PEHKO Project 2015-2025, increasing the productivity of paved road management in Finland

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Digital Object Identifier (DOI): dx.doi.org/10.14311/EE.2016.144

ABSTRACT

The decline in national budgets for paved roads in Finland has been causing increasing deterioration rates on the Finnish paved road network that will soon lead to major problems on the network. To counter this concern the Finnish Transport Agency has started to put emphasis on new methods and policies that could address the problem. Two 10 year R&D pilot projects will commence in 2015 in the areas of Lapland and Central Finland. Their ambitious goal will be to cut down the annual paving costs in the areas by 40-50% from the current levels.

The basic idea and goal for the PEHKO project will be to improve the practices and policies in paved road maintenance and management. Its aim will be to enhance the productivity of funding investments and improve the condition of the paved road network, or at least keep at the current level with less resources. This goal will be achieved by focusing on three targets: 1) Improving the daily drainage maintenance standards for paved roads. This will lead to increased pavement life times and lower annual paving costs. 2) Applying new NDT (non destructive testing) road survey technologies in the diagnostics of paved roads allowing to engineers to their focus rehabilitation measures exactly on the problem sections and address the roots of the problems rather than just treating the symptoms. 3) Changing maintenance policies from reactive to proactive maintenance. This will mean that maintenance crews will fix the potential problem sections before serious pavement damages appear.

This presentation will present in detail the goals, polices and techniques that will be used in the project.

Keywords: Bearing capacity, Design of pavement, Drainage, Economics, Maintenance

1. INTRODUCTION

The management of the paved roads in Finland will face great challenges in the coming years. First of all, during the last decade the heavy trucks in Finland have started to primarily use super single tyres which has caused the stress on the pavement surface to increase substantially (Figure 1). This trend has especially decreased the remaining lifetime of the roads with thin pavements (<150 mm). These types of pavement structure are dominant in Finland. According to calculations made by the Finnish Transport Agency "Weights and Dimensions" project, the lifetime of the typical roads in Finland will go down from 40 years to 10 years when 60 tonne trucks with super single tyres became a significant majority on Finnish Roads (Varin and Saarenketo 2014). The new 76 tonne trucks that mainly have dual tyres will alleviate this problem a little however their effect is only 3-5 extra years onto pavement lifetime.

In addition, a growing problem has been the fact that the funding level for annual pavement management is currently at a much lower level than is required for keeping the service level of the paved roads at an adequate level. That is new backlog for pavement repair has been calculated to be 100-300 million euro/year. Together with the increase of this backlog the condition of the paved road network has become worse and the relative amount of poor quality road sections has clearly increased. At the same time the road user satisfaction of the road condition has been decreasing.

The problem, described above, is not only a Finnish problem and there are several ways that officials can react to these issues. These can be classified into three classes which are described shortly below:

1. **Accept the picture, but do not want to change pavement management policies and practices. Solution examples:**

a. Changing poor quality paved roads into gravel roads and, if the traffic volume is low, change them to private roads.
b. Lowering the service level standards of the paved roads, for instance maximum allowed rut depths or winter maintenance standards and/or apply speed limits on poor quality road sections.

2. **Improve the maintenance practices of paved roads in a way, which increases productivity and thus road condition can be managed / improved from the current level with less resources. Solution examples:**

c. Improving the daily maintenance practices and standards, especially drainage maintenance, which increases pavement lifetime and cuts down on annual paving costs.
d. New technology will be implemented in pavement diagnostics and design allowing precise rehabilitation and strengthening. This enables higher efficiency and cost to benefit ratio in pavement projects, i.e. more with less and leads to substantially lower annual paving costs.
e. Proactive pavement maintenance policy will be implemented and maintenance measures will be made to problems that arise before they turn into damages that are difficult and expensive to repair.

3. **Affecting the vehicles that have a great influence in reducing the pavement condition in such a way that the deterioration rate will be reduced and therefore annual paving costs will be reduced. Solution examples:**

f. Influencing / governing the technical properties of the vehicles with negative effect on pavements (studded tyres, super single tyres, tyre pressures, etc.), which reduces the rutting speed and as a result pavement lifetime increases and in turn annual paving costs decrease.
g. Weight restrictions for heavy vehicles will be implemented especially during the spring thaw period when the roads are weakest and 80-90 % of the road damages occur.

In the PEHKO 2015-2025 project, class 2 models will be tested in the areas of Lapland and Central-Finland Centres for Economic Development and the Environment. The road networks cover all the paved roads in the Karstula and Kemi-Tornio maintenance areas and the main roads in Rovaniemi maintenance area. The project will develop and test new and innovative methods that can improve the productivity of the pavement management in a way that increases pavement lifetime. At the same time new data will be collected concerning paved road performance and that can be used when the design and maintenance standards of paved roads are renewed in order to meet the challenges caused by new heavy trucks. PEHKO project will also produce valuable information about the life cycle costs of paved roads and the about the factors that have the greatest impact on them. In other words, the goal is to detect the "weakest links" that affect the annual paving costs of the road network and to find new solutions to fix these problems – and increase the productivity of road maintenance practices.

Figure 1: Top down cracking is a typical new pavement damage in Finnish roads after super single tyres have been taken into general use.

2. PEHKO 2015-2025 PROJECT FOCUS

The basic idea of the PEHKO-project is to pilot a maintenance model that is based on the latest research results in the area of road diagnostics instruments and exact positioning systems. With these methods it is possible to focus maintenance measures exactly on the weakest road sections in each pilot area. In addition, repair work will rectify the source of the problems not only the symptoms. Regarding pavement lifetime costs, the rehabilitated structure will be considerably more economical than before (Saarenketo et al 2012).

The planning and realization of this pilot requires a new and open-minded way of thinking with regard to pavement surveys, diagnostics, programming, planning and contracting. The project challenges the most common assumptions related to maintenance and daily maintenance of paved roads. For example in Finland, studded tires have recently been blamed too much for rutting of paved roads. The latest tests and calculations have shown that the maximum wear and tear of pavement made of good quality aggregate in the asphalt mixture is only 1.5 mm/year. All other rutting is due to other reasons of which pavement fatigue caused by the repeated load pulses of heavy trucks is the main reason. This fatigue occurs noticeably faster on road sections with thin pavement.

Another new idea to be tested in the PEHKO project is the development of common goals for the daily maintenance and pavement maintenance contracts in a way that encourages contractors in their daily work to focus on actions that enable longer pavement lifetimes (Crist et al 2013). That is why new and incentive based models will be tested in daily maintenance contracts to encourage better road drainage management. Potential savings achieved by improved drainage might drop pavement maintenance costs by 10-30% (Saarenketo et al 2012). If this were to be combined with the above mentioned strengthening of pavement, i.e. making pavement thicker, the savings could even be much higher.

The third idea to be tested, based on the latest road survey techniques and innovations, is the proactive maintenance of pavement. This means that pavement will be enforced/ repaired before fatigue cracks weakening the pavement stiffness occur. If this can be realized at least in parts of the PEHKO project roads, the pavement maintenance costs caused by pavement fatigue will drop, at best, by more than 50% compared to current costs. In practice this means future savings of over 50 – 100 million Euro in annual pavement maintenance costs of the paved road network in Finland.

3. TEST AREAS AND SURVEY METHODS

3.1 Test Areas

Two pilot areas were chosen for the PEHKO project. The first and biggest area is Kemi-Tornio daily maintenance contract area belonging to the territory of Lapland’s Centre for Economic Development, Transport and the Environment (ELY) and the other area is Karstula daily maintenance area which is part of Central Finland's ELY territory (figure 2). In both areas new daily maintenance contract work will start at the end of 2016. In Lapland the main roads and connecting roads of Rovaniemi were also chosen as PEHKO objects. All together the project covers 1653 km of paved roads.

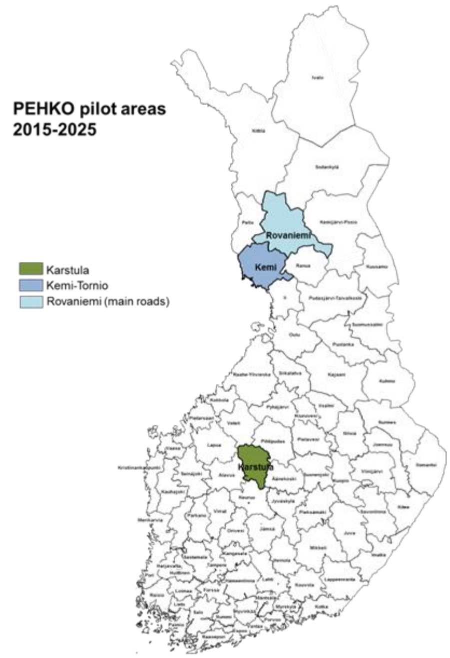

Figure 2: Pehko project pilot areas in Finland

3.2 Survey Methods

PEHKO project has begun with extensive new data collection as well as analysis of the old data in order to build as broad a knowledge base as possible concerning the actual condition of the pilot road network and to predict the future development of these roads. The management history of these road networks will also be examined and what kind of influence it has had on the present condition and the effect this will have on future repair alternatives. Using different road survey and diagnostics techniques the weakest road sections will be located, the reasons for their existing problems will be defined and their rehabilitation design will focus on making these roads as uniform as possible.

In the future, the condition of the pilot roads will be monitored annually using the Road Doctor Survey Van (RDSV) technique which utilizes, among other things, Ground Penetrating Radar (GPR), Laser Scanner, 3D accelerometer and digital video techniques (Figure 3). Every five years (2015, 2020 and 2025) extensive pavement deflection measurements will be done using a Traffic Speed Deflectometer (TSD) technique. During the so-called intermediate years, monitoring will be carried out to follow the condition with the help of the GPR measured dielectric constant, acceleration transducer, laser scanner and videoing. The collected data will be analysed automatically in order to detect even small changes in the pavements.

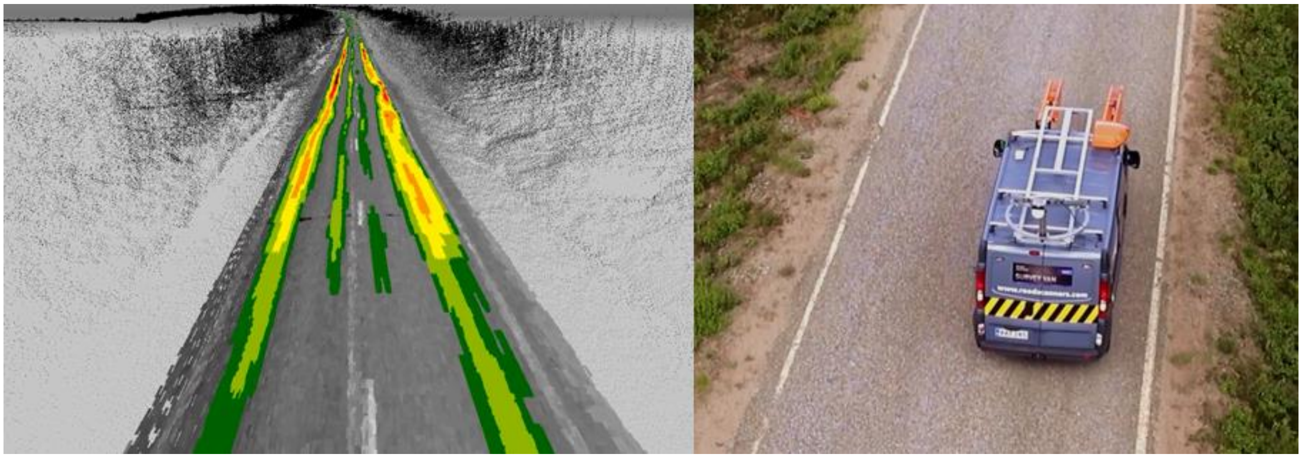

Figure 3: Point Cloud data showing exact location of deformations in the road surface. The data has been collected using Road Doctor Survey Van technique.

3.2 Data analysis and Diagnostics

The functional condition, i.e. service level of the roads is, among other things, influenced by the following factors: longitudinal roughness (bumps, etc.), transverse roughness (rutting, shoulder deformation) and cracks. Their development will be followed with the help of the laser scanners and 3D accelerometer and these surveys will be repeated annually.

The structural condition of roads is mainly influenced by the current pavement structure (especially pavement thickness and thickness of the total pavement structure). This condition will be assessed by comparing Ground Penetrating Radar (GPR) layer thickness data with rutting velocity (mm/year). In addition, the bearing capacity indexes based on Traffic Speed Deflectometer (TSD) / Falling Weight Deflectometer (FWD) measurements, such as BCI (Base Curvature Index), SCI (Surface Curvature Index) and strain, will be used to assess the structural condition of roads (figure 4).

Drainage also has an influence on the structural condition. The assessment of the drainage condition of the road network will be done by visual observation (video) and laser scanner measurements. By comparing the laser scanner data depth of the bottom of the ditch with the interpreted depth of the bottom of the pavement structure in the GPR data, it will be determined whether the depth of the bottom of the ditch is sufficient (> 20 cm lower than the bottom level of pavement structure). If this is not the case and rutting is fast, a new target depth for the ditch will be determined and excavated in relation to the road surface. After that, drainage condition will be followed with laser scanner to monitor whether the maintenance contractor has taken care to maintain flawless drainage in the ditch.

Another important factor related to the durability of pavements and the condition of drainage are private road accesses and the condition of their culverts. The EU ROADEX project (www.roadex.org) has shown that they have a major influence on the condition of the main road pavement. Within this project, problematic culverts which have caused damages to roads shall be located and a repair –and renovation plan will be made for them. Once these problem culverts have been fixed their condition will also be monitored using laser scanners.

A third new drainage related factor is that through the PEHKO project contracts it will also be ensured that snow walls are removed early enough in winter so that the melting water will not infiltrate the frozen pavement structure and cause permanent deformations in the upper part of the pavement structure during the frost thaw period. Surveys of damaged roads with laser scanner and GPR have recently delivered new evidence of the connection between the late removal of snow walls and pavement damages. New and strict guidelines for daily maintenance contracts starting in 2016 will be created for both pilot areas.

In addition to the above, exact guidelines will also be created for new daily maintenance contracts related to the removal of soil verges. The monitoring of soil verges will be also done using laser scanners.

In Northern Finland sheet ice blockages cause especially severe pavement damages to roads. The influence of this phenomenon and different techniques to remove it will be tested during the PEHKO-project phase.

For pavement lifetime calculations, road sections with typical Finnish pavement structure will be chosen from the pilot roads for a more detailed evaluation. After additional data and information from TSD measurements, layer thicknesses measurements and traffic volume counting has been obtained, the estimated lifetime will be checked using current prediction models. After that, based on TSD measurements from year 5 and 10, the reliability of these current models with respect to the Finnish road network and different structures and subgrade soils will be reviewed. Based on these results current lifetime models can be corrected in a way that they will come closer to reality. These results will also be used for new measurement instructions.

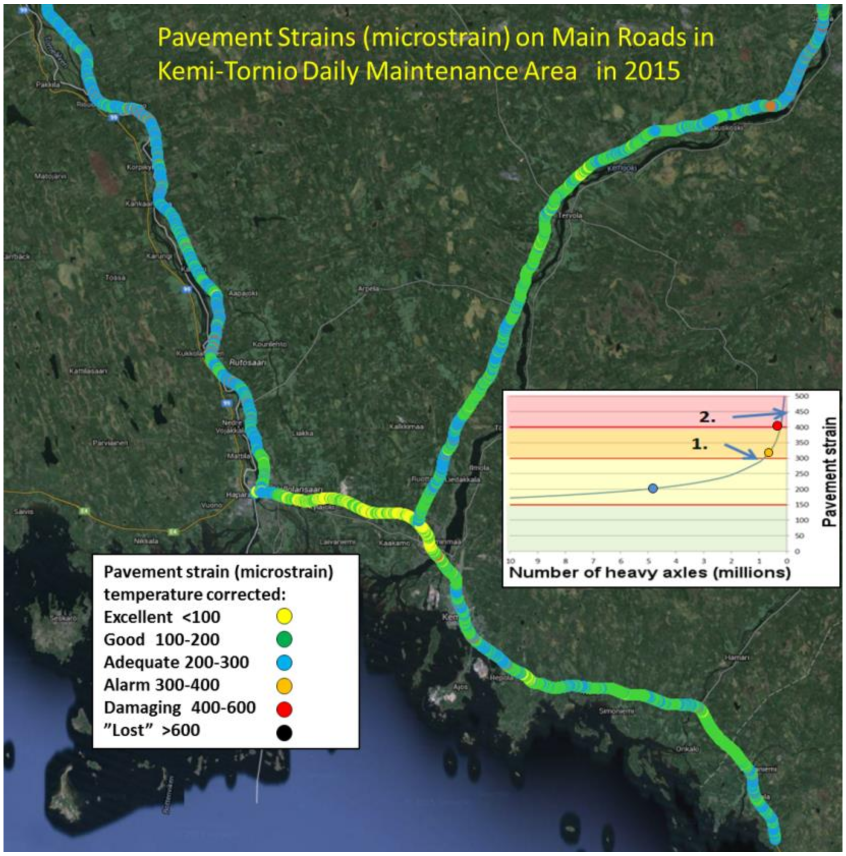

Figure 4: Example of pavement strain analysis from the Traffic Speed Deflectometer (TSD) data made using Road Doctor software. Figure also indicates remaining pavement lifetime (millions of axles).

4. CHANGES IN ASSET MANAGEMENT PRACTICES

4.1 General

The adaptation and implementation of new technologies alone do not increase the productivity of asset management practices and pavement lifetime but there is a clear need for changes to both the paving policy and daily maintenance practices in Finland. One of the problems with this issue is that paving contracts and maintenance contracts and their goals have diverged over the years. Because of that daily maintenance crews do not always pay enough attention to the measures that prevent early fatigue and distress in the pavements. In pavement design, on the other hand, the main focus has been to repave the road sections with high rutting instead of addressing the cause of the problems. That is why in PEHKO project contracts many new practices and policies will be tested and their effect on pavement performance will be evaluated. The key changes are listed in the following.

4.2 Pavement maintenance

The decisions on all repaving or rehabilitation measures will be based on diagnostics that utilize objective road survey data measured with the latest technologies. The deciding factor in the selection of the pavement measures will be the return on the investment in the long term and, as such, life cycle cost analysis is vital to the pavement programming. In conjunction with repair works, the source of a problem will always be investigated instead of treating only its symptoms. The general target is to obtain thicker pavement for the road network as this will bring more stiffness against stresses caused by heavy trucks, super single tires and high tyre pressure (figure 5). Measures will be designed for much shorter pavement sections as the main goal is to have bearing capacity become more homogenous than it has been earlier. To deal with problematic road sections that do not have repair funds in the beginning, speed limits and, during springtime, weight limits will be set.

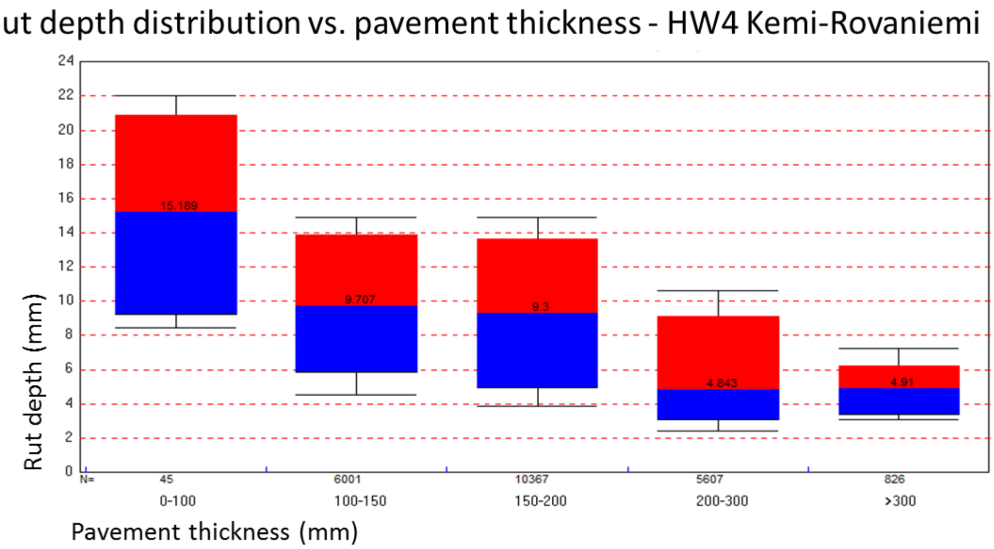

Figure 5. Rut depth distribution at different pavement thickness classes on highway 4 Kemi-Rovaniemi. Data shows that rut depth median with pavements thicker than 200 mm is only 4.8 mm while corresponding value with pavement thinner than 100 mm is 15.1 mm.

4.3 Daily Maintenance

In the PEHKO project, daily maintenance works road sections with problematic drainage will be checked regularly with the laser scanner to ensure that they remain in good condition. Special attention will be paid to access road junctions and improving their drainage especially during the spring time (figure 6). Maintenance contract procurement documents have strict and precise requirements for the removal of snow walls and possible ice on the pavement. These measure have to be done rather too early than too late. The maintenance contractor will be in charge of the small repair works on road sections where pavement is rutting fast and/or increase in the pavement strains are growing faster than predicted. A good example of such work is the clearing the ditches and culverts in sections where poor drainage is causing faster rutting.

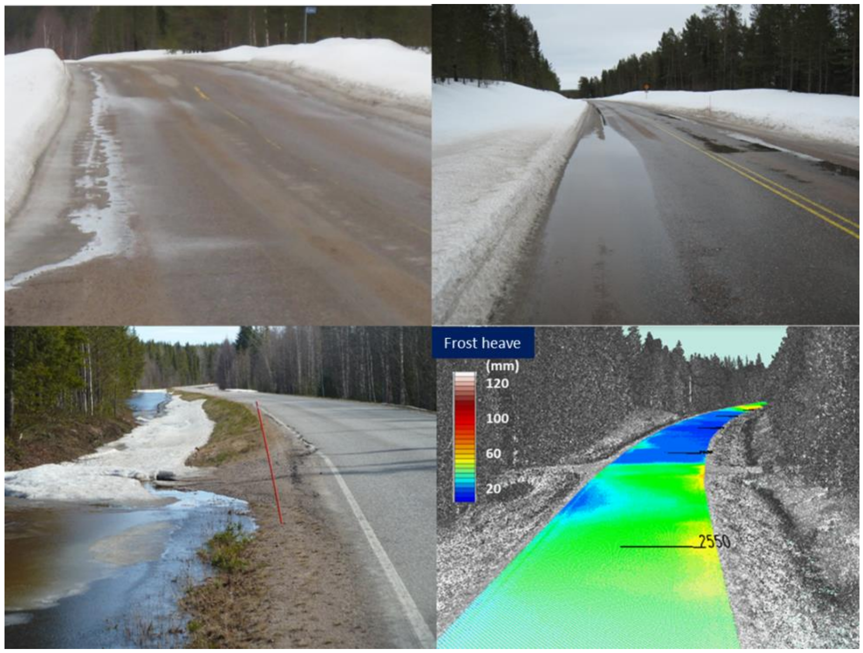

Figure 6. Typical daily maintenance problems that cause major problems with pavement condition and increase the annual paving costs substantially. If snow walls are not removed early enough the pavement structure will be saturated with melting water and deformations will take place under heavy vehicles (above). Clogged or frozen private access road culverts lead water infiltrating the pavement structure which in turn leads to frost heave damages and deformations during the thawing period (below).

5. PRELIMINARY RESULTS

The PEHKO project 2015-2025 has only just started and consequently only preliminary analysis results are available. However, thus far, the results look promising. Currently Finland has been spending 135-145 million € annually on paving works, equating to an average cost of 2.25 €/m/year. The PEHKO analysis shows that almost 80 % of the paved road network in both the Karstula and Kemi-Tornio maintenance areas costs less than this average (Figure 7). Focusing rehabilitation investments on the more expensive critical 20% problem sections and, at the same time, improving maintenance practises should make the general goal of the PEHKO project attainable. This strategy of focussing on the critical sections has been shown to be successful in the outputs of the EU ROADEX projects (Leviäkangas 2015) and has also been recognised in other research projects. Crist et al. (2013) states that “Funding for road maintenance is often postponed when budgets are tight because a lack of maintenance does not necessarily lead to immediate failure of the network. However, maintenance deferral can be expensive in the long term. Short-term cost savings from deferring maintenance may be overweighed, even in present value terms, by the consequent need for more expensive treatments in the future”.

Early PEHKO project results have also revealed that a substantial amount of the pavement rutting surveyed can be classified as Mode 2 rutting (Dawson and Kolisoja 2004), that takes place in the road structure / subgrade interface. This is considered to be due to trafficking by the new generations of heavy trucks but problems can also be found in sections with drainage deficiencies and peat subgrades. The PEHKO results show also that steel grid structures in the unbound base course have been given very good resistance against these deformations. By 2025, the PEHKO project aims to have the roads in the PEHKO pilot areas in much better shape than today, but the available money for annual pavement maintenance by that time will be 50% less compared to that which is currently needed.

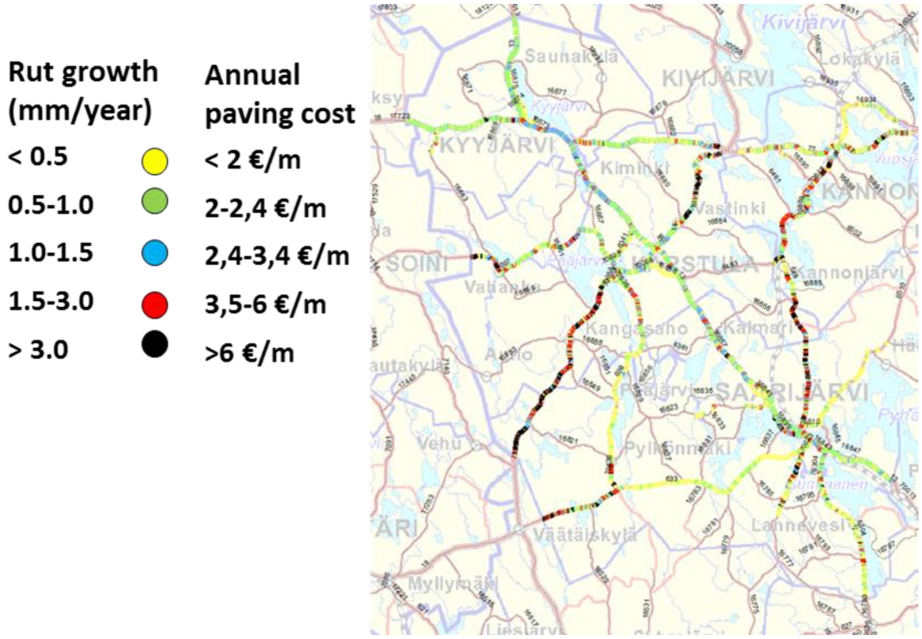

Figure 7. Annual rut growths (100m average) and annual paving costs in the Karstula maintenance area in Central Finland.

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