Mara Nord Project

Final Report

Rovaniemi University of Applied Sciences

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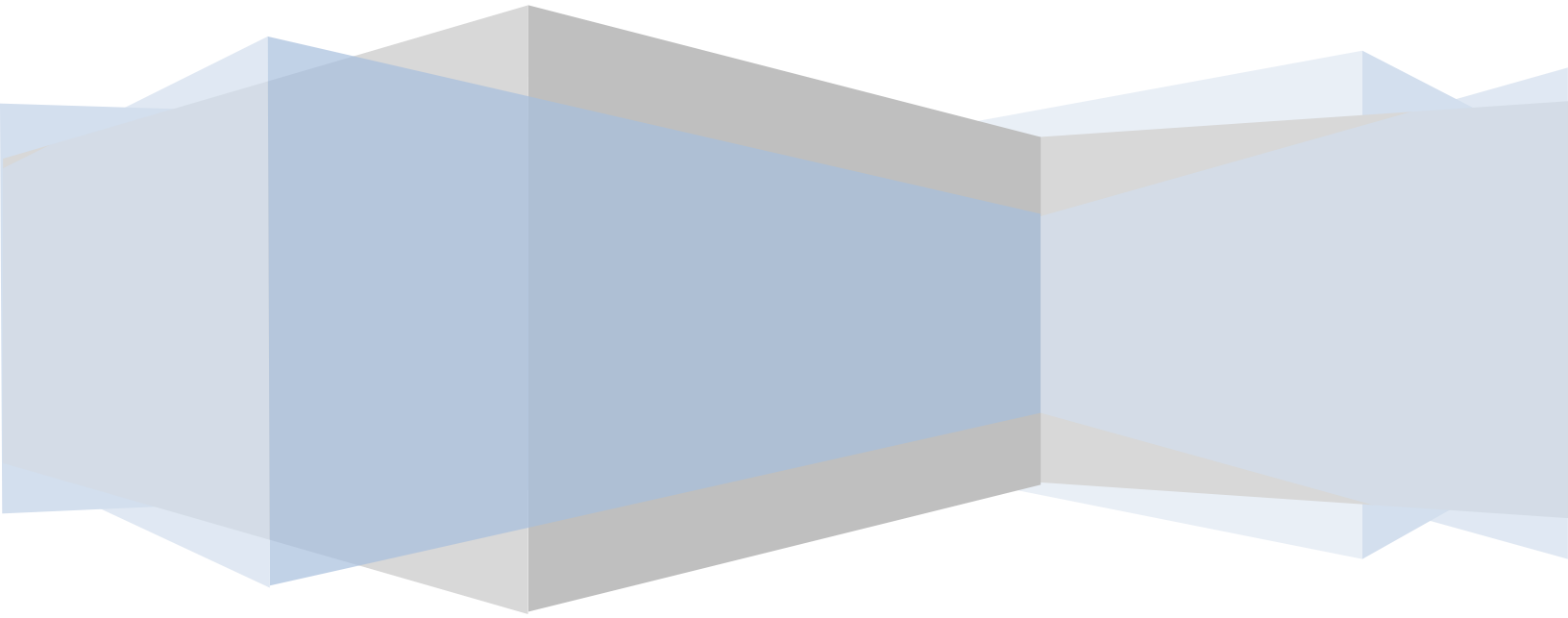
2012



Rovaniemi University of Applied Sciences	**30 June 2012**
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Nordic Region Overview

Sparsity and remoteness have been recognized as major specifics of the Nordic regions in the European context that bear influence on social and economic developments *(see Annex 1)*. These regions have been recognized as suffering from lack of volume in business activities, access to social services as well as poor infrastructure in terms of cities and towns. Sparsity and remoteness are distinct concepts - the first relating to the distribution of population within the region, the later referring to the distance between the region and the main economic centers of Europe [7]. In this context it means that for regions further away from the main economic centers of Europe it is harder to reach potential customers and enter the markets of Europe.

Sparsely populated areas are characterised by higher unemployment rates and also a higher degree of dependence on public sector employment [7]. This means that there is less money in the region as well as poor economic capacity. The business structures are small or medium size and there are very few large industries to boost the economy.

To summarize the Northern peripheral regions experience serious disadvantages when compared to other parts of Europe. These disadvantages are sparsity, peripherality and structural weakness. Some of the disadvantages such as climate constraints are clearly not convertible. Therefore it is important to recognize the opportunities where efforts should be made to improve the situation. The opportunities lie within the human and social capital, developing more effective business networks, sharing the knowledge and addressing the challenges in an organised way. It is also important to recognize and make use of the particular assets such as high quality of life and successful cases. It is obvious that the North and the Arctic region is playing increasingly important role in the economic development of future. The unexplored natural resources and the potential in new transportation routes might lead the Arctic to become a major energy reserve and transportation channel for Europe [9].

Taking in to consideration the challenges of the Nordic region it has to be highlighted that some specific business areas have developed exceptionally well. For example tourism industry is benefiting from the Nordic conditions attracting vast amounts of tourists from across the world wanting to experience the unique and clean nature, healthy and high living standards.

Among the success stories in the North is the business sector related to geophysical instrument research, development and production. Over the years the development and innovation in this field has been rapid and the technology has developed from basic to three dimensional real time image viewing with an sight towards automated data interpretation. The application of the Ground Penetrating Radar (GPR) has expanded from the geophysical application to civil engineering and construction. The Nordic countries have played the main role in this development and still have the leading experts in this field.

GPR in Nordic Countries – history and present

Ground Penetrating Radar technology development has begun as early as the 1888s with tests utilizing electromagnetic waves. During the last 80 years Scandinavian countries have been actively involved in the development work of this technology. Commercial GPR systems appeared in 1970s but it wasn't until 1981 that GPR was present in Finland [11]. Although originally GPR technology was developed for geological research very soon it was noticed that it is applicable wider including the surveying of construction sites, natural and archeological objects as well as roads and other elements of infrastructure [10]. As early as 1980s the first projects where done on road network surveys in Denmark and Sweden. Soon after those tests also Finland started utilizing this method for road survey. Finland was the first to implement the method for surveying of roads commercially [11]. Since that time three decades has passed and currently GPR method is an accepted tool in various kinds of road survey projects in Finland. The situation though is different in other Scandinavian countries where the method has not been so successful. However, with the advances in technology and research GPR is viewed as playing a significant role in the future of road quality monitoring and civil engineering investigation projects in Finland, Norway and Sweden.

GPR technique today in Finland is applied within rather strict specifications and guidelines for different purposes. These guidelines and regulations are unique as they do not exist in any other Nordic country or Europe. The area of GPR applications on road surveys has widened from the original structural layer thickness measurements to evaluation of quality, strength and

deformation properties of subgrade soils and road materials. Even though in Finland the GPR use in road surveys is rather favored the field in overall still is rather small and fairly limited [11].

The limited business sector and specifics of the field bring challenges for the companies to stay in the market. Pricing is often an important evaluation criterion when it comes to subcontracting of GPR services. Subcontracting through public procurements is a complex process where the national rules and legislation of each country apply. These rules and legislation vary from country to country mainly based on the size of the job. Companies struggle to get contracts across the borders.

To estimate the current situation in the GPR business for application on road projects a questionnaire was carried out. The questionnaire was divided in two parts one for the service providers (companies doing GPR measurements) and other for the customers (Road Administrations). Combining the answers from both parts we can estimate the GPR market in Nordic countries and its further development.

The findings of the survey conclude that Nordic GPR hardware and software developers as well as service providers face common challenges of fierce competition, high costs of the GPR technology and unclear conditions and regulations. It is also obvious that the GPR market is generally rather small in which it is difficult to differentiate. The lack of knowledge and specialized expertise is a problem as the field is so specific and complex.

On the other hand the challenges faced by the customers are the lack of understanding of GPR survey results that contribute to the unreliability of the results and the high costs of the service.

When combining the results the overall market estimation is optimistic foreseeing growth in coming future as well as estimating the past three year performance as growth in the GPR related assignments on roads. This in combination with the technological development signs gives hope for the GPR business growth.

Mara Nord project description

To implement the routine surveys of roads customer (Transport Administration) needs to be able to purchase the right service that gives the expected type of the results. That is not always easy as the methods used for surveying the roads with GPR and the results of those surveys can be various. To be able to purchase the right service and understand the survey results the customer would need to have a good understanding of the various methods. This is a challenge because of the lack of in house expertise and knowledge in the Transport Administrations. The methods are too complex and require specialized expertise that customer does not have.

When talking about the GPR application on roads the Finnish Transport Agency has the most experience in the Nordic countries. It was identified that it would be beneficial to transfer the existing practices to Swedish and Norwegian Transport Administrations and create common Nordic Recommendations that would lead towards standardizing of GPR services for road surveys. Mara Nord project was created to implement these changes. The project started in January 2010 financed by EU Interreg IVA North programme.

The aim of Mara Nord project is to boost the cooperation between the Nordic Transport Administrations, research organizations and the business sector specifically by improving the market conditions for GPR method application in civil engineering for nondestructive testing of roads.

The project objective is reached through five main work packages: (1) providing GPR training to road administrations (EDU1) and to companies (EDU2), (2) creating joint Nordic Recommendations for Finland, Sweden and Norway, (3) benchmarking of different GPR systems, (4) networking and dissemination of the results, (5) further testing of the GPR method applicability to new asphalt pavement quality monitoring and (6) project management.

With the different work packages the project aimed to reach different audiences of the GPR related sector presented in stakeholder analysis table *(Annex 2)*. The table defines the organization, their interests in regards to GPR on road surveys and also how the project has been approaching those stakeholder groups.

Project trainings, Nordic Recommendations and Networking

To answer to the needs of the different stakeholder groups Mara Nord project work was divided into five content work packages. This chapter will focus on the work packages (1) providing GPR training to road administrations (EDU1) and to companies (EDU2), (2) creating joint Nordic Recommendations for Finland, Sweden and Norway and (4) networking and dissemination of the project results.

One of the main parts of the project was to provide the training to GPR service buyers (Transport Administrations) with the training package 1 (EDU1) and the needs of the service providers (companies) with the training package 2 (EDU2). Each of the training courses where held in Norway, Sweden and Finland. The training course 1, being of a more general overview was very well attended in total educating more than hundred participants. The (EDU1) consisted of the GPR history, general applications, hardware, control units and different antenna types and their application to road surveys. It also included parts such as legislation and licensing and traffic safety. The practical examples where given to present the GPR data collection process and introduce the software options for data analysis and presentation. This training was attended well by the GPR companies, already working within the field, Road Administrations of all three countries as well as in Finland by the regional offices of The Centre for Economic Development, Transport and the Environment of Finland. The training material was developed by the project consultant Roadscanners Oy, experienced and knowledgeable expert in the field.

The (EDU2) was of more depth in the content and was targeted especially towards the GPR service providers so that they can provide better service and understand the customer needs better. This training was including topics such as how to prepare better for the job with design a GPR project and how to prepare the procurement documents. It also covered the topics of arranging GPR field data collection, safety issues and combining the survey methods, data analysis methods and interpretation techniques. It also covered important parts such as quality assurance. Many practical examples where discussed during the training and participants had the chance to explore the software and try interpreting the data under the supervision of experts.

Writing the Nordic Recommendations is a step forwards towards joined management and standardized procurement practices of GPR surveys on roads across the Nordic countries and the whole world. Meanwhile the national standards exist in Finland similar or the same type of coordinated procurement and service requirements do not exist either in Sweden or Norway. For the companies to compete fairly across the borders it is easier if the rules and regulations are standardized across the borders and implemented as jointly as possible. During the Mara Nord project five different joint recommendations have been developed to address the different types of surveys most commonly performed on road surveys. Those recommendations are:

- Use of GPR in pavement design and road rehabilitation projects
- Use of GPR in bridge applications
- Use of GPR in site investigation
- Use of GPR in road construction quality control
- Use of GPR in asphalt quality control

"These recommendations have been produced due to new procurement policies in Nordic road administrations which means that road condition surveys will be ordered through open competition. That in mind, it is essential that current practice is described precisely so that new entrepreneurs will know how and at what level the GPR surveys should be done and what the basic quality level for the results is. There is also a need to specify separately the procedures that should be followed in two dimensional (2D) and three dimensional (3D) GPR survey projects." [13]

To gain the recognition of our activities Mara Nord project has been visible in different external communication platforms and has disseminated the project idea and the project results outside the project network. Most important forums we have been present at are (1) Barents region transportation forum 2011 in Rovaniemi; (2) European Geosciences Union Assembly (EGU) 2011; (3) European Geosciences Union Assembly (EGU) 2012 and (4) Publication for Non-destructive Testing Magazine 2012 as well as (5) Presentation in GPR circle of Finland annual meeting 2012

Benchmarking of different GPR systems

To address the varied needs of the different stakeholder groups *(see Annex 2)* one of the projects work packages (WP3) was coordinated by the Norwegian Road Administration with an aim to describe different types of GPR equipment available and their performance. This chapter focuses on the results of that work package (WP3) and presents the summary of the findings.

In the benchmarking of the different GPR equipments for use in road surveys the target was to collect information on the equipments, perform field tests in street and highway sections and a brief data analysis. In the field tests, only the GPR manufacturers, who were interested in this study and participated in the costs, where represented in the tests. The units and the antennas had to be ECC/ ETSI approved. The target was not to put the equipment in any specific order, but to describe what kind of equipment is available, how they can be used, how they perform in field work and how the results look. The units and the antennas had to be FCE approved. GPR manufacturers present in the test were:

- 3D-radar AS, Norway
- Geophysical Survey Systems, Inc., USA
- IDS, Italy
- Malå Geoscience, Sweden

The GPR systems were tested at two sites, Talvitie Street and a section 505 of HW4 outside Rovaniemi. Both roads were rehabilitated in 2010 and therefore the layers of the road where fresh and clear. The survey sites were very good for GPR method and all the systems worked at their best levels concerning depth penetration and resolution.

The main conclusion from the tests where that all the tested equipment showed to be reliable and produced good quality data. All of the achieved results showed to be good or very good.

It is clear that in the high frequency range the horn antennas still advantages over ground coupled antennas on high speed road surveys, but when the survey speeds are lower, the high frequency ground coupled antennas produce good quality data and the horizontal resolution is better than can be reached with the horn antennas. The benefit in using horn antennas is also the additional data gathered at the same time: bouncing and dielectric value. Refer to the benchmarking report [12] for more details.

Quality assurance of new asphalt pavement

In 1997 Petri Roimela introduced a regression model between dielectric value measured by GPR and void content of new asphalt pavement. Since that time GPR have been used as a quality assurance method for new asphalt pavements in Finland. [1, 2] In this method a continuous void content profile of asphalt pavement is determined by GPR survey. The void content method is based on a regression model between dielectric value and void content of asphalt mixture that was introduced by Roimela in 1997. Moreover, it requires some reference drill cores to be taken from the pavement for calibration of the model.

The main objective in Work Package 5 (WP 5) of Mara Nord project was to improve the reliability of the current void content method. First the research focused on the examination of current regression model. The aim was to improve the accuracy of the current regression model as well as to find out if new models need to be used with different asphalt types. Furthermore, the influence of environmental factors (temperature, moisture) on GPR results was investigated.

Another objective in WP 5 was to investigate the possibility to abandon asphalt core samples in calibration. The use of an asphalt calibration plate and some NDT method (e.g. Troxler) was investigated. After all, it was recognized that it might be impossible to abandon asphalt core samples with the current void content method. Therefore, another ways to access the quality of new asphalt pavement through GPR survey was also investigated. Suggestions have been made that the quality could be determined from the homogeneity of new asphalt pavement. One aim in WP 5 was to define this homogeneity and how it relates to GPR data.

Various laboratory measurements (GPR, Troxler, Percometer, 3D laser, air-water weighing, environmental factors, and core samples) were carried out with asphalt plates to validate the regression model used in void content method. Two common asphalt types in Finland AB (asfalttibetoni, asphalt concrete) and SMA (kivimastiksiasfaltti, stone mastic asphalt) were used and the plates were made to different compaction. Unfortunately, due to too wide variation in regression data an accurate regression model could not be validated.

Field test (GPR, core samples) were done on roads 18 and 725. The main aims of the field tests was to produce good quality GPR data for the Mara Nord research and to test operators and their equipment in void content measurements. The field test demonstrated that GPR has good repeatability and reproducibility in the current void content method used in Finland when the same reference drill cores are used.

As a summary of Mara Nord project WP5 findings, the improvements of the current void content method are the following:

- More than one reference core should be taken from each reference point location. Moreover, reference points should be placed in a location where GPR does not detect remarkable changes in dielectric values.
- Core samples should be taken from each survey line particularly when asphalt mass, working method, base treatment or environmental circumstances change.
- In case traffic compaction has been realized the possibility to place survey line between wheel paths needs to be examined.
- To avoid significant differences in dielectric value level of separate GPR surveys metal plate measurement should be done in the same circumstances as the survey.
- GPR operator needs to monitor GPR data to detect possible long term changes in direct pulse amplitude. If such is found, the changes need to be eliminated in dielectric value calculation.

Wavelet analysis gives another perspective to quality assurance of new asphalt pavements. Wavelet analysis can be used to illustrate the homogeneity of asphalt pavement. It also localizes the significant variation in GPR survey. To utilize this method for quality assurance the connection of significant dielectric value variation to detected pavement damages should be investigated in long term surveillance. [14]

Conclusions

Today GPR is used widely across the world and the Nordic countries. The level of how much the service is being used, and in which areas, are varying between the countries and regions.

Many of the systems that are used today was developed during the late 80's, 90's and the early 21st century, and that is somewhat reflected on their performance and capability. The early computers limited data storage and slow processing speeds resulted in single or dual channel systems with basic interpretations as only possible result. In the last years there has been an impressive development in the GPR field, with many promising steps taken both in hardware and software improvements. The change from single channel systems to today's possibilities of full range 3D-systems is widening the usage of GPR into new market sectors.

Pulse radar and stepped frequency radars, which are the two dominating types of radar systems on the market now are competing with new technologies. Data collection speed is much higher in today's modern GPR-systems, and the possibility of real time processing and viewing of data is given by the rapid increase of computer power. The possibility of automated/semi-automated interpretations has seen some great improvements, especially on 3D GPR data, and this is likely to be developed further.

There is a clear trend that GPR is being more and more integrated with other systems and that GPR data can be used for so much more than just revealing layer thicknesses in different structures. The results from GPR surveys are increasingly being used as important part in road analysis tools. The integration of GPR data with for instance deflection data, thermal camera information and laser scanning of the road surface gives the road industry a powerful tool to identify problematic sections and in good time deploy preventive measures.

In spite of all this promising development and the future possibilities of new techniques, there are still some obstacles that have to be overcome in order to make full use of the capabilities of GPR. The road industry historically is not very prone to changes in methods and procedures. The GPR market, at least in the Nordic countries, is somewhat limited and uncertain. This has the effect that the industry is reluctant to make large investments in the newest technology.

At the same time the road industry is going through big changes, and projects like Mara Nord are a good indicator of the increasing will to adopt new techniques and exchange knowledge across borders. With the common efforts of the transport administrations in the Nordic countries, consultant companies and manufacturers of GPR systems there is great possibilities to expand even further.

The Recommendations for Guidelines created in Mara Nord project will be an important tool in creating a common Nordic market, with actors operating across borders. Each nation's transport administration will need to make national adaptations of the recommendations, but the base now is available for creating good possibilities of common improvements *(Annex 3)*.

Mara Nord project through the WP5 has also produced recommendations for further developments to improve the reliability of the void content method. Those are:

- The regression model between dielectric value and void content should be based rather on field tests (test site or road sections) than on laboratory test (pavement plates).
- Homogeneity is an alternative property for the void content to indicate quality assurance of new asphalt pavement. Wavelet analysis is one promising method to investigate asphalt pavement homogeneity.
- Long term surveillance of road sections is needed to validate quality assurance methods. For example, in the homogeneity model correlation between statistically significant variations with pavement damage should be determined.

The first step towards the future of GPR after the Mara Nord project has ended is to ensure that the harmonization between the countries continues, and this is most important between the different transport administrations. A common interest is to put effort into creating a good learning environment, in order to ensure that new actors entering the market are providing the right kind of quality. This can be done in many ways, but it is important that the entire chain is involved, all the way from the tendering process to the final result.

The future of GPR in the Nordic countries is looking bright, and with the results from the Mara Nord project we are all better equipped to do our part in making sure that we reach our goals.

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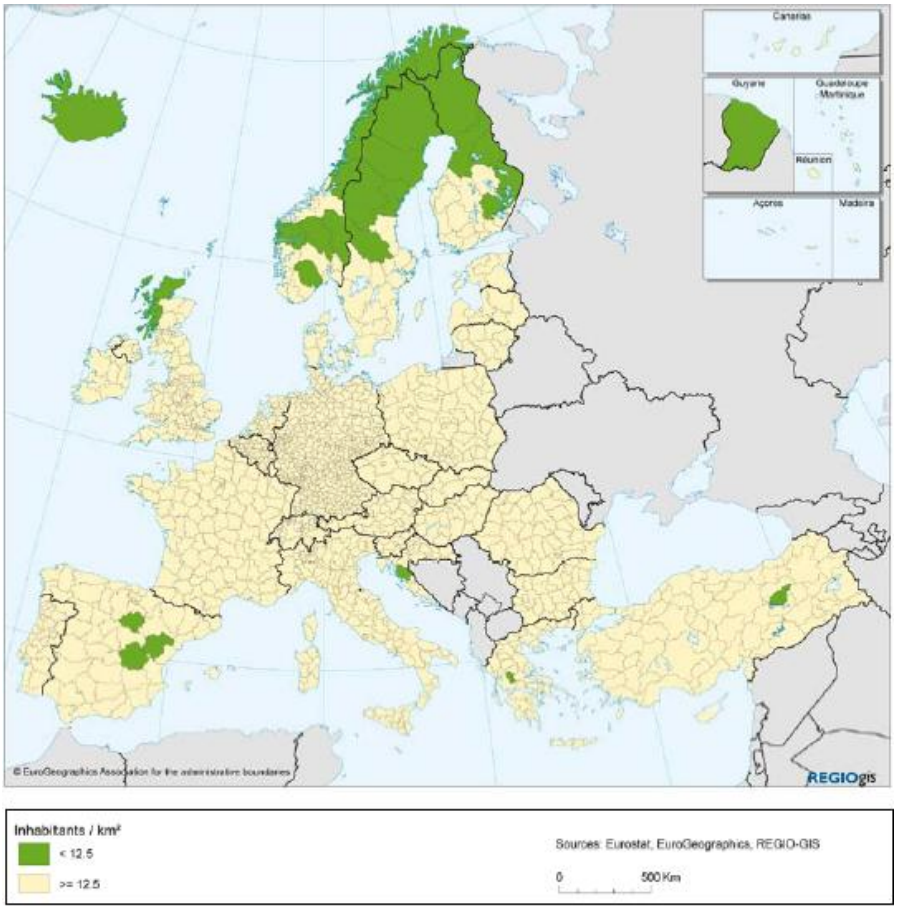
Annex 1 Eurostat GISCO: Sparsely populated regions in 2007



Annex 2 Stakeholder Analysis Table

	Name of the stakeholder or stakeholder group	Stakeholder interests	Projects approach to address the stakeholders needs
Beneficiaries	Finnish, Swedish and Norwegian Transport Administrations and ELY-center	- Updated or gained knowledge on GPR technology - Improve the understanding of the GPR hardware and software - Easier buying of the GPR services - Better quality more reliable results	- Training packages EDU 1 and EDU2 - Demonstration of different equipments and reporting their usability - Nordic recommendations for improving the buying and selling process
	Companies: Carement Oy, Malå GS Ab, NCC Roads As, Ramböll Sverige Ab, Road Consulting Oy, Roadscanners Oy, Sintef, 3D Radar As.	- Sell more GPR services - Development of the technology (software and hardware) - Better understanding of the customer's needs - Possibility to differentiate - Updates knowledge about GPR technology	- Nordic Recommendations - Network of Nordic Road Administrations - Trainings of EDU1 and EDU2 - Networking seminar amongst the companies
	Students in RAMK	- Participating in real cases to students - Develop thesis work during the studies linked to real case studies - Current and up-to-date knowledge	- Updated and current educational materials - Offer cases for thesis work and practical training placements - Opportunity to participate in training
	Staff in RAMK	- Interaction with regional business and regional organizations - New ideas for education - Integrating teaching and research in projects	- Network and international partners - Active company interaction - Students actively participating in project work
Other Target Groups	Maatutkarengas ry	- GPR user discussion forum - Disseminate current issues related to the use of GPR method	- Integrating the project activities with organizations activities - Sharing the knowledge
	European Geosciences Union EGU	- International Network of Geosciences related activities - Series of seminars and conferences for dissemination of information - Scientific publications and articles on relevant topics	- Presentations in EGU annual assembly - Article in NDT magazine - Abstract for seminar publication
	Barents transportation forum	- Current issues and activities of the Barents region - Utilizing the existing good	- Project presentation

		practices	
	Other Nordic Road Administrations	- Current issues and activities of the Barents region - Utilizing the existing good practice	- NDT article - Discussions through project team experts - Invitation to final seminar - Dissemination of the recommendations
	European Road Administrations	- Current issues and activities of the Barents region - Utilizing the existing good practice	- NDT article - Discussions through project team experts
	Non partner GPR manufacturers and users	- Selling their products - Updating products - Promoting products	- Including in benchmarking test - Disseminating information
Project Partners	Rovaniemi University of Applied Sciences	- Applied research - Developing the education to address the needs of the regional business sector - Real life cases to students - Active partner in regional development tasks - Building international recognition	- Opportunity to develop Master's thesis while working with the project activates. - Providing the education and training on GPR - Gaining new and valuable knowledge - Company and study work integration - International partnership
	Oulu University of Applied Sciences	- Applied research - Asphalt quality tests - Support the Finnish Transport Agency - Laboratory tests	- Laboratory tests of the quality of different pavement types - Updating the current national guidelines
	The Centre for Economic Development, Transport and the Environment of Finland	- Better quality and more reliable results - Defining the services as precise as possible to get better results	- Further testing of the GPR method applicability to new asphalt pavement quality monitoring - Nordic recommendations for improving the buying and selling process
	Swedish Transport Administration	- Updated knowledge on GPR technology - Easier buying of the GPR services - Better quality and more reliable results	- Training packages EDU 1 and EDU2 - Nordic recommendations for improving the buying and selling process
	Norwegian Public Roads Administration	- Updated knowledge on GPR technology - Easier buying of the GPR services - Better quality and more reliable results - Understanding the GPR potential	- Training packages EDU 1 and EDU2 - Nordic recommendations for improving the buying and selling process - Demonstration of different equipments and reporting their usability

Financiers	EU Interreg IVA Norht	- Developing cross border activities - Developing common public services and practices - Financing successful project	- Network among the Public administrations of Finland, Sweden and Norway - Common recommendation written to be used in FI, SE, NO - International Project
	North Calotte Council	- development of the economy and the infrastructure - communication and traffic services - research and educational cooperation - development of shared service solutions across national borders	- Proving support to business sector with training and network - Common Recommendations across the borders - Integrating research, education and business activities in project
	Regional Council of Lapland	- Encouraging and protecting the common interests of the region and its municipalities - Working in cooperation with regional organizations - Support regional business needs - Co-financing projects and development work	- Network among the Public administrations of Finland, Sweden and Norway - Providing the support to regional business organizations - Practical project implementation
	Finnish, Swedish and Norwegian Transport Administrations	- Updated or gained knowledge on GPR technology - Improve the understanding of the GPR hardware and software - Easier buying of the GPR services - Better quality more reliable results	- Training packages EDU 1 and EDU2 - Demonstration of different equipments and reporting their usability - Nordic recommendations for improving the buying and selling process
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Annex 3

Ground Penetrating Radar in Road Monitoring and Evaluation Now and in the Future

Radisson Blue Royal Garden

Trondheim

Panel discussion notes

18.4.2012

Panel leader:

Øystein Myhre, Norwegian Public Road Administration

Panel participants:

Katri Eskola, Finish Transport Agency

Per Andersson, Swedish Transport Administration

Leif Bakløkk, Norwegian Public Road Administration

Martin Karlsson, Ramböll RST

Egil Eide, 3D Radar

Jari Marjeta, Carement

Question 1: What are the main applications for GPR in your country?

Katri Eskola: In Finland GPR has been used as a routine measurement tool for quality assurance of new asphalt pavements, road analysis and rehabilitation, also in quality assurance of road construction.

Per Andersson: Client is interested to buy the results not the measurements. Road authorities are conservative customers and this need to be changed. By Mara Nord project the work has been started especially with educating the staff in the Road Administrations. Today the GPR is used for inventory reasons and road rehabilitation. The quality assurance of new roads is a huge coming market with large sums for projects. Sweden is interested to get good working and reliable methods for the quality assurance of new roads.

Leif Bakløkk: In Nordic countries Norway has the least experience in use of GPR. The GPR technique has been applied in R&D projects mainly. For Norway the GPR is interesting for mapping old road and for the rehabilitation planning of the old roads. Lately GPR has been used for several purposes such as surveying tunnels and frost in the road. It is also possible that in future the GPR could be used for the quality assurance of new roads, but then we are looking at future quite far ahead.

Question 2: How is the use of GPR implemented by the road administration in your country?

Øystein Myhre: Now during the project a great step has been made to create the common recommendations. The next phase should be about the implementation of these recommendations.

Martin Karlsson: Finland has had guidelines already for quite a while. It would be interesting to know was the guidelines first or was the guidelines developed after the growth of the market? So for Sweden it also would be interesting to understand do we need the guidelines first or the growth of the GPR business first that creates the need for the guidelines?

Katri Eskola: In Finland GPR service came first and guidelines where created after that.

Per Andersson: To get the guidelines in action is a real challenge. NDT group has been established in Sweden and the guidelines are one of the topics of this group. The group is very eager to get the guidelines active and to be taken in use. Education towards the GPR and the promotion is important.

Leif Bakløkk: At the moment Norway does not have guidelines for the GPR measurements. In future GPR services might be included in other National guidelines. Mara Nord guidelines should be somehow included to the National guidelines.

Øystein Myhre: GPR guidelines can be attached to Road rehabilitation guidelines.

Egil Eide: Quality assurance might be a good starting project. It could also save the costs of the client.

Leif Bakløkk: In Norway we plan to carry out some tests next summer with thermal cameras, GPR and other methods to introduce the quality control.

Question 3: Supplementary techniques used in your country to verify or calibrate the GPR data?

Øystein Myhre: This was already discussed during day and therefore the question will be skipped.

Question 4: What are the shortcomings and challenges for today's equipment and procedures for the use of GPR, incl. data interpretation?

Leif Bakløkk: Norway needs more information about GPR. There is need for development of the software that produces easier understandable results. The feature shown in the seminar is looking very promising.

Joralf Aurstad: Authorities are worried about competence. Training is needed. Client needs to be trained as well.

Martin Karlsson: Level of knowledge of consultants also is important. There are not so many GPR experts in Sweden. More basic education is needed (universities provided courses etc.).

Egil Eide: Learning by doing is important! Not only R&D projects. Consultants need to invest in learning about the opportunities. Of course the market size influences on the amount of consultants willing to invest.

Katri Eskola: Learning by doing is the best way. Pilot projects.

Martin Karlsson: Pilot projects often tend to go to companies that are already experts so the new entry in the market on learning by doing is challenging.

Question 5: What are the most obvious tasks for further development of the GPR technique?

Timo Saarenketo: Training of the consultants is a good idea. What is the level that a new consultant needs to have to enter the market? It should be good to have some standard basic training. Something like GPR driving license, like road safety course. EuroGPR has a course for basic GPR but is not for road measurements. Another issue is that universities need to have courses on the use of GPR and rehabilitation of roads.

Leif Bakløkk: It is a good idea to get some kind of certification in GPR use.

Jari Marjeta: Nordic school of GPR. Education is needed and training courses for new consultants.

Øysten Myhre: Short material of GPR such as a demo or education to decision makers is missing. It could be a short Power Point presentation for the use of authorities or a one to two page leaflet.

Thomas Örnevik: Client need to be able to say what is the result that they needed. So the education is necessary for both sides the consultants and also the service buyers.

Question 6: When guidelines become mandatory how do we insure that the cooperation amongst the Nordic Countries continues? (Asked by Johan Ullberg)

Per Andersson: Benchmarking was a good result. Good cooperation has to continue and the established contacts should be kept active amongst the Road Administrations and the business.

Leif Bakløkk: Harmonizing is important because the Nordic Countries are small and the market potential is small if each country is doing things their own way.

Per Andersson: Once the Nordic Countries are harmonized then the issue can be lifted to EU level. Nordic Countries can be the leader of the way.

Bernth Johansson, Malå GS: This is a very nice thing. Great relieve would be to have a common standard and in one language, in English language. The language often tends to be a problem.

Timo Saarenketo, Roadscanners Ltd.: Training of consultants is a good idea. This would eliminate the fake expertise. There should be some kind of a basic training standard to be a GPR consultant. Nordic Countries could establish and accredit 2-3 day course that some universities would provide in each country.

Further discussion with Audience:

Øystein Myhre: Development of accuracy is promising. Costs of the service when automatic interpretation is possible are very interesting.

Egil Eide: Timo is right that interpretation can never be totally automated. Expert work is needed. Interpretation process is developing so that perhaps the road where there is no problem can be done automatically and that can increase the speed and lover the costs.

Timo Saarenketo: Automated interpretation is still a mission impossible in tricky structures. But there are of course things that can be done simpler. Using for example structure examples/ types. First interpretation costs but afterwards interpreting same thing is much cheaper. First model needs to be accurate.

Thomas Kind: Human interpretation can’t be replaced. But there are many things that can be semi-automated.

Bernth Johansson, Malå GS: Can road authorities give support when the issue comes to the European regulations? We all know that GPR can face a situation with the Radio frequency authorities that still oppose the GPR business and the result potentially can be closing of the business. These discussions will need to be taken again 2014. When the Nordic Road administrations put their voices together that is much more valuable than individual companies.

Thomas Kind: Road authorities should step up when the support is needed

Per Andersson: Swedish Transport Administration is committed.

Katri Eskola: Finnish Transport Agency is committed.

Leif Bakløkk: Norwegian Public Road Administration will give the support.

Final words:

Jari Marjeta: Education is important and client needs to know what they are ordering.

Martin Karlsson: Mara Nord is a product of long planning. Three countries have worked in co-operation successfully.

Øystein Myhre: Don't underestimate the need of the compact information package.

Leif Bakløkk: This is an end of the project but a start to a process. We shall continue to work on this.

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