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ROADEX III
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Policies for Forest Roads – Some Proposals

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PREFACE

This is a final report from Task B4 of the ROADEX III project, a technical trans-national co-operation project between The Highland Council, Forestry Commission Scotland and Comhairle Nan Eilean Siar from Scotland; The Northern Region of The Norwegian Public Road Administration; The Northern Region of The Swedish Road Administration and the Swedish Forest Agency; The Savo-Karjala Region of The Finnish Road Administration; the Icelandic Road Administration; and the Municipality of Sisimiut from Greenland. The lead partner in the project is The Northern Region of The Swedish Road Administration and project consultant is Roadscanners Oy from Finland. ROADEX III project Chairman is Per-Mats Öhberg from The Northern Region of The Swedish Road Administration and project manager is Ron Munro of Roadscanners Oy.

The report was prepared by Svante Johansson and Kristofer Johansson, Roadscanners Sweden AB and Fredrik Ekedahl, Swedish Forest Agency.

The authors should like to thank for contributions to the report from Stefan Gunnarsson, Swedish Forest Agency and for nice photos and good support from Timo Saarenketo, Roadscanners Oy. Thanks also to Kent Enkell, VTI, for good advice and for supplying nice photos to our damage catalogue.

Mika Pyhähuhta of Laboratorio Uleåborg designed the report layout.

Finally the authors would like to thank the ROADEX III Project Partners and the Project Steering Committee for their guidance and encouragement in this work.

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ABSTRACT

Forest roads differ from other paved and gravel roads in that they are designed and constructed for a specific business requirement. Their main purpose is to enable access to forests to assist in general management, timber extraction and recreation. But forest roads have also other users than the forest owners and the timber industry. They are used by private persons with summer cottages in the neighbourhood of the road, by berry pickers, by hunters, by fishermen and by people having other leisure activities in the forest areas.

It has been found that many road managers and road users for forest roads have difficulties in getting information about the road conditions on forest roads. This report describes a simple method for road condition surveys to handle this problem. By using a pocket PC with GPS included and programmed for the purpose defects can be registered in a simple way on a forest road network. A number of defect types are described and shown on photos in an enclosed defect catalogue and on the PC screen. By using only three classes for every defect easily defined from photos on the PC screen the survey can be done by almost any person after a short introduction. The survey data is delivered to a data base server and from there data can be acquired and visualized in a computer using e g the soft ware Road Doctor. The results can be shown on different types of GIS maps as classified defects in different colours.

The method will facilitate the collection and the visualisation of the road condition results and make it cheaper and quicker to get them. Quick and reliable information of the road conditions on forest roads will facilitate planning of maintenance and rehabilitation and also transportation planning and reduce costs. Documentation of regular road condition survey results will also make it possible to follow the development of the road deterioration.

The report describes also a classification of forest roads based on practicability and accessibility, and some proposals for road standard levels. In an annex some templates are given to help the road manager setting up own road standard levels (trigger values) for the different damage types on his road network.

Chapter 1 Introduction

1.1 THE ROADEX PROJECT

The ROADEX Project is a technical co-operation between roads organisations across northern Europe that aims to share roads related information and research between the partners. The Project was started in 1998 as a 3 year pilot co-operation between the roads districts of Finnish Lapland, Troms County of Norway, the Northern Region of Sweden and The Highland Council of Scotland and was subsequently followed and extended with a second project, ROADEX II, from 2002 to 2005, and a third, ROADEX III, from 2006 to 2007.

The partners in ROADEX III "The Implementation Project" comprised public road administrations and forestry organizations from across the European Northern Periphery. These were The Highland Council, Forestry Commission Scotland & Comhairle Nan Eilean Siar from Scotland, The Northern Region of The Norwegian Public Roads Administration, The Northern Region of The Swedish Road Administration and the Swedish Forest Agency, The Savo-Karjala Region of The Finnish Road Administration, the Icelandic Road Administration and the Municipality of Sisimiut from Greenland.

Figure 1-1 Northern Periphery Area and ROADEX III Partners

A priority of this Project was to take the collected ROADEX knowledge out into the Partner areas and deliver it first hand to practising engineers and technicians. This was done in a series of 14 seminars across the Partner areas to a total audience of 800. Reports were translated into the 6 partner languages of Danish, Icelandic, Finnish, Greenlandic, Norwegian and Swedish as well as English. ROADEX research continued through 5 projects: measures to improve drainage performance, pavement deformation mitigation measures, health issues of poorly maintained roads, road condition management policies, and a case study of the application of ROADEX methodologies to roads in Greenland. All of the reports are available on the ROADEX website at www.roadex.org.

1.2 INTRODUCTION

Forest roads differ from other paved and gravel roads in that they are designed and constructed for a specific business requirement. Their main purpose is to enable access to forests to assist in general management, timber extraction and recreation. The standard of the road is directly related to the business needs, the accessibility needs and the general traffic impact, where the challenge is to construct a road capable of carrying large and heavy vehicles while meeting all of the environmental criteria at a cost commensurate with the quality, volume and value of the transportations (mainly roundwood but also other products).

Forest roads have also other users than the forest owners and the timber industry. They are used by private persons with summer cottages in the neighbourhood of the road, by berry pickers, by hunters, by fishermen and by people having other leisure activities in the forest areas. As people have increasing time off the need for private persons to use forest roads is also increasing. This must be kept in mind when the road standard shall be classified.

The forest road is a key component of the supply chain to the timber industry and as the industry moves towards “just in time” stock control many forest roads must remain serviceable throughout the year in all weather conditions, even during the spring thaw period. A forest road network with good accessibility and good practicability will give benefits for the forest owners and for the society by

- Low transportation costs – less vehicle costs, less transportation time
- Improved delivery safety – just in time deliveries
- Improved accessibility - for forest activities and leisure activities.

After a clear-felling of an area, there is a certain risk that the used road will be left to deteriorate as it will take a rather long time to the next felling, e g thinning. Nowadays though, as also other participants are using the forest roads frequently, there is an increased need to keep the roads in proper shape. This means that there are at least two different stages for transportation needs for a forest road:

- The active stage, when the road will be used for timber haulage
- The passive stage, when the road needs to assist for general management and surveys of forest areas and for other road users.

These two stages require different road conditions, and as such, also different road condition surveys and different road condition levels. Proposals for policies and road condition classes for forest roads have been described earlier in ROADEX II (1) and this report is an upgrading and a step further. The report will suggest practicability classes based on the geometric standard and accessibility classes based on access for heavy vehicles on forest roads and bearing capacity and then standard classes based on practicability, accessibility and operation speed. For each standard class we will suggest a road condition standard level as a minimum value or “trigger value” for road maintenance.

The road standard level is a key factor at planning the road maintenance and the transportation of timber from the forest to the industries. This is illustrated by figure 1-2, showing areas of different forest type and age and a road network of variable condition. To check the road condition standard level we suggest a simple road condition survey method to collect necessary data. The data are collected in a pocket PC with GPS and data from the pocket PC will then be transferred to a computer to demonstrate the road condition on the forest road network on GIS maps. These maps can show the geological map or the normal geographical map, the different forest areas with description of tree species composition, age, the bearing capacity within the specific stands, the road network and the road condition. This will be a powerful tool for the forest owner and the road manager to plan the forest road maintenance and rehabilitation in due time before any felling activities in the forest areas. The manager will easily be able to level the road actions in accordance to the surrounding stand bearing capacities.

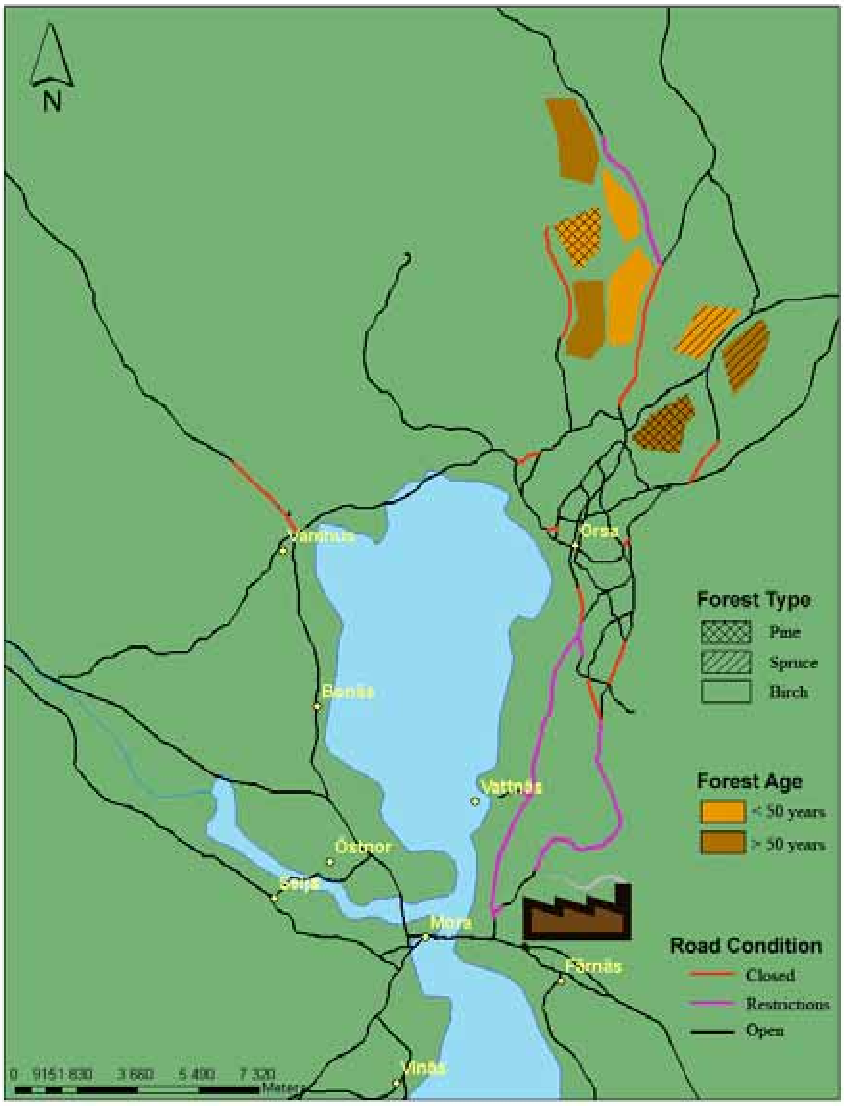

Figure 1-2 Sketch of forest areas and a road network in variable condition.

1.3 THE AIM

The aim for this task was to try to find methods to improve the road maintenance planning and the transportation planning for the timber from the forest to the industries.

To do this there is a need for good knowledge of the condition of the road network when the time comes for timber transportation.

Chapter 2 Forest road classification

The impact of the road condition on the road user's comfort is to a great deal depending on vehicle speed. As different forest roads have different design speeds it seems to be suitable to arrange the forest roads in standard classes partly depending on speed. In Sweden there is a classification system described by Alzubaidi (2) which can be suitable to use for this purpose. The system is based on geometric standard (width, curves, inclinations etc) and on bearing capacity. The geometric standard decides the practicability and the bearing capacity decides the accessibility.

2.1 PRACTICABILITY STANDARD

With regard to the geometric standard and design speed the Swedish proposal contains six classes according to table 2-1.

Table 2-1 Practicability classes for forest roads

Practicability class	Description
1	Single track permanent road with wearing course of crushed gravel. The dimensioning speed is normally 60 km/h. The road class is primarily intended for particularly important roads, where the requirements for traffic speed are relatively high, e g the longest of all forest roads or for the combined roads where also other traffic than forest transports is of great number.
2	Single track permanent road with wearing course of crushed gravel. The dimensioning speed is normally 40 km/h. The road class is primarily intended for bigger forest roads.
3	Single track permanent road with wearing course of crushed gravel or assorted natural gravel. The dimensioning speed is normally 30 km/h. The road class is primarily intended for roads with low requirements for traffic speed.
4	Single track permanent road with carriageway with no real wearing course. The dimensioning speed is normally 20 km/h. The technical design assumes that the road standard is not maintained by continuous maintenance measures In stead the road is restored before any using period. The roads in this class are considered to have a substantially shorter life length than the roads in class 1-3.
5	Single track road normally not allowing traffic by vehicles longer than 18 m. The carriageway is about 3 m wide.
6	Simple road normally not allowing traffic by vehicles with trailers.

The classes 1-4 have all a carriageway width of 3,5 m and should be designed for the same type of vehicles. New constructed forest roads shall always be within the standard classes 1-4. The road classes 5 and 6 are only used to designate the standard of existing forest roads.

2.2 ACCESSIBILITY STANDARD

The accessibility standard is divided into 4 classes depending on the access of heavy vehicles as shown in table 2-2.

Table 2-2 Accessibility classes for forest roads

Accessibility class	Description
A	The road shall be able to carry traffic from heavy vehicles and personal cars throughout the year.
B	The road shall be able to carry traffic from heavy vehicles the whole year except for the spring thaw period. The road shall be able to carry personal cars throughout the year.
C	The road shall be able to carry traffic from heavy vehicles the whole year except for the spring thaw period and periods with heavy rainfall. The road shall be able to carry personal cars throughout the year except for the spring thaw period.
D	The road shall be able to carry traffic from heavy vehicles mainly when the road structure is frozen. The road shall be able to carry personal cars also in the summer.

2.3 FOREST ROAD STANDARD CLASSES

By combining the practicability standard and the accessibility standard it is possible to form forest road standard classes as demonstrated in table 2-3. Each standard class will have performance requirements for road surface properties and bearing capacity properties depending on accessibility and design speed.

Table 2-3 Standard classes for forest roads

Standard classes	Satisfactory unbound road-way		Road-way without proper wearing course		Existing older roads	
					Practicability for 18 m long vehicles.	Practicability for truck without trailer
Accessibility	Dim speed normally, km/h					
	60	40	30	20		
Heavy vehicles and personal cars around the year	A1	A2	A3	A4	A5	
Heavy vehicles around the year except at spring thaw. Personal cars around the year.	B1	B2	B3	B4	B5	
Heavy vehicles around the year except at spring thaw and periods with heavy rainfall. Personal cars around the year except at spring thaw.	C1	C2	C3	C4	C5	C6
Heavy vehicles mainly in wintertime. Personal cars also in the summertime.	-	-	-	D4	-	D6

Chapter 3 Road condition inventory for planning of maintenance and strengthening of forest roads

3.1 INTRODUCTION

The information of the actual road standard condition of a road network in a forest area is very important information for the forest owners, but also for other road users in the road network. In some cases there are several different owners of the road network and these road owners have a common responsibility for the network. Usually, at least in Sweden, the responsibility rests on a local road association with a board taking the decisions. In other cases the road network is owned by a forest company having a road engineer to look after the road standard condition. In any case there is a lack of means to make objective road condition surveys in an easy way and to forward that information to the road users. We propose a system for collecting road survey data and to forward this data to the road users and to the people who are affected by the road and the road standard.

The flow chart in figure 3-1 illustrates the two different types of road condition surveys to register the road condition standard for road user information, for planning transportation and for planning maintenance and rehabilitation activities.

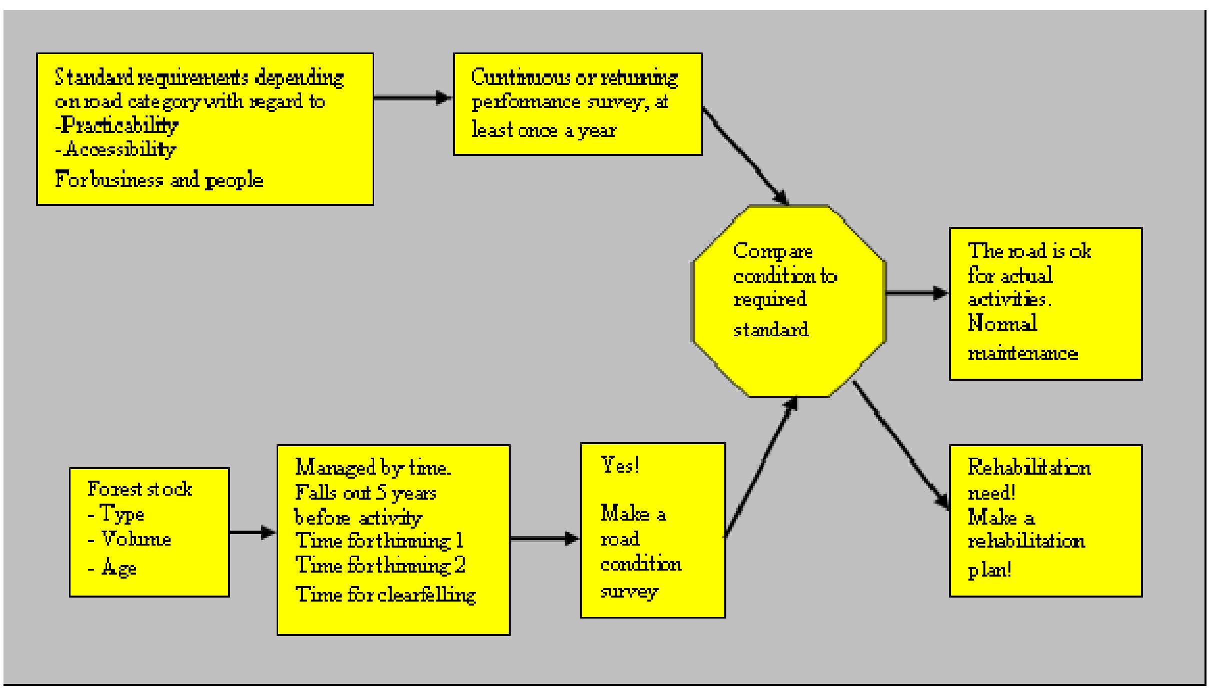

Figure 3-1 Flow chart of road condition surveys

The upper part of the flow chart shows the returning routine survey to keep an updated record of the road condition. The lower part is a more careful survey to check the state some time before a major transportation activity will take place. The proper time for the survey is depending on the investment planning of the road owner.

3.2 RETURNING PERFORMANCE SURVEY

The standard levels are controlled by continuous or returning, at least once a year, visual performance inspections. The inspections are proposed to be done with a car and a pocket PC with built in GPS. The defects and damages shall be registered in the pocket PC during the ride and special things, like defects on a culvert, can be registered by stopping at the location and registered by typing in the pocket PC.

3.3 PERFORMANCE INSPECTION BEFORE FELLING ACTIVITIES

If the road shall be used for timber transports within the next 5 years, or more or less, depending on the budget planning process in the actual company, a more careful inspection should be done to survey the need for strengthening and thereby the budget need before the timber transports will take place. In this case some type of bearing capacity judgment should be added to the survey described in clause 3.2. If a rehabilitation design is planned can e g photos, video, ground penetration radar measurement (GPR), falling weight measurements (FWD) and sampling be of good help to form a good base for decision making.

3.4 REGISTRATION OF DEFECTS AND PROPERTIES

Different defect types and properties have been considered and we propose that the following defects and properties should be registered. The main problem, as in most cases in connection with road deterioration, is undesired water in the road structure:

1) Bad drainage, ditches
2) Vegetation, grass turf, plants
3) Appearing stones and boulders
4) Potholes
5) Rutting
6) Frost damages
7) Surface softening
8) Cracking
9) Standing water on the road surface
10) Culvert defects
11) Depth of wearing course
12) Crossfall
13) Roughness measured with accelerometer

The proposal is to use only three grades of every damage type:

Grade 1. No defects

Grade 2. Minor defects

Grade 3. Severe defects

This will make it easy to judge also for a surveyor with little experience. A defect catalogue is shown in appendix 2.

3.5 DEFECTS AND POSSIBLE MEASURES

The defects and some possible measures to rectify the defects are described in a simple way in the following paragraphs.

3.5.1 Bad drainage, ditches

Much of the problems with bad road conditions and deterioration are linked to water. Sufficient drainage is a key factor in the road maintenance to keep the road in good shape. Ditches should be working properly and if possible without standing water for longer times. If the ditch has growing plants, typical for water, it is a safe sign of long term standing water.

Ditches shall be kept free from growing bushes by roadside cutting at intervals and be deep enough to keep the water outside the road structure. At intervals the ditches should be cleared and reformed.

3.5.2 Vegetation, grass turf, plants

Grass turf and plants start to grow on the sides of the wheel paths and will eventually create problems for the road users depending on standing water on the road surface and reduced sight at driving.

The grass turf should be taken away at the road edges to prevent surface water from standing on the road surface and to allow surface water to run off to the ditches. The grass could be taken away with a grader or by using herbicides. Plants growing in from the road sides shall be kept at a specified distance to the road edges to keep good sight for the road user. This can be done by sight clearance when needed.

3.5.3 Appearing stones and boulders

Stones or boulders can emerge through the road surface due to frost actions.

The unevenness can be temporarily reduced by levelling with added gravel or the boulder can be excavated and the hole refilled with aggregate similar to the aggregate in the surrounding structure.

3.5.4 Potholes

Potholes are often causing unpleasant rides on forest roads. The reasons can be e g wrong grading of the wearing course or unsufficient crossfall.

The problems can be solved by light formation grading to get a better crossfall or to add new wearing course material to improve the grading and mix it in with the old wearing course by means of a grader.

3.5.5 Rutting

There can be many different reasons for rutting. The rutting can depend on low bearing capacity, high water content in the structure, too thick layers of wearing course, bad compaction or use of bad aggregates.

Formation grading can solve the problem temporarily but the reason for the rutting should be analysed and then a suitable treatment should be selected if needed.

3.5.6 Frost damages

Frost problems can arise in cold areas mainly on subgrades of silt and clay. If such places have bad drainage and thin structures and the traffic is heavy there is a risk for surface cracks, rutting, deformations and local frost damages mainly in the springtime.

The problem can be reduced by improved drainage and a temporary measure is to put on unbound base course material on the road surface.

3.5.7 Surface softening

Surface softening will often arise in the spring or in the autumn due to excess water in the upper layers of the road structure. Reasons can be high fines in the upper layers, bad drainage or insufficient crossfall.

Suitable measures can be to improve the crossfall with grading to get better dewatering of the road surface or to improve the drainage.

3.5.8 Cracking

Cracks can be of different kinds depending on the origin. In areas with seasonal frost cracks can arise depending on uneven frost heave. They can be quite wide on frost sensitive soils in cold areas. Cracking can also arise in the wheel paths due to traffic and due to settlements e g on the road edges.

Formation grading can give temporarily help to solve the problems but in the long run the origin of the cracks should be analysed and suitable measures selected to eliminate the problems if needed.

3.5.9 Standing water on the road surface

There can be many reasons for standing water on the road surface after rain showers. It can depend on clogged ditches, insufficient crossfall, rutting, turf on the road edges, etc.

3.5.10 Culvert defects

Culverts can be damaged or clogged which will reduce the drainage capacity.

Damaged culverts should be replaced partly or completely depending on the damage. Culverts should be free from foreign matter in more than 75 % of the cross section. Clogged culverts should be cleaned with high pressure water or other suitable method.

3.5.11 Depth of wearing course

On roads with specified wearing course the wearing course thickness can be measured with a ruler.

If the wearing course thickness is too thin it should be made thicker by adding new surface course material and formation with a grader. If it is too thick the thickness should be reduced by excavation of excess material.

3.5.12 Crossfall

Crossfall should be measured by using a 2 m straight edge with an inclination meter. Measurements should be done at wet road surfaces and at spots with standing water.

An unpleasant crossfall can be adjusted with a grader and if needed some extra surface course material.

3.5.13 Roughness measured with accelerometer

Roughness should be measured with accelerometer if available. If the roughness level is higher than the specified standard some action should be taken to reduce the roughness.

Roughness can be adjusted with a grader and if needed some extra base course or/and wearing course material. If the roughness is returning to quick some added action might be needed.

Chapter 4 Survey program for forest roads

4.1 BACKGROUND

There are big problems to survey the road conditions and to plan maintenance and rehabilitation activities in road networks managed by different road owners, who have responsibility for different parts of the road network, and also a part of the common responsibility for the actual road network. One road section can be directly depending on another road section for practicability. If one road section is impassable also the previous section will be affected. If no other road is available to pass the problem section, the traffic will be stopped or performed with reduced efficiency. To avoid this there is a need for updated road condition information. If the different road owners had a simple method to survey the road conditions and to supply this information to some central unit which could take care of the information it should be a big help.

Mapping the different damages on a road section, their severity and extent, will give good knowledge of the actual road condition on the section. By putting all road condition data from a road network together and visualize it, complete road condition maps can be created, e g on GIS-maps in some homepage on internet. From there forest owners, transportation companies and other road users could obtain information to plan and optimize their transportation routes and activities. But the map information should also give good possibilities for the road owners to get savings from more efficient planning of maintenance and rehabilitation activities needed to get the timber from the forest to the industrial units in due time. Another advantage is that with a simple survey method there should not be a need for a road specialist to do the survey and the road condition data could be collected more often.

4.2 ROAD CONDITION DATA COLLECTION/USE OF EQUIPMENT

The program for collecting road condition data should be included in some type of hand unit, easy to carry in the field, to be mobile and movable during the survey, but also to be handed over to another user. Then the other user can take over without any need for any changes like installation of new software. The proposal is to use a pocket PC with built in GPS and programmed for the purpose.

By using a standard apparatus with special software for the road condition data collection the information should be rather homogenous and rather objective even if it is collected by different persons, with different skills and experiences, on different road sections. The apparatus and the software should be so simple that any person could use it after a short introduction and learning. The only thing the operator needs to do is to identify the road on the map on the PC screen (figure 4-1) and then to identify damage/defect type, e g rutting, potholes, standing water on the road, and the severity (figure 4-2). The identification is done by comparing the road defect with a photo in the PC screen and to decide the severity level. Then by choosing the actual level and press the button at the starting point, the computer starts to register at the location fixed by the

GPS. At the end of the damaged part another press at the button will end the registration. The principles for the survey are shown in figure 4-3.

Figure 4-1 Map shown on pocket PC

Figure 4-2 Identifying damage type and damage severity

The user could drive slowly in one direction to detect the overall road damages to the end of the road section or to some determined point along the section. Then turn back and register by stopping at places like e g culverts to check the performance, at pothole areas to check the cross-fall by measuring or to check the thickness of the wearing course. These defects or measures should be registered by pressing the symbol for the current damage and make some notes for the register.

The operator feeding the data will have a simple interface to be able to make a quick assessment of damage type and severity to avoid complicated manuals and learning processes. He does not need to think of the positioning as the GPS-coordinates are stored simultaneously as the operator registers the damages. A simple tool will also give the user a better feeling and make him more positive to the survey system and willing to do it again. This will give data with improved quality.

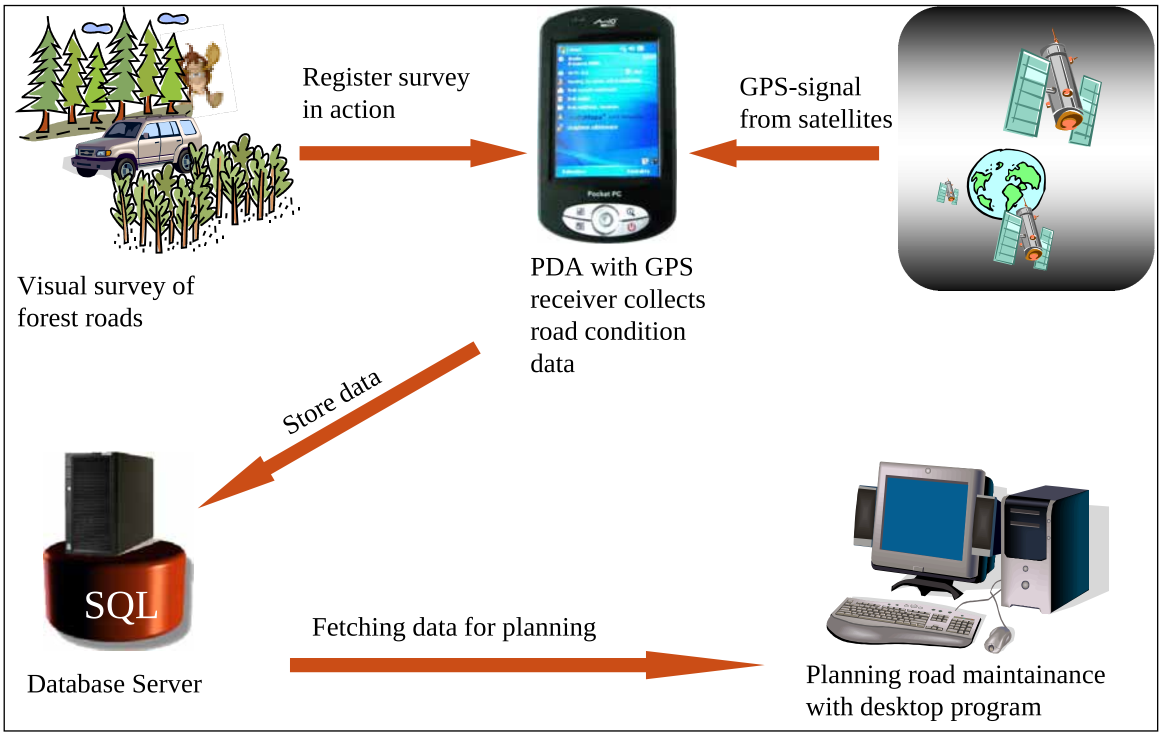

Figure 4-3 Principle for road survey with pocket PC.

4.3 DATA PROCESSING

When the road condition data collection is finished for a part road network the data should be transferred to a data base server for storage. From there a computer can acquire data to be processed and by using some road data visualizing software, e g Road Doctor, to make a geographic information system with road condition maps to visualize road damage types and their extent. This could be shown on different maps e g geological maps and maps showing forest areas with different silvicultural plans. All this information data could be accessible for the forest owners and the transportation companies, e g in a homepage on Internet.

4.4 OUTPUT AND USE OF INFORMATION

After data processing the data could be presented in different ways and showing different things. Down below an example demonstrating the drainage in three classes for a road network is shown on a GIS map (figure 4-4). The same type of map can be formed showing any other defect type which has been surveyed and registered. The map gives an overview of the road network from an area in Scotland. The data could also be shown on other maps, e g a geological map showing the basic ground conditions (figure 4-5) or a map showing planned silvicultural actions for the future. If statistical data from earlier surveys are available in the data base it is possible also to show the development of the different defects and to see if maintenance measures taken, if registered, have given any effects.

The maps can be used to plan the maintenance activities in an area and to ensure that the measures will be taken at the right position by using the coordinates at the beginning and the end of a damaged road section. It will create possibilities to combine maintenance activities in different parts of the road network and to combine maintenance actions of different kinds. The method may also be used as a quality control tool to find out if the measures taken have given the planned effects. The GIS-maps will be excellent means to make better decisions of correct actions at the right locations, which will make the maintenance cheaper and facilitate to keep the road conditions at the proper level.

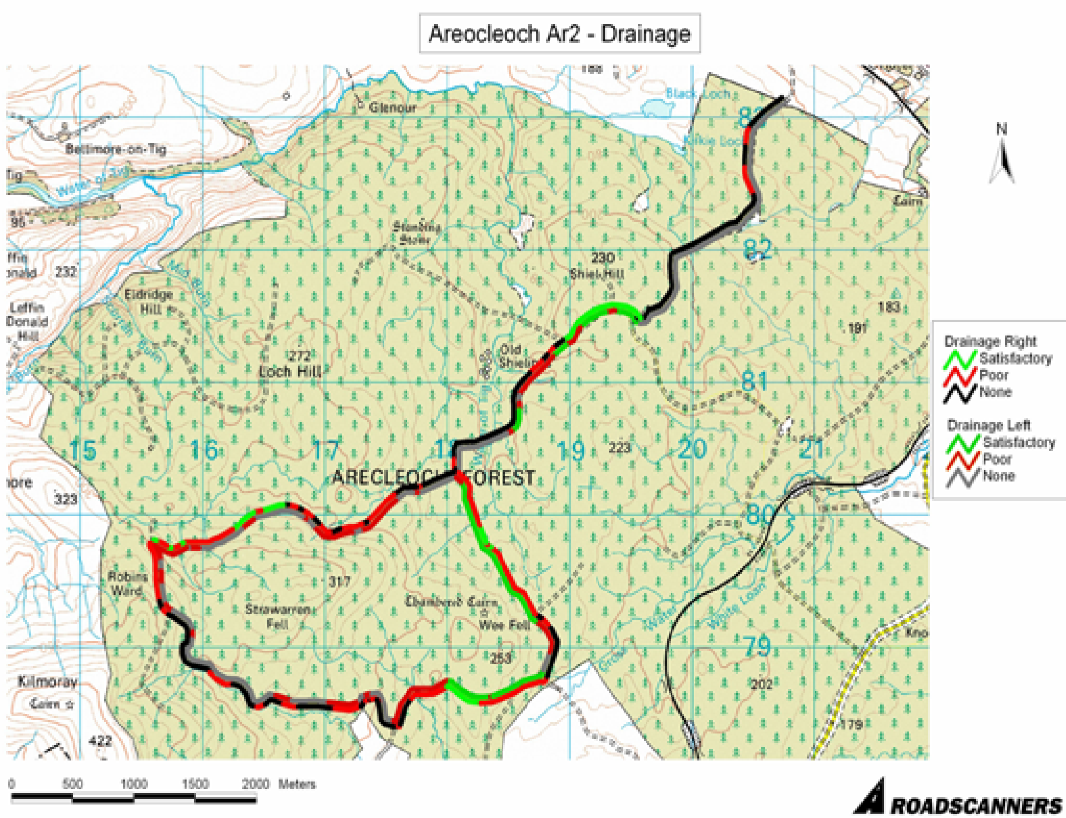

Figure 4-4 GIS-map showing drainage conditions on a forest road.

For timber transportation and road rehabilitation purposes the map should also show the current transportation needs and the planned felling activities together with the current road condition data.

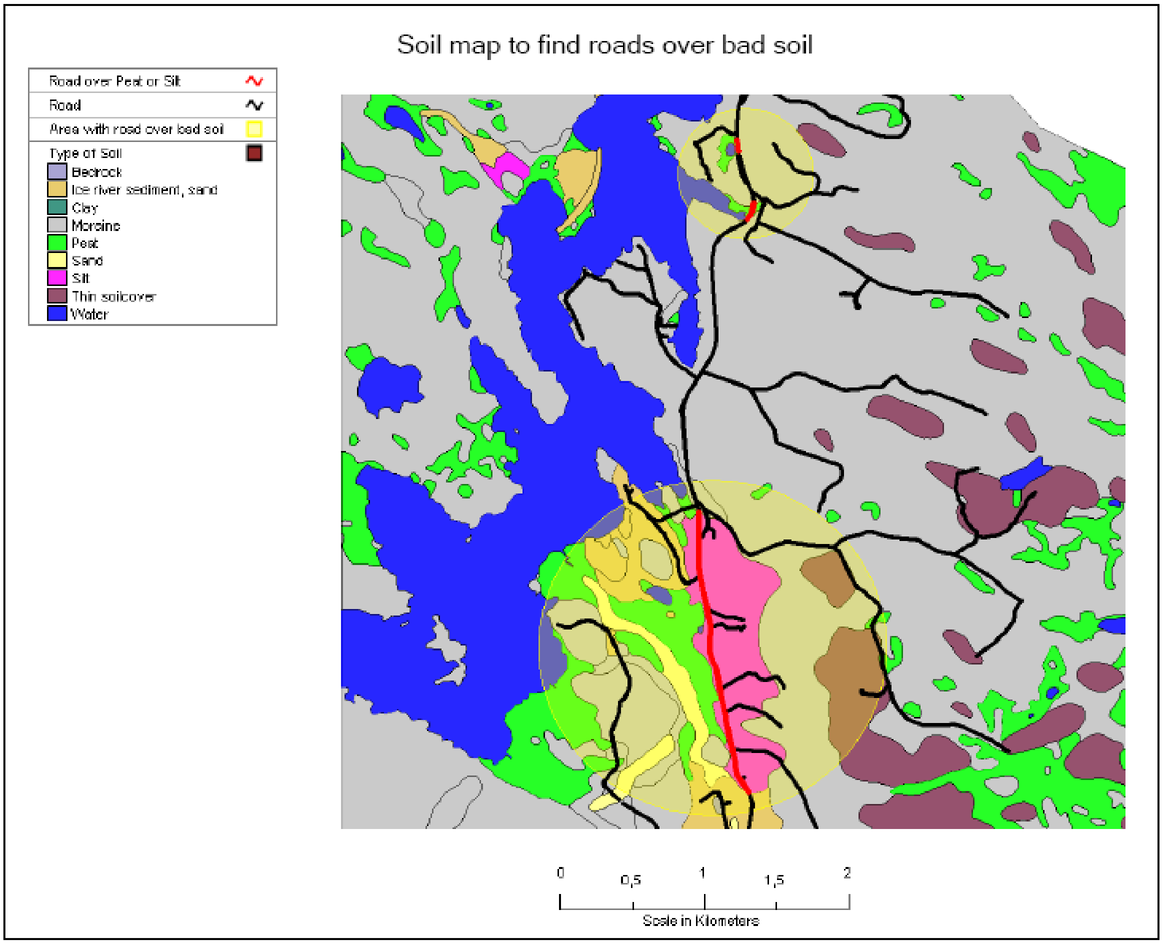

Figure 4-5 GIS map showing bad spots for special care.

Chapter 5 Road standard - Intervention levels

The intervention levels should be based on type, severity and extent of defects. The roughness values from a Finnish proposal are introduced as trigger values in the tables for gravel roads. It has not been possible to check the proposed values within the project and search on Internet has not resulted in any useful findings, so this is still left to be investigated. The roughness measurement shall be done at the actual design speed of the road or recalculated from the measurement speed to the design speed of the actual road. The standard level should be controlled continuously, but at least annually, by performance inspections. If the road condition does not meet the standard some measure should be done within the action time given in the tables. The tables shown below are from the ROADEX II report (1), and should be regarded as examples of intervention levels for different standard classes. It is recommended that the road managers decide an own defect level for each defect type, severity and extent for every forest road standard class within a forest road network. The templates in appendix 1 can be used for the purpose.

STANDARD CLASS A FOR FOREST ROADS, Intervention levels

Defect	**Extent intervention level**	**Activity**
a) Depth of wearing course gravel 0 mm	On > 20 % of sub-length.	Resheeting of pavement including supply and placing of imported material
d) Roughness measured with accelerometer	A1, 20-30 m/s^2	

STANDARD CLASS B FOR FOREST ROADS, Intervention levels

Defect	**Extent intervention level**	**Activity**
a) Defect depth > 150 mm or water ponds	On > 20 % of sub-length.	Heavy formation grading including re-watering and compaction.
b) Crossfall < 3 % or > 7 %	On > 20 % of sub-length.	
d) Roughness measured with accelerometer	10-20 m/s^2	

STANDARD CLASS C FOR FOREST ROADS, Intervention levels

Defect	Extent intervention level	Activity
a) Crossfall < 3 % or > 7 %	On > 20 % of sub-length of 1 km	Medium formation grading including re-watering and compaction
b) Ruts, potholes and corrugations > 50 mm deep	On > 20 % of sub-length of 1 km	
c) Roughness measured with accelerometer	5-10 m/s^2	

STANDARD CLASS D FOR FOREST ROADS, Intervention levels

Defect	Extent intervention level	Activity
a) Soft or slippery areas; loose material	On > 5 % of a sub-length of 1 km.	Light formation grading. Restoring of general defects.
b) Safe travel speed < 80 % of safe driving speed	On > 20 % of sub-length	
c) Ruts, corrugations, potholes < 50 mm depth	On > 20 % of sub-length.	
d) Roughness measured with accelerometer	< 5 m/s^2	

Chapter 6 Conclusions

It has been found that many road managers and road users for forest roads have difficulties in getting information about the road conditions on forest roads. A simple method for road condition surveys will take care of this problem. The method will facilitate the collection and the visualisation of the road condition results and make it cheaper and quicker to get them.

Quick and reliable information of the road conditions of forest roads will facilitate planning of maintenance and rehabilitation and also transportation planning and reduce costs.

Documentation of regular road condition survey results will make it possible to follow the development of the road deterioration.

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APPENDIX 1 ROAD STANDARDS – INTERVENTION LEVELS

STANDARD CLASS A FOR FOREST ROADS, Intervention levels

Defect	Minor	Severe	Extent	Activity	Action required within					
					A1	A2	A3	A4	A5	A6
1) Drainage, ditches	X		> 20 % of 1 km	Clear and/or reform ditches						
		X								
2) Vegetation	X		> 20 % of 1 km							
		X								
3) App stones, boulders	X		> 20 % of 1 km							
		X								
4) Potholes	X		> 20 % of 1 km							
		X								
5) Rutting	X		> 20 % of 1 km							
		X								
6) Frost damages	X		> 20 % of 1 km							
		X								
7) Surface softening	X		> 20 % of 1 km							
		X								
8) Cracking	X		> 20 % of 1 km							
		X								
9) Standing water on the road surface	X									
		X								
10) Culverts	X		> 25 % filled	Cleaning	Before autumn/ next spring					
		X	Damaged	Fix or exchange						
11) Depth of wearing course	X		> 20 % of 1 km	Reshaping						
		X								
12) Crossfall	X									
		X								
13) Roughness measured with accelerometer	X									
		X								

STANDARD CLASS B FOR FOREST ROADS, Intervention levels

Defect	Minor	Severe	Extent	Activity	Action required within					
					B1	B2	B3	B4	B5	B6
1) Drainage, ditches	X		> 20 % of 1	Clear and/or						
		X	km	reform ditches						
2) Vegetation	X		> 20 % of 1							
		X	km							
3) App stones, boulders	X		> 20 % of 1							
		X	km							
4) Potholes	X		> 20 % of 1							
		X	km							
5) Rutting	X		> 20 % of 1							
		X	km							
6) Frost damages	X		> 20 % of 1							
		X	km							
7) Surface softening	X		> 20 % of 1							
		X	km							
8) Cracking	X		> 20 % of 1							
		X	km							
9) Standing water on the	X									
road surface		X								
10) Culverts	X		> 25 % filled	Cleaning	Before autumn/ next spring					
		X	Damaged	Fix or exchange						
11) Depth of wearing	X		> 20 % of 1	Reshaping						
course		X	km							
12) Crossfall	X									
		X								
13) Roughness measured	X									
with accelerometer		X								

STANDARD CLASS C FOR FOREST ROADS, Intervention levels										
Defect	**Minor**	**Severe**	**Extent**	**Activity**	**Action required within**					
					C1	**C2**	**C3**	**C4**	**C5**	**C6**
1) Drainage, ditches	X		> 20 % of 1	Clear and/or						
		X	km	reform ditches						
2) Vegetation	X		> 20 % of 1							
		X	km							
3) App stones, boulders	X		> 20 % of 1							
		X	km							
4) Potholes	X		> 20 % of 1							
		X	km							
5) Rutting	X		> 20 % of 1							
		X	km							
6) Frost damages	X		> 20 % of 1							
		X	km							
7) Surface softening	X		> 20 % of 1							
		X	km							
8) Cracking	X		> 20 % of 1							
		X	km							
9) Standing water on the	X									
road surface		X								
10) Culverts	X		> 25 % filled	Cleaning	Before autumn/ next spring					
		X	Damaged	Fix or exchange						
11) Depth of wearing	X		> 20 % of 1	Reshaping						
course		X	km							
12) Crossfall	X									
		X								
13) Roughness measured	X									
with accelerometer		X								

STANDARD CLASS D FOR FOREST ROADS, Intervention levels

Defect	Minor	Severe	Extent	Activity	Action required within					
					D1	D2	D3	D4	D5	D6
1) Drainage, ditches	X		> 20 % of 1	Clear and/or						
		X	km	reform ditches						
2) Vegetation	X		> 20 % of 1							
		X	km							
3) App stones, boulders	X		> 20 % of 1							
		X	km							
4) Potholes	X		> 20 % of 1							
		X	km							
5) Rutting	X		> 20 % of 1							
		X	km							
6) Frost damages	X		> 20 % of 1							
		X	km							
7) Surface softening	X		> 20 % of 1							
		X	km							
8) Cracking	X		> 20 % of 1							
		X	km							
9) Standing water on the	X									
road surface		X								
10) Culverts	X		> 25 % filled	Cleaning	Before autumn/ next spring					
		X	Damaged	Fix or exchange						
11) Depth of wearing	X		> 20 % of 1	Reshaping						
course		X	km							
12) Crossfall	X									
		X								
13) Roughness measured	X									
with accelerometer		X								

APPENDIX 2 DEFECT CATALOGUE

1a) Bad drainage, minor

1b) Bad drainage, severe

2a) Vegetation, minor

2b) Vegetation, severe

3a) Appearing stones and boulders, minor

3b) Appearing stones and boulders, severe

4a) Potholes, minor

4b) Potholes, severe

5a) Rutting, minor

5b) Rutting, severe

6a) Frost damages, minor

6b) Frost damages, severe

7a) Surface softening, minor

7b) Surface softening, severe

8a) Cracking, minor

8b) Cracking, severe

9a) Standing water on the road surface, minor

9b) Standing water on the road surface, severe

10a) Culverts, minor

10b) Culverts, severe

11) Depth of wearing course

Depth of wearing course should be measured with a ruler in places where incorrect thickness can be causing a defect. A thickness between 40-50 mm can be considered as suitable thickness.

12) Crossfall

The crossfall on straight road should have an aim value of 4 % but should never be less than 1,5 %. At all sections the crossfall together with the vertical road inclination shall provide the sufficient water run off.

13) Roughness measured with accelerometer

Measurements should be made at the design speed of the measured road section and the obtained values should be compared with intervention levels for the standard class of the road section.