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STATE OF THE ART TOOLS USED IN FOREST ROAD NETWORK PLANNING IN A PRIVATE FOREST DISTRICT FROM LOWER AUSTRIA

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Introduction

Sustainable use of forests in mountainous regions requires a properly developed forest infrastructure. Strategic decisions in timber harvesting have long term consequences on the further development of forests (Kfihmaier, 2010) and efficient harvesting systems are based on well established forest road networks (Stampfer, 2010). Under these circumstances, forest road network planning plays a crucial role in fulfilling the goals of sustainable forest management and in valuing the multiple uses of forests and in finding the pragmatic solutions which are best adapted to the local socio-economic and environmental conditions (Enache, 2009).

Goals and Objectives

The aim of this paper was to develop a forest road network in a project area from Trauch Forest District, Lower Austria. Because of damaged valley roads, the access to forest stands from upper part of the slopes is limited. Forest operations are difficult to realize, the risk of accidents among forest workers is high, timber extraction and road maintenance costs are also high. This project had to fulfill the following objectives: improve the access to forest stands; facilitate tending operations and other forest management activities; reduce harvesting costs; create possibility for use of harvesters, forwarders and uphill cable yarding systems; assess road construction costs.

Material and methods

This paper was elaborated using a project management approach and state of the art tools for road network planning. A general planning with compass step method (Steinmfiller, 2008) was developed on a contour line map, followed by field measurements and zero plane marking in the field (Enache, 2009). The data has been then analyzed and processed using the state of the art tools for forest road network planning: RoadEng® software for detailed project planning (calculation of earth mass movements ï Fig.3; horizontal and vertical curvature corrections ï Fig.2; cross sections design; plan of the designed road; longitudinal profile; technical report ï Fig.1), Microsoft® Excel data sheets and synthetic tables, and ESRI® Arc GIS for mapping the new forest road network.

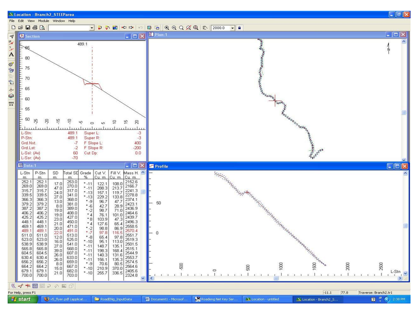

Fig. 1 *Location Module in RoadEng® (Enache, 2009)*

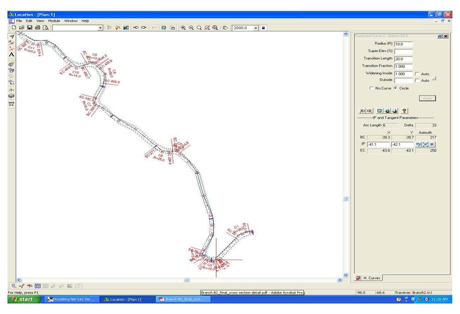

Fig.2 *Plan window in Location module, RoadEng® (Enache, 2009)*

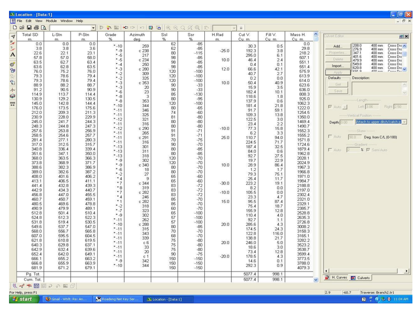

Fig.3 *Data report for branch B2 in RoadEng® (Enache, 2009)*

RoadEng® Forest Engineer version is a Canadian software for planning and designing forest operations and forest roads, consisting of three modules (www.softree.com, 23rd April, 2009): Survey/Map, Terrain and Location. The field data was introduced in Survey module and was processed in the Location module following the next procedure: defining special templates (Earthwork, Rocky area, Culverts); assigning defined templates to certain sectors of the forest road; horizontal and vertical curves alignment; printing the results (cross sections, longitudinal profile, data reports).

The templates refer to special elements of the road that must be applied during designing, depending on terrain characteristics, geomorphology and slope. Using these templates, the width of the road bed in rocky terrain was defined to 4,50 m and for earthy terrain to 5,00 m. In both cases the pavement was designed in crown shape with slope of 3% on each side. The width of the pavement was defined to 3,50 m for rocky terrain and to 4,00 m for earthy terrain. Metallic pipes with diameter of 400 mm were designed for ditch water evacuation, and of 600 mm or 800 mm in combination with fords for crossing existing streams. The distance between culverts was set to 70 m, their position being adjusted according to the longitudinal profile.

Using the outputs of Terrain module, the GPS coordinates collected in certain surveyed points from the project area were assigned in AutoCAD® to points on the alignment of the designed road and in this way geo-referencing the plan of the road network was realized (Enache, 2009). The geo-referenced plan of the road network was imported in GIS, where, together with available orthophotos and forest data base, a map of the project area with the designed forest road network was generated.

Project Area

The project area of 400 ha is located in the southern part of Lower Austria, in Trauch Forest District. The elevation varies between 750 m and 1300 m above sea level. The climate is characterized by cold winters with average January temperatures of -2,6ºC, and hot summers with average July temperatures of 15,5ºC. The annual average temperature is 6,5ºC and the annual average precipitation is about 1300 mm. The geomorphology is characterized by dolomites and limestone (96%), and by alluvial valley deposits (4%). About 7% of the project area is located in flat terrain (slope < 25%), 45% in moderate slope conditions and 48% in steep terrain (>55%, Fig.4). Current forests in the project area are dominated by maple (41%), beech (32%) and Norway spruce (22%), more than 50% of these forests being over aged (>120 years).

The forest road density in project area is about 18,5 m/ha, due to mainly surrounding valley roads, but taking in consideration damaged valley roads the density reduces to 14,9 m/ha. Current main harvesting technology used in the project area is downhill cable yarding systems (medium and long distance).

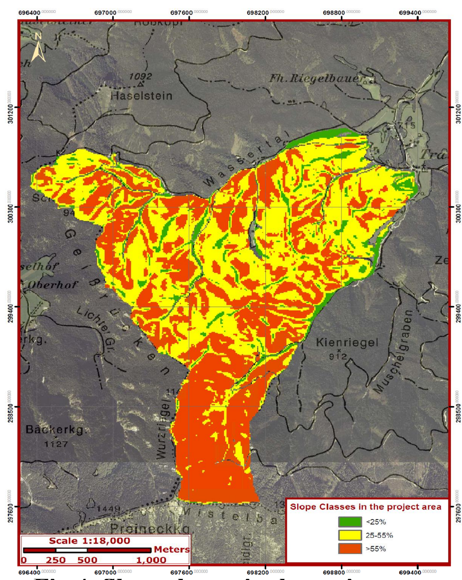

Fig.4. *Slope classes in the project area (Enache, 2009)*

General characteristics of Trauch Forest Road Network

Table 1.

Specification	Branches					Total
	Main	B1	B2	B3	B4	
Total Length (km)	13.35	0.75	1.68	0.32	1.00	17.10
Rocky area (km)	1.74	0.13	0.65	0.00	0.06	2.58
Fords /Stone Walls (m)	0.00	99.20	45.00	0.00	8.00	152.20
Φ 800 mm culverts	4	1	3	0	2	10
Φ 600 mm culverts	2	0	2	0	1	5
Segments ≤9% (km)	10.53	0.55	0.52	0.32	0.43	12.35
Segments 9-12% (km)	2.47	0.20	1.08	0.00	0.40	4.15
Segments ≥12% (km)	0.35	0.00	0.08	0.00	0.17	0.60

Results

Through a participatory process of the project stakeholders for choosing the best road alternatives for specific sectors, resulted a final forest road network with a total length of 17.10 km, consisting of one main road and four branches (Table 1). The designed road density is 42.77 m/ha and the road distance is of 234 m.

The slope gradient change between consecutive pegs was kept in the range of 3-5%, resulting a road network with slope gradients below 9% for 12.35 km and slope gradients between 10 ï 12% for 4.15 km. For short distances, slope gradients of 14% to 16% have been used. For road drainage, 250 metallic pipes with diameter of 400 mm were set at an interval of 70 m. Metallic pipes of 600 mm and 800 mm diameter were used in combination with fords and downhill stabilizing stone walls, for crossing permanent water streams.

The efficiency analysis counted the benefits the forest owner will earn by implementing this project. The return on investment was calculated considering road construction costs, its maintenance costs and timber harvesting costs for 30 years, at an interest rate of 4%. The overall average construction cost is 33.52ú/m. Construction costs vary from 25 ï 30 ú/m in moderate terrain conditions to 49.00 ú/m (branch B1) and 62.50 ú/m (branch B2) in difficult terrain conditions. Before the new road network design only 14% (56.18 ha) of the project area could be harvested by skidder or harvester ï forwarder, for the rest of 86% of the area (345.02 ha) downhill cable yarding systems had to be used. Under these circumstances, the average extraction costs were 27.90 ú/m3. With the new road network, the area where the use of skidder, harvester and forwarder technologies became possible increased to 211.60 ha and 189.60 ha can be harvested by uphill cable yarding systems. Thus the harvesting costs decreased to 22.60 ú/m3.

The combined use of RoadEng® and ESRI® Arc GIS proved to be very useful in the decision making process, as it provided sound information regarding cross sections, earth mass movements, longitudinal profile, drainage system and possible road variants.

Acknowledgements

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