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FORECASTING INTERMODAL TRANSPORT REQUIREMENTS ON CORRIDOR X

ABSTRACT

The increase of market share of railway in cargo transport on Corridor X is considered a precondition in order to make railway operation cost-effective and commercially attractive to private operators. Railway sector has suffered damage during the war and the infrastructure needs modernization in order to create efficient and environmentally-friendly transport modes. The intervention is necessary in order to allow the railway network to be successful in the corridor competition. The forecasting model would be used to forecast the requirements for intermodal transport by the year 2018 on Corridor X using forecasting model for the future of the development of cargo transport requirements on Corridor X.

KEY WORDS

intermodal transport, cargo flows, transport forecast

1. INTRODUCTION

Corridor X is a double-track main railway line on Savski Marof – Zagreb main railway station – Novska –Tovarnik relation which connects Central and South-eastern Europe from Salzburg via Ljubljana, Zagreb and Skopje to the port of Solun. Corridor X has four more auxiliary branches:

- Branch a of Corridor X – from Graz (Austria) via Maribor (Slovenia) to Zagreb (Croatia);
- Branch b of Corridor X – from Budapest (Hungary) to Belgrade (Serbia and Montenegro);
- Branch c of Corridor X – from Niš (Serbia and Montenegro) to Sophia (Bulgaria) and further connection to Corridor IV to Istanbul;
- Branch d of Corridor X – from Veles (Macedonia) to Florin (Greece) and further via Via Egnatia to Volos (Greece) and Athens (Greece).

Regarding traffic it represents the backbone of railway traffic from the East to the West which is connected to almost all the North – South lines and lines from Bosnia and Herzegovina. Within Croatia, this route connects important industrial and agricultural areas. During the 1990s the events in the area of former Yugoslavia brought to a significant reduction in cargo and passenger transport which was mainly redirected to alternative traffic corridors. Transit traffic on Corridor X was completely destroyed during a period of more than five years. In the recent several years, HŽ Infrastructure has marked traffic growth on Corridor X.

The total length of Corridor X amounts to 2,528.2km, out of which 1,622.7km (64.2 percent) are single-track lines and 905.5 (35.8 percent) are double-track lines. Out of the total length of all lines in the Corridor, 2,244.5 (88.7 percent) have been electrified. By the year 2010, the plan is to have 1,461.3km (57.8 percent) of single-track lines, 1,066.9km (42.2 percent) double-track and 2,348.7km (92.9 percent) electrified lines [1]. The forecasting model will be used to respond on time to all demands for transportation on Corridor X.

2. CARGO FLOWS ON CORRIDOR X

The technical and technological parameters of the railway line on Corridor X range within the following limits: permitted vehicle mass is D4, permitted speed is between 50 and 160km/h, relevant gradient is 2-26‰, the line is electrified by 25kV 50Hz A.C. system, there are all types of telecommunication instruments, security is provided by automatic block. The most critical condition is on the line from Savski Marof via the Main Railway Station in Zagreb to Dugo Selo, thus limiting the route capacity.

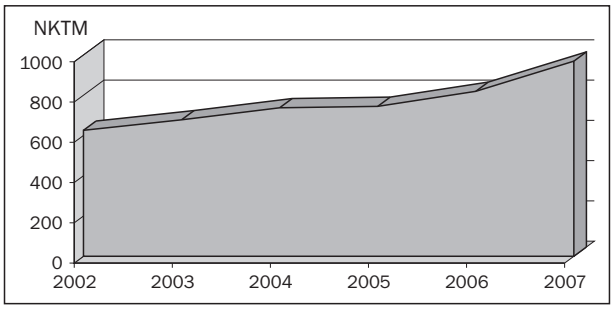
Table 1 - Realized NTKM per corridors

X, Branch b and c of CORRIDOR V - REALIZED NTKM						
	in millions of net tonne kilometres					
Year	2002	2003	2004	2005	2006	2007
CORRIDOR X	630.5	684.0	742.1	747.0	824.2	974.3
Branch b Corridor V	810.7	952.2	832.0	947.5	1,000.8	1,161.5
Branch c Corridor V	37.0	40.5	58.1	113.3	112.9	111.4
TOTAL CORRIDORS	1,478.2	1,676.7	1,632.2	1,807.8	1,937.9	2,247.2
Other HŽ lines	941.8	1,067.7	1,100.9	1,298.6	1,665.1	1,623.2
TOTAL HŽ CARGO	2,420.0	2,744.4	2,733.1	3,106.4	3,603.0	3,870.4

Source: Database IST HŽ and Tables of cargo transport of HŽ Cargo

The realized NTKM per corridors are presented in *Table 1*.

According to the data from the IST HŽ Database and Table of cargo transport of HŽ Cargo in the period from 2002 to 2007, Corridor X has marked a growth of 18 percent, on Branch b of Corridor V a growth of 13.85 percent and on Branch c of Corridor V a decline of 1.4 percent. The ratio of intermodal transport on Corridor X is about 85% of the whole freight regarding the waybill. In the *Graph 1* the NTKM on Corridor X are presented [2].



Graph 1 - Realized NTKM in millions on Corridor X

3. FORECASTING MODEL FOR CORRIDOR X

According to the actual data obtained from HŽ Cargo (*Table 1*), using a simple linear regression (polynomial of 1st order) the future traffic and intermodal transport requirements on Corridor X and Branches b and c of Corridor V have been forecast. The analysis encompassed the time period from 2002 to 2007, making it thus quite a conservative one. Considering the traffic condition since 2002, it was concluded that it was not consistent since in the post-war period the traffic was unstable and unusable for analysis. The general condition of the railways in Croatia until the Croatian War for Independence was not favourable. The network was characterized by relatively low technical level of the condition of the lines and equipment on the lines. The most part of the network consisted of single-track lines. Only the Savski Marof – Zagreb – Vinkovci – Tovarnik line could provide the quality of service at the European level where most of the track is a double-track line, with achieving maximum train running speed of 160km/h. Higher transport quality was reached also by the introduction of EC and IC (Euro City and Inter City) trains into operation towards Munich, Vienna and Venice. The traffic volume on HŽ lines from 1986 to 1990 ranged between 35 – 42 million tonnes of carried cargo, with a tendency of slight decline [3].

Corridor X on the Croatian territory is mainly transit. Because of that and regarding the European transport policy with high probability in the future the growth of traffic will be based on the growth of intermodal transport. Especially when the number of transit permits for road traffic will be reduced. Of course some goods will be also carried in future using conventional transport.

The methodology of calculation consists of:

1. *computing Pearson's correlation coefficient* which assigns values from the closed interval [-1,1]. When the coefficient value equals zero it means that there is no linear correlation between the phenomena, value plus one says there is perfect correlation and of positive direction.
2. *computing linear regression*; the model of simple linear regression expresses the statistical relationship between two phenomena presented by values of numerical variables.
3. *forecasting future traffic*; the simple regression model contains one dependent and one independent variable. If the linear function is the functional part of the model, the model parameters and the powers of the variable equal one, and if random variable is added to the functional part of the model, then this is as in this case a simple linear regression model [4].

The correlation analysis consists of the application of procedures that determine the indicators of the power of the statistical relationship among phenomena. If the relationship is linear in form, we speak of linear correlation. The standardized measure of the power of the statistical relationship among phenomena presented by two quantitative variables is the correlation coefficient. When the phenomena are presented in the forms of two rank variables, the degree of statistical relationship will be expressed by the rank

Table 3 - Basic statistics for Corridor X in time period 2002 - 2007

Simple Statistics						
Variables	N	Mathematical expectation	Normal deviation	Sum	Minimum	Maximum
	6	16,254	683.33359	97,524	15,341	17,167
CORRIDOR X	6	767.01667	120.65354	4,602	630.50	974.30

Source: output SAS/ENTERPRISE GUIDE 3.0.

correlation coefficient. The covariance of the standardized values of variables X and Y is called the Pearson's correlation coefficient. The closer the coefficient regarding absolute value to one, the closer the relationship.

Table 4 - Pearson's correlation coefficient for Corridor X in the time period 2002 - 2007

Pearson's correlation coefficient, N = 6 Prob > |r| under H0: Rho=0	
	CORRIDOR X
Year	0.95000 0.0037

Source: output SAS/ENTERPRISE GUIDE 4.1.

In order to determine whether the model is good, the model is divided by the error. *Table 4* shows that the influence of error in the model is small (Pr > F amounts to 0.0037).

The analysis of the variance for the simple regression model relies on the breakdown of the sum of squares of the deviation of the dependent variable value from its arithmetic mean. From the formal viewpoint this decomposition equals the decomposition presented for the simple regression model as part of the descriptive statistics:

$$\sum_{i=1}^{n} y_i^2 - n\bar{y}^2 = \left[\alpha \sum_{i=1}^{n} y_i + \beta \sum_{i=1}^{n} x_i y_i - n\bar{y}^2\right] + \left[\sum_{i=1}^{n} y_i^2 - \alpha \sum_{i=1}^{n} y_i - \beta \sum_{i=1}^{n} x_i y_i\right] \quad (1)\ [5]$$

Where n is number of pares observed years; y is amount of transported goods; x stands for years; β is intercept and α means coefficients of the regression line.

Apart from estimating the variance, i.e. estimating the standard deviation of regression, the coefficient of determination and the corrected coefficient of determination also serve as specific indicators of representativeness. The coefficient of determination is the ratio between the interpreted part of the sum of squares and the total sum of squares, i.e.

$$\gamma^2 = \frac{\alpha \sum_{i=1}^{n} y_i + \beta \sum_{i=1}^{n} x_i y_i - n\bar{y}^2}{\sum_{i=1}^{n} y_i^2 - n\bar{y}^2};\ 0 \le \gamma^2 \le 1 \quad (2)\ [5]$$

Table 5 shows that the coefficient of determination ranges between zero and one and in this case the model is representative since the coefficient of determination is closer to one, $\gamma^2 = 0.9025$. The proportion of the model-interpreted part of the sum of squares in the total sum of squares. The interpreted part of the squares equals the sum of the squares of the deviation of regression values from the arithmetic mean of the dependent variable, and the total sum of squares refers to the sum of squares of the deviation of the value of the dependent variable from its arithmetic mean.

It should be noted that there is linear relationship from year to year and the cargo growth per years, which can be seen in *Graph 2*. The standard deviation shows the average deviation of empirical values of the dependent variable from the regression values in the

Table 5 - Analysis of variance (ANOVA)

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	1	65,690	65,690	37.03	0.0037
Error	4	7,096.68399	1,774.17100		
Corrected Total	5	72,786			

Source: output SAS/ENTERPRISE GUIDE 4.1.

Table 6 - Statistics coefficients

Estimate of standard deviation of regression	42.12091	Coefficient of determination	0.9025
Mathematical dependent expectation	767.01667	Corrected coefficient of determination	0.8781
Estimate of regression variation coefficient	5.49152		

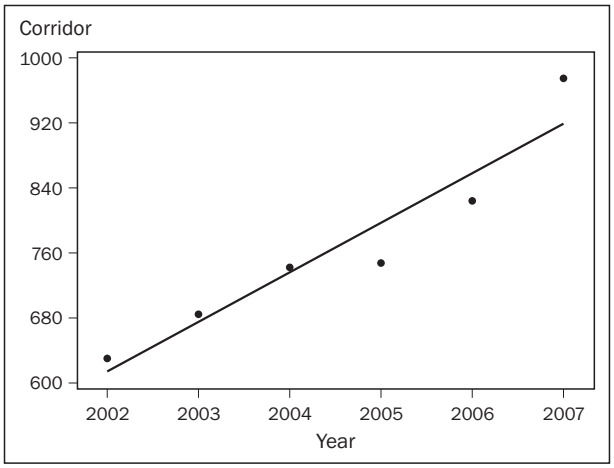
Source: output SAS/ENTERPRISE GUIDE 3.0.

measuring units of the dependent variable, and the coefficient of variation how much it is in the relative amount (in percentage).

Calculating linear regression intercept is -122,052 and slope is 61.271, which means the regression equation is:

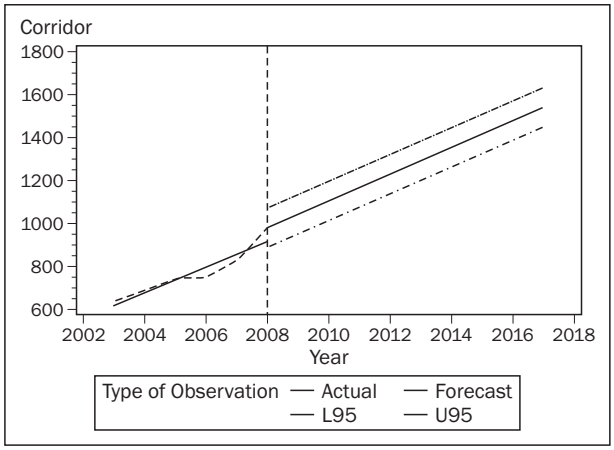
$$y = 61.271x - 122{,}052 \quad (3)$$

Graph 2 shows the relationship between the real amount of transported goods by years on corridor and the related linear regression.



Graph 2 - Linear model for Corridor X in time period 2002 -2007

The regression model with estimated parameters is used to predict (forecast) the level of dependent variable. Forecasting is carried out by the number and interval. The forecasting value for the assumed value of independent variable x_p is calculated as regression value, i.e. by inserting the assumed value of the independent variable into the regression equation with the estimated parameters. *Graph 3* and *Table 7* show the actual condition of the carried goods on Corridor X as well as the forecast condition and prognostic model with lower confidence limit (L95) and upper confidence limit (U95).



Graph 3 - Forecasting model for Corridor X in time period 2008 - 2018

Table 7 - Results of the forecasting model for Corridor X in time period 2009 – 2018

Ord.No.	Year	Type of forecast	Corridor X
1	2009	Forecast	1,042.59
2	2009	Minimal value	954.40
3	2009	Mean value	44.99
4	2009	Higher value	1,130.77
5	2010	Forecast	1,103.87
6	2010	Minimal value	1,014.97
7	2010	Mean value	45.36
8	2010	Higher value	1,192.76
9	2011	Forecast	1,165.14
10	2011	Minimal value	1,075.42
11	2011	Mean value	45.78
12	2011	Higher value	1,254.87
13	2012	Forecast	1,226.42
14	2012	Minimal value	1,135.74
15	2012	Mean value	46.27
16	2012	Higher value	1,317.11
17	2013	Forecast	1,287.70
18	2013	Minimal value	1,195.92
19	2013	Mean value	46.83
20	2013	Higher value	1,379.48
21	2014	Forecast	1,348.98
22	2014	Minimal value	1,255.97
23	2014	Mean value	47.46
24	2014	Higher value	1,441.99
25	2015	Forecast	1,410.26
26	2015	Minimal value	1,315.87
27	2015	Mean value	48.16
28	2015	Higher value	1,504.65
29	2016	Forecast	1,471.54
30	2016	Minimal value	1,375.62
31	2016	Mean value	48.94
32	2016	Higher value	1,567.46
33	2017	Forecast	1,532.82
34	2017	Minimal value	1,435.21
35	2017	Mean value	49.80
36	2017	Higher value	1,630.42

Source: output SAS/ENTERPRISE GUIDE 4.1.

According to the forecasting model for Corridor X in the time period 2008 – 2018 the forecast traffic growth for each year is by 0.16. that is 160,000 NTKM.

4. CONCLUSION

Railway Corridor X represents the connection between the South-eastern and Central Europe, and with

its further modernization it may become a significant traffic connection with the Middle and Far East and Africa.

In Croatia, Corridor X is suitable for the development of combined transport which operates from Spačva to Ljubljana (*huckepack* technology).

The development of intermodal transport in Croatia by the year 2018[1] depends directly or indirectly on several factors, such as: development per industrial branches and regions, macro-economic policy, level of attracting foreign investments, competitiveness of products and services on the market, regulations of intermodal transport, etc. It is very difficult to analyse, and especially to predict in the future period, the influence and the value of some of the mentioned factors. Also, one of the main problems is the lack of strategic plans and studies related to the development of intermodal transport. The results of the work show an increase in the traffic on Corridor X, and thus also further growth of intermodal transport, and taking into consideration the neighbouring eastern countries that have a large number of requests for transit permits for Croatia, all this transit surplus would be used by using huckepack technology on this line and part of the costs would be automatically covered by its charging at the same time alleviating the burden on the motorway sections which cause traffic congestion, especially during the summer months.

Because of all the mentioned reasons as well as the limitation of the available data (especially in the area of intermodal flows), the estimate of intermodal transport development was done on the estimate of the NTKM flows on Corridor X.

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SAŽETAK

PROGNOZA ZAHTJEVA ZA INTERMODALNIM TRANSPORTOM NA KORIDORU X

Povećanje tržišnog udjela željeznice u teretnom prometu na koridoru X smatra se preduvjetom kako bi se poslovanje željeznice učinilo financijski isplativim i komercijalno privlačnim privatnim operaterima. Najveću štetu infrastrukture u domovinskom ratu pretrpio je željeznički sektor kome je potrebna modernizacija, kako bi se stvorili učinkoviti i za okoliš prihvatljivi oblici prijevoza. Da bi se željezničkoj mreži omogućilo ostvarenje uspjeha u konkurenciji koridora potrebna je intervencija. Korištenjem prognostičkog modela predvidjeli bi se zahtjevi za intermodalnim transportom do 2018. godine na X koridoru pomoću prognoze o budućnosti razvoja zahtjeva za prijevozom tereta na koridoru X.

KLJUČNE RIJEČI

intermodalni transport, robni tokovi, prognoza prometa

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