Forest road network in the Republic of Croatia – Status and perspectives

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Abstract – Nacrtak

Forest traffic infrastructure is one of the basic preconditions for good quality forest ecosystem management. Since 1991, when the Republic of Croatia gained independence and the company Hrvatske šume d.o.o. Zagreb (then Public Enterprise Hrvatske Šume Zagreb) was founded, a large amount of financial resources has been invested in the construction of new and the maintenance and repair of the existing forest roads. Despite considerable past investments in this forestry segment, many more kilometres of forest roads will have to be built until optimal forest openness is achieved. This article analyzes the situation with regard to forest roads in Croatia and focuses on the current state of openness, planned openness, annual construction plans, average construction costs, design costs and others. Problems occurring in the procedure of opening up forests (planning, design, construction with supervision and maintenance) are defined and some basic guidelines for their solution proposed.

Keywords: forest roads, planning, design, construction, maintenance, costs, Croatia

1. Introduction and Research Topic – *Uvod i problematika istraživanja*

Forest traffic infrastructure can be divided into three groups: primary, secondary and special-purpose infrastructure. This paper deals with primary and secondary forest traffic infrastructure. Primary forest traffic infrastructure comprises all truck forest roads – haul forest roads (TFR) and those public roads (PR) which can be used for forest operations (as a rule these are lower-level public roads). Secondary forest traffic infrastructure is made up of skid roads (SR) and skid trails (ST). Skid roads, like truck forest roads, are construction amenities of a permanent character, whereas skid trails are formed by repeated passage of a machine along the same route without any construction work and are temporary in character.

Planning, design (field and office part), construction with supervision, and maintenance are essential components of a complex procedure of establishing an optimal network of primary forest traffic infrastructure in the field (Pentek et al. 2004b). The core elements in the establishment of an optimal network of secondary forest roads in the field include planning, construction with supervision and repairs. These operation stages are closely intertwined and inseparably linked, which means that one operation stage cannot be started unless the previous one has been successfully completed.

From the standpoint of modern forest ecosystem management, an ideal solution is to plan SR simultaneously with planning TFR. This makes it possible to predict in advance the preliminary routes of both primary and secondary forest roads and their category (which is characterized by given technical features and construction standards), evaluate construction costs and subsequent maintenance (repairs), and define annual plans of construction dynamics in accordance with management plans, felling plans, profits and losses, etc. (Pentek et al. 2006).

In order to make quality planning of all forest operations, and in particular of harvesting and opening up forests with forest roads, it is necessary to review the existing transportation infrastructural resources. For this reason, a cadastre of primary forest traffic infrastructure was set up for state forests in Croatia within the company Hrvatske Šume Zagreb (hereinafter »HŠ«), conclusively with December 31, 2001. The methodology of its design was developed in cooperation with the »HŠ« and the Department of Forest Engineering of the Faculty of Forestry, University of Zagreb (Anon. 1998b). The cadastre consists of textual (tables) and pictorial (maps) parts.

Once a cadastre of primary forest traffic infrastructure is established, it should be reviewed at the end of the year and updated with new components built in the course of the current year.

At present there is no cadastre of secondary forest traffic infrastructure at the level of the company »HŠ«; in other words, the components of permanent character (skid roads) are missing. Pentek et al. (2003) propose a methodology of drawing up a secondary forest road cadastre, prepare a cadastre for the Management Unit Veprinačke Šume, Opatija Forest Administration, Buzet Forest Office, and list its advantages.

After the potential route of a TFR is positioned in the field using a GPS device, the axle polygon of the designed TFR is fitted in; this is a transition from the planning stage to the designing stage (Pentek et al. 2004b). Designing consists of two temporally and spatially separated subphases: field subphase and office subphase. All parameters necessary for a detailed design of the TFR are collected in the field using geodetic measuring stations. The collected data are

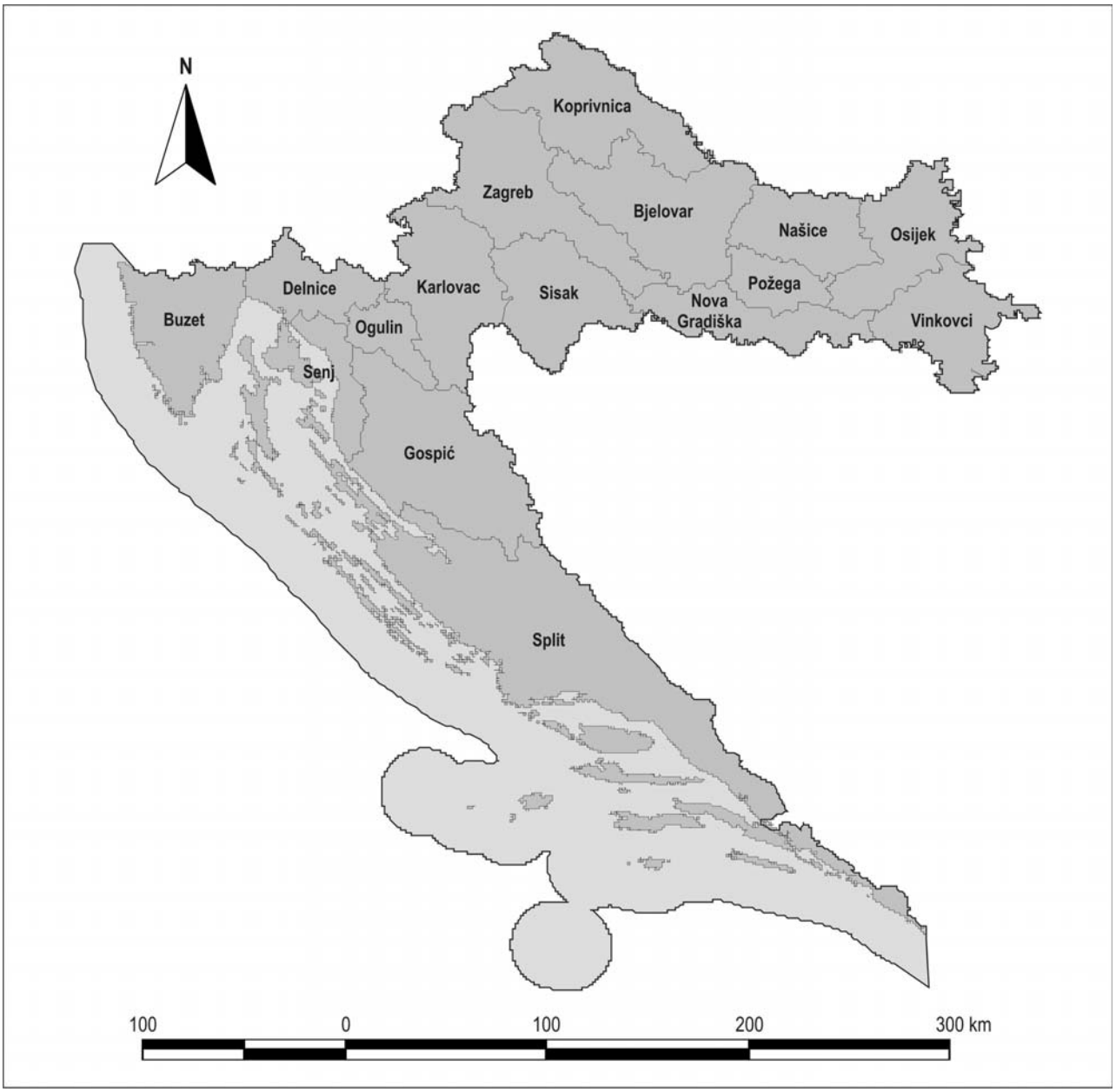

Fig. 1 Map of the Republic of Croatia with marked Forest Administrations
Slika 1. *Karta Republike Hrvatske s ucrtanim UŠP*

processed with the computer programme »CESTA«. The TFR detailed design, signed by a certified engineer, is submitted for verification to County Offices of State Administration of Environmental Protection, Physical Planning and Construction. After verification, the design is put into operation.

Forest roads are built by both the »HŠ« (their own capacities) via their operational units »Građevinarstvo« (located in 8 out of 16 Forest Administrations), and by private entrepreneurs. Private entrepreneurs compete for jobs in public bids (best bid), in which the highest (upper) investment cost is cited (in line with the bill of charges from the detailed design), while prospective contractors submit their bids, together with other requested documentation, in writing. Bid opening is public.

The investor and the contractor sign a Service Agreement and a Protocol on the Receipt of the building site, which introduces the contractor into work. The investor designates a supervising engineer and the contractor designates their representative on the building site.

After a truck forest road has been built, it should be regularly and periodically maintained so that the required quality of the forest transport network is retained. The higher the category of a truck forest road is, the more frequent and extensive periodic maintenance jobs, and vice versa (Pentek et al. 2006).

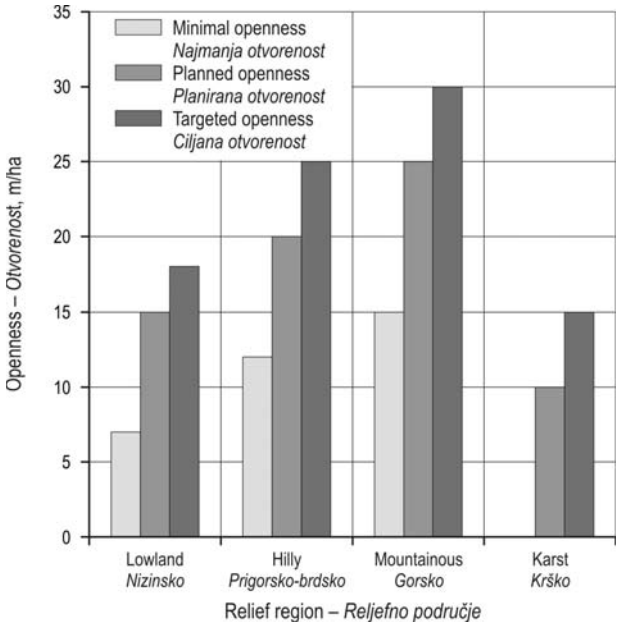

Fig. 2 Minimal, planned and targeted openness for different relief areas in the Republic of Croatia

Slika 2. *Najmanja, planirana i ciljana otvorenost za različita reljefna područja Republike Hrvatske*

2. Goal and Research Methods – *Cilj i metode istraživanja*

The goal of research is to analyze the situation relative to forest roads in the Republic of Croatia, recognize and clearly define the detected problems according to the stages of optimal forest road network establishment in the field (planning, design, construction with supervision and maintenance-repair), and propose procedures for their solution.

3. Research Area – *Područje istraživanja*

The area of research embraces forests and forestland in the Republic of Croatia managed by the company »HŠ« (2,018,987 ha or 75.1%) through their sixteen Forest Administrations (hereinafter: FA). Natural forests account for 95% and artificially raised cultures and plantations for only 5% of the above area. Forested areas in the continental part of Croatia cover 59% and forests on karst 41% of the area.

4. Research Results – *Rezultati istraživanja*

4.1 Current situation related to forest road network in the Republic of Croatia – *Postojeća situacija glede šumskih prometnica u Republici Hrvatskoj*

4.1.1 Primary forest openness – *Primarna otvorenost šuma*

Figure 2 shows the minimal prescribed openness in 1990 (Šikić et al. 1989), planned openness by 2010 (Anon. 1997a) and targeted openness by 2020 (Pentek et al. 2006) for different relief regions in the Republic of Croatia. This allows a comparison between varying kinds of primary openness and existing primary openness.

The above openness values are only preliminary guidelines which should be followed in the absence of better ones, but they should not be blindly adhered to, because the opening up of any management unit, watershed or gravitational area is a specific problem that calls for specific solutions concordant with the concrete stand and site conditions (Pentek et al. 2005).

Table 1 shows existing primary openness in Forest Administrations (FA) calculated as average openness, although the majority of FA are characterized by a combination of different relief areas. The years in which the cadastres were updated differ for some FA; consequently, the present situation, particularly in those FA that are being intensively opened up by

Table 1 Existing primary openness in the Republic of Croatia (according FA)
Tablica 1. *Postojeća primarna otvorenost UŠP*

Forest Administration *Uprava šuma podružnica*	Category Roads *Kategorija ceste*	Length *Duljina*	Effective length *Ulazi u otvorenost*	Forested area *Obrasla površina*	Openness *Otvorenost*	Condition *Stanje*
		km	km	ha	m/ha	Year – *Godina*
Vinkovci	Public – *Javna*	–	91.61	68,173.92	1.34	2003
	Forest – *Šumska*	397.03	349.95		5.13	
	Total – *Ukupno*	**397.03**	**441.56**		**6.47**	
Osijek	Public – *Javna*	–	82.05	57,286.05	1.43	2002
	Forest – *Šumska*	418.12	298.06		5.20	
	Total – *Ukupno*	**418.12**	**380.11**		**6.63**	
Našice	Public – *Javna*	–	140.74	78,537.60	1.79	2003
	Forest – *Šumska*	1,624.82	1,352.38		17.22	
	Total – *Ukupno*	**1,624.82**	**1,493.12**		**19.01**	
Požega	Public – *Javna*	–	85.19	48,714.84	1.75	2003
	Forest – *Šumska*	707.74	598.58		12.29	
	Total – *Ukupno*	**707.74**	**683.77**		**14.04**	
Bjelovar	Public – *Javna*	–	282.34	123,633.00	2.28	2003
	Forest – *Šumska*	1,838.37	1,216.78		9.84	
	Total – *Ukupno*	**1,838.37**	**1,499.12**		**12.12**	
Koprivnica	Public – *Javna*	–	309.21	59,040.00	5.24	2003
	Forest – *Šumska*	793.15	664.03		11.25	
	Total – *Ukupno*	**793.15**	**973.24**		**16.49**	
Zagreb	Public – *Javna*	–	419.32	75,354.53	5.56	2004
	Forest – *Šumska*	802.95	641.90		8.52	
	Total – *Ukupno*	**802.95**	**1,061.22**		**14.08**	
Sisak	Public – *Javna*	–	135.75	83,906.16	1.62	2003
	Forest – *Šumska*	549.06	421.00		5.02	
	Total – *Ukupno*	**549.06**	**556.75**		**6.64**	
Karlovac	Public – *Javna*	–	99.63	76,782.00	1.30	2003
	Forest – *Šumska*	958.82	674.36		8.78	
	Total – *Ukupno*	**958.82**	**773.99**		**10.08**	
Ogulin	Public – *Javna*	–	81.53	51,902.00	1.57	2002
	Forest – *Šumska*	865.82	718.55		13.84	
	Total – *Ukupno*	**865.82**	**800.08**		**15.41**	
Delnice	Public – *Javna*	–	241.26	92,437.99	2.61	2003
	Forest – *Šumska*	1,989.93	1,742.14		18.85	
	Total – *Ukupno*	**1,989.93**	**1,983.40**		**21.46**	
Senj	Public – *Javna*	–	137.00	67,688.56	2.02	2001
	Forest – *Šumska*	1,612.98	1,033.81		15.27	
	Total – *Ukupno*	**1,612.98**	**1,170.81**		**17.29**	
Gospić	Public – *Javna*	–	345.00	266,324.24	1.30	2005
	Forest – *Šumska*	1,904.22	1,731.11		6.50	
	Total – *Ukupno*	**1,904.22**	**2,076.11**		**7.80**	

Forest Administration *Uprava šuma podružnica*	Category Roads *Kategorija ceste*	Length *Duljina*	Effective length *Ulazi u otvorenost*	Forested area *Obrasla površina*	Openness *Otvorenost*	Condition *Stanje*
		km	km	ha	m/ha	Year – *Godina*
Buzet	Public – *Javna*	–	289.31	63,276.36	4.57	2003
	Forest – *Šumska*	434.26	331.97		5.25	
	Total – *Ukupno*	**434.26**	**621.28**		**9.82**	
Split	No comparable data – *Nema usporedivih podataka*					
Nova Gradiška	Public – *Javna*	–	64.94	69,019.25	0.94	2003
	Forest – *Šumska*	650.30	574.79		8.33	
	Total – *Ukupno*	**650.30**	**639.73**		**9.27**	
Total »HŠ« *Ukupno HŠ*	Public – *Javna*	–	2,804.88	1,282,076.50	2.19	–
	Forest – *Šumska*	15,547.57	12,349.41		9.63	
	Total – *Ukupno*	**15,547.57**	**15,154.29**		**11.82**	

truck forest roads, is much better. A part of the data for FA Split is missing and is therefore not presented here. The total data on the quantity of public roads and truck forest roads, as well as on primary forest openness at the level of the »HŠ« does not include FA Split.

In order to make an in-depth analysis of primary openness and obtain comparable results, the data should be reduced to the level of management unit. The management unit must previously be categorized according to the relief area. The data on primary openness of a particular management unit should also be complemented with the data on the mean skidding distance. This allows for the analysis of the quality of spatial positioning of a TFR.

4.1.2 Engineering operations in the period 2004–2006 in the company Hrvatske šume – *Radovi na niskogradnji u razdoblju 2004 – 2006. na razini poduzeća »Hrvatske šume« d.o.o.*

Engineering activities performed by the company »HŠ« in the period 2004–2006 are given in Table 2. The selected time period is also the period of the present »HŠ« management board's activity; thus, the presented data simultaneously show the results of the company's business policy. Engineering operations are divided into four basic categories: building the lower TFR layer, building the upper TFR layer, TFR maintenance and building SR.

An average of 272 km of the lower forest road layer is constructed annually at a cost of 118,134 kn/km on average. Construction work on the upper layer entails 319 km of forest roads at a mean cost of 135,020 kn/km. The average price of one fully completed kilometer of a forest road is 253,154 kn. The real cost of overall FR construction differs considerably from the planned cost, especially if the real cost is the one cited in the bill of charges of the detailed design, and not the one achieved in a public bid.

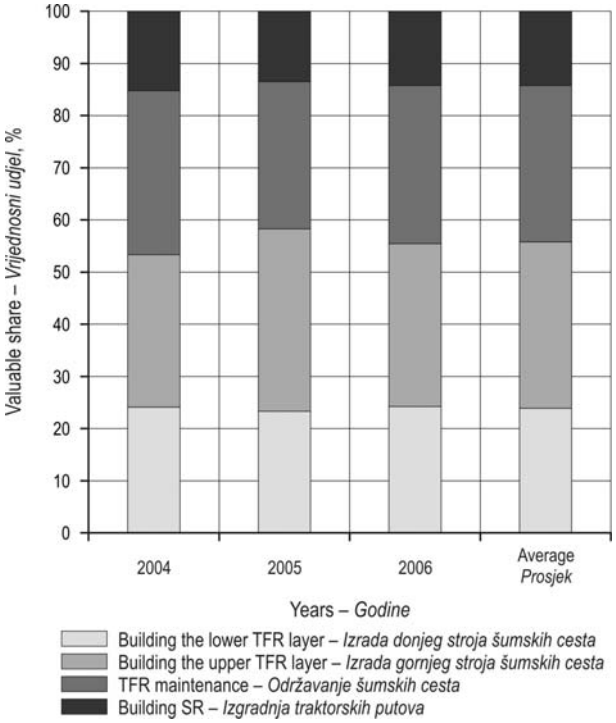

Fig. 3 Share of a particular group of engineering operations within the company »HŠ« in the period 2004–2006

Slika 3. *Udio pojedine skupine radova na niskogradnji u razdoblju 2004 - 2006. na razini poduzeća HŠ*

On average, 3,521 km of truck forest roads are maintained annually (21% of the total quantity of TFR in Croatia according to the available data from the TFR cadastre, also taking into account the TFR in

Table 2 Engineering activities undertaken within the company »HŠ« in the period 2004–2006
Tablica 2. *Obavljeni radovi na niskogradnji u razdoblju 2004 – 2006. na razini poduzeća HŠ*

	Engineering activities – *Radovi na niskogradnji*			Executed with HŠ capacities – *Obavljeno vlastitim kapacitetima*		
	Quantity *Količina*	Value *Vrijednost*	Price *Cijena*	Quantity *Količina*	Value *Vrijednost*	Share *Udio*
	km	10^3 x kn	kn/km	m	10^3 x kn	%
Lower TFR layer – *Izrada donjega stroja ŠC*						
2004	251.60	26,788	106,471	173,95	19,042	71.08
2005	292.43	31,267	106,921	163,14	18,850	60.29
2006	272.68	38,426	140,920	168,00	24,848	64.66
Total / average – *Ukupno/prosječno*	816.71	96,481	118,134	505,09	62,740	65.03
Upper TFR layer – *Izrada gornjega stroja ŠC*						
2004	229.64	32,471	141,400	133,58	18,002	55.44
2005	374.36	47,039	125,652	146,48	22,787	48.44
2006	351.62	49,518	140,828	205,25	30,692	61.98
Total / average – *Ukupno/prosječno*	955.62	129,028	135,020	485,31	71,481	55.40
TFR Maintenance – *Održavanje ŠC*						
2004	3,049.07	34,965	11,467	1,267,15	17,461	49.94
2005	3,287.52	37,880	11,522	1,257,43	18,388	48.54
2006	4,226.50	48,119	11,385	1,804,20	24,646	51.22
Total / average – *Ukupno/prosječno*	10,563.09	120,964	11,452	4,328,78	60,495	50.01
SR Construction – *Izgradnja TP*						
2004	799.11	16,946	21,206	229.93	3,929	23.19
2005	876.68	18,115	20,663	242.18	4,252	23.47
2006	952.73	22,567	23,687	249.10	5,041	22.34
Total / average – *Ukupno/prosječno*	2,628.52	57,629	21,925	721.21	13,222	22.94
All engineering operations – *Svi radovi na niskogradnji*						
2004		111,170			58,434	52.56
2005		134,301			64,277	47.86
2006		158,630			85,227	53.73
Total – Ukupno		404,101			207,938	/
Average – *Prosječno*		134,700			69,313	51.46

the area of FA Split) costing 11,452 kn/km (1 EUR = 7.40 kn). A total of 876 km of skid roads are built every year at an average cost of 21,925 kn/km.

The overall value of all engineering work amounts to 134,000,000 kn annually on average, of which over half (51.46%), calculated on the basis of the value of executed work, was accomplished by the company »HŠ« with their own capacities.

In the overall structure of engineering operational costs (Fig. 3), costs of building the upper layer of a TFR (31.93%) account for the highest average share in the period 2004–2006, followed by costs of TFR maintenance (29.93%), then costs of building the lower layer of a TFR (23.88%) and finally costs of building SR (14.26%).

4.1.3 Forest road planning – identifying problems – *Planiranje šumskih prometnica – definiranje problema*

Forest road planning (hereinafter FR) is the first and the most important phase in the optimization procedure, which leads to determining the preliminary route of a FR and allows for a comprehensive

solution to the issue of opening up a particular forest area (usually a management unit).

This phase of establishing an optimal FR network is often omitted in practice. On the one hand, justification is sought in the non-existence of a Study of Primary Forest Opening and a Study of Secondary Forest Opening, which should define preliminary TFR and SR routes, and on the other hand, there is constant urgency to construct new TFR and SR necessary for the accomplishment of activities set down in Management plans.

New preliminary routes of FR in the field are determined imprecisely and no account is taken of the best possible TFR and SR route variants (optimized in terms of all optimization evaluation criteria). In addition, the problem of opening up forests is not solved at the level of management units but partially (usually without any consideration for the existing primary and secondary forest traffic infrastructure). As a result, the targeted mean skidding distances are achieved with the construction of more kilometres of forest roads than necessary. This increases the costs of TFR construction and maintenance in a given area (due to the higher number of kilometres); furthermore, in both horizontal and vertical sense, TFR and SR routes are laid out in such a manner that the unit cost of construction and maintenance (repair) exceeds the cost of TFR and SR routes defined by the basic Study of Primary and Secondary Forest Opening.

4.1.4 TFR design – identifying problems – *Projektiranje ŠC – definiranje problema*

The basic problems occurring in the procedure of truck forest road design are linked with:

⇒ The absence of suitable *Technical Requirements for Forest Roads*, since the effective *Technical Requirements for Economic Roads* are outdated, incomplete, contradictory and over-general,

⇒ The non-existence of a *Handbook of Truck Forest Road Design*, which would clearly and unequivocally respond to all the questions and problems a project engineer encounters in the field or office part of the work,

⇒ The newly established *Croatian Chamber of Forestry and Wood Technology Engineers* (hereinafter *Forestry Chamber*), which is still insufficiently active in the protection of the interests of the forestry profession,

⇒ The outdated computer programme »CESTA«, used as an official tool for TFR design,

⇒ Lack of uniformity in the produced TFR designs (form, content, and quality),

⇒ An insufficient number of well educated forest road project engineers (in terms of annual volume of planning, design, and supervising activities related to truck forest road construction),

⇒ The absence of lifelong training of forestry engineers that deal with FR-related problems.

4.1.5 TFR and SR construction and supervision of construction – identifying problems – *Izgradnja ŠC i TP te nadzor gradnje – definiranje problema*

This operational stage should ensure consistent compliance with project documentation and transfer of the designer's idea from the paper to the terrain. In order to achieve the conditions that will guarantee compliance with project documentation and a systematic inspection of activities, prior to starting the activities, the axle of a truck forest road should be laid out anew.

The following basic problems occur in the process of TFR and SR construction and supervision:

⇒ Lack of a procedure of licensing operations (technology) and forest road contractors. As a result, contractors are often untrained legal persons who, contrary to the provisions in the effective laws, generally do not employ suitable skilled personnel and do not possess adequate machinery and equipment. The final outcome is forest roads of poor quality and harmful environmental impacts.

⇒ The non-existence of a professional association of contractors dealing with the construction and maintenance of truck forest roads, which would protect their interests on the labour market, evaluate and assess its members and allow healthy competition. This is the reason that the prices in public bids are formed freely (no binding limits – the only limit is the upper, bid price put forward by the ordering party) and may drop by more than 30% in relation to the realistic, initial price. Later, the contractors often cannot meet the requirements set down in the contracted price, which again results in TFR that do not fully respect detailed designs.

⇒ In practice, contractors often fail to renew the layout of the route axle of a TFR and mark its cross-sections (although these operations are listed as primary items in cost estimates and bill of charges of any TFR). This renders good quality supervision of work and the transfer of detailed design to the field almost impossible, which again results in a TFR of inferior quality.

Table 3 TFR plan 2006–2015 and simulated openness in 2015 per FA
Tablica 3. *Plan izgradnje šumskih cesta 2006 – 2015. i projekcija otvorenosti 2015. godine po UŠP*

Forest Administration *Uprava šuma podružnica*	Construction Plan *Plan izgradnje*	Value of Work *Vrijednost radova*	Openness – Otvorenost		
			Existing *Postojeća*	Plan in 2015 *Plan 2015.*	Plan in 2015 corrected *Plan 2015. – korigirani*
	km/10 yrs. – km/10 god.	kn	m/ha		
Vinkovci	68.10	15,118,200	6.47	7.47	7.77
Osijek	116.20	25,796,400	6.63	8.67	9.28
Našice	105.38	23,123,880	19.01	20.35	20.75
Požega	94.70	21,023,400	14.04	15.98	16.56
Bjelovar	100.07	22,214,868	12.12	12.93	13.17
Koprivnica	46.80	10,678,200	16.49	17.28	17.52
Zagreb	172.50	38,295,000	14.08	16.37	17.06
Sisak	55.50	12,321,000	6.64	7.30	7.50
Karlovac	79.80	17,715,600	10.08	11.12	11.43
Ogulin	127.30	20,256,600	15.41	17.87	18.61
Delnice	135.00	29,970,000	21.47	22.92	23.36
Senj	215.88	44,183,270	17.29	20.49	21.43
Gospić	890.02	135,283,040	7.80	11.14	12.14
Buzet	115.00	17,480,000	9.82	11.64	12.19
Split	566.00	86,032,000	-	-	-
Nova Gradiška	102.40	22,732,800	9.27	10.75	11.20
Total »HŠ« - *Ukupno HŠ*	**2,990.65**	**542,224,258**	**11.82**	**14.15**	**14.72**

⇒ Frequent absences of a building site manager (contractor's employee) on the site, who should manage the construction of the TFR route without consulting the design project.

⇒ The absence of supervising engineer on the site and the replacement of permanent supervision with temporary supervision. This makes it hard to keep things under control and record the operations not listed in the bill of costs. Once a TFR is built, it is often too late to correct mistakes and rectify irregularities on its route.

4.1.6 TFR maintenance – identifying problems – *Održavanje ŠC – definiranje problema*

After a TFR has been built, it is necessary to conduct permanent and periodic maintenance activities so as to retain the prescribed quality of a primary forest road network.

Bellow are the basic problems currently occurring in TFR maintenance, with respect to the fact that TFR maintenance activities in the period 2004–2006 took up an average 40,000,000 kn annually (which is 54% of the value of building the lower and upper TFR layer):

⇒ The absence of regulations that define the scope of permanent maintenance activities and the frequency and intensity of periodic maintenance activities in accordance with the TFR category;

⇒ The absence of a methodology of determining the condition of primary forest road infrastructure and the need for maintenance (using samples);

⇒ The absence of a TFR network maintenance plan at the level of management unit and of a maintenance study for a concrete TFR,

⇒ The application of equal maintenance standards to all TFR categories.

4.2 Operational guidelines – *Smjernice djelovanja*

4.2.1 TFR plan for the period 2006–2015 within the company »HŠ« – *Plan izgradnje šumskih cesta u razdoblju 2006 – 2015. na razini poduzeća HŠ*

A ten-year (2006–2015) plan of truck forest road construction is given in Table 3. The construction plan

also determines the planned FA accessibility in 2015. Since the main TFR have already been built and those of lower categories are currently under way, we assume that all new TFR will affect openness in their entire lengths. The value of operations was calculated on the basis of planned costs (planned costs of forest fire-prevention roads are 152,000 kn/km and truck forest economic roads 222,000 kn/km). Since the existing cadastre of TFR in the majority of FA was updated in 2003, openness in 2015 must be increased by the average three-year construction plan in each FA.

The TFR construction plan contains the following items: annual construction of about 300 km of new TFR; annual construction costs of about 54,000,000 kn; and unbalanced building activities per TFA caused by varying primary openness, different stand and site conditions and the related different harvesting techniques and technologies.

4.2.2 Forest road planning – recommended activities and procedures – *Planiranje šumskih prometnica – preporučene mjere i postupci*

An improved procedure of forest road planning requires strict adherence to the following activities and procedures:

⇒ The need to produce a *Study of Primary Forest Opening* and a *Study of Secondary Forest Opening* should be regulated by law. The mentioned *Studies of Forest Opening* should make up a constituent part of Management plans (in the form of an annex for easier use in the field), and should cover a period of 10 (20) years. *Studies of Forest Opening* should be approved by a designated commission consisting of experts in the field of forest opening.

⇒ FR planning entails the use of GIS (a system consisting of integrated geocoded cartographic bases and relation databases, then of algorithms which manage these data, and of procedures for rapid and economic establishment of the changes, which is particularly important for monitoring the dynamics of changes in forestry) and GPS devices (to inventory the existing forest roads, prepare cadastres and transfer preliminary TFR routes, chosen with computer models and simulated on adequate bases, to the field).

⇒ *Studies of Primary Forest Opening* and *Studies of Secondary Forest Opening* should be drawn up by certified forestry engineers – members of the *Department of Forest Roads and Forest Construction* within the *Croatian Chamber of Forestry and Wood Technology Engineers*, who are skilled and trained for this task.

⇒ All physical and legal persons should take part in the preparation of the Study of Forest Opening (private forest owners, local management and self-management units, competent ministries and institutions); in other words, all those in whose interest it is to participate in making decisions on a particular forestry issue (in this case selecting the routes of future TFR). In West European countries the »public voice« is increasingly being acknowledged. The public takes part, when FR are concerned, in planning procedures but also participates, on an equal footing, in the allocation of construction and maintenance (repairs) costs.

4.2.3 TFR design – recommended activities and procedures – *Projektiranje ŠC – preporučene mjere i postupci*

In order to improve TFR design, the following activities must be undertaken:

⇒ Create, as soon as possible, new *Technical Requirements for Forest Roads* with defined basic content components of a detailed TFR design. Every subappendix should be elaborated in detail for the purpose of achieving uniformity and balanced quality of the created project.

⇒ Urgently prepare a *Handbook of Truck Forest Road Design* which will provide answers, in one place, to a large number of questions occurring during the designing procedure (both in the field and in the office stage).

⇒ Appoint managers for special programmes in the Forest Chamber, including a specialist programme *Forest Roads and Forest Engineering*, who will coordinate, create and implement activities within the Forest Chamber at the level of specialist programmes. One of the prime tasks is also the organization of lifelong education.

⇒ Design a new computer programme for TFR design which will specialize exclusively in TFR (the currently used programme »CESTA« was originally intended for public road design but was later adjusted for TFR design).

⇒ Establish a professional, qualified commission entrusted with the revision of the created TFR designs. This will ensure credibility and quality of technical documentation before the construction activities are launched. Apart from forestry experts, the commission should include spatial management experts and civil engineering experts.

⇒ Consider the creation of detailed SR designs since they, like TFR, represent permanent engineering forest amenities. Past experience shows

that it is better when forestry professionals themselves set down certain rules than let others do it for them (even at a risk of initial misunderstandings of this practice, it is generally a much better and less painful variant in the long run).

4.2.4 TFR and SR construction and supervision of construction – recommended activities and procedures – *Izgradnja ŠC i TP te nadzor gradnje – preporučene mjere i postupci*

The recommended activities and procedures aimed at improving the existing situation relating to TFR and SR construction and supervision entail the following:

⇒ The procedure of licensing operations and contractors related to forest road construction should be initiated via the *Forestry Chamber* and within the specialist programme *Forest Roads and Forest Engineering*. It is also necessary to establish a registry of licensed private entrepreneurs dealing with the subject activities (and using licensed machines and equipment). The registry should also contain annual evaluations of entrepreneur quality and reliability (which should, together with other criteria, be taken into account during the selection of the best bidder in public bids).

⇒ Contractors engaged in the construction, maintenance and repair of forest roads should organize themselves and establish their *Trade association*, which will protect their interests and ensure fair market competition.

⇒ The supervising engineer should insist on renewing the layout of the TFR axle route and marking all cross sections in the field before the contractors start working.

⇒ The building site manager, appointed by the contractor, should be present at the building site at all times (in case of his absence at the building site, the supervising engineer should suspend all construction activities).

⇒ The supervising engineer should be present at the building site at all times to supervise work, compare it with the detailed design and follow the *Engineering Record* and *Engineering Log*. It is recommended that supervision is undertaken by the designer.

4.2.5 TFR maintenance – recommended activities and procedures – *Održavanje ŠC – preporučene mjere i postupci*

Improvement of TFR maintenance activities requires the following measures and procedures:

⇒ Define the scope of permanent maintenance activities and the frequency and intensity of periodic maintenance activities in accordance with the new TFR categorization in the chapter *TFR Maintenance* within *Technical Requirements for Forest Transportation Network.*

⇒ Develop a methodology of sample collection at the level of a management unit, which will allow a rapid and accurate insight into the quality status of the existing TFR network. Together with the TFR category, their current status should provide an entry parameter for determining the amount of maintenance operations.

⇒ Draw up annual plans of TFR network maintenance for a particular management unit within the *Study of Primary Forest Opening.*

⇒ Prepare a maintenance study for a particular TFR, especially for truck forest roads that require major interventions.

5. Discussion and Conclusive Remarks– *Rasprava i zaključna razmatranja*

The establishment of a cadastre of primary forest traffic infrastructure at the level of »HŠ« is the prime contribution to modern, integrated management with forests in Croatia. Regular cadastre update and the possibility of viewing the current status will ensure even better planning of all forestry operations, and in particular forest opening and harvesting activities. The future cadastre of secondary forest roads, whose preparation methodology has already been defined, will add yet another step towards the quality of forest resource management.

The analysis of existing primary openness of Croatian forests managed by the company »HŠ« reveals considerable differences among FA. Apart from being caused by varying site and stand conditions, these differences are also due to different approaches to primary forest opening using different harvesting techniques and technologies (but also to dissimilar past financial investment possibilities in primary forest road).

The majority of FA cannot be classified into one relief area only (lowland, hilly, mountainous or karst); rather, they are a combination of two or more relief areas. For this reason, primary openness within a particular FA should be expressed separately for each relief area. Therefore, no comparisons should be made between current and planned primary openness unless the FA in question is homogeneous

in terms of relief (or one type of relief is predominant over a large area).

One of the criteria used to evaluate the optimality of the existing FR network and plan future forest opening activities is the technical-technological criterion (Pentek et al. 2004a). Operative terrain classification should be made at the level of Croatia in order to determine the type of optimal harvesting techniques and technologies to be applied in certain terrain and stand conditions. The FR network should be optimized using the operative terrain classification.

Existing primary openness should be analyzed at the level of a particular management unit and should be supplemented with compulsory presentation of the mean skidding distance value. Instead of classical primary openness, it is even better to determine relative primary openness (it shows the ratio between open and unopened forest area for targeted mean skidding distance in percentages), which is an indicator of the quality of spatial TFR arrangement.

Ever since the public enterprise »Hrvatske šume« (presently »Hrvatske šume« Zagreb) was established, substantial financial resources have been invested in TFR construction and maintenance and in TR building and repairs. From 2004 to 2006, engineering activities accounted for an average 134,000,000 kn annually (about 6% of the total revenue of »HŠ«). In terms of FA, the largest amount of engineering activities were, understandably, undertaken in FA Gospić: this FA is characterized by poor primary and secondary openness due to being largely situated in demanding terrains in terms of opening up forests and timber harvesting.

According to the TFR construction plan for the period 2006–2015, about 300 km of new TFR (lower and upper layer) are planned at an annual construction cost of about 54,000,000 kn (calculated on the basis of planned price). On average, in the period 2004–2006 an annual amount of 75,000,000 kn were invested in the building of lower and upper TFR layers: 272 km of TFR lower layer and 319 km of TFR upper layer were built on average. The difference in the price with approximately equal quantity of new TFR annually indicates that planned prices were too low in relation to the realized building costs. It is realistic to expect that annual TFR building costs will exceed planned costs. The analysis of the 2015 openness plan indicates that the volume of TFR construction should be greater than planned.

The present quality of FR planning, TFR design and TFR and SR construction and supervision procedures, as well as TR maintenance is at a much higher level than it was at the beginning of the 1990s. However, a detailed analysis of each stage in the establishment of an optimal forest road network in the field has revealed certain problems, defects, deficiencies, and irregularities. Our effort to identify, pinpoint and describe them, as well as recommend efficient actions for their removal, is geared towards rationalising forest opening costs, improving the quality of forest road network, cutting down on harvesting costs and promoting overall forest ecosystem management of the highest quality.

The basic preconditions (legal and organizational ones in particular), highlighted as crucial in earlier debates on the improvement of forest opening procedures, have been met. By this we mean the establishment of the Croatian Chamber of Forestry and Wood Technology Engineers and its separate specialist programme Forest Roads and Forest Engineering. Their establishment provides a framework for positioning this forestry segment within and out of the forestry profession. The foundations have been laid for good developmental possibilities, but we should always be aware of the fact that the final result will for the most part depend on our own resources.

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Sažetak

Šumske prometnice u Republici Hrvatskoj – stanje i perspektiva

Šumska je prometna infrastruktura jedan od temeljnih preduvjeta kvalitetnoga gospodarenja šumskim ekosustavom. Unatoč dosadašnjim značajnim investicijama u ovom segmentu šumarstva, poglavito od osamostaljenja Republike Hrvatske, treba izgraditi puno kilometara šumskih prometnica do dostizanja optimalne otvorenosti.

Cilj je istraživanja raščlaniti situaciju u svezi sa šumskim prometnicama u Republici Hrvatskoj, prepoznati i jasno definirati uočene probleme prema fazama uspostave optimalne mreže šumskih prometnica na terenu (planiranje, projektiranje, izgradnja s nadzorom i održavanje) te predložiti postupke za njihovo rješavanje. Područje istraživanja zapravo su sve šume i šumsko zemljište kojim gospodari poduzeće HŠ u Republici Hrvatskoj (1 920 000 ha ili 80,2 %) preko svojih 16 UŠP (slika 1).

U tablici 1 donosi se postojeća primarna otvorenost uprava šuma podružnica (dalje UŠP) koja je izračunata kao prosječna, iako se u većini UŠP nalazi kombinacija različitih reljefnih područja. Raščlani li se postojeća primarna otvorenost šuma kojima u Republici Hrvatskoj gospodari poduzeće HŠ preko UŠP, uočavaju se velike razlike. Te su razlike, osim različitih stanišnih i sastojinskih prilika, uvjetovane i drugačijim pristupom primarnomu otvaranju šuma različitim tehnikama i postupcima pridobivanja drva (ali i u prošlosti nejednakim financijskim mogućnostima investiranja u primarnu šumsku prometnu infrastrukturu).

Raščlamba bi se postojeće primarne otvorenosti trebala iskazivati na razini pojedine gospodarske jedinice uz obvezan prikaz vrijednosti srednje udaljenosti privlačenja. Još je bolje, umjesto klasične primarne otvorenosti, odrediti relativnu primarnu otvorenost (prikazuje omjer otvorene i neotvorene šumske površine za ciljanu srednju udaljenost privlačenja drva u postocima) koja je pokazatelj kakvoće prostornoga razmještaja ŠC.

U tablici su 2 prikazani radovi na niskogradnji obavljeni u razdoblju 2004 – 2006. godine na razini poduzeća HŠ. Ukupna vrijednost svih radova na niskogradnji iznosi u prosjeku 134 000 000 kn svake godine (oko 6 % ukupnoga godišnjega prihoda HŠ), od čega poduzeće HŠ preko polovice (51,46 %), računajući prema vrijednosti radova, izvede vlastitim kapacitetima. Najviše se radova na niskogradnji, gledano po UŠP, obavilo u UŠP Gospić, što je i razumljivo; ova uprava šuma podružnica ima slabu primarnu i sekundarnu otvorenost, a većinom se nalazi na zahtjevnim terenima sa stajališta otvaranja šuma i pridobivanja drva.

Desetogodišnji (2006 – 2015) plan izgradnje šumskih cesta nalazi se u tablici 3. Prema planu izgradnje ŠC u razdoblju 2006 – 2015. godišnje se planira izgraditi oko 300 km novih ŠC (donji i gornji stroj) uz planirani godišnji trošak gradnje oko 54 000 000 kn (izračunat temeljem planske cijene). U razdoblju 2004 – 2006. u izvedbu

je donjega i gornjega stroja ŠC uloženo prosječno 75 000 000 kn godišnje, a izvedena su prosječno 272 km donjega stroja i 319 km gornjega stroja ŠC godišnje. Razlika u cijeni uz približno jednaku količinu novih ŠC godišnje upućuje na preniske planske cijene u odnosu na ostvarene troškove gradnje. Realno je očekivati veće godišnje troškove izgradnje ŠC od planiranih. Raščlamba plana otvorenosti 2015. godine upućuje na potrebu većega obujma gradnje ŠC nego što je planirano.

Jedan od kriterija procjene optimalnosti postojeće mreže ŠP te planiranja daljnjega otvaranja šuma jest i tehničko-tehnološki kriterij (Pentek i dr. 2004a). Potrebno je izraditi operativnu klasifikaciju terena na razini Hrvatske koja će odgovoriti na pitanje koje su tehnike i postupci pridobivanja drva optimalni u određenim terenskim i sastojinskim uvjetima pa temeljem operativne klasifikacije terena optimizirati mrežu ŠP.

Današnja kvaliteta postupaka planiranja ŠP, projektiranja ŠC, izgradnje i nadzora gradnje ŠC i TP te održavanja ŠC na puno je višoj razini nego što je bila početkom devedesetih godina. Ipak su, detaljnom raščlambom svake od spomenutih faza uspostave optimalne šumske prometne infrastrukture na terenu, uočeni određeni problemi, nedostaci, manjkavosti i nepravilnosti.

Za unapređivanje planiranja šumskih cesta potrebno je pridržavati se ovih mjera i postupaka:

- ⇒ *Nužno je zakonski propisati obvezu izrade Studije primarnoga otvaranja šuma te Studije sekundarnoga otvaranja šuma. Navedene bi studije otvaranja šuma trebale biti sastavni dio programa gospodarenja, a izrađivale bi se za razdoblje od 10 (20) godina.*
- ⇒ *Studiju primarnoga otvaranja šuma i Studiju sekundarnoga otvaranja šuma trebaju izrađivati ovlašteni inženjeri šumarstva – članovi Hrvatske komore inženjera šumarstva i drvne tehnologije, koji su jedini stručni i osposobljeni za taj posao.*
- ⇒ *U izradu je studija otvaranja šuma potrebno uključiti sve fizičke i pravne osobe (privatni šumovlasnici, jedinice lokalne uprave i samouprave, nadležna ministarstva i institucije) kojima je u interesu sudjelovati pri donošenju određenih odluka u šumarstvu.*

Ako se želi unaprijediti projektiranje ŠC, potrebne su ove aktivnosti:

- ⇒ *Nužno je u što skorije vrijeme izraditi nove Tehničke uvjete za šumske prometnice.*
- ⇒ *Prioritet je i izrada Priručnika za projektiranje šumskih cesta.*
- ⇒ *Treba dizajnirati novi računalni program za projektiranje ŠC.*
- ⇒ *Potrebno je ustrojiti stručno, kvalificirano Povjerenstvo za reviziju izrađenih projekata ŠC, čime bi se prije ulaska u izgradnju osigurala vjerodostojnost i kakvoća tehničke dokumentacije.*
- ⇒ *Treba razmisliti o izradi glavnih projekata TP jer su oni, kao i ŠC, građevinski objekt trajnoga karaktera u šumi.*

Kao preporučene mjere i postupke poboljšanja postojeće situacije u svezi s izgradnjom ŠC i TP te nadzora gradnje navodi se sljedeće:

- ⇒ *Preko Šumarske komore, a unutar stručnoga smjera Šumske prometnice i šumarsko graditeljstvo treba započeti s postupkom licenciranja radova i izvoditelja radova povezanih sa šumskim prometnicama.*
- ⇒ *Izvođači izgradnje, održavanje i popravaka šumskih prometnica trebaju se organizirati i ustrojiti svoje strukovno udruženje koje će štititi njihove interese.*
- ⇒ *Stalna prisutnost voditelja gradilišta, kojega imenuje izvoditelj radova, na gradilištu (u slučaju izostanka voditelja gradilišta nadzorni inženjer treba obustaviti izgradnju).*
- ⇒ *Stalna prisutnost nadzornoga inženjera na gradilištu uz kontrolu radova i usporedbu s glavnim projektom te praćenje Građevinske knjige i Građevinskoga dnevnika.*

Trebalo bi, radi unapređivanja radova na održavanju ŠC, uzeti u obzir navedene mjere i postupke:

- ⇒ *U okviru je Tehničkih uvjeta za šumske prometnice, u poglavlju Održavanje ŠC, nužno definirati obujam radova na stalnom održavanju te učestalost i intenzitet radova na periodičnom održavanju ŠC sukladno novoj kategorizaciji ŠC.*
- ⇒ *Razvijanje metodologije prikupljanja uzoraka na razini gospodarske jedinice kojima će se brzo i dovoljno točno dobiti pregled stanje kakvoće postojeće mreže ŠC.*
- ⇒ *Unutar Studije primarnoga otvaranja šuma treba napraviti godišnje planove održavanja mreže ŠC u pojedinoj gospodarskoj jedinici.*
- ⇒ *Izrada elaborata održavanja pojedine ŠC poglavito onih koje zahtijevaju veće intervencije.*

Osnovni, u prvom redu zakonski i organizacijski preduvjeti koji su u ranijim raspravama o poboljšanju postupaka otvaranja šuma određeni kao ključni, ostvareni su. Tu mislimo na osnivanje Hrvatske komore inženjera šumarstva i drvne tehnologije i unutar nje zasebnoga stručnoga smjera Šumske prometnice i šumarsko graditeljstvo. Time su stvoreni okviri u kojima se treba zalagati za pozicioniranje ovoga segmenta šumarstva unutar šumarske struke, a i izvan nje. Postavljeni su temelji koji pružaju dobre mogućnosti razvoja, ali treba biti svjestan kako će konačan rezultat ovisiti ponajviše o nama samima.

Ključne riječi: šumske prometnice, planiranje, projektiranje, izgradnja, održavanje, troškovi, Hrvatska

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Received (*Primljeno*): December 8, 2006
Accepted (*Prihvaćeno*): March 8, 2007