AM-version with combined hydraulic controls. Rest snow/water was up to 80 % less than old-school plough with stiff blade number 2. Typically, we got 50 % better results with 4) even compared with stiff plough and double blade. This equipment makes more sense than good old “ploughing by salting”-method.

But if that 50 % is not enough, what then. The solution for even more accurate snow removal is coming from the Øveraasen / AM airport repertoire. Øveraasen RS 200 Vegsoper combine ploughing, sweeping and chemical treatment also for highway purposes. Pictures + Video

Resume
There are methods for getting 90 % cleaner road surface than with old methods. That is the way for better and safer driving conditions not forgetting huge salt reduction and other environment benefits. Why not invest for the best snow removal for getting those extras.

Rauno Kuusela, Quality Manager, Destia Ltd.

Janne Mäkipää, Arctic Machine Ltd.

Janne Mäkipää has worked 18 years in Arctic Machine’s R&D and exports. His main interest is developing of innovative machines for winter maintenance.

www.arcticmachine.fi
Passive Snow Control on High-Speed Roads

Daria Korneeva, Assistant Professor, Ph.D. in engineering science, MADI
Co-author Ushakov Victor, Ph.D. in Engineering Science, Professor, head of road construction and maintenance department, Moscow Automobile and Road Construction State Technical University MADI

One way to protect high-speed roads and motorway from snow drifts is the use of effective snow fences. The experimental research was conducted to determine the requirement for the design and type of snow fences on high-speed roads and motorway. The experimental research included modelling of the formation of snow deposits in the area of different types of road barriers, as well as simulation of the snow fence effect in the wind tunnel.

For experiment using reduced models of the motorway section, parapet failing and metal barriers, model of snow fences of seven different designs were created by 3D-printing. The height of the snow fence models was 50 mm, which is equivalent to 2 m.

As a result of the investigations optimal snow fence design and rational area of their application were determined. The influence of the terrain on the performance of snow fences was found out. Also the unfavourable combination of road barriers was defined in terms of snow drifts.

Daria Korneeva, Ph.D. in Engineering Science, Moscow Automobile and Road Construction State Technical University (MADI)

Daria Korneeva was born in Smolensk in 1990, finished high school in 2007, graduated from MADI with honours in 2012 majoring in highway engineering, after that graduated from the post-graduate studies in 2016. Now she is working in MADI as Assistant Professor. Priority scientific field is passive snow control.
OptiDrifT - Optimizing Winter and Spring Street Maintenance for Improved Air Quality, Accessibility and Safety

Mats Gustafsson, Researcher, Ph.D., Swedish National Road and Transport Research Institute VTI

In Sweden, in cities where high particle concentrations are a problem in spring, street operation is an important abatement measure. Winter maintenance can both contribute to air pollution by increasing the street dust load and affect dust emissions as winter salting, which both exposes the pavement for wear by reducing ice and snow covers as well as keeps the street surfaces moist, which increase wear but also reduces suspension of road dust. Special street operations are used to reduce the dust load and its suspension. Dust binding with CMA (calcium magnesium acetate) or chloride salts (MgCl2 and CaCl2) is decreasing dust suspension by traffic and advanced street sweeping reduces the road dust load. The dust binders are more commonly used as deicing agents. Since winter and dust reducing measures overlap during parts of the winter season but are not coordinated, there is obviously a potential to optimize the street operations. The project OptiDrifT is investigating this potential in the city of Stockholm, Sweden. The project involves researchers and municipality street managers as well as contractors and a road sweeper constructing company. The results show a potential to improve methods and strategies for specific measures and on possibilities to coordinate different operations. A detailed follow-up of road operation measures in time and space has resulted in possibilities to analyze how an applied strategy has worked in relation to exceedances of air quality limit values for PM10. A concept developed within the project is maintenance regimes, meaning sets of operational measures, techniques and strategies adapted to different parts of the winter and spring season and related to general meteorological conditions and the use of studded tyres. The project outcome is expected to be improved and optimized street operation methods and strategies for cold climate cities where road dust is an air quality problem.

Mats Gustafsson, Ph.D., Researcher, Swedish National Road and Transport Research Institute (VTI)

Mats has a PhD in physical geography and has been working mainly with research within air quality and transport at VTI since 2000. His main research interest is wear particles from pavements and tyres, their emission processes, properties and how to abate them. Secondary interests include exhaust emissions, road salt and environment and landscape interaction with infrastructure. He has been the project leader for over 40 research projects and published 25 scientific papers, over 50 conferences contributions and 40 research reports.
Patching Potholes with New Geopolymer Materials

Minna Sarkkinen, Researcher, D.Sc. (Tech.), Kajaani University of Applied Sciences
Co-authors: K. Kujala & S. Gehör

Potholes are small, typically sharp-edged holes in the pavement hampering traffic. They have become more common due to climate change and consequent increasing amounts of freeze-thaw cycles, for example in Finland. Several different pavement damage types have been identified and reported in literature. The reasons for such damage are diverse and interrelated, the most common being traffic and weather stress (temperature, freezing and thawing, precipitation), and the own structural weight of the road structures. Prerequisite for the pothole formation, in addition to traffic load, is water ingress through the pavement. Such holes are typically initiated when damage to the pavement allows water ingress through the pavement. It is commonly believed that repeated freeze-thaw cycles accelerate pothole formation due to increased pressure during freezing periods and an oversaturated state under the pavement during warmer periods.

The aim of this work was to study the usability of geopolymer materials for the repair of paved roads, especially during the cold winter and spring seasons when the need for repair is most urgent and the use of hot asphalt is not possible. The objective was to find a material which exceeds both in cost-efficiency and durability those of cold asphalt. In addition, properties such as rapid strength development and good bonding with old pavement material are required.

The focus of the study was on the use of materials in cold (5…-10°C) weather conditions, for example, towards spring when the problems tend to appear and the conducting repairs are urgently required. The influence of selected factors on material performance was studied using the design of experiments method. The first experiment was conducted using 13 control factors, with special attention given to strength development and weather resistance characteristics. The results indicated that the geopolymer material studied had good weather resistance. Especially, using bitumen as an additive had a positive impact on the performance of the patching material. In addition, relations between the responses were analysed using structural equation modelling. According to the model, higher water demand indicated an increase in water absorption and further lowered water and freeze-thaw resistance.

The next series of studies comprised composite materials based on geopolymer binder and cold asphalt or recycled asphalt pavement (RAP) as the main constituents. The aim was to combine the advantages of asphalt and geopolymer binders. Geopolymer binder, like normal cement, contributes to the hardening of cold asphalt by improving bonding between aggregate particles and by using water in the reaction process. Compared to conventional cement, geopolymer binders can provide more rapid hardening requiring less curing, and improved resistance against salt. In addition, they can also be ecological due to their ability to utilize high amounts of the constituents of industrial by-products. According to the experiments conducted in this study the main benefits of the geopolymer binder were improved bonding strength to old asphalt pavement, usability in cold conditions and consequently improved durability. Several field tests in the Kainuu region showed that the geopolymer binder provided good resistance against traffic load and weather changes after a two year follow-up period.

Minna Sarkkinen, D.Sc. (Tech.), Kajaani University of Applied Sciences

Dr. Minna Sarkkinen represents department of mechanical and mining engineering of Kajaani University of Applied Sciences. She has worked in the group of applied geopolymer technology since 2013. Her research work has focused on use of industrial by-products in different applications for construction sector including concrete, soil and road construction. She has over 20 years long experience in construction material industry and cement based products.
CONTRACTS

Wednesday 15.30–16.30

Chaired by Otto Kärki and Jari Mustonen

Otto Kärki, Expert of Maintenance and Digitalization, Finnish Transport Agency


Kärki has 20 years’ experience of state organisations. Kärki has previously worked as a Research Scientist at Technical Research Centre of Finland (VTT) and University of Technology (TUT) and in his home town Vaasa.

Jari Mustonen, Lecturer (Infra Construction), Häme University of Applied Sciences
The project managed performance based maintenance contract (PMPBMC) was developed on the basis of preliminary studies in 2013. It is a contract model with a target price, and is based on documents of project management projects, the alliance model, and traditional care and maintenance intended primarily for demanding and extremely demanding highway maintenance contracts. Finland’s first project managed performance based maintenance contract (PMPBMC Espoo 2014-2019) is in its fourth year.

The PMPBMC is put out to tender through a two-stage negotiation method with the price/quality ratio deciding the most cost-effective bidder. Once the contract is decided the project managed performance based maintenance contractor puts all procurements out to tender in his or her own name (product deliveries, work performance, services, and subcontracts) with the exception of separately defined separate procurements in which the project managed performance based maintenance contractor gives a separate price. The buyer is actively involved in the competitive bidding and decision-making of the procurements. All information on the project managed performance based maintenance contract is available to the buyer (so-called open book principle).

In a PMPBMC efforts are made to equalise risk management and some of the risks are borne by the buyer.

PMPBMC is clear step forward in reforming traditional maintenance contracts. In PMPBMC parties are genuinely working together. This is ensured by agreeing common targets and working some part of the time in a same room.

In contractor’s point of view most important thing in PMPBMC model is that earning is dealt with service fee, so contractors are relieved to optimize earnings from the maintenance work itself. All parties collaborate and focus on delivering the best results for the project.

Based on the experiences the overall atmosphere has improved among the site staff. People are working more closely together to achieve common targets while the previous, potentially more conflicting approach has disappeared. Operations are transparent and efficient and clients can rely on contractor’s performance and commitment to deliver best results for the project.

In the experience of the buyer, the project managed performance based maintenance contracts have excellently fulfilled the goals set for them. Big changes are constantly taking place in the Espoo area owing to brisk urban construction. It has been possible to agree flexibly on changes affecting the content of the contract and it has been possible to target the work sensibly, taking the interests of road users into consideration. The contractor has actively proposed small changes in content and procedure with which services of road users have been improved. Generally speaking constant innovation and the testing of new methods or devices are the working method in the contract. In the project managed performance based maintenance contract the buyer is better aware of the exact situation of the contract at any given time. Cooperation and dialogue with the buyer function well.

There are additional improvements which can be introduced by engaging subcontractors more widely in the planning phase and the bonus scheme. A major challenge is how to engage every subcontractor with their workers to commit in the contract and quality requirements. Also important is how to guide everyone to find common understanding and agree on the meaning of appropriate quality in the end result.

Tuomo Ratia, B. Sc., Maintenance Coordinator, Centre of Economic Development, Transport and the Environment of Southeast Finland
Professional experience in municipal engineering (27 years). Areas of expertise are road construction, road maintenance and surfacing, quality and safety, contracts, road maintenance including tunnels.

Timo Paavilainen, Manager, YIT Ltd.
Effective Road Maintenance Monitoring

*Meelis Toome, Chief Specialist at Road Maintenance Department, Estonian Road Administration*

The number of officials gradually decreases from year to year, mainly due to national savings that are perfectly understandable – the tax payer’s money is never received in sufficient amount. This, in turn, makes planning of road engineers’ working time very challenging. ICT solutions may be helpful; activities need to undergo simplification and fine tuning, while not neglecting quality of work. Many countries have moved in that direction for years, and Estonia has made efforts to achieve that goal as well. Estonia is unique in that we are a small country with very small traffic load compared to neighbouring countries; at the same time, our small size is favourable for implementing changes. In my presentation, I aim to give an overview of our efforts in the field, for example, that we do not describe maintenance work processes in detail in maintenance contracts; I will introduce ICT tools and validation methods implemented in Estonia; and talk about contacting road users.

*Meelis Toome, Chief Specialist, Road Maintenance Department, Estonian road Administration*

Meelis Toome is a Chief Specialist at the Estonian Road Administration in the department of Road Maintenance. He is a lecturer on subjects such as Road Construction and Road Planning at the Tallinn University of Applied Sciences, where he also received his diploma of professional higher education in Roadbuilding. Presently he is in the process of obtaining magisters degree at the Tallinn University of Technology.
Alliance contracting in maintaining public areas in Helsinki

Anna Tienvieri Maintenance Engineer, M.Sc., City of Helsinki

Introduction

The economic situation forces municipalities to be more cost effective. This can be achieved through evaluation and enhancement of current processes and procedures. In addition the expectations of citizens regarding the quality of service provided have been increasing and the people would like to participate more in the decision-making than before. The field of maintenance needs new methods and new ways to operate.

Therefore the city of Helsinki has used alliance contract concerning maintenance of public areas, streets and parks since 2014. Targets of the alliance contract is to improve satisfaction of citizens, allocate the funds more effectively and develop the new methods for maintaining public areas.

The alliance contract

The alliance contract area is the neighbourhood of Pakila with 30 000 citizens and the contract includes all maintenance work on street and park areas with 115 km of streets and 52 ha of parks (including playgrounds and dogparks). The area is mostly residential area consisting of detached houses, kindergartens, schools, hospitals and industrial area. Winter maintenance including ploughing, de-icing and snow removal takes up the majority of the budget.

One important part of the alliance model is to establish a collective organisation which puts the contract into action. The leadership team makes all the strategic decisions and the alliance project team is responsible for daily activities.

In the alliance model risks as well as benefits are collectively shared with the owner and the contractor. Commercial framework consists of direct costs and project specific overheads, normal profit and corporate overheads and a performance pool. (Morwood R., et. al. 2008).

The owner, the city of Helsinki, has placed the following key targets regarding the whole 5-year contract period. The targets are to improve satisfaction of citizens, allocate the funds more effectively and develop the new methods for maintaining public areas.

a) Quality level: Citizen satisfaction regarding maintenance work will improve during contract period.

b) Productivity: Quality level of maintenance will stay on current level, even though the budget won’t increase aligned with the level of costs.

c) Development: Methods, techniques and processes of maintenance will be developed to achieve better quality purchasing, to improve cost awareness and eco-friendliness.

The annual target cost for the project is 1.4 million euros and the annual amount of bonus pool is 45 000 euros. The accomplishment of the annual target cost and key result areas are evaluated annually, as well as the contractor’s pain/gain share.

Commercial framework and “best for project” decision making are the basis of all operations. Maintenance shouldn’t be regarded as a separate project, like construction, but rather as a continuous process. Thus target costs and key result areas are evaluated annually, not only once after the project.

The project development phase lasted for four months and during that period a detailed maintenance plan, key results areas, a target cost for the first year and a contract with the subcontractor were made and the
Outcomes during three years

Currently the alliance project has continued three years and some key findings are already visible.

All targets that client set in the beginning hasn’t actualized yet. Some improvement during three years has happened. Key result areas are evaluated annually and importance of areas are varied between years. Client’s cost knowledge has improved and being part of negotiating with sub-contractors has been worthwhile. Communication and co-operation with contractor is more open than before and solutions to problems are found together.

Different ways to communicate with citizens are increased, “the jury of citizens” gives monthly feedback according to level of service of maintenance. As well new events has arranged (for example one with kindergarten) and different ways of social media are used all the time.

One of the advantage of the alliance is the cost guidance: money are used by “best for area” –method and that has allowed for example to renew playground areas in neighborhood.

Any decisions regarding the continuation of the alliance contract haven’t been made, but these results already indicate the alliance model being suitable for maintenance works. Thus contracting model is quite heavy, some areas need more precise evaluation, for instance the commercial framework and pain/gain share, as well as key results areas.

References


Anna Tienvieri, maintenance engineer, M.Sc. (tech.), City of Helsinki

Mrs. Anna Tienvieri is working as a maintenance engineer in City environment sector in City of Helsinki. She is responsible for subscribing street maintenance, especially winter maintenance, in the northern parts of the city. She has an active role in many development projects as handling snow in Helsinki and alliance contracting.
KEYNOTE SESSION

Wednesday 16.45–17.45

Chair by Nina Raitanen, Finnish Road Association

Nina Raitanen, D.Sc. (Tech.), Managing Director of Finnish Road Association

Ms. Raitanen has made her career in the field of infrastructure. Before joining Finnish Road Association in the year 2015, she worked for Aalto University, Destia Ltd. and Ministry on Transport and Communications.
Climate Change, Extreme Weather and Maintenance of Infrastructures

Dr. Pekka Leviäkangas, Principal Scientist at VTT Technical Research Centre of Finland

Synopsis

Climate change and extreme weather phenomena challenge our infrastructures and how we must maintain them. Traditional models seeking short-term cost-efficiency will not work. The infrastructure managers face the challenge of uncertainty, unpredictability, and increased pace of asset deterioration, while at the same meeting the demands of cost-effectiveness and generational equity. The last mentioned demand is one of the gravest issues along the road towards sustainable development.

The recent OECD research report issued by the International Transport Forum lists nine strategies to tackle the challenges (ITF 2016). These strategies range from the use of new assessment tools to practical suggestions how to realign our present asset management and maintenance strategies. These recommendations require that we need to understand the behaviour of our infrastructures, including roads, much better we do today. The economics, engineering, and management of infrastructures have many complex issues yet unresolved by research.

For example, the deterioration models used for asset management strategies work today based on simplistic approaches and can be successfully applied to simple structural elements such as pavements. As to road structure as a dynamic technical system, our knowledge is limited. Moving on to more complex structures, the dynamics becomes ever more challenging and good models to be applied in engineering and asset management decision making are rare.

Also the role and procurement practices of the public infrastructure owners need equally reconsideration. The standard setting of maintenance key performance indicators, the contract models, and overall performance measurement call for renewed thinking and out-of-the-box approaches. The procurement of long-term, multi-technology applying, asset value preserving and end-user satisfying services is a testing task for the infrastructure managers – particularly when past experience might be partly redundant in order to meet the new challenges.

This key note paper addresses the OECD research report’s strategies and raises the key points that can be found when taking the report’s recommendations in to practice and to the field. Modern technology, such as BIM, cloud-based solutions, utilisation of Big Data, and smart performance metering offer some tools to meet the future demands.

The extreme weather and climate change challenge... the OECD’s concerns

At the turn of the year, the Organisation for Economic Co-operation and Development’s (OECD) International Transport Forum (ITF) published a research report on the challenges posed by extreme weather phenomena and climate change to the transport system, the transport infrastructure in particular (ITF 2016). The report Adapting Transport to Climate Change and Extreme Weather: Implications for Infrastructure Owners and Network Managers lists nine recommendations for OECD Member Countries for mitigating and reducing the adverse effects. VTT Technical Research Centre of Finland Ltd was one of the main authors of several chapters of the report, and the EWENT project that VTT coordinated a few years ago served as an important source of information for the report.

The results of the EWENT project showed that the damage caused by extreme weather could account for up to 0.15% of the EU Member States’ GDP. Every year!

The first step to take is to react immediately: Act now!
The challenges must be acknowledged now, and it is time to start processing them in the long term at once. By means of reports and seminars alone the matters will not advance as concretely as they should.

The way we have designed and built our transport system (as well as many other infrastructure systems) is based on old information. Infrastructure refers to the basic structures with life cycles extending across generations that must pass from father to son, grandson, and even great-grandson.

The transport infrastructure – ports, railways, airports, roads, streets – must be designed preparing for strain caused by increasingly stronger weather phenomena. The most important starting point for such design is the location. For example, if there is hint of risk of flooding, seek for higher ground. If flooding waters stop traffic every year or a few years apart, something is wrong. One can be prepared to face the same headache in the coming years, and even in an increasing extent.

Investing in preventive maintenance is an absolute requirement as part of preparedness: the existing structures must be maintained in such a way that the stress of weather will not damage them before the end of their natural life cycle. Maintenance usually costs less than building new structures. Sometimes, however, it may be necessary to renew the threatened basic structures that require expensive maintenance. Searching and operationalising the optimal strategy is a complex process, where research will help.

The infrastructure budgets are scarce almost everywhere in the world, and Finland is no exception. Keeping infrastructure safe and functional is swallowing an increasing share of our resources. If we do not make the necessary investments and take care of the maintenance, the future generations will need to pick up the tab.

Second recommendation: Prepare for more frequent problems caused by weather, and even failure of transport infrastructure in certain places

If all traffic into and out of a city mainly takes place through one passage or bridge, that bottleneck may turn out to be a strategic problem. All eggs should not be put in one basket, but there should be alternative routes or modes of transport available even if serious phenomena hit the area.

This strategy does not apply to extreme weather phenomena only, but also to other threats, such as terrorism or vandalism. Also it is wise to have modal options – when rails fail, the roads must offer the alternative, and vice versa.

Third recommendation: Make business continuity plans

When the transport system fails, one must know what to do next, who needs to be informed, and which chains of action to launch. When there are floods in Ostrobothnia, army engineers are needed to blow up the ice dykes. As a rule, Finnish authorities have good business continuity plans, and the local fire brigades and rescue services are on the ball together with other actors.
But are the resources scaled in such a way that preparations have also been made for more frequently occurring and intensive problems?

Technology plays a major role in all the three strategic activities described above:

- The technologies and architectures for disseminating and sharing information serve the needs of coordinated co-operation, which is needed when dealing with extreme weather phenomena. In some contexts, novel ideas such as block chains could turn out to offer new possibilities for information exchange.
- Sensorization and real-time monitoring of the basic structures and environment enable early reaction and minimisation of damage. New asset management philosophies and tools are needed to make use of modern technology, old ways of thinking might not work.
- Risk management methods, system analyses and scenario techniques are tools that provide means for managing resilience, or resistance and operational reliability. Decision-makers and analysts need to start using these tools for real, and not only for academic exercises.

Fourth: Account for the temporary unavailability of transport systems in service continuity plans

Extreme weather events can disrupt connections, interrupt traffic and adversely affect operations in various ways – even if weather phenomena are not at their most extreme. In such cases, an organisation’s preparedness to respond is the key to managing the situation and keeping damage to a minimum.

Various tools are available to public authorities and companies, including in the form of standards such as the ISO 22301 Societal security – Business continuity management systems standard. This standard is primarily designed for business performance management of companies, but it in fact works well also for public organisations, once the word ‘business’ is put in parentheses. The standard will help organisations to protect themselves from disruptive events by means such as reducing their likelihood, preparing for them, or enabling rapid recovery. The standard focuses on information exchange, the allocation of duties and cooperation between parties, by defining criteria for effective contingency management, planning and operations. Major operational improvements can be made and capacity for managing exceptional situations built by going through the checklists in the standard. The standard, which is general in nature, helps to prepare for various disruptions other than just extreme weather events.

Information exchange, planning and operational systems play a key role in organisational contingency planning. All of these, in turn, are partly relying on technological tools. A wide range of such tools is available. The challenge lies in how to incorporate technology in organisational and institutional processes, to prevent them from being paper tigers that lack concrete, practical tools. A strong services continuity plan will support an organisation in managing disruptive scenarios by providing solutions and models for re-routing transportation or asset management recovery plans, for example.
No. 5: Assess the vulnerability of transport infrastructure assets

Vulnerability is challenging to define whether one tries to do it in theoretical or practical terms. However, the basic idea is to identify the probability that threatening events will occur, their domino and distributional effects, and ‘weak links’, i.e. the structures and locations that are most exposed, vulnerable and most susceptible to extreme weather-related stress. Merely summing up these factors provides a preliminary idea of vulnerability.

The EWENT project, which focused on extreme weather impacts, defined vulnerability as follows (Molarius et al. 2014):

\[
\text{Vulnerability} = \frac{\text{Exposure} \times \text{Susceptibility}}{\text{Coping capacity}}
\]

The above equation is useful because it defines the components of vulnerability, which in the best case facilitates the concept’s operationalisation into measurable set of variables.

For instance, in the aforementioned EWENT project a risk index for main routes in Finland was calculated using the above formula as a function of vulnerability and risk (Figure 2).
The transport system can be further divided into subsystems (modes of transport, their infrastructures, rolling stock, organisations, services), making the complex system block more manageable. It is simpler and more understandable to assess the vulnerability and risks of these elements than to process the system as a whole. In a way, vulnerability can be considered as the inverse value of resilience, the ability to resist and recover.

Unless we invest in maintaining our transport system, our ageing infrastructure will accumulate an increasing investment deficit and become more vulnerable, whilst extreme weather phenomena become more common. In addition to infrastructure’s condition itself, factors influencing the system’s vulnerability include traffic volumes (the more traffic, the more negative aggregate effects), and general economic capacity (the more economic resources, the better you are able to cope with adverse impacts).

**Recommendation 6: Focus on transport system resilience, not just infrastructure**

The construction and maintenance of a robust and invulnerable infrastructure pays dividends. Other elements of a resilient system include flexibility, responsiveness, adaptation and fast recovery. Less attention has perhaps been paid to these elements than they deserve. In thick snow, do snowploughs start moving fast enough and is there enough fleet and equipment? When services of this type are outsourced, this may be a purely contractual issue, which means that e.g. public procurements can play a role in resilience. Or, has sufficient attention been paid to proactive maintenance in infrastructure maintenance contracts, or has the lowest bidder been selected? As climate warming proceeds and extreme weather becomes more frequent, have we renewed our maintenance fleet and service contracts accordingly, or have we simply begun to wait for snowless winters and iceless routes?

Cities play a key role because most mobility needs arise in cities. Both the population (in 2015, almost 86% of the Finnish population lived in cities) and high-value production and services are concentrated in cities. Urban transport system resilience has most impact on the everyday lives of citizens.

When the tram fails, take a bus, or vice versa. The construction, maintenance and servicing of bicycle routes not only serves to keep people fit or supports a nice way of moving around, it plays a more important role in ensuring the functionality of the entire transport system. Access to cities for residents of sparsely populated areas can be supported by constructing connective infrastructure (i.e. parking areas, connecting stations) at public transport nodes on the outer reaches of core areas. As a rule of thumb,
diversity is a strength in systemic resilience, which is why it should always be on the checklist of urban planners. On the other hand, there are drawbacks to diversity, because to be market attractive, public transport should be able to serve its customers at the time of need. A public transport network, that is sufficiently dense and high-capacity increases, in turn, the risk of buses or trams running empty, thus contributing to higher emissions. Enhancing flexibility may require a re-evaluation of the public transport system, shifting the emphasis from economies of scale (which works sometimes, but not always) to a more agile and flexible system.

No. 7: Re-evaluate: are there infrastructures that are redundant or less useful?

When one part of a network fails, an old part of the network that has perhaps previously been considered redundant or less useful may suddenly turn out to be quite usable. Let us use an old bridge as an example. If a new bridge is built next to the old one, and its service ability drops for one reason or another, due to such a reason as extreme weather phenomenon or an accident, the old bridge may increase in importance beyond all recognition.

Under certain circumstances, an old and useless part of a transport network may be a useful emergency passage or an alternative route e.g. for light traffic.

8: Traditional cost-benefit analysis is not sufficient for appraising the profitability of transport projects

A traditional cost-benefit analysis does not observe the increased extreme weather risks and climate risks to a sufficient degree. Forecasting the future constitutes a specific risk factor (because the future is always uncertain!). In transport projects, the appraisal is made for a time horizon of 30–50 years ahead, and such a horizon already includes major climate change risks. However, we need to be able to assess and monetise such risks to ensure that we make as wise project and investment decisions as possible for now and with a view to the future in particular.

Therefore, project evaluations and cost-benefit analyses must be developed to take better account of the changed “risk landscape”. The same advice applies to almost all other long-term investment activities as well. Already in the course of the EWENT project, the European Investment Bank started to develop its own project evaluation system, and today climate risks are observed in EIB project evaluations.

Recommendation no. 9: Develop decision-support tools and methods for the new age of uncertainty

Advanced and often a little hard-to-understand decision-support methods, such as real-options and multi-criteria analyses are excellent decision tools in spite of the complicated mathematics involved, as long as they are applied correctly and the users understand the nature, the framework conditions and the limitations of the tool. Real-options analysis is particularly well suited for the appraisal of new investments – this involves making significant decisions that are difficult to reverse and that you need to live with for a long time. Transport infrastructure projects are typical examples of such decisions. Real-options analysis can be used, for example, for monetising “flexibility” (keeping different options open) and postponement of a decision (when the future is uncertain, it may be wise to wait…). In other words, sometimes it may be sensible to update old infrastructure and postpone large investments, when there are major uncertainty factors involved.

Multi-criteria analysis methods can be applied, for example, for selecting investments, projects and strategies in such a manner that enables finding options that function sufficiently well in most of the selected scenarios – even if the selected option was not the best in any of them. In game theory, this is referred to as minimising the possible losses instead of trying to maximise the gains.
The transport system under extreme weather risks

In the broad sense, the transport system consists of the infrastructure, as well as the vehicles using the infrastructure, the transport information infrastructure, transport system operators (administration, companies, transport operators, passengers), and the operating and steering systems associated with all of the above. This is in fact a genuine “meta system”, a system of systems.

The physical modes of transport – road, rail, water and airborne transport systems – differ significantly from each other in terms of technology, utilisation rate and properties affecting their resilience. Furthermore, each physical infrastructure is supported by subsystems supplementing it, such as drainage systems, lighting, signs and intelligent transport applications (e.g. changing signals, information systems), not to mention the vehicles, terminals, railway yards and stations. Therefore, the transport system consists of complex subsystems, the management of which requires not only a holistic approach, but also an immense amount of concrete hands-on work varying from managerial strategy drafting to snow-plowing.

<table>
<thead>
<tr>
<th>Route structures</th>
<th>Physical structures (e.g.)</th>
<th>Supplementing subsystems (e.g.)</th>
<th>Hubs (e.g.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads</td>
<td>Bridges, tunnels</td>
<td>Lighting, signs, drainage, intelligent transport applications, transport control centres</td>
<td>Ground transport terminals, logistics centres, bus stations, border crossing stations, harbours</td>
</tr>
<tr>
<td>Railways</td>
<td>Bridges, tunnels</td>
<td>Information systems, electric system, safety systems, transport control centres</td>
<td>Terminals, stations, harbours, railway yards</td>
</tr>
<tr>
<td>Light traffic</td>
<td>Bridges, tunnels</td>
<td>Lighting, signs, drainage</td>
<td>Stations, shopping centres</td>
</tr>
<tr>
<td>Waterways</td>
<td>Harbour structures, locks, canals</td>
<td>Buoye, signs, vessel traffic control centres</td>
<td>Harbours</td>
</tr>
<tr>
<td>Aviation</td>
<td>Connected ground transport routes and stations</td>
<td>Flight control, security checks</td>
<td>Airports</td>
</tr>
</tbody>
</table>

*Figure 3. Transport system and elements affecting its resilience (adopted from Leviäkangas & Aapaoja 2015)*

Resilience can be most efficiently and cost-effectively affected when transport systems are in their planning stages. As a rule, any solutions added at later stages, no matter how necessary, are in relative terms more expensive and less efficient. Therefore, the primary starting point for ensuring a functional operation system lies in the planning of transport systems and land use.
Figure 4. Opportunities to influence and expenses required for improved resilience (adopted from Leviäkangas & Michaelides, 2014).

The Finnish transport system is relatively complete, comprehensive and functional, and the share of major network investments of the overall expenses of the system is relatively low. The use and maintenance of the existing infrastructure constitute the biggest expense items over the life-cycle of the asset. Therefore, there is only a limited amount of methods available for improving resilience once the infrastructure asset is put in its place. Efforts can still be made by focusing on preventive and enhanced maintenance strategies.

Some threats to the resilience of the transport system are associated with the subsystems supporting the physical infrastructure, such as serious disturbances in the power supply, communications and information systems (cyber threats), transport logistics and security of supply; increasingly severe and exceptional extreme weather phenomena; and, to a certain degree, crime that threatens societal order (e.g. terrorism) as well. It is necessary to draw up risk management strategies, plans and guidelines also for these threats. It is equally important to increase the resource readiness by making sure that maintenance and removal fleets and manpower are at disposal once the adverse event hits.

Is maintenance an investment?

Road structures are considered to be relatively simple and straightforward. A simplified road structure system used is presented in Figure 5. There is a pavement (that in principle can be any type of pavement, here it is assumed to be asphalt), bearing course that assumes the load on the road and sub course that works as a bed for the bearing course. The drainage system comprises ditches, culverts, drainage pipes, etc. depending on the particular road structure in question. The illustration is simplified and by no means attempt to present all the details that may be part of a road structure. The life-cycles are also rough approximates that may vary significantly depending on the type of road as well as the deterioration and preservation factors present.
There is dynamics and interdependencies between the structural components of the road asset, and the condition and performance of each will have an impact on other components. For example, if drainage system fails to keep the road structures dry, the water may infiltrate from the sides to the structures and weaken their bearing capacity. This in turn leads to cracking of pavement, which allows more water to be infiltrated and evidently results in an accelerating deterioration spiral of the entire system. This is a very typical problem encountered especially in the Northern hemisphere’s cold climate (Saarenketo et al. 2012).

The deterioration models applied by the infrastructure managers are typically probabilistic (e.g. Markovian chains) or deterministic (e.g. deterioration curves). Also very heuristic practices are in place. What is in most cases missing is the system dynamics between the structural components. Yet we know, and as stated above, that for example maintaining pavements, cleaning drainage and removing snow stacks can have a more substantial impact on the life-cycle of the infrastructure than what appears at first sight. When repairs, renewals and upgrading are done for the asset, the asset’s service life can be extended and more future benefits generated. This equally applies to enhanced maintenance.

Let us play with some numbers… and assume the following variables:

- \( t \) = service life of the asset in years; without maintenance the asset will be totally consumed by year \( t \)
- \( n = 0, 1, 2, ..., t \); indicating the year between 0 and final year \( t \)
- \( i \) = selected interest rate; the rate refers to the annual rate of return generated by the asset
- \( I_0, I_t' \) = investment made in year 0 and improvements and additional investments in year \( t' \)
- \( B \) = total future net benefits, generated by the asset over its entire service life
- \( SV \) = service value of the asset (expressed as a percentage 0%...100%)
Investment generates total net benefits after the investment outlay (here $I_0 = 1$), when the annual return on a compounding basis is $i$.

$$B = (1 + i)^t - I_0 = (1 + i)^t - 1, \quad n = 0, 1, 2, \ldots, t$$

This is the ‘stock of wealth’ which is accumulated in the future, as defined by the OECD guidelines on the valuation of capital (capital assets include e.g. road assets; OECD 2009). The total benefits are accumulatively consumed each year $n$, until $n = t$ and the entire asset is consumed. Then the service value can be defined as the accumulated net benefits (i.e. benefits less the investment) minus the consumed benefits, hence giving the remaining service value for the asset as follows:

$$\text{Total net benefits} - \text{consumed or deteriorated benefits by year } n = \frac{(1 + i)^t - 1 - [(1 + i)^n - 1]}{(1 + i)^t - 1} \times 100\%$$

$$= \text{Service Value in year } n = SV_n, \quad n = 0, 1, 2, \ldots, t$$

The calculus is exemplified in Figure 6, when $t = 10$ years and $i = 10\%$.

Figure 6. Service Value for an asset with $i = 10\%$ and $t = 10$ a

Let us assume further that we enhance the maintenance over the life-cycle of the investment (asset). We add 1% of the investment cost each year to maintenance and by doing so extend the service life of the asset by 50%, i.e. from 10 years to 15 years. The return on the investment is still the same, 10% per annum. We get the following graph, as shown in Figure 7.
We can now compare the utility of the two approaches by looking at service value per investment and maintenance cost. In other words, we literally compare value for money. The comparison is visualised in Figure 8.

The real outcome of an analysis as demonstrated by Figure 8 depends on many factors. One important factor is the benefit generation capacity which builds the service value. The higher the return on investment (meaning also higher benefit-cost ratio), it is likely that it makes more sense to extend its service life with enhanced maintenance. The other, and even more relevant, factor is the concept of service value. Service value must be seen as a mixed indicator of technical and socio-economic parameters and there is no single rule how to operationalise it. If service value relies on benefits, it explicitly then also follows the logic of benefit-cost analysis applied to the asset.

However, a new paradigm is in place: we must consider the aspects of resilience too, and these are not necessarily the typical parameters we are used to deal with: travel time, traffic safety, emissions, for example. Another new paradigm is the reducing importance of time value of money. This means essentially that we must start to consider implications beyond our typical investment horizon. In plain words, long-term investments should be made thinking first the future generations and only then ourselves (Leviäkangas & Michaelides 2014). These two paradigm shifts will have a radical effect on decision-making and investment strategies if adopted seriously.

Figure 7. Service Value for an asset with $i = 10\%$ and $t = 10+5 \alpha$; enhanced maintenance enabling extended service life
Conclusion

The OECD has provided research-based guidelines for infrastructure management that incorporates the aspects of resilience. Most of the guideline recommendations do not require very sophisticated decision-making tools, but some obviously do. Yet the resilience building can be started already now and with the tools and capabilities at hands. Climate change and extreme weather phenomena do not wait. If infrastructure managers delay resilience building, the future costs may be considerable. In addition, there will be inevitable social and economic externalities in addition to the direct costs.

The system resilience will not only be about infrastructure and its durability against outside shocks and deterioration forces. Therefore also infrastructure managers need to adopt a systemic view in order to capture those responses, those investments, and those operations that pay off the most from the systemic perspective. There is no single winning strategy, but only a complex decision-making problem, the solution of which depends on set priorities, preferences and limiting factors. As many infrastructure operations and services are outsourced and offered by the market, the role of the procurement will be of paramount importance. The age of sole price competition is over.

Infrastructure maintenance plays a key role in resilience and sustainability build-up. Maintenance must be seen as an investment, which it factually is, even when considering it purely theoretically. Maintenance is able to extend the service life of the asset and hence also increase the service value of the asset. Hence maintenance is a socio-economic investment and its impact on asset values should be recognised on both corporate accounting (e.g. a road agency) and national accounting levels. It can be shown that neglecting maintenance investments in the accounting system may lead to over-estimation of repair debt.
References

EWENT project: http://ewent.vtt.fi/index.htm


Pekka Leviäkangas, Principal Scientist at VTT Technical Research Centre of Finland

Pekka Leviäkangas (born in 1962, PhD in technology) has worked in management and expert positions in civil service, business and research. He is currently Principal Scientist at VTT Technical Research Centre of Finland Ltd. For 2012-2016 he acted as Associate Professor at Curtin University in the School of Built Environment, Programme Director of the Australasian Centre for Building Information Modelling and Research Professor at University of Oulu in industrial engineering and management. His previous positions include Chief Research Scientist, Team Leader and Customer Manager at VTT, Vice-President of Jaakko Pöyry Group subsidiary (JP-Transplan), Corporate Analyst of Finnish Railways (VR-Group Ltd), R&D Manager of Finnish National Road Administration's South-eastern region, and private consultant. He was an adjunct professor of Tampere University of Technology in the department of Logistics and Business Information for 2008-2014.

His own research covers innovation management, value analysis, impact analysis, service sciences, project finance, investment, financial and socio-economic analysis, restructuring issues and new technology deployment. His primary research area has been transport sector, but his activities have extended to other fields such as bioeconomy, climate change, meteorology, education, construction and infrastructure management. He has published widely: more than 40 peer-reviewed articles or monographs and more than
60 conference papers, plus many other literal contributions to books, reports and media. He has about 20 years’ experience on international R&D projects and almost 30 years of working experience in public and private sectors.

He has been awarded by National Academy of Sciences (Transportation Research Board), VTT, Finnish Road Administration, ITS Japan/ERTICO/ITS America, University of Indonesia and scholar funds. He has represented Finland in the OECD’s International Transport Forum working groups and in European science & technology researcher networks (COST). He has also been a member of Transportation Research Board committees and sub-committees, Special Interests Groups of the World Congress on Transport Research Society, as well as expert groups of UNECE (United Nations Economic Commission for Europe). He has also contributed to the work of International Union of Railways (UIC) and World Meteorological Organisation (WMO).

Dr. Leviäkangas has advised companies, agencies and ministries.
Changing Road Conditions and predicting the in the Future
Meteorologist Kerttu Kotakorpi

Climate is changing and getting warmer. In the high latitudes and in Finland climate warming is above global average. In Finland the change is more notable in the winter than in the summer. Climate change has a significant impact on the future winter road conditions.

Climate models predict that climate change has at least these impacts in Finland:
- Temperatures rise
- Less freezing temperatures
- More temperatures close to zero
- More precipitation
- More snow in the northern parts of Finland
- Shorter period of snow coverage
- Less frost in the ground

By the end of the century the winter temperatures can rise by 4 to 11 degrees in Finland. At the same time precipitation will grow for 20 to 40 percent. Weather prediction models will get more specific as the computation capacity will grow. In the future it is possible to make even more precise operations for roads.

Kerttu Kotakorpi, Meteorologist, YLE

Kerttu Kotakorpi (M.Sc) is working as a meteorologist for YLE, the Finnish Broadcasting Company, which is Finland's national public service media company owned by the Finnish people. Previously between 2008 and 2012 Kotakorpi served as a meteorologist for Nelonen, which is commercial television Channel. Kotakorpi has studied meteorology in the University of Helsinki.
HEAVY DUTY VEHICLES & PROFESSIONAL DRIVERS

Thursday 8th February 9.00–10.40 am

Chair by Janne Kojo, ELY Centre and Mikko Markkula, Koiviston Auto Ltd.

Janne Kojo, M.Sc., Head of Unit, ELY Centre

Janne Kojo, M.Sc. in Logistics holds the position of Head of Operations Management Unit in the area of Transport and Infrastructure in the Centre for Economic Development, Transport and the Environment (ELY-Centre). His main responsibility is management of road network operations, maintenance and development.

Janne Kojo is experienced logistics and transportation professional with work-opinion from both private and governmental sector. He has over 15 years of experience in different kind of positions including for example managing bus traffic operations in Finland, planning of transport systems and cargo-transportation and trucking business in Finland and Russia.

Mikko Markkula, LL.M., Managing Director, Koiviston Auto Ltd.

Mikko Markkula, managing director of the subsidiary Koiviston Auto Ltd. and master of laws, has 15 years of experience in managing bus traffic operations in Finland. Koiviston Auto Ltd. is a subsidiary of Koiviston Auto corporation, the largest Finnish bus operator with appr. 1000 buses and a turnover of 175 Meur. In Lahti city traffic and its 60 buses Koiviston Auto Ltd, as part of a co-operation with AC Panther / AC Electric Vehicles Ltd., has developed a vehicle computer reporting that provides both traffic safety and cost savings and also helps bus drivers to follow and develop safe driving practises. Especially in winter conditions it is essential that the safest way of bus driving can be delivered for the safety of passengers, drivers and all the other road users.
The Future Elements of Successful Winter Maintenance

Iiro Lehtonen, Managing Director, LL.M, MBA, (Transport and Logistics SKAL)

Mr. Iiro Lehtonen, LL.M, MBA, holds the position of Managing Director of Finnish Transport and Logistics SKAL since 2007. Prior to that, he served SKAL as Manager, International and Legal Affairs between 1997–2007.

His earlier career includes, among others, Managing Director position in the Association of Transport Centres in Finland.

Iiro Lehtonen holds various positions of trust within the logistics sector, among others, SKAL representative in IRU and President of National Emergency Supply Agency's Transport Logistics Sector.

Finnish Transport and Logistics SKAL represents companies who offer road haulage services and enterprises providing logistical services. SKAL has some 5 200 member companies.
Heavy-duty Vehicle Driver’s Perspective into Winter Maintenance

Mika Venäläinen Transport Coordinator, B.Sc., (Transport Company Ilmari Lehtonen Ltd.)

A study at heavy-duty vehicle driver’s perspective into winter maintenance is my thesis in Häme University of Applied Sciences in 2017.

The work has thoroughly studied winter maintenance and its level on the basis of transport task, vehicle type and regional distribution throughout the Finnish territory, as well as the study of the impact of the weather conditions on mobility problems, different factors and regions.

I examined various disadvantage / risk factors experiences by drivers during winter transport, conditions, technic and road maintenance investigated.

Additionally, I investigated whether the winter experience or the vehicle type has an effect on the disadvantage / risk factors or sensations of winter maintenance.

Drivers were also asked what type of winter maintenance they would like to be in a different roads, different times or different days of the week on the road.

The following disadvantages / risk factors were in the large part:

Regions where road is near lakes or sea, freezing rain on the road surface very locally, that is very dangerous in the driver’s view.

There are no salt or sand in the hills and intersections

Trucks that come from abroad are a danger at these areas where they are moving like much: Uusimaa, Southeast Finland, Kainuu and Lapland.

The reason that truck tires are not suitable for winter in Finland. The reason that truck tires are not suitable for winter in Finland.

In summary, timely ploughing possibly same time when it rains snow, and must be same maintenance on the same road section, are important factors.

In addition quicker operations to the problems was hoped, especially if heavy vehicle driver’s gives it via different feedback channels.

Mika Venäläinen, B.Sc., Transport Coordinator at Kuljetusliike Ilmari Lehtonen Oy

Mika works as a Transport Coordinator at the Transport company Ilmari Lehtonen Oy.

He has over 20 years of experience in the transportation of heavy vehicles in Finland before his current job, which he started in May 2017.

Between 2014-2017 he has been studying same time while working.

His education is Traffic Planner from Häme university of Applied Sciences (HAMK). He gratuated in June 2017.
A bus company achieves significant economical and safety benefits if the company is able to find a way to reduce the number of traffic accidents occurring to buses, passengers and drivers.

Especially in Finnish winter conditions the risk of collisions becomes more obvious and traffic accidents take place more often. Therefore being able to avoid ending up in accidents in slippery conditions creates significant advantages for a bus operator.

Avoiding personal injuries is essential. After that, being also able to keep material damages low creates savings in, among other things:
- the costs that injuries to personnel or passengers or other trafficants cause
- the costs that vehicle repairing cause
- the insurance costs

To avoid accidents and their costs, a very effective measure is to affect a bus driver’s way of driving. But to be able to tell the driver how to change things and improve his performance, one has to also measure relevant things in his driving.

Koiviston Auto Ltd., in co-operation with a Finnish technology company AC Sähköautot Ltd., has created a driver’s report that is based on data produced by AC Panther vehicle computer.

AC Panther measures carefully chosen critical components in driver’s performance:
- vehicle’s speed compared with the speed limit on the street
- vehicle’s speed in crossings and curves
- the number of hard-braking situations
- the time of idling, i.e. running the engine out of gear

One needs to understand that just measuring these components is not enough. The driving data must be reported to the driver in a way that helps him to understand what needs to be changed.

It is necessary to give feedback and practical instructions to the driver; goals need to be set and managers need to help and supervise drivers in reaching the goals.

Only a combination of effective reporting and manager feedback gives permanent results. There lies great potential in changing the negative habits in bus drivers’ driving!

Mikko Markkula, LL.M., Managing Director, Koiviston Auto Ltd.

Mikko Markkula, managing director of the subsidiary Koiviston Auto Ltd. and master of laws, has 15 years of experience in managing bustraffic operations in Finland. Koiviston Auto Ltd. is a subsidiary of Koiviston Auto corporation, the largest Finnish bus operator with appr. 1000 buses and a turnover of 175 Meur. In Lahti city traffic and its 60 buses Koiviston Auto Ltd, as part of a co-operation with AC Panther / AC Electric Vehicles Ltd., has developed a vehicle computer reporting that provides both traffic safety and cost savings and also helps bus drivers to follow and develop safe driving practises. Especially in winter conditions it is essential that the safest way of bus driving can be delivered for the safety of passengers, drivers and all the other road users.
Maintenance Contracts – Safety with New and Traditional Methods
Petteri Tervamäki, R&D Manager, Arctic Machine Ltd.

Road maintenance contracts have always involved safety aspects concerning both the devices and the instructions for the actual work and operations. The driver’s decisions are guided by these. Over the years, the devices have developed and become easier to use while their efficiency has improved significantly. New, high-strength steel grades have been introduced in the structures of road maintenance equipment, and some steel parts have been replaced with plastics. The working width of ploughing units has increased, which has further highlighted the safety aspects. In the past few years, more attention has been paid to the visibility of devices and other safety issues, thereby achieving significant improvements in the safety of the equipment for other road users compared with older equipment.

So far, the development of safety has mainly resulted from various passive warning devices, warning lights, reflective tapes, etc., whose introduction has considerably improved the visibility of road maintenance vehicles in recent years. Technology will never stop developing; looking at history alone, we can notice that technological development has sped up rather than slowed down. At the moment, various sensor technologies, cameras and radar systems are quickly becoming part of the control systems of road maintenance vehicles. The vehicles are able and even allowed to make decisions of their own, including autonomous emergency braking, lane departure warning systems and other functions to assist the driver.

Many of the technical solutions needed for autonomous traffic and robot cars have already been made, and these are becoming part of our daily lives. Maybe not tomorrow, but in a couple of years, such vehicles are also projected to be running on the arctic roads of Finland. Will road maintenance vehicles and their devices remain conventional plough units without a similar development? We at Arctic Machine believe that this sector of technology will see developments in safety and efficiency resulting in a next-generation road maintenance vehicle.

Petteri Tervamäki, Product Development Manager, Arctic Machine Ltd.

Petteri Tervamäki, a Bachelor of Engineering Degree Program in Mechanical and Production Engineering, has over 20 years of experience in product development leadership, both in road maintenance processes and the development of road maintenance equipment in numerous projects. He is responsible for developing Arctic Machines products and design processes with modern CAD / FEM / PDM / ERP methods. Recent years product development projects has been at the forefront of the development of intelligent machines and control systems. Machinery is moving into the network with the rapidly growing digitalisation.
After Market - Siping of Truck Tires - Does it Give More Traction and Safety?

Bård Nonstad, Senior Principal Engineer, M.Sc., Norwegian Public Roads Administration

In this project, we have tested traction and braking length of heavy vehicles under different winter conditions. It all started with a field test of traffic flow quality of trucks in a slope under slippery conditions. The experiment was done with four different trucks with different axle configurations and different cargo load and with and without the use of bogie. As expected, the results from the test showed that the weight over the driving wheels is essential to whether the vehicle is able to reach the top of the slope or not. The test also demonstrated the great advantage to have a vehicle with bogie. The experiments also showed that the properties of the tyres are very important, and tyres with a soft rubber compound achieved better results than tyres with a hard rubber compound. This lead to several tests to look at the correlation between both vehicle traction and braking length of a heavy vehicle and the hardness of the rubber compound. The experiments showed that a tire with harder rubber compound reduces tractive effort and consequently reduced accessibility.

Measurements showed that the traction effort increased considerably (up to 56 %) by increasing the axle load. The vehicle traction is greatest with good tires (good tread depth and softer rubber compound) and axle load within the tire's maximum load bearing capacity. Tires with little tread depth and hard rubber seems to have significantly lower ability to mobilize traction effort by increasing the axle load. It has also been a discussion about eventual benefits and disadvantages of after-market siping of tires in Norway. We haven’t found any documentation or tests done in the Nordic countries about this. After-market siping of truck tires involves a process of cutting slices across the tire tread. The idea is that the slice will open up on the surface of the road, giving better contact with the ice and snow, and dispersing water to improve traction.

Siping of truck tires has been done in Norway for a long time, and most of the tire dealers has siping machines for truck tires. In January 2017 we did a test over two days at Bjorli airport with 40 different tires, both siped and unsiped of the same brand and type. We tested both the traction and the braking length. The measuring of the traction force was done with a load cell and a strap between the test vehicle and a heavy loader. The loader performed an even braking from 10 to 0 km/h. The maximal traction force during this sequence was documented for each tire. The braking length is of course very important for the traffic safety so the test also included that. The truck started with an initial speed of 60 km/h and did a full braking until total stop. The braking length was then measured. During a test in winter time the road conditions can change because of changes in temperature, precipitation or solar irradiance. A reference vehicle for measuring the friction were used to have control of changes in the road conditions. The results from this test show that after-market siping has an effect under the snowy and icy condition these tests were executed. The siped tires had both a higher traction force and a shorter braking length than the unsiped tires of the same brand and type.

Bård Nonstad, M.Sc., Senior Principal Engineer, Norwegian Public Roads Administration

He is a Senior Principal Engineer working at Norwegian Public Roads Administration in Trondheim. He has a Master of Science from the Norwegian University of Science and Technology. He graduated in 2002 and since then he has been working for Norwegian Public Roads Administration. Bård Nonstad is currently working at a team called Operation and Maintenance. His working tasks are mostly attached to research projects on maintenance, particularly with winter maintenance and friction measurements.
CYCLING NETWORK

Thursday 13.00-15.00

Chair by Katja Rekilä, NPRA and Liisa-Maija Thompson, Finnish Road Association

Katja Rekilä, M.Sc., Engineer, Norwegian Public Roads Administration NPRA

Katja Rekilä is an engineer at the NPRA working with research and development of winter maintenance operations with focus on maintenance of cycle ways and sidewalks for 4th year. She has a Master of Science (Tech.) in Highway Engineering from Aalto University. She had a three months employee exchange in spring-summer 2017 at the Danish Road Directorate, where she was working with analyzing measures that promote cycling.

Liisa-Maija Thompson, M.Sc. (Admin.), Finnish Road Association

Mrs. Thompson is a specialist at Finnish Road Association. She is working with associations event planning and monitoring the changes in the transport sector. Liisa-Maija has a background working with issues related to traffic systems operations, spatial planning and land use at Road Administrations regional office and Centre for Economic Development, Transportation and Environment in Uusimaa. She is driven by challenges, co-operation and doing things together for creating a better reality.
Main Bicycle Lanes: Joint Winter Maintenance Contract with Three Road Keepers
Kai Mäenpää, Maintenance Manager, (City of Oulu)

The contract on winter management of the main cycling network in cooperation with the City of Oulu, North Ostrobothnia Centre for Economic Development, Transport and the Environment and Kempele Municipality

The proprietors of three separate cycling networks decided to invite tenders for winter management of the busiest main cycling paths in one contract. The contract covers 130 km main network in Oulu Region.

The objective is to receive good, uniform quality of service around the clock. Then cycling would be a good option also for shift workers. Contract performance shall be monitored by cycling and the contractor, too, shall be obliged to inspect conditions by bike.

At the bidding stage, the contractors shall award points to their offers by selecting the quality undertakings into their contract. When the quality undertakings are fulfilled, the contractor can get a financial contract bonus. Bonus may be awarded also on the basis of customer satisfaction. On the other hand, serious sanctions may follow if the quality score is not achieved or the performance is of low quality.

Kai Mäenpää, Maintenance Manager, City of Oulu

Kai Mäenpää lives in Oulu and he has worked with winter maintenance since 2000. His work also includes permission for the street areas (house construction, cranes, events etc.), street lights maintenance, transfers of abandoned cars and head of airport (for small airplanes). He is a passionate winter cycler in all weathers.
Bicycle Path Surface Wetness - a Very Different Matter than Street and Road Surface Wetness

Göran Blomqvist, Researcher, Ph.D., Swedish National Road and Transport Research Institute
Co-authors are Anna Niska and Ida Järlskog, Swedish National Road and Transport Research Institute

Evaluating the efficiency of new winter maintenance techniques on bicycle paths require knowledge of both the effects, the processes involved and the resources needed to perform the winter maintenance actions. A lot of research has been done during the last several decades regarding evaluating winter maintenance of roads, streets and airport runways, including monitoring of road surface condition, residual salt amount, road surface friction and the effects on traffic flow and safety. The processes on bicycle paths, however, differ substantially from the ones valid on roads and airports, due to different type and speed of traffic, different tire and road surface characteristics and often different surroundings. Hence, the cause and effect relationships involved on bicycle paths are different, especially regarding the factors governing the processes of salt loss and spatial and temporal variation of road surface wetness, why knowledge from roads and airports cannot be used for calculating the duration of the effects on bicycle paths without adaptation to the bicycle path system scale.

The bicycle path construction often differs substantially from street and road construction, which influences the temperature response due to different heat fluxes in the construction, but also the run-off characteristic due to lack of cross-fall, uneven surfaces resulting from frost-heave phenomena and impacts/surface damage from heavy winter maintenance vehicles.

This presentation will present and discuss findings from field trials and bicycle path monitoring in Stockholm and Linköping 2013–2017, especially focused on understanding the surface wetness processes on bicycle paths as compared to streets and roads. The presented results will have implications on how to plan and perform winter maintenance on bicycle paths.

Göran Blomqvist, Ph.D., Researcher, Swedish National Road and Transport Research Institute

Göran Blomqvist is a researcher at VTI, with 21 years of experience of winter maintenance research. He has a Master of Science in Civil Engineering and a PhD in Land and water resources, with a doctoral thesis on the subject “De-icing salt and the roadside environment”. His main field of research is dealing with the interrelationships between road surface characteristics and conditions and their effects on traffic and environment, with special focus on evaluating operational and maintenance activities.
In all the Nordic countries cycling, as a mode of transport is promoted, since there are environmental and health benefits to gain. Considering the safety and accessibility of cyclists, a high winter maintenance service level is needed and using salt for skid control of bicycle paths could be one solution, although it has its drawbacks and difficulties. Most of the research done regarding the use of salt for de-icing has been focusing on roadways and consequently methods, equipment and strategies are primarily developed for roadways, and are not enough taking in to consideration the specific conditions on bicycle paths. However, in recent years a method using a front-mounted power broom for snow clearance and salt for de-icing – commonly called “sweep-salting” – has been more and more popular for winter maintenance of bicycle paths in municipalities in Denmark, Sweden, Norway and Finland. One challenge is to find the optimal equipment, methods and maintenance strategies with “sweep-salting”, when striving to achieve a maintenance service level as high as possible under different conditions and circumstances. To gain more knowledge in the field, there are several on-going studies in the Nordic countries at the moment. In this joint-presentation that we suggest, we will present findings and experiences regarding salt use for winter maintenance of bicycle paths from Denmark, Sweden and Norway, based on the following studies:

In order to ensure uniform handling of winter service on the cycle paths, the Danish Road Directorate has established cooperation with the municipalities, so calls out for state roads paths will take place simultaneously with calls out for municipality’s paths. There have also been made a common describing service levels for different kind of path.

In order to give recommendations, it is necessary to have more knowledge about residual salt on cycle paths. The Danish Road Directorate will conduct studies in 2018, whose results will account for residual salt relative to weather conditions.

The follow-up studies in Stockholm 2013–17 has emphasized the importance of having maintenance vehicles and equipment that are scaled for the bicycle path scale. Contractors would be greatly helped by correct weather forecasts combined with relevant salting guidelines and bringing simple tools in the maintenance vehicle: a road surface temperature sensor and a refractometer that can verify that the salt concentration in the tank.

In Trondheim, Norway, an increase in winter maintenance standard of bike paths was introduced in autumn 2015. A two years follow-up study documented the effect of the new standard. The effects were not only beneficial, specially on those parts of the cycle path network where the quality of the road construction was poor. After only couple of months, the asphalt started cracking and some local frost heaving was observed which lead to unevenness of the bike path surface. The follow-up study concluded that it is important to have good quality road construction when introducing salting as a winter maintenance method. In general, there should be a correlation between the structural condition of the bike path and the choice of winter maintenance level.
Anna Niska, Ph.D., Research leader, Swedish National Road and Transport Research Institute

Anna Niska is a research leader at VTI, with 20 years of experience of bicycle related research. She has a Master of Science in Environmental Engineering and a PhD in Highway Engineering, with a doctoral thesis on the subject “Winter maintenance and cycleways”. Her main field of research is within effects on cycling of road maintenance and operation including accident analysis, evaluations of winter maintenance methods, etc.

Tine Damkjær, B. Sc. (Eng.), Engineer, Danish Road Directorate

Tine Damkjær is Mechanical Engineer (Bachelor of Science in Engineering, BSc Eng) and is employed at Danish Road Directorate. She has many years of experience as a project leader for several development projects. Tine works with quality management in winter service and current focus is on quality of winter service performed on cycle paths.

Katja Rekilä, M.Sc., Engineer, Norwegian Public Roads Administration NPRA

Katja Rekilä is an engineer at the NPRA working with research and development of winter maintenance operations with focus on maintenance of cycle ways and sidewalks for 4th year. She has a Master of Science (Tech.) in Highway Engineering from Aalto University. She had a three months employee exchange in spring-summer 2017 at the Danish Road Directorate, where she was working with analyzing measures that promote cycling.
Developing Winter Maintenance of the Bicycle Paths
Tuomas Lautaniemi Maintenance Engineer, City of Helsinki

The city of Helsinki’s strategy program promotes walking, cycling and public transportations as means of transport. In Helsinki, winters present a significant challenge to cycling, which is why one of the most effective methods of increasing the share of cycling is to improve winter maintenance for bicycle paths. It’s justifiable to further winter cycling so that the infrastructure that’s being built for cycling could be used all year round.

The city conducted a route-based pilot in the winter 2015-2016 on a one popular cycling route, in which sweeping and different de-icing solutions were tested with quality standards far above the city’s normal winter maintenance standards. The pilot was conducted in close co-operation with the Helsinki Cyclists association, which provided feedback and assessed quality.

To answer the needs of the city’s strategy program and user feedback, the city decided to develop a winter maintenance method suitable for the street network and climate of Helsinki. The goal was to create winter maintenance quality standards sufficient for increasing the number of winter cyclists and to find out how much the improved winter maintenance would cost. Based on the results and feedback from the maintenance pilot in the winter 2015-2016, the city has extended the experiment and tested new ways of maintain the main routes of cycling.

During the winter season 2017-2018 three main cycling routes snow is removed by sweeping and the slip resistance is done by using salt. Sweeping is an effective way to keep the bike paths in high condition during winter time. Improvement in usability is also achieved in the spring, after winter when the fairways do not have crushed stones. According to cyclists’ feedback, crushed stones may break the tires and makes the path surface uneven and arguably less pleasant to ride on. On the other hand some cyclists oppose the use of salt. The fundamental advantage of route-based maintenance is continuity. This means that the whole route is maintained by a single contractor, possibly by just one vehicle. The desired effect from this is that the quality of winter maintenance remains the same throughout the whole route, even if the route was situated on areas maintained by two or more different contractors.

Sweeping and salting is commonly used method to maintain cycling routes in many cities in Central and Northern Europe in winter time.

Tuomas Lautaniemi, Maintenance engineer, City of Helsinki

Tuomas Lautaniemi works as a maintenance engineer in City of Helsinki. His job is subscribe to maintenance of street areas in Eastern Helsinki. His job is also to develop winter maintenance of the bike paths. Lautaniemi cycles all year round though less in winter.
Hot Topic Keynote: Winter Road Maintenance and Reacting to Customer Needs

Jukka Karjalainen, Transport Agency, Division Director of Infrastructure Management

Division Director of Infrastructure Management Jukka Karjalainen from the Finnish Transportation Agency has long history in infrastructure management.

Road officials has received a lot of feedback about road conditions from individual road users and companies operating in the transport sector. It is important to guarantee safe, effective and reliable freight transportation in all conditions. The weather conditions this winter have been exceptionally difficult in terms of road management and transport. The subject has received widespread media attention.