

Traffic forecasting, AADT, road network management, highways

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## **TRAFFIC FLOW FORECASTING BASED ON NO COMPLETE HIGHWAY DATABASE**

**Summary.** In accordance with the Guidelines for working out highway prefeasibility studies (made under the authority of the World Bank), it can be said traffic flows forecasting is the base for preparing of other phases of road network management. The main prerequisite for successful traffic forecasting is relevant, high-quality and reliable database. This paper deals with methods used in the frame of prefeasibility study for the Veles-Prilep highway, in order to forecast traffic flows on the base of no complete highway data. The study brings up a practical application of the Transport Strategy of the Republic of Macedonia, set to achieve the attributes determining the so called sustainable road network.

## **PROGNOZOWANIE POTOKÓW RUCHU NA AUTOSTRADZIE W WARUNKACH NIEKOMPLETNEJ BAZY DANYCH**

**Streszczenie.** Zgodnie z metodyką przeprowadzania analizy wykonalności dla autostrady (wykonywaną pod patronatem Banku Światowego), prognozowanie potoków ruchu jest podstawą do przygotowania kolejnych faz zarządzania ruchem drogowym. Warunkiem koniecznym dla skutecznego prognozowania ruchu jest posiadanie stosownej, wysokiej jakości i wiarygodnej bazy danych. W artykule przedstawiono metody użyte w ramach analizy wykonalności dla autostrady Veles-Prilep, zrealizowanej w celu prognozy potoków ruchu, bazując na niekompletnej bazie danych. W rozważaniach podnoszone są praktyczne aspekty zastosowania Strategii Transportowej Macedonii, w celu osiągnięcia parametrów opisujących tzw. trwałą i zrównoważoną sieć drogową.

### **1. INTRODUCTION**

Traffic forecasting for building and road reconstruction is a base for preparing prefeasibility and feasibility studies. The forecasting quality is a strong related with available data quality. Many times available data are not corresponding with the needs and the authors have to make some approximation and feel the missing and unavailable data. In this paper is presented practical example for traffic

forecasting with incomplete historical traffic flow data. The example is from the prefeasibility for highway solution Veles – Prilep in The Republic of Macedonia.

In accordance with the "Project Prefeasibility Study for the Veles – Prilep freeway solution (traffic analyses and forecasts)" elaborated by the Fund for National and Regional Roads of the Republic of Macedonia, three variants ought to be analyzed: variant of layout across the hump Kodrostan-V1, V2-variant over the hump Derven, and variant of layout V3, through the city of Gradsko.

## 2. AVAILABLE HISTORICAL DATA

This sub point comprises the analysis of data obtained by the Fund for national and regional roads of the Republic of Macedonia for the years 1994, 1995, 1997, 1998, 1999, 2000, 2001 and 2002. Data collected by counting are presented within the respective tables. Additionally, missing years are being estimated upon the records on GDP/capita or the data interpolation.

Table 1 represents the cumulated values on the traffic flows along the sections Veles – Prilep (highway and national road, the both). Data set obtained by the Fund for National and regional roads provides information for the AADT on the national road Veles – Gradsko no more than the years 1999 and 2000. This road is being intensively used for the most part in order to avoid the toll payment. Since we had only two counts at disposal, we tried to extend the data for all the other years according to the AADT percentage share to the national road and the highway. The total AADT between Veles and Gradsko is being a sum of the ones from Veles – Gradsko highway and the national road Veles – Gradsko. This is quite reasonable since the Gradsko – Prilep traffic flows come either from the highway or the national road Veles – Gradsko.

Data in tab. 1, 2, 3 are adjusted by the members of the advisory team.

Table 1

AADT on the section Veles - Gradsko (1994-2007)

YEAR	MC	BUS	LCV	MCV	HCV	CVT	TOTAL 1	TOTAL 2	TOTAL
1994	6580	195	916	679	947	154	<b>4519</b>	4953	9472
1995	3703	110	516	382	533	87	<b>2543</b>	2787	5330
1996	3857	115	537	398	555	90	2637	2914	5551
1997	4011	119	558	414	577	94	<b>2710</b>	3063	5773
1998	3638	108	506	375	523	85	<b>2498</b>	2738	5236
1999	3690	110	514	381	531	86	<b>2712</b>	<b>2599</b>	5311
2000	3843	114	535	397	553	90	<b>2515</b>	<b>3016</b>	5531
2001	3107	92	433	321	447	73	<b>2134</b>	2339	4473
2002	1892	56	263	195	272	44	<b>1299</b>	1424	2723
2003	3996	119	556	412	575	93	2641	3167	5752
2004	4237	126	590	437	609	99	2773	3325	6098
2005	4448	132	619	459	640	104	2911	3491	6403
2006	4671	139	650	482	672	109	3057	3666	6723
2007	4904	146	683	506	705	115	3210	3849	7059

In addition, the AADT flows on the highway Veles – Gradsko are presented within the column "TOTAL 1", while the column "TOTAL 2" comprises the records of AADT on the national road Veles – Gradsko. Column "TOTAL" indicates the sum of the other two columns.

Data marked off with a bold font are computed from the AADT figures collected by the Fund for national and regional roads. The others denote the 4 percentage points annual increase of the traffic. Statistics on AADT for 1996 is computed by means of the interpolation method.

The Republic of Macedonia suffered an internal disorder in 2001 imposing destabilization within many segments including the economic matters. The analyses have shown the traffic average increase of 4%. Therefore, we have decided to estimate the annual increase for the missing data on AADT whereupon the year 2000 is to be considered the base for the year 2003. It is believed that no huge economic turmoil have happened in the particular year, although the country has entered the transition period since 1991. Ever since all the segments in the Republic of Macedonia have knocked under a great disarray, principally due to the transformation of property.

Table 2 represents the data on the section Gradsko – Prilep, collected by the Fund for National and regional roads.

Table 2  
AADT on the section Gradsko - Drenovo (1994-2007)

YEAR	MC	BUS	LCV	MCV	HCV	CVT	<b>TOTAL</b>
1994	1987	59	277	205	286	46	<b>2860</b>
1995	2100	62	292	217	302	49	<b>3023</b>
1996	2533	75	353	261	364	59	3646
1997	2965	88	413	306	427	69	<b>4268</b>
1998	2656	79	370	274	382	62	<b>3823</b>
1999	3571	106	497	369	514	83	<b>5140</b>
2000	2818	84	392	291	405	66	<b>4056</b>
2001	3160	94	440	326	455	74	<b>4549</b>
2002	2243	67	312	231	323	52	<b>3228</b>
2003	2931	87	408	302	422	69	4218
2004	3048	91	424	315	438	71	4387
2005	3170	94	441	327	456	74	4562
2006	3297	98	459	340	474	77	4745
2007	3428	102	477	354	493	80	4935

Data inscribed with a bold font have been undertaken out of the statistics collected by the Fund for national and regional roads. In addition, the record on 1996 is being computed by interpolation of the years close to the one in particular. The records from 2003 to 2007 are being estimated by 4% annual growth, whereupon 2000 stands for the reference year for 2003 i.e. the one before the internal disorder. Noteworthy is to mention that the year 1999 might not to be included within the further analyses due to the extreme value of the traffic intensity in.

Table 3 represents the data on the section Drenovo – Prilep, collected by the Fund for National and regional roads.

The records on the section Drenovo – Prilep, marked with a bold font, have been also assumed of the data collected by the traffic counting organized by the Fund for national and regional roads. Figure for 2006 is being interpolated by the two years close to the particular one, while data from 2003 to 2004 have been also computed allowing for the traffic growth rate of 4 percentage points.

### 3. SOME CONCLUSION FOR TRAFIC FLOWS FOR THE PERIOD 1994-2007

The traffic on the existing Veles - Prilep road network without investment is mainly carried out over the existing road, i.e. Veles - Gradsko - Drenovo - Pletvar - Prilep. The other two roads, i.e. Veles - Stari Grad - Derven - Prilep and Veles - Stari Grad - Bogomila - Desovo - Prilep are not in function because the first one has an earth section at the Derven passageway, which is not asphalted. Only a terrain vehicle can pass over this section, thus it is not suitable for normal traffic. It is a similar situation with the travel road section passing through Bogomila. There is no road at all from Bogomila to Desovo on this travel road section, and the section from Veles to Bogomila has very poor technical and utilization characteristics, meaning that it is not suitable for an intense traffic.

The analysis of the traffic flow shows out a vast variability. The traffic flow exhibits an increasing rate year-by-year until 2000-2001. After 2000-2001, there is a decreasing trend of the traffic itself. There are many reasons for this phenomenon, both political and economical, as well.

Table 3  
AADT on the section Drenovo - Prilep (1994-2007)

YEAR	MC	BUS	LCV	MCV	HCV	CVT	TOTAL
1994	1693	50	236	175	244	40	<b>2437</b>
1995	1699	50	237	175	244	40	<b>2446</b>
1996	1667	50	232	172	240	39	2400
1997	1598	47	222	165	230	37	<b>2300</b>
1998	1642	49	229	169	236	38	<b>2364</b>
1999	1612	48	224	166	232	38	<b>2320</b>
2000	2027	60	282	209	292	47	<b>2918</b>
2001	2065	61	287	213	297	48	<b>2972</b>
2002	2133	63	297	220	307	50	<b>3070</b>
2003	2218	66	309	229	319	52	3193
2004	2307	69	321	238	332	54	3321
2005	2399	71	334	248	345	56	3453
2006	2495	74	347	258	359	58	3591
2007	2595	77	361	268	373	61	3735

In 2001 Republic of Macedonia has faced internal disturbances which had a strong impact upon the weakening of its economy and has negatively reflected in all social spheres.

The progressive rise of fuel prices during recent years had a great influence on the number of travels, which is a huge restrictive factor. Taking into consideration the fact that the average salary is about 200-250 EUR throughout this whole period, it is more than obvious that the fuel expenses present a great burden. The increase of the vehicles' registration fees is moving in parallel with the fuel prices increase, which also presents a limiting factor. Even though Republic of Macedonia is facing constant increasing of the GDP per capita, the travel costs are growing up even more. All these factors have a significant influence upon the decreasing trend of the number of travels.

If analyses of the trends are going to be performed, one can conclude numerous variations.

It is already known that the increasing of the GDP per capita results in increasing of the traffic intensity approximately with the same rate, i.e. these two trends are mutually correlated by a correlation factor of 0,98 - 0,99 in developed countries. It has shown out that in former Yugoslavia and in the countries sharing similar characteristics, traffic growth rate is more expressed than the increasing of the GDP per capita, by a coefficient of 1,2 and more. This is to be a result of the non-resident foreign currency transfers in the state carried out by the persons who are temporarily working abroad.

Nevertheless, the situation in the Republic of Macedonia can not be explained by this, because the travel costs are growing up much faster than the GDP per capita, as well as the non-resident incomes.

As a result of this fact, we have limited ourselves on the period when there was a normal traffic trend (1995 - 1997). During this period the annual traffic increase in Republic of Macedonia can be approximated by a growth rate of 4% per annum. The coefficient of determination is 87%, which denotes a high level of determination.

#### 4. FORECASTING METHOD

The redistribution of the traffic flow would take place after the building up of the Veles - Prilep highway. If the construction of the highway would start now and it would come to an end in 2012, the redistribution of the traffic would happen in 2013.

If a variant of the highway across the Gradsko - Drenovo - Prilep traffic corridor is going to be chosen, it would also absorb the traffic that does not flow through Veles, i.e. it would potentially absorb the traffic which relative origin is Prilep (East), including Kavadarci, Negotino, Gradsko and the South-East region of Republic of Macedonia. In this case, this category of traffic would also use the highway.

Still, if the highway is going to be constructed across the other two traffic corridors which are taken into consideration by the study, i.e. Veles - Stari Grad - Bogomila - Prilep or Veles - Stari Grad - Derven - Prilep, it would absorb the traffic currently flowing from Prilep to Veles. The redistribution of the traffic would happen in 2013 anyway.

After the building up of the highway, a redistribution of the traffic flow is going to take place, meaning:

- one portion of the traffic would continue to flow on the existing road, which is going to be improved by adding a third traffic lane on the critical spots,
- one portion of the traffic would be redirected on the new highway.

The redistribution of the traffic would be result of several factors, including:

- improving the service level offered by the highway,
- shortening of travel time,
- cutting off travel expenses,
- enhancing of travel safety.

The traffic forecasting is performed using the AADT measurements from the previous years, as well as the GDP per capita trend.

The GDP per capita in Republic of Macedonia during the past period is shown in tab. 4. Data in tab. 4, fig. 1 and 2 are based in State Statistical Office of the Republic of Macedonia

Table 4  
GDP per capita in Republic  
of Macedonia (1995-2005)

Year	GDP per capita (\$)	%
1995	1209	
1996	1420	17%
1997	1480	4%
1998	1573	6%
1999	1656	5%
2000	1771	7%
2001	1821	3%
2002	1917	5%
2003	2032	6%
2004	2114	4%
2005	2226	5%

Figure 1 shows that GDP per capita is quite stable and comply with the linear trend. It shows the nominal increase, whilst the real one is between 3% and 4%. According to the current projections, the

GDP nominal growth should be between 5% and 7% per annum, while its real level would have a growth rate of 4%.

The data obtained from previous feasibility studies, as well as the traffic counting and polling results performed for the needs of this study are the basis for the traffic forecasting.

AADT in Republic of Macedonia shows a large level of oscillations, while in the period after 2000, it complies a decreasing trend. The reasons for these observable facts are seen as being a result of the internal disturbances, the fuel prices increase, as well as the unfavorable social and political periods Republic of Macedonia is passing through.

If the period until 2000 is going to be excerpt from the available data, it can be determined that the traffic growth can be approximated to 4% per annum, including a high coefficient of determination, i.e. 87%.

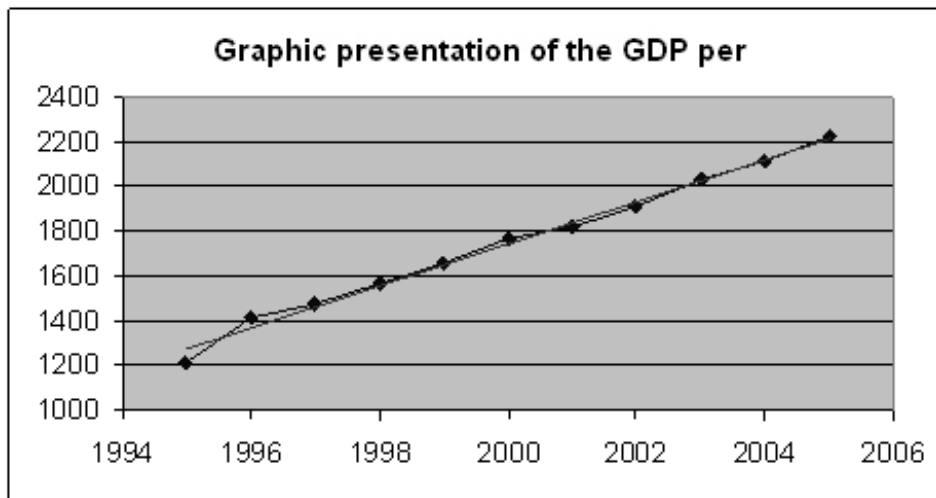


Fig. 1. Graphic presentation of the GDP per capita (\$)

Rys. 1. Graficzna prezentacija PKB per capita (\$)

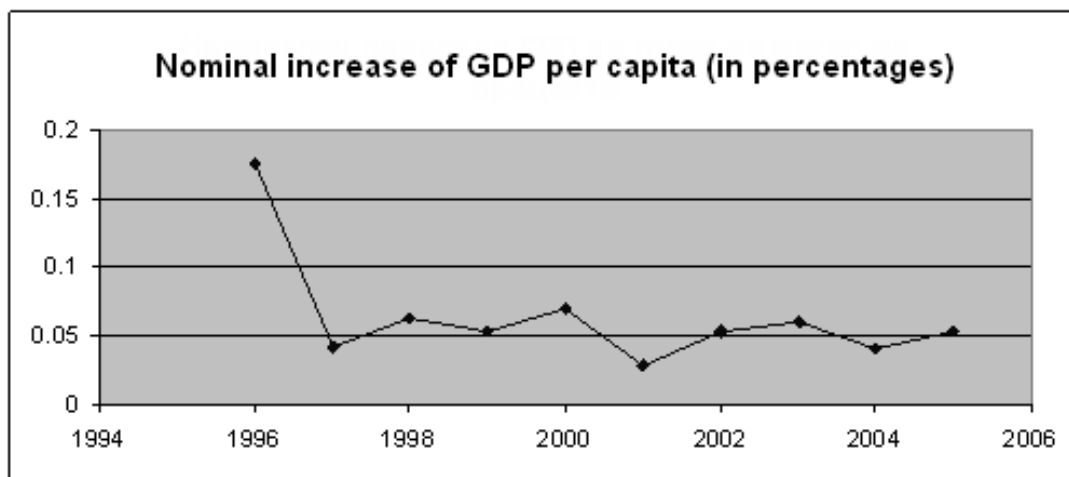


Fig. 2. Nominal increase of GDP per capita (in percentages)

Rys. 2. Nominalny wzrost PKB per capita (%)

If one takes into consideration the fact that the real growth of the GDP per capita is about 4%, including the western experiences of a strong correlation between the GDP per capita and AADT, the traffic growth of 4% is used in this study for forecasting purposes of the future normal traffic.

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Using these theses the forecasting is based on power function on three variants - expected, pessimistic and optimistic.

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